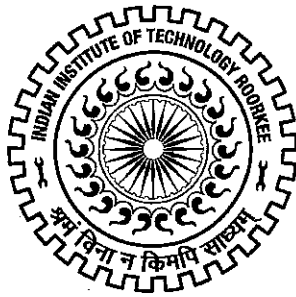


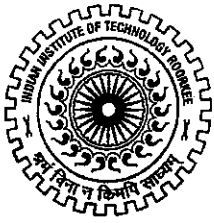
सीनेट की चौतीसवीं बैठक का कार्यवृत्त
MINUTES OF THE 34th MEETING OF THE SENATE

16TH JULY 2010



भारतीय प्रौद्योगिकी संस्थान रुड़की
रुड़की – 247 667 (भारत)

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
ROORKEE - 247 667 (INDIA)**



Lt. Col A K Srivastava (Retd)
Registrar

भारतीय प्रौद्योगिकी संस्थान रुड़की

रुड़की-247 667, उत्तराखण्ड, भारत

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No. IITR/MS/34th Senate/ 4172

Dated: 26th October 2010

ALL MEMBERS OF THE SENATE
Indian Institute of Technology Roorkee

Subject: Minutes of the 34th Meeting of the Senate held on 16th July 2010.

Enclosed herewith please find a copy of the Minutes of the 34th Meeting of the Senate held on 16th July 2010 in the Senate Hall of the Institute, for your perusal. Your comments, if any, on the minutes may please be sent within 15 days.

Encls: Minutes & Annexure (03 Booklets)

(A.K. Srivastava)
Lt. Col. (Retd)

Registrar & Secretary, Senate

26 OCT 2010

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE
ROORKEE - 247 667 (INDIA)



I N D E X

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Minutes of the 34th meeting of the Senate held on 16.7.2010 in the Senate Hall of the Institute.

The following were present:-

1.	Prof. S.C. Saxena, Director	-Chairman
2.	Prof. R. Shankar	(Architecture & Planning)
3.	Prof. S.Y. Kulkarni	(Architecture & Planning)
4.	Prof. (Mrs) Pushplata	(Architecture & Planning)
5.	Prof. Surendra Kumar	(Chemical Engineering)
6.	Prof. Vijay Kumar Agarwal	(Chemical Engineering)
7.	Prof. R.N. Goyal	(Chemistry)
8.	Prof. Kamaluddin	(Chemistry)
9.	Prof. Anil Kumar	(Chemistry)
10.	Prof. A.K. Singh	(Chemistry)
11.	Prof. U.P. Singh	(Chemistry)
12.	Prof. M.R.Maurya	(Chemistry)
13.	Prof. A.K. Jain	(Civil Engineering)
14.	Prof. N.M. Bhandari	(Civil Engineering)
15.	Prof. V.K. Gupta	(Civil Engineering)
16.	Prof. S.S. Jain	(Civil Engineering)
17.	Prof. M.N. Viladkar	(Civil Engineering)
18.	Prof. Pradeep Kumar	(Civil Engineering)
19.	Prof. U.C. Kothiyari	(Civil Engineering)
20.	Prof. P.K. Garg	(Civil Engineering)
21.	Prof. Pradeep Bhargava	(Civil Engineering)
22.	Prof. S.K. Ghosh	(Civil Engineering)
23.	Prof. Manoj K. Arora	(Civil Engineering)
24.	Prof. M.Parida	(Civil Engineering)
25.	Prof. Praveen Kumar	(Civil Engineering)
26.	Prof. D.K. Paul	(Earthquake Engineering)
27.	Prof. Ashwini Kumar	(Earthquake Engineering)
28.	Prof. H.R. Wason	(Earthquake Engineering)
29.	Prof. Ashok Kumar	(Earthquake Engineering)
30.	Prof. H.O. Gupta	(Electrical Engineering)
31.	Prof. Rajendra Prasad	(Electrical Engineering)
32.	Prof. R.S.Anand	(Electrical Engineering)
33.	Prof. A.K. Sarje	(Electronics & Computer Engg.)
34.	Prof. (Mrs) Kumkum Garg	(Electronics & Computer Engg.)
35.	Prof. Manoj Mishra	(Electronics & Computer Engg.)
36.	Prof. D.K. Srivastava	(Hydrology)
37.	Prof. Himanshu Joshi	(Hydrology)
38.	Prof. Rashmi Gaur	(Humanities & Social Scienes)
39.	Prof. A.K. Singh	(Paper Technology)
40.	Prof. V.K. Nangia	(Management Studies)
41.	Prof. G.S. Srivastava	(Mathematics)
42.	Prof. (Mrs.) Rama Bhargava	(Mathematics)
43.	Prof. R.C. Mittal	(Mathematics)
44.	Prof. M.L. Mittal	(Mathematics)

45.	Prof. Pradeep Kumar	(Mechanical & Industrial Engg.)
46.	Prof. Satish C. Sharma	(Mechanical & Industrial Engg.)
47.	Prof. P.K. Jain	(Mechanical & Industrial Engg.)
48.	Prof. Dinesh Kumar	(Mechanical & Industrial Engg.)
49.	Prof. Akhilesh Gupta	(Mechanical & Industrial Engg.)
50.	Prof. B.K.Gandhi	(Mechanical & Industrial Engg.)
51.	Prof. P.K. Ghosh	(Metallurgical & Materials Engg.)
52.	Prof. Surendra Singh	(Metallurgical & Materials Engg.)
53.	Prof. Ishwar Singh	(Physics)
54.	Prof. Jagdish Rai	(Physics)
55.	Prof. B.D. Indu	(Physics)
56.	Prof. Vir Singh	(Physics)
57.	Prof. D. Das	(WRD&M)
58.	Prof. S.K.Tripathi	(WRD&M)
59.	Prof. Nayan Sharma	(WRD&M)
60.	Prof. M.L.Kansal	(WRD&M)
61.	Mr. Yogendra Singh, Librarian	
62.	Dr. Sunil Singhal, Chief Warden, Cautley Bhawan & Scientist AHEC.	
63.	Dr. K.L. Yadav, Associate Professor, Department of Physics	
64.	Dr. C.B. Majumdar, Associate Professor, Department of Chemical Engg.	
65.	Dr. R. Krishnamurthy, Associate Professor, Department of Earth Sciences	
66.	Dr. (Ms) Babita Sinha, Asstt. Prof., Department of Hum. & Social Sciences	
67.	Lt. Col. A.K. Srivastava, Registrar	- Secretary

The Chairman (Director) welcomed the members to the 34th Meeting of the Senate.

The Senate recorded the communications received from the following members for not attending the meeting:

1. Prof. H.K. Verma, Dy.Director
2. Prof. N. Puri, Department of Civil Engineering
3. Prof. H. Sinval, Department of Earth Sciences
4. Prof. I.D. Mall, Department of Chemical Engineering
5. Prof. P. Jha, Department of Humanities & Social Sciences
6. Prof. Deepak Khare, Department of WRD&M

Before taking up the agenda items, the Senate thanked the under-mentioned outgoing members and recorded its appreciation for their valuable contribution in the meetings of the Senate.

1. Prof. Arvind Kumar, Department of Civil Engineering
2. Prof. Ram Pal Singh, Department of Water Resources Development & Management.

The Agenda was then taken up:

Item No. 34.1: To consider the structure and syllabi of PG Courses under new PG programme of the Departments of Architecture & Planning, Earthquake Engineering and Electronics & Computer Engineering.

As considered and recommended by the Board of Studies, the Senate decided that the Curricular Structure and Syllabus of P.G. Courses under new P.G. Programmes of the following departments be approved:

- (i) M.Arch. and MURP Programmes, Department of Architecture & Planning (**Appendix 'A'**)
- (ii) M.Tech. Structural Dynamics and M.Tech. Soil Dynamics Programmes, Department of Earthquake Engineering (**Appendix 'B'**)
- (iii) All M. Tech Programmes, Department of Electronics & Computer Engineering (**Appendix 'C'**)

Item No.34.2: To consider the Structure and Syllabi of PG Courses under new PG programmes.

As considered and recommended by the Board of Studies, the Senate decided that the Curricular Structure and Syllabi of P.G. Courses under new P.G. Programmes of the following Departments be approved:

- (i) Syllabi of the courses to be taught in the various M. Tech Programmes of Dept. of Mechanical and Industrial Engineering (**Appendix 'D'**).
- (ii) Structure of the M.Tech. programmes and the syllabi of the courses to be taught in various M. Tech Programmes of Department of Metallurgical and Materials Engineering (**Appendix 'E'**).
- (iii) Structure of the M.Tech. programme and the syllabi of the courses to be taught in Autumn Semester of the M. Tech Programme of Department of Chemistry (**Appendix 'F'**).
- (iv) Syllabi of the courses to be taught in the Autumn Semester of the various M. Tech Programmes of the Department of Water Resources Development & Management (**Appendix 'G'**).

- (v) Syllabi of the courses to be taught in Autumn Semester of the various M. Tech Programmes of Department of Hydrology (**Appendix 'H'**).
- (vi) Syllabi of the courses to be taught in Autumn Semester of the M. Tech Programme of the Centre of Nano Technology (**Appendix 'I'**).
- (vii) Syllabi of the courses to be taught in the Autumn Semester of the M. B. A. Programme of the Department of Management Studies (**Appendix 'J'**).
- (viii) Syllabi of the courses to be taught in the Autumn Semester of the M. Tech Programme of the Department of Paper Technology (**Appendix 'K'**).

Item No.34.3: To reconsider the proposal of IPR Cell to start a new PG programme in IPR i.e. M.Tech. (IPM) .

As considered and recommended by the Board of Studies, the Senate decided that the required faculty for the new PG programme in IPR should first be in place, before starting the programme.

Item No.34.4: To report that the Director has approved the acceptance of proposal for "Col. Bajpai Cash Prize" of Rs.5,000/- p.a. for the girl student obtaining highest CGPA amongst girls students in undergraduate programme.

Noted that the Director & Chairman, Senate has approved the proposal of Col. (Retd.) G.N. Bajpai for institution of "Col. Bajpai Cash Prize" of Rs.5,000/- p.a. for the girl student obtaining the highest CGPA amongst the girl students in the undergraduate programme.

Item No.34.5: To report that the Director has approved the acceptance of proposal for "Om Bala Thapar Cash Prize" of Rs.12,000/- p.a. for best all round girl student in the B.Tech. Degree programme.

Noted that the Director & Chairman, Senate has approved the proposal of Mr. Rakesh Thapar, for institution of the "Om Bala Thapar Cash Prize" of Rs.12,000/- p.a. for the best all round girl student in the B.Tech. Degree programme.

Item No. 34.6: To consider the structure and syllabi of PG courses under new PG programme in respect of the Departments of (i) Biotechnology, (ii) Physics and (iii) Civil Engineering.

As considered and recommended by the Board of Studies, the Senate decided that the curricular structure and syllabi of the PG courses under the new PG Programme of the following departments be approved:

- (i) Syllabi of the courses to be taught in the various M.Sc. Programmes of the Department of the Bio Technology (**Appendix 'L'**).
- (ii) Syllabi of the courses to be taught in the various M.Tech. Programmes of the Department of Physics (**Appendix 'M'**).
- (iii) Structure of the M.Tech. programmes and the syllabi of the courses to be taught in the various M.Tech. programmes of the Department of Civil Engineering (**Appendix 'N'**).

Item No. 34.7: To consider the proposal from the Head, Electronics & Computer Engineering Department to make minor modifications in the approved UG/IDD scheme of the Department.

As considered and recommended by the Board of Studies, the Senate decided that the under-mentioned proposal of the Department of Electronics & Computer Engineering be approved:

- (i) Inclusion of the course "EC-655N: Introduction to Bioinformatics", in the list of courses approved as DEC IV and V for the B.Tech. (CSE) scheme and PEC III to VI for the IDD (CSI) scheme.
- (ii) Change of course No. EC-562N to EC-630N.
- (iii) Removal of suffix 'N', from all the course numbers.

Item No. 34.8: To consider the list of 54 students not satisfying the prerequisite requirement.

The Senate decided that permission to register the 54 students for various subjects who are not satisfying the respective prerequisites as given at **Appendix 'O'**, be granted w.e.f. the Spring Semester 2010-2011.

Item No.34.9: To consider the structure and syllabi of PG Courses under the new PG programme in respect of the Department of Electrical Engineering.

As considered and recommended by the Board of Studies, the Senate decided that the structure of the M.Tech. programmes and the syllabi of the courses to be taught in the various M. Tech Programmes of the Department of Electrical Engineering as given at **Appendix 'P'** be approved.

Item No.34.10: To consider the minor change in the teaching scheme of the MCA programme of the Department of Mathematics.

As considered and recommended by the APC (MCA) of the Department of Mathematics and by the Dean (Academic Studies) in the capacity of the Chairman, BOS, the Senate decided that minor modifications in the teaching scheme of the MCA programme of the Department of Mathematics be approved as under:

- (a) CA-504: Operating Systems and CA-605: Operations Research be interchanged (II and III Semester).
- (b) CA-701: Artificial Intelligence and CA-606: Organizational Behaviour be interchanged.

Item No.34.11: To consider the recommendations of the DFB of the Department of Architecture and Planning regarding the syllabi of the subjects to be taught under the two UG teaching schemes currently running in the department

As considered and recommended by the DFB of the Department of Architecture & Planning and by the Dean (Academic Studies), the Senate approved, as under:

- (i) Changes in the course numbers, course titles and pre-requisites for the B. Arch II year courses to be taught in the Autumn Semester 2010-2011 (**Appendix 'Q'**).
- (ii) Syllabi for B. Arch II courses to be taught in the Autumn Semester 2010-2011, as per the above minor changes (**Appendix 'R'**).

- (iii) List of departmental electives for the Under Graduate Batches 2007-08 and 2008-09 under the old scheme (**Appendix 'S'**).
- (iv) Syllabus of "AR-409: Contemporary World Architecture", Departmental elective to be taught in the Autumn Semester 2010-2011 (**Appendix 'T'**).

The meeting ended with a vote of thanks to the Chair.

Appendix 'O'
Item No. Senate/34.8

ENR NO	NAME	SUBJECT	GRADE	YEAR	PREREQUISITE	CLEARED
071415	MANOJ KUMAR MEENA	BT-222	D	131	BT-213	N
071415	MANOJ KUMAR MEENA	BT-315	D	131	BT-213	N
071415	MANOJ KUMAR MEENA	BT-468	C	131	BT-213	N
071415	MANOJ KUMAR MEENA	BT-467	C	131	BT-213	N
070415	LALIT MOHAN SINGH MEENA	MI-333	D	131	MI-203	N
070415	LALIT MOHAN SINGH MEENA	MI-333	D	131	MI-206	N
071406	CHANDRA PRAKASH MEENA	BT-222	C+	131	BT-213	N
071406	CHANDRA PRAKASH MEENA	BT-315	D	131	BT-213	N
071406	CHANDRA PRAKASH MEENA	BT-468	C+	131	BT-213	N
071406	CHANDRA PRAKASH MEENA	BT-467	C+	131	BT-213	N
070917	ASHOK KUMAR MEENA	PP-320	C	131	PP-211	N
070917	ASHOK KUMAR MEENA	PP-320	C	131	CE-102	N
070349	VINOD KUMAR DIVYA	MI-304	D	131	MI-263	N
070349	VINOD KUMAR DIVYA	MI-364	D	131	MI-203	N
070606	ANAND KUMAR	MT-303	D	131	MT-205	N
070606	ANAND KUMAR	MT-311	C	131	MT-205	N
070606	ANAND KUMAR	MT-306	D	131	MT-205	N
070420	NEERAJ MADAN	MI-231	D	131	MI-102	N
070420	NEERAJ MADAN	MI-232	D	131	MI-102	N
070819	RAVINDRA	EC-252	D	131	EC-203	N
070819	RAVINDRA	EC-262	D	131	EC-203	N
070819	RAVINDRA	EC-262	D	131	EC-203	N
070503	AMIT KUMAR MEENA	EC-202	D	131	MA-102	N
070503	AMIT KUMAR MEENA	EC-262	D	131	EC-203	N
070503	AMIT KUMAR MEENA	EC-262	D	131	EC-203	N
070328	PRAVEEN CHANDRA	MI-351	D	131	MI-204	N
070328	PRAVEEN CHANDRA	IEE-04	D	131	EC-101A	N
071115	VIKAS SHRIWAS	CH-306	C	131	CH-305	N
070722	RAHUL VERMA	CH-303	B	131	CH-203	N
071210	VAIBHAV THAKUR	EC-262	C+	131	EC-203	N
071210	VAIBHAV THAKUR	EC-262	C+	131	EC-203	N
071210	VAIBHAV THAKUR	EC-202	D	131	MA-102	N
071210	VAIBHAV THAKUR	EC-252	C	131	EC-203	N
071112	PRABHAT KUMAR THAKUR	CH-306	C+	131	CH-305	N
070804	ANUBHAV SINGH	EC-252	D	131	EC-203	N
070804	ANUBHAV SINGH	EC-262	D	131	EC-203	N
070804	ANUBHAV SINGH	EC-262	D	131	EC-203	N
070728	SAHIL MAKKAR	CH-206	D	131	CH-207	N
070728	SAHIL MAKKAR	CH-301	D	131	CH-207	N
070728	SAHIL MAKKAR	CH-306	C	131	CH-207	N
070728	SAHIL MAKKAR	CH-306	C	131	CH-305	N
070519	PUSHPENDAR GHOYAL	EC-252	D	131	EC-203	N
070519	PUSHPENDAR GHOYAL	EC-262	D	131	EC-203	N
070519	PUSHPENDAR GHOYAL	EC-262	D	131	EC-203	N
070340	SHUBHAM SUNDER	MI-351	D	131	MI-204	N
070413	KARANPREET MALHAN	IEE-04	D	131	EC-101A	N
070232	LOKESH KISHAN BHOJWANI	EE-303	B+	131	EE-202	N
070724	RAVINDER KUMAR	CH-206	D	131	CH-207	N
070724	RAVINDER KUMAR	CH-309	B+	131	CH-204	N
070724	RAVINDER KUMAR	CH-305	D	131	CH-207	N
070724	RAVINDER KUMAR	CH-301	C+	131	CH-207	N
070724	RAVINDER KUMAR	CH-306	C+	131	CH-207	N
070706	ARKAPOL BASU	CH-206	D	131	CH-207	N
070706	ARKAPOL BASU	CH-305	D	131	CH-207	N
070706	ARKAPOL BASU	CH-301	D	131	CH-207	N
070706	ARKAPOL BASU	CH-303	C	131	CH-203	N
070706	ARKAPOL BASU	CH-306	C+	131	CH-207	N

060404	ARPIT THAKUR	MI-333	B+	131	MI-206	N
060402	AMIT KUMAR DEHRA	MI-333	C	131	MI-206	N
060402	AMIT KUMAR DEHRA	MI-335	C	131	MI-231	N
060402	AMIT KUMAR DEHRA	MI-336	C+	131	MI-231	N
070645	RAHUL MEENA	MT-305	C	131	MA-102	N
08115021	ASHISH RANJAN	EE-203	D	121	EE-101	N
08115021	ASHISH RANJAN	EE-201	D	121	EE-101	N
08115021	ASHISH RANJAN	EE-208	D	121	EC-102	N
08115021	ASHISH RANJAN	EE-202	D	121	EE-101	N
08115030	ESAMPALLY SUMANTH	EE-203	D	121	EE-101	N
08115030	ESAMPALLY SUMANTH	EE-201	C	121	EE-101	N
08115030	ESAMPALLY SUMANTH	EE-206	D	121	EE-101	N
08115047	MUTHYALA VAMSI KRISHNA	PH-201	D	121	PH-101	N
08115047	MUTHYALA VAMSI KRISHNA	MT-201A	D	121	PH-101	N
08115047	MUTHYALA VAMSI KRISHNA	EE-204	D	121	PH-101	N
08115052	NISHANT PRAKASH TIRU	EE-201	D	121	EE-101	N
08115052	NISHANT PRAKASH TIRU	EE-206	D	121	EE-101	N
08115056	PARMINDER SINGH	EE-208	C+	121	EC-102	N
08115064	PUSHYA PRIYATAM BOLISSETTY	EE-201	D	121	EE-101	N
08115078	SHIVANI CHAUDHARY	EE-208	C	121	EC-102	N
08115093	VIJAY MADHAV MADALA	EE-206	C	121	EC-102	N
08115093	VIJAY MADHAV MADALA	EE-208	D	121	EC-102	N
08116004	AKHILESH SINGLA	EC-242	C	121	EC-102	N
08116005	ANKIT HANS	EC-201	C	121	MA-102	N
08116005	ANKIT HANS	EC-202	D	121	MA-102	N
08116035	RAKESH BHATIA	EC-201	C+	121	MA-102	N
08116035	RAKESH BHATIA	EC-202	B	121	MA-102	N
08116036	RAKESH REDDY KONDAM	EC-201	D	121	MA-102	N
08116036	RAKESH REDDY KONDAM	EC-202	D	121	MA-102	N
08116037	SAGINA VENKATA SESHU	EC-203	D	121	EC-102	N
08116037	SAGINA VENKATA SESHU	EC-201	C	121	MA-102	N
08116037	SAGINA VENKATA SESHU	EC-242	C	121	EC-102	N
08116039	SHIVAM YADAV	EC-202	D	121	MA-102	N
08116039	SHIVAM YADAV	EC-262	D	121	EC-203	N
08116039	SHIVAM YADAV	EC-262	D	121	EC-203	N
08116041	SHUBHAM GUPTA	EC-201	C	121	MA-102	N
08116041	SHUBHAM GUPTA	EC-202	D	121	MA-102	N
08213003	ARADHYULA TANDAVA KRISHNA YADAV	EC-201	D	121	MA-102	N
08213003	ARADHYULA TANDAVA KRISHNA YADAV	EC-252	D	121	EC-203	N
08213003	ARADHYULA TANDAVA KRISHNA YADAV	EC-262	C	121	EC-203	N
08213003	ARADHYULA TANDAVA KRISHNA YADAV	EC-262	C	121	EC-203	N
08213003	ARADHYULA TANDAVA KRISHNA YADAV	EC-202	C+	121	MA-102	N
08213006	KOLLI GANAPATHI	EC-203	D	121	EC-102	N
08213006	KOLLI GANAPATHI	EC-242	C	121	EC-102	N
08213008	M. REVANTH	EC-201	C	121	MA-102	N
08213008	M. REVANTH	EC-262	B	121	EC-203	N
08213008	M. REVANTH	EC-262	B	121	EC-203	N
070716	NAVEEN KUMAR SINGH	CH-301	D	131	CH-207	N
070716	NAVEEN KUMAR SINGH	CH-206	C	131	CH-207	N
070716	NAVEEN KUMAR SINGH	CH-306	B	131	CH-207	N
070716	NAVEEN KUMAR SINGH	CH-306	B	131	CH-305	N
08114020	NITIN KUMAR GAUTAM	EC-202	C	121	MA-102	N
08117025	KALLA RAJENDRA KUMAR	MI-231	C+	121	MI-102	N
08117025	KALLA RAJENDRA KUMAR	MI-207	D	121	MI-101	N
08117025	KALLA RAJENDRA KUMAR	MI-232	C	121	MI-102	N
08117050	SHREY KUMAR VATSA	MI-207	D	121	MI-101	N
08119021	PAWAN	MI-231	D	121	MI-102	N
08119021	PAWAN	MI-232	C+	121	MI-102	N

08211015	SHREYANSH BELE	EC-251	C+	121	EC-101A	N
070821	ROKADE MAYUR GANGESH	EC-262	D	131	EC-203	N
070821	ROKADE MAYUR GANGESH	EC-262	D	131	EC-203	N
070821	ROKADE MAYUR GANGESH	EC-351	D	131	EC-251	N
070821	ROKADE MAYUR GANGESH	EC-252	D	131	EC-203	N
070263	SHUBHRAJYOTI KIRTANIA	EE-304	D	131	EE-206	N
070130	DIPU KUMAR	PH-201	D	131	PH-101	N
070130	DIPU KUMAR	CE-351	D	131	CE-252	N
070631	MRUTYUNJAY HIREMATH	MT-305	D	131	MA-102	N
070631	MRUTYUNJAY HIREMATH	MT-301	D	131	MT-209	N
070813	MADDURI LOHITH	EC-311	D	131	EC-202	N
070813	MADDURI LOHITH	EC-382	C+	131	EC-251	N
070813	MADDURI LOHITH	EC-356	D	131	EC-252	N

DEPARTMENT OF ARCHITECTURE AND PLANNING
INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

S. NO.	PROPOSED (BATCH 2009-10 ONWARDS)			OLD (BATCHES 2007-08 AND 2008-09)		
	SUB. CODE	COURSE TITLE	PREREQUISITE	SUB. CODE	COURSE TITLE	PREREQUISITE
1.	AR-201	Architectural Design-II	AR-102: Architectural Design-I	AR-202	Architectural Design	AR-201 : Architectural Design-I
2.	AR-203	Building Construction – II	AR-106: Introduction to Building Materials and Construction I	AR-204	Building Construction – I	AR-203: Introduction to Building Materials & Construction I
3.	AR-205	Climatology in Architecture	Nil	AR-209	Climatology in Architecture	Nil
4.	AR-207	Measured Drawing Camp	Nil	AR-212	Measured Drawing	CE-291: Introduction to Geomatics Tech.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **ARCHITECTURE AND PLANNING**

1. Subject Code: **AR-201** Course Title: **Architectural Design-II**

2. Contact Hours: L: 1 T: 2/2 P: 6

3. Examination Duration (Hrs): Theory: Practical:

4. Relative Weightage: CWS PRS MTE ETE PRE

5. Credits 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **AR-102**

9. Objective:

To impart an understanding about the design of small buildings with respect to site, landscape and climate.

1. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to the design assignments, their aims and objectives, scope, special emphasis and limitation; Application of planning and design standards for the proposed design problems.	2
2.	Major design problems such as a house, clinic, elementary school and restaurant, with site orientation, prevailing wind direction and the use of local building materials.	7
3.	Minor design problems such as a small weekend cottage, monument, band stand in a park and way side restaurant.	5
	Total	14

- Seminar on 'Visually Experiencing Architecture'
- Architectural Study Tour

2. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Neufert, P., "Architects' Data", 3 rd Ed., Blackwell Science.	2000
2.	Watson, D. (Editor), "Time-saver Standards for Architectural Design: Technical Data for Professional Practice", 8 th Ed., McGraw-Hill.	2005
3.	Agkathidis, A., Hudert, M. and Schillig, G., "Form Defining Strategies: Experimental Architectural Design", Wasmuth.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **ARCHITECTURE AND PLANNING**

1. Subject Code: **AR-203** Course Title: **Building Construction - II**

2. Contact Hours: L: 1 T: 0 P: 4

3. Examination Duration (Hrs): Theory: 4 Practical: 0

4. Relative Weightage: CWS 0 PRS 50 MTE 20 ETE 30 PRE 0

5. Credits 3 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **AR-106**

9. Objective:

To enable the students to learn detailing of roofs, stairs, partitions, metal windows and temporary work.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Roofs: Simple flat, jack arch, lean to and coupled roofs; Construction details of king-post trusses; Method of construction of RCC/RB roofs including terracing details; Hollow roof construction; Construction of domes, vaults and shell roofs; Expansion and Construction joints.	4
2.	Temporary Work: Centering for arches, vaults and domes.	2
3.	Openings: Metal windows (Z sections and L sections).	2
4.	Partitions: Various types of glazed and wooden partitions and paneling; Curtain walls; Sound proof and light weight partitions.	3
5.	Stairs: Principles of staircase construction and its elements; Details of various stair cases in wood, stone, steel and RCC.	3
	Total	14

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Kumar, S.K., "Building Construction", 19 th Ed., Standard Publishers Distributors.	2001
2.	Rangwala, S.C., "Building Construction", 19 th Ed., Charotar Publishing House.	2001
3.	Mckay, W.B., "Building Construction, Vol. I", Longman.	2005
4.	Mckay, W.B., "Building Construction, Vol. II", Longman.	2005
5.	Mckay, W.B., "Building Construction, Vol. III", Longman.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **ARCHITECTURE AND PLANNING**

1. Subject Code: **AR-205** Course Title: **Climatology in Architecture**

2. Contact Hours: L: **2** T: **1** P: **0**

3. Examination Duration (Hrs): Theory **2** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits **3**

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective:

To expose the students to climatic design principles, their influence on building design and energy conservation through passive techniques.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Climatology: Tropics, climatic zones, macro and micro climate, elements of climate and climatology data needed for planning of buildings.	4
2.	Human Comfort: Human heat balance and comfort, heat stress, effective temperature and bioclimatic analysis.	2
3.	Air Temperature: Factors that influence air temperature – latitude, altitude, seasons, water, trees, areas etc.; Inversion of temperature, thermal diffusivity, thermal conductivity and heat transmission through building elements.	4
4.	Solar Radiation: Calculation of solar radiation on building surfaces, solar charts; Design and application of shading devices, sun machines and their uses; Opaque building elements and heat transfer through these elements.	4
5.	Wind: Study of diurnal and seasonal variations, heating and cooling, effect of topography; Effect of wind on location on industrial areas, airports and other land uses and road patterns; Air	4

	movement in and around buildings, wind eddies, size and positions; Effect of wind on design and siting of buildings.	
6.	Precipitation: Water vapour, relative humidity, condensation, rain, fog, snow and architectural responses.	2
7.	Day Light: Glare, amount of light, sky as a source of light and day light factor; Effect of size and shape of openings in different planes with and without obstructions.	4
8.	Orientation and Application of Climatic Principles: Siting of buildings with respect of sun, wind and view; Use of evaporative cooling, ground cooling, cavity walls, topography, landscape elements; Ventilation of roof spaces and controlled ventilation.	4
	Total	28

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Bansal, N.K., Hauser, G. and Minke, G., "Passive Building Design: A Handbook of Natural Climatic Control", Elsevier Science.	1994
2.	Givoni, G., "Climatic Considerations in Building and Urban Design", Van Nostrand Reinhold.	1998
3.	Hausladen, G., "Climatic Design: Solutions for Buildings that can Do More with Less Technology", Birkhauser.	2005
4.	Drake, S., "The Third Skin: Architecture, Technology and Environment", UNSW Press.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **ARCHITECTURE AND PLANNING**

1. Subject Code: **AR-207** Course Title: **Measured Drawing Camp**

2. Contact Hours: L: **0** T: **2** P: **0**

3. Examination Duration (Hrs) Theory **0** Practical **0**

4. Relative Weightage: CWS **100** PRS **0** MTE **0** ETE **0** PRE **0**

5. Credits **2** 6. Semester: **Autumn.** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective:

To train the students in conducting detailed building measurements including the application of surveying techniques.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Measurement of some historical or modern building using simple methods and plane table for plans and site plans.	14 X 2
2.	Measurement of elevations and sections by using instruments such as theodolites.	
3.	Village or neighbourhood study, preparing settlement plans, socio-economic and conservation studies etc.	
	Total	28

▪ Measured Drawing Camp

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Rasmusson, S.E., "Experience Architecture", Chapman and Hall.	1964
2.	Frank, D.K. Ching, "Drawing: A Creative Process", Van Nostrand Reinhold.	1990
3.	Frank, D.K. Ching, "Design Drawing", Van Nostrand. Reinhold.	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Architecture and Planning Department**

1. Subject Code: **CE-291** Course Title: **Introduction to Geomatics Techniques**

2. Contact Hours: L: **3** T: **0** P/D: **3**

3. Examination Duration (Hrs): Theory **3** Practical **3**

4. Relative Weightage: CWS **0** PRS **25** MTE **25** ETE **40** PRE **10**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective:

To impart knowledge about the basic principles of geomatics engineering techniques for mapping and various other architectural applications.

10. Details of Course:

S. No.	Contents	Contact Hours
3.	Importance of geomatics engineering techniques to architecture, field surveying, photogrammetry, remote sensing, Geographic Information System and Global Positioning System.	2
4.	Type of maps, scales and uses, map sheet numbering, map projection, definition of surveying, principles, importance, classification, surveying equipment namely levels, compass, theodolites, tachometer, EDM, Total Stations and other instruments.	4
5.	Measurement of distance, angles and directions; Determination of elevation through spirit leveling, trigonometrical leveling and tachometric surveying, contouring.	13
6.	Method of control establishment namely traversing, triangulation, trilateration, coordinate computations, plane table surveying and mapping; Introduction to GPS surveys.	4
7.	Introduction to GPS surveys.	3
8.	Aerial and terrestrial photogrammetry, applications of photogrammetry, types of photographs, geometry of an aerial photograph, flying height and scale, relief (height) displacement,	5

	stereoscopy, measurement of parallax and height determination.	
9.	Basics concepts of remote sensing, electromagnetic spectrum, platforms and sensors, remote sensing data products; Introduction to visual and digital image interpretation.	6
10.	Introduction to GIS, Digital Elevation Model (DEM).	3
11.	Applications of geomatics techniques to architecture and planning; Utility of high resolution remote sensing data, close range photogrammetry, visualization etc.	2
	Total	42

List of Practicals

1. Visit to Geomatics Engineering laboratory. Study of Maps and Map Numbering Systems, Map in the Making and Map Projection Systems, conventional symbol chart.
2. Demonstration of various surveying equipment.
3. Study of Dumpy and IOP levels, and Staff. Practice to take readings. Check levelling using Dumpy level.
4. Profile levelling and Cross-sectioning using IOP level.
5. Study of different parts of Vernier Theodolite. Practice for taking horizontal and vertical circle readings. Horizontal angle measurement using Method of Reiteration.
6. Determination of constants of a Tacheometer. Determination of length and gradient of a line using Tacheometric surveying. Measure the included angle using method of repetition.
7. Determination of height of an object using various trigonometric levelling methods.
8. Plotting of control points. Three point problem and its solution using trial and error method.
9. Preparation of a map of given area using plane table surveying.
10. Determination of scale and flying height of an aerial photograph. Use of parallax scale.
11. Base lining of a pair of stereo-photograph. Creation of 3-dimensional model. Practice of taking readings using parallax bar to find heights of at least 5 points.
12. Demonstration of a GIS and Image Processing System.
13. Demonstration of Total Station and Global Positioning System (GPS) equipment.

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Schofield, W. and Breach, M., "Engineering Surveying", 6 th Ed., Butterworth-Heinemann.	2007
2.	Chandra, A. M., "Surveying", New Age Publishers.	2002
3.	Lillesand, T.L. and Kieffer, R. W., "Remote Sensing Image Interpretation", John Wiley and Sons.	2000
4.	Gopi, S., "Global Positioning System: Principles and Applications", Tata McGraw Hill.	2005
5.	Lo, C. P. and Young, A. K. W., "Concepts and Techniques of Geographical Information System", Prentice Hall.	2002
6.	Chandra, A.M and Ghosh S.K., "Remote Sensing and Geographical Information Systems", Alpha Science.	2005

DEPARTMENT OF ARCHITECTURE AND PLANNING
INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

Department Electives for Batches 2007- 08 and 2008 – 09

Code	Course Name	Credit	Code	Course Name	Credit
Departmental Elective - I			Departmental Elective - II		
AR-306:	Solar Architecture	3	AR-312:	History of Modern Architecture	3
AR-308:	Fire Protection & Security System	3	AR-314:	Ekistics	3
AR-310:	Prefabrication & Modular Coordination	3	AR-316:	Acoustics & Lighting	3
			AR-318:	Applied Art	3
Departmental Elective - III			Departmental Elective – IV		
AR-403:	Vastu Shastra & Vernacular Architecture	3	AR-408:	Modern Indian Architecture	3
AR-405:	Resource Conserving Architecture	3	AR-410:	Design of New Structural Systems	3
AR-407:	High Tech. Building	3	AR-412:	Design of Multi Storyed Building	3
AR-409:	Contemporary World Architecture	3	AR-414:	Futuristic Architecture	3
Departmental Elective – V					
AR-507:	Housing	3			
AR-509:	Interior Design	3			
AR-511:	Urban Design	3			
AR-513:	Architectural Conservation	3			

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **ARCHITECTURE AND PLANNING**

1. Subject Code: **AR-409** Course Title: **Contemporary World Architecture**

2. Contact Hours: L: **2** T: **1** P/D: **0**

3. Examination Duration (Hrs): Theory: 3 Practical: 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits 3 6. Semester: **Autumn** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective:

The course objective is to expose the students to the development of contemporary architecture and update their knowledge about influencing directions, theories and trends in contemporary architecture.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to contemporary development in world architecture subsequent to the modern movement (after industrial revolution).	2
2.	Contemporary architectural theories and directions in architecture.	3
3.	Contemporary design thinking and architectural technologies.	4
4.	Contemporary trends in building materials, structural systems and construction techniques.	4
5.	From the rejection of international modernism to the growth of universalism.	4
6.	Regional variations and cultural identity.	4
7.	Contemporary development of high rise buildings.	3
8.	Contemporary development of architectural styles and urbanism.	4
	Total	28

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Ballard B., Victoria, Rank, P., "Materials for Architectural Design", Laurance King Publishing	2006
2.	Gossel, P. and Leuthauser, G., "Architecture in the 20 th Century", Vol. 1, Taschen	2005
3.	Gossel, P. and Leuthauser, G., "Architecture in the 20 th Century", Vol. 2, Taschen	2005

**THE NEW CURRICULUM STRUCTURE AND SYLLABI OF
THE POST GRADUATE PROGRAMMES
(Approved by the Senate in the
34th meeting held on 16th July 2010)**

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Appendix 'A'
Item No. Senate/34.1

DEPARTMENT OF ARCHITECTURE AND PLANNING
Master of Architecture

Teaching Scheme					Contact Hrs. per week			Exam. Duration (Hrs.)		Relative Weightage (%)				
S. No.	Sub. Code	Course Title	Sub. Area	Crs.	L	T	P/D	T	P	CWS	PRS	MTE	ETE	PRE
1st YEAR					I SEMESTER (AUTUMN)									
1.	AR-601	Architectural Design Studio-1	PCC	4	1	-	6	-	-	-	100	-	-	-
2.	AR-603	Contemporary Architecture: Theories and Trends	PCC	4	3	1	-	3	-	25	-	25	50	-
3.	AR-605	Urban Design	PCC	4	3	-	2	3	-	15	15	30	40	-
4.		Open Elective-I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
5.	AR-607	Computer Applications in Architecture and Planning	ICC	4	2	0	4	2	4	15	15	15	30	25
6.	HS-501	Technical Communication (Optional)	-	2	1	0	2	2	0	15	15	30	40	-
		Sub Total		19/22										
					II SEMESTER (SPRING)									
1.	AR-602	Architectural Design Studio-II	PCC	4	1	-	6	-	-	-	100	-	-	-
2.		Programme Elective I	PEC	4	-	-	-	-	-	-	-	-	-	-
3.		Programme Elective II	PEC	4	-	-	-	-	-	-	-	-	-	-
4.		Programme Elective III	PEC	4	-	-	-	-	-	-	-	-	-	-
5.		Open Elective II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
		Sub Total		19/20										
2nd YEAR					III SEMESTER (AUTUMN)									
1.	AR-701	Architectural Design Studio-III (Project)*	RP	4	-	-	8	-	-	-	100	-	-	-
2.	AR-703	Seminar	SEM	2	-	-	-	-	-	-	-	-	-	100
3.	AR-705	Dissertation	DIS	-	-	-	-	-	-	-	-	-	25	-
4.	AR-624	Institutional/ Professional Training**	RP	2	-	2	-	-	-	100	-	-	-	-
		Sub Total		8										
					IV SEMESTER (SPRING)									
1.	AR-705	Dissertation (continued from III Semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
		Sub Total		20										
		TOTAL		66/70										
PROGRAMME ELECTIVES														
1.	AR-604	Resource Conserving Architecture	PEC	4	3	1	-	3	-	25	-	25	50	-
2.	AR-606	Housing	PEC	4	3	1	-	3	-	25	-	25	50	-
3.	AR-608	Building Byelaws and Professional Practice	PEC	4	3	1	-	3	-	25	-	25	50	-
4.	AR-610	Low Cost Building Design and Techniques	PEC	4	3	1	-	3	-	25	-	25	50	-
5.	AR-612	High Rise Buildings	PEC	4	3	1	-	3	-	25	-	25	50	-
6.	AR-614	Advanced Landscape Design	PEC	4	3	1	-	3	-	25	-	25	50	-
7.	AR-616	Research Techniques in Architecture and Planning	PEC	4	3	1	-	3	-	25	-	25	50	-
8.	AR-618	Advanced Building Technologies	PEC	4	3	1	-	3	-	25	-	25	50	-
9.	AR-620	Futuristic Architecture	PEC	4	3	1	-	3	-	25	-	25	50	-
10.	AR-622	Project Management	PEC	4	3	1	-	3	-	25	-	25	50	-

* In lieu of Project

** During summer vacation of 6 weeks between 1st and 2nd year

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: **AR-601** Course Title: **Architectural Design Studio- I**
2. Contact Hours: **L: 1** **T: 0** **P: 6**
3. Examination Duration (Hrs) Theory: 0 Practical: 0
4. Relative Weightage: **CWS** 0 **PRS** 100 **MTE** 0 **ETE** 0 **PRE** 0
5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective: To explore various building design aspects through architectural design studio exercises.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Understanding of functional activities to be performed in building, aspects of ergonomics.	3
2.	Architectural and engineering aspects of building design.	3
3.	Site planning and environmental considerations.	3
4.	Physical and economic constraints in designing.	2
5.	Elements and principles of design of solar passive buildings. Study of design standards.	3
TOTAL		14

Design Exercises: Major design exercises in residential, educational, commercial and recreational buildings.

Minor design exercises on specific aspects related to spatial planning, site planning, structural innovations, passive designing and building services.

1 1. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Agkathidis, A., Hudert, M. and Schillig, G., "Form Defining Strategies: Experimenting Architectural Design", Wasmuth International.	2007
2.	Ching, F.D.K., "Architecture: Form, Space and Order", 3 rd ed., John Wiley & Sons.	2007
3.	Morgan, C.L., "Jean Nouvel – The Elements of Architecture", Thames and Hudson.	1998
4.	Neufert, P., "Architects' Data", 3 rd ed., Blackwell Science.	2000
5.	Parmar, V.S., "Design Fundamentals in Architecture", Somaiya Publications.	1973

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: **AR-602** Course Title: **Architectural Design Studio- II**
2. Contact Hours: **L: 1** **T: 0** **P: 6**
3. Examination Duration (Hrs) Theory: 0 Practical: 0
4. Relative Weightage: **CWS** 0 **PRS** 100 **MTE** 0 **ETE** 0 **PRE** 0
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective: To explore challenging aspects of building design through architectural design studio exercises.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Building functional efficiency in relation to space, form and aesthetics.	2
2.	Building standards and building bye laws for different types of buildings in various locations.	2
3.	Design of low rise and mid rise buildings with high density.	2
4.	Specialized buildings design such as hospital, airport and hotel.	3
5.	Disaster resistant building design.	2
6.	Sustainable building design aspects and Green buildings design concepts.	3
	TOTAL	14

Design Exercises: Major design exercises in large scale housing projects, especially mid rise with high density, urban design projects, hospital projects etc.

Minor design exercises related to disaster resistant buildings for earthquake, cyclone etc.; Disaster mitigation and rehabilitation projects; Sustainable and green building design.

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprints
1.	Agkathidis, A., Hudert, M. and Schillig, G., "Form Defining Strategies: Experimental Architectural Design", Wasmuth International.	2007
2.	Ching, F.D.K., "Architecture Theoretician", John Wiley & Sons.	2007
3.	Kieran, S. and Timberlake, J., "Elements of a New Architecture", Princeton Architectural Press.	2008
4.	Smith, P.F., "Architecture and the Human Dimensions", George Baldwin Ltd.	1979
5.	Watson, D. (ed.), "Time-saver Standards for Architectural Design: Technical Data for Professional Practice", 8 th ed., McGraw-Hill.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: **AR-603** Course Title: **Contemporary Architecture: Theories and Trends**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs) Theory: 3 Practical: 0
4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0
5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge of contemporary theories and trends in architecture through the examples of emerging building typologies.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Overview of world architecture since 1970 with the study of Late Modernism, Post Modernism and Deconstructivism.	6
2.	Theories governing contemporary architecture through case studies, evolving architectural trends and their impact on urban built environment.	6
3.	Emerging building typologies with emphasis on residential developments, offices, skyscrapers, institutional and public buildings.	8
4.	Evolving building materials and technologies, contemporary approach towards disaster mitigation in the built environment.	6
5.	Energy efficient and built environment with emphasis on the use of energy simulation modeling, embodied energy estimation and application of governing codes, viz., LEED and ECBC in contemporary buildings.	8
6	Applications of advanced software by architects, viz, virtual reality, parametric design, programme generated architecture and building information modelling (BIM) in contemporary architecture.	8
TOTAL		42

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Ballard B. and Rank, V. P., "Materials for Architectural Design", Laurance King.	2006
2.	Frampton, K., "Modern Architecture-A Critical History", 3 rd ed. Thames and Hudson..	2002
3.	Gossel, P. and Leuthauser, G., "Architecture in the 20 th Century", Vol. 1, Taschen.	2005
4.	Gossel, P. and Leuthauser, G., "Architecture in the 20 th Century", Vol. 2, Taschen.	2005
5.	Troman, R. (ed.), "History of Architecture, From Classic to Contemporary", Parragon.	2009

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

- ### 10. Details of Course:

11 . Suggested Books:

S. No.	Name of Authors/ Books / Publishers	Year of Publication/ Reprint
1.	Greg P., "Natural Home Heating", Sterling Hill Production.	2003
2.	Hyde R., Wodson S., Chehire W. and Thowson M., "The Environmental Brief Pathways for Green Design", Taylor & Francis.	2006
3.	Yudelson J., "Greening Existing Buildings", Mc Graw Hills.	2009
4.	Baker, N. and Steemers, K., "Energy and Environment in Architecture: A Technical Design Guide", Routledge.	2000
5.	Gonzalo R. and Habermann K.J., "Energy-efficient Architecture: Basics for Planning and Construction", Birkhauser.	2006
6.	Clark W.H., "Retrofitting for Energy Conservation", Mc Graw Hills.	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: **AR-605** Course Title: **Urban Design**
2. Contact Hours: **L: 3** **T: 0** **P: 2**
3. Examination Duration (Hrs) Theory: 3 Practical: 0
4. Relative Weightage: **CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0
5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge on various aspects, elements, concepts and principles of urban design.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Various aspects of urban design; relationship of urban design to architecture, planning and landscape; Evolution of professional discipline.	6
2.	Review of urban forms, patterns and spaces in different periods of history viz. ancient river valley civilization, Greek, Roman, Medieval, Renaissance, Baroque, post industrial revolution period in Europe and India and their influencing factors.	8
3.	Elements of urban environment-urban form, townscape, urban spaces, streetscapes, building forms and facades, public art.	6
4.	Concepts of urban design, public perception, imageability and townscape	6
5.	Emerging concepts in urban design, modern examples of urban settlements, town centers and urban spaces in India and foreign countries.	8
6.	Urban design principles, tools, techniques and paradigms; Role and types of urban design guidance.	8
TOTAL		42

Design Exercises: Field studies- observational and analytical studies of important urban/ public spaces, roads; Imageability and townscape of selected areas/ settlements.
Design evaluation/ analytical study of modern examples.
Urban design proposal for improvement/ renewal/ redevelopment/ new development of an area.

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Broadbent, G., "Emerging Concepts of Urban Space Design", Van Nostrand Reinhold.	1990
2.	Cowan, R., "Urban Design Guidance by UD Group", Thomas Telford Publishing.	2002
3.	Punter, J. and Carnoma, M., "The Design Dimension of Planning-Theory, Content and Best Practices for Design Policies", E&FN Spon.	1997
4.	Spreiregen, P. D., "Urban Design; Architecture of Towns & Cities", McGraw Hill.	1965
5.	Watson D. et. al (ed), "Time Saver Standard for Urban Design", McGraw Hill.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: **AR-606 Course** Title: **Housing**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs) Theory: 3 Practical: 0
4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To impart comprehensive knowledge about housing design, planning and finance
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to housing, social and economic infrastructures in planning, housing shortage- reasons and remedies.	8
2.	Housing policies and programmes, mass housing programmes, slums and renewal schemes.	8
3.	Housing finance and schemes, HUDCO and other housing/ building financial institutions, role of revolving funds in housing.	6
4.	Housing design standards for various income group housing, analysis and design for HIG, MIG and LIG housing schemes.	6
5.	Rural and EWS housing schemes, affordable housing, cost effective housing.	7
6.	Selected case studies of housing schemes by government and private developers in India and abroad.	7
TOTAL		42

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Balaji V. & Rajmanohar, "Housing Sector in India; Issues, Opportunities and Challenges", ICFAI University Press.	2008
2.	Christian Schittich(ed), "High Density Housing; Concepts, Planning, Construction", Birkhauser.	2004
3.	French H., "Key Urban Housing of the Twentieth Century", Lawrence King.	2008
4.	Reeves P., "Introduction to Social Housing", Elsevier.	2005
5.	Davis S., "The Architecture of Affordable Housing", University of California Press.	1995

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: AR-607 Course Title: **Computer Applications in Architecture and Planning**
2. Contact Hours: L: 2 T: 0 P: 4
3. Examination Duration (Hrs) Theory: 2 Practical: 4
4. Relative Weightage: CWS 15 PRS 15 MTE 15 ETE 30 PRE 25
5. Credits: 4 6. Semester: Autumn 7. Subject Area: ICC
8. Pre-requisite: Nil
9. Objective: To impart knowledge of computer and GIS applications in architecture and planning projects.
10. Details of Course:

S. No.	Contents	Contact Hours
1	Application of software such as Revit Architecture Suite including building information modeling (BIM) and 3D Max.	4
2	Application of software such as Sketchup, Podium and E-view.	3
3	Application of software such as Catia, Primavera for construction planning management.	6
4	Application of software such as Design Builders and other software related to energy simulation modeling.	6
5	Application of software such as M.S. Pro, Power Sim, MATLAB, Arc GIS for planning.	9
TOTAL		28

List of Practicals:

1. Revit Architectural Suite: Auto CAD 2009 and 3D Max for design studio problems.
2. Building Information modeling for a given project.
3. Sketchup Pouching and e-view for a given design
4. Catia application for at least 2 design schemes
5. Primavera: Construction planning management applied to ongoing design studio project
6. Application of Design Builder and DOE2 for energy simulation modeling of one ongoing and one new project.
7. M.S. Pro, Power Sim, MATLAB, Arc GIS application in planning/ architectural design studio problem/s.

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Omura G., "Mastering Revit 2009", Sybex Publication.	-
2.	Omura G., "Bible 3D. Max 2009", Sybex Publication.	-
3.	Manuals of Sketchup, Podium, E-view, Catia and Primavera.	-
4.	Manuals of Design Builders and Energy Simulation Modeling.	-
5.	Manuals of M.S. Pro and Power Sim.	-
6.	Manuals of MATLAB and Arc GIS.	-

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

S. No.	Contents	Contact Hours
1.	Introduction to building byelaws, its needs, objectives, nature, purpose and scope of byelaws.	7
2.	Critical evaluation of building byelaws, need of reform in building byelaws to achieve good built environment.	4
3.	Building byelaws of selected towns, cities and development authorities.	6
4.	Architects Act of 1972, code of conduct, professional responsibilities and scale of charges, architectural competitions.	9
5.	Building contract systems, administration of building contract, invitation of tenders and procedure of award.	6
6.	Architects office management, methods of communication, documentation and computerization.	10
	TOTAL	42

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Development Controls/ Building Byelaws of various Development Authorities of Indian cities.	
2.	Namavati, R. H., "Professional Practice with Elements of Estimating, Valuation, Contract and Arbitration" Lakhani Book Depot.	2009
3.	Orr F., "Professional Practice in Architecture", Van Nostrand Reinhold.	1982
4.	Demkin J. A., "Architect's Handbook of Professional Practice; Ethics and the Practice of Architecture", 14 th ed. John Wiley & Sons.	2001
5.	Bureau of Indian Standards, "National Building Code (NBC)"	2005
6.	Puri V.K, "Compendium of Delhi Building Bye-laws and Development regulations as per Master Plan of Delhi 2021", Nabhi Publication.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1.	Subject Code: AR-610 Course Title: Low Cost Building Design and Techniques				
2.	Contact Hours:	L: 3	T: 1	P: 0	
3.	Examination Duration (Hrs)	Theory: 3		Practical: 0	
4.	Relative Weightage:	CWS 25	PRS 0	MTE 25	ETE 50 PRE 0
5.	Credits: 4	6. Semester: Spring		7. Subject Area: PEC	
8.	Pre-requisite: Nil				
9.	Objective: To impart knowledge on various building materials, construction and execution techniques for designing low cost buildings.				

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to low cost buildings, building components influencing cost of buildings.	6
2.	Modular coordination in building design, prefabrication- total and partial, impact of prefabrication on employment.	10
3.	Use of CPM and PERT methods in building construction	6
4.	Building construction detailing for cost reduction.	5
5.	Application of low cost building materials and various construction techniques.	5
6.	Building cost control techniques, research and development by various organizations in the country and foreign countries to reduce the cost.	10
	TOTAL	42

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Davis, S., "Architecture of Affordable Housing", University of California Press.	1995
2.	Ruiz, F.P., "Building an Affordable House", Taunton Press.	2005
3.	Nunan, J., "The Complete Guide to Alternative Home Building Materials and Methods", Atlantic Publishing.	1980
4.	Lal, A.K., "A Handbook of Low Cost Housing ", New Age International.	1995
5.	Mathur, G.C., "Low Cost Housing in Developing Countries", South Asia Book.	1999
6.	Sowman, M. and Urquhart, P., "A Place called Home: Environmental Issues and Low-Cost Housing", Juta Academic.	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: **AR-612** Course Title: **High Rise Buildings**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs) Theory: 3 Practical: 0
4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0
5. Credits: 4
6. Semester: Spring
7. Subject Area: PEC
8. Pre-requisite: Nil
9. Objective: To understand basic design concepts and emerging technologies of high rise buildings.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction, high rise buildings in urban environment, physical planning considerations.	7
2.	Architectural design considerations for high rise buildings, space planning and design standards, building byelaws and codes.	7
3.	Structural systems in RCC and steel for high rise buildings, composite structural system considerations for wind loads and earthquake loads.	10
4.	Building services- mechanical, electrical, firefighting and protection, vertical transportation, HVAC, BAS and parking; Codes for these services.	8
5.	Construction planning and management, equipments and construction techniques, materials for cladding, prefabrication.	6
6.	An approach to sustainable and green high rise buildings including the concepts of Zero Energy Habitat.	4
TOTAL		42

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Smith, B.S. and Coull, A., "Tall Building Structures- Analysis and Design" John Wiley & Son.	1991
2.	Lin, C.F., "Construction Technology for Tall Buildings", Singapore University Press.	2001
3.	Craighead G., "High Rise Security & Fire Life Safety", Butterworth-Heinemann.	2009
4.	Viswanath H.R., Tolloczko J.J.A. and Clarke J.N. , "Multi-purpose High Rise Towers and Tall Buildings" , Taylor & Francis.	1997
5.	International Building Code 2009, International Code Council.	2009
6.	Lawarance, W.C. L. and Daniel, C.W.H, "Planning Buildings for a High Rise Environment", Hong Kong University Press.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: **AR-614** Course Title: **Advanced Landscape Design**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs) Theory: 3 Practical: 0
4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge on advanced concepts of landscape design ranging from local to regional scales.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to landscape design, types of landscapes and their characteristics, linkages with nature and built environment.	9
2.	Elements and materials of landscapes, characteristics of various types of plants, topography and their suitability of landscaping.	6
3.	Landscape conservation- its purpose, preparatory procedure, maintenance of existing landscape.	6
4.	Urban and regional landscapes- ecological and environmental aspects of landscape design.	7
5.	Landscape profession and practice in relation to architecture and total built environment	7
6.	Landscape design schemes for various building types, formal and informal design schemes, landscaping paths, gardens and roads.	7
	TOTAL	42

11. Suggested Books:

S. No	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Barlow, R.E., "Landscape Design: A Cultural and Architectural History", Harry N. Abrams.	2001
2.	Hunt, J.D., "Greater Perfections: The Practice of Garden Theory", Thames & Hudson.	2000
3.	Kaplan, R., Kaplan, S. and Ryan, R., "With People in Mind: Design and Management of Everyday Nature", Island Press.	1998
4.	Reid, G.W., "Landscape Graphics", Watson-Guptyl.	2002
5.	Ruggles, D.F., "Islamic Gardens and Landscapes", Univ. of Pennsylvania Press.	2008
6.	Simonds, J.O., "Landscape Architecture, A Manual of Land Planning and Design", McGraw Hill.	2006

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

S. No.	Contents	Contact Hours
1.	Research in architecture and planning-its importance, purpose and scope in the professional and academic fields; common and exclusive areas of research in architecture and planning.	3
2.	Overview of architectural and design research techniques in areas such as architectural technology, environment and behavior, design methods, architectural theory, design programming; Post-occupancy evaluation; Users' participation.	5
3.	Overview of planning research areas that contributes to the shaping of neighborhoods, communities, settlements and regions as well as infrastructure provisions and sustainable development.	5
4.	Research sequence and methods; Problem identification, formulation of hypothesis, objectives and methodology; Literature survey and preparation of bibliography and sources of data.	3
5.	Qualitative, interpretative, correlation, analytical, experimental and quasi-experimental, modeling and simulation research methods; Case- studies.	7
6.	Field surveys- physical, architectural, land use, environmental, organizational and household surveys; Preparation of schedules, questionnaires and other data sheets; Pilot surveys; Formulation of database.	6
7.	Techniques and methods of analyzing architectural /planning data, establishing correlations and interrelationships; Environmental network analysis and conclusions; Forecasting and modeling and validation.	7
8.	Evaluation and appraisal of architectural and planning projects; Techniques	6

	of writing thesis, project and master plan reports, research papers for publication; Presentation techniques	
	TOTAL	42

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Knight, A. and Ruddock, L., "Advanced Research Methods in Built Environment", John Wiley & Sons.	2008
2.	Groat, L. and Wang D., "Architectural Research Methods", John Wiley & Sons.	2002
3.	Gibbs, J.P., "Urban Research Methods", (rev.ed.) Von Nostrand.	1988
4.	Khanzode, V.V., "Research Methodology -Techniques and Trends", APH Publishing.	1995
5.	Kothari, C.R., "Research Methodology- Methods and Techniques", New Age International.	2004
6.	Ross, R., "Research: An Introduction", Barnes and Noble Books.	1974

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: **AR-618** Course Title: **Advanced Building Technologies**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs) Theory: Practical:
4. Relative Weightage: CWS PRS MTE ETE PRE
5. Credits:
6. Semester: **Spring**
7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge on advancements in different disciplines related to building technology.
10. Details of Course:

S. No.	Contents	Contact Hours
1	Evolution of building technology and advancements; Industrial Revolution and its impact, mass housing, rapid construction methods and materials; Structural systems as elements of architectural expressions, modernism and post-modernism.	6
2	Shells, cable, frame, prismatic and geodesic structures, load carrying mechanism, large span structure, lessons from failures.	7
3	Passive building technologies, building skin, material and construction details for thermal, light and ventilation control; Traditional Architecture-vernacular vocabulary.	7
4	Indoor environment, HVAC and artificial lighting, Sick Building Syndrome, performance efficiency, energy efficiency, CFL and LED.	7
5	Construction technology and lean construction; Toyota experience- just-in-time, controlled inventory.	7
6	Building management system(BMS); Safety-entry control; CCTV; Fire and smoke detection, alarm; Thermal and working environment - temperature, humidity, air movement, light level; Occupancy sensors; Simulation techniques.	8
TOTAL		42

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Clements, C. D.J, "Intelligent Buildings – Design, Management & Operation", Thomas Telford.	2004
2.	Haulden, G., Saldanha, M. and Liedt P., "Climate Skin : Building Skin Concepts that can do more with less energy", Birkhauser.	2008
3.	Alarcen, L., "Lean Construction", Balkema	1997
4.	Salvadori, M. and Heller R., " Structure in Architecture", Engle Wood.	1986
5.	Bansal, N.K., "Practical Handbook on Energy Conservation in Buildings", Indian Building Congress, Nabhi Publication.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: AR-620 Course Title: Futuristic Architecture
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs) Theory: 3 Practical: 0
4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0
5. Credits: 4 6.Semester: Spring 7. Subject Area: PEC
8. Pre-requisite: Nil
9. Objective: To understand and explore new building materials, future building technologies and various futuristic architectural concepts

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Future concepts envisioned by Antonio Saint Elia, Frank Lloyd Wright, Corbusier.	4
2.	Future trends being evolved by Marcos Novak, Neil Denari, Greg Lynn, Toyo Ito and others.	8
3.	Evolution of contemporary architectural concepts such as biomimcry, adaptive reuse, low cost development and urban regeneration.	8
4.	Futuristic building materials, building tectonics and systems of the future.	8
5.	"Zero energy" and "Energy +" buildings with emphasis on an integrated approach.	8
8.	Socio-cultural and economic impacts of future urban habitats.	6
TOTAL		42

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Bell, J., "21 st Century House", Laurence King Publishing.	2006
2.	Jodidio, P., "Building a New Milleneum", Vol.1 Taschen	2003
3.	Jodidio, P., "Architecture Now", Vol. 2, Taschen.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: **AR-622** Course Title: **Project Management**
2. Contact Hours: L: **3** T: **1** P: **0**
3. Examination Duration (Hrs) Theory: Practical:
4. Relative Weightage: CWS PRS MTE ETE PRE
5. Credits: 6. Semester: **Autumn** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge on project management methods and techniques.
10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction to project management, probability theory and its application in construction planning and project management.	7
2	Introduction to network techniques LOB, CPM, PERT application to mass housing; Scheduling and controlling of construction projects.	7
3	Personal management- concept, definition, growth, role and function of manpower estimation for company and for projects; Personal administration at the project site.	7
4	Building construction industry- components of building industry, building material industry.	7
5	Development of value analysis techniques and life cycle costing of buildings, components of cost, criteria for cost companies and cost industries.	7
6	Case studies- critical appraisal of few selected projects.	7
TOTAL		42

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Naik, B.M., "Project Management: Scheduling and Monitoring by PERT/CPM", South Asia Books.	1985
2.	Kerzner, H., "Project Management: A Systems Approach to Planning, Scheduling, and Controlling", 10 th ed., John Wiley & Sons.	2009
3.	Lewis, J. P., "Fundamentals of Project Management", Amacom.	2007
4.	Wholey, J. S., Harry, P. H. and Newcomer, K.E., "Handbook of Practical Program Evaluation", John Wiley & Sons	2004
5.	Binnekamp, R., Gunsteren L. A. and Peter-Paul van Loon, "Open Design- A Stakeholder Oriented Approach in Architecture, Urban Planning and Project Management ", Tudelft.	2006
6.	Berger, S. and Godel, J.B., "Estimating and Project Management for Small Construction Firms", Van Nostrand Reinhold Co.	1977

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1.	Subject Code: AR-701 Course Title: Architectural Design Studio- III (Project)			
2.	Contact Hours:	L: 0	T: 0	P: 8
3.	Examination Duration (Hrs)	Theory:	0	Practical: 0
4.	Relative Weightage:	CWS 0	PRS 100	MTE 0 ETE 0 PRE 0
5.	Credits:	4	6. Semester: Autumn	7. Subject Area: RP
8.	Pre-requisite: Nil			
9.	Objective: To develop professional approach to design more challenging specialized building design projects through architectural design studio exercises.			
10.	Details of Course:			
	Design Exercises: Major design exercises in high-tech architecture, industrial buildings, intelligent futuristic buildings etc.			
	Minor design exercises in engineering structures such as power houses and futuristic building forms.			

DEPARTMENT OF ARCHITECTURE AND PLANNING
Master of Urban and Rural Planning

Teaching Scheme					Contact Hrs. per week			Exam. Duration (Hrs.)		Relative Weightage (%)				
S. No.	Sub. Code	Course Title	Sub. Area	Crs.	L	T	P/D	T	P	CWS	PRS	MTE	ETE	PR
1st YEAR					I SEMESTER (AUTUMN)									
1.	AR-651	Planning Design Studio-I	PCC	4	1	-	6	-	-	-	100	-	-	-
2.	AR-653	Planning Theories and Techniques	PCC	4	3	1	-	3	-	25	-	25	50	-
3.	AR-655	Planning Legislation and Local Self Government	PCC	4	3	1	-	3	-	25	-	25	50	-
4.		Open Elective I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
5.	AR-607	Computer Applications in Architecture and Planning	ICC	4	2	0	4	2	4	15	15	15	30	25
6.	HS-501	Technical Communication (Optional)	-	2	1	0	2	2	0	15	15	30	40	-
Sub Total			19/22											
II SEMESTER (SPRING)														
1.	AR-652	Planning Design Studio II	PCC	4	1	-	6	-	-	-	100	-	-	-
2.		Programme Elective I	PEC	4	-	-	-	-	-	-	-	-	-	-
3.		Programme Elective II	PEC	4	-	-	-	-	-	-	-	-	-	-
4.		Programme Elective III	PEC	4	-	-	-	-	-	-	-	-	-	-
5.		Open Elective II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
Sub Total			19/20											
2nd YEAR					III SEMESTER (AUTUMN)									
1.	AR-751	Planning Design Studio-III (Project)*	RP	4	-	-	8	-	-	-	100	-	-	-
2.	AR-753	Seminar	SEM	2	-	-	-	-	-	-	-	-	-	100
3.	AR-755	Dissertation	DIS	-	-	-	-	-	-	-	-	-	25	-
4.	AR-672	Institutional/ Professional Training**	RP	2	-	2	-	-	-	100	-	-	-	-
Sub Total			8											
IV SEMESTER (SPRING)														
1.	AR-755	Dissertation (continued from III Semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
Sub Total			20											
TOTAL			66/70											
PROGRAMME ELECTIVES														
1.	AR-654	Urban Dynamics	PEC	4	3	1	-	3	-	25	-	25	50	-
2.	AR-606	Housing	PEC	4	3	1	-	3	-	25	-	25	50	-
3.	AR-656	Demography and Quantitative Techniques	PEC	4	3	1	-	3	-	25	-	25	50	-
4.	AR-658	Regional Planning	PEC	4	3	1	-	3	-	25	-	25	50	-
5.	AR-660	Ecology and Sustainable Development	PEC	4	3	1	-	3	-	25	-	25	50	-
6.	AR-662	Urban and Rural Economics	PEC	4	3	1	-	3	-	25	-	25	50	-
7.	AR-664	Infrastructure Planning	PEC	4	3	1	-	3	-	25	-	25	50	-
8.	AR-666	Traffic and Transportation Planning	PEC	4	3	1	-	3	-	25	-	25	50	-
9.	AR-668	Futuristic and Visionary Planning	PEC	4	3	1	-	3	-	25	-	25	50	-
10.	AR-670	Integrated Rural Development	PEC	4	3	1	-	3	-	25	-	25	50	-

* In lieu of Project

** During summer vacation of 6 weeks between 1st and 2nd year

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

S. No.	Contents	Contact Hours
1.	Introduction to housing, social and economic infrastructures in planning, housing shortage- reasons and remedies.	8
2.	Housing policies and programmes, mass housing programmes, slums and renewal schemes.	8
3.	Housing finance and schemes, HUDCO and other housing/ building financial institutions, role of revolving funds in housing.	6
4.	Housing design standards for various income group housing, analysis and design for HIG, MIG and LIG housing schemes.	6
5.	Rural and EWS housing schemes, affordable housing, cost effective housing.	7
6.	Selected case studies of housing schemes by government and private developers in India and abroad.	7
	TOTAL	42

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Balaji V. & Rajmanohar, "Housing Sector in India; Issues, Opportunities and Challenges", ICFAI University Press.	2008
2.	Christian Schittich(ed), "High Density Housing; Concepts, Planning, Construction", Birkhauser.	2004
3.	French H., "Key Urban Housing of the Twentieth Century", Lawrence King.	2008
4.	Reeves P., "Introduction to Social Housing", Elsevier.	2005
5.	Davis S., "The Architecture of Affordable Housing", University of California Press.	1995

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: **AR-607** Course Title: **Computer Applications in Architecture and Planning**
2. Contact Hours: L: 2 T: 0 P: 4
3. Examination Duration (Hrs) Theory: 2 Practical: 4
4. Relative Weightage: CWS 15 PRS 15 MTE 15 ETE 30 PRE 25
5. Credits: 4
6. Semester: **Autumn**
7. Subject Area: **ICC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge of computer and GIS applications in architecture and planning projects.
10. Details of Course:

S. No.	Contents	Contact Hours
1	Application of software such as Revit Architecture Suite including building information modeling (BIM) and 3D Max.	4
2	Application of software such as Sketchup, Podium and E-view.	3
3	Application of software such as Catia, Primavera for construction planning management.	6
4	Application of software such as Design Builders and other software related to energy simulation modeling.	6
5	Application of software such as M.S. Pro, Power Sim, MATLAB, Arc GIS for planning.	9
TOTAL		28

List of Practicals:

1. Revit Architectural Suite: Auto CAD 2009 and 3D Max for design studio problems.
2. Building Information modeling for a given project.
3. Sketchup Pouching and e-view for a given design
4. Catia application for at least 2 design schemes
5. Primavera: Construction planning management applied to ongoing design studio project
6. Application of Design Builder and DOE2 for energy simulation modeling of one ongoing and one new project.
7. M.S. Pro, Power Sim, MATLAB, Arc GIS application in planning/ architectural design studio problem/s.

11. Suggested Books:

Sl No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Omura G., "Mastering Revit 2009", Sybex Publication.	-
2.	Omura G., "Bible 3D. Max 2009", Sybex Publication.	-
3.	Manuals of Sketchup, Podium, E-view, Catia and Primavera.	-
4.	Manuals of Design Builders and Energy Simulation Modeling.	-
5.	Manuals of M.S. Pro and Power Sim.	-
6.	Manuals of MATLAB and Arc GIS.	-

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: **AR-651** Course Title: **Planning Design Studio - I**
2. Contact Hours: L: 1 T: 0 P: 6
3. Examination Duration (Hrs) Theory: Practical:
4. Relative Weightage: CWS PRS MTE ETE PRE
5. Credits: 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective: To impart basic skills of planning through physical planning exercises.
10. Details of Course:

S. No.	Contents	Contact Hours
1	Planning surveys; Field and secondary sources based surveys.	2
2	Planning and design standards- purpose and basis of standards.	2
3	Planning Reports- type, purpose and contents of planning reports; Guidelines for preparation of reports.	3
4	Planning for urban renewal, urban redevelopment schemes.	2
5	Development of residential neighborhoods, communities and sectors.	3
6	Planning for small scale urban and rural projects.	2
TOTAL		14

Design Exercises: Major projects such as renewal design, development of medium sized neighborhood, small and medium size villages, physical planning of commercial area, recreational or institutional area or planning urban and rural infrastructure.
 Minor projects- study of planning reports, land use study, transportation study, appraisal of plan projects and technical proposal for urban and rural problems.

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Building Byelaws, Development Control Rules (DCR) of metropolitan cities.	-
2.	Institute of Town Planner's, India, "Urban Development Plans Formulation & Implementation Guidelines", ITPI Publication.	1996
3.	Chiara, J.D. and Lee K., "Time Saver Standards for Site Planning", McGraw Hill.	2007
4.	Chiara, J. D., Julius, P. and Zelnik, M., "Time Saver Standards for Housing and Residential Development", McGraw Hill.	2007
5.	National Building Code (NBC), Bureau of Indian Standards.	2006
6.	Kostof, S. and Tobias, R., "The City Shaped- Urban Pattern and meanings through History" Thames & Hudson.	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1.	Subject Code: AR-652		Course Title: Planning Design Studio - II	
2.	Contact Hours:	L: 1	T: 0	P: 6
3.	Examination Duration (Hrs)	Theory:	0	Practical: 0
4.	Relative Weightage:	CWS 0	PRS 100	MTE 0 ETE 0 PRE 0
5.	Credits:	4	6. Semester: Spring	7. Subject Area: PCC
8.	Pre-requisite:	Nil		
9.	Objective:	To impart advanced and professional planning skills through urban and rural planning design exercises.		

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Preparation of planning data base for perspective plans, development plans, sectoral plans and schemes.	3
2.	Planning policies, guidelines and strategies for urban and rural development. Review of case studies.	2
3.	Methodology for the preparation of development plan of new towns and urban extensions.	3
4.	Development issues and methodology and guidelines for the preparation of development plans for block, district etc.	2
5.	Study of settlement infrastructure and planning for the development of urban and rural infrastructure.	2
6.	Varieties of planning reports and their contents. General and specific guidelines for the preparation of planning reports.	2
	TOTAL	14

Design Exercises: Major projects such as – development plan of existing or new towns; Metropolitan region plan; Development plans for block, district or other region with respect to physical development, ecological enhancement and networks.

Minor projects - model community of futuristic nature, environmental studies of small communities, planning of facilities and amenities within a settlement or region. Development and redevelopment of urban and rural communities.

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Sendikh, E., "Planning and Urban Design Standards", American Planning Association.	2006
2.	Master Plan Reports of Important Cities like Delhi, Mumbai and Chennai	2007
3.	Moughtin, C., "Urban Design Methods and Techniques", Oxford Architectural Press.	2000
4.	Reports on City Development Plans of Mysore, Pune, Jaipur etc.	2008
5.	Katz, R. D., "Design of the Housing Site" Small Homes Council-Building Research Council, University of Illinois.	2004
6.	"Urban Development Plans Formulation and Implementation" (UDPFI) Guidelines, ITPI Publication.	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: **AR-653** Course Title: **Planning Theories and Techniques**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs) Theory: 3 Practical: 0
4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0
5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective: To understand basic principles, various theories and techniques of planning.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction and orientation to town planning, evolution of cities, evolution of town planning practice and planning agencies in India.	4
2.	Data bank, data processing and source of data. Demographic data and presentation techniques.	4
3.	Identification of planning problems; Future growth trends; Human needs and physical environment; Development and redevelopment; Appraisal of planning proposals.	6
4.	Planning as social and physical activity; Identifying objectives, setting goals and their relationship in planning schemes.	5
5.	Comprehensive planning; Planning as interdisciplinary process; Public participatory planning.	5
6.	Integrated planning and development at various levels such as city, town, neighbourhood and sectoral planning.	8
7.	Techniques of gaming and simulation, CBA for evaluation of planning proposals.	5
8.	Planning research and report writing.	5
	TOTAL	42

11. Suggested Books:

S- No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Campbell S., and Faiustein, S.S., "Readings in Planning Theory", Blackwell Publishing.	2003
2.	"Master Plan for Delhi", Delhi Development Authority, DDA Publication.	2009
3.	Keeble, L., "Principles and Practice of Town Planning and Country Planning" Rev.Ed. London: Estates, Gazette 1964.	1989
4.	Lynch, K., "Good City Form", MIT Press.	1995
5.	Taylor, N., "Urban Planning Theory since 1945", London Sage	2006
6.	"National Five Year Plans", Planning Commission, Govt. of India, Publication.	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: **AR-654** Course Title: **Urban Dynamics**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs) Theory: 3 Practical: 0
4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge on dynamic functions of the urban system.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Definitions of urban, urbanization, destabilization, stabilization; Factors responsible for urbanization.	4
2.	Impact of urbanization, spread effect, backwash effects, urban crisis, housing, housing problems, slums, housing demand estimates, housing policy.	9
3.	Urbanization in developed and developing countries, urban growth in India with case studies, special economic zones (SEZ).	7
4.	Urbanization in India. Problems and prospects, system, system dynamics, urban dynamics, functions of urban system.	8
5.	Pattern of urban growth, case studies with practical inputs, surveys, survey techniques, application of survey techniques in urban planning.	8
6.	Special problems - based on current issues and field studies.	6
	TOTAL	42

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Chauhan, A.S., "Society and Environment", Jain Brothers.	2007
2.	Mc Loughlin J. B. "Urban & Regional Planning-A systems approach", Faber and Faber.	1962
3.	Mohapatra, P.K.J., Mandal, P. and Bora, M.C., "Introduction to System Dynamics Modelling", Orient Longman.	1994
4.	Sterman J. D. "Business Dynamics", Irwin McGraw Hill.	2000
5.	Prakasa, V.L.S.R., "Urbanization in India", Concept Publishers.	1983
6.	Forrestor, W.J., "Urban Dynamics", MIT Press.	1969

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: **AR-655** Course Title: **Planning Legislation and Local Self Government**
2. Contact Hours: L: **3** T: **1** P: **0**
3. Examination Duration (Hrs) Theory: **3** Practical: **0**
4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective: To understand legislation and its implementation applicable to urban and rural planning and development.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction, scope and objectives of legislation related to settlement planning and development; Constitutional framework of secular, democratic republic at the central, state and sub-state levels.	4
2.	Historical review of evolution and growth of planning legislation and institutional systems in India; Study of milestone legislations and their effects.	6
3.	Review of planning and legislative systems in UK, USA and other countries; Case studies on effective planning and development practices.	6
4.	Contemporary legislation and institutional provisions for planning and plan implementation; Planning agencies and development authorities; Impact of economic reforms on urban and rural planning and development.	8
5.	Urban and rural institutions for planning, development and governance. Review of 73 rd and 74 th constitutional amendments and their relevance to planning and plan implementation.	9
6.	Case studies on planning and implementation mechanism- building bye laws, development controls and zoning regulations; Alternative land management models; Local self –government (LSG).	9
	TOTAL	42

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Building Byelaws of various states, master plan reports of various cities	-
2.	Constitutional Amendment 73 rd and 74 th of 1992, Deptt. of Publications, GOI	1993
3.	The Delhi Laws (Special Provision) Act, 2006.	2006
4.	The Karnataka Urban Development Authorities Act, 1987.	1987
5.	The Maharashtra Regional and Town Planning Act, 1996.	1996
6.	Various Acts of City and Regional Planning Development Authorities	-

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1.	Subject Code: AR-656 Course Title: Demography and Quantitative Techniques				
2.	Contact Hours:	L: 3	T: 1	P: 0	
3.	Examination Duration (Hrs)	Theory:	3	Practical:	0
4.	Relative Weightage:	CWS	25	PRS	0
		MTE	25	ETE	50
		PRE	0		
5.	Credits:	4	6. Semester: Spring	7. Subject Area: PEC	
8.	Pre-requisite:	Nil			
9.	Objective:	To understand the use of various population theories and quantitative techniques in planning for balanced socio- economic development.			

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Population theories- optimum population, logistical curve, biological and demographic transition theories. Measurement of crude, general, age specific, fertility and mortality rates.	5
2.	Census operations - sample survey strategies in collection and compilation of census data; Various population projections methods; Impact of population growth on socio-economic growths.	7
3.	Relationship between population growth and socio-economic developments, effect of growth rate of population on measurement and per capita income; The western experience.	7
4.	Migration, internal migration, sources of data, direct methods of estimation for migration, indirect measures of estimating migration.	7
5.	Statistics and probability, collection and presentation of data, different types of data, frequency distribution, types of frequency distribution.	7
6.	Measures of central tendency, mean, median, mode; Skewness; Standard deviation and coefficient of variation; Least square method; Multiple regression.	9
	TOTAL	42

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Bhende, A.A. and Kanatkar T., "Principles of Population Studies", Himalaya Publishing.	2006
2.	Spiegel, M.R., "Probability and & Statistics", Schaum's Series.	2002
3.	Land, K.(ed.), "Demographic Methods and Population Analysis", Dordrecht- Springer.	2009
4.	Willemain, R., "Statistical Methods for Planners", MIT Press.	1980
5.	"Urban Development Plans Formulation and Implementation" (UDPFI) Guidelines, ITPI Publication.	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: **AR-658** Course Title: **Regional Planning**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs) Theory: 3 Practical: 0
4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To understand the basic concepts of regions, their development issues, various theories and overall process of regional planning.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Delineation of regions , delineation of formal region, delineation of functional region, flow analysis, gravitational analysis, the factor analysis method.	4
2.	Regional long run growth, aggregate growth models, growth from inside and outside, sector theory, economic models, industrial structure analysis, strife and share component regional growth.	6
3.	Spatial structure of regions, central place theory, spatial competition between providers of individual service. Alternative forms of hierarchy. Limitations and application to regional planning.	6
4.	Basic concepts of growth pole theory, leading industries and propulsive firms, polarization effects and agglomeration economies, spread effects, models of spatial interaction.	6
5.	Planning in India an overview; Strategy of decentralized verses centralized planning, role of district planning, regional imbalances and inequalities in India, post independence situation in India, some reasons for disparities.	7
6.	City and metropolitan planning, trends in urban growth and urbanization in India, migration and urbanization and economic development, need for comprehensive urban regional planning.	7
7.	Case studies such as National Capital Region, 2021; Metropolitan regions.	6
	TOTAL	42

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Unaeghu, G. C., "Issues in Urban and Regional Planning", Washington House.	2005
2.	Glasson, J., "An Introduction to Regional Planning" Rev. Ed. Routledge.	1995
3.	Calthorpe P. and Fulton, W.B., "The Regional City: Planning for the End of Sprawl", Island Press.	2001
4.	Hall, P., "Urban and Regional Planning", 4 th Ed. Routledge.	2002
5.	Regional Plan-2021-NCR/11 th Five Year Plan, Govt. of India.	2007
6.	"Urban Development Plans Formulation and Implementation" (UDPFI) Guidelines, ITPI Publication.	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: **AR-660** Course Title: **Ecology and Sustainable Development**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs) Theory: 3 Practical: 0
4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0
5. Credits: 4 6. Semester: Spring 7. Subject Area: PEC
8. Pre-requisite: Nil
9. Objective: To understand application of ecology in architecture and planning for sustainable development.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to ecology- understanding the concept of environment and ecology as environmental biology, and study of ecosystems.	3
2.	Importance of ecology to man in general and environmental designer, planner and technologist in particular in the context of growing global environmental concerns.	6
3.	Structure and functions of eco-systems in general. Ecosystem components and functional inter relationships; Food chain, food web, bio-geochemical cycles, energy flow and productivity.	7
4.	Community organization, species and population, inter-species interactions, habitat, niche, natural selection; Growth, decline and balance in populations. Concept of environmental resistance.	7
5.	Factors responsible for development of diverse ecosystems; Role of climate and geochemical factors. Ecological succession; Study of representative samples of different ecosystems.	6
6.	Summary of principles of ecology derived from ecosystem study and useful guidelines for human beings. Comparison of natural ecological system and man-made systems.	6
7.	Application of ecological and environmental principles and guidelines to architecture and planning; Designing ecologically sustainable settlements and other man-made systems; Ecological foot print analysis and other contemporary concepts.	7
TOTAL		42

1 1. Suggested Books:

S. No.	Name of Authors/Books/Publishers	Year of publication/ reprint
1.	Paolo, S., "Arcology: The City in the Image of Man", Rev. Edn. MIT Press	2001
2.	Perlman, D. and Milder, J., "Practical Ecology for Planners Developers and Citizens", Island Press.	2005
3.	Platt, R.H., "The Ecological City: Preserving and Restoring Urban Bio diversity", N.Y.Academy of Sciences.	2007
4.	Register, R., "Ecocities: Building cities in balance with Nature", New Society Publishers.	2006
5.	Todd, N.J. and Todd, J., "Principles of Ecological Designs", North Atlantic Book.	2004
6.	Voula, M., "Sustainable Development, Energy and the city: A Civilization of Concepts and Actions", Elsevier.	2005

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

S. No.	Contents	Contact Hours
1.	Basic concepts, definition of economics, significance of economics in urban and rural planning, national income, methods of calculating national income significance of national income statistics in urban and rural planning.	6
2.	Urban land economics, urban crisis, real estate industry and land use plans; Location factors affecting land use and real estate industry.	6
3.	Economics of regional development; Development plans, regional analysis. Five year plans and their impacts in urban and rural system.	7
4.	Economic theories- demand, supply, investment, production, and their application in urban and rural planning.	7
5.	Rural economic, problems and prospects, indicators of development, human development index (HDI); Economic analysis of different states in India.	8
6.	Urban and rural finance, budgeting, financial institutions in the urban and rural systems.	8
	TOTAL	42

1 1. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Balchin, P.N., "Urban Economics", Palgrav Publishers .	1985
2.	Gasper, D., "Ethics of Development", Vistaar.	2004
3.	Raghavan, P., "Indian Economy". Spectrum Books.	2008
4.	Barlowe, R., "Land Resource Economics", Prentice Hall Publishers.	1986
5.	Richardson, H. W., "Regional and Urban Economics", Harmondsworth.	1979
6.	Samuelson and Nordhaus, "Economics", Tata McGraw Hill Publishers.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: **AR-664** Course Title: **Infrastructure Planning**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs) Theory: Practical:
4. Relative Weightage: CWS PRS MTE ETE PRE
5. Credits: 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To understand importance and management of infrastructure planning for appropriate development schemes.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to infrastructure planning, definition and categorization of infrastructure as applicable to urban and rural planning.	4
2.	Energy- classification and characteristics of energy resources, energy use, and energy demand in different sectors of economy and settlement; Comparative energy statistics; Planning for energy needs; Concepts and guidelines.	10
3.	Water supply, sewerage and drainage- basic facts on use and characteristics; Planning for integrated and sustainable management of water system, sewerage and drainage- concepts, guidelines, technologies and strategies; Case studies.	10
4.	Solid waste management; Nature and classification of urban waste; Working of the existing system and shortcomings; Management of urban solid waste- guidelines, technologies and strategies; Case studies.	9
5.	Social infrastructure for different size and types of human settlements- typologies and standards; Planning for educational, health, recreational and socio-cultural facilities, amenities for different categories of urban and rural settlements.	9
TOTAL		42

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Dragan, S., "Sustainable Water Management Solutions for Large Cities", IAHS Publication.	2005
2.	Tchobanoglous, G., "Integrated Solid Waste Management: Engineering Principles and Management Issues", McGraw Hill.	1993
3.	Goodman, A.S. and Hastak, M., "Infrastructure Planning Handbook: Planning Engineering and Economics", New York: ASCE Press.	2006
4.	"Solid Waste Management in Class I Cities in India". Report of the expert Committee constituted by Hon. Supreme Court of India.	1999
5.	Baum, V., "Energy Planning in Developing Countries", Australian Govt. Publishing Service.	1994
6.	Zaini, U. and Mogens, H., "Municipal Wastewater Management in Developing Countries", Elsevier.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1.	Subject Code: AR-666	Course Title: Traffic and Transportation Planning			
2.	Contact Hours:	L: 3	T: 1	P: 0	
3.	Examination Duration (Hrs)	Theory:	3	Practical:	0
4.	Relative Weightage:	CWS	25	PRS	0
		MTE	25	ETE	50
		PRE	0		
5.	Credits:	4	6. Semester:	Spring	
			7. Subject Area:	PEC	
8.	Pre-requisite:	Nil			
9.	Objective:	To acquire professional capacity in traffic and transportation planning.			

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to traffic and transportation planning in urban and regional context; Traffic and transportation characteristics and problems of India.	3
2	Types of roads and planning standards; Road design and layout; Road intersections; Road cross sections; Street furniture; Design for road safety.	5
3	Traffic and transportation surveys; Traffic zones, cordon lines and control stations; O and D surveys, home interviews and travel pattern data; Inventory of existing transportation facilities including parking.	8
4	Traffic Management- traffic control systems, traffic signs, signals, speed regulations etc; Design for traffic segregation; Planning for parking.	7
5	Traffic planning and forecasting- trip generation and methods of predicting trip generation; Models of traffic assignments.	5
6.	Roads and transport services in urban and rural settlement; Mass transportation in urban environment; Urban form in relation to traffic and transportation patterns; Sustainable transport systems; Environmental considerations.	8
7.	Case studies on best practices of traffic management and transportation services from India and abroad; New innovations and concepts in traffic and transportation.	6
	TOTAL	42

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Bohlinger, M., "Planning Traffic Management", Springer.	2010
2.	Bruton, M.J., "Introduction to Transportation Planning", Amazon Co.	2009
3.	Burton E. and Mitchell, L., "Inclusive urban design: streets for life", Elsevier.	2006
4.	Tiwari G., "The Way Forward Transportation Planning and Road Safety", IITD Publication.	2003
5.	Kadiyal, L.R "Traffic Engineering and Transport Planning", Khanna Publisher.	2002
6.	Vuchic, V.R. "Urban Transport Systems and Technology", Wiley & Sons.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: AR-668 Course Title: Futuristic and Visionary Planning
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs) Theory: 3 Practical: 0
4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0
5. Credits: 4 6. Semester: Spring 7. Subject Area: PEC
8. Pre-requisite: Nil
9. Objective: To understand futuristic planning concepts in the context of changing techno-economic scenarios.

10. Details of Course:

S. No.	Contents	Contact Hours
1	The realm of futurology and visionary planning; Utopias and visionary plans of the past centuries. Contents of futuristic ideas of settlements and living in literature.	7
2	Present planning horizons and future visions. Understanding of future man and society; Planning for future habitats in relation to technology and resource development.	8
3	Planning strategies and utopian city structure; Alternative future scenarios; Contributions from famous futurologists.	9
4	Concepts for future settlements - planning and design parameters; Environmental considerations; Growing needs of sustainable and ecologically appropriate developments.	9
5	Case studies of futuristic and visionary projects related with human aspirations, needs and technological developments.	9
TOTAL		42

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Toffler, A., "Future Shock", Bantam Books Rev.	2005
2.	Brian, R., "Future Transport in Cities", London Spon Press	2001
3.	Alison, J., "Future City: Experiment and Utopia in Architecture", Thames & Hudson.	2007
4.	Jenks, M. and Dempsey, N., "Future Forms and Design for Sustainable Cities", Elsevier.	2005
5.	Spiller, N., "Visionary Architecture: Blue Prints of the Modern Imagination", Thames & Hudson.	2006
6.	Read, S., "Future City", London Spon Press.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: **AR-670** Course Title: **Integrated Rural Development**

2. Contact Hours: L: **3** T: **1** P: **0**

3. Examination Duration (Hrs) Theory: **3** Practical: **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To understand various issues of integrated rural development.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Rural planning and development; Rural planning methodology, data and sources, schedule and questionnaire preparation, executing surveys.	6
2	Rural system, analysis of rural system, tabulation and its analysis; Application of statistical techniques in rural planning.	6
3	Rural growth pattern; Rural land economics, production function in agriculture, livestock development; Rural industrialization, impact of rural industrialization in the rural system.	6
4	Rural infrastructure planning in different sectors, which include transport, health, education, marketing, energy, communication, dairy, housing, science and technology programs in integrated rural development.	8
5	Institutions for rural development, community development block; DRDA; Local self governments; District planning offices; State planning boards; Planning commission; State rural development institutions; NIRD.	10
6	Rural project management, case studies.	6
	TOTAL	42

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Francies P. W., "Energy Crises and Environment", Loyola College.	1997
2.	Ramchandran, H., "Integrated Rural Development in Asia", Concept Publishers.	1991
3.	Kumar U., "Science and Technology for Rural Development", Deep and Deep Publishers.	1997
4.	Siddiqui, N. A., "Natural Resource and Env. Management Systems", Khanna Publishers.	2008
5.	Patnayak, R., "Rural Development in India", Vikas Publishers.	1990
6.	Arora, R.K., "Indian Public Administration", Wishwa Prakashan Ltd.	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: ARCHITECTURE AND PLANNING

1. Subject Code: **AR-751** Course Title: **Planning Design Studio-III (Project)**
2. Contact Hours: L: 0 T: 0 P: 7
3. Examination Duration (Hrs) Theory: Practical:
4. Relative Weightage: CWS PRS MTE ETE PRE
5. Credits: 6. Semester: **Autumn** 7. Subject Area: **RP**
8. Pre-requisite: **Nil**
9. Objective: To develop professional attitude and a comprehensive approach to sustainable physical planning projects.
10. Details of Course:
Design Exercises: Major project (any one of the following)- i) Integrated development plan for a large rural settlement. ii) Development plan for a rural region. iii) Regional plan for larger regions like valley regions and watershed regions etc.

Minor project (any two)- these are to be related to the main project with emphasis on analysis and innovation.

Program: M.Tech. (Earthquake Engineering) (Structural Dynamics)

Year: I

Autumn Semester

Teaching Scheme					Contact Hours Per Week			Exam Duration		Relative Weightage				
S. No.	Sub. Code	Course Title	Sub. Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	MA-501E	Optimization Techniques	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	EQ-501	Theory of Vibration	PCC	4	3	1	2/2	3	-	15	15	30	40	-
3.	EQ-504	Finite Element Method	PCC	4	3	1	-	3	-	25	-	25	50	-
4.	EQ-563	Earthquake Resistant Design of Structures	PCC	4	3	1	-	3	-	25	-	25	50	-
5.		Open Elective - I	OEC	4/3	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (Optional)	IEC	2	1	0	2	2	-	15	15	30	40	-
Sub Total				19-22										

Spring Semester

Teaching Scheme					Contact Hours Per Week			Exam Duration		Relative Weightage				
S. No.	Sub. Code	Course Title	Sub. Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.		Programme Elective - I	PEC	4	-	-	-	-	-	-	-	-	-	-
2.		Programme Elective - II	PEC	4	-	-	-	-	-	-	-	-	-	-
3.		Programme Elective - III	PEC	4	-	-	-	-	-	-	-	-	-	-
4.		Programme Elective - IV	PEC	4	-	-	-	-	-	-	-	-	-	-
5.		Open Elective - II	OEC	4/3	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (Optional)	IEC	2	1	0	2	2	-	15	15	30	40	-
Sub Total				19-22										

Program: M.Tech. (Earthquake Engineering) (Structural Dynamics)

Year: II

Autumn Semester

Teaching Scheme					Contact Hours Per Week			Exam Duration		Relative Weightage				
S. No.	Sub. Code	Course Title	Sub. Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	EQ-601	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	EQ-602	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	EQ-603	Dissertation*	DIS	-	-	-	-	-	-	-	-	-	25	-
Sub Total				6										

***NOTE: To be continued and Grade to be awarded in the next semester.**

Spring Semester

Teaching Scheme					Contact Hours Per Week			Exam Duration		Relative Weightage				
S. No.	Sub. Code	Course Title	Sub. Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	EQ-603	Dissertation (Contd. From III Semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
Sub Total				20										
Total				64-68										

List of Programme Elective Courses (Structural Dynamics)

Teaching Scheme					Contact Hours Per Week			Exam Duration (Hrs.)		Relative Weightage (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1.	EQ-511	Earthquake Resistant Design of Masonry Structures	PEC	4	3	1	0	3	0	25	0	25	50	0
2.	EQ-512	Advanced Earthquake Resistant Design of Structures	PEC	4	3	1	0	3	0	25	0	25	50	0
3.	EQ-513	Numerical Methods For Dynamic Systems	PEC	4	3	1	0	3	0	25	0	25	50	0
4.	EQ-514	Seismic Evaluation and Retrofitting of Structures	PEC	4	3	1	0	3	0	25	0	25	50	0
5.	EQ-515	Mechanics of Deformable Media	PEC	4	3	1	0	3	0	25	0	25	50	0
6.	EQ-525	Seismic Hazard Assessment	PEC	4	3	1	0	3	0	25	0	25	50	0
7.	EQ-546	Instrumentation and Model Testing Techniques	PEC	4	3	1	0	3	0	25	0	25	50	0
8.	EQ-548	Discrete Time Signal Processing	PEC	4	3	1	0	3	0	25	0	25	50	0
9.	EQ-551	Random Vibrations	PEC	4	3	1	0	3	0	25	0	25	50	0
10.	EQ-552	Reliability Based Design	PEC	4	3	1	0	3	0	25	0	25	50	0
11.	EQ-558	Advanced Structural Dynamics	PEC	4	3	1	0	3	0	25	0	25	50	0
12.	EQ-560	ERD of Bridges and Concrete Dams	PEC	4	3	1	0	3	0	25	0	25	50	0
13.	EQ-562	Dynamics of Plates, Shells and Arches	PEC	4	3	1	0	3	0	25	0	25	50	0
14.	EQ-566	Structural Response Control for Seismic Protection	PEC	4	3	1	0	3	0	25	0	25	50	0
15.	EQ-590	Strong Motion Seismology	PEC	4	3	1	0	3	0	25	0	25	50	0

**RESTRUCTURED PROGRAMME OF MASTER OF TECHNOLOGY
IN EARTHQUAKE ENGINEERING WITH SPECIALIZATION IN
STRUCTURAL DYNAMICS**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: EQ – 501 Course Title: Theory of Vibration
2. Contact Hours: L: 03 T: 01 P: 2/2
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 15 PRS 15 MTE 30 ETE 40 PRE 00
5. Credits: 4 6. Semester: Autumn 7. Subject Area: PCC
8. Pre-requisite: Nil
9. Objective: To provide the basic framework for studying time-dependent response of mechanical systems to external excitations.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Vibrations and the nature of time dependent phenomena, inertia, dynamic equilibrium and mathematical models of physical systems; Energy storing and dissipation mechanisms.	3
2.	Dynamics of Single Degree of Freedom Systems, undamped and damped, free and forced vibrations; Steady-state and transient response, impulse response.	10
3.	Harmonic response and applications to vibration isolation; theory of seismic pickups; Seismometers, accelerometers.	4
4.	Convolution integral and solution of equation of motion; Numerical methods for solution of linear and non-linear equations of motion; response/shock spectra; Fourier transforms and analysis in frequency domain.	6
5.	Dynamics of Multi-Degree of Freedom Systems, Lagrange's equations; equations of motion for MDOF systems; Algebraic eigenvalue problem and free vibration analysis; Undamped and damped normal modes; Mode superposition method for dynamic analysis of linear systems; Mode-truncation and correction for the missing mass.	12
6	Dynamics of Continuous Systems, Hamilton's principle; Axial and transverse vibrations of beams, torsional vibrations of shafts; Normal modes; Free and forced vibration analysis by mode superposition; Vibrations of elastic half-space.	4
7	Approximate Methods for Vibration Analysis, Rayleigh quotient, rayleigh-ritz method.	3
Total		42

List of Experiments:

1. Vibration transducers and elementary data processing.
2. Free vibration characteristics of structural systems-natural frequency and damping ratio.
3. Harmonic forced vibration response of structural models and frequency response functions.
4. Dynamic vibration absorber.
5. Prototype testing and system identification.

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Warburton, G. B., "The Dynamic Behaviour of Structures", 2 nd edition, Pergamon Press.	1976
2.	Clough, R. W. and Penzien, J., "Dynamics of Structures", 2 nd edition, Mc-Graw Hill Book Company.	1993
3.	Humar, J. L., "Dynamics of Structures", 2 nd edition, Taylor & Francis.	2002
4.	Chopra, A. K., "Dynamics of Structures", 3 rd edition, PHI Learning.	2006
5.	Craig, R. R., Jr. and Kurdila, A., "Fundamentals of Structural Dynamics", 2 nd edition, John Wiley & Sons.	2006
6.	Villaverde, R., "Fundamental Concepts of Earthquake Engineering", Taylor & Francis.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: EQ – 504 Course Title: Finite Element Method
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 25 PRS 00 M TE 25 ETE 50 PRE 00
5. Credits: 4 6. Semester: Autumn 7. Subject Area: PCC
8. Pre-requisite: Nil
9. Objective: To provide a framework for developing computational models for solving engineering problems.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Mathematical Modeling: Differential equations; Boundary conditions; Method of weighted residuals; Variational principles and approximate solutions; Convergence of approximate solutions; Concept of finite element method as extension of method of weighted residuals to piecewise continuous approximation; Rules of domain discretization; Discretization errors.	5
2.	Finite Elements of One Dimension: Continuity requirement; Truss/rod/shaft, beam bending; Locking in shear deformable beam elements and solution; Modeling of framed structures; Skewed boundary conditions; constraint equations; Rules for monotonic convergence of the finite element solution.	7
3.	Finite Elements of Two/Three Dimensions: Equations of 3-D elasticity; Plane stress, plane strain and axi-symmetric idealizations; Triangular and rectangular elements; Interpolation functions; Degree of complete polynomial; Pascal's triangle; Evaluation of domain and surface integrals; Tetrahedral and brick elements; Incompatible modes; Patch test.	10
4.	Mapped Elements: Parametric distortions and finite elements; Numerical integration; Full reduced and selective integration; Constraint counting techniques; Modeling of unbounded domains.	10
5.	Plates and Shells: Finite elements for plates and shells; Shear and membrane locking and solution; Semi-analytical procedure for axi-symmetric shells.	4
6.	Time Dimension: Consistent mass matrix; Lumping procedures; Algebraic eigenvalue problem; Time-marching schemes; Adequacy of the finite element mesh.	3
7.	Error Analysis: Posteriori error estimation procedures; Adaptive finite element analysis – h , p and r adaptivity; Super-convergent patch recovery.	3
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Zienkiewicz, O.C. and Morgan, K. "Finite Elements and Approximation", John Wiley & Sons.	1983
2.	Reddy, J.N. "Finite Element Method", 2 nd edition, McGraw-Hill Book Company.	1993
3.	Bathe, K. J., "Finite Element Procedures", 2 nd edition, PHI Learning.	1994
4.	Dow, J.O., "A Unified Approach to the Finite Element Method and Error Analysis Procedures", Elsevier Publications.	1999
5.	Cook, R.D., Malkus, D., Plesha, M. and Witt, J. "Concepts and Applications of Finite Element Method", 4 th edition, John Wiley & Sons.	2004
6.	Akin, J.E. "Finite Element Analysis with Error Estimators", Elsevier Publications.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: **EQ – 563** Course Title: **Earthquake Resistant Design of Structures**
2. Contact Hours: L: **03** T: **01** P: **00**
3. Examination Duration (Hrs.): Theory **3** Practical **0**
4. Relative Weightage: CWS **25** PRS **00** M TE **25** ETE **50** PRE **00**
5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective: This course will provide insight into design of structures to withstand earthquake forces and related seismic safety issues.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Basic Concepts: Seismic performance of structures and structural components during earthquakes; Ground motion parameters; Response spectrum, design spectrum.	5
2.	Seismic Design Philosophy: Concept of strength, overstrength and ductility, Concept of equal displacement and equal energy principles, capacity design; seismic design consideration in buildings with irregularities.	7
3.	Seismic Analysis of Buildings: Equivalent static analysis, response spectrum analysis, mode superposition method; Time history analysis; Modelling concept of reinforced concrete building.	10
4.	Seismic Design of Building Components: Seismic resistant properties of reinforced concrete; Seismic behaviour and design of linear reinforced concrete elements; Seismic behavior of planar reinforced concrete elements, codal provisions.	10
5.	Seismic Provisions for Structural Steel Buildings: Materials, connections, joints and fasteners; Columns, ordinary, intermediate and special moment resisting frame; Centrically and eccentrically braced frames.	10
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Pauley, T. and Priestley, M.J.N "Seismic Design of Reinforced Concrete and Masonry Buildings", John-Wiley & Sons.	1992
2.	Drysdale, R.G. Hamid, A. H. and Baker, L.R "Masonry Structure: Behaviour and Design", Prentice Hall, Englewood Cliffs.	1994
3.	Schneider, R.R. and Dickey, W.L. "Reinforced Masonry Design", 3 rd Ed., Prentice Hall.	1994
4.	Edmund Booth, "Concrete Structure in earthquake regions – Design & Analysis" Longman Scientific & Technical.	1994
5.	"Seismic Evaluation and retrofit of concrete building – Vol. I & II", Applied Technology Council, California, ATC 40.	1996
6.	Penelis, George G., and Kappos, Andreas J., "Earthquake Resistant Concrete Structures", E & F. N., Spon.	1997
7.	"Building Seismic Safety Council", Federal Emergency Management Agency, Washington, D.C, FEMA 356, 2000, FEMA 440 / ATC 55, 2005, FEMA 310.	1998
8.	Amrhein, J. E. "Reinforced Masonry Engineering Handbook", Masonry Institute of America, CRC Press.	1998
9.	Allan Willians, "Seismic Design of Building & Bridges", Oxford University Press.	2003
10.	Robert E. Englekirk "Seismic Design of Reinforced and Precast Concrete Buildings", John Wiley & Sons.	2003
11.	Steven L. Krammer "Geotechnical Earthquake Engineering", Low Priced Edition, First Indian Reprint, Prentice-Hall International Series in Civil Engineering and Engineering Mechanics, Pearson Education.	2003
12.	Edmund Booth and David Key, "Earthquake Design Practice for Buildings", Tomas Telford publishing, Thomas Telford , London.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: EQ – 511 Course Title: Earthquake Resistant Design of Masonry Structures

2. Contact Hours: L: 03 T: 01 P: 00

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 25 PRS 00 M TE 25 ETE 50 PRE 00

5. Credits: 4 6. Semester: Spring 7. Subject Area: PEC

8. Pre-requisite: Nil

9. Objective: To provide insight into relevant theories, simulation techniques and principles of earthquake resistant design and construction for various types of masonry structures and to introduce various code provisions.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Behaviour of Masonry Structures During Past Earthquakes: Common modes of failure, effect of unit shapes and mortar type, effect of roof and floor systems; Common deficiencies.	4
2.	Material Properties: Masonry units- stones, brick and concrete blocks, hollow and solid units; Manufacturing process; Mortar, grout and reinforcement; Various tests and standards.	5
3.	Masonry Under Compression: Prism strength, Failure mechanism, types of construction and bonds; Eccentric loading; Slenderness – effective length and effective height, effect of openings; Code provisions.	5
4.	Masonry Under Lateral Loads: In-plane and out-of-plane loads, bending parallel and perpendicular to bed joints; Shear and flexure behaviour of piers; Test and standards; Analysis of perforated shear walls, lateral force distribution for flexible and rigid diaphragms; Arching action; Combined axial and bending actions.	10
5.	Earthquake Resistant Measures: Analysis for earthquake forces, role of floor and roof diaphragm; Concept and design of bands, bandages, splints and ties; Reinforced masonry; Vertical reinforcement at corners and jambs; Measures in random-rubble masonry; Confined masonry; Code provisions.	5
6.	Masonry Infills: Effect of masonry infills on seismic behaviour of framed buildings; Failure modes; Simulation of infills – FEM and equivalent strut; Safety of infills in in-plane action – shear, compression and buckling; Out-of-plane action, arching; Code provisions.	5
7.	Retrofitting of Masonry Building: Techniques of repair and retrofitting of masonry buildings; IS: 13935-1993 provision for retrofitting.	3

8.	Advance Concepts: Strength and ductility; Nonlinear pushover analysis; Performance based design; Vulnerability and fragility analysis.	5
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Drysdale, R. G., Hamid, A. H. and Baker, L. R., "Masonry Structure: Behaviour and Design", Prentice Hall, Englewood Cliffs.	1994
2.	Schneider, R.R. and Dickey, W. L., "Reinforced Masonry Design", 3 rd Ed, Prentice Hall.	1994
3.	Päulay, T. and Priestley, M. J. N., "Seismic Design of Reinforced Concrete and masonry Buildings", John Wiley & Sons.	1995
4.	Amrhein, J. E., "Reinforced Masonry Engineering Handbook," Masonry Institute of America, CRC Press.	1998
5.	Hendry, A. W., "Structural Masonry", Macmillan Press Ltd.	1998
6.	"Prestandard and Commentary For The Seismic Rehabilitation of Buildings," FEMA 356, Federal Emergency Management Agency, Washington, D.C.9	2000
7.	Tomazevic, M., "Earthquake Resistant Design of Masonry Buildings", Imperial Colleges Press.	2000
8.	Donald Anderson and Svetlana Brzev, "Seismic Design Guide for Masonry Buildings," Canadian Concrete Masonry Producers Association.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: **EQ – 512** Course Title: **Advanced Earthquake Resistant Design of Structures**
2. Contact Hours: L: 03 T: 01 P: 0
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 25 PRS 00 M TE 25 ETE 50 PRE 00
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **EQ-501 or equivalent**
9. Objective: The course deals with special provisions and requirements of structures for their safety against earthquake forces.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Concepts of Earthquake Resistant Design: Force based vs. displacement based design, performance based design, seismic input characteristics and their effect on seismic design, comparative study of different national codes.	4
2.	Modelling and Analysis of Structures for Displacement Based Design: Back-bone curve, Idealized component models, estimation and modelling of stiffness, strength and ductility of RC, steel and masonry structures, nonlinear static and dynamic analyses.	10
3.	Direct Displacement Based Design: Structure performance objectives, performance levels and limit states; P-Delta effects; Torsion; Capacity design for direct displacement based design.	10
4.	Performance Based Design: Structural and non-structural performance, quantification of performance, performance evaluation of structures, services and equipment.	6
5.	Overhead Water Tanks: Modelling and analysis of overhead water tanks, hydrostatic and hydrodynamic effects, earthquake resistant provisions.	6
6.	Cooling Towers : Seismic behaviour and design of cooling towers, chimneys and silos; Seismic analysis and design of hyperbolic cooling towers, axisymmetric bodies subjected to non-axisymmetric loads, analysis and design of short and tall stacks & chimney structures, foundation compliance, codal provisions.	6
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Paulay, T. and Priestley, M.J.N. "Seismic Design of Reinforced Concrete and Masonry Buildings," John Wiley & Sons.	1992
2.	M.J.N. Priestley, F. Seible, and G.M. Calvi, "Seismic Design and retrofit of Bridges," John Wiley & Sons.	1996
3.	Skinner, R., Robinson, W.H., McVerry, G.H., "An Introduction to Seismic Isolation", John Wiley and Sons.	1996
4.	George G. Penelis and Andreas J. Kappos, "Earthquake Resistant Concrete Structures," E & FN Spon.	1997
5.	FEMA-356, "Prestandard and Commentary for the Seismic Rehabilitation of Buildings," Federal Emergency management Agency.	2000
6.	FEMA-450, "NEHRP Recommended provisions for Seismic Regulations for New Buildings and Other Structures," Federal Emergency management Agency.	2003
7.	Priestley, M.J.N., Calvi, G.M. and Kowalsky, M.J., "Displacement-Based Seismic Design of Structures," IUSS Press.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: **EQ – 513** Course Title: **Numerical Methods for Dynamic Systems**
2. Contact Hours: L: **03** T: **01** P: **0**
3. Examination Duration (Hrs.): Theory **3** Practical **0**
4. Relative Weightage: CWS **25** PRS **00** MTE **25** ETE **50** PRE **00**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: The course provides the conceptual basis of analysis of dynamic systems with emphasis on computer implementation.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Elementary concepts of vector spaces, subspaces; Column and row space of a matrix; Range, null space, and rank of a matrix, ortho-normal bases, vector and matrix norms, testing for convergence, errors in floating point arithmetic.	6
2.	Computer implementation of matrix and vector operations, operation counting, structures of matrices and their storage, block algorithms, vector processing and parallel processing.	6
3.	Computational aspects of elimination and in-situ factorisation methods for solution of large system of equations for dynamic problems; Implementation details for band and/or skyline solvers.	9
4.	Problems associated with choice and implementation of solution techniques; Eigen solution of large problems arising in dynamic systems.	9
5.	Application of Interpolation and extrapolation, numerical differentiation and quadrature methods	4
6.	Response evaluation by the Integration of ordinary differential equations with emphasis on accuracy and stability considerations, integration of stiff ordinary differential equations, concepts of <i>A</i> -stability and stiff-stability.	8
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Pariett, B. N., "The Symmetric Eigenvalue Problem" Prentice-Hall.	1980
2.	George, A. and Liu J.W.H., "Computer Solution of Large Sparse Positive Definite Systems", Prentice Hall.	1981
3.	Hager, W. W., "Applied Numerical Linear Algebra", Prentice-Hall.	1988
4.	W. H., Teukolsky S. A., Vetterling W.T. and Flannery B.P., "Numerical Recipes – The Art of Scientific Computing," Second Edition, Cambridge University Press.	1992
5.	Clough, R. W. and Penzien J., "Dynamics of Structures," Second Edition, McGraw-Hill.	1993
6.	Golub, G. H. and Van Loan C.F., "Matrix Computations," Third Edition, The Johns Hopkins University Press.	1996
7.	Bathe, K.J., "Finite Element Procedures", Prentice Hall.	1996
8.	Hughes, T.J. R., "The Finite Element Method - Linear Static and Dynamic Finite Element Analysis," Dover Publications.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER: **Department of Earthquake Engineering**

1. Subject Code: **EQ – 514** Course Title: **Seismic Evaluation and Retrofitting of Structures**

2. Contact Hours: L: 03 T: 01 P: 00

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **2 5** PRS **0 0** MTE **2 5** ETE **5 0** PRE **0 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart the knowledge for improve with the performance of buildings not designed as per seismic codes of practice.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Terminology; Basic principles of seismic evaluation and retrofitting.	2
2.	Qualitative Methods of Seismic Evaluation: Rapid visual screening procedure (RVSP) and simplified evaluation of buildings; Visual inspection method and non-destructive testing (NDT) method.	8
3.	Quantitative Methods of Seismic Evaluation: Performance based method using nonlinear static push-over analysis (NSP) and non linear dynamic method of analysis (NDP); Estimation of seismic capacity (strength and ductility).	8
4.	Local and Global Methods of Seismic Retrofitting of RC Buildings: System completion; Strengthening of existing components; RC, Steel and FRP Jacketing; Addition of new components – frames, shear walls and braced frames; Introduction to supplemental energy dissipation and base isolation.	8
5.	Re-evaluation of Buildings with Retrofitting Elements: Linear and Non-linear modelling; Modelling of soil and foundations.	4
6.	Seismic Repair and Retrofitting of Earthquake Damaged RC Buildings: Schemes of temporary shuttering damages; Methods of repair and retrofitting.	3
7.	Seismic Evaluation and Retrofitting of RC Bridges: Seismic evaluation and retrofitting techniques for reinforced concrete bridges – columns/piers, cap beams, cap beam-column joint, footing.	3
8.	Seismic Safety of Equipments and Accessories: Retrofitting solutions against sliding and overturning of equipments and accessories.	2
9.	Case Studies in Seismic Retrofitting: Case studies RC buildings, masonry buildings, bridges, water tanks and gravity dams.	4
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	"Seismic Evaluation and retrofit of concrete building – Vol. I & II", Applied Technology Council, California, ATC 40.	1996
2.	M.J.N., Seible, F. and Calvi, G.M "Seismic Design and Retrofit of Bridges", John-Wiley & Sons.	1996
3.	Penelis, George G., and Kappos, Andreas J., "Earthquake Resistant Concrete Structures", E & FN Spon.	1997
4.	"Rapid Visual Screening of Buildings for Potential Seismic Hazards", Federal Emergency Management Agency, Building Seismic Safety Council, Washington, D.C., FEMA 154/155.	2002
5.	"Evaluating the Seismic Resistance of Existing Building" ATC -14 project, Applied Technology Council, California.	2002
6.	"Seismic Evaluation of Existing Building" ASCE/SEI 31-03.	2003
7.	"Seismic Rehabilitation of Existing Buildings" ASCE & SEI.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: **EQ – 515** Course Title: **Mechanics of Deformable Media**
2. Contact Hours: L: 03 T: 01 P: 0
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 2 5 PRS 0 0 MTE 2 5 ETE 5 0 PRE 0 0
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the theories related to elasticity, plasticity and visco-elasticity and their applications to engineering problems.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Basic Theory: Concept of continuum, vector and tensor analysis.	7
2.	Elasticity: Generalized Hook's Law and Stress Strain Relationship for Isotropic Elastic Material, stress tensor and transformation, equilibrium condition; Compatibility, simple state of stress, strain displacement relation, strain tensors and its transformation, impartibility condition, constitutive relation, energy principles, problems of linear elasticity - basic equation, boundary value problems, solution of basic equation and equation of plane problems, St. Venant's Principle, Energy theorems.	10
3.	Plasticity: Plastic solid, loading and unloading conditions, isotropic stress theory, deformation theory, yield functions, work hardening and flow rules.	10
4.	Visco-elasticity: Visco-elastic material, stress strain relation, various models, creep and relaxation, compliance and modulus of mechanical models, Navier's equation.	5
5.	Visco-plasticity: Viscoplastic medium, Basic relation and equation of viscoplastic flow; Creeping plastic medium, Basic relation; Equations of creeping plastic flow.	5
6.	Fracture Mechanics: Stress and displacements fields in the vicinity of Cracks; Stable and unstable crack growth; Integral variational principle in Crack Theory; Basic characteristic of a cracked body.	5
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Fung, Y.C. "Fundamentals of Continuum Mechanics", Prentice Hall, Englewood Cliffs.	1965
2.	Spencer, A.J.M. "Continuum Mechanics", Longman Group.	1980
3.	Truesdell, C. "The Elements of Continuum Mechanics", Springer-Verlag, Berlin.	1985
4.	Karasudhi, P. "Fundamentals of Solid Mechanics", Kluwer Academic.	1991
5.	Khan A.S. and Huang S. "Continuum Theory of Plasticity", John Wiley & Sons.	1995
6.	Shames, I.H. and Cozzarelli, F.A., "Elastic and Inelastic Stress Analysis, Taylor and Francis.	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: EQ – 525

Course Title: Seismic Hazard Assessment

2. Contact Hours:

L: 03

T: 01

P: 2/2

3. Examination Duration (Hrs.): Theory

3

Practical

0

4. Relative Weightage: CWS

25

PRS

00

MTE

25

ETE

50

PRE

00

5. Credits: 4

6. Semester: Spring

7. Subject Area: PEC

8. Pre-requisite: Nil

9. Objective: This course is designed to provide the necessary conceptual and analytical background for seismic hazard assessment.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Seismic hazard and risk, definition of seismic hazard, types of magnitudes, MCE, DBE, SSE, OBE, MPE, site specific design earthquake parameters.	4
2.	Earthquake Catalogues: Existing important earthquake catalogues, historical and instrumental seismicity, magnitude homogenisation, regression methods, orthogonal regression analysis, declustering and completeness models, minimum magnitude of completeness.	5
3.	Ground Motion Prediction Equations: Strong motion attenuation relationships, dependent and independent parameters, PGA and spectral accelerations, elastic and inelastic response spectra, displacement spectra, periods of interest.	6
4.	Earthquake Recurrence Models: Statistical properties of an earthquake sequence, foreshocks and aftershocks, asperity and barrier models, size distribution of earthquakes, temporal and spatial distributions, Gutenberg-Richter relationship, migration of seismicity.	4
5.	Temporal Distribution of Earthquakes: Poissonian model, time dependent Poisson process, characteristic earthquake model, periodicity, conditional probabilities, Gamma distribution, Weibul distribution, Gaussian distribution, log normal distribution, Markov and semi-Markov models, Gumbel distributions and mixed Gumbel distribution; Time and slip predictable earthquake models; Use of ANN models.	10
6.	Seismic Hazard Assessment: Deterministic and probabilistic seismic hazard assessment, seismotectonic modelling; Line, point and volume sources, random seismicity method, seismotectonic province method, geological slip rate method, Zoneless seismic hazard estimation, spatial and size uncertainties, prediction of strong ground motion, mean annual rates of exceedance and their engineering aspects, uniform seismic hazard spectra, desegregation.	6

7.	Uncertainties and their Treatments: Aleatory and epistemic uncertainties, uncertainties at different stages of PSHA, quantification and classification of uncertainties, logic tree approaches, Monte Carlo simulations, COV maps.	7
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Reiter, L., "Earthquake Hazard Analysis: Issues and Insights", Columbia University Press.	1990
2.	Taylor, J.R. "An introduction to Error Analysis", 2 nd edition, University Science Books.	1997
3.	Chernick, M. R., "Bootstrap methods: A practitioner's guide, in Wiley Series in Probability and Statistics," W. A. Shewhart (Editor), John Wiley and Sons.	1999
4.	"Seismotectonic Atlas of India and its Environs," Geological Survey of India.	2000
5.	McGuire, R.K., "Seismic Hazard and Risk Analysis", Monograph MNO-10, Earthquake Engineering Research Institute.	2004
6.	Draper, N.R. and Smith, H., "Applied regression analysis", John Wiley & Sons (Asia).	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: EQ-546 Course Title: Instrumentation and Model Testing Techniques

2. Contact Hours: L: 3 T: 1 P: 0

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 00

5. Credits: 4

6. Semester: Spring

7. Subject Area: PEC

8. Pre-requisite: EQ-501 or equivalent

9. Objective: The course introduces basic principles and applications of seismic instrumentation and also imparts knowledge on model studies for experimental validation in dynamic environment.

10. Details of Course:

S. No.	Particulars	Contact Hours
1.	Introduction of Motion Measurement: Devices for relative motion measurement, requirements of ground motion measurement; Requirements for Instrumentation of structures.	2
2.	Seismic Sensors: Description of seismic sensors, Equation of motion, acceleration, velocity and displacement sensors, seismographs, strong motion accelerographs, SRRs; Characteristics and calibration of sensors, seismic instrumentation networks.	8
3.	Sampling and Recording: Conditioning of analog signal, sampling theorem, anti-aliasing filter, AD Conversion, parameters for configuration of data acquisition system, laboratory demonstration of a typical data acquisition system.	6
4.	Processing of Recorded Data: Causes and characteristics of noise, transducer correction in frequency domain and time domain; Basics of digital filters, examples of some typical low pass and high pass filters, Filter implementation in time domain and in frequency domain.	6
5.	Characteristics of Recorded Data Determination of response spectra, determination of Fourier spectra, shape of spectra and its relation with site condition, algorithms for development of spectrum compatible time history.	4
6.	Real Time Engineering Seismology: Development of shake maps using strong ground motion data, ground motion parameters for early warning systems, description and case studies of some existing early warning systems in different parts of world.	4
7.	Model Analysis: Similitude, true model, dead load effect, adequate model, distorted models, model material.	4
8.	Dynamic Model Testing: Details of shake tables, issues in design of structural models, model material and fabrication of models, simulation of shake table excitation, data acquisition, interpretation and prediction of response of prototype.	6

9.	Case Studies: Case studies of seismic testing of models of buildings and dams.	2
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Harry, G. Harris and Gajanan M. Sabnis, "Structural Modeling and Experimental Techniques", CRC Press.	1999
2.	Samuel, D. Stearns, "Digital Signal Processing with Examples in MATLAB", Prentice Hall.	2003
3.	Havskov, J., Gerardo Alguacil, "Instrumentation in Earthquake Seismology", Springer Verlag.	2004
4.	Agarwal, Pankaj and Shrikhande, Manish, "Earthquake Resistant Design of Structures", PHI Learning Pvt. Ltd, Eastern Economy Edition.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: **EQ – 548** Course Title: **Discrete Time Signal Processing**
2. Contact Hours: L: **03** T: **01** P: **0**
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 2 5 PRS 0 0 MTE 2 5 ETE 5 0 PRE 0 0
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: This course is designed to cover the elements of discrete time signal processing and the application of relevant techniques in processing earthquake records.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Signal Processing: Basic Theory and Introduction, types of signals; Properties of digital system (time invariance, causality, linearity).	4
2.	Data Analysis: Z - transform, sampling theorem, antialiasing filter, discrete Fourier Transform, Fast Fourier Transform; Inverse Transform.	6
3.	Digital Filters: Characterisation of digital filters (non recursive and recursive filters), properties of some commonly used analog filters for low pass, high pass and band pass operation.	8
4.	Realization of Filters: Transformation for realisation of digital filters from transfer functions of analog filters (matched Z-transform, bilinear transform etc.), some commonly used non recursive filter windows.	9
5.	Convolution: Convolution theorem, unit impulse response and transfer function, convolution in time domain and in frequency domain; Interpolation and decimation of digital data; Correlation and Power Spectrum Estimation; Application in processing of earthquake records.	8
6.	Processing and Applications: Interpolation and decimation, Correlation and power spectral estimation, processing procedure of earthquake ground motion data.	7
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Soisson, E.H., "Instrumentation in Industry". John Wiley & Sons.	1975
2.	Rabiner, L.R. and Gold B "Theory and Application of Digital Signal Processing". NJ: Prentice-Hall.	1975
3.	Lam H.Y.F , "Analog and Digital Filters-Design and Realization" , Prentice Hall.	1979
4.	Oppenheim, A.V. and Schafer, R.W, "Discrete Time Signal Processing". Prentice Hall.	1989
5.	Antoniou, A, "Digital Filters-Analysis, Design and Applications". McGraw-Hill Science/Engineering/Math.	2000
6.	Proakis, J.G. and Manolakis, D.G "Digital Signal Processing". Prentice Hall.	1996
7.	Steven W. Smith "The Scientist and Engineer's Guide to Digital Signal Processing California Technical Publishing.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: **EQ – 551** Course Title: **Random Vibrations**
2. Contact Hours: L: 03 T: 01 P: 0
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 2 5 PRS 0 0 MTE 2 5 ETE 5 0 PRE 0 0
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **EQ-501 or equivalent**
9. Objective: This course covers the basic principles of random variables and stochastic processes and applications to the response of systems subjected to random vibrations.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Basic Theory: Meaning and axiom of probability, events, random variables, discrete and continuous distribution, some examples; Functions of random variables, expectations, characteristic functions; Orthogonality principles, sequence of random variables.	10
2.	Stochastic Processes: Counting process, random walk, Markov chain, Gaussian process, filtered point process, Markov process and non-stationary Gaussian process; Stochastic continuity and differentiation, integral, time average, ergodicity; Correlation and power spectrum; Threshold crossing, peak, envelope distribution and first passage problem.	12
3.	Response of Linear Systems to Random Vibrations: Linear response of single and multiple-degree of freedom systems subjected to random inputs; Linear response of continuous systems.	10
4.	Response of Non linear Systems to Random Vibrations: Response of nonlinear systems to random inputs; Equivalent linearization and Gaussian closure technique.	10
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Nigam, N. C., "Introduction to Random Vibration", MIT Press.	1983
2.	Preumont Andre, "Random Vibration and Spectral Analysis", Kluwer Academic Publishers.	1994
3.	Lin, Y. K., "Probabilistic Structural Dynamics Advanced Theory and Applications", McGraw Hill.	1995
4.	Cho T. W. S., "Nonlinear Random Vibration", Taylor and Francis.	2000
5.	Lalanne, C., "Random Vibration", CRC Press.	2002
6.	Wirsching, P. H, Paez, T. L. and Ortiz, H., "Random Vibration", Dover Publications.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: EQ – 552 Course Title: Reliability Based Design
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 2 5 PRS 0 0 MTE 2 5 ETE 5 0 PRE 0 0
5. Credits: 4 6. Semester: Spring 7. Subject Area: PEC
8. Pre-requisite: Nil
9. Objective: To provide a framework for ascertaining safety margins associated with structural design procedures.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Nature of Structural Design and Safety: Evolution of design codes; Hazards, risks and economy of structural design.	2
2.	Uncertainty Modeling: Probability theory, random variables, probability distributions, moments, extreme value statistics, utility and descriptive statistics; Fuzzy set theory.	10
3.	Bayesian Decision Theory: A priori and posteriori probability; Bayes strategy and computation.	3
4.	Statistical Inference: Model estimation, hypothesis testing, confidence intervals and significance testing.	3
5.	Stochastic Models for Material Strengths: Classic strength models - ideal brittle material, ideal plastic material, fibre bundle; Fatigue - damage accumulation laws, cycle counting, damage statistics; Bogdanoff's cumulative damage model.	5
6.	Stochastic Models for Loads: Gust wind loads, wave loads, earthquake loads, traffic load and live load modeling; Stochastic theory of load combinations.	4
7.	Reliability Methods: Multiple safety factor formats; Characteristic values; Reliability index and system reliability; code calibrations.	15
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Ang , A.H., S. and Tang, W.H.. "Probability Concepts in Engineering Planning and Design", Vol. I & II., John Wiley & Sons.	1975
2.	Blockley , D.L. "The Nature of Structural Design and Safety", Ellis Horwood.	1980
3.	Augusti, G., Baratta, A. and Casciati, F., "Probabilistic Methods in Structural Engineering", Chapman & Hall.	1984
4.	Chernoff, H. and Moses, L.E., "Elementary Decision Theory", Dover Publications.	1986
5.	Elishakoff, I., "Probabilistic Theory of Structures", 2nd edition, Dover Publications.	1999
6.	Ditlevson, O. and Madsen, H.O., "Structural Reliability Methods, Department of Mechanical Engineering".	2002
7.	Madsen, H.O., Krenk, S. and N.C. "Lind. Methods of Structural Safety", Dover Publications.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: **EQ – 558** Course Title: **Advanced Structural Dynamics**
2. Contact Hours: L: **03** T: **01** P: **0**
3. Examination Duration (Hrs.): Theory **3** Practical **0**
4. Relative Weightage: CWS **2 5** PRS **0 0** MTE **2 5** ETE **5 0** PRE **0 0**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **EQ-501 Theory of vibration or equivalent**
9. Objective: The objective of the course is to impart advance structural dynamics in particular reference to earthquake problems.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Nonlinear Systems: Common types of nonlinearity, material and geometric nonlinearity, cubic stiffness, bilinear stiffness and damping, piecewise linear stiffness, nonlinear damping, coulomb friction, systems with finite deflection.	4
2.	Dynamics of Nonlinear Systems: Concept of nonlinear vibration; State space models, phase portraits, jump phenomenon, strange attractors and chaos parametric or self-excited oscillations; Approximate solution methods-perturbation techniques, equivalent linearization.	10
3.	Seismic Response of Nonlinear Systems: Inelastic earthquake analysis of multi-storey building frames, Pushover Analysis, Concepts of ductility and inelastic response spectrum, ductility in a multi-storey structure.	8
4.	Stability of Dynamic Systems: Concepts of stability of motion, Liapunov's criterion, Routh-Hurwitz criterion, Nyquist stability criterion; Stability of nonlinear and time varying systems.	10
5.	Inverse Problems in Vibrations: Review of linear algebra concepts; System identification as an inverse problem; Discrete time approach, linear discrete time models, model validity, system identification using neural networks; Continuous time approach, system identification using genetic algorithms; Updating finite element models using vibration records.	10
	Total number of lectures	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Dordrecht, The Netherlands, Friswell , "Finite Element Model Updating In Structural Dynamics", Kluwer Academic Publisher.	1995
2.	Japanese Society of Civil Engineers, Dynamic Analysis and Earthquake Resistant Design, Volume 2: Methods of dynamic Analysis, Oxford & IBH Publishing Company.	2000
3.	Graham, M.L. Gladwell, "Inverse Problems in Vibration", Springer Verlag.	2004
4.	Wei-Chau Xie, Dynamic Stability of Structures, Cambridge University Press.	2006
5.	T. K. Datta, Seismic Analysis of Structures, John Wiley & Sons (Asia).	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: EQ – 560 Course Title: Earthquake Resistant Design of Bridges and Concrete Dams
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 25 PRS 00 MTE 25 ETE 50 PRE 00
5. Credits: 4 6. Semester: Spring 7. Subject Area: PEC
8. Pre-requisite: EQ-501 or equivalent
9. Objective: This course provides an insight into earthquake resistant design of RC bridges and concrete gravity dams.
10. Details of Course:

S. No.	Contents	Contact Hours*
1.	Performance of RC Bridges in Past Earthquakes: Types of failures and lessons learnt; Terminology related to bridges.	3
2.	General Concept and Seismic Design Principles: Earthquake loading and analysis; Forced based design and displacement based design including the concept of performance based design.	4
3.	Conceptual Design of Bridges: Constraints, bent configuration; Superstructure pier connection, superstructure-abutment connection; Foundation systems.	4
4.	Mathematical Modelling of RC Bridges: Modelling of super structure, substructure and bearings; Modelling of foundations; Concept of non-linear modelling of bridge components.	4
5.	Seismic Analysis of RC Bridges: Seismic coefficient method of analysis; Response spectrum analysis, time history method, push-over analysis.	4
6.	Seismic Design Codes of RC Bridges: Seismic design provision based on Indian codes (IRC-6, IS 1893); Major international codes (ASTHO, CALTRANS, EURO, NZ and JSCE).	5
7.	Seismic Design of RC Bridges: Capacity based design of piers; Design and ductile detailing of piers; Joints, footings and pile caps; Movement design, unseating prevention systems, bearing; Design using isolation and energy dissipation devices.	7
8.	Seismic design of Gravity Dams: Performance of concrete gravity dam in past earthquakes; Types of loading and its consideration, issues in dam; Traditional methods of analysis; Consideration of dam-reservoir, dam- foundation, and dam-reservoir-foundation interaction effects; Modelling aspects of concrete gravity dam in seismic analysis including foundation and reservoir interaction aspects; Issues and modelling aspects in non-linear analysis.	11
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	"Earthquake Engineering for Concrete Dams: and Research Needs" National Academy Press.	1990
2.	Seible F., Calvi G.M "Seismic Design and Retrofit of Bridges", John Wiley and Sons.	1996
3.	"Design specifications of Highway Bridges", Part V. Seismic Design, PWRI.	1998
4.	Mark Yashinsky and Karshenas, M.J. "Fundamentals of Seismic Protection for Bridges", Earthquake Engineering Research Institute.	2003
5.	Allan Willians "Seismic Design of Building & Bridges", Oxford University Press.	2003
6.	Robin Fell, Patrick Macgregor, David Stapleton Graeme Bell, "Geotechnical Engineering of Dams" A.A. Balkeme Publishers.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: EQ – 562 Course Title: Dynamics of Plates, Shells and Arches
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 2 5 PRS 0 0 MTE 2 5 ETE 5 0 PRE 0 0
5. Credits: 4 6. Semester: Spring 7. Subject Area: PEC
8. Pre-requisite: Nil
9. Objective: The course provides knowledge on the theories and solution techniques, both classical and contemporary, to study the dynamic behaviour of plates, shells and arches.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Plates: Small deflection theory of thin plates, analysis of rectangular plates under static vertical loads; Navier and Levy solution for rectangular plates, free vibration of rectangular and circular plates, effects of transverse and rotatory inertia, finite difference method for rectangular plates, introduction to large deflection theory of thin plates, analysis of orthotropic, anisotropic and laminated plates.	10
2.	Shells: Membrane solution of shells of revolution under axisymmetric and nonsymmetric static loads; Analysis and design of shell roofs and vertical and lateral loads, beam theory and DKJ theory, free vibration of cylindrical shell roofs.	10
3.	Arches: Free vibration of curved members in their own plane, partial differential equation of motion for thin curved member, closed form expressions of natural frequencies and mode shapes for hinged and fixed circular arches, influence coefficient method, out of plane vibration of arches, earthquake effects on arches.	10
4.	Finite Element Simulation of Plates and Shells: Finite elements for plates, mindlin plate elements, discrete Kirchhoff element, shell elements, flat shell elements, axisymmetric shell elements, arch elements, straight and curved arch elements; Mindlin arch elements.	12
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Timoshenko, S.P. and Winowski-Krieger, S., "Theory Of Plates And Shells", McGraw-Hill.	1965
2.	Szilard, R., "Theory And Analysis of Plates", Prentice-Hall.	1974
3.	Ramaswamy, G.S., "Design Of Concrete Shell Roofs", Tata-McGraw Hill.	1978
4.	Calladine, C., "Theory of Shell Structures", Cambridge University Press.	1983
5.	Cook, R.D., Malkus, David S. and Plesha Michael E., "Concepts and Applications of Finite Element Analysis," Third Edition, John Wiley & Sons.	1989
6.	Ugural, A. C., "Stresses in Plates and Shells", 2nd ed., McGraw-Hill.	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: EQ – 566 Course Title: Structural Response Control for Seismic Protection
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 2 5 PRS 0 0 MTE 2 5 ETE 5 0 PRE 0 0
5. Credits: 0 4 6. Semester: Spring 7. Subject Area: PEC
8. Pre-requisite: EQ-501 or equivalent
9. Objective: To provide insight into the concepts and theories of devices used to control seismic response of structures for their seismic protection and to introduce techniques to simulate the seismic response of structures using control devices.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Structural Control: Historical development of structural control and base isolation, active control, passive control, hybrid control, semi active control; Application to new and existing buildings.	5
2.	Theory of Vibration Isolation: Principle of base isolation; Theory of vibration isolation; Components of base isolation; Advantages and limitations; General Design Criteria; Linear and Nonlinear procedures of isolation design; Application of theory to multiple degree of freedom system.	10
3.	Isolation Devices: Laminated rubber bearing, lead rubber bearing, high damping rubber bearing, PTFE sliding bearing, friction pendulum system and sleeved pile system; Modelling of isolation bearings; Design process for multi-layered elastomeric bearings and buckling behaviour of elastomeric bearings; Isolation system testing.	10
4.	Energy Dissipation Devices: General requirements; Implementation of energy dissipation devices; Metallic yield dampers, friction dampers, viscoelastic dampers, tuned mass dampers, tuned liquid dampers; Shape memory alloy dampers; Modelling, linear and nonlinear procedures; Detailed system requirements; Application to multistorey buildings; Testing of energy dissipation devices.	17
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Skinner, R., Robinson , W.H., Mc Verry, G. H., "An Introduction to Seismic Isolation", John Wiley and Sons.	1996
2.	Pristley, M.J.N., Seible, F., Calvi, G.M. "Seismic Design and Retrofit of Bridges", John Wiley and Sons.	1996
3.	James, M., Kelly, "Earthquake - Resistant Design with Rubber", Springer Verlag .	1997
4.	"Prestandard and Commentary for The Seismic Rehabilitation of Buildings," FEMA 356, Federal Emergency Management Agency.	2000
5.	Kelly, Trevor E. "Base Isolation of Structures – design Guidelines," Holmes Consulting Group.	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: **EQ – 590** Course Title: **Strong Motion Seismology**
2. Contact Hours: L: **03** T: **01** P: **0**
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 25 PRS 00 MTE 25 ETE 50 PRE 00
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: This course provides insight into the characteristics and parameters of strong ground motion (SGM), measurement of SGM, interpretation of accelerogram, strong motion attenuation relations and theoretical models for estimation of SGM.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Definitions, basic concepts and historical development in the field of Strong Motion Seismology (SMS); Characteristics of Strong Ground Motion (SGM); SGM parameters based on amplitude, frequency content and duration of shaking.	4
2.	Physics of the SGM Earthquake Source: Representation theorems; Source effect in the near-field and far-field; Aki's scaling law of seismic spectrum, Brune's model and finite source models.	5
3.	Measurement of SGM: Principle and theory of accelerometer, forced balanced accelerometer, seismoscope and structural response recorder; Construction and working of analog and digital accelerographs; Seismic alarm/circuit tripping and control devices.	5
4.	Processing and Interpretation of Accelerogram: Digitization of accelerogram, digitization errors and filtering to control these errors; transducer correction; Routine processing and double integration of accelerogram; Computation of frequency spectra and response spectra.	6
5.	Factors Affecting SGM: Asperity, Barrier and Stochastic ω -square models to explain the high frequency SGM; Effect of radiation pattern, fault type and directivity on SGM; Various type of scaling laws, differences in the scaling laws of interplate and intraplate earthquakes; Modification of SGM due to propagation path effects such as geometrical spreading, scattering and attenuation; Basin response and site effects including nonlinearity.	6
6.	Strong Motion Instrument Arrays: Principles of site selection for favorable array locations; Source mechanism and wave propagation arrays; Various types of local effects arrays to study site effects; Operation and maintenance of strong motion arrays; Indian strong motion program.	6

7.	Strong Motion Attenuation Models: General form of attenuation model relating specific SGM parameter to seismological parameters; Description of various earthquake source parameters (e.g., size, focal mechanism, stress drop) and strong motion parameters that enter into regression; Hanging wall and footwall effects; Various types of source to site distances; Different classifications of local site conditions, site classifications based on shear wave velocity (e.g., 30-meter velocity and effective velocity); Effect of site location and tectonic environment on SGM; Analysis and interpretation of random errors.	6
8.	Theoretical Models for Estimation of SGM: Stochastic models, synthetic Green's function and empirical Green's function models to predict SGM.	4
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Iwan, W.D, Proceedings of the International Workshop on Strong-Motion Earthquake Instrument Arrays held at Honolulu, Hawaii, May 2-5, 1978.	1978
2.	Hudson, D.E., "Reading and Interpreting Strong Motion Accelerogram," Earthquake Engineering Research Institute.	1979
3.	Aki, K. and Richard, P. G., "Quantitative Seismology, Theory and Methods", Vol. I and II, W. H. Freeman & Company.	1980
4.	Bolt, B. A., "Seismic Strong Motion Synthetics", Academic Press.	1987
5.	Kramer, S.L., "Geotechnical Earthquake Engineering", Prentice Hall.	1996
6.	Lee, W.H.K., Kanamori, H., Jennings, P.C., and Kisslinger, C. "International Handbook of Earthquake and Engineering Seismology," (Part B), Academic Press.	2003

Program: M.Tech. (Earthquake Engineering) (Soil Dynamics)

Year: I

Autumn Semester

Teaching Scheme					Contact Hours Per Week			Exam Duration		Relative Weightage				
S. No.	Sub. Code	Course Title	Sub. Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	MA-501E	Optimization Techniques	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	EQ -501	Theory of Vibration	PCC	4	3	1	2/2	3	-	15	15	30	40	-
3.	EQ-504	Finite Element Method	PCC	4	3	1	-	3	-	25	-	25	50	-
4.	EQ-521	Geotechnical Earthquake Engineering	PCC	4	3	1	-	3	-	25	-	25	50	-
5.		Open Elective - I	OEC	4/3	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (Optional)	IEC	2	1	0	2	2	-	15	15	30	40	-
Sub Total				19-22										

Spring Semester

Teaching Scheme					Contact Hours Per Week			Exam Duration		Relative Weightage				
S. No.	Sub. Code	Course Title	Sub. Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.		Programme Elective - I	PEC	4	-	-	-	-	-	-	-	-	-	-
2.		Programme Elective - II	PEC	4	-	-	-	-	-	-	-	-	-	-
3.		Programme Elective - III	PEC	4	-	-	-	-	-	-	-	-	-	-
4.		Programme Elective - IV	PEC	4	-	-	-	-	-	-	-	-	-	-
5.		Open Elective - II	OEC	4/3	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (Optional)	IEC	2	1	0	2	2	-	15	15	30	40	-
Sub Total				19-22										

Program: M.Tech. (Earthquake Engineering) (Soil Dynamics)

Year: II

Autumn Semester

Teaching Scheme					Contact Hours Per Week			Exam Duration		Relative Weightage				
S. No.	Sub. Code	Course Title	Sub. Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	EQ-601	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	EQ-602	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	EQ-603	Dissertation*	DIS	-	-	-	-	-	-	-	-	-	25	-
Sub Total				6										

***NOTE: To be continued and Grade to be awarded in the next semester.**

Spring Semester

Teaching Scheme					Contact Hours Per Week			Exam Duration		Relative Weightage				
S. No.	Sub. Code	Course Title	Sub. Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	EQ-603	Dissertation (Contd. From III Semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
Sub Total				20										
Total				64-68										

List of Programme Elective Courses (Soil Dynamics)

Teaching Scheme					Contact Hours Per Week			Exam Duration (Hrs.)		Relative Weightage (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1.	EQ-503	Engineering Seismology	PEC	4	3	1	2/2	3	0	15	15	30	40	0
2.	EQ-513	Numerical Methods For Dynamic Systems	PEC	4	3	1	0	3	0	25	0	25	50	0
3.	EQ-519	Dynamic Soil-Structure Interaction	PEC	4	3	1	0	3	0	25	0	25	50	0
4.	EQ-522	Seismic Microzonation	PEC	4	3	1	2/2	3	0	15	15	30	40	0
5.	EQ-524	Earthquake Resistant Design of Foundations	PEC	4	3	1	0	3	0	25	0	25	50	0
6.	EQ-533	Seismotectonics	PEC	4	3	1	0	3	0	25	0	25	50	0
7.	EQ-571	Ground Improvement Techniques	PEC	4	3	1	0	3	0	25	0	25	50	0
8.	EQ-572	Machine Foundation	PEC	4	3	1	2/2	3	0	15	15	30	40	0
9.	EQ-577	Constitutive Modelling in Soil Dynamics	PEC	4	3	1	0	3	0	25	0	25	50	0
10.	EQ-576	Seismic Slope Stability: Earth Dams & Retaining Walls	PEC	4	3	1	0	3	0	25	0	25	50	0
11.	EQ-584	Engineering Applications of Geophysical Techniques	PEC	4	3	1	0	3	0	25	0	25	50	0

**RESTRUCTURED PROGRAMME OF MASTER OF TECHNOLOGY
IN EARTHQUAKE ENGINEERING WITH SPECIALIZATION IN
SOIL DYNAMICS**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: **EQ – 501** Course Title: **Theory of Vibration**
2. Contact Hours: L: **03** T: **01** P: **2/2**
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 15 PRS 15 MTE 30 ETE 40 PRE 00
5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective: To provide the basic framework for studying time-dependent response of mechanical systems to external excitations.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Vibrations and the nature of time dependent phenomena, inertia, dynamic equilibrium and mathematical models of physical systems; Energy storing and dissipation mechanisms.	3
2.	Dynamics of Single Degree of Freedom Systems, undamped and damped, free and forced vibrations; Steady-state and transient response, impulse response.	10
3.	Harmonic response and applications to vibration isolation; theory of seismic pickups: Seismometers, accelerometers.	4
4.	Convolution integral and solution of equation of motion; Numerical methods for solution of linear and non-linear equations of motion; response/shock spectra; Fourier transforms and analysis in frequency domain.	6
5.	Dynamics of Multi-Degree of Freedom Systems, Lagrange's equations; equations of motion for MDOF systems; Algebraic eigenvalue problem and free vibration analysis; Undamped and damped normal modes; Mode superposition method for dynamic analysis of linear systems; Mode-truncation and correction for the missing mass.	12
6	Dynamics of Continuous Systems, Hamilton's principle; Axial and transverse vibrations of beams, torsional vibrations of shafts; Normal modes; Free and forced vibration analysis by mode superposition; Vibrations of elastic half-space.	4
7	Approximate Methods for Vibration Analysis, Rayleigh quotient, rayleigh-ritz method.	3
	Total	42

List of Experiments:

1. Vibration transducers and elementary data processing.
2. Free vibration characteristics of structural systems-natural frequency and damping ratio.
3. Harmonic forced vibration response of structural models and frequency response functions.
4. Dynamic vibration absorber.
5. Prototype testing and system identification.

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Warburton, G. B., "The Dynamic Behaviour of Structures", 2 nd edition, Pergamon Press.	1976
2.	Clough, R. W. and Penzien, J., "Dynamics of Structures", 2 nd edition, Mc-Graw Hill Book Company.	1993
3.	Humar, J. L., "Dynamics of Structures", 2 nd edition, Taylor & Francis.	2002
4.	Chopra, A. K., "Dynamics of Structures", 3 rd edition, PHI Learning.	2006
5.	Craig, R. R., Jr. and Kurdila, A., "Fundamentals of Structural Dynamics", 2 nd edition, John Wiley & Sons.	2006
6.	Villaverde, R., "Fundamental Concepts of Earthquake Engineering", Taylor & Francis.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: **EQ – 504** Course Title: **Finite Element Method**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0
4. Relative Weightage: CWS 25 PRS 00 M TE 25 ETE 50 PRE 00
5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: Nil
9. Objective: To provide a framework for developing computational models for solving engineering problems.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Mathematical Modeling: Differential equations; Boundary conditions; Method of weighted residuals; Variational principles and approximate solutions; Convergence of approximate solutions; Concept of finite element method as extension of method of weighted residuals to piecewise continuous approximation; Rules of domain discretization; Discretization errors.	5
2.	Finite Elements of One Dimension: Continuity requirement; Truss/rod/shaft, beam bending; Locking in shear deformable beam elements and solution; Modeling of framed structures; Skewed boundary conditions; constraint equations; Rules for monotonic convergence of the finite element solution.	7
3.	Finite Elements of Two/Three Dimensions: Equations of 3-D elasticity; Plane stress, plane strain and axi-symmetric idealizations; Triangular and rectangular elements; Interpolation functions; Degree of complete polynomial; Pascal's triangle; Evaluation of domain and surface integrals; Tetrahedral and brick elements; Incompatible modes; Patch test.	10
4.	Mapped Elements: Parametric distortions and finite elements; Numerical integration; Full reduced and selective integration; Constraint counting techniques; Modeling of unbounded domains.	10
5.	Plates and Shells: Finite elements for plates and shells; Shear and membrane locking and solution; Semi-analytical procedure for axi-symmetric shells.	4
6.	Time Dimension: Consistent mass matrix; Lumping procedures; Algebraic eigenvalue problem; Time-marching schemes; Adequacy of the finite element mesh.	3
7.	Error Analysis: Posteriori error estimation procedures; Adaptive finite element analysis – h , p and r adaptivity; Super-convergent patch recovery.	3
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Zienkiewicz, O.C. and Morgan, K. "Finite Elements and Approximation", John Wiley & Sons.	1983
2.	Reddy, J.N. "Finite Element Method", 2 nd edition, McGraw-Hill Book Company.	1993
3.	Bathe, K. J., "Finite Element Procedures", 2 nd edition, PHI Learning.	1994
4.	Dow, J.O., "A Unified Approach to the Finite Element Method and Error Analysis Procedures", Elsevier Publications.	1999
5.	Cook, R.D., Malkus, D., Plesha, M. and Witt, J. "Concepts and Applications of Finite Element Method", 4 th edition, John Wiley & Sons.	2004
6.	Akin, J.E. "Finite Element Analysis with Error Estimators", Elsevier Publications.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: **EQ – 521** Course Title: **Geotechnical Earthquake Engineering**
2. Contact Hours: L: **03** T: **01** P: **00**
3. Examination Duration (Hrs.): Theory **3** Practical **0**
4. Relative Weightage: CWS **25** PRS **00** MTE **25** ETE **00** PRE **00**
5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective: To provide fundamental knowledge of soil-dynamics and seismic behavior of soils.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Background and lessons learnt from damages in past earthquakes.	1
2.	Wave Propagation: Waves in semi-infinite media – one, two and three dimensional wave propagation; Attenuation of stress waves – material and radiation damping; Dispersion, waves in a layered medium.	2
3.	Dynamic Soil Properties: Stress & strain conditions, concept of stress path; Measurement of seismic response of soil at low and high strain, using laboratory tests; Cyclic triaxial, cyclic direct simple shear, resonant column, shaking table, centrifuge and using field tests - standard penetration test, plate load test, block vibration test, SASW/MASW tests, cross bore hole; Evaluation of damping and elastic coefficients; Stress-strain behavior of cyclically loaded soils; Effect of strain level on the dynamic soil properties; Equivalent linear and cyclic nonlinear models; Static and dynamic characteristics of soils.	10
4.	Ground Response Analysis: Introduction, one, two and three dimensional analyses; Equivalent and nonlinear finite element approaches; Introduction to soil-structure interaction.	4
5.	Liquefaction: Introduction, pore pressure, liquefaction related phenomena – flow liquefaction and cyclic mobility, factors affecting liquefaction, liquefaction of cohesionless soils and sensitive clays, liquefaction susceptibility; State Criteria –CVR line, SSL, FLS; Evaluation of liquefaction potential: characterization of earthquake loading and liquefaction resistance, cyclic stress ratio, Seed and Idriss method; Effects of liquefaction.	10
6.	Earth Pressure: Active and passive earth pressures; Terzaghi's passive wedge theory, numerical methods, earth pressure measurements.; Seismic design of retaining walls: types, modes of failures, static pressure, seismic response (including M-O Method), seismic displacement, design considerations.	6

7.	Seismic Slope Stability: Types of earthquake induced landslides; Evaluation of slope stability – stability analysis with dynamic loading, friction circle method, effective and total stress methods of analysis, factor of safety, yield acceleration, damage potential, displacement analysis, effect of saturated and submerged conditions, FEM analysis of slope stability.	4
8.	Ground Improvement Techniques: Densification, reinforcement, and grouting and mixing, drainage; Reinforced earth: application of reinforced earth under static and dynamic loads, determination of properties of reinforcements, composite materials, reinforced earth drains and other applications.	5
	Total	42

11. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Prakash, S., "Soil Dynamics", McGraw Hill Book Company.	1981
2.	Ranjan, G. and Rao A.S.R., "Basic and Applied Soil Mechanics", New Age Int. Ltd.	2000
3.	Kameshwara, Rao, N.S.V, "Dynamic Soil Tests & Applications", Wheeler Publications.	2000
4.	Day Robert, W., "Geotechnical Earthquake Engineering Handbook", McGraw-Hill.	2001
5.	Kramer, S.L., "Geotechnical-Earthquake Engineering", Pearson Education – Indian Low Price Edition.	2004
6.	Saran, S. "Soil Dynamics & Machine Foundation", Galgotia Publication.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: EQ – 503

Course Title: Engineering Seismology

2. Contact Hours: L: 03 T: 01 P: 2/2

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 15 PRS 15 MTE 30 ETE 40 PRE 00

5. Credits: 4 6. Semester: Spring 7. Subject Area: PEC

8. Pre-requisite: Nil

9. Objective: To introduce the relevant principles and prevalent practices in Engineering Seismology from Earthquake Engineering viewpoint.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Scope of seismology; Definitions of important terms; Causes of earthquakes and their classifications; Earthquake effects on ground and structures.	4
2.	Plate Tectonics and Seismicity: Plate tectonics- continental drift, types and characteristics of various plate margins; Earthquake catalogue and seismicity of the earth; Major earthquakes in the world; Important Indian earthquakes.	6
3.	Wave Propagation and Internal Structure of Earth: Theory of elasticity; Wave equation; Body and surface waves; Laws of reflection, refraction, attenuation, diffraction and dispersion; Local site effects; Seismic phases; Ray parameter; Travel time curves; Internal structure of earth; Reference models.	8
4.	Earthquake Size: Earthquake intensity scales and isoseismal map; Earthquake magnitude scales, energy, acceleration, frequency magnitude relations and return period.	4
5.	Instrumentation: Earthquake recordings – principles and theory of seismograph; Various kinds of seismographs; Analog and digital recording, WWSSN, GDSM; Real time warning system; International monitoring system (IMS); Local seismological networks, strong motion networks and their engineering importance.	6
6.	Data Processing and Analysis: Processing, analysis and interpretation of seismograms; Estimation of earthquake parameters, source parameters and fault plane solutions.	4
7.	Seismic Hazard Assessment: Definitions- seismic hazard, disaster and risk; Probabilistic and deterministic approach; Earthquake occurrence models; Seismotectonic modeling and type of sources; Estimation of maximum magnitude, maximum credible earthquake, design basis earthquake; Frequency magnitude relationship; Poissonian and Non Poissonian models; Ground motion prediction equations; Uncertainties in seismic hazard assessment and their quantification; Return periods and strong motion exceedance rates; Site-specific design earthquake parameters; Case studies.	10
Total		42

List of Experiments:

1. Installation and operation of seismograph to record ground motion.
2. Calibration of seismograph to compute its response.
3. Background noise survey for selection of site.
4. Interpretation of seismograms and estimation of source parameters.

11. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Bullen, K.E. and Bolt, B.A., "An introduction to the Theory of Seismology", Fourth Edition, Cambridge University Press, Cambridge.	1985
2.	Kulhanek, O., "Anatomy of Seismograms", Elsevier Science Publication.	1990
3.	Lay Thorne and Wallance Terry C., "Modern global seismology", Academic press.	1995
4.	William Lowrie, "Fundamentals of Geophysics", Cambridge, Univ. Press.	1997
5.	Kramer, S.L., "Geotechnical Earthquake Engineering", Second Indian reprint, Pearson Education.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: EQ – 513 Course Title: Numerical Methods for Dynamic Systems
2. Contact Hours: L: 03 T: 01 P: 0
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 25 PRS 00 MTE 25 ETE 50 PRE 00
5. Credits: 4 6. Semester: Spring 7. Subject Area: PEC
8. Pre-requisite: Nil
9. Objective: The course provides the conceptual basis of analysis of dynamic systems with emphasis on computer implementation.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Elementary concepts of vector spaces, subspaces; Column and row space of a matrix; Range, null space, and rank of a matrix, ortho-normal bases, vector and matrix norms, testing for convergence, errors in floating point arithmetic.	6
2.	Computer implementation of matrix and vector operations, operation counting, structures of matrices and their storage, block algorithms, vector processing and parallel processing.	6
3.	Computational aspects of elimination and in-situ factorisation methods for solution of large system of equations for dynamic problems; Implementation details for band and/or skyline solvers.	9
4.	Problems associated with choice and implementation of solution techniques; Eigen solution of large problems arising in dynamic systems.	9
5.	Application of Interpolation and extrapolation, numerical differentiation and quadrature methods	4
6.	Response evaluation by the Integration of ordinary differential equations with emphasis on accuracy and stability considerations, integration of stiff ordinary differential equations, concepts of A -stability and stiff-stability.	8
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Pariett, B. N., "The Symmetric Eigenvalue Problem" Prentice-Hall.	1980
2.	George, A. and Liu J.W.H., "Computer Solution of Large Sparse Positive Definite Systems", Prentice Hall.	1981
3.	Hager, W. W., "Applied Numerical Linear Algebra", Prentice-Hall.	1988
4.	W. H., Teukolsky S. A., Vetterling W.T. and Flannery B.P., "Numerical Recipes – The Art of Scientific Computing," Second Edition, Cambridge University Press.	1992
5.	Clough, R. W. and Penzien J., "Dynamics of Structures," Second Edition, McGraw-Hill.	1993
6.	Golub, G. H. and Van Loan C.F., "Matrix Computations," Third Edition, The Johns Hopkins University Press.	1996
7.	Bathe, K.J., "Finite Element Procedures", Prentice Hall.	1996
8.	Hughes, T.J. R., "The Finite Element Method - Linear Static and Dynamic Finite Element Analysis," Dover Publications.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: **EQ – 519** Course Title: **Dynamic Soil-Structure Interaction**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 25 PRS 00 MTE 25 ETE 50 PRE 00
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **NIL**
9. Objective: To provide basic background on dynamic soil-structure interaction.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Objectives and practical significance and importance of soil-structure interaction (SSI); Fixed base structure, structures on soft ground; Modeling of unbounded media.	2
2.	Fundamentals of Soil-Structure Interaction: Direct and substructure methods of analysis; Equation of motion for flexible and rigid base; Kinematic interaction, inertial interaction and effect of embedment.	4
3.	Modeling of Structure: Temporal and spatial variation of external loads (including seismic loads); Continuous models, discrete models (lumped mass) and finite element models.	2
4.	Wave Propagation for SSI: Waves in semi-infinite medium – one, two and three-dimensional wave propagation; Dynamic stiffness matrix for out-of-plane and in-plane motion.	4
5.	Free-Field Response of Site: Control point and control motion for seismic analysis; Dispersion and attenuation of waves; Half-space, single layer on half-space; Parametric studies.	4
6.	Modeling of Boundaries: Elementary, local, consistent and transmitting boundaries.	4
7.	Modeling of Soil: Green's influence functions, boundary-element method, finite element model; Dynamic stiffness coefficients for different types of foundations – surface foundation, embedded foundation, shallow (strip) foundation and deep (piles) foundations.	4
8.	Soil Structure Interaction in Time Domain: Direct method; Substructure method (using dynamic stiffness and Green's functions of soil); Hybrid frequency-time domain approach.	6
9.	Nonlinear Analysis: Material nonlinearity of soil (including plasticity and strain hardening), geometrical nonlinearity (slip and separation of foundation with soil); Nonlinear structure with linear soil considering both soil and structure nonlinearity.	4

10-	Engineering Applications of Dynamic Soil-Structure Interaction: Low-rise residential buildings, multistory buildings, bridges, dams, nuclear power plants, offshore structures, soil-pile-structure interactions.	8
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1	Wolf, J. P., "Dynamic Soil-Structure Interaction", Prentice-Hall.	1985
2.	Cakmak, A.S. – Editor, "Soil-Structure Interaction", Developments in Geotechnical Engineering 43, Elsevier and Computational Mechanics Publications.	1987
3.	Wolf, J.P., "Soil-Structure Interaction in the Time-Domain", Prentice-Hall.	1988
4.	Wolf, J.P. and Song C. "Finite Element Modelling of Unbounded Media", John Wiley & Sons.	1996
5.	Kramer, S.L., "Geotechnical-Earthquake Engineering", Pearson Education.	1996
6.	Hall, W.S. and Oliveto G., "Boundary Element Method for Soil-Structure Interaction", Kluwer Academic Publishers.	2003
7.	Chen, Wai-Fah and Duan Lian, "Bridge Engineering (Seismic Design)", CRC Press.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: **EQ – 522** Course Title: **Seismic Microzonation**
2. Contact Hours: L: 03 T: 01 P: 2/2
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 15 PRS 15 MTE 30 ETE 40 PRE 00
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To deal with all aspects of seismic microzonation, including basic principles and prevailing practices, surveys and techniques.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Seismic microzonation and its objectives, historical developments; Seismic microzonation exploration, investigation and data interpretation.	4
2.	Use of GIS and GPS in Microzonation: Type of surveys, map scales; GIS-components, vector and raster data; GIS-techniques, methodology software; Use of GIS in microzonation; GPS, mapping using GPS & GIS.	7
3.	Seismic Waves and Local Site Effects: Body and surface waves; Factors affecting ground motion characteristics; Local site effects basic physical concept, impedance contrast, resonance, basement topography, attenuation, trapping; Basin-edge, topography, ridge, valley, slope; Lateral discontinuity.	7
4.	Geophysical Methods for Determination of Soil Properties: Seismic methods; Well logging; Steady state Rayleigh method; Spectral analysis of surface waves-SASW and MASW methods; Ground penetrating radar, bedrock profiling.	7
5.	Quantification of Site Effects: Experimental methods; Microearthquake-standard spectral ratio method & horizontal to vertical spectral ratio method; Microtremors -absolute spectra, SSR method & H/V ratio; Empirical relations; Analytical method; 1D ground response of layered medium	6
6.	Site-specific Ground Motion Estimation: Empirical Green's function; Numerical methods; Basic concept, recent developments; Domain method, boundary method & hybrid method; Effects of nonlinearity on ground motion.	4
7.	Seismic Microzonation: PSHA and DSHA; Seismic microzonation of mega cities, scales used in seismic microzonation; Recent developments and case studies.	5
8.	Computer Programs: Computer programs to estimate seismic ground motion knowing the seismic response at given point using linear and non-linear properties of layered medium; Seismic hazard assessment; H/V ratio method.	2
	Total	42

List of Experiments:

1. Locating sites using GPS survey.
2. Preparation of various types of maps using GIS technique.
3. Determination of S-wave velocity and thickness of soil layers using MASW method.
4. Bed rock and soil amplification determination using H/V ratio method.

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Dobrin, M.B. and Savit, C.H., "Introduction to Geophysical Prospecting", Fourth Edition, McGraw Hill Book Company.	1988
2.	Leon Reiter, "Earthquake Hazard Analysis", Columbia University Press".	1990
3.	Antoni Roca and Carlos Oliveria, "Earthquake Microzoning" , Birkhauser Verlag.	2002
4.	Konency, G., "Geoinformation, Remote Sensing, Photogrammetry and Geographic Information System", Taylor and Francis.	2003
5.	Kramer, S.L., "Geotechnical Earthquake Engineering", Second Indian reprint, Pearson Education.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: **EQ – 524** Course Title: **Earthquake Resistant Design of Foundations**
2. Contact Hours: L: **03** T: **01** P: **0**
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 25 PRS 00 MTE 25 ETE 50 PRE 00
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: The course covers various types of soil investigations, soil parameters, foundations, and codes of practice and design considerations for seismic resistant design of foundations.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: General requirements, types of shallow and deep foundations and their use; Performance of various types of foundations during past earthquakes.	3
2.	Design Seismic Data: Design seismic coefficients for various foundation soil systems, provisions of IS code and their limitations; Influence of local geology, depth & properties of soil cover on seismic coefficient and response spectra; Ground response magnification by wave propagation, predominant period of ground vibrations, approximate check for occurrence of resonance of structure foundation system, factors to be considered in foundation design.	6
3.	Shallow Foundations: IS code for foundation design, allowable differential & total settlements, allowable bearing pressures, increase in permissible stress under earthquake type of loading; Transient loads, examples of transient loads, methods of analysis, experimental investigations, critical review of the state of art; Combined footings, raft foundation, modulus of subgrade reaction, Winkler model, beam on elastic foundation, soil line method.	10
4.	Pile Foundations: Bearing capacity of piles, dynamic pile formulae, group action, influence of pile cap; Laterally loaded piles, elastic analysis; Reese and Matlock approach, fixity of pile heads, dimensionless factors; Pile with dynamic loads, soil-pile analysis with spring-mass & FEM idealisation, slip elements, IS code of practice for design of pile foundations.	10
5.	Well Foundations & Caissons: Types; casting, floating and sinking of caissons; Well sinking scour depth, depth & bearing capacity of wells, static forces considered in stability of wells; Pseudo-static analysis with earthquake induced loads, displacement dependent earth pressures for wells; Lateral load resistance of well foundation; IRC, IS and Indian Railway Codes, their limitations; Dynamic analysis of wells, discretisation of soil-well, scour around wells in analysis.	7

6.	Bearing Capacity under Transient & Earthquake Type Loads: Types of dynamic loads; Footing requirements to account for settlements and earthquake induced forces; Pseudo-Static analysis of footings with eccentric & inclined loads; Foundations of framed structures with isolated footings; Moments on connecting beams & columns due to differential settlements.	6
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Prakash, S., "Soil Dynamics", McGraw Hill Book Company.	1981
2.	Bowles, J.E., "Foundation Analysis and Design", McGraw Hill International Editions.	1997
3.	Ranjan, G. and Rao, A.S.R., "Basic and Applied Soil Mechanics", New Age Int.	2004
4.	Kramer, S.L., "Geotechnical Earthquake Engineering", Second Indian reprint, Pearson Education.	2004
5.	Kuriyan, N.P., "Design of Foundations System: Principles and Practice", Narosa Publishing House.	2005
6.	Saran, S., "Soil Dynamics & Machine Foundation", Galgotia Publication.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: EQ – 533 Course Title: Seismotectonics
2. Contact Hours: L: 03 T: 01 P: 0
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 25 PRS 00 MTE 25 ETE 50 PRE 00
5. Credits: 4 6. Semester: Both 7. Subject Area: PEC
8. Pre-requisite: Nil
9. Objective: This course provides knowledge regarding the relationship between occurrence of earthquakes and tectonic processes, characteristics of seismic sources and assessing their seismic potential.
10. Details of Course:

S. No.	Contents	Contact Ho
1.	Introduction: Definition, geological and seismological data required to study seismotectonics; An overview of seismicity and tectonics of the earth's crust and upper mantle.	03
2.	Seismotectonics of Plate Boundaries: Seismotectonics of divergent, transform and convergent plate boundaries.	06
3.	Seismotectonics and Mountain Building Processes: Seismicity and mountain building; Seismotectonic models of the Himalaya; Seismicity and tectonics of Tibetan plateau and surrounding region.	06
4.	Seismotectonic Sources: Geological, geophysical and other criteria used to identify faults; Definition of active fault and capable fault; Geological and seismological attributes of active fault; Characteristics of seismotectonic structures and seismotectonic provinces; Importance of stress data for the demarcation of seismotectonic provinces.	08
5.	Characteristics and Delineation of Seismic Sources for Seismic Hazard Analysis: Geological and seismological criteria used for source identification and source geometry; Buried or Blind sources; Modeling of fault segments in hazard analysis.	05
6.	Maximum Earthquake: Different types of maximum earthquakes; The physical basis for maximum earthquake; Concept of characteristic earthquake; Different methods (e.g., methods based on dimension of fault rupture and historic seismicity) to estimate maximum earthquake.	06
7.	Estimation of Earthquake Recurrence Rate: Different types of recurrence models (e.g., exponential recurrence model and characteristic earthquake model); Methods to treat earthquake catalogues. Importance of paleoseismology for estimating the recurrence rate of large earthquakes; Computation of fault slip-rate.	04

8.	Seismotectonics of Indian Subcontinent: Seismotectonic source zones of Peninsular India and Himalayan region; Different types of seismic zoning maps (e.g., deterministic and probabilistic maps) of Indian subcontinent and their engineering significance.	04
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Repr
1.	Reiter, Leon, "Earthquake Hazard Analysis: Issues and Insights", Columbia University Press.	1990
2.	Coppersmith, Kevin J., "Seismic Source Characterization for Engineering Seismic Hazard Analysis," Proceedings of forth ICSZ, Stanford, California, PP 3-60.	1991
3.	Thorne and Wallace, T.C., "Modern Global Seismology," Lay, Academic Press.	1995
4.	Stein, Seth and Wysession, M., "An Introduction to Seismology, Earthquake, and Earth Structure," Blackwell Publishing.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: **EQ – 571** Course Title: **Ground Improvement Techniques**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 25 PRS 00 MTE 25 ETE 50 PRE 00
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: Nil
9. Objective: The course describes various ground improvement techniques to mitigate the effects of earthquakes.
10. Details of Course:

S. No.	Contents	Contact Hou
1.	Introduction: Objective, history and development; Classifications of techniques; Advantage and limitations of various techniques.	2
2.	Densification using Vibration Techniques: Vibro Compaction:- blasting, vibratory probe, vibratory compactors; Vibro-displacement compaction:- displacement piles, vibro flotation, sand compaction piles, stone columns, heavy tamping.	8
3.	Geosynthetics: Types, Geotextiles, Geomembranes, Geonets, Geocomposites; Manufacturing, Functions and Applications; Modeling for Dynamic analysis.	6
4.	Reinforcement Techniques: Reinforced earth; engineering applications, strength characteristics; Improvement in bearing capacity and settlement characteristic; Randomly distributed fiber reinforced soil: strength characteristics, improvement in bearing capacity and reduction in settlement; Soil nailing; Analysis and design of steep open cuts.	12
5.	Drainage Methods: Introduction, Ground water and seepage control, methods of dewatering system including design steps, various types of drains with their design.	6
6.	Precompression: Introduction, compressibility of soils & consolidation, preloading and surcharge fills, monitoring of compression, dynamic consolidation, consolidation by electro-osmosis	4
7.	Grouting and Injection: Introduction; Aspects of grouting; Grouting procedure; Applications.	4
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Rao, G.V. and Raju, G.V.S.S., "Engineering with Geosynthetics", Tata McGraw-Hill Publishing Company.	1990
2.	Koerner, R.M., "Designing with Geosynthetics", Prentice-Hall.	1990
3.	Shukla, S.K., "Geosynthetics and their Applications", Thomas Telford.	2002
4.	Kramer, S.L, "Geotechnical-Earthquake Engineering", Pearson Education – Indian Low Price Edition.	2004
5.	Purushothama, R.P., "Ground Improvement Techniques", Laxmi Publications.	2005
6.	Saran, S., "Reinforced Soil and its Engineering Applications", IK International.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: **EQ – 572** Course Title: **Machine Foundation**
2. Contact Hours: L: 03 T: 01 P: 2/2
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 15 PRS 15 MTE 30 ETE 40 PRE 00
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: The course provides an insight into different types of machine foundations and their design to withstand for various types of loads in accordance with the prevalent codes of practice.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Various types of machine foundations; Permissible amplitudes of vibrations, factors affecting the resonant frequency and amplitudes of vibrations; Estimation of damping and plastic coefficients.	4
2.	Foundations under Reciprocating Machine: Resonant frequency of the block foundations; Weightless spring and weighted spring method, elastic half space method, miscellaneous methods; Behaviour and design of block foundations, permissible amplitudes.	12
3.	Hammer Foundations: Hammer foundations, classification, natural frequencies and amplitudes of foundation vibrations; Design principles, permissible amplitudes.	6
4.	Framed Foundations: Framed foundations, their advantage for high-speed machines; Permissible amplitudes, design principles.	6
5.	Vibration Isolation and Screening: Methods of decreasing vibrations on existing foundations; Isolation of vibrations; Screening of vibrations.	5
6.	IS Code of Practice: Critical review of IS code provisions for design of machine foundations.	4
7.	Structural Design: General principles of design; Construction aspects; Case studies on failures of machine foundations.	5
Total		42

List of Experiments:

1. Horizontal and Vertical Block Vibration Tests for determination of c_u and c_v .
2. Shear Velocity Profile using Cross-Bore Test.
3. Liquefaction Resistance of Soil using Cyclic Triaxial Test Apparatus.
4. Wave Propagation Tests for Dynamic Soil Properties.

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Barkan, D.D., "Dynamics of Bases and Foundation", McGraw Hill Book Company.	1962
2.	Richart, F.E., Jr., Hall, J.R., Jr. and Woods, R.D., "Vibrations of Soils and Foundations", Prentice Hall.	1962
3.	Srinivasu, P. and Vaidyanathan, C. V., "Hand Book of Machine Foundations", Tata McGraw Hill.	1976
4.	Prakash S., "Soil Dynamics", McGraw Hill Book Company.	1981
5.	Saran S., "Soil Dynamics & Machine Foundation", Galgotia Publication.	2006
6.	Bhatia K.G., "Foundation for Industrial Machines – A Handbook for Practicing Engineers", D-CAD Publishers.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: **EQ – 576** Course Title: **Seismic Slope Stability: Earth Dams and Retaining Walls**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 25 PRS 00 MTE 25 ETE 50 PRE 00
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: Nil
9. Objective: It deals with the issues pertaining to earth dams and retaining walls and their analysis using classical and contemporary approaches.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to Earth Dams: Performance of earth and rockfill dams in past earthquakes; Homogenous and non-homogenous dams, general features, zoned dams, influence of inclined and vertical core; Dams with upstream impervious linings, composite dams, slope protection measures; Seepage in earth and rockfill dams, estimation of pore pressure by flow net, standard analytical solutions for seepage problems, piping and liquefaction, foundation problems.	6
2.	Stability Analysis of Earth Dams: Effective and total stress methods of analysis; Analysis by Fellinius, Spencer and Bishop methods; Pseudo-static analysis by Friction-circle, Fellinius and Bishop's methods, factor of safety, yield accelerations and damage potential under saturated and submerged conditions; Displacement analysis by Newmark and Makdisi-Seed methods.	9
3.	FEM for Earth Dams: Application of FEM, dam-foundation interaction; Identification of zones of hydraulic fractures and cracks; Nonlinear analysis, tangent stiffness, secant stiffness methods and no-tension analysis.	7
4.	Earth Pressures Under Static and Dynamic Conditions: History; State of stress in semi-infinite medium with level/sloping surface; Rankine and Coulomb's theories; Critical wall friction, its choice and design curves for its determination; Method of slices to obtain earth pressures; Terzaghi's general wedge theory for passive pressure; Velocity field method; Method of characteristics.	4
5.	Mononobe-Okabe theory; Rehban's and Culman's methods and their extension to dynamic case; Dimensionless earth pressure factors; Structural surcharges; Pressures induced by soil compaction.	2
6.	Displacement Analysis of Soil-Wall System: Displacement dependent earth pressures and failure of walls; Types of movements and shape of failure surfaces; Arching action its influence on earth pressures; Consideration of movement of structures in static/dynamic pressures; Factor of safety.	6

7.	Design of Retaining Walls: Types of walls; Earth pressures for gravity/counterfort walls; Structural design of wall and its foundation; Stability of wall-soil system; Slip circle analysis; Anchored retaining structures.	5
8.	Computer Applications: Software to evaluate static/dynamic earth pressures; Pressure distribution, stability of retaining structures and critical wall friction.	3
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Prakash, S., "Soil Dynamics", McGraw Hill Book Company.	1981
2.	Duncan, J.M., "State-of-the-art: static stability and deformation analysis," in R.B. Seed and R.W. Boulanger, Eds., Proc. Specialty Conf. on Stability and Performance of Slopes & Embankments, II, ASCE, Vol. I, pp. 222-266.	1992
3.	Bharat Singh & R.S. Varshney, "Embankment Dam Engineering", Nem Chand & Brothers.	2004
4.	Kramer, S.L., "Geotechnical-Earthquake Engineering", Pearson Education – Indian Low Price Edition.	2004
5.	Saran, S., "Soil Dynamics & Machine Foundation", Galgotia Publication.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: **EQ – 577** Course Title: **Constitutive Modelling in Soil Dynamics**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 25 PRS 00 MTE 25 ETE 50 PRE 00
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: The objective of the course is to appraise the governing constitutive laws and applicable models for soil as a medium.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Stress-Strain Laws of Soils: Stress and strain invariants, linear and bilinear elastic laws; K-G model, nonlinear elastic models (hyperbolic models), elasto-plastic and elasto-viscoplastic models; Basic concepts of plasticity, yield function, flow rules-dilatancy, strain hardening and softening laws.	9
2.	Mohr-Coulomb and Tresca Models: Yield functions, derivation of constitutive matrix; Formulation suitable for finite element analysis.	5
3.	Critical State Models: Yield function, hardening law, soil parameters; Drucker-Prager Model, HISS models and their performance.	6
4.	Bounding Surface Models: Multi-surface model, Dafalias two surface model; Kinematic hardening laws, soil parameters.	5
5.	Basic Formulation of Soil in Finite Element Analysis: Static and quasi static problems; Drained, undrained analysis and their discretisation in finite element procedure; Consolidation transient and its discretisation statement; Drained and undrained dynamic analysis.	8
6.	Two Phase Formulation: Two phase formulation of saturated soil; Finite element discretisation of saturated soil; Transient response of saturated soil, consolidation, liquefaction.	9
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Chen, W.F., Baladi G.Y., "Soil Plasticity: Theory and Implementation", Elsevier.	1985
2.	Wolf, J.P., "Soil-Structure Interaction in the Time Domain", Prentice Hall.	1988
3.	Kolymbs, D., "Constitutive Modelling of Granular Materials", Springer.	2000
4.	Desai, C. S., "Mechanics of materials and interfaces: the disturbed state concept", CRC Press.	2001
5.	Kramer, S.L., "Geotechnical-Earthquake Engineering", Pearson Education – Indian Low Price Edition.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER:

Department of Earthquake Engineering

1. Subject Code: **EQ – 584** Course Title: **Engineering Applications of Geophysical Techniques**
2. Contact Hours: L: **03** T: **01** P: **0**
3. Examination Duration (Hrs.): Theory **3** Practical **0**
4. Relative Weightage: CWS **25** PRS **00** MTE **25** ETE **50** PRE **00**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge on various geophysical techniques for engineering applications related to site investigations.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Basic concepts and objectives of geophysical techniques-gravity, magnetic, electrical and well logging; need of Geophysics in Earthquake Engineering.	5
2.	Seismic method: Seismic refraction method, time-distance relations for horizontal layers, dipping layer and linearly increasing velocity with depth, elevation and weathering time corrections, limitations of seismic refraction method; Seismic reflection method, Time-distance relation for horizontal and dipping layers, static and dynamic time corrections, simple interpretation techniques.	4
3.	Gravity Method: Earth gravitational field, gravimeters, gravity field measurements, gravity field reduction and interpretation, gravity effects of subsurface bodies of simple shapes.	3
4.	Magnetic Method: Earth magnetic field, magnetism of rocks and minerals, magnetometers, field operations, local magnetic anomaly, magnetic effects of buried magnetic bodies and interpretation.	3
5.	Electrical Method: Electrical properties of rocks, resistivity method, electrode arrangements, soundings and profiling, data acquisition, analysis and interpretation.	3
6.	Well logging: General aspects of well logging; Resistivity methods; SP-logging, Density logging, acoustic logging.	2
7.	Delineation of Subsurface Parameters: Seismic velocity, density, modulus of elasticity, water saturation, saline contamination, porosity, permeability.	5
8.	Site Investigations: Seismic potential, induced seismicity, water mining blast, lineament mapping, depth and topography of bedrock, water table, water leakage, fault, dike, landfill sites.	6
9.	Identification of Subsurface Structures: Archaeological sites, weak zones, cavities and voids, tunnelling, underground excavation.	5

10.	Case histories: Case studies of geophysical methods for engineering applications.	6
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Dobrin, M. B. and C. H. Savit, "Introduction to Geophysical Prospecting", Fourth Edition, McGraw Hill.	1988
2.	Telford, W.M., Geldart, L.P. and Sheriff, R.E., "Applied Geophysics", Second edition, Cambridge Univ. Press.	1990
3.	William Lowrie, "Fundamentals of Geophysics", Cambridge Univ. Press.	1997
4.	Reynolds, John M., "An Introduction to Applied and Environmental Geophysics", John Wiley & Sons.	1997
5.	Darling, T. "Well Logging and Formation Evaluation" Gulf Professional Publishing.	2005

Appendix 'C'
Item No. Senate/34.1

**PROPOSED CURRICULAR STRUCTURE AND SCHEME
FOR
M. TECH (COMMUNICATION SYSTEMS)**

DEPARTMENT OF ELECTRONICS AND COMPUTER ENGINEERING														
Communication Systems (CMS)														
Teaching Scheme					Contact Hours Per Week			Examination Duration(Hr)		Relative Weight (In %)				
Serial No.	SUBJECT CODE	COURSE TITLE	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
YEAR I														
Ist Semester (Autumn)														
1.	MA 501A	Complex Analysis and Linear Algebra	ICC	4	3	1	0	3	-	25	-	25	50	-
2.	EC-500	Object Oriented Programming and Design	PCC	4	3	0	2	3	-	15	15	30	40	-
3.	EC-511	Digital Communication Systems	PCC	3	3	0	0	3	-	15	-	35	50	-
4.	EC-512	Information and Communication Theory	PCC	3	3	0	0	3	-	15	-	35	50	-
5.	EC-510	Laboratory	PCC	2	0	0	3	-	-	-	100	-	-	-
6.		Open Elective	OEC	3/4	-	-	-	-	-	-	-	-	-	-
7.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				19 - 22										
IInd Semester (Spring)														
1.		Programme Elective 1	PEC	3	-	-	-	-	-	-	-	-	-	-
2.		Programme Elective 2	PEC	3	-	-	-	-	-	-	-	-	-	-
3.		Programme Elective 3	PEC	3	-	-	-	-	-	-	-	-	-	-
4.		Programme Elective 4	PEC	3	-	-	-	-	-	-	-	-	-	-
5.		Open Elective	OEC	3/4	-	-	-	-	-	-	-	-	-	-
7.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				15 - 18										

**PROPOSED CURRICULAR STRUCTURE AND SCHEME
FOR
M. TECH (COMMUNICATION SYSTEMS)**

DEPARTMENT OF ELECTRONICS AND COMPUTER ENGINEERING														
Communication Systems (CMS)														
Teaching Scheme					Contact Hours Per Week			Examination Duration(Hr)		Relative Weight (In %)				
Serial No.	SUBJECT CODE	COURSE TITLE	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
YEAR II														
IIIrd Semester (Autumn)														
1.	EC-601	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	EC-602	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	EC-603	Dissertation*	DIS	-	-	-	-	-	-	-	-	-	25	-
Sub Total				6										
* To be continued and grade to be awarded in the next semester														
IVth Semester (Spring)														
1.	EC-603	Dissertation (continued from Semester III)	DIS	20	-	-	-	-	-	-	-	-	75	-
Sub Total				20										
GRAND TOTAL				60 - 64										

Programme Electives for M.Tech (Communication Systems)

Teaching Scheme					Contact Hours Per Week			Examination Duration (Hr.)		Relative weight (In %)				
Serial No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1.	EC-513	Telecommunication Networks	PEC	3	3	0	0	3	-	15	-	35	50	-
2.	EC-515	Coding Theory and Applications	PEC	3	3	0	0	3	-	15	-	35	50	-
3.	EC-516	Advanced Digital Communication Techniques	PEC	3	3	0	0	3	-	15	-	35	50	-
4.	EC-517	Optical Communication Systems	PEC	3	3	0	0	3	-	15	-	35	50	-
5.	EC-518	Speech and Audio Processing	PEC	3	3	0	0	3	-	15	-	35	50	-
6.	EC-519	Selected Topics in Communication	PEC	3	3	0	0	3	-	15	-	35	50	-
7.	EC-612	Wireless Networks	PEC	3	3	0	0	3	-	15	-	35	50	-
8.	EC-614	Adaptive Signal Processing Techniques	PEC	3	3	0	0	3	-	15	-	35	50	-

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT /CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC – 510**

Course Title: **Laboratory**

2. Contact Hours:

L: 0

T: 0

P: 3

3. Examination Duration (Hrs.):

Theory

0

Practical

0

4. Relative Weight:

CWS

0

PRS

100

MTE

0

ETE

0

PRE

0

5. Credits:

2

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To expose students to the techniques of communication hardware design through fabrication and testing of simple communication subsystems.

10. Details of Course:

Sl. No.	Contents	Contact Hours
	Design and fabrication of: PCM system using sample and hold, ADC and DAC ICs. Linear and adaptive Delta modulator and demodulator. Differential Pulse Code Modulator. Line coder and Hamming Code generator and decoder. ASK modulator and demodulator using (i) multiplier IC (ii) envelope detection PSK modulator and demodulator using multiplier IC Integrate and Dump filter. FSK modulator using function generator/VCO IC, and FSK demodulator using PLL IC. Frequency synthesizer and carrier recovery circuit using PLL IC. Clock recovery circuit using early-late gate. Baseband transmission system using fiber optic kit.	14 x 3
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication/reprint
1.	Gayakwad, R. A., "Op-Amps and Linear Integrated Circuits", 3 rd Ed., Prentice-Hall of India.	2002
2.	Lathi, B. P. and Ding, Z., "Modern Digital and Analog Communication Systems", Intl 4 th Ed., Oxford University Press.	2009
3.	Soclof, S., "Applications of Analog Integrated Circuits", Prentice-Hall of India.	1990
4.	Smith, J. R., "Modern Communication Circuits", 2 nd Ed., McGraw-Hill.	1998
5.	Roddy, D. and Coolen, V., "Electronic Communications", 4 th Ed., Dorling Kindersley (India).	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC-511** Course Title: **Digital Communication Systems**

2. Contact Hours: **L: 3 T: 0 P: 0**

3. Examination Duration (Hrs.): **Theory 3 Practical 0**

4. Relative Weight: **CWS 15 PRS 0 MTE 35 ETE 50 PRE 0**

5. Credits: **3** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the students to the principles, techniques and applications of digital communication.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Block diagram and sub-system description of a digital communication system. Sampling of low-pass and band-pass signals, analysis of instantaneous, natural and flat-top sampling, signal reconstruction; PAM and bandwidth considerations.	5
2.	PCM, signal to quantization noise ratio analysis of linear and non-linear quantizers; Line codes and bandwidth considerations; PCM- TDM hierarchies, frame structures, frame synchronization and bit stuffing.	4
3.	Quantization noise analysis of DM and ADM; DPCM and ADPCM; Low bit rate coding of speech and video signals.	5
4.	Baseband transmission, matched filter, performance in additive Gaussian noise; Intersymbol interference (ISI), Nyquist criterion for zero ISI, sinusoidal roll-off filtering, correlative coding, equalizers and adaptive equalizers; Digital subscriber lines.	5
5.	Geometric representation of signals, maximum likelihood decoding; Correlation receiver, equivalence with matched filter	3
6.	Generation, detection and probability of error analysis of OOK, BPSK, coherent and non-coherent FSK, QPSK and DPSK; QAM, MSK and multicarrier modulation; Comparison of bandwidth and bit rate of digital modulation schemes.	8
7.	Types of satellite orbits, satellite transponder, multiple access techniques, basic link design.	4
8.	Cellular concepts, propagation characteristics, GSM and CDMA standards.	4
9.	Optical fiber propagation, loss and dispersion, types of fibers; Optical sources and detectors, connectors and splices; Optical link.	4
Total		42

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publishers	Year of Publication/Reprint
1.	Haykin, S., "Communication Systems", 4 th Ed., John Wiley & Sons.	2001
2.	Lathi, B.P. and Ding, Z., "Modern Digital and Analog Communication Systems", Intl. 4 th Ed., Oxford University Press.	2009
3.	Roden, M.S., "Analog and Digital Communication Systems", 5 th Ed., Discovery Press.	2005
4.	Sklar, B., and Ray, P.K., "Digital Communication: Fundamentals and Applications", 2 nd Ed., Dorling Kindersley (India).	2009
5.	Carlson, A.B., Crilly, P.B. and Rutledge, J.C., "Communication Systems: An Introduction to Signals and Noise in Electrical Communication", 4 th Ed., McGraw-Hill.	2002
6.	Roddy, D., and Coolen, J., "Electronic Communication", 4 th Ed., Dorling Kindersley (India).	2009

**PROPOSED CURRICULAR STRUCTURE AND SCHEME
FOR
M. TECH (COMPUTER SCIENCE AND ENGINEERING)**

DEPARTMENT OF ELECTRONICS AND COMPUTER ENGINEERING														
Computer Science and Engineering (CSE)														
Teaching Scheme					Contact Hours Per Week			Examination Duration(Hr)		Relative Weight (In %)				
Serial No.	SUBJECT CODE	COURSE TITLE	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
YEAR I														
Ist Semester (Autumn)														
1.	MA 501D	Discrete Mathematics	ICC	4	3	1	0	3	-	25	-	25	50	-
2.	EC-500	Object Oriented Programming and Design	PCC	4	3	0	2	3	-	15	15	30	40	-
3.	EC-551	Advanced Operating Systems	PCC	3	3	0	0	3	-	15	-	35	50	-
4.	EC-552	Network Programming in Unix	PCC	3	3	0	0	3	-	15	-	35	50	-
5.	EC-550	Laboratory	PCC	2	0	0	3	0	-	-	100	-	-	-
6.		Open Elective	OEC	3/4	-	-	-	-	-	-	-	-	-	-
7.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				19 - 22										
IInd Semester (Spring)														
1.	EC-501	Modeling and Simulation	PEC	3	3	0	0	3	-	15	-	35	50	-
2.		Programme Elective 1	PEC	3	-	-	-	-	-	-	-	-	-	-
3.		Programme Elective 2	PEC	3	-	-	-	-	-	-	-	-	-	-
4.		Programme Elective 3	PEC	3	-	-	-	-	-	-	-	-	-	-
5.		Open Elective	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				15 - 18										

**PROPOSED CURRICULAR STRUCTURE AND SCHEME
FOR
M. TECH (COMPUTER SCIENCE AND ENGINEERING)**

DEPARTMENT OF ELECTRONICS AND COMPUTER ENGINEERING														
Computer Science and Engineering (CSE)														
Teaching Scheme					Contact Hours Per Week			Examination Duration(Hr)		Relative Weight (in %)				
Serial No.	SUBJECT CODE	COURSE TITLE	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
YEAR II														
IIIrd Semester (Autumn)														
1.	EC-601	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	EC-602	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	EC-603	Dissertation*	DIS	-	-	-	-	-	-	-	-	-	25	-
Sub Total				6										
* To be continued and grade to be awarded in the next semester														
IVth Semester (Spring)														
1.	EC-603	Dissertation (continued from Semester III)	DIS	20	-	-	-	-	-	-	-	-	75	-
Sub Total				20										
GRAND TOTAL				60 - 64										

Programme Electives for M.Tech (Computer Science and Engineering)

Teaching Scheme					Contact Hours Per Week			Examination Duration (Hr.)		Relative weight (In %)				
Serial No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1.	EC-553	Soft Computing Techniques	PEC	3	3	0	0	3	-	15	-	35	50	-
2.	EC-554 / EC-650	Network Security / Intrusion Detection Systems	PEC	3	3	0	0	3	-	15	-	35	50	-
3.	EC-555	Advanced Computer Networks	PEC	3	3	0	0	3	-	15	-	35	50	-
4.	EC-556	Advanced Computer Architecture	PEC	3	3	0	0	3	-	15	-	35	50	-
5.	EC-557	Advanced Database Management Systems	PEC	3	3	0	0	3	-	15	-	35	50	-
6.	EC-558	Mobile Computing	PEC	3	3	0	0	3	-	15	-	35	50	-
7.	EC-559	Data Mining and Warehousing	PEC	3	3	0	0	3	-	15	-	35	50	-
8.	EC-612	Wireless Networks	PEC	3	3	0	0	3	-	15	-	35	50	-
9.	EC-652	Parallel and Distributed Algorithms	PEC	3	3	0	0	3	-	15	-	35	50	-
10.	EC-653	Introduction to Bioinformatics	PEC	3	3	0	0	3	-	15	-	35	50	-

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC-500**

Course Title: **Object Oriented Programming and Design**

2. Contact Hours:

L: 3

T: 0

P: 2

3. Examination Duration (Hrs.):

Theory

3

Practical

0

4. Relative Weight:

CWS

15

PRS

15

MTE

30

ETE

40

PRE

0

5. Credits:

4

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the object-oriented paradigm of programming.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Introduction to concepts of object oriented programming; Functions and argument passing - by value and by reference.	6
2.	Class declaration, member functions, objects as function arguments, constructors, operator overloading and its use; Derived and base classes, class hierarchies.	8
3.	Polymorphism, virtual functions, abstract classes, programming examples; Implementation of linked structure, use of templates for generalized structures.	7
4.	Exception handling, container classes, use of inheritance and templates in general containers.	6
5.	Object modeling, properties of object, relationship among objects links and aggregation, relationship among classes.	7
6.	Multiple inheritance; Metaclasses; Interplay of classes and objects; Building quality classes and object; concept of foundation class library.	8
	Total	42

	Laboratory component: Programming exercises in C++ on the use of functions and files, classes, derived classes and class hierarchies, friend function of a class, virtual functions, function and operator overloading, templates, streams, handling input and output for user defined types, STL based programming.	14x2

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication/reprint
1.	Dietel, H.M. and Dietel, P.J., "C++ How to Program", 7 th Ed., Pearson.	2010
2.	Eckel, B., "Thinking in C++", Vol. 1 and 2, Pearson.	2001
3.	Deacon, J., "Object Oriented Analysis and Design", Pearson.	2009
4.	Sahni, S., "Data Structure Algorithms Applications in C++", 2 nd Ed., University Press India.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC-550**

Course Title: **Laboratory**

2. Contact Hours:

L: 0

T: 0

P: 3

3. Examination Duration (Hrs.):

Theory

0

Practical

0

4. Relative Weight:

CWS

0

PRS

100

MTE

0

ETE

0

PRE

0

5. Credits:

2

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To expose students to programming techniques in object oriented programming, network programming and operating systems.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Java Programming: Programming exercises in Java to cover arrays, enumerations, formatted output, design of classes, recursive methods, Object class, toString method, inheritance, abstract classes, polymorphism, interface implementation, inner classes, exception handling, linked data structures, generic methods and classes, applet design and use, multithreading.	14
2.	Network Programming: Client and server programs using RPC, stream and datagram sockets, I/O multiplexing, RAW sockets: ping and trace route.	14
3.	Operating Systems: Programming exercises on IPC mechanisms in Unix: Pipes, FIFO, message queues and shared memory; programming exercises on the use of semaphores for producer-consumer, dining philosophers and readers-writers problems, programming exercises on CPU scheduling algorithms.	14
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication
1.	Deitel, H.M., and Deitel, P. J., "Java: How to Program", 7 th Ed., Pearson Education.	2007
2.	Stevens, R.W., Fenner, B., and Rudoff, A., "Unix Network Programming," Vol. I, 3 rd Ed., Addison Wesley.	2003
3.	Stevens, R.W., "UNIX Network Programming: Interprocess Communications", Volume 2, 2 nd Ed., PHI	1999
4.	Storustrup, B., "The C++ Programing Language", Addison Wesley.	1991
5.	Tanenbaum, A., "Modern Operating Systems", PHI.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC-557** Course Title: **Advanced Database Management Systems**

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weight: CWS **15** PRS **0** MTE **35** ETE **50** PRE **0**

5. Credits: **3** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **EC451 or equivalent**

9. Objective: To educate students about relational database practices, approaches, and issues like security, knowledge discovery, data mining and warehousing.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Review of DBMS concepts; Relational database systems, applications of DBMS.	4
2.	Structured Query Processing and optimization, choice of evaluation plans.	5
3.	Serializability: View and conflict serializability, Testing for	6
4.	Object oriented Database Management Systems: Complex data type, object oriented data model, object containment, persistence of objects.	6
5.	Design of distributed databases, security and integrity of databases.	5
6.	Deductive databases, image databases and multimedia databases.	6
7.	Knowledge discovery, data mining functionalities, interestingness measures, classification of data mining systems, data warehousing concepts, slicing, dicing, schemas, data warehouse architecture, introduction to Data Mining Query Language (DMQL)	6
8.	Study of typical DBMS packages.	4
Total		42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication
1.	Silberchatz, A., Korth, H. F. and Sudarshan, S., "Database System Concepts", 4 th Ed., Tata-McGraw Hill.	2008
2.	Han, J. and Kamber, M., "Data Mining: Concepts and Techniques", 2 nd Ed., Morgan Kaufmann.	2006
3.	Ray Chhanda, "Distributed Database Systems", Pearson.	2009
4.	Date, C. J, "An Introduction to Database Systems", 8 th Ed., Pearson.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT./CENTRE:

Electronics and Computer Engineering

1. Subject Code: **EC – 558N**

Course Title: **Mobile Computing**

2. Contact Hours:

L: 3

T: 0

P: 0

3. Examination Duration (Hrs.):

Theory: 3

Practical: 0

4. Relative Weight:

CWS

15

PRS

00

MTE

35

ETE

50

PRE

00

5. Credits: **3**

6. Semester : **Spring**

7. Pre-requisite: **EC - 252, EC - 356 or equivalents**

8. Subject Area: **PEC**

9. Objective: To impart knowledge of mobile and wireless computing systems and techniques.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Mobility: Issues, challenges, and benefits; Review of mobile and cellular communication technology; Review of distributed/network operating systems, ubiquitous computing.	4
2.	Network Programming: Process communication techniques, remote login, ftp, socket programming, RPC, RMI, client-server programming.	4
3.	Process Migration: Steps, advantages, application taxonomy, alternatives, case study of DEMOS/MP.	3
4.	Mobile Computing: Physical mobility, challenges, limits and connectivity, mobile IP and cellular IP in mobile computing, case study of CODA.	6
5.	Wireless LANs: Introduction to IEEE 802.11, Bluetooth and IrDA technologies and standards.	4
6.	Mobile Adhoc Networks: Hidden and exposed terminal problems; Routing protocols: DSDV, DSR, AODV.	6
7.	Wireless Sensor Networks: Motes, smart dust, TinyOS, routing protocols.	4
8.	Handheld Devices and OS: Palm, HP; PalmOS, WindowsCE, Windows Mobile.	4
9.	Mobile Internet and WAP: WWW programming model, WAP programming model, gateways.	4
10.	Mobile agents: Aglets, Tcl, PMADE.	3
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication
1.	Tanenbaum, A. S., "Computer Networks", 4 th Ed., Pearson Education.	2003
2.	Milojicic, D., Douglis, F. and Wheeler R., (ed.), "Mobility Processes, Computers and Agents", Addison Wesley.	2000
3.	Lange, D. B. and Oshima, M., "Programming and Deploying Java Mobile Agents with Aglets", Addison Wesley.	1998
5.	Schildt, H., "The Complete Reference Java2", 5 th Ed., McGraw-Hill.	2002
6.	Stevens, W. R., "UNIX Network Programming", Prentice-Hall of India.	1998
7.	Hansman, U. and Merck, L., "Principles of Mobile Computing", 2 nd Ed., Springer.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Electronics and Computer Engineering**

1. Subject Code: **EC-559** Course Title: **Data Mining and Warehousing**

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.):	Theory	3	Practical	0

4. Relative Weight:	CWS	15	PRS	0	MTE	35	ETE	50	PRE	00

5. Credits: **3** 6. Semester: **Spring**

7. Pre-requisite: **EC251 and EC451 or their equivalents** 8. Subject Area: **PEC**

9. Objective: To expose students to the various concepts, algorithms and techniques in data mining and warehousing and their applications.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Introduction to data mining: Motivation and significance of data mining, data mining functionalities, interestingness measures, classification of data mining system, major issues in data mining.	2
2.	Data pre-processing: Need, data summarization, data cleaning, data integration and transformation, data reduction techniques – Singular Value Decomposition (SVD), Discrete Fourier Transform (DFT), Discrete Wavelet Transform (DWT), data discretization and concept hierarchy generalization.	5
3.	Data warehouse and OLAP technology: Data warehouse definition, multidimensional data model(s), data warehouse architecture, OLAP server types, data warehouse implementation, on-line analytical processing and mining.	5
4.	Data cube computation and data generalization: Efficient methods for data cube computation, discovery driven exploration of data cubes, complex aggregation, attribute oriented induction for data generalization.	5
5.	Mining frequent patterns, associations and correlations: Basic concepts, efficient and scalable frequent itemset mining algorithms, mining various kinds of association rules – multilevel and multidimensional, association rule mining versus correlation analysis, constraint based association mining.	6
6.	Classification and prediction: Definition, decision tree induction, Bayesian classification, rule based classification, classification by backpropagation and support vector machines, associative classification, lazy learners, prediction, accuracy and error measures.	6

7.	Cluster analysis: Definition, clustering algorithms – partitioning, hierarchical, density based, grid based and model based; Clustering high dimensional data, constraint based cluster analysis, outlier analysis – density based and distance based.	7
8.	Data mining on complex data and applications: Algorithms for mining of spatial data, multimedia data, text data; Data mining applications, social impacts of data mining, trends in data mining.	6
Total		42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication
1.	Han, J. and Kamber, M., “Data Mining - Concepts and Techniques”, 2 nd Ed., Elsevier.	2006
2.	Ali, A. B. M. S. and Wasimi, S. A., “Data Mining - Methods and Techniques”, Cengage Publishers.	2009
3.	Tan, P.N., Steinbach, M. and Kumar, V., “Introduction to Data Mining”, Addison Wesley – Pearson.	2008
4.	Pujari, A. K., “Data Mining Techniques”, 4 th Ed., Sangam Books.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT./ CENTRE: **Electronics and Computer Engineering**

1. Subject Code: **EC – 652** Course Title: **Parallel and Distributed Algorithms**

2. Contact Hours: **L: 3 T: 0 P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weight: **CWS** 15 **PRS** 00 **MTE** 35 **ETE** 50 **PRE** 00

5. Credits: 3

6. Semester : **Spring**

7. Pre-requisite: **EC – 351 or equivalent**

8. Subject Area: **PEC**

9. Objective: To provide an in-depth understanding of the fundamentals of parallel and distributed algorithms.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Introduction to data and control parallelism.	2
2.	PRAM model and its variants, EREW, ERCW, CRCW, PRAM algorithms, cost optimality criterion, Brent's theorem and its importance.	8
3.	Processor organizations such as mesh and hypercube, embedding of problem graphs into processor graphs.	4
4.	Parallel algorithms for matrix multiplication, merging and sorting for different processor organizations such as mesh and hypercube.	8
5.	Introduction to distributed systems, synchronous / asynchronous network models, leader election problem in ring and general networks; Type of faults, fail safe systems, Byzantine faults, distributed consensus with link and process failures.	8
6.	Algorithms for BFS, DFS, shortest paths and spanning trees in distributed systems.	6
7.	Asynchronous networks: Broadcast and multicast, logical time, global snapshot and stable properties; Network resource allocation.	6
Total		42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication
1.	Quinn, M. J., "Parallel Computing Theory & Practice", McGraw-Hill	1994
2.	Horowitz, E., Sahni, S. and Rajasekaran, S., "Computer Algorithms: C++", Galgotia Publications	2002
3.	Lynch, N. A., "Distributed Algorithms", Morgan Kaufmann.	2003
4.	Miller, R. and Boxer, L., "Algorithms Sequential & Parallel: A Unified Approach", 2 nd Ed., Charles River Media.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC-655** Course Title: **Introduction to Bioinformatics**

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.):	Theory	3	Practical	0

4. Relative Weight:	CWS	15	PRS	0	MTE	35	ETE	50	PRE	0

5. Credits:	3	6. Semester: Spring	7. Subject Area: PEC

8. Pre-requisite: Nil

9. Objective: To expose students to the algorithms, data structures and application areas in bioinformatics.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Sequence comparison and alignment methods: Dynamic programming; Global, semi global and local alignment algorithms; Gap model; Database searching tools; Multiple sequence alignment.	6
2.	Suffix tree: Implicit suffix tree; Explicit suffix tree; Suffix link; Ukkonen's algorithm; Applications of Suffix tree.	6
3.	Phylogenetic tree: Rooted and unrooted tree, Newick format, scaled and unscaled tree, character and distance based methods, distance matrix, UPGMA, WPGMA, additive tree, neighbor joining method, parsimony, maximum likelihood approach, phylogenetic comparison, agreement tree.	6
4.	Gene network analysis: Bayesian network, Gene network, clustering, classification, DNA array; Gene network reconstruction methods: Boolean, linear, non-linear and machine learning.	8
5	Sequencing techniques by hybridization: Microarray, Hamiltonian path, Euler path.	6
6.	RNA structure prediction: RNA secondary structure, pseudoknot, loops, RNA secondary structure prediction algorithm, RNA structure comparison, inferring RNA structure.	8
7.	Computational aspects of drug designing.	2
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication
1.	Krane, D. E. and Raymer, M. L., "Fundamental Concepts of Bioinformatics", Benjamin Cummings.	2005
2.	Baxevanis, A. D. and Ouellette, B. F. F., "Bioinformatics: A Practical Guide to Analysis of Genes and Proteins", 2 nd Ed., Wiley.	2003
3.	Rastogi, S.C., Mendiratta, N. and Rastogi, P., "Bioinformatics: Concepts, Skills and Applications", CBS Publications.	2001
4.	Xiong, J., "Essential Bioinformatics", Cambridge University Press.	2007

**PROPOSED CURRICULAR STRUCTURE AND SCHEME
FOR
M. TECH (INFORMATION TECHNOLOGY)**

DEPARTMENT OF ELECTRONICS AND COMPUTER ENGINEERING														
Information Technology (IT)														
Teaching Scheme					Contact Hours Per Week			Examination Duration(Hr)		Relative Weight (In %)				
Serial No.	SUBJECT CODE	COURSE TITLE	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
YEAR I														
Ist Semester (Autumn)														
1.	MA 501D	Discrete Mathematics	ICC	4	3	1	0	3	-	25	-	25	50	-
2.	EC-500	Object Oriented Programming and Design	PCC	4	3	0	2	3	-	15	15	30	40	-
3.	EC-551	Advanced Operating Systems	PCC	3	3	0	0	3	-	15	-	35	50	-
4.	EC-552	Network Programming in Unix	PCC	3	3	0	0	3	-	15	-	35	50	-
5.	EC-550	Laboratory	PCC	2	0	0	3	0	-	-	100	-	-	-
6.		Open Elective	OEC	3/4	-	-	-	-	-	-	-	-	-	-
7.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				19 - 22										
IInd Semester (Spring)														
1.	EC-501	Modeling and Simulation	PEC	3	3	0	0	3	-	15	-	35	50	-
2.		Programme Elective 1	PEC	3	-	-	-	-	-	-	-	-	-	-
3.		Programme Elective 2	PEC	3	-	-	-	-	-	-	-	-	-	-
4.		Programme Elective 3	PEC	3	-	-	-	-	-	-	-	-	-	-
5.		Open Elective	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				15 - 18										

**PROPOSED CURRICULAR STRUCTURE AND SCHEME
FOR
M. TECH (INFORMATION TECHNOLOGY)**

DEPARTMENT OF ELECTRONICS AND COMPUTER ENGINEERING														
Information Technology (IT)														
Teaching Scheme					Contact Hours Per Week			Examination Duration(Hr)		Relative Weight (in %)				
Serial No.	SUBJECT CODE	COURSE TITLE	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
YEAR II														
IIIrd Semester (Autumn)														
1.	EC-601	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	EC-602	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	EC-603	Dissertation*	DIS	-	-	-	-	-	-	-	-	-	25	-
Sub Total				6										
* To be continued and grade to be awarded in the next semester														
IVth Semester (Spring)														
1.	EC-603	Dissertation (continued from Semester III)	DIS	20	-	-	-	-	-	-	-	-	75	-
Sub Total				20										
GRAND TOTAL				60 - 64										

Programme Electives for M.Tech (Information Technology)

Teaching Scheme					Contact Hours Per Week			Examination Duration (Hr.)		Relative weight (in %)				
Serial No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1.	EC-513	Telecommunication Networks	PEC	3	3	0	0	3	-	15	-	35	50	-
2.	EC-518	Speech & Audio Processing	PEC	3	3	0	0	3	-	15	-	35	50	-
3.	EC-553	Soft Computing Techniques	PEC	3	3	0	0	3	-	15	-	35	50	-
4.	EC-554 / EC-556	Network Security / Intrusion Detection Systems	PEC	3	3	0	0	3	-	15	-	35	50	-
5.	EC-555	Advanced Computer Networks	PEC	3	3	0	0	3	-	15	-	35	50	-
6.	EC-557	Advanced Database Management Systems	PEC	3	3	0	0	3	-	15	-	35	50	-
7.	EC-558	Mobile Computing	PEC	3	3	0	0	3	-	15	-	35	50	-
8.	EC-559	Data Mining and Warehousing	PEC	3	3	0	0	3	-	15	-	35	50	-
9.	EC-612	Wireless Networks	PEC	3	3	0	0	3	-	15	-	35	50	-
10.	EC-652	Parallel and Distributed Algorithms	PEC	3	3	0	0	3	-	15	-	35	50	-
11.	EC-654	Multimedia Techniques	PEC	3	3	0	0	3	-	15	-	35	50	-
12.	EC-655	Introduction to Bioinformatics	PEC	3	3	0	0	3	-	15	-	35	50	-

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC-500**

Course Title: **Object Oriented Programming and Design**

2. Contact Hours:

L: 3

T: 0

P: 2

3. Examination Duration (Hrs.):

Theory 3

Practical 0

4. Relative Weight:

CWS 15

PRS 15

MTE 30

ETE 40

PRE 0

5. Credits:

4

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the object-oriented paradigm of programming.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Introduction to concepts of object oriented programming; Functions and argument passing - by value and by reference.	6
2.	Class declaration, member functions, objects as function arguments, constructors, operator overloading and its use; Derived and base classes, class hierarchies.	8
3.	Polymorphism, virtual functions, abstract classes, programming examples; Implementation of linked structure, use of templates for generalized structures.	7
4.	Exception handling, container classes, use of inheritance and templates in general containers.	6
5.	Object modeling, properties of object, relationship among objects links and aggregation, relationship among classes.	7
6.	Multiple inheritance; Metaclasses; Interplay of classes and objects; Building quality classes and object; concept of foundation class library.	8
	Total	42

	Laboratory component: Programming exercises in C++ on the use of functions and files, classes, derived classes and class hierarchies, friend function of a class, virtual functions, function and operator overloading, templates, streams, handling input and output for user defined types, STL based programming.	14x2

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication/reprint
1.	Dietel, H.M. and Dietel, P.J., "C++ How to Program", 7 th Ed., Pearson.	2010
2.	Eckel, B., "Thinking in C++", Vol. 1 and 2, Pearson.	2001
3.	Deacon, J., "Object Oriented Analysis and Design", Pearson.	2009
4.	Sahni, S., "Data Structure Algorithms Applications in C++", 2 nd Ed., University Press India.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC-550**

Course Title: **Laboratory**

2. Contact Hours:

L: 0

T: 0

P: 3

3. Examination Duration (Hrs.):

Theory

0

Practical

0

4. Relative Weight:

CWS

0

PRS

100

MTE

0

ETE

0

PRE

0

5. Credits:

2

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To expose students to programming techniques in object oriented programming, network programming and operating systems.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Java Programming: Programming exercises in Java to cover arrays, enumerations, formatted output, design of classes, recursive methods, Object class, toString method, inheritance, abstract classes, polymorphism, interface implementation, inner classes, exception handling, linked data structures, generic methods and classes, applet design and use, multithreading.	14
2.	Network Programming: Client and server programs using RPC, stream and datagram sockets, I/O multiplexing, RAW sockets: ping and trace route.	14
3.	Operating Systems: Programming exercises on IPC mechanisms in Unix: Pipes, FIFO, message queues and shared memory; programming exercises on the use of semaphores for producer-consumer, dining philosophers and readers-writers problems, programming exercises on CPU scheduling algorithms.	14
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication
1.	Deitel, H.M., and Deitel, P. J., "Java: How to Program", 7 th Ed., Pearson Education.	2007
2.	Stevens, R.W., Fenner, B., and Rudoff, A., "Unix Network Programming," Vol. I, 3 rd Ed., Addison Wesley.	2003
3.	Stevens, R.W., "UNIX Network Programming: Interprocess Communications", Volume 2, 2 nd Ed., PHI	1999
4.	Storustrup, B., "The C++ Programing Language", Addison Wesley.	1991
5.	Tanenbaum, A., "Modern Operating Systems", PHI.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC-553** Course Title: **Soft Computing Techniques**

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.):	Theory	3	Practical	0

4. Relative Weight:	CWS	15	PRS	0	MTE	35	ETE	50	PRE	0

5. Credits: **3** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: Nil

9. **Objective:** To acquaint students with techniques for finding solutions to computationally hard problems that cannot be solved in polynomial time using conventional techniques.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Introduction: From conventional AI to computational intelligence, neural networks, fuzzy set theory, genetic algorithms, evolutionary computation, characteristics of soft computing systems.	6
2.	Fuzzy set theory: Fuzzy sets, set-theoretic operations, membership functions; Union, intersection and complement, fuzzy rules, reasoning and interference.	7
3.	Neural networks: Back-propagation, feed-forward, hybrid systems; Supervised learning: Perceptrons, multilayer perceptrons, radial basis function; Unsupervised learning: Kohonen self-organizing networks, Hebbian learning, Hopfield learning.	7
4.	Genetic algorithms: GA concepts – encoding, fitness function, population size, selection, crossover and mutation operators, along with the methodologies of applying these operators; Binary GA and their operators, real coded GA and their operators.	7
5.	Hybrid systems: Neuro-fuzzy modeling, adaptive neuro-fuzzy inference systems (ANFIS), classification and regression trees, CART algorithm, data clustering, neuro-fuzzy control, fuzzy logic and GAs, neural network weights using GAs.	5
6.	Discrete optimization: Use of hybrid techniques to solve optimization problems like traveling salesman problem, time table problem and vehicle routing problem.	5
7.	Soft computing applications: Case studies in various areas like management, life-sciences, automobile industry, robotics, and agriculture.	5
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication
1.	Karray, F.O. and DeSilva, C., "Soft Computing and Intelligent System Design", Pearson.	2009
2.	Rich, E., Knight, K. and Nair, S.B., "Artificial Intelligence", 3 rd Ed., Tata McGraw Hill.	2009
3.	Deb, K., "Optimization for Engineering Design Algorithms and Examples", Prentice Hall of India.	1998
4.	Fu, L.M., "Neural Networks in Computer Intelligence", McGraw Hill.	1994
5.	Andrea, B., "Soft Computing Applications", Physica Verlag.	2003
6.	Jang, J.S.R., Sun, C.T. and Mizutani, E., "Neuro-fuzzy and Soft Computing", Pearson.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC-557** Course Title: **Advanced Database Management Systems**

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.): Theory Practical

4. Relative Weight: CWS PRS MTE ETE PRE

5. Credits: 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **EC451 or equivalent**

9. Objective: To educate students about relational database practices, approaches, and issues like security, knowledge discovery, data mining and warehousing.

10. Details of the Course:

SL No.	Contents	Contact Hours
1.	Review of DBMS concepts; Relational database systems, applications of DBMS.	4
2.	Structured Query Processing and optimization, choice of evaluation plans.	5
3.	Serializability: View and conflict serializability, Testing for	6
4.	Object oriented Database Management Systems: Complex data type, object oriented data model, object containment, persistence of objects.	6
5.	Design of distributed databases, security and integrity of databases.	5
6.	Deductive databases, image databases and multimedia databases.	6
7.	Knowledge discovery, data mining functionalities, interestingness measures, classification of data mining systems, data warehousing concepts, slicing, dicing, schemas, data warehouse architecture, introduction to Data Mining Query Language (DMQL)	6
8.	Study of typical DBMS packages.	4
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication
1.	Silberchatz, A., Korth, H. F. and Sudarshan, S., "Database System Concepts", 4 th Ed., Tata-McGraw Hill.	2008
2.	Han, J. and Kamber, M., "Data Mining: Concepts and Techniques", 2 nd Ed., Morgan Kaufmann.	2006
3.	Ray Chhanda, "Distributed Database Systems", Pearson.	2009
4.	Date, C. J., "An Introduction to Database Systems", 8 th Ed., Pearson.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT./CENTRE: **Electronics and Computer Engineering**

1. Subject Code: **EC – 558N** Course Title: **Mobile Computing**

2. Contact Hours: **L: 3 T: 0 P: 0**

3. Examination Duration (Hrs.): **Theory: 3 Practical: 0**

4. Relative Weight: **CWS 15 PRS 00 MTE 35 ETE 50 PRE 00**

5. Credits: **3**

6. Semester : **Spring**

7. Pre-requisite: **EC - 252, EC - 356 or equivalents**

8. Subject Area: **PEC**

9. Objective: To impart knowledge of mobile and wireless computing systems and techniques.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Mobility: Issues, challenges, and benefits; Review of mobile and cellular communication technology; Review of distributed/network operating systems, ubiquitous computing.	4
2.	Network Programming: Process communication techniques, remote login, ftp, socket programming, RPC, RMI, client-server programming.	4
3.	Process Migration: Steps, advantages, application taxonomy, alternatives, case study of DEMOS/MP.	3
4.	Mobile Computing: Physical mobility, challenges, limits and connectivity, mobile IP and cellular IP in mobile computing, case study of CODA.	6
5.	Wireless LANs: Introduction to IEEE 802.11, Bluetooth and IrDA technologies and standards.	4
6.	Mobile Adhoc Networks: Hidden and exposed terminal problems; Routing protocols: DSDV, DSR, AODV.	6
7.	Wireless Sensor Networks: Motes, smart dust, TinyOS, routing protocols.	4
8.	Handheld Devices and OS: Palm, HP; PalmOS, WindowsCE, Windows Mobile.	4
9.	Mobile Internet and WAP: WWW programming model, WAP programming model, gateways.	4
10.	Mobile agents: Aglets, Tcl, PMADE.	3
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication
1.	Tanenbaum, A. S., "Computer Networks", 4 th Ed., Pearson Education.	2003
2.	Milojicic, D., Douglass, F. and Wheeler R., (ed.), "Mobility Processes, Computers and Agents", Addison Wesley.	2000
3.	Lange, D. B. and Oshima, M., "Programming and Deploying Java Mobile Agents with Aglets", Addison Wesley.	1998
5.	Schildt, H., "The Complete Reference Java2", 5 th Ed., McGraw-Hill.	2002
6.	Stevens, W. R., "UNIX Network Programming", Prentice-Hall of India.	1998
7.	Hansman, U. and Merck, L., "Principles of Mobile Computing", 2 nd Ed., Springer.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Electronics and Computer Engineering**

1. Subject Code: **EC-559** Course Title: **Data Mining and Warehousing**

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.):	Theory	3	Practical	0

4. Relative Weight:	CWS	15	PRS	0	MTE	35	ETE	50	PRE	00

5. Credits: **3** 6. Semester: **Spring**

7. Pre-requisite: **EC251 and EC451 or their equivalents** 8. Subject Area: **PEC**

9. Objective: To expose students to the various concepts, algorithms and techniques in data mining and warehousing and their applications.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Introduction to data mining: Motivation and significance of data mining, data mining functionalities, interestingness measures, classification of data mining system, major issues in data mining.	2
2.	Data pre-processing: Need, data summarization, data cleaning, data integration and transformation, data reduction techniques – Singular Value Decomposition (SVD), Discrete Fourier Transform (DFT), Discrete Wavelet Transform (DWT), data discretization and concept hierarchy generalization.	5
3.	Data warehouse and OLAP technology: Data warehouse definition, multidimensional data model(s), data warehouse architecture, OLAP server types, data warehouse implementation, on-line analytical processing and mining.	5
4.	Data cube computation and data generalization: Efficient methods for data cube computation, discovery driven exploration of data cubes, complex aggregation, attribute oriented induction for data generalization.	5
5.	Mining frequent patterns, associations and correlations: Basic concepts, efficient and scalable frequent itemset mining algorithms, mining various kinds of association rules – multilevel and multidimensional, association rule mining versus correlation analysis, constraint based association mining.	6
6.	Classification and prediction: Definition, decision tree induction, Bayesian classification, rule based classification, classification by backpropagation and support vector machines, associative classification, lazy learners, prediction, accuracy and error measures.	6

7.	Cluster analysis: Definition, clustering algorithms – partitioning, hierarchical, density based, grid based and model based; Clustering high dimensional data, constraint based cluster analysis, outlier analysis – density based and distance based.	7
8.	Data mining on complex data and applications: Algorithms for mining of spatial data, multimedia data, text data; Data mining applications, social impacts of data mining, trends in data mining.	6
Total		42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication
1.	Han, J. and Kamber, M., “Data Mining - Concepts and Techniques”, 2 nd Ed., Elsevier.	2006
2.	Ali, A. B. M. S. and Wasimi, S. A., “Data Mining - Methods and Techniques”, Cengage Publishers.	2009
3.	Tan, P.N., Steinbach, M. and Kumar, V., “Introduction to Data Mining”, Addison Wesley – Pearson.	2008
4.	Pujari, A. K., “Data Mining Techniques”, 4 th Ed., Sangam Books.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT./ CENTRE: **Electronics and Computer Engineering**

1. Subject Code: **EC – 652** Course Title: **Parallel and Distributed Algorithms**

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weight: CWS 15 PRS 00 MTE 35 ETE 50 PRE 00

5. Credits: 3

6. Semester :**Spring**

7. Pre-requisite: **EC – 351 or equivalent**

8. Subject Area: **PEC**

9. Objective: To provide an in-depth understanding of the fundamentals of parallel and distributed algorithms.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Introduction to data and control parallelism.	2
2.	PRAM model and its variants, EREW, ERCW, CRCW, PRAM algorithms, cost optimality criterion, Brent's theorem and its importance.	8
3.	Processor organizations such as mesh and hypercube, embedding of problem graphs into processor graphs.	4
4.	Parallel algorithms for matrix multiplication, merging and sorting for different processor organizations such as mesh and hypercube.	8
5.	Introduction to distributed systems, synchronous / asynchronous network models, leader election problem in ring and general networks; Type of faults, fail safe systems, Byzantine faults, distributed consensus with link and process failures.	8
6.	Algorithms for BFS, DFS, shortest paths and spanning trees in distributed systems.	6
7.	Asynchronous networks: Broadcast and multicast, logical time, global snapshot and stable properties; Network resource allocation.	6
Total		42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication
1.	Quinn, M. J., "Parallel Computing Theory & Practice", McGraw-Hill	1994
2.	Horowitz, E., Sahni, S. and Rajasekaran, S., "Computer Algorithms: C++", Galgotia Publications	2002
3.	Lynch, N. A., "Distributed Algorithms", Morgan Kaufmann.	2003
4.	Miller, R. and Boxer, L., "Algorithms Sequential & Parallel: A Unified Approach", 2 nd Ed., Charles River Media.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT./CENTRE: **Electronics and Computer Engineering**

1. Subject Code: **EC – 654** Course Title: **Multimedia Techniques**

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weight: CWS 15 PRS 00 MTE 35 ETE 50 PRE 00

5. Credits: 3

6. Semester : **Spring**

7. Pre-requisite: **EC – 202 or equivalent**

8. Subject Area: **PEC**

9. Objective: To expose students to the concepts and issues of multimedia data acquisition, communication and presentation technologies.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Introduction to Multimedia Systems: Architecture and components, multimedia distributed processing model, synchronization, orchestration and quality of service architecture.	5
2.	Audio and Speech: Data acquisition, sampling and quantization, human speech production mechanism, digital model of speech production, analysis and synthesis, psycho-acoustics, low bit rate speech compression, MPEG audio compression.	7
3.	Images and Video: Image acquisition and representation, composite video signal, NTSC, PAL and SECAM video standards; Bilevel image compression standards, JPEG and MPEG.	6
4.	Multimedia Communication: Fundamentals of data communication and networking, bandwidth requirements of different media; Real time constraints: Audio latency, video data rate; Multimedia over LAN and WAN, multimedia conferencing.	8
5.	Hypermedia Presentation: Authoring and publishing, linear and non-linear presentation, structuring information, different approaches of authoring hypermedia documents, hypermedia data models and standards.	8

6.	Multimedia Information Systems: Operating system support for continuous media applications, limitations of OS, new OS support, media stream protocol, file system support for continuous media, data models for multimedia and hypermedia information, content based retrieval of unstructured data.	8
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication
1.	Li, Z.N. and Drew, M.S., "Fundamentals of Multimedia", Pearson Education.	2004
2.	Hillman, D., "Multimedia Technology and Application", Galgotia Publication.	1998
3.	Steinmetz, R., "Multimedia Computing, Communication and Applications", Pearson Education.	2001
4.	Buford, J., "Multimedia Systems", Addison Wesley.	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC-655** Course Title: **Introduction to Bioinformatics**

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.):	Theory	3	Practical	0

4. Relative Weight:	CWS	15	PRS	0	MTE	35	ETE	50	PRE	0

5. Credits:	3	6. Semester: Spring	7. Subject Area: PEC

8. Pre-requisite: Nil

9. Objective: To expose students to the algorithms, data structures and application areas in bioinformatics.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Sequence comparison and alignment methods: Dynamic programming; Global, semi global and local alignment algorithms; Gap model; Database searching tools; Multiple sequence alignment.	6
2.	Suffix tree: Implicit suffix tree; Explicit suffix tree; Suffix link; Ukkonen's algorithm; Applications of Suffix tree.	6
3.	Phylogenetic tree: Rooted and unrooted tree, Newick format, scaled and unscaled tree, character and distance based methods, distance matrix, UPGMA, WPGMA, additive tree, neighbor joining method, parsimony, maximum likelihood approach, phylogenetic comparison, agreement tree.	6
4.	Gene network analysis: Bayesian network, Gene network, clustering, classification, DNA array; Gene network reconstruction methods: Boolean, linear, non-linear and machine learning.	8
5	Sequencing techniques by hybridization: Microarray, Hamiltonian path, Euler path.	6
6.	RNA structure prediction: RNA secondary structure, pseudoknot, loops, RNA secondary structure prediction algorithm, RNA structure comparison, inferring RNA structure.	8
7.	Computational aspects of drug designing.	2
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication
1.	Krane, D. E. and Raymer, M. L., "Fundamental Concepts of Bioinformatics", Benjamin Cummings.	2005
2.	Baxevanis, A. D. and Ouellette, B. F. F., "Bioinformatics: A Practical Guide to Analysis of Genes and Proteins", 2 nd Ed., Wiley.	2003
3.	Rastogi, S.C., Mendiratta, N. and Rastogi, P., "Bioinformatics: Concepts, Skills and Applications", CBS Publications.	2001
4.	Xiong, J., "Essential Bioinformatics", Cambridge University Press.	2007

**PROPOSED CURRICULAR STRUCTURE AND SCHEME
FOR
M. TECH (MICROELECTRONICS AND VLSI)**

DEPARTMENT OF ELECTRONICS AND COMPUTER ENGINEERING														
Microelectronics and VLSI (MEV)														
Teaching Scheme					Contact Hours Per Week			Examination Duration(Hr)		Relative Weight (In %)				
Serial No.	SUBJECT CODE	COURSE TITLE	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
YEAR I														
Ist Semester (Autumn)														
1.	MA 501B	Numerical Analysis	ICC	4	3	1	0	3	-	25	-	25	50	-
2.	EC-502	Device and Circuit Simulation	PCC	4	3	1	0	3	-	25	-	25	50	-
3.	EC-545	Semiconductor Materials and Devices	PCC	3	3	0	0	3	-	15	-	35	50	-
4.	EC-546	MOS Device Physics and Modeling	PCC	3	3	0	0	3	-	15	-	35	50	-
5.	EC540	Laboratory	PCC	2	0	0	3	-	-	-	100	-	-	-
6.		Open Elective	OEC	3/4	-	-	-	-	-	-	-	-	-	-
7.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				19 - 22										
IInd Semester (Spring)														
1.		Programme Elective 1	PEC	3	-	-	-	-	-	-	-	-	-	-
2.		Programme Elective 2	PEC	3	-	-	-	-	-	-	-	-	-	-
3.		Programme Elective 3	PEC	3	-	-	-	-	-	-	-	-	-	-
4.		Programme Elective 4	PEC	3	-	-	-	-	-	-	-	-	-	-
5.		Open Elective	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				15 - 18										

**PROPOSED CURRICULAR STRUCTURE AND SCHEME
FOR
M. TECH (MICROELECTRONICS AND VLSI)**

DEPARTMENT OF ELECTRONICS AND COMPUTER ENGINEERING														
Microelectronics and VLSI (MEV)														
Teaching Scheme					Contact Hours Per Week			Examination Duration(Hr)		Relative Weight (In %)				
Serial No.	SUBJECT CODE	COURSE TITLE	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
YEAR II														
IIIrd Semester (Autumn)														
1.	EC-601	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	EC-602	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	EC-603	Dissertation*	DIS	-	-	-	-	-	-	-	-	-	25	-
Sub Total				6										
* To be continued and grade to be awarded in the next semester														
IVth Semester (Spring)														
1.	EC-603	Dissertation (continued from Semester III)	DIS	20	-	-	-	-	-	-	-	-	75	-
Sub Total				20										
GRAND TOTAL				60 - 64										

Programme Electives for M.Tech (Microelectronics and VLSI)

Teaching Scheme					Contact Hours Per Week			Examination Duration (Hr.)		Relative weight (In %)				
Serial No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1.	EC-541	VLSI Physical Design	PEC	3	3	0	0	3	-	15	-	35	50	-
2.	EC-542	Semiconductor Microwave Devices and Applications	PEC	3	3	0	0	3	-	15	-	35	50	-
3.	EC-543	Optoelectronic Materials and Devices	PEC	3	3	0	0	3	-	15	-	35	50	-
4.	EC-544	Digital VLSI Circuit Design	PEC	3	3	0	0	3	-	15	-	35	50	-
5.	EC-547	Compound Semiconductors and RF Devices	PEC	3	3	0	0	3	-	15	-	35	50	-
6.	EC-548	Analog VLSI Circuit Design	PEC	3	3	0	0	3	-	15	-	35	50	-
7.	EC-549	VLSI Technology	PEC	3	3	0	0	3	-	15	-	35	50	-
8.	EC-641	CAD for VLSI	PEC	3	3	0	0	3	-	15	-	35	50	-
9.	EC-642	Nanoscale Devices and Circuit Design	PEC	3	3	0	0	3	-	15	-	35	50	-

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC-502** Course Title: **Device and Circuit Simulation**

2. Contact Hours: L: 3 T: 1 P: 0

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weight: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To acquaint the students with fundamentals of building device and circuit simulators, and efficient use of simulators.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Introduction: Prime importance of circuit and device simulations in VLSI; Nodal, mesh, modified nodal and hybrid analysis equations.	4
3.	Solution of network equations: Sparse matrix techniques, solution of nonlinear networks through Newton-Raphson technique, convergence and stability.	6
4.	Multistep methods: Solution of stiff systems of equations, adaptation of multistep methods to the solution of electrical networks, general purpose circuit simulators.	10
5.	Mathematical techniques for device simulations: Poisson equation, continuity equation, drift-diffusion equation, Schrodinger equation, hydrodynamic equations, trap rate, finite difference solutions to these equations in 1D and 2D space, grid generation.	10
6.	Semiconductor parameter modeling: Models of mobility, lifetime and bandgap.	4
7.	Simple device simulator: Computation of characteristics of simple devices like p-n junction, MOS capacitor and MOSFET; Small-signal analysis.	8
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Arora, N., "MOSFET Models for VLSI Circuit Simulation", Springer-Verlag.	1993
2.	Selberherr, S., "Analysis and Simulation of Semiconductor Devices", Springer-Verlag.	1984
3.	Fjeldly, T., Yetterdal, T. and Shur, M., "Introduction to Device Modeling and Circuit Simulation", Wiley-Interscience.	1997
4.	Grasser, T., "Advanced Device Modeling and Simulation", World Scientific Publishing Company.	2003
5.	Chua, L.O. and Lin, P.M., "Computer-Aided Analysis of Electronic Circuits: Algorithms and Computational Techniques", Prentice-Hall.	1975

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC – 540**

Course Title: **Laboratory**

2. Contact Hours:

L: 0

T: 0

P: 3

3. Examination Duration (Hrs.):

Theory

0

Practical

0

4. Relative Weight:

CWS

0

PRS

100

MTE

0

ETE

0

PRE

0

5. Credits:

2

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge of characterization of devices and fabrication techniques.

10. Details of the Course:

SL No.	Contents	Contact Hours
	Study of Hall effect in semiconductors. Four probe method for resistivity and bandgap measurement of semiconductors. Study of Magneto resistance in semiconductors. I-V characteristics of devices with variation in temperature. h-parameter measurement for MOSFETs. C-V characteristics of p-n junction and MOS capacitor. Device characteristics of LED, lasers and solar cells. Study of working of diffusion furnace. Fabrication and characterization of Schottky diodes. Fabrication and characterization of MOS capacitor. Deposition of thin films using physical vapor deposition (vacuum evaporator) and spin coating techniques. MOSFET process/device simulation and parameter extraction.	14x3
	Total	42

11. Suggested Books:

SL No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Lindmayer, J. and Wrigley, C. Y., "Fundamentals of Semiconductor Devices", D. Van Nostrand Co.	2004
2.	Streetman, B.G. and Banerjee, S., "Solid State Electronic Devices", 6 th Ed., Prentice Hall of India.	2008
3.	Tyagi, M.S., "Introduction to Semiconductor Materials and Devices", John Wiley & Sons.	1991

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC – 541**

Course Title: **VLSI Physical Design**

2. Contact Hours:

L: 3

T: 0

P: 0

3. Examination Duration (Hrs.):

Theory

3

Practical

0

4. Relative Weight:

CWS

15

PRS

00

MTE

35

ETE

50

PRE

00

5. Credits: **3**

6. Semester: **Spring**

7. Subject Area: **PEC**

8. Pre-requisite: **EC-242 or equivalent**

9. Objective: To develop understanding of state-of-the-art tools and algorithms, which address design tasks such as floor planning, module placement and signal routing for VLSI logic and physical level design.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Introduction: Layout and design rules, materials for VLSI fabrication, basic algorithmic concepts for physical design, physical design processes and complexities.	2
2.	Partition: Kernigham-Lin's algorithm, Fiduccia Mattheyses algorithm, Krishnamurty extension, hMETIS algorithm, multilevel partition techniques.	6
3.	Floor-planning: Hierarchical design, wirelength estimation, slicing and non-slicing floorplan, polar graph representation, operator concept, Stockmeyer algorithm for floorplanning, mixed integer linear program.	10
4.	Placement: Design types: ASICs, SoC, microprocessor RLM; Placement techniques: Simulated annealing, partition-based, analytical, and Hall's quadratic; Timing and congestion considerations.	8
5.	Routing: Detailed, global and specialized routing, channel ordering, channel routing problems and constraint graphs, routing algorithms, Yoshimura and Kuh's method, zone scanning and net merging, boundary terminal problem, minimum density spanning forest problem, topological routing, cluster graph representation.	12
6.	Sequential logic optimization and cell binding: State based optimization, Library binding and its algorithms, concurrent binding.	4
Total		42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Sarrafzadeh, M. and Wong, C.K., "An Introduction to VLSI Physical Design", 4 th Ed., McGraw-Hill.	1996
2.	Wolf, W., "Modern VLSI Design System on Silicon", 2 nd Ed., Pearson Education.	2000
3.	Sait, S.M. and Youssef, H., "VLSI Physical Design Automation: Theory and Practice", World Scientific.	1999
4.	Dreschler, R., "Evolutionary Algorithms for VLSI CAD", 3 rd Ed., Springer.	2002
5.	Sherwani, N.A., "Algorithm for VLSI Physical Design Automation", 2 nd Ed., Kluwer.	1999
6.	Lim, S.K., "Practical Problems in VLSI Physical Design Automation", Springer.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC- 542**

Course Title: **Semiconductor Microwave Devices and Applications**

2. Contact Hours:

L: 3

T: 0

P: 0

3. Examination Duration (Hrs.):

Theory

3

Practical

0

4. Relative Weight:

CWS

15

PRS

00

MTE

35

ETE

50

PRE

00

5. Credits:

3

6. Semester:

Spring

7. Subject Area: **PEC**

8. Pre-requisite: **EC-332 or equivalent**

9. Objective: To introduce to the students the principles of operation of various microwave and millimeter wave semiconductor devices and their circuit applications.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Transient and ac behaviour of p-n junctions, effect of doping profile on the capacitance of p-n junctions, noise in p-n junctions, high-frequency equivalent circuit, varactor diode and its applications; Schottky effect, Schottky barrier diode and its applications; Heterojunctions.	8
2.	Tunneling process in p-n junction and MIS tunnel diodes, V-I characteristics and device performance, backward diode.	3
3.	Impact ionization, IMPATT and other related diodes, small-signal analysis of IMPATT diodes.	4
4.	Two-valley model of compound semiconductors, v_d -E characteristics, Gunn effect, modes of operation, small-signal analysis of Gunn diode, power-frequency limit.	4
5.	Construction and operation of microwave PIN diodes, equivalent circuit, PIN diode switches, limiters and modulators.	3
6.	High frequency limitations of BJT, microwave bipolar transistors, heterojunction bipolar transistors; Operating characteristics of MISFETs and MESFETs, short-channel effects, high electron mobility transistor.	7
7.	Characteristics and design of microstrips, slotlines and coplanar waveguides.	3
8.	Design considerations for microwave and millimeter wave amplifiers and oscillators, circuit realization, noise performance.	7
9.	Introduction to MEMS for RF applications: micromachining techniques for fabrication of micro switches, capacitors and inductors.	3
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication/Re print
1.	Liao, S.Y., "Microwave Devices and Circuits", 4 th Ed., Pearson Education.	2002
2.	Rebeiz, M.G., "R.F. MEMS: Theory, Design and Technology", 2 nd Ed., Wiley-Interscience.	2003
3.	Sze, S.M., and Ng, K.K., "Physics of Semiconductor Devices", 3 rd Ed., Wiley-Interscience.	2006
4.	Glover, I.A., Pennoek, S.R. and Shepherd P.R., "Microwave Devices, Circuits and Sub-Systems", 4 th Ed., John Wiley & Sons.	2005
5.	Golio, M., "RF and Microwave Semiconductor Devices Handbook", CRC Press.	2002
6.	Zumbahlen, H. (ed.), "Linear Circuit Design Handbook", Elsevier.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC – 543**

Course Title: **Optoelectronic Materials and Devices**

2. Contact Hours:

L: 3

T: 0

P: 0

3. Examination Duration (Hrs.):

Theory

3

Practical

0

4. Relative Weight:

CWS

15

PRS

00

MTE

35

ETE

50

PRE

00

5. Credits:

3

6. Semester: **Spring**

7. Subject Area: **PEC**

8. Pre-requisite: **EC-242 or equivalent**

9. Objective: To develop understanding of optical materials, working of optoelectronic devices and their applications.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Optical processes in semiconductors, EHP formation and recombination, absorption and radiation in semiconductor, deep level transitions, Auger recombination, luminescence and time resolved photoluminescence, optical properties of photonic band-gap materials.	7
2.	Junction photodiode: PIN, heterojunction and avalanche photodiode; Comparisons of various photodetectors, measurement techniques for output pulse.	5
3.	Photovoltaic effect, V-I characteristics and spectral response of solar cells, heterojunction and cascaded solar cells, Schottky barrier and thin film solar cells, design of solar cell.	6
4.	Modulated barrier, MS and MSM photodiodes; Wavelength selective detection, coherent detection; Microcavity photodiode.	7
5.	Dynamic effects of MOS capacitor, basic structure and frequency response of charge coupled devices, buried channel charge coupled devices.	5
6.	Electroluminescent process, choice of light emitting diode (LED) material, device configuration and efficiency; LED: Principle of operation, LED structure, frequency response, defects, and reliability.	5
7.	Semiconductor laser diode, Einstein relations and population inversion, lasing condition and gain, junction lasers, heterojunction laser, multi quantum well lasers, beam quantization and modulation.	7
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Streetman, B.G. and Banerjee, S., "Solid State Electronic Devices", 6 th Ed., Prentice-Hall of India.	2008
2.	Tyagi, M.S., "Introduction to Semiconductor Materials and Devices", John Wiley & Sons.	1991
3.	Bhattacharya, P., "Semiconductor Optoelectronic Devices", 3 rd Ed., Prentice-Hall.	1998
4.	Piprek, J., "Introduction to Physics and Simulation of Semiconductor Optoelectronic Devices", 4 th Ed., Academic Press.	2003
5.	Fakuda, M., "Optical Semiconductor Devices", 4 th Ed., John Wiley & Sons.	1998
6.	Kanu, K., "Semiconductor Devices", Pearson Education.	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC – 544**

Course Title: **Digital VLSI Circuit Design**

2. Contact Hours:

L: 3

T: 0

P: 0

3. Examination Duration (Hrs.):

Theory

3

Practical

0

4. Relative Weight:

CWS

15

PRS

00

MTE

35

ETE

50

PRE

00

5. Credits:

3

6. Semester: **Spring**

7. Subject Area: **PEC**

8. Pre-requisite: **EC-203 or equivalent**

9. Objective: To provide a thorough knowledge of digital VLSI circuit design - from inverter to memory - at various levels of abstraction.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Review: Basic MOS structure and its static behaviour; Quality metrics of a digital design: Cost, functionality, robustness, power, and delay.	2
2.	CMOS inverter: Static CMOS inverter, switching threshold and noise margin concepts and their evaluation, dynamic behaviour, power consumption and effect of scaling on CMOS performance metrics.	6
3.	CMOS combinational logic: Static CMOS design, ratioed logic, pass transistor logic, dynamic logic, speed and power dissipation in dynamic logic, cascading dynamic gates, CMOS transmission gate logic.	7
4.	CMOS sequential logic: Static latches and registers, bistability principle, MUX based latches, static SR flip-flops, master-slave edge-triggered register, dynamic latches and registers, concept of pipelining, pulse registers, nonbistable sequential circuit.	7
5.	Timing issues: Synchronous timing basics, classification, skew and jitter, and their sources, clock distribution techniques, self-timed circuit design, synchronisers and arbiters, clock synthesis and synchronization using PLL.	7
6.	Design of arithmetic building blocks: Adder, multiplier, shifter, and other operators; Power and speed trade-off in datapath structures.	5
7.	Memory and array structure: Core, ROM, RAM, peripheral circuitry, memory reliability and yield, SRAM and DRAM design, evaluation of RNM and WNM from butterfly curves, flash memory.	8
Total		42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Rabaey, J.M., Chandrakasan, A. and Nikolic, B., "Digital Integrated Circuits: A Design Perspective", 2 nd Ed., Prentice-Hall of India.	2006
2.	Kang, S. and Leblebici, Y., "CMOS Digital Integrated Circuits, Analysis and Design", 3 rd Ed., Tata McGraw-Hill.	2003
3.	Pucknell, D.A. and Eshraghian, K., "Basic VLSI Design", 3 rd Ed., Prentice-Hall of India.	1994
4.	Eshraghian, K., Pucknell, D.A. and Eshraghian, S., "Essentials of VLSI Circuit and System", 2 nd Ed., Prentice-Hall of India.	2005
5.	Hodges, D.A., Jackson, H.G. and Saleh, R.A., "Analysis and Design of Digital Integrated Circuits in Deep Submicron Technology", 3 rd Ed., Tata McGraw-Hill.	2005
6.	Uyemera, P.J., "Introduction to VLSI Circuits and Systems", 4 th Ed., John Wiley & Sons.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC-545** Course Title: **Semiconductor Materials and Devices**

2. Contact Hours: **L: 3 T: 0 P: 0**

3. Examination Duration (Hrs.): **Theory 3 Practical 0**

4. Relative Weight: **CWS 15 PRS 0 MTE 35 ETE 50 PRE 0**

5. Credits: 3 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To provide a thorough knowledge of semiconductor materials, devices and their characterization.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Semiconductor properties: Crystal structure, intrinsic and doped crystals, excess carriers and current transport.	4
2.	Band structure of semiconductors: Band structure, carrier energy and Fermi distributions for free carriers, donor and acceptor impurities, determination of band gap, impurity ionization, and critical temperatures for intrinsic ionization and onset of impurity deionization.	6
3.	Inhomogeneous impurity distribution: Impurity diffusion processes and profile derivations, built-in electric field and carrier profiles.	4
4.	Junction diode: p-n junction, tunnel diode, quasi Fermi levels, depletion width capacitance and its application in doping profile determination, I-V characteristics of narrow and wide base diodes and their equivalent circuits, breakdown mechanisms, small signal ac impedance.	6
5.	Bipolar transistor fundamentals: Formation of transistor, current gains, dc and low frequency characteristics, base resistance and power gain, drift and graded base transistors.	6
6.	Surface field effect transistors: Surface states, measurement of surface charge, Q-V/I-V characteristics and equivalent circuit models of MOS capacitor and MOSFET.	6
7.	Metal-semiconductor junctions: Rectifying and ohmic contacts, role of surface states, application in energy level characterization; Comparison of p-n junction and Schottky diodes.	6
8.	Pressure effects: Dependence of energy bandgap on pressure, evaluation of energy pressure coefficients, direct-indirect conversion and identification of defect levels.	4
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication /Reprint
1.	Lindmayer, J. and Wrigley, C. Y., "Fundamentals of Semiconductor Devices", D.Van Nostrand Co.	2004
2.	Streetman, B.G. and Banerjee, S., "Solid State Electronic Devices", 6 th Ed., Prentice Hall of India.	2005
3.	Tyagi, M.S., "Introduction to Semiconductor Materials and Devices", John Wiley & Sons.	1991

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: EC- 546 Course Title: MOS Device Physics and Modeling

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.):	Theory	3	Practical	0

4. Relative Weight: CWS 15 PRS 0 MTE 35 ETE 50 PRE 0

5. Credits: **3** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: Nil

9. Objective: To impart knowledge in the area of device modeling and back-end modeling techniques for circuit simulation.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Introduction: Circuit design, MOSFET modeling, model parameters, interconnects.	3
2.	MOS transistor structure and its operation: Characteristics, scaling theory, hot carrier effects, parasitic elements, MOSFET circuit models, modeling of hot carrier and short channel effects	8
3.	MOS capacitor: MOS capacitor with zero and nonzero bias, C-V curves, anomalous C-V curves, nonuniform doped substrate.	6
4.	MOSFET DC models: Pao-Sah model, charge sheet model, piece-wise linear model, models for depletion devices, carrier mobility models in deep-submicron and nanoscale dimensions, short geometry models, source/drain resistance evaluation.	6
5.	Dynamic models: Intrinsic charges and capacitance, Meyers model, quasi-static and non-quasi-static model, low frequency modeling of MOS transistors, high frequency modeling of MOS transistors.	8
6.	SPICE MOSFET models: Level 1, 2, 3 and 4 models and their comparison.	5
7.	Statistical modeling: Model sensitivity, principal factor method, principal component analysis, regression models.	6
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication /Reprint
1.	Arora, N., "MOSFET Models for VLSI Circuit Simulation: Theory and Practice", 4 th Ed., Springer-Verlag.	1993
2.	Tsividis, Y., "Operation and Modeling of the MOS Transistor", 2 nd Ed., Oxford University Press.	2003
3.	Sze, S. M., and Ng, K. K., "Physics of Semiconductor Devices", 3 rd Ed., Wiley-Interscience.	2006
4.	Liu, W., "MOSFET Models for Spice Simulation (including BSIM3v3 and BSIM4)", Wiley-IEEE Press	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC- 547**

Course Title: **Compound Semiconductors and RF Devices**

2. Contact Hours:

L: 3

T: 0

P: 0

3. Examination Duration (Hrs.):

Theory

3

Practical

0

4. Relative Weight:

CWS

15

PRS

0

MTE

35

ETE

50

PRE

0

5. Credits:

3

6. Semester: **Spring**

7. Subject Area: **PEC**

8. Pre-requisite: **EC-242 or equivalent**

9. Objective: To provide knowledge of various compound semiconductor alloys, and their growth, properties, devices and applications.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	III-V opto- and high frequency materials: Bonds, crystal lattices, crystallographic planes and directions, direct and indirect semiconductors and their comparison for optical applications, optical processes of absorption and emission, radiative and non-radiative deep level transitions, phase and energy band diagrams of binary, ternary and quaternary alloys, determination of cross-over compositions and band structures.	10
2.	High frequency devices: Gunn diode, RWH mechanism, v-E characteristic, formation of domains, modes of operation in resonant circuits, fabrication, control of v-E characteristics by ternary and quaternary alloys.	8
3.	Heterostructures: Introduction, abrupt isotype/anisotype junctions, band diagrams and band off-sets, electrical and optoelectronic properties, symmetrical and asymmetrical p-n diodes and their characteristics, 2-Dimensional Electron Gas (2-DEG).	8
4.	Heterostructure devices: HBT, MOSFET, HEMT, quantum well and tunneling structures, lasers, LED and photodetectors, optoelectronic IC's and strained layer structures.	8
5.	Miscellaneous devices: Compound semiconductor MESFETs, infrared and window effect in photovoltaic converters, strain sensors and their sensitivities, QWITT and DOVETT devices.	8
Total		42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication /Reprint
1.	Streetman, B.G. and Banerjee, S., "Solid State Electronic Devices", 6 th Ed., Prentice Hall of India.	2008
2.	Sharma, B.L. and Purohit, R.K., "Semiconductor Heterojunctions", Pergamon Press.	1991
3.	Mayer, J.W. and Lau, S.S., "Electronic Materials Science: For Integrated Circuits in Si and GaAs", Macmillan.	1990
4.	Tyagi, M.S., "Introduction to Semiconductor Materials and Devices", John Wiley & Sons.	1991
5.	Sze, S.M., "VLSI Technology", 4 th Ed., Tata McGraw-Hill.	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC-548** Course Title: **Analog VLSI Circuit Design**

2. Contact Hours: **L: 3 T: 0 P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weight: **CWS** 15 **PRS** 0 **MTE** 35 **ETE** 50 **PRE** 0

5. Credits: 3 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **EC-301 or equivalent**

9. Objective: To acquaint the students with basic CMOS analog building blocks, sub-system design and challenges in deep sub-micron technologies.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	CMOS device fundamentals: Introduction; Basic MOS models, device capacitances, parasitic resistances, substrate models, transconductance, output resistance, f_T , frequency dependence of device parameters, device parameters in subthreshold operation.	2
2.	Basic analog building blocks: Single stage amplifier configurations, cascade stage, frequency response of single stage amplifiers, basic differential pair, differential pair with MOS loads, device mismatch effects, frequency response of differential amplifiers, Basic current mirrors, cascode current mirrors, active current mirrors, biasing, impact of device mismatch, on-chip feedback network, noise, impact of feedback on noise.	7
3.	Operational amplifiers: Performance parameters, one-stage and two-stage Op Amps, gain boosting, comparison, common mode feedback, input range, slew rate, power supply rejection, noise in Op Amps.	4
4.	Non-linear analog blocks: Comparators, charge-pump circuits and multipliers.	6
5.	Oscillators and phase locked loop: Ring oscillators, LC oscillators, voltage controlled oscillators, simple Phase Locked Loop (PLL), charge pump PLL, delay locked loops.	6
6.	Data converters: Data converters fundamentals, DAC architectures, ADC architectures	6
7.	Basic CMOS RF IC Design: Circuit design of transceivers, CMOS Low noise amplifiers and mixers, power amplifiers	6
8.	DSM issues: Impact of DSM effects on analog circuits, analog interconnects, layout issues, low voltage and low-power circuits.	5
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Razavi, B., "Design of Analog CMOS Integrated Circuits", McGraw Hill.	2003
2.	Gray, P. R., Hurst, P. J., Lewis, S. H., and Meyer, R.G., "Analysis and Design of Analog Integrated Circuits", 4 th Ed., John Wiley & Sons.	2001
3.	Baker, R. J., Li, H. W. and Boyce, D. E., "CMOS Circuit Design Layout and Simulation", Prentice-Hall of India.	2000
4.	Lee, T. H., "The Design of CMOS Radio-Frequency Integrated Circuits", 2 nd Ed., Cambridge University Press.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC-549**

Course Title: **VLSI Technology**

2. Contact Hours:

L: 3

T: 0

P: 0

3. Examination Duration (Hrs.):

Theory

3

Practical

0

4. Relative Weight:

CWS

15

PRS

0

MTE

35

ETE

50

PRE

0

5. Credits:

3

6. Semester: **Spring**

7. Subject Area: **PEC**

8. Pre-requisite: **EC-242 or equivalent**

9. Objective: To provide knowledge of various processes and techniques for VLSI fabrication technologies.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Introduction to VLSI technology: Device scaling and Moore's law, basic device fabrication methods, alloy junction and planar process.	4
2.	Crystal growth: Czochralski and Bridgman techniques, characterization methods and wafer specifications, defects in Si and GaAs.	4
3.	Oxidation: Surface passivation using oxidation. Deal-Grove model, oxide characterization, types of oxidation and their kinematics, thin oxide growth models, stacking faults, oxidation systems.	4
4.	Diffusion and ion-implantation: Solutions of diffusion equation, diffusion systems, ion implantation technology, ion implant distributions, implantation damage and annealing, transient enhanced diffusion and rapid thermal processing.	6
5.	Epitaxy and thin film deposition: Thermodynamics of vapor phase growth, MOCVD, MBE, CVD, reaction rate and mass transport limited depositions, APCVD/LPVD, equipments and applications of CVD, PECVD, and PVD.	5
6.	Etching: Wet etching, selectivity, isotropy and etch bias, common wet etchants, orientation dependent etching effects; Introduction to plasma technology, plasma etch mechanisms, selectivity and profile control plasma etch chemistries for various films, plasma etch systems.	4
7.	Lithography: Optical lithography contact/proximity and projection printing, resolution and depth of focus, resist processing methods and resolution enhancement, advanced lithography techniques for nanoscale patterning, immersion, EUV, electron, X-ray lithography.	5

8.	Interconnect and backend technology: Interconnect RC delay and scaling, multilevel interconnect, inter-metal dielectric films, planarization, chemical mechanical polishing (CMP), oxide and metal CMP, metal migration, Cu interconnect technology.	4
9.	VLSI process integration: CMOS IC technology, strained Si processes, high k-metal gate and Copper low-k technologies, MOS memory technology, bipolar IC fabrication.	3
10.	Assembly, packaging yield and reliability: Package types, VLSI assembly technologies; Yield loss and modeling, reliability requirements, accelerated testing, BIST.	3
Total		42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication /Reprint
1.	Plummer, J.D., Deal, M.D. and Griffin, P.B., "Silicon VLSI Technology: Fundamentals, Practice and Modeling", 3 rd Ed., Prentice-Hall.	2000
2.	Sze, S.M., "VLSI Technology", 4 th Ed., Tata McGraw-Hill.	1999
3.	Chang, C.Y. and Sze, S.M., "ULSI Technology", McGraw-Hill.	1996
4.	Gandhi, S. K., "VLSI Fabrication Principles: Silicon and Gallium Arsenide", John Wiley and Sons.	2003
5.	Campbell, S.A., "The Science and Engineering of Microelectronic Fabrication", 4 th Ed., Oxford University Press.	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC-641** Course Title: **CAD for VLSI**
2. Contact Hours: L: **3** T: **0** P: **0**
3. Examination Duration (Hrs.): Theory **3** Practical **0**
4. Relative Weightage: CWS **15** PRS **00** MTE **35** ETE **50** PRE **00**
5. Credits: **3** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **EC203 or equivalent**

9. Objective: To provide knowledge on the front end design aspects of VLSI chip manufacturing cycle.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Introduction: Evolution of design automation; CMOS realizations of basic gates.	3
2.	Circuit and system representation: Behavioral, structural and physical models, design flow.	4
3.	Modeling techniques: Types of CAD tools, introduction to logic simulation and synthesis.	4
4.	HDL: Syntax, hierarchical modeling, Verilog construct, simulator directives, instantiating modules, gate level modeling.	6
5.	Delay modeling: Event based and level sensitive timing control, memory initialization, conditional compilation, time scales for simulation.	5
6.	Advanced modeling techniques: Static timing analysis, delay, switch level modeling, user defined primitive (UDP), memory modeling.	5
7.	Logic synthesis: Logic synthesis of HDL construct, technology cell library, design constraints, synthesis of Verilog construct.	6
8.	Model optimization: Various optimization techniques, design size.	4
9.	FPGAs based system design: Commercial FPGA architecture, LUT and routing architecture, FPGA CAD flow; Typical case studies.	5
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors/Books/ Publishers	Year of Publication /Reprint
1.	Weste, N. and Eshraghian, K., "Principles of CMOS VLSI Design –A Systems Perspective", 2 nd Ed., Addison Wesley.	2006
2.	Palnitkar, S., "Verilog HDL", 2 nd Ed., Pearson Education.	2004
3.	Wolf, W., "Modern VLSI Design: System on Chip", 2 nd Ed., Prentice Hall of India.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC-642** Course Title: **Nanoscale Devices and Circuit Design**

2. Contact Hours: **L: 3 T: 0 P: 0**

3. Examination Duration (Hrs.): **Theory 3 Practical 0**

4. Relative Weight: **CWS 15 PRS 00 MTE 35 ETE 50 PRE 00**

5. Credits: **3** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **EC242 or equivalent**

9. Objective: To provide knowledge of fabrication technologies, device physics/operation, circuit design trends, and issues in nanoscale CMOS and emerging devices.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	CMOS scaling challenges in nanoscale regimes: Leakage current mechanisms in nanoscale CMOS, leakage control and reduction techniques, process variations in devices and interconnects.	4
2.	Device technologies for sub 100nm CMOS: Silicidation and Cu-low k interconnects, strain silicon – biaxial stain and process induced strain; Metal-high k gate; Emerging CMOS technologies at 32nm scale and beyond – FINFETs, surround gate nanowire MOSFETs, heterostructure (III-V) and Si-Ge MOSFETs.	7
3.	Device scaling and ballistic MOSFET: Two dimensional scaling theory of single and multigate MOSFETs, generalized scale length, quantum confinement and tunneling in MOSFETs, velocity saturation, carrier back scattering and injection velocity effects, scattering theory of MOSFETs.	7
4.	Emerging nanoscale devices: Si and hetero-structure nanowire MOSFETs, carbon nanotube MOSFETs, quantum wells, quantum wires and quantum dots; Single electron transistors, resonant tunneling devices.	6
5.	Nanoscale CMOS design: CMOS logic power and performance, voltage scaling issues; Introduction to low power design; Performance optimization for data paths.	7
6.	Nanoscale circuits: Statistical circuit design, variability reduction, design for manufacturing and design optimization; Sequential logic circuits, registers, timing and clock distribution, IO circuits and memory design and trends.	7

7.	Non-classical CMOS: CMOS circuit design using non-classical devices – FINFETs, nanowire, carbon nanotubes and tunnel devices.	4
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication /Reprint
1.	Lundstrom, M., "Nanoscale Transport: Device Physics, Modeling, and Simulation", Springer.	2000
2.	Maiti, C.K., Chattopadhyay, S. and Bera, L.K., "Strained-Si and Hetrostructure Field Effect Devices", Taylor and Francis.	2007
3.	Hanson, G.W., "Fundamentals of Nanoelectronics", Pearson India.	2008
4.	Wong, B.P., Mittal, A., Cao Y. and Starr, G., "Nano-CMOS Circuit and Physical Design", Wiley.	2004
5.	Lavagno, L., Scheffer, L. and Martin, G., "EDA for IC Implementation Circuit Design and Process Technology", Taylor and Francis.	2005

**PROPOSED CURRICULAR STRUCTURE AND SCHEME
FOR
M. TECH (RF AND MICROWAVE ENGINEERING)**

DEPARTMENT OF ELECTRONICS AND COMPUTER ENGINEERING														
RF and Microwave Engineering (RFM)														
Teaching Scheme					Contact Hours Per Week			Examination Duration(Hr)		Relative Weight (in %)				
Serial No.	SUBJECT CODE	COURSE TITLE	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
YEAR I														
Ist Semester (Autumn)														
1.	MA 501A	Complex Analysis and Linear Algebra	ICC	4	3	1	0	3	-	25	-	25	50	-
2.	EC-500	Object Oriented Programming and Design	PCC	4	3	0	2	3	-	15	15	30	40	-
3.	EC-531	Microwave Engineering	PCC	3	3	0	0	3	-	15	-	35	50	-
4.	EC-532	Electromagnetic Field Theory	PCC	3	3	0	0	3	-	15	-	35	50	-
5.	EC-530	Microwave Laboratory	PCC	2	0	0	3	0	-	-	100	-	-	-
6.		Open Elective-I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
7.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				19 - 22										
IInd Semester (Spring)														
1.		Programme Elective 1	PEC	3	-	-	-	-	-	-	-	-	-	-
2.		Programme Elective 2	PEC	3	-	-	-	-	-	-	-	-	-	-
3.		Programme Elective 3	PEC	3	-	-	-	-	-	-	-	-	-	-
4.		Programme Elective 4	PEC	3	-	-	-	-	-	-	-	-	-	-
5.	EC-630	Wireless communications Laboratory	PCC	2	0	0	3	-	-	-	100	-	-	-
6.		Open Elective-II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
7.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				17 - 20										

**PROPOSED CURRICULAR STRUCTURE AND SCHEME
FOR
M. TECH (RF AND MICROWAVE ENGINEERING)**

DEPARTMENT OF ELECTRONICS AND COMPUTER ENGINEERING														
RF and Microwave Engineering (RFM)														
Teaching Scheme					Contact Hours Per Week			Examination Duration(Hr)		Relative Weight (in %)				
Serial No.	SUBJECT CODE	COURSE TITLE	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
YEAR II														
IIIrd Semester (Autumn)														
1.	EC-601	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	EC-602	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	EC-603	Dissertation*	DIS	-	-	-	-	-	-	-	-	-	25	-
Sub Total				6										
* To be continued and grade to be awarded in the next semester														
IVth Semester (Spring)														
1.	EC-603	Dissertation (continued from Semester III)	DIS	20	-	-	-	-	-	-	-	-	75	-
Sub Total				20										
GRAND TOTAL				62 - 66										

Programme Electives for M.Tech (RF and Microwave Engineering)

Teaching Scheme					Contact Hours Per Week			Examination Duration (Hr.)		Relative weight (In %)				
Serial No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1.	EC-534	Antenna Theory and Design	PEC	3	3	0	0	3	-	15	-	35	50	-
2.	EC-535	RF Packaging and Electromagnetic Compatibility	PEC	3	3	0	0	3	-	15	-	35	50	-
3.	EC-536	Radar Systems	PEC	3	3	0	0	3	-	15	-	35	50	-
4.	EC-537	Microwave and Millimeter Wave Circuits	PEC	3	3	0	0	3	-	15	-	35	50	-
5.	EC-538	Wireless Channels and UWB Radio	PEC	3	3	0	0	3	-	15	-	35	50	-
6.	EC-539	Fibre Optic Systems	PEC	3	3	0	0	3	-	15	-	35	50	-
7.	EC-631	RF Receiver Design for Wireless Applications	PEC	3	3	0	0	3	-	15	-	35	50	-
8.	EC-632	RF and Microwave MEMS	PEC	3	3	0	0	3	-	15	-	35	50	-
9.	EC-633	Computational Methods for Electromagnetics	PEC	3	3	0	0	3	-	15	-	35	50	-

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Electronics and Computer Engineering**

1. Subject Code: **EC- 530**

Course Title: **Microwave Laboratory**

2. Contact Hours:

L: 0

T: 0

P: 3

3. Examination Duration (Hrs.):

Theory

0

Practical

0

4. Relative Weight:

CWS

00

PRS

100

MTE

00

ETE

00

PRE

00

5. Credits:

2

6. Semester: **Autumn**

7. Pre-requisite: **EC-332 or equivalent**

8. Subject Area: **PCC**

9. Objective: To introduce to the students various microwave sources, components, equipment, and simulation software used in the practice of microwave engineering.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	Study of microwave sources and components Study of crystal detector characteristics Measurement of VSWR, impedance and frequency Measurement of attenuation and dielectric constant Measurement of phase shift Measurement of Q of a cavity resonator Measurement of directional coupler characteristics Measurement of antenna characteristics Study of Spectrum Analyzer Study of Network Analyzer Study and use of different electromagnetic simulation software For the design of microwave circuits	14x3
Total		42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication
1.	Pozar, D.M., "Microwave Engineering", 3 rd Ed., John Wiley & Sons.	2004
2.	Collin, R.E., "Foundations for Microwave Engineering", 2 nd Ed., John Wiley & Sons.	2000
3.	Collier, R. and Skinner, D., "Microwave Measurements", 3 rd Ed., Artech House.	2007
4.	Laverghetta, T.S., "Modern Microwave Measurements and Techniques", Artech House.	1988

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Electronics and Computer Engineering**

1. Subject Code: **EC-532** Course Title: **Electromagnetic Field Theory**

2. Contact Hours: **L: 3 T: 0 P: 0**

3. Examination Duration (Hrs.): **Theory 0 Practical 0**

4. Relative Weight: **CWS 15 PRS 0 MTE 35 ETE 50 PRE 0**

5. Credits: **3** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the students to analytical techniques used in solving electromagnetic field theory problems.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	Electromagnetic waves: Coordinate systems; Maxwell's equations for time-varying fields and boundary conditions; Poynting vector; Wave equation; Wave polarization; Wave propagation in perfect and lossy dielectrics; Reflection of waves on a material boundary; Wave functions.	10
2.	Fundamental Theorems and Concepts: Electric and magnetic current sources; Duality; Image theory; Equivalence principle; Babinet's principle; Induction theorem; Reciprocity theorem; Auxiliary potentials; Construction of general solutions from wave functions; Radiation fields.	7
3.	Plane Wave Functions: Elementary wave functions in rectangular coordinates; TE, TM, and hybrid modes in rectangular waveguides; Partially filled waveguides; Rectangular cavity; Modal expansion of fields in a waveguide; Apertures in conducting screens.	8
4.	Cylindrical Wave Functions: Elementary wave functions in cylindrical coordinates; Homogeneously filled and partially filled circular waveguides; Radial waveguides; Cylindrical cavities; Sources of cylindrical waves.	8
5.	Spherical Wave Functions: Elementary wave functions in spherical coordinates; Spherical resonator; Sources of spherical waves.	4
6.	Wave Propagation in Anisotropic Media: Plane wave propagation in anisotropic and uniaxial crystals; TEM wave propagation in Ferrites; Faraday rotation.	5
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors / Books /Publishers	Year of Publication
1.	Harrington, R.F., "Time-harmonic Electromagnetic Fields", Wiley-IEEE Press.	2001
2.	Ramo, S., Whinnery, J.R., and Van Duzer, T., "Fields and Waves in Communication Electronics", 3 rd Ed., John Wiley & Sons.	1994
3.	Collin, R.E., "Foundations for Microwave Engineering", 2 nd Ed., John Wiley & Sons.	2000
4.	Balanis, C.E., "Advanced Engineering Electromagnetics", Wiley India Pvt. Ltd., Reprint	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT./CENTRE: **Electronics and Computer Engineering**

1. Subject Code: **EC – 538** Course Title: **Wireless Channels and UWB Radio**

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weight: CWS 15 PRS 00 MTE 35 ETE 50 PRE 00

5. Credits: 3

6. Semester : **Spring**

7. Pre-requisite: **EC - 334 or equivalent**

8. Subject Area: **PEC**

9. Objective: The objective of this course is to provide to the students a detailed understanding of the characteristics of common wireless channels and their influence on system performance. The students will also be exposed to the upcoming area of UWB systems.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	Fundamental Concepts: Terrestrial links, satellite links, macrocells, microcells, picocells, body-centric systems, UWB systems; Cellular concept; Multiple-access schemes and duplexing; Review of antenna parameters; Friis transmission formula.	5
2.	Propagation Mechanisms: Review of reflection, refraction, and transmission of electromagnetic waves on a plane boundary; Rough surface scattering; Computation of field strength using ray optics; Wedge diffraction theory; Ray-fixed coordinate system; Uniform theory of diffraction.	8
3.	Basic Propagation Models: Path loss, noise modeling, free space loss, plane earth loss, link budget.	2
4.	Terrestrial Fixed Links: Path profiles, tropospheric refraction, obstruction loss, multiple knife-edge diffraction, multiple edge diffraction integral, diffraction over objects of finite size, influence of clutter.	4
5.	Satellite Fixed Links: Effect of troposphere and ionosphere on path loss and noise.	2
6.	Mobile Communication Links: Empirical and physical models for path loss; Statistical shadowing and its impact on coverage; Correlated shadowing; Narrowband fast fading: AWGN channel and narrowband fast fading channels, Rayleigh and Rician distributions, Doppler effect; Wideband fast	10

	fading: Cause and effect, wideband channel model and its parameters, frequency domain effects; Diversity techniques to overcome the effects of multipath channel.	
7.	Ultra-wideband (UWB) Radio: Definition, benefits and applications of UWB, properties of UWB signals and systems; Waveform generation: Gaussian waveforms, waveform design for specific spectral masks, practical constraints; UWB channel models: Multipath channel model, path loss model, two-ray propagation model, measurement of channel characteristics; UWB antennas: Challenges in UWB antenna design, radiation of UWB signals, types of UWB antennas, beamforming for UWB signals.	9
8.	Introduction to Body-Centric Wireless Systems.	2
	Total	42

11. Suggested Books:

Sl. No.	Names of Authors/Books/Publishers	Year of Publication
1.	Saunders, S.R., "Antennas and Propagation for Wireless Communication Systems", John Wiley & Sons.	1999
2.	Stutzman, W.L. and Thiele, H.A. "Antenna Theory and Design", 2 nd Ed., John Wiley & Sons.	1998
3.	Rappaport, T.S., "Wireless Communications: Principles and Practice", Pearson Education.	2002
4.	Ghavami, M., Michael, L.B., and Kohno, R., "Ultra Wideband Signals and Systems in Communication Engineering", 2 nd Ed., John Wiley & Sons.	2007
5.	Siwiak, K. and McKeown, D., "Ultra-wideband Radio Technology", John Wiley & Sons.	2004
6.	Hall, P.S. and Hao, Y. (Eds.), "Antennas and Propagation for Body-Centric Wireless Communication", Artech House.	2006
7.	Pahlavan, K. and Levesque, A.H., "Wireless Information Networks", John Wiley & Sons.	1995
8.	Hess, G.C., "Land-mobile Radio System Engineering", Artech House.	1993

**PROPOSED CURRICULAR STRUCTURE AND SCHEME
FOR
M. TECH (SYSTEM MODELING AND CONTROL)**

DEPARTMENT OF ELECTRONICS AND COMPUTER ENGINEERING														
System Modeling and Control (SMC)														
Teaching Scheme					Contact Hours Per Week			Examination Duration(Hr)		Relative Weight (in %)				
Serial No.	SUBJECT CODE	COURSE TITLE	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
YEAR I														
Ist Semester (Autumn)														
1.	MA 501E	Optimization Techniques	ICC	4	3	1	0	3	-	25	-	25	50	-
2.	EC-500	Object Oriented Programming and Design	PCC	4	3	0	2	3	-	15	15	30	40	-
3.	EC-524	System Theory	PCC	3	3	0	0	3	-	15	-	35	50	-
4.	EC-525	Control Systems	PCC	3	3	0	0	3	-	15	-	35	50	-
5.	EC-520	Laboratory	PCC	2	0	0	3	0	-	-	100	-	-	-
6.		Open Elective	OEC	3/4	-	-	-	-	-	-	-	-	-	-
7.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				19 - 22										
IInd Semester (Spring)														
1.		Programme Elective 1	PEC	3	-	-	-	-	-	-	-	-	-	-
2.		Programme Elective 2	PEC	3	-	-	-	-	-	-	-	-	-	-
3.		Programme Elective 3	PEC	3	-	-	-	-	-	-	-	-	-	-
4.		Programme Elective 4	PEC	3	-	-	-	-	-	-	-	-	-	-
5.		Open Elective	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				15 - 18										

**PROPOSED CURRICULAR STRUCTURE AND SCHEME
FOR
M. TECH (SYSTEM MODELING AND CONTROL)**

DEPARTMENT OF ELECTRONICS AND COMPUTER ENGINEERING														
System Modeling and Control (SMC)														
Teaching Scheme					Contact Hours Per Week			Examination Duration(Hr)		Relative Weight (In %)				
Serial No.	SUBJECT CODE	COURSE TITLE	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
YEAR II														
IIIrd Semester (Autumn)														
1.	EC-601	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	EC-602	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	EC-603	Dissertation*	DIS	-	-	-	-	-	-	-	-	-	25	-
Sub Total				6										
* To be continued and grade to be awarded in the next semester														
IVth Semester (Spring)														
1.	EC-603	Dissertation (continued from Semester III)	DIS	20	-	-	-	-	-	-	-	-	75	-
Sub Total				20										
GRAND TOTAL				60 - 64										

Programme Electives for M.Tech (System Modeling and Control)

Teaching Scheme					Contact Hours Per Week			Examination Duration (Hr.)		Relative weight (In %)				
Serial No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1.	EC-521	Fuzzy Control	PEC	3	3	0	0	3	-	15	-	35	50	-
2.	EC-522	Digital Control Systems	PEC	3	3	0	0	3	-	15	-	35	50	-
3.	EC-523	Robotics and Computer Vision	PEC	3	3	0	0	3	-	15	-	35	50	-
4.	EC-527	Dynamic Systems and Optimization	PEC	3	3	0	0	3	-	15	-	35	50	-
5.	EC-526	Non – Linear and Adaptive Control	PEC	3	3	0	0	3	-	15	-	35	50	-
6.	EC-553	Soft Computing Techniques	PEC	3	3	0	0	3	-	15	-	35	50	-

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT /CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC – 520**

Course Title: **Laboratory**

2. Contact Hours:

L: 0

T: 0

P: 3

3. Examination Duration (Hrs.):

Theory

0

Practical

0

4. Relative Weight:

CWS

0

PRS

100

MTE

0

ETE

0

PRE

0

5. Credits:

2

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To expose students to the techniques of modeling, analysis and design of simple linear and non-linear dynamic control systems.

10. Details of Course:

Sl. No.	Contents	Contact Hours
	Study of linear systems of different order and type numbers. Controller design and performance improvement. Setting up and evaluation of position and speed control systems. Study of digital control systems. Process control system study- a temperature control model. Stepper motor control using microprocessor and microcontroller. Nonlinear system study using phase plane technique.	14 x 3
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Ogata, K., "Modern Control Engineering", 5 th Ed., Prentice Hall of India.	2009
2.	Kuo, B.C., "Digital Control Systems", 2 nd Ed., Oxford University Press.	2008
3.	Chen, C. T., "Linear System Theory and Design", 3 rd Ed., Oxford University Press.	1998
4.	Gopal, M., "Control Systems: Principles and design", 2 nd Ed., Tata-McGraw-Hill	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT./CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC – 523** Course Title: **Robotics and Computer Vision**

2. Contact Hours: **L: 3 T: 0 P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weight: **CWS** 15 **PRS** 0 **MTE** 35 **ETE** 50 **PRE** 0

5. Credits: 3 6. Semester : **Spring** 7. Subject Area: **PEC**

7. Pre-requisite: **EC- 321 or equivalent**

9. Objective: The course introduces the fundamentals of robot dynamics, its features and performance, controller techniques, and image analysis for obstacle avoidance.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Definition, structure and application areas of Robotics; Introduction to the range of robots currently in use.	4
2.	Direct kinematics of the robot arm, link description and its connection; Frame assignment; Concept of actuator space, joint space and Cartesian space; Inverse kinematics, algebraic solution, geometric solution; Solvability considerations and examples.	6
3.	Manipulator dynamics, basic equations, Newton-Euler dynamic formulation; Lagrange formulation of the manipulator dynamics; Simulation.	8
4.	Controller design, linear and non-linear control approaches, special considerations like coupling, time-variation and model uncertainty; Computed torque, variable structure and adaptive control techniques.	9
5.	Digital image fundamentals, digitization and 2-D parameters, types of operation; Basic tools: Convolution, Fourier transforms and statistical approaches.	6
6.	Image analysis and processing, basic enhancement and restoration techniques, unsharp masking, noise suppression, distortion suppression, segmentation, thresholding, edge finding, binary mathematical morphology, grey-value mathematical morphology.	9
Total		42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Fu, K.S., Gonzalez, R.C. and Lee, C.S.G., "Robotics: Control, Sensing, Vision and Intelligence", McGraw-Hill.	1987
2.	Pratt, W.K., "Digital Image Processing", 2 nd Ed., John Wiley & Sons.	1991
3.	Gonzalez, R.C. and Woods, R.E., "Digital Image Processing", 3 rd Ed., Prentice-Hall.	2008
4.	Klafter, R.D., Chmielewski, T.A. and Negin, M., "Robotic Engineering An Integrated Approach", Prentice-Hall of India.	2007
5.	Schilling, R. J., "Fundamental of Robotics: Analysis and Control", Prentice-Hall of India.	2007
6.	Sciavicco, L., "Modeling and Control of Robot Manipulators", McGraw-Hill.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC- 524**

Course Title: **System Theory**

2. Contact Hours:

L: 3

T: 0

P: 0

3. Examination Duration (Hrs.): **Theory**

3

Practical

0

4. Relative Weight: **CWS**

15

PRS

0

MTE

35

ETE

50

PRE

0

5. Credits:

3

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To provide the students with a background in the mathematical system theory used in the analysis and design of linear dynamical systems.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Basic concepts and approach – system modeling, analysis and design, options.	4
2.	System characterization and representation – input-output and state variable, properties and examples, inter-conversion.	6
3.	Coordinate transformation, development of canonical forms; Composite systems.	5
4.	Solution of LTIV system equations, controllability and observability, duality, pole-zero cancellation and relation with transfer function.	5
5.	State feedback, output feedback, single and multivariable cases, observer theory; Decoupling.	8
6.	Realization theory, irreducible realizations of proper rational functions, transfer functions and matrices, co-prime fraction method.	8
7.	Polynomial system matrix representation and analysis.	6
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors/Books/Publishers	Year of Publication /Reprint
1.	Chen, C. T., "Linear System Theory and Design", 3 rd Ed., Oxford University Press.	1998
2.	Patel, R.V. and Munro N., "Multivariable System Theory and Design", Pergamon Press.	1982
3.	Ogata, K., "Modern Control Engineering", 5 th Ed., Prentice Hall of India.	2009
4.	D'Azzo, J.J. and Houpis, C.H., "Control System Analysis and Design", 5 th Ed., Taylor and Francis.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept .of Electronics and Computer Engineering**

1. Subject Code: **EC-525**

Course Title: **Control Systems**

2. Contact Hours:

L: 3

T: 0

P: 0

3. Examination Duration (Hrs.): **Theory**

Practical

4. Relative Weight: **CWS** **PRS** **MTE** **ETE** **PRE**

5. Credits:

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To introduce conventional design techniques of control systems including carrier control systems, the concepts of sensitivity and robustness, and frequency domain design of multivariable systems.

10. Details of the course:

Sl. No.	Contents	Contact Hours
1.	Characteristics of simple compensation networks, trial-and error design of SISO systems in frequency domain and in s-plane.	10
2.	PID controllers, features, Ziegler-Nichol and Cohen-Coon tuning rules; Simulation examples.	8
3.	Carrier system components and their characteristics; Analysis of carrier control systems; Design of carrier compensation networks.	8
4.	Multivariable systems in the frequency domain; Concepts of decoupling zeros, diagonal dominance; Gershgorin bands; Design of multivariable systems.	10
5.	Sensitivity and robustness of control systems, sensitivity matrix, robust system design.	6
Total		42

11. Suggested Books:

Sl. No.	Name of Authors / Books / Publishers	Year of Publication / Reprint
1.	Morari, M. and Zafiriou, E., "Robust Process Control", Prentice Hall.	1989
2.	Lunze, J., "Robust Multivariable Feedback Control", Prentice Hall.	1989
3.	Rosenbrock, H. H., "State Space and Multivariable Theory", John Wiley and Sons.	1970
4.	Patel, R. and Munro, N., "Multivariable System Theory and Design", Pergamon Press.	1982
5.	Ivey, K. A., "Carrier Control Systems", John Wiley.	1964
6.	Bequette, B.W., "Process Control: Modeling, Design and Simulation", Prentice Hall.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC-526** Course Title: **Non-linear and Adaptive Control**

2. Contact Hours: **L: 3 T: 0 P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weight: **CWS** 15 **PRS** 0 **MTE** 35 **ETE** 50 **PRE** 0

5. Credits: 3 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **EC-525 or equivalent**

9. Objective: To introduce the techniques used for the analysis of nonlinear systems, and the concepts of adaptive systems and their design principles.

10. Details of the course:

Sl. No.	Contents	Contact Hours
1.	Definition and sources of non-linearity in physical systems; Categorization of non-linearities and their analysis using Describing Function method.	8
2.	Phase plane method, approximate sketching, singular points and their properties, application to stability studies; Simulation examples.	6
3.	Lyapunov's definition of stability; First and second methods of Lyapunov; Generation of Lyapunov's function.	10
4.	Exact frequency domain stability criterion of Popov, extensions – pole shifting, zero shifting and circle criterion; Examples.	8
5.	Concept and simple examples of adaptive control; Automatic methods of process identification; Model reference adaptive control.	10
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors/Books/Publishers	Year of Publication/ Reprint
1.	Astorn, K. J. and Wittenmark, B., "Adaptive Control", 2nd Ed., Pearson.	2001
2.	Golnaraghi, F. and Kuo, B. C., "Automatic Control Systems", 9 th Ed., Wiley.	2009
3.	Ogata, K., "Modern Control Engineering", 5 th Ed., Prentice Hall of India.	2009
4.	Hsu, J.C. and Meyer, A.U., "Modern Control Principles and Applications", McGraw Hill.	1968
5.	Timothy, L. K. and Bona, B. E., "State Space Analysis – An Introduction", McGraw-Hill.	1968

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **Dept. of Electronics and Computer Engineering**

1. Subject Code: **EC-527** Course Title: **Dynamic Systems and Optimization**

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.): **Theory**

3

Practical

0

4. Relative Weight: CWS 15 PRS 0 MTE 35 ETE 50 PRE 0

5. Credits: **3** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: EC- 321 or equivalent

9. Objective: To introduce the concepts of analytical optimization techniques for dynamic systems in time and frequency domains.

10. Details of the course:

Sl. No.	Contents	Contact Hours
1.	Introduction to optimum control, analytical and search methods.	1
2.	Idea of analytical design in the frequency domain – stochastic signals and their characterization; Fixed, free and semi-free configurations, concept of mean square error and its minimization.	10
3.	Constraints and their handling in frequency domain design, saturation avoiding, minimum bandwidth designs.	3
4.	Optimum control problem in time domain, performance index; Unconstrained and constrained optimization, variational calculus based solution, boundary conditions.	10
5.	Hamiltonian formulation, Pontryagin maximum principle, minimum-time, minimum fuel and other problems.	6
6.	Dynamic programming and its relationship with other methods; Linear regulator problem and its solution.	6
7.	Optimum state estimation and Kalman filter.	6
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors/Books/Publishers	Year of Publication /Reprint
1.	Bryson, A.E. and Ho, C. H., "Applied Optimum Control", Taylor and Francis.	1979
2.	Sage, A. P. and White, C.C., "Optimum Systems Control", Prentice Hall.	1997
3.	Newton, G.C, Gould, L.A. and Kaiser, J.F., "Analytical Design of Linear Feedback Control Systems", Wiley.	1957
4.	McCausland, I., " Introduction to Optimal Control", Revised Ed., Krieger.	1979

Department of Mechanical and Industrial Engineering

M. Tech. (Thermal Engineering)

I Year

Autumn Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage (%)				
S No	Course No.	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MA-501A	Complex Analysis and Linear Algebra	ICC	4	3	1	0	3	--	25	--	25	50	--
2	MI-520	Advanced Thermodynamics	PCC	4	3	1	0	3	--	25	--	25	50	--
3	MI-521	Advanced Fluid Mechanics	PCC	4	3	1	0	3	--	25	--	25	50	--
4	MI-522	Advanced Heat Transfer	PCC	4	3	1	0	3	--	25	--	25	50	--
5		Open Elective - I	OEC	3/4	--	--	--	3	--	25	--	25	50	--
6	HS-501	Technical Communication (Optional)	--	2	1	0	2	2	--	15	15	30	40	--
Sub Total				19-22										

Spring Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage (%)				
S No	Course No.	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MI-511A	Modeling and Simulation	PCC	4	3	1	2/2	3	--	15	15	30	40	--
2		Program Elective-I	PEC	4	3	1	0	3	--	25	--	25	50	--
3		Program Elective-II	PEC	4	3	1	0	3	--	25	--	25	50	--
4		Program Elective-III	PEC	4	3	1	0	3	--	25	--	25	50	--
5		Open Elective-II	OEC	3/4	--	--	--	3	--	25	--	25	50	--
6	HS-501	Technical Communication (Optional)	--	2	1	0	2	2	--	15	15	30	40	--
Sub Total				19-22										

II Year

Autumn Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage (%)				
S No.	Sub code	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MI-601	Seminar	SEM	2	-	-	-	--	--		--	100	--	--
2	MI-602	Project	RP	4	-	-	-	--	--		--	100	--	--
3	MI-603	Dissertation*	DIS	0	-	-	-	--	--		--	--	25	--
Sub Total				6										

* NOTE: To be continued and grade to be awarded in the next semester.

Spring Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage (%)				
S No.	Sub code	Course Title	Subject Area	Credit	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MI-603	Dissertation (continued from III semester)	DIS	20	-	-	-	--	--	--	--	--	75	--
Sub Total				20										
Total				64-68										

Program Electives for M. Tech. (Thermal Engineering)

Teaching Scheme					Contact Hrs Per Week			Exam Duration (Hrs)		Relative Weightage (%)				
S No.	Course No.	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MI-523	Gas Turbines & Compressors	PEC	4	3	1	0	3	--	25	--	25	50	--
2	MI-524	Two Phase Flow & Heat Transfer	PEC	4	3	1	0	3	--	25	--	25	50	--
3	MI-525	Solar Energy	PEC	4	3	1	0	3	--	25	--	25	50	--
4	MI-526	Advanced Gas Dynamics	PEC	4	3	1	0	3	--	25	--	25	50	--
5	MI-527	Computational Fluid Dynamics & Heat Transfer	PEC	4	3	1	0	3	--	25	--	25	50	--
6	MI-528	Boundary Layer Theory	PEC	4	3	1	0	3	--	25	--	25	50	--
7	MI-529	Turbulent Flow	PEC	4	3	1	0	3	--	25	--	25	50	--
8	MI-530	Cold Preservation of Food	PEC	4	3	1	0	3	--	25	--	25	50	--
9	MI-531	Hydro-dynamic Machines	PEC	4	3	1	0	3	--	25	--	25	50	--
10	MI-532	Renewable Energy Systems	PEC	4	3	1	0	3	--	25	--	25	50	--
11	MI-533	Refrigeration & Air-Conditioning System Design	PEC	4	3	1	0	3	--	25	--	25	50	--
12	MI-534	Air Conditioning and Ventilation	PEC	4	3	1	0	3	--	25	--	25	50	--
13	MI-535	Cryogenic Systems	PEC	4	3	1	0	3	--	25	--	25	50	--
14	MI-536	Convective Heat and Mass Transfer	PEC	4	3	1	0	3	--	25	--	25	50	--
15	MI-537	I. C. Engines	PEC	4	3	1	0	3	--	25	--	25	50	--
16	MI-538	I. C. Engine Combustion Processes Modeling	PEC	4	3	1	0	3	--	25	--	25	50	--
17	MI-539	Micro and Nano Scale Thermal Engineering	PEC	4	3	1	0	3	--	25	--	25	50	--
18	MI-540	Combustion	PEC	4	3	1	0	3	--	25	--	25	50	--
19	MI-541	Bio-Fluid Mechanics	PEC	4	3	1	0	3	--	25	--	25	50	--
20	MI-542	Energy Management	PEC	4	3	1	0	3	--	25	--	25	50	--
21	MI-543	Fluid Power Engineering	PEC	4	3	1	0	3	--	25	--	25	50	--
22	MI-544	Design of Heat Exchangers	PEC	4	3	1	0	3	--	25	--	25	50	--
23	MI-545	Fuel Cells	PEC	4	3	1	0	3	--	25	--	25	50	--
24	MI-500	Instrumentation and Experimental Methods	PEC	4	3	1	0	3	--	25	--	25	50	--

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE:

Department of Mechanical and Industrial Engineering

1. Subject Code: **MI-520** Course Title: **Advanced Thermodynamics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of the advanced aspects of classical thermodynamics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review of I and II Laws of Thermodynamics: Transient flow analysis, entropy balance, entropy generation.	5
2.	Exergy Analysis: Concepts, exergy balance, exergy transfer, exergetic efficiency, exergy analysis of power and refrigeration cycles.	9
3.	Real Gases and Mixtures: Equations of state, thermodynamic property relations, residual property functions, properties of saturation states.	6
4.	Thermodynamic Properties of Homogeneous Mixtures: Partial molal properties, chemical potential, fugacity and fugacity coefficient, fugacity relations for real gas mixtures, ideal solutions, phase equilibrium, Rault's law.	8
5.	Reacting Systems: I and II law analysis of reacting systems, absolute entropy and the third law, fuel cells, chemical energy, exergetic efficiency of reacting systems, chemical equilibrium, equilibrium flame temperature.	14
Total		42

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Wark, K., "Advanced Thermodynamics for Engineers", John Wiley & Sons.	1995
2.	Bejan, A., "Advanced Engineering Thermodynamics", 3 rd Ed., John Wiley & Sons.	2006
3.	Annamalai, K. and Puri, I.K., "Advanced Thermodynamics Engineering", CRC Press.	2001
4.	Moran, M. J., and Shapiro, H. N., "Fundamentals of Engineering Thermodynamics", 6 th Ed., John Wiley & Sons	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE:

Department of Mechanical and Industrial Engineering

1. Subject Code: **MI-521** Course Title: **Advanced Fluid Mechanics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge on advanced analytical tools for fluid flow analysis.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Review of Basic Concepts: Concept of continuum, types of fluid, tensor analysis.	3
2.	Basic Laws in Integral Form: Reynold's transport theorem, mass, momentum and energy equations in integral form and their applications.	5
3.	Differential Fluid Flow Analysis: Continuity equation, Navier-Stokes equations and exact solutions, energy equation.	7
4.	Ideal Fluid Flow Analysis: Two dimensional flow in rectangular and polar coordinates; Continuity equation and the stream function; Irrotationality and the velocity potential function; Vorticity and circulation; Plane potential flow and the complex potential function; Sources, sinks, doublets and vortices; Flow over bodies and d'Alembert's paradox; Aerofoil theory and its application.	8
5.	Low Reynolds Number Flow: Approximation of Navier-Stokes equation, approximate solutions of Navier-Stokes equation, Stokes and Oseen flows, hydrodynamic theory of lubrication.	4
6.	Large Reynolds Number Flow: Prandtl's boundary layer equations, Blasius solutions, Falkner-Skan solutions, momentum integral equation, Halstein and Bohlen method, thermal boundary layers.	8
7.	Compressible Fluid Flow: One dimensional isentropic flow, Fanno and Rayleigh flows, chocking phenomenon, normal and oblique shocks.	7
Total		42

11. Suggested Books:

S.N.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Kundu, P. K., and Cohen, I. M., "Fluid Mechanics", 4 th Ed., Academic Press.	2008
2.	Panton, R. L., "Incompressible Flow", 3 rd Ed., John Wiley & Sons.	2005
3.	Murlidhar, K., and Biswas, G., "Advanced Engineering Fluid Mechanics", 2 nd Ed., Narosa Publishing House.	2005
4.	Batchlor, G.K., "Introduction to Fluid dynamics", Cambridge University Press.	2000
5.	White, F. M., "Viscous Fluid Flow", 3 rd Ed., McGraw Hill.	2006
6.	Munson, B. R., Young, D. F., and Okiishi, T. H., "Fundamentals of Fluid Mechanics". 6 th Ed., John Wiley & Sons.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE:

Department of Mechanical and Industrial Engineering

1. Subject Code: **MI-522** Course Title: **Advanced Heat Transfer**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: It provides the knowledge of advanced techniques for analysis of heat transfer processes in thermal systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Heat Conduction: Fourier's law, thermal conductivity of matter, heat diffusion equation for isotropic and anisotropic media, boundary and initial conditions; One-dimensional steady-state conduction through plane wall, cylinder and sphere, conduction with thermal energy generation, heat transfer from extended surfaces, radial fins and fin optimization; Multidimensional-dimensional steady-state heat conduction; Transient conduction – lumped capacitance method and its validity, plane wall and radial systems with convection, semi-infinite solid, multi-dimensional transient heat conduction.	12
2.	Heat Convection: Boundary layers concepts, laminar and turbulent flows, conservation equation, non-dimensional analysis, boundary layer equations, Reynolds analogy for turbulent flows; Forced convection inside tubes and ducts – correlations for laminar and turbulent forces convection; Forced convection over exterior surfaces – bluff bodies, packed beds, tube bundles in cross flow, free jet; Natural convection; Combined free and forced convection; Combined convection and radiation.	11
3.	Heat Transfer with Phase Change: Nucleate, film and pool boiling, boiling in forced convection; Filmwise and dropwise condensation; Heat pipes	5
4.	Thermal Radiation: Fundamental concepts, radiation intensity and its relation to emission, irradiation and radiosity, blackbody radiation, Planck distribution, Wien's displacement law, Stefan-Boltzmann law, surface emission, surface absorption, reflection, and transmission, Kirchoff's law, gray surface; Radiation exchange between surfaces, Poljack's and Gehbart's methods and view factor, blackbody radiation exchange, radiation exchange between diffuse gray surfaces in an enclosure with absorbing and emitting media; Flame Radiation, solar Radiation.	10

5.	Numerical Methods in Heat Transfer: Finite difference method for numerical simulation of steady state and transient heat transfer problems, iterative methods for solution of multi-dimensional problems, time integration methods.	4
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/R eprint
1.	Kreith, F. and Bohn, M. S., "Principles of Heat Transfer", 6 th Ed., Thomson Learning.	2007
2.	Burmeister, L. C., "Convective Heat Transfer", 2 nd Ed., John Wiley & Sons.	1993
3.	Kays, W. M., Crawford, M. E., and Weigand, B., "Convective Heat and Mass Transfer", 4 th Ed., McGraw Hill.	2004
4	Ozisik, M. N., "Heat Conduction", 2 nd Ed., John Wiley & Sons.	1993
5.	Siegel, R., and Howell, J. K., "Thermal Radiation Heat Transfer", Taylor & Francis.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE:

Department of Mechanical and Industrial Engineering

1. Subject Code: **MI-511A** Course Title: **Modeling and Simulation**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **15** PRS **15** MTE **30** ETE **40** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To cover concepts, techniques and tools for modeling and simulation of thermal system

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to Modeling: Concept of system, continuous and discrete systems, types of models, steps in simulation study.	6
2.	Mathematical Modeling of Thermal Processes: Conservation laws, mass, momentum and energy balance; Classification of governing equations, boundary conditions; Dimensional analysis, model development for various thermal processes and system; Dynamics of thermo-fluid systems.	12
4.	Simulation of Thermal Systems: Numerical methods for solution of partial and ordinary differential equations; Numerical solution of linear and nonlinear algebraic equations; Numerical simulation of steady state and dynamic systems.	12
5.	Optimization of Thermal Systems: Introduction to optimization, formulation of objective function, constrained single and multivariable optimization, dynamic integer and geometric programming.	6
6.	Thermodynamic Optimization: Entropy generation minimization, application to internal and external flows, heat exchangers and other energy-equipment optimization.	6
	Total	42

Laboratory Component: Student will be required to develop mathematical models and computer program for numerical simulation of various thermal systems.

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication /Reprint
1.	Suryanarayana, N.V., and Arici, O., "Design and Simulation of Thermal Systems", McGraw Hill.	2001
2.	Jaluria, Y., "Design and Optimization of Thermal Systems", 2 nd Ed., CRC Press.	2007
3.	Bejan, A., Tsatsaronic, G., and Moran, M., "Thermal Design and Optimization", John Wiley & Sons.	1995
4.	Close, C. M., and Frederick, D. K., "Modeling and Analysis of Dynamic Systems", John Wiley & Sons.	2001
5.	Jaluria, Y., and Torrance, K.E., "Computational Heat Transfer", Taylor & Francis.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE:

Department of Mechanical and Industrial Engineering

1. Subject Code: **MI-523** Course Title: **Gas Turbines and Compressors**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: It is intended to give a thorough understanding of gas turbines, compressors, gas turbine cycles, energy and fluid flow dynamics, and power plants based on gas turbines.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Development, classification and field of application of gas turbines.	3
2.	Gas Turbine Cycles: Ideal and actual cycles, multi-stage compression, reheating, regeneration, combined and cogeneration.	6
3.	Energy Transfer and Fluid Flow Characteristics: Energy transfer between fluid and rotor, axi-symmetric flow in compressors and gas turbines.	6
4.	Centrifugal Compressors: Principles of operation, compressor losses, adiabatic efficiency, slip factor, pressure coefficient, power unit, design consideration for impeller and diffuser systems, performance characteristics.	6
5.	Axial Flow Compressors: Elementary theory, vortex theory, degree of reaction, simple design, elementary air-foil theory, isolated airfoil and cascade theory, three dimensional flow, stages, stage efficiency and overall efficiency, performance characteristics.	6
6.	Turbines: Axial flow and radial flow turbines, impulse and reaction turbines, fundamental relations and velocity triangles, elementary vortex theory, limiting factors in turbine design, application of airfoil theory to the study of flow through turbine blades, aerodynamic and thermodynamic design considerations, blade materials, blade attachment and blade cooling.	10
7.	Gas Turbine Power Plants: Fuel and fuel feed systems, combustion systems-design considerations and flame stabilization, regenerator types and design, gas turbine power plant performance and matching, applications.	5
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication /Reprint
1.	Saravanamuttoo, H.I.H., Rogers, G.F.C., Cohen, H. and Straznicky, P.V., "Gas Turbine Theory", 6 th Ed., Pearson Prentice Hall.	2008
2.	Bathie, W. W., "Fundamentals of Gas Turbines", 2 nd Ed., John Wiley & Sons.	1995
3.	Boyce, M. P., "Gas Turbine Engineering Handbook", 3 rd Ed., Gulf Professional Publishing.	2006
4.	Lefebvre, H. and Ballal, D. R., "Gas Turbine Combustion", 3 rd Ed., CRC Press.	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE:

Department of Mechanical and Industrial Engineering

1. Subject Code: **MI-524** Course Title: **Two Phase Flow and Heat Transfer**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide a thorough understanding of basic mechanism involved in two phase flow and heat transfer with special emphasis on boiling and condensation processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Types of flow, volumetric concentration, void fraction, volumetric flux, relative velocity, drift velocity, flow regimes, flow maps, analytical models.	5
2.	Homogeneous Flow: One dimensional steady homogeneous equilibrium flow, homogeneous friction factor, turbulent flow friction factor.	8
3.	Separated Flow: Slip, Lockhart-Martinelli method for pressure drop calculation, pressure drop for flow with boiling, flow with phase change.	8
4.	Drift Flow Model: General theory, gravity flows with no wall shear, correction to simple theory, Armond or Bankoff flow parameters.	7
5.	Boiling: Regimes of boiling, nucleation, gas nucleation in bulk liquid, growth of bubbles, motion at a heating surface, heat transfer rates in pool boiling, forced convection boiling, heat transfer correlations, maximum heat flux or burnout, boiling of metals.	7
6.	Condensation: Nusselt theory, boundary layer treatment of laminar film condensation, experimental results for vertical and horizontal tubes, condensation inside a horizontal tube.	7
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication /Reprint
1.	Ishii, M. and Hibiki, T., "Thermo-fluid Dynamics of Two-Phase Flow", Springer.	2009
2.	Brennen, C. E., "Fundamentals of Multiphase Flow", Cambridge University Press.	2009
3.	Collier, J. G. and Thome, J. R., "Convective Boiling and Condensation", Oxford University Press	1996
4.	Rohsenow, W.M., Hartnett, J.P. and Ganic, E.N. (Ed.), "Handbook of Heat Transfer", McGraw Hill.	1998
5.	Tong, L.S. and Tang, Y. S., "Boiling Heat Transfer and Two-phase Flow", 2 nd Ed., CRC Press.	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-525** Course Title: **Solar Energy**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of solar energy with respect to its availability, utilization and economic viability.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Energy demand and supply, energy crisis, conventional and non-conventional energy resources, solar energy applications.	2
2.	Solar Radiation: Sun, solar radiation, attenuation by atmosphere, solar radiation on earth, measurement, presentation and utilization of data.	6
3.	Heat Transfer Concepts: Radiation characteristics of surface and bodies, absorbance, reflectance and transmittance, selective surface, sky radiation and wind convection.	6
4.	Flat Plate Collectors: General description of flat plate collectors, general characteristics, performance, short term and long term performance, design.	8
5.	Focusing Collectors: General description of focusing solar collectors, concentrators, receivers and orienting systems, general characteristics, performance, materials, design.	5
6.	Energy Storage: Energy storage in solar process system, different types of storages, characteristics and capacity of storage medium, solar pond.	5
7.	Solar Heating and Cooling: Passive heating and cooling, nocturnal radiations, green house concept, ponds, active heating and cooling, solar water heaters, absorption cooling, combined solar heating and cooling systems, performance, economics of solar heating and cooling.	4
8.	Solar Process Modeling: Solar process systems and components, component models, system models.	2
9.	Solar Photovoltaics: Description and principle of working, performance characteristics, efficiency of solar cells, module design, PV systems, applications.	4
Total		42

11. Suggested Books:

S. NO.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Duffie, J.A. and Beckman, W.A., "Solar Engineering of Thermal Processes", John Wiley & Sons.	2006
2.	Goswami, D.Y., Kreith, F. and Kreider J., "Principles of Solar Energy", Taylor & Francis.	2000
3.	Sukhatme, S.P. and Naik, J.K., "Solar Energy", 3 rd Ed., Tata McGraw Hill.	2009
4.	Garg, H.P. and Prakash, J., "Solar Energy", Tata McGraw Hill.	2000
5.	Tiwari, G.N., "Solar Energy", Narosa Publishing House.	2002
6.	Meinel, A.B., "Applied Solar Energy", Addison Wesley.	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-526** Course Title: **Advanced Gas Dynamics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge of advanced topics in gas dynamics related to shock waves, perturbations and methods of characteristics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Basic Equations: Application of the general differential equation of continuity, momentum and energy to compressible inviscid fluids, compressible Bernoulli equation, irrotational flow, velocity potential and stream function.	6
2.	Shock Waves in Supersonic Flow: A review of normal shock relations, Mach waves, equations for finite strength oblique shock waves, Rankine-Hugoniot relations, extended Prandtl relation, hodograph shock polars, reflection and interaction of shock, curved shocks.	7
3.	Small Perturbation Theory: Linearization, small perturbation equation, pressure coefficient, subsonic flow past a wave shaped wall, general solution of supersonic flows, supersonic flow past a wave – shaped wall, elements of supersonic thin aerofoil theory.	9
4.	Similarity Rules: Similarity rules between two-dimensional subsonic compressible flows and incompressible flows, Gothert rule, Prandtl Glauert rule, application to supersonic flows.	6
5.	Hodograph Method for Subsonic Flow: Hodograph equations for two-dimensional subsonic flows, Chaplygin's equation, the tangent gas approximation of Karman and Tsien for subsonic flows, Karman-Tsien formula for pressure correction, comparison with Prandtl-Glauert rule	7
6.	Method of Characteristics for Supersonic Flow: Method of characteristics for two dimensional supersonic flows, the characteristic curves, equation of hodograph characteristics, characteristics network, computational methods.	7
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication /Reprint
1.	Anderson, J. D. "Modern Compressible Flow", McGraw Hill.	2004
2.	Liepmann, H.W. and Roshko, A., "Elements of Gas Dynamics", Dover Publication.	2002
3.	Rathakrishnan, E., "Applied Gas Dynamics", John Wiley & Sons.	2010
4.	John, J. E. A. and Keith, T. G., "Gas Dynamics", 3 rd Ed., Prentice Hall.	2006
5.	Zucker, R. D. and Biblarz, O., "Fundamentals of Gas Dynamics", 2 nd Ed., John Wiley & Sons.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-527** Course Title: **Computational Fluid Dynamics and Heat Transfer**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of the basic tools for numerical simulation of fluid flow and heat transfer processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Conservation equations; Mass, momentum and energy equations; Conservative forms of the equations and general description.	3
2.	Classification and Overview of Numerical Methods: Classification into various types of equations -- parabolic elliptic and hyperbolic; Boundary and initial conditions; Overview of numerical methods.	4
3.	Finite Difference Method: Introduction, finite difference approximations, Taylor series expansion, polynomial fitting, approximation of boundary conditions, applications to conduction and advection-diffusion problems.	5
4.	Finite Volume Method: Basic methodology, finite volume discretization, approximation of surface and volume integrals, interpolation methods - central, upwind and hybrid formulations and comparison for convection-diffusion problem.	5
5.	Methods of Solution: Solution of finite difference equations, iterative methods, matrix inversion methods, ADI method, operator splitting, fast Fourier transform, applications.	7
6.	Numerical Grid Generation: Basic ideas, transformation and mapping, unstructured grid generation.	5
7.	Finite Element Method: Introduction to Rayleigh-Ritz, Galerkin and least square methods, interpolation functions, one and two dimensional elements, applications.	9
8.	Phase Change Problems: Different approaches for moving boundary, variable time step method, enthalpy method.	4
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication /Reprint
1.	Anderson, D.A., Tannehill, J.C. and Pletcher, R.H., "Computational Fluid Mechanics and Heat Transfer", Taylor & Francis.	1997
2.	Anderson, J.D., Jr., "Computational Fluid Dynamics", McGraw Hill.	1995
3.	Ferziger, J. H. and Peric, M., "Computational Methods for Fluid Dynamics, 3 rd Ed., Springer.	2003
4.	Versteeg, H. and Malalasekera, M., "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", 2 nd Ed., Prentice Hall.	2007
5.	Reddy, J. N. and Gartling, D. K., "The Finite Element Method in Heat Transfer and Fluid Dynamics", 3 rd Ed., CRC Press.	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-528** Course Title: **Boundary Layer Theory**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide in-depth knowledge of the concept of boundary layer, and analytical tools for prediction, investigation and control of the boundary layers.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Ideal and real fluids, the concept of boundary layer, Navier- Stokes equations, the limiting cases of large and small Reynolds number, energy equation.	5
2.	Laminar Boundary Layer Equation: Two dimensional equations, displacement and momentum thickness, general properties of the boundary layer equations, skin friction.	6
3.	Similarity Solutions: Wedge flow and its particular cases, flow past a cylinder, two dimensional inlet flow in straight channel.	5
4.	Approximate Methods: Karman-Polhausen methods, numerical methods.	4
5.	Axially Symmetrical Boundary Layers: Circular jet, body of revolution, Manglers transfixion.	3
6.	Boundary Layer Control: Different methods of boundary layer control, flow over a flat plate with uniform suction.	4
7.	Turbulent Boundary Layer: Two-dimensional equation, Prandtl's mixing layer Karman's hypothesis universal velocity distribution, flow over a flat plate, skin friction drag.	9
8.	Thermal Boundary Layers: Two-dimensional equations forced flow over flat plate at zero in advances, natural flow over a vertical plate.	6
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication /Reprint
1	Schlichting, H. and Gersten, K., "Boundary Layer Theory", Springer-Verlag.	2004
2.	White, F. M., "Viscous Flow", 3 rd Ed., McGraw Hill.	2005
3.	Cebeci, T. and Cousteix, J., "Modeling and Computation of Boundary-Layer Flows", 2 nd Ed., Springer-Verlag.	2005
4.	Rozenhead, L., "Laminar Boundary Layers", Dover Publications	1988
5.	Kays, W. M., Crawford, M. E., and Weigand, B., "Convective Heat and Mass Transfer", 4 th Ed., McGraw Hill.	2004
6.	Welty, J. R., Wicks C. E., Wilson R. E. and Rorrer, G. L., "Fundamentals of Momentum, Heat, and Mass Transfer", 5 th Ed., John Wiley & Sons	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-529** Course Title: **Turbulent Flow**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of analytical, experimental, modeling and computational tools for the analysis of turbulent flow.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Turbulence and equations of fluid motion.	3
2.	Statistical Descriptions of Turbulent Flows: Random nature of turbulence, random variables, probability distributions, and averaging techniques.	5
3.	Experimental Techniques for Measurement of Turbulent Flows: Hot-wire and hot-film anemometry, laser Doppler velocimetry, and particle image velocimetry.	5
4.	Dynamics of Turbulence: Scales of turbulent motion, energy cascade, Kolmogorov hypothesis, structure function, two-point correlations, Fourier modes and velocity spectra.	7
5.	Homogeneous and Isotropic Turbulence: Implications of isotropy, energy decay, energy spectrum, homogeneous shear flows.	5
6.	Anisotropic Turbulence: Wall bounded flows (channel flow, pipe flow, boundary layers) and free shear flows (jets and mixing layers), coherent structures.	7
7.	Turbulence Modeling: RANS modeling, eddy viscosity models, algebraic Reynolds stress models and near-wall models.	5
8.	Direct Numerical Simulation and Large Eddy Simulation: Filtering, subgrid scale models (Smagorinsky and dynamic models), LES in wave number space.	5
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication / Reprint
1.	Pope, S. B., "Turbulent Flows", Cambridge University Press.	2000
2.	Bernard, P., and Wallace, J. A., "Turbulent Flow", John Wiley & Sons	2002
3.	Mathieu, J., and Scott, J., "Introduction to Turbulent Flow", Cambridge University Press.	2000
4.	Biswas, G., and Eswaran, V., "Turbulent Flows", Narosa Publishing House.	2002
5.	Piquet, J., Richards, J. A., Jia, X., "Turbulence Flows: Models and Physics", Springer-Verlag.	2001
6.	Lesieur, M., "Turbulence in Fluids", Springer-Verlag.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-530** Course Title: **Cold Preservation of Food**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of various aspects of cold preservation techniques for the perishable commodities.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Necessity of food preservation, general techniques, cold preservation of food.	4
2.	Biological Aspects: Live and dead foods, biology of food products such as fruits, vegetables, milk, meat and fish, effect of temperature on food ingredients, respiration rates of food products, controlled atmospheric storage, diseases and deterioration of foods.	10
3.	Preservation of Food: Short and long term preservation, methods of chilling, freezing and freeze drying, heat and mass transfer analysis of cooling and freezing.	9
4.	Cold Storages: Necessity and present status in the country, site selection, building constructional features, load calculation, equipment, selection, safety consideration, insurance and management of cold storages, storage of some important food products, modern trends in cold storage practices.	10
5.	Refrigerated Food Handling: Preparation for cooling/ freezing, packaging of foods, modes of transportation (land, sea and air), thermal load and equipment, marketing of refrigerated food.	9
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication /Reprint
1.	Karel, M. and Lund, D. B., "Physical Principles of Food Preservation", 2 nd Ed., CRC Press.	2003
2.	"ASHRAE Handbook", American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).	2009
3.	Shafiur Rahman, M., "Handbook of Food Preservation", 2 nd Ed., CRC Press.	2007
4.	Evans, J. A., "Frozen Food Science and Technology", Blackwell Publishing.	2008
5.	Wallis-Tayler, A. J., "Refrigeration: Cold Storage and Ice Making", Knowledge Publications.	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-531** Course Title: **Hydrodynamic Machines**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To expose students to theory, design and analysis of hydrodynamic machines such as turbines, pumps etc.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Basic fluid mechanics of turbo-machinery, torque-momentum and head-momentum equations, one-dimensional theory and its limitations, two-dimensional theory of flow through axial and radial-flow machines, three-dimensional effects; Classification of turbines and various forms of turbine runners.	8
2.	Reaction Turbines: General theory of reaction machines, performance characteristics, types, Francis and Kaplan turbines, runner design, blade design, design of the spiral casing, guide vanes and draft tube design, theory of cavitation flows in hydrodynamic runners.	10
3.	Impulse Turbines: General theory of impulse machines, performance characteristics, design of runner, bucket shape and size, design of nozzles, regulation mechanisms, penstock design.	8
4.	Hydrodynamic Pumps: Classification of pumps and various forms of pump impellers, general theory of centrifugal pumps, performance characteristics, design of casings and diffusers, cavitation effects in impellers.	10
5.	Hydrodynamic Transmissions: General features, primary and secondary units of the systems, fluid couplings and torque converters, general theory, performance characteristics, basic design considerations.	6
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1	Round G.F., "Incompressible Flow Machines", Elsevier Butterworth-Heineman.	2004
2.	Dixon, S. L., "Fluid Mechanics and Thermodynamics of Turbomachinery", 5 th Ed., Butterworth Heineman.	2005
3	Douglas J. F., Gasiorek, J. M. and Swaffied, J. A., "Fluid Mechanics", Pearson Education.	2001
4	Karassik, I. J., Messina, J. P., Cooper, P. and Heald, C. C., "Pump Handbook", 3 rd Ed., McGraw Hill.	2001
5.	Gopalkrishnan, G. and Prithvi Raj, D., "A Treatise on Turbomachinery", Scitech Publication.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-532** Course Title: **Renewable Energy Systems**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce various renewable energy systems and their applications for sustainable development.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Energy and development, energy demand and availability, energy crisis, conventional and non-conventional, renewable and non-renewable energy resources, environmental impact of conventional energy usage, basic concepts of heat and fluid flow useful for energy systems.	5
2.	Solar Energy Systems: Solar radiations data, solar energy collection, storage and utilization, solar water heating, air heating, power generation, refrigeration and air conditioning, solar energy system economics.	7
3.	Micro and Small Hydro Energy Systems: Resource assessment of micro and small hydro power, micro, mini and small hydro power systems, economics, pump as turbine, special engines for low heads, velocity head turbines, hydrams, water mills.	6
4.	Ocean Energy Systems: Ocean temperature energy conversion system (OTEC), Wave energy systems, Tidal power systems.	4
5.	Biomass Energy Systems: Availability of biomass- agro, forest, animal, municipal and other residues, bioconversion technologies, cooking fuels, biogas, producer gas, power alcohol from biomass, power generation, internal combustion engine modifications and performance, system economics.	8
6.	Wind Energy Systems: Wind data, horizontal and vertical axis wind mills, wind farms, performance and economics of wind energy.	6
7.	Integrated Energy Systems: Concept of integration of conventional and non-conventional energy resources and systems, integrated energy system design and economics.	6
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication /Reprint
1.	Boyle, G. "Renewable Energy", 2 nd Ed., Oxford University Press.	2004
2.	Da Rosa, A. V. "Fundamentals of Renewable Energy Processes", 2nd Ed., Academic Press.	2009
3.	Hodge, B. K., "Alternative Energy Systems and Applications", John Wiley & Sons.	2009
4.	Sukhatme, S.P. and Naik, J.K., "Solar Energy", 3 rd Ed., Tata McGraw Hill.	2009
5.	Duffie, J.A. and Beckman, W.A., "Solar Engineering of Thermal Processes", John Wiley & Sons.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-533** Course Title: **Refrigeration and Air Conditioning System Design**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce basic design principles of refrigeration and air conditioning equipment and components.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Load Calculations: Solar heat gains through structures, review of refrigeration and air conditioning load calculations.	6
2.	Refrigeration Systems: Vapour compression, multiple evaporator and compound compression system with and without inter cooling, dual compressors, cascade systems, vapour absorption system-analysis, solid carbon dioxide, principle of production, three stage system with water and flash inter-cooler, pressure snow chambers, regenerative liquid, binary system.	10
3.	Refrigeration System Components: Performance characteristics and capacity control of reciprocating, rotary and centrifugal compressors, screw compressors, hermetically sealed units, analysis of centrifugal compressors, water cooled and air-cooled condensers, overall heat transfer coefficients, fouling factor, performance characteristics and design, performance and heat transfer processes in evaporative condenser, flooded and dry expansion type evaporators, liquid chiller, overall performance of evaporators, capillary tubes, system design factors, pressure and temperature distribution, ASHRAE simplified calculation procedure, expansion valves, operation and performance calculation of thermostatic expansion valve, application of constant pressure expansion valve.	14
4.	Pressure Drop and Heat Transfer: Two phase flow, flow regimes, maps, pressure drop in evaporator and condensers, Martinelli relation.	6
5	Applications and System Design: Ice manufacture, design of refrigerated cars and ware houses.	6
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication /Reprint
1	Stoecker, W. F. and Jones, J. W., "Refrigeration and Air-conditioning", McGraw Hill.	1983
2.	"ASHRAE Handbook", American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).	2009
3.	Whitman, B., Johnson, B., Tomczyk, J. and Silberstein, E., "Refrigeration and Air Conditioning Technology", 6 th Ed., Delmar Cengage Learning	2008
4.	Hundy, G. H., Trott, A. R. and Welch, T. C., "Refrigeration and Air-Conditioning", 4 th Ed., Butterworth-Heinemann.	2008
5	Arora, C. P., "Refrigeration and Airconditioning", 3rd Ed., Tata-McGrawHill	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-534** Course Title: **Air-conditioning and Ventilation**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the basic physiological principles, comfort charts, air conditioning systems and the design of piping and ducts.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Psychrometry: Goff and Gratch method of calculation of moist air properties, mass transfer and evaporation of water into moist air, theory of psychrometer, correlation of w.b.t. with temperature of adiabatic saturation, Lewis number, construction of h.w. psychrometric chart.	6
2.	Physiological Principles: Comfort, thermal interchanges with environment, physiological body regulatory processes against heat or cold, high and low temperature hazards, extreme environmental conditions, heat stress index, ASHRAE comfort standards.	4
3.	Simultaneous Heat and Mass Transfer: Direct contact transfer equipment, simple air washer and indirect evaporative cooling, contact mixture principle, enthalpy potential, basic equation for direct contact transfer equipment, graphical and analytical methods for heat and mass transfer analysis of air-washers with heated and chilled water sprays, cooling towers.	8
4.	Extended Surface Heat Transfer Apparatus: Cooling and dehumidifying coils, design of finned surfaces, adsorption cooling systems.	5
5.	Ventilation: Necessity, ventilation standards, natural and mechanical ventilation, forces for natural ventilation, general ventilation rules, advantages of mechanical ventilation, various methods, ejector systems, determining ventilation requirement, use of decay equation.	7
6.	Air Cleaning: Physical and chemical vitiation of air, permissible concentration of air contaminants, mechanical and electronic air cleaners, dry and wet filters, air sterilization, odour control.	4
7.	Steam Heating Systems: Elements of steam, water and warm-air heating systems, radiators and convectors, design of a year-round air conditioning system.	4
8.	Piping and Ducts: Pressure drops in piping and fittings, design of water and refrigerant piping, air conditioning duct design methods.	4
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication /Reprint
1	Kuehn, T. H., Ramsey, J. W. and Threlkeld J. L., "Thermal Environmental Engineering", 3 rd Ed., Prentice Hall.	1998
2.	"ASHRAE Handbook", American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).	2009
3.	Whitman, B., Johnson, B., Tomczyk, J. and Silberstein, E., "Refrigeration and Air Conditioning Technology", 6 th Ed., Delmar Cengage Learning	2008
4.	Hundy, G. H., Trott, A. R. and Welch, T. C., "Refrigeration and Air-Conditioning", 4 th Ed., Butterworth-Heinemann.	2008
5	Arora, C. P., "Refrigeration and Air-conditioning", 3rd Ed., Tata-McGrawHill	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-535** Course Title: **Cryogenic Systems**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the field of low temperature engineering (*cryogenics*) having applications in rocket propulsion, electronics, biological and medical science.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Historical background, present areas involving cryogenics.	4
2.	Low Temperature Properties of Engineering Materials: Mechanical properties, thermal properties, electrical and magnetic properties, properties of cryogenic fluids.	4
3.	Gas-Liquefaction System: Joule-Thomson effect, adiabatic expansion, simple Linde-Hampson system, pre-cooled Linde-Hampson system, Linde dual-pressure system, cascade system, Claude system, Kapitza system, Collins helium liquefaction system.	6
4.	Critical Components of Liquefaction System: Effect of heat exchanger effectiveness on system performance, effect of compressor and expander efficiency on system performance, effect of heat transfer to the system.	6
5.	Cryogenic Refrigeration Systems: Philips refrigerator, importance of regenerator effectiveness for Philips refrigerator, Gifford-McMohan refrigerator	6
6.	Measurement Systems for Low Temperatures: Temperature measurement, flow rate measurement, liquid level measurement.	4
7.	Cryogenic Storage and Transfer Systems: Cryogenic fluid storage vessels, insulations, cryogenic transfer systems	4
8.	Vacuum Technology: Importance of vacuum technology in cryogenics, flow regimes in vacuum systems, conductance in vacuum systems, calculation of pump-down time for a vacuum system, components of a vacuum system, mechanical vacuum pumps, diffusion pumps, ion pumps, cryo-pumping, vacuum gauges and valves.	8
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Barron, R. F., "Cryogenic Systems", Oxford University Press.	1985
2.	Flynn, T., "Cryogenic Engineering", 2 nd Ed., CRC Press.	2004
3.	Jha, A. R., "Cryogenic Technology and Applications", Elsevier.	2006
4.	Barron, R. F., "Cryogenic Heat Transfer", Taylor & Francis.	1999
5.	Kays, W. M., and London, A. L., "Compact Heat Exchangers", Krieger Publishing Company.	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-536** Course Title: **Convective Heat and Mass Transfer**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of various aspects of the convective heat and mass transfer.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Concepts, conservation principles and laws; Equations of continuity, momentum, and energy; Dimensional analysis and similarity principles.	7
2.	Laminar Boundary Layer Flow: Concept of boundary layer, velocity and thermal boundary layer thickness, integral solutions and similarity solutions, laminar forced flow over a flat plate, thermal boundary layer on an isothermal/constant surface heat flux flat plate, flat plate with varying surface temperature	7
3.	Laminar Duct Flow: Hydrodynamic entrance length, fully developed flow, hydraulic diameter and pressure drop, heat transfer to developed and developing flow, laminar forced convection in pipe and ducts, dimensional analysis, some exact solutions of Navier-Stokes equations.	6
4.	Laminar Natural Convection: Vertical boundary layer equations, integral and similarity solutions, plumes, wakes, buoyant flows, film condensation.	5
5.	Natural Convection in Enclosures: Transient heating from the side, boundary layer regime, dimensional analysis	5
6.	Turbulence Models: Eddy diffusivity of heat and momentum.	4
8.	Turbulent Boundary Layers: Velocity distribution in turbulent flow, Analogies between heat and momentum transfer, turbulent flow through circular tubes and parallel plates, Turbulent heat transfer correlations	4
9.	Mass Transfer: Properties of mixtures, mass conservation, laminar forced/natural convection, steady and unsteady state molecular diffusion.	4
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Arpaci, V. S. and Larsen, P. S., "Convection Heat Transfer", Prentice Hall.	1984
2.	Burmeister, L.C., "Convection Heat Transfer", John Wiley & Sons.	1993
3.	Bejan, A. "Convection Heat Transfer", 3 rd Ed., John Wiley & Sons.	2004
4.	Kays, W. M. and Crawford, M. E., "Convective Heat and Mass Transfer", Tata McGraw Hill.	2005
5.	Welty, J. R., Wicks, C. E. , Wilson, R. E. and Rorrer, G. L., "Fundamentals of Momentum, Heat and Mass Transfer", 5 th Ed., John Wiley & Sons.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-537** Course Title: **I.C. Engines**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: This course deals with the analysis of internal combustion (IC) engine processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Overview and historical perspectives on development of internal combustion engines.	2
2	Thermodynamic Analysis of IC Engines Cycle: Properties of working fluid, fuel air cycle analysis, real cycles, availability analysis of engine processes.	8
3	Gas Exchange Processes: Inlet and exhaust processes in the four stroke cycle, volumetric efficiency, quasi-static and dynamic effects, flow through valves, scavenging in two- stroke cycle engines, scavenging parameters and models, actual scavenging processes, flow through ports, supercharging and turbo-charging, basic relationships, compressors, turbines characteristics, matching of compressor, turbines and engine characteristics.	10
4	Combustion in SI Engines: Essential features of the process, thermodynamic analysis of SI engine combustion, combustion process characterization, cyclic variations in combustion.	6
5	Combustion in Compression Ignition Engines: Essential features of process, types of diesel combustion systems, phenomenological model of compression- ignition engine combustion, fuel spray behaviour, spray structure, atomization, spray penetration droplet size distribution, spray evaporation, ignition delay.	8
6	Pollutant Formation and Control: Nature and extent of problem, nitrogen oxides, kinetics of NO formation, NO _x formation in spark- ignition engines, NO _x formation in CI engines, carbon monoxide, unburned hydrocarbon emissions, particulate emissions, exhaust gas treatment, catalytic converters, three way catalysts, particulate traps.	8
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication / Reprint
1.	Heywood, J.B., "Internal Combustion Engine Fundamentals", McGraw Hill.	1988
2.	Taylor, C.F., "Internal Combustion Engines", Vol. 1 & 2, 2 nd Ed., MIT Press.	1985
3.	Ferguson, C.R. and Kirkpatrick, A. T., "Internal Combustion Engines", 2 nd Ed., John Wiley & Sons.	2000
4.	Pulkrabek, W. W., "Engineering Fundamentals of the Internal Combustion Engine", 2 nd Ed., Prentice-Hall.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-538** Course Title: **I.C. Engine Combustion Processes Modeling**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: The course is intended to expose the students to the most widely used mathematical models for in-cylinder spray and combustion processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Essential features of combustion process in S.I. and C.I. engines, flame structure and speed, spray structure, auto-ignition.	4
2.	Engine combustion modeling – an overview.	2
3.	Modeling fluid motions in engines, intake jet flow, swirl generation during induction, squish, pre-chamber flows, crevice flow and blow-by.	6
4.	Modeling Flame Propagation and Heat Release in Engines, laminar burning speed, flame propagation relations, heat release in diesel engines, zero dimension burning rate function, free gas jet theory, packet models.	8
5.	Knock, fundamentals, kinetic modeling of hydrocarbon combustion, autoignition, knock models.	6
6.	Modeling Spray, spray equation, droplet kinematics, spray atomization, droplet breakup droplet/droplet and spray wall interactions, fuel vaporization.	8
7.	Modeling pollutant formation in SI and CI engines, Models for NOx, CO and soot formation.	8
Total		42

11. Suggested Books:

S. N o.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Heywood, J.B., "Internal Combustion Engine Fundamentals", McGraw Hill.	1988
2.	Stiesch, G., "Modeling Engine Spray and Combustion Processes", Springer-Verlag.	2003
3.	Lakshminarayanan, P. A. and Aghav, Y. V., "Modeling Diesel Combustion", Springer-Verlag.	2010
4.	Sirignano, W. A., "Fluid Dynamics and Transport of Droplets and Sprays", Cambridge University Press.	2000
5.	Warnatz, J., Mass, U., and Dirbble, R. W., "Combustion: Physical and Chemical Fundamentals, Modeling and Simulation, Experiments, Pollutant Formation", 4 th Ed., Springer-Verlag	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-539** Course Title: **Micro and Nano Scale Thermal Engineering**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide a thorough understanding of heat transfer at micro and nano scales in microchannels, microbiological systems, micro heat pipes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Microscale Energy Transport in Solids: Microstructure of solids, crystal vibrations and phonons, photon interactions, particle transport theories, non-equilibrium energy transfer.	7
2.	Molecular Clusters: Clusters and clustering, thermo-physical properties of clusters, control of clusters and condensation.	4
3.	Molecular Forces and Phase Change in Thin Liquid Films: Thermodynamics of thin films, interfacial meniscus properties, interfacial mass flux.	7
4.	Heat Transfer and Pressure Drops in Microchannels: Single phase and two phase flow, flow boiling, dryout, bubble behavior, flow pattern	6
5.	Micro Heat Pipes: Fundamental operating principles, steady state and transient modeling and construction techniques.	6
6.	Microscale Heat Transfer in Biological Systems at Low Temperature: Life above and below the freezing temperature of water, freezing of cells and tissues, mechanism of freeze survival.	3
7.	Microscale Thermal Sensors and Actuators: MEMS technology, flow sensors, infrared radiation detectors, thermal conductivity sensor, thermal expansion actuators and micro-steam engine.	4
8.	Nanofluids: Preparation of nano-fluids, sputtering, characterization of nano-fluids, thermal properties of nano-fluids, single phase convective and boiling heat transfer processes.	5
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Tien, C. L., Majumdar, A. and Gerner, F. M., "Microscale Energy Transport", Taylor & Francis.	2003
2.	Zhang, Z., "Nano/Microscale Heat Transfer", McGraw Hill.	2007
3.	Volz, S., "Microscale and Nanoscale Heat Transfer", Springer-Verlag.	2007
4.	Celate, G. P., "Heat Transfer and Transport Phenomena in Microscale", Begell House.	2000
5.	Kakac, S., Vasiliev, L. L., Bayazitoglu, Y., Yener, Y., "Microscale Heat Transfer: Fundamentals and Applications", Springer-Verlag.	2005
6.	Sobhan, C. B. and Peterson, G. P., "Microscale and Nanoscale Heat Transfer: Fundamentals and Engineering Applications", CRC Press.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-540** Course Title: **Combustion**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0
4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge of the basic principles involved in the combustion phenomenon and various practical combustion systems.
10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Importance of combustion, combustion equipment, hostile fire problems, pollution problems arising from combustion.	2
2	Thermodynamics of Combustion: Enthalpy of formation, enthalpy of reaction, heating values, first and second law analysis of reacting systems, chemical equilibrium, equilibrium composition, adiabatic and equilibrium flame temperature.	6
3	Kinetics of Combustion: Law of mass action, reaction rate, simple and complex reactions, reaction order and molecularity, Arrhenius law, activation energy, chain reactions, steady state and partial equilibrium approximations, chain explosion, explosion limits and oxidation characteristics of hydrogen, carbon monoxide and hydrocarbons.	8
4	Flames: Structure and propagation of flames in homogeneous gas mixtures, simplified Rankine-Hugoniot relations, properties of hugoniot curve, analysis of deflagration and detonation branches, properties of Chapman Jouguet wave; Laminar flame structure, theories of flame propagation and calculation of flame speeds, flame speed measurements, stability limits of laminar flames, flammability limits and quenching distance; Burner design; Mechanisms of flame stabilization in laminar and turbulent flows; Flame quenching, diffusion flames, comparison of diffusion with premixed flame, combustion of gaseous fuel jets, Burke and Shumann development.	12
5	Burning of Condensed Phase: General mass burning considerations, combustion of fuel droplet in a quiescent and convective environment. Introduction to combustion of fuel sprays.	6
6	Ignition: Concepts of ignition, chain ignition, thermal spontaneous ignition, forced ignition.	4
7.	Combustion Generated Pollution and its Control: Introduction, nitrogen oxides thermal fixation of atmospheric nitrogen prompt NO, thermal NO _x formation and control in combustors; Fuel NO _x and control, post-combustion destruction of NO _x , nitrogen dioxide, carbon monoxide, oxidation-quenching, hydrocarbons, sulphur oxides.	4
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication /Reprint
1.	Glassman, I., "Combustion", 4 th Ed., Academic Press.	2008
2.	Warnatz, J., Mass, U., and Dirbble, R. W., "Combustion: Physical and Chemical Fundamentals, Modeling and Simulation, Experiments, Pollutant Formation", 4 th Ed., Springer-Verlag.	2006
3.	Kuo, K. K., "Principles of Combustion", 2 nd Ed., Wiley-Interscience	2005
4.	Annamalai, K. and Puri, I. K., "Combustion Science and Engineering", CRC Press.	2006
5.	Williams, F.A., "Combustion Theory", Addison Wesley	1993

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-541** Course Title: **Bio-fluid Mechanics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide an understanding of fluid dynamics in biological systems in general, and human physiological system in particular.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Overview of basic anatomy and physiology from fluid flow perspective.	4
2.	Review of Basic Equations and Constitutive Models: Mass and momentum conservation, models for non-Newtonian fluids.	4
3.	Blood Rheology and Mechanics of Circulation: Composition, structure and flow properties of blood; Structure, flow and pressure characteristics of the blood flow in cardio-vascular system; Flow of non-Newtonian fluids in elastic tubes.	7
4.	Arterial Wave Propagation: Oscillatory and pulsatile flow, pulse waves, behaviour at bifurcations, wave propagation in flexible tubes.	7
5.	Flow through Pulmonary System: Structure and function of pulmonary system, fluid exchange processes, fluid mechanics of breathing.	5
6.	Flow and Lubrication in Musculo-skeletal System: Haemodynamics of red blood cells, synovial fluid in joints.	5
7.	Flow through the Porous Media: Oxygen diffusion from blood to tissues, flow in ocular and renal system.	5
8.	Computational Biofluid Mechanics: Computational methods for flow and wave propagation through elastic tubes, flow through porous media.	5
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Chandran, K. B., Yoganathan, A. P. and Rittgers, S. E., "Biofluid Mechanics: The Human Circulation", CRC Press.	2006
2.	Humphrey, J. D. and Delange, S. L., "An Introduction to Biomechanics", Springer-Verlag.	2004
3.	Fournier, R. L. L., "Basic Transport Phenomena in Biomedical Engineering", Taylor & Francis.	1998
4.	Fung, Y. C., "Biomechanics: Circulation", Springer-Verlag.	1996
5.	Kleinstreuer, C., "Biofluid Dynamics: Principles and Selected Applications", CRC Press.	2006
6.	Waite, L. and Fine, J., "Applied Biofluid Mechanics", McGraw Hill.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-542** Course Title: **Energy Management**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): Theory **3** Practical **0**
4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge of concepts and techniques required for energy management.
10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Energy scenario, various forms of energy, energy management and its importance, recent trends in energy conservation.	3
2	Energy Auditing and Instrumentation: Definition, methodology, analysis of past trends (plan data), closing the energy balance, laws of thermodynamics, measuring instruments, portable and online instruments.	8
3	Energy Economics: Payback period, time value of money, IRR NPV, life cycle cost, cost of saved energy, cost of energy generated.	6
4	Monitoring and Targeting: Elements of monitoring and targeting, data and information, analysis techniques; Energy consumption, production, cumulative sum of differences.	7
5	Energy Efficiency in Thermal Utilities: Boilers, steam system, furnace insulation and refractories, fluidized bed boilers, cogeneration power plants, waste heat recovery systems.	7
6	Energy Efficiency in Electrical Utilities: Electrical systems, electric motors, compressed air system, HVAC and refrigeration systems, fans and blowers, pumps and pumping systems, cooling towers, lighting system, diesel generating system.	11
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication /Reprint
1.	Witte, L.C., Schmidt, P.S., Brown, D.R., "Industrial Energy Management and Utilization", Taylor and Francis.	1987
2.	Gyftopoulos, E.P., "Industrial Energy Conservation Manuals", MIT Press.	1988
3.	Capehart, B.L., Turner, W.C., Kennedy, W.J., "Guide to Energy Management", 6 th Ed., Fairmont Press.	2008
4.	Turner, W.C. and Doty, S., "Energy Management Handbook", 7 th Ed., Fairmont Press.	2009
5.	Kreith, F. and Yogi Goswami, D., "Handbook of Energy Efficiency and Renewable Energy", CRC Press.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-543** Course Title: **Fluid Power Engineering**

2. Contact Hours: **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge of fluid power systems and control circuits.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Types of fluid power control systems and its components; Physical properties of hydraulic fluids and governing equations.	5
2.	Pumps and Valves: Classification, working and performance of gear, vane, piston pumps and their selection; Pressure intensifiers, direction control valves, pressure control valves, flow control valves, servo valves, pressure switches.	8
3.	Hydraulic Actuators: Linear and rotary actuators, gear, vane and piston motors, performance of hydraulic motors, hydrostatic transmission.	5
4.	Hydraulic Circuit Design and Analysis: Control of single-acting and double-acting cylinders, study of various circuits like regenerative, unloading, counterbalance, speed control etc., maintenance of hydraulic circuits.	5
5.	Pneumatic Control Systems: Air preparation and components, compressors and conditioners, air control valves and actuators.	5
6.	Pneumatic Circuit Design and Analysis: Design considerations, pressure and energy loss, basic pneumatic systems, vacuum and accumulator systems, circuit analysis.	5
7.	Fluid Logic Control Systems: Principles, basic fluidic devices, fluid sensors, Boolean algebra, fluidic control of fluid power systems.	4
8.	Electrohydraulic Servo Control Systems: Electric components and controls, dual cylinder sequence circuits, electrohydraulic servo system and their analysis, programmable logic controllers.	5
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication
1.	Esposito, A., "Fluid Power with Applications", 7 th Ed., Prentice Hall.	2008
2.	Cundiff, J. S., "Fluid Power Circuits and Controls: Fundamentals and Applications", CRC Press.	2001
3.	Watton, J., "Fundamentals of Fluid Power Control", Cambridge University Press.	2009
4.	Johnson, J. L., "Basic Fluid Power ", Delmar Cengage Learning.	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-544** Course Title: **Design of Heat Exchangers**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of various types of heat exchangers, their construction and design, optimization criteria, performance behaviour and testing.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Classification, constructional details, two and multi-fluid heat exchangers, extended surfaces.	4
2	Design of Heat Exchangers: Engineering design – steps for designing, designing a workable system, feasible/workable design and optimum systems, economics, equation fitting, probabilistic approach to design, sizing and rating problems; LMTD and ϵ -NTU approach of design, design of tubular, shell and tube, finned (radial and longitudinal), regenerative and compact heat exchangers.	12
3	Optimum Design: Criteria for optimization of heat exchangers, different constraints, feasible and optimum design, optimization based on volume, weight, cost, entropy generation and thermoeconomics; Brief introduction to some traditional and non-traditional optimization techniques.	12
4	Performance Behaviour: Design vs simulation, steady state performance – effectiveness, transient performance, non-uniformities in temperature and flow; Three-fluid/ multifluid heat exchanger behaviour.	8
5	Testing: Steady state and transient testing technique, j and f characteristics, empirical relations, numerical approach.	6
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication /Reprint
1	Kays, W.M., and London, A.L., "Compact Heat Exchangers", Krieger Publishing Company.	1998
2.	Shah, R. K. and Sekulic, D. P., "Fundamentals of Heat Exchanger Design", John Wiley & Sons.	2002
3	Kraus A.D., Aziz A. and Welty J.R., "Extended Surface Heat Transfer", Wiley-Interscience.	2001
4	Rao, S. S., "Engineering Optimization: Theory and Practice", 3 rd Ed., Wiley-Interscience.	1996
5.	Hesselgreaves, J.E., "Compact Heat Exchangers: Selection, design and operation", Pergamon Press.	2001
6	Webb, R.L., and Kim, N.H., "Principles of Enhanced Heat Transfer", Taylor and Francis.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-545** Course Title: **Fuel Cells**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the basics of fuel cell operation and their applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Basic principle and operation of Hydrogen fuel cells, types of fuel cells.	4
2.	Fuel Cell Thermodynamics: Free energy change of a chemical reaction, heat of reaction, reversible and net output voltage, theoretical fuel cell efficiency, effect of pressure	8
3.	Fuel Cell Electrochemistry: Electrode kinetics, Butler-Volmer equation, voltage losses, cell potential-polarization curve, fuel cell efficiency.	6
4.	Transport Mechanisms: Fuel cell charge transport, electron conductivity of metals, ionic conductivity of polymer electrolytes, fuel cell mass transport- fuel cell mass balance, diffusive and convective mass transports, heat transfer – fuel cell energy balance, heat management	9
5.	Main Cell Components: Materials, properties, processes, membrane, electrodes, bipolar plates, stack design, hydrogen and oxygen supply systems, PEM fuel cell	9
6.	Fuel Cell Applications: Automobiles, stationary power, fuel cells and hydrogen economy, medium and high temperature fuel cells	6
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication / Reprint
1.	Barbir, F., "PEM Fuel Cells: Theory and Practice", Academic Press.	2005
2.	Larminie, J. and Dicks, A., "Fuel Cell Systems Explained", John Wiley & Sons.	2003
3.	Spiegel, C., "PEM Fuel Cell Modeling and Simulation using MATLAB", Academic Press.	2008
4.	Sammes, N. M., "Fuel Cell Technology – Reaching towards commercialization", Springer.	2006
5.	Gregor, H., "Fuel Cell Technology Handbook", CRC Press.	2003
6.	Srinivasan, S., "Fuel Cells – From Fundamentals to Applications", Springer.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-500** Course Title: **Instrumentation and Experimental Methods**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide a thorough understanding of a measuring system, different transduction principles, error analysis and response related to instrumentation systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Significance of Measurement and Instrumentation: Introduction, generalized configuration and functional stages of measuring systems; Transducer and its environment, an overview, sensing process and physical laws; Types of measurement problems; Transducer classification and their modeling, information, energy and incremental models, characteristics of instruments, design and selection of components of a measuring system.	5
2	Dynamic Response of Instruments: Mathematical model of a measuring system, response of general form of instruments to various test inputs, time-domain and frequency domain analysis; Elementary transfer functions and Bode plots of general transfer functions.	10
3	Errors in Measurement and its Analysis: Causes and types of experimental errors, systematic and random errors; Uncertainty analysis, computation of overall uncertainty, estimation for design and selection for alternative test methods.	4
4	Transducers: Developments in sensors, detectors and transducer technology, displacement transducers, force, torque and motion sensors, piezoelectric transducers, capacity type transducers, strain gage transducers, accelerometers, pressure transducers based on elastic effect of volume and connecting tubing.	10
5	Data Acquisition and Signal Processing: Systems for data acquisition and processing, modules and computerized data system, digitization rate, time and frequency domain representation of signals, and Nyquist criterion; A brief description of elements of mechatronics, modular approach to mechatronics and engineering design.	5
6	Flow Measurement: Flow visualization, shadowgraph, Schlieren and interferometric techniques, Pitot static tubes, hot wire anemometers, laser Doppler velocimeter, flow measurements using Coriolis effect.	4
7	Temperature and Heat Flux Measurement: Thermoelectric sensors, electric resistance sensors, thermistors, radiations pyrometers, Temperature measuring problems in flowing fluids, dynamic compensation.	4
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Doebelin, E. O., "Measurements System Application and Design", 5 th Ed., McGraw Hill	2004
2.	Trietley, H. L., "Transducers in Mechanical and Electronic Design", CRC Press.	1986
3.	Marangoni R D and Lienhard J H, "Mechanical Measurements by Beckwith T G", 6 th Ed., Prentice Hall.	2006
4.	Eckert, R. G. and Goldstein, R. J., "Measurements in Heat Transfer", 2 nd Ed., Springer.	1986
5.	Goldstein, R. J., "Fluid Mechanics Measurement", 2 nd Ed., CRC Press.	1996

Department of Mechanical and Industrial Engineering
M. Tech. (Machine Design Engineering)

I Year
Autumn Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage (%)				
S No	Course No.	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MA-501B	Numerical Analysis	ICC	4	3	1	0	3	--	25	--	25	50	--
2	MI-511B	Modeling and Simulation	PCC	4	3	1	2/2	3	--	15	15	30	40	--
3	MI-551	Dynamics of Mechanical Systems	PCC	4	3	1	0	3	--	25	--	25	50	--
4	MI-552	Advanced Mechanics of Solids	PCC	4	3	1	0	3	--	25	--	25	50	--
5		Open Elective - I	OEC	3/4	--	--	--	3	--	25	--	25	50	--
6	HS-501	Technical Communication (Optional)	---	2	1	0	2	2	--	15	15	30	40	--
Sub Total				19-22										

Spring Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage (%)				
S No	Course No.	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MI-550	Advanced Machine Design	PCC	4	3	1	0	3	--	25	--	25	50	--
2		Program Elective-I	PEC	4	3	1	0	3	--	25	--	25	50	--
3		Program Elective-II	PEC	4	3	1	0	3	--	25	--	25	50	--
4		Program Elective-III	PEC	4	3	1	0	3	--	25	--	25	50	--
5		Open Elective-II	OEC	3/4	-	-	-	3	--	25	--	25	50	--
6	HS-501	Technical Communication (Optional)	---	2	1	0	2	2	--	15	15	30	40	--
Sub Total				19-22										

II Year

Autumn Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage (%)				
S No.	Sub code	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MI-601	Seminar	SEM	2	-	-	-	--	--		--	100	--	--
2	MI-602	Project	RP	4	-	-	-	--	--		--	100	--	--
3	MI-603	Dissertation*	DIS	0	-	-	-	--	--		--	--	25	--
Sub Total				6										

* NOTE: To be continued and grade to be awarded in the next semester.

Spring Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage (%)				
S No.	Sub code	Course Title	Subject Area	Credit	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MI-603	Dissertation (continued from III semester)	DIS	20	-	-	-	--	--	--	--	--	75	--
Sub Total				20										
Total				64-68										

Program Electives for M. Tech. (Machine Design Engineering)

Teaching Scheme					Contact Hrs Per Week			Exam Duration (Hrs)		Relative Weightage (%)				
S No.	Course No.	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MI-500	Instrumentation and Experimental Methods	PEC	4	3	1	0	3	--	25	--	25	50	--
2	MI-508	Advanced Automatic Control	PEC	4	3	1	0	3	--	25	--	25	50	--
3	MI-509	Extended Finite Element Methods	PEC	4	3	1	0	3	--	25	--	25	50	--
4	MI-553	Industrial Tribology	PEC	4	3	1	0	3	--	25	--	25	50	--
5	MI-554	Computer Aided Mechanism Design	PEC	4	3	1	0	3	--	25	--	25	50	--
6	MI-555	Experimental Stress Analysis	PEC	4	3	1	0	3	--	25	--	25	50	--
7	MI-556	Dynamics of Road Vehicles	PEC	4	3	1	0	3	--	25	--	25	50	--
8	MI-557	Finite Element Methods	PEC	4	3	1	0	3	--	25	--	25	50	--
9	MI-558	Fracture Mechanics	PEC	4	3	1	0	3	--	25	--	25	50	--
10	MI-559	Computer Aided Design	PEC	4	3	1	0	3	--	25	--	25	50	--
11	MI-560	Mechanics of Composite Materials	PEC	4	3	1	0	3	--	25	--	25	50	--
12	MI-561	Advanced Mechanical Vibrations	PEC	4	3	1	0	3	--	25	--	25	50	--
13	MI-562	Noise Control in Mechanical Systems	PEC	4	3	1	0	3	--	25	--	25	50	--
14	MI-563	Mechatronics	PEC	4	3	1	0	3	--	25	--	25	50	--
15	MI-565	Smart Materials, Structures, and Devices	PEC	4	3	1	0	3	--	25	--	25	50	--

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-511B** Course Title: **Modeling and Simulation**

2. Contact Hours: L: **3** T: **1** P: **2/2**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **15** PRS **15** MTE **30** ETE **40** PRE **0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To cover concepts, techniques and tools for modeling and simulation of thermal systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Systems and models, examples of models, models for systems and signals.	4
2	Physical modeling: Principles of physical modeling, basic relationship, bond graphs, and computer aided modeling.	4
3	Mathematical modeling: Estimating transient response, spectra and frequency functions, parameter estimation in dynamic models, system identification as a tool for model building.	6
4	Simulation: Simulation of a system of rigid bodies, mechanical systems and components including machine elements.	4
5	Control techniques: Modeling systems for control strategies and design of control strategies in physical domain.	6
6	Numerical techniques: Numerical prototyping as modeling for design and synthesis using computational tools, Introduction to techniques for validation of models.	12
7	Simulation application: Simulation of electromechanical, thermo-mechanical, hydraulic and pneumatic elements.	6
	Total	42

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1	Gordon, G., "System Simulation", Prentice Hall.	1978
2	Lennart, L. and Torkel, G., "Modeling of Dynamic Systems" Prentice Hall.	1994
3	Bhonsle, S.R. and Weinmann, K.J., "Mathematical Modeling for Design of Machine Components", Prentice Hall.	1998
4	D'Souza, A.F., and Garg, V.K., "Advanced Dynamics: Modeling and Analysis", Prentice-Hall.	1983
5	Mukherjee, A., Karmaker, R. and Samantaray, A.K., "Bond Graph in Modeling, Simulation and Fault Identification", I & K International.	2007

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-551** Course Title: **Dynamics of Mechanical Systems**

2. Contact Hours : L: **3** T: **1** P: **0**

3. Examination Duration (Hrs.) : Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4**

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of principles governing the motion of mechanical systems and to develop their skills in analysis and control of their motion.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Basic concepts: Inertial coordinate system, fundamental laws of motion, mechanics of particles and system of particles, principles of linear and angular momentum, work-energy principles.	4
2	Lagrangian dynamics: Degrees of freedom, generalized coordinates and generalized forces, holonomic and non-holonomic constraints, Lagrange's equation from d'Alembert's principles, application of Lagrange's equation for conservative and non-conservative autonomous systems with holonomic and non-holonomic constraints, applications to systems with very small displacements and impulsive motion; Hamilton principle from d'Alembert's principle, Lagrange equation from Hamilton's principle.	10
3	Multi-body dynamics: Space and fixed body coordinate systems, coordinate transformation matrix, direction cosines, Euler angles, Euler parameters, finite and infinitesimal rotations, time derivatives of transformations matrices, angular velocity and acceleration vectors, equations of motion of multi-body system, Newton-Euler equations, planer kinematic and dynamic analysis, kinematic revolute joints, joint reaction forces, simple applications of planer systems.	15
4	Stability of motion: Fundamental concept in stability, autonomous systems and phase plane plots, Routh's criteria for stability, Liapunov's method, Liapunov's stability theorems, Liapunov's function to determine stability of the system.	7
5	Control system dynamics: Open and close loop systems, block diagrams, transfer functions and characteristics equations, proportional integral and derivative control actions and their characteristics.	6
Total		42

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1	Ginsberg, J.H., "Advanced Engineering Dynamics", Harper and Row.	1988
2	Meirovitch, L., "Methods of Analytical Dynamics", McGraw Hill Inc.	1970
3	Harold Josephs and Ronald Huston, "Dynamics of Mechanical Systems", CRC Press.	2002
4	Katsuhiko Ogata, "System Dynamics", 4 th Ed., Prentice Hall;	2003
5	Robert L. Woods and Kent L. Lawrence, "Modeling and Simulation of Dynamic Systems", Prentice Hall.	1997
6	Ramin S. Esfandiari and Bei Lu, "Modeling and Analysis of Dynamic Systems", CRC Press.	2010
7	Dean C. Karnopp, Donald L. Margolis, and Ronald C. Rosenberg, "System Dynamics: Modeling and Simulation of Mechatronic Systems", 4 th Ed., Wiley.	2006
8	Richard A. Layton, "Principles of Analytical System Dynamics" (Mechanical Engineering Series), Springer.	1998

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-552** Course Title: **Advanced Mechanics of Solids**

2. Contact Hours : L: **3** T: **1** P: **0**

3. Examination Duration (Hrs.) : Theory **3** Practical **0**

4. Relative Weightage : CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4**

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: The course aims at providing advanced concepts in behavior of solids under various loading conditions and to train the graduates in analyzing the resulting stresses and deformations.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction to Advanced Elasticity: Cartesian stress components, direct shear and resultant stresses on an oblique plane, stresses and strains in three-dimensions and their transformations, graphical construction for the state of stress at a point, graphical construction for the state of strain on a general strain plane, stress and strain invariants, octahedral planes and stresses; Deviatoric stresses and strains, plane stress and plane strain problems, the stress equations of equilibrium, the strain-displacement relationships and compatibility; The stress function concept and application of Airy's stress function in solving plane elasticity problems.	12
2	Torsion of Non-Circular Sections: Torsion of solid rectangular, square, elliptical cross-sections and thin-walled closed tubes of non-circular section, approximate solutions for rectangular, triangular and thin rectangular open sections, membrane analogy, warping of section.	8
3	Flat Plates: Stresses and deflections in circular plates subjected to axi-symmetric loads with clamped and simply supported edges, circular plates with circular holes, approximate solution for rectangular plates subjected to uniformly distributed load.	8
4	Beams of Elastic Foundation: Introduction to elastic/Winkler foundations and infinite beams, stresses and deflections for infinite beam subjected to concentrated forces, couples and distributed load segment; Semi-infinite beams, short beams, application to rail road tracks and symmetrically loaded cylindrical shells.	6
5	Composite Materials: Introduction, mechanical behavior of anisotropic material, rule of mixture and HalpinTsai equation, stress and strain relations for an off-axis lamina.	8
Total		42

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1	Solecki, R. and Conant, R.J., "Advanced Mechanics of Materials", Oxford University Press.	2004
2	Boresi, A.P. and Sidebottom, O.M., "Advanced Mechanics of Materials", 5 th Ed., John Wiley and Sons.	2007
3	Jones, R.M., "Mechanics of Composite Materials", 1 st Ed., Taylor & Francis.	1998
4	Timoshenko, S.P., and Goodier, J.M., "Theory of Elasticity", 3 rd Ed., McGraw Hill.	2004
5	Timoshebko, S.P. and Kreiger, S.W., "Theory of Plates and Shells", 2 nd Ed., McGraw Hill.	2006
6	O. T. Bruhns, "Advanced Mechanics of Solids", Springer.	2010
7	Kazumi Watanabe and Franz Ziegler, "Dynamics of Advanced Materials and Smart Structures", Springer.	2003

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

- 1.** Subject Code: **MI-550** Course Title: **Advanced Machine Design**
- 2.** Contact Hours : **L: 3** **T: 1** **P: 0**
- 3.** Examination Duration (Hrs.) : Theory **3** Practical **0**
- 4.** Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
- 5.** Credits: **4** **6.** Semester: **Autumn** **7.** Subject Area: **PCC**
- 8.** Pre-requisite: **Nil**
- 9.** Objective: The course is intended to train the graduates in methods of failure analysis and design of machine parts against likely failures, using advanced concepts and also to design for reliability.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Review of failure theories, their scope of applications under different loading and environmental conditions, Hertzian contact stresses and their effect on load carrying capacities of members, effect of small inelastic strains and residual stresses on load carrying capacity, theory of limit design; Machinery construction principles.	12
2	Designing against Fracture: Linear elastic fracture mechanics approach, theories of brittle fracture, fundamental aspects of crack growth and fractures, use of fracture in design.	10
3	Designing against Fatigue and Creep: Causes and interpretation of failures, influence of various factors, low cycle and high cycle fatigue, cumulative damage theories, acoustical and thermal fatigue, corrosion and fretting fatigue, pitting of gears, fatigue strength of joints, components and structures; creep behavior; the mechanical equation of state, an elastic and plastic creep, rupture theory, analysis of tensile creep data, creep in high temperature low cycle fatigue, creep analysis of thick walled cylinders and rotating discs.	10
4	Design for Reliability: Application of statistics to material properties, fatigue and reliability, early chance and wear out failures, reliability prediction against chance and wear out failures, probabilistic approach to design and its comparison with safety factor approach, reliability prediction of series, parallel and stand by systems.	10
	Total	42

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication /Reprint
1	Faupel, J.H., and Fisher, F.E., "Engineering Design", Wiley-Interscience.	1981
2	Burr, A.H., "Mechanical Analysis and Design", Elsevier.	1982
3	Smith, N., "Advances in Creep Design", Applied Science.	1971
4	Bazovsky, I., Reliability Theory & Practice, Courier Dover Publications.	2004
5	Haugen, E.B., Probabilistic Approach Design, John Wiley.	1968
6	Yotaro Hatamura and Yoshio Yamamoto, "The Practice of Machine Design" Oxford University Press.	1999
7	Kai Cheng, "Machining Dynamics: Fundamentals, Applications and Practices" Springer.	2008

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-508** Course Title: **Advanced Automatic Controls**

2. Contact Hours : L: **3** T: **1** P: **0**

3. Examination Duration (Hrs.) : Theory **3** Practical **0**

4. Relative Weightage : CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4**

6. Semester: **Spring**

7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the advanced concepts of state space approach in control system stability, controllability and observability issues and synthesis of industrial control systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Mathematical Models of Linear Systems: Linear systems and state equations, linearization of non linear equations, linearizing functions, linearizing differential equations	4
2	Linear Algebra: Vector spaces, linear dependence and independence, bases, change of basis, rank and degeneracy, norms, Gram-Schmidt orthonormalization, subspaces and projection theorem	4
3	State Variable Analysis: State variable representation, conversion of state variable model to transfer function, characteristic equation, eigenvalues, eigenvectors, conversion of transfer function to canonical state variable models, solution to state equations,	6
4	Stability of Control Systems: Bounded input, bounded output stability, zero input and asymptotic stability of continuous data system, Lyapunov stability, Lyapunov's direct method, external stability, relationship between stability types	6
5	Controllability and Observability: Controllability tests for LTI systems, modal controllability and observability, controllability and observability of time varying systems, discrete time systems	5
6	System Realizations: Minimal realization, specific realization, Markov parameters, balanced realizations	4
7	State Feedback and Observers: State feedback for SISO systems, multivariable canonical forms and feedback, observers, state estimator- multivariable case	5
8	Optimal Control and Estimation: The principle of optimality, optimal estimator	5
9	Pole Placement and Model Matching: Unity feedback configuration, implementable transfer function, multi variable unity feedback system, multivariable model matching	3
Total		42

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/Reprint
1	Ogata, K., "Modern Control Engineering", Prentice Hall of India.	2002
2	Raven, F.H., "Automatic control Theory", McGraw Hill.	1995
3	Kuo, B.C., "Automatic Control System", 5 th , Prentice Hall of India.	1995
4	Chen, C.T., "Linear System Theory & Design", 3 rd Edition, Oxford University Press.	1999
5	Harrison, H.L. and Bollinger, J. G., "Automatic Controls", International Text Book Company.	1970
6	Bay, J.S., "Fundamentals of Linear State Space Systems", McGraw Hill.	1999
7	Norman, S.N., "Control Systems Engineering", John Wiley and Sons.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-509** Course Title: **Extended Finite Element Methods**
2. Contact Hours : L: **3** T: **1** P: **0**
3. Examination Duration (Hrs.) : Theory **3** Practical **0**
4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the recent developments in field of finite element analysis for a better engineering design.
10. Details of Course:

S. No.	Contents	Contact Hours
1	Basic Concepts of Finite Element Methods: Introduction, weighted residual and weak formulations, variational methods, numerical problems.	4
2	Finite Element in 1-D: Basis steps of finite element analysis, Applications to solid mechanics, heat transfer and fluid flow problems.	6
3	Finite Element in 2-D: Single variable problems in 2-D, applications to solid mechanics and heat transfer problems, numerical integration, higher order shape functions, plane stress and plane strain problems.	8
4	Basics of Extended Finite Element Method (XFEM): Brief introduction, partition of unity finite element method (PUFEM), generalised finite element method (GFEM), principles of XFEM, concept of phantom node, blending elements, concept of level sets, weak formulation.	8
5	Engineering Applications: XFEM on element level: shape functions, displacement, strain, element stiffness matrix, XFEM for weak and strong discontinuities e.g. cracks, crack growth problems, bi-materials, phase change problems (solidification, melting).	8
6	Advanced Concepts of XFEM: Tracking the crack path, embedded elements, interface elements, introduction to cohesive zone models, embedded elements, crack initiation/propagation, smeared cracks.	8
Total		42

11. Suggested Books:

S. No.	Name of Authors /Books /Publisher	Year of Publication/Reprint
1	Rao, S.S., "The Finite Element Method in Engineering", 4 th Ed., Elsevier Science.	2005
2	Reddy, J.N., "An Introduction to Finite Element Methods", 3 rd Ed., Tata McGraw-Hill.	2005
3	Fish, J., and Belytschko, T., "A First Course in Finite Elements", John Wiley and Sons.	2007
4	Chaskalovic J., Finite Element Methods for Engineering Sciences, Springer.	2008
5	Mohammadi, S., "Extended Finite Element Method", Blackwell Publisher.	2008

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-553** Course Title: **Industrial Tribology**
2. Contact Hours : L: **3** T: **1** P: **0**
3. Examination Duration (Hrs.): Theory **3** Practical **0**
4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: The course has been designed to give an understanding of tribological phenomena, industrial lubricants and additives.
10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Tribological consideration, nature of surfaces and their contact. Introduction, physico-mechanical properties of surface layer; Geometrical properties of surfaces, method of studying surface; Contact of smooth surfaces, contact of rough surfaces. Role of friction, laws of static friction, causes of friction; Adhesion. Adhesion theory, laws of rolling friction, friction of metals and nonmetals, friction measurement; Wear definitions, types of wear, mechanism of wear, factors affecting wear behavior, measurement of wear a brief introduction of wear test equipments, wear in plastics.	10
2	Industrial Lubricants and Their Additives: Functions of lubricants, types of lubricants and their industrial uses; Solid lubricants and their functions, liquid mineral lubricants, synthetic liquid lubricants, greases, properties of liquid and grease lubricants, viscosity, Newtonian and Non-Newtonian lubricants, temperature and pressure dependence measurement, other properties of lubricants; Lubricant additives, general properties and selection for machines and processes; Oil reclamation and preventive maintenance for lubricants.	8
3	Fluid-Film Lubrication: Fluid mechanics concepts, equations of continuity and motion; Generalized Reynold's equation with incompressible and compressible lubricants; Hydrodynamic lubrication, Tower's experiment, finite bearings, partial journal bearings, solution of finite bearings using Galerkin, finite difference and FEM.	7
4	Dynamically loaded journal bearings: Solution of the generalized Reynold's equation for infinite and short bearing, load carrying capacity, Sommerfield numbers, journal centre locus, whirling; Hydrostatic lubrication-- basic concepts, applications, compensated thrust and journal bearings and their solution using FEM, controlling flow with restrictors, design of restrictors for compensated bearings.	7

5	Gas Lubrication: Types of gas bearings and their characteristics; Reynolds equation for iso-thermal, polytropic and adiabatic supporting gas films; Introduction to porous bearing permeability, solution of thrust and journal bearings.	5
6	Bearing Design and Selection of Bearings: Comparative performance of various modes of lubrication, and bearing selection; Design of slideway bearing and hydrostatic thrust bearing, fixed type hydrodynamic and hydrostatic journal bearings, materials for sliding bearings; Bearing types, selection of rolling elements bearing, bearing life, bearing load, bearing selection.	5
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books/ Publisher	Year of Publication/ Reprint
1	Conner, J.J. and Boyd, J., "Standard Handbook of Lubrication Engineering", McGraw Hill.	1968
2	Stachowiak, G. and A W Batchelor, A. W., "Engineering Tribology", 3 rd Ed, Butterworth-Heinemann.	2005
3	Khonsari, M. M. and Booser, E. R., "Applied Tribology: Bearing Design and Lubrication", 2 nd Ed, Wiley.	2008
4	Kudish, I. I. and Covitch, M. J., "Modeling and Analytical Methods in Tribology", Chapman and Hall/CRC.	2010
5	Bhushan, B., "Principles and Applications of Tribology", Wiley.	1999

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-554** Course Title: **Computer Aided Mechanism Design**

2. Contact Hours : L: **3** T: **1** P: **0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: The course aims at providing the basic concepts of analysis and design of mechanisms.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Review of concepts related to kinematic analysis of mechanisms, degrees of freedom, Grashof's and Gruebler's criteria, transmission and deviation angles, mechanical advantage.	10
2	Kinematic Synthesis of Mechanisms: Type, number and dimensional synthesis, spacing of accuracy points, Chebyshev polynomials, path motion and function generation, graphical synthesis with two, three, and four prescribed positions and points.	9
3	Analytical Synthesis Techniques: complex number modeling, dyad and standard form equation, Freudenstein's equation for three point function generation, coupler curves, Robert's law, cognates of linkages.	9
4	Path Curvature Theory: Fixed and moving centrode, inflection points and inflection circle, Euler-Savary equation, Bobillier and Hartmann's construction.	8
5	Dynamic Force Analysis: Introduction, inertia forces in linkages, kinetic-static analysis by superposition and matrix approaches and its applications, introduction to spatial mechanisms.	6
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books/ Publisher	Year of Publication /Reprint
1	Hall, A.S., "Kinematic and Linkage Design", Prentice Hall Inc.	1978
2	Sacks, E. and Joskowicz, L., "The Configuration Space Method for Kinematic Design of Mechanisms", MIT Press.	2010
3	Erdman, A. G. and Sandor, G. N., "Mechanism Design: Analysis and Synthesis", 3 rd Ed, Prentice Hall.	1996
4	Shabana, A. A., "Computational Dynamics", 3 rd Ed., Wiley.	2010
5	Shabana, A. A., "Dynamics of Multibody Systems", 2 nd Ed., Cambridge University Press.	2003
6	Eckhardt, H. D., "Kinematic Design of Machines and Mechanisms", McGraw-Hill.	1998

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-555** Course Title: **Experimental Stress Analysis**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: The course aims at providing fundamental concepts and applications of the most conventional experimental stress analysis methods used in practice.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Importance of experimental methods and their scope, whole field and point by point methods.	2
2	Photoelasticity: Nature of light, photoelastic effect and polarized light, permanent and temporary birefringence, types of polariscopes and their basic elements, optics of plane and circular polariscope, isoclinics and isochromatics, stress optic law and secondary principal stresses; Photoelastic model materials their properties and selection, preparation of models, transition from model to prototypes, measurement of relative retardation and fringe order, compensation techniques, separation of principal stresses by oblique incidence, shear difference and numerical integration of Laplace's equation.	8
3	Photoelastic methods: Calibration methods and determination of stress trajectories from isoclinic data; Basic elements of three dimensional photoelasticity, stress freezing and slicing the model and interpretation of the resulting fringe patterns, fringe sharpening and fringe multiplication techniques; Photoelastic methods to determine stress intensity factors.	4
4	Birefringent Coatings: Surface stress determinations using birefringent coatings, sensitivity of birefringent coatings; Reinforcing, thickness and other effects of photoelastic coatings; Separation of principal stresses; Birefringent coating materials and applications; Photoelastic stress and strain gauges.	6
5	Scattered Light Photoelasticity: Scattering phenomenon and polarization associated with scattering, scattered light technique to solve general three dimensional problem; Scattered light polariscope.	5
6	Moire Method of Strain Analysis: Moire phenomenon and formation of Moire fringes; Geometric and displacement approach for in-plane problems, Moire grating production, printing and photography.	5
7	Brittle Coatings: Introduction, coating stresses; Brittle coating failure theories; Factors affecting analysis of coating data; Crack patterns due to direct and	6

	relaxation loading; Refrigeration technique, calibration methods and scope of application of brittle coating method.	
8	Digital Image Processing: Fringe multiplication, fringe thinning and fringe clustering through data acquisition by DIP methods; Phase shifting, polarization stepping and Fourier transform techniques phase unwrapping and optical enhanced tiling, use of colour image processing techniques for data acquisition in digital photoelasticity.	6
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication /Reprint
1	Phillips, E.A., Durelli, A.J. and Tsao, C.H., "Analysis of Stress and Strain", McGraw Hill.	1958
2	Daily, J.W. and Riley, W.F., "Experimental Stress Analysis", McGraw Hill.	1991
3	Durelli, A.J. and Riley, W.F., "Introduction to Photomechanics", Prentice Hall.	1965
4	Frocht, M.M., "Photoelasticity (Vol. I and II)", John Wiley.	1948
5	Ramesh, K., "Digital Photoelasticity: Advanced Techniques and Applications", Springer-Verlag.	2000
6	James W. Dally and William F. Riley, "Experimental Stress Analysis", College House Enterprises.	2005
7	James F. Doyle, "Modern Experimental Stress Analysis: Completing the Solution of Partially Specified Problems", Wiley.	2004
8	Pramod K. Rastogi, "Photomechanics"(Topics in Applied Physics),Springer.	2000

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-556** Course Title: **Dynamics of Road Vehicles**

2. Contact Hours: **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide fundamental engineering principles underlying the control, stability, handling and cornering behavior of road vehicles.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction to Vehicle Dynamics: Various kinds of vehicles, motions, mathematical modelling methods; Multibody system approach and Lagrangian formulations, methods of investigations, stability concepts.	4
2	Mechanics of Pneumatic Tyre: Tyre construction, physics of tyre traction on dry and wet surfaces, tyre forces and moments, SAE recommended practice, rolling resistance of tyres, ride properties of tyres.	10
3	Performance Characteristics: Equation of motion and maximum tractive effort, aerodynamic forces and moments, vehicle power plant and transmission characteristics, prediction of vehicle performance, operating fuel economy, braking performance, antilock braking systems.	8
4	Handling and Stability Characteristics: Steering geometry; steady state handling characteristics, steady state response to steering input, transient response characteristics directional stability, effects of tyre factors, suspension, braking and vehicle parameters on stability and handling.	8
5	Vehicle Ride Characteristics: Human response to vibration, vehicle ride models, road surface profile as a random function; frequency response function, evaluation of vehicle vertical vibration in relation to ride comfort criterion.	7
6	Experimental Testing: Instruments for vehicle measurements, recording and evaluation methods, test methods and measurement procedures for vehicle dynamics, interpretation of test results and correlation between measured values and subjective evaluation of the vehicle handling.	5
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication / Reprint
1.	Wong, J.Y., "Theory of Ground Vehicles", John Wiley.	2001
2.	Gillespie, T.D., "Fundamental of Vehicle Dynamics", S.A.E.	1992
3	Rao, V. D., "Road Vehicle Dynamics", SAE International.	2008
4	Rajesh, R., "Vehicle Dynamics and Control", Springer.	2005
5	Hans, T., "The Dynamics of Vehicles on Roads and on Tracks", Taylor and Francis,	2003
6	Barnard, R. H., "Road Vehicle Aerodynamic Design: An Introduction", 2 nd Ed., Mechaero Publishing.	2001
7	Wong, J. Y., "Theory of Ground Vehicles", 4 th Ed., Wiley.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-557** Course Title: **Finite Element Methods**

2. Contact Hours: L: 3 T: 1 P: 0

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8 Pre-requisite: **Nil**

9 Objective: To provide the basic concepts of finite element method and its applications to wide range of engineering problems.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Basic Concepts: Introduction, weak formulations, weighted residual methods, variational formulations, weighted residual, collocation, subdomain, least square and Galerkin's method, virtual work principle.	6
2	One Dimensional Problems: Basis steps, discretization, element equations, linear and quadratic shape functions, assembly, local and global stiffness matrix and its properties, boundary conditions, penalty approach, multipoint constraints, applications to solid mechanics, heat and fluid mechanics problems, axisymmetric problems, transient problems	8
3	Trusses: Plane truss, local and global coordinate systems, stress calculations, temperature effect on truss members, solution of practical problems.	3
4	Beams and Frames: Euler Bernoulli beam element, Rayleigh beam element, frame element, problems.	5
5	Two Dimensional Problems: Single variables in 2-D, triangular and rectangular elements, constant strain triangle, isoparametric formulation, higher order elements, six node triangle, nine node quadrilateral, master elements, numerical integration, computer implementation.	8
6	Scalar Field Problems: Torsion, heat transfer, heat transfer in thin fins, potential flow problems.	4
7	Elasticity Problems: Review of equations of elasticity, stress-strain and strain-displacement relations, dynamic problems on vibrations, plane stress and plane strain problems.	8
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication /Reprint
1	Huebner, K.H., Dewhirst, D.L., Smith, D.E. and Byrom, T.G., "The Finite Element Method for Engineers", 4 th Ed., John Wiley and Sons.	2001
2	Rao, S.S., "The Finite Element Method in Engineering", 4 th Ed., Elsevier Science.	2005
3	Reddy, J.N., "An Introduction to Finite Element Methods", 3 rd Ed., Tata McGraw-Hill.	2005
4	Fish, J. and Belytschko, T., "A First Course in Finite Elements", John Wiley and Sons.	2007
5	Chaskalovic, J., "Finite Element Methods for Engineering Sciences", Springer.	2008

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-558** Course Title: **Fracture Mechanics**

2. Contact Hours: L: 3 T: 1 P: 0

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: Nil

9. Objective: To introduce the mechanics of anisotropic material, and provide insight into different failure mechanisms typical of anisotropic and heterogeneous systems

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction to Fracture Mechanics: Introduction to the realm of fracture and back ground history of development of fracture mechanics; Discrepancy between theoretical and real strength of materials, conventional failure criteria based on stress concentration and characteristic brittle failures, Griffith's work.	5
2	Linear Elastic Fracture Mechanics (LEFM) Based Design Concepts: Crack deformation modes and basic concepts, crack tip stresses and deformation, stress intensity factor (SIF) and its criticality in different modes, superposition of SIFs, LEFM design concept applications; Concept of energy release rate, equivalence of energy release rate and SIF.	10
3	Fracture toughness: Fracture toughness and its laboratory determination procedure, test specimen size requirement etc.; Effect of temperature and loading rate on fracture toughness; Fatigue and fatigue crack propagation laws, fatigue life calculations under constant and variable amplitude loading, mixed-mode fatigue crack propagation.	10
4	Strain Energy Density Failure Criterion: Introduction, volume strain energy density, basic hypothesis and application of energy density based failure criteria for two and three dimensional linear elastic crack problems.	7
5	Elastic Plastic Fracture Mechanics Based Design Criteria: Design criteria for non-brittle materials; plastic zone corrections, crack opening displacement (COD), J-contour integral and crack growth resistance (R-curve) concepts.	10
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1	Gdoutos, E.E., "Fracture Mechanics: An Introduction", 2 nd Ed., Springer.	2005
2	Broek, D., "Elementary Engineering Fracture Mechanics", 3 rd Ed., Springer.	1982
3	Kumar, P., "Elements of Fracture Mechanics", Wheeler Publishing.	1999
4	Anderson, T. L., "Fracture Mechanics: Fundamentals and Applications", 3 rd Ed., CRC Press.	2005
5	Shukla, A., "Practical Fracture Mechanics in Design", 2 nd Ed., CRC Press.	1989
6	Bazant, Z. P. and Cedoliin, L., "Stability of Structures: Elastic, Inelastic, Fracture and Damage Theories", World Scientific Publishers.	2010

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-559**

Course Title: **Computer Aided Design**

2. Contact Hours: L: 3 T: 1 P: 0

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4

6. Semester: **Spring**

7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objectives of Course: The course aims at providing the basic concepts and elementary tools of CAD.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: The design process, elements of CAD	01
2	Principles of Software Design: Characteristics of good software, data structures, algorithm design, flow chart, coding, top-down programming, modular programming, structural coding, testing of the software.	04
3	Computer Graphics: Graphics display, transformations, visualizations, computer animation.	05
4	3D Modeling and Viewing: Coordinate systems, sketching and sketch planes; Modeling aids and tools; Layers, grids, clipping, arrays, editing.	05
5	Curves Modeling: Analytical and synthetic curves, curve manipulations.	06
6	Surface Modeling: Surface representation and surface analysis, analytical and synthetic surfaces, surface manipulations, NURBS.	06
7	Solid Modeling: Geometry and topology, solid entities, solid representation, fundamental of solid modeling, half spaces, boundary representation, constructive solid geometry, sweeps, solid manipulations.	05
8	Features: Feature entities, feature representation, three dimensional sketching, parametrics, relations, constraints, feature manipulation.	02
9	Mass properties: Geometric and mass properties evaluation, assembly modeling; product data exchange	05
10	Optimization technique: Single variable optimization, multi-variable optimization, Johnson's method of optimum design, genetic algorithm.	03
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1	Zeid, I., "Mastering CAD/CAM", Tata McGraw Hill.	2007
2	Onwubiko, C., "Foundation of Computer Aided Design", West Publishing Company.	1989
3	Hsu, T. R. and Sinha, D. K., "Computer Aided Design: An Integrated Approach", West Publishing Company.	1991
4	Dimarogonas, A. D., "Computer Aided Machine Design", Prentice Hall.	1988
5	Mortenson, M. E., "Geometric Modeling", 3 rd Ed., Industrial Press.	2006

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-560** Course Title: **Mechanics of Composite Materials**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the mechanics of anisotropic material and to provide insight into different failure mechanisms typical of anisotropic and heterogeneous systems.
10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Composite materials, characteristics, classification, advantages and typical problems.	2
2	Unidirectional Lamina: Introduction, longitudinal strength and stiffness, transverse strength and stiffness, failure modes, thermal expansion and transport properties.	6
3	Short Fibre Composites: Theories of stress transfer, modulus and strength of short fibre composites.	4
4	Analysis of an Orthotropic Lamina: Hook's law, stress-strain relation for lamina with an arbitrary orientation, strength of a lamina subjected to biaxial stress field.	6
5	Analysis of Laminated Composites: Classical lamination theory, thermal stress in laminates.	12
6	Special Design Considerations: Analysis after initial failure, inter-laminar stress, free edge effect, design of joints, elementary fracture mechanics concepts related to composite materials.	8
7	Experimental Characterization: Uni-axial tension test, compression test, in-plane shear test, three and four point bending test, determination of interlaminar shear strength.	4
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1	Agarwal, B.D. and Broutman, L.J., "Analysis and Performance of Fibre Composites", 3 rd Ed., John Wiley & Sons.	2006
2	Jones, R.M., "Mechanics of Composite Materials", Taylor & Francis.	1998
3	Ashbee, K.H.G. and Ashbee, H.G., "Fundamental Principles of Fibre Reinforced Composites", 2 nd Ed., CRC Press.	1993
4	Daniel, I.M. and Ishai, O., "Engineering Mechanics of Composite Materials", 2 nd Ed., Oxford University Press.	2007
5	Christensen, R.M., "Mechanics of Composite Materials", Dover Publications.	2005
6	Kaw, A. K., "Mechanics of Composite Materials", 2 nd Ed., CRC Press.	2005

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-561** Course Title: **Advanced Mechanical Vibrations**
2. Contact Hours: L: **3** T: **1** P: **0**
3. Examination Duration (Hrs.): Theory **3** Practical **0**
4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To provide detail knowledge about nonlinear and random vibration with fault diagnosis of machinery.
10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Review of free and forced vibrations with and without damping.	3
2	Isolation: Vibration isolation and transmissibility; Un-damped vibration absorbers.	4
3	Multi degree of freedom system: Generalized coordinates and coordinate coupling; Orthogonality of modes, Free and forced vibration of multi-degree of freedom systems with and without viscous damping; Lagrange's equation; Holzer's method. Solution of Eigen value problem, transfer matrix and modal analysis.	12
4	Stability criterion: Self excited vibrations; Criterion of stability; Effect of friction on stability.	4
5	Non linear vibration: Free vibrations with non-linear spring force or nonlinear damping; Phase plane; Energy curves; Lienard's graphical construction; Method of isoclines.	5
6	Vibration of continuous system: Vibrations of strings; Free and forced longitudinal vibrations of prismatic bars; Ritz and Galerkin methods.	6
7	Random vibration: Mathematical descriptions of stochastic processes; Stationary and ergodicity; Gaussian random process, correlation functions and power spectral density.	4
8	Diagnostic techniques: Introduction to diagnostic maintenance and signature analysis.	4
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication /Reprint
1	Rao, S.S., "Mechanical Vibrations", 4 th Ed., Pearson Education.	2007
2	Meirovitch, L., "Fundamental of Vibrations", Mc-Graw Hill.	2001
3	Inman, D.J., "Vibration and Control", John Willey & Sons.	2002
4	Tamaddonni, S. and Kelly, G.S., "Mechanical Vibrations", Mc-Graw Hill.	1998
5	Rao, J. S., "Vibration Condition Monitoring of Machines", Tata Mc-Graw Hill.	2006

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-562** Course Title: **Noise Control in Mechanical Systems**

2. Contact Hours : L: 3 T: 1 P: 0

3. Examination Duration (Hrs.) : Theory 3 Practical 0

4. Relative Weightage :CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4

6. Semester: **Spring**

7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart fundamental knowledge of the subject on noise control problems in mechanical systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Sound vs noise; Time and frequency domain representation, hearing mechanism -- assessment of noise, its units, human response to noise of different types- stead, fluctuating and impulsive, physiological effects of noise, control of noise, need, concepts and options, and its relation to vibrations.	6
2	Homogeneous Wave Equation: Linearized wave equation, acoustic velocity potential acoustic impedance, plane wave propagation, intensity, energy density and power, Simple Source models, monopole, dipole, quadrupole and linear, effect of proximity of rigid boundaries, directivity patterns.	6
3	Inhomogeneous Wave Equation and Aerodynamic Noise Theory: Effect of solid bodies in flow, vortex flow; Ray Acoustics-- propagation of sound outdoors, divergence, excess attenuation factors, effects of wind, temperature gradient and turbulence anomalous propagation, shadow zones, ground and terrain effects, harriers, cuttings and elevation.	7
4	Wave-Structure Interaction: Sound radiation from plates infinite and bounded; radiation ratio, sound transmission through layered media, behavior of infinite and finite panels, coincidence phenomena and design curves, sound transmission loss, fluid loading on structure, impact noise, introduction to statistical energy analysis.	6
5	Instrumentation: Sound measuring equipment, microphones, preamplifiers, sound level meters, recorders, frequency analysers statistical measurements, FFT analysers.	5
6	Noise Control Principles: Control strategies and limitations, integrated approach to low noise design, typical mechanical noise sources, mechanism of noise generation-- vibration, impact, flow excitation, control of solid borne and air-home noise, concept of impedance mismatch, filters, silencers, damping, enclosure, absorbers, active noise control principle.	8

7	Case Studies: Noise control in reciprocating and rotating machinery, and fluid flow systems: e.g., gears, bearing, piping systems, automobiles, aircrafts, refrigeration and air conditioning systems elements, machine tools, presses etc., environmental noise control and receiver protection.	4
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication /Reprint
1	Faulkner, L.L, "Handbook of Industrial Noise Control", Industrial Press.	2001
2	Lyon, R.H., "Machinery Noise and Diagnostics", Butterworths.	1995
3	Norton, M.P., "Fundamentals Noise and Vibration Analysis", Cambridge University Press.	1989
4	Rahn, C. D., "Mechatronic Control of Distributed Noise and Vibration", Springer.	2001
5	Fuller, C. C., Elliott, S.J., and Nelson, P. A., "Active Control of Vibration", Academic Press.	1996
6	Moser, M., Zimmermann, S. and Ellis, R., "Engineering Acoustics: An Introduction to Noise Control", 2 nd Ed., Springer.	2009

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-563** Course Title: **Mechatronics**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs.): Theory **3** Practical **0**
4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: The course deals with basic principles of Mechatronics involving sensors, actuators, control systems, and microprocessor systems.
10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Definition of mechatronics, measurement system, control systems, microprocessor based controllers, mechatronics approach.	2
2	Sensors and Transducers: Sensors and transducers, performance terminology, photoelectric transducers, flow transducers, optical sensors and transducers, semiconductor lasers, selection of sensors, mechanical / electrical switches, inputting data by switches.	7
3	Actuators: Actuation systems, pneumatic and hydraulic systems, process control valves, rotary actuators, mechanical actuation systems, electrical actuation systems.	5
4	Signal Conditioning: Signal conditioning, filtering digital signal, multiplexers, data acquisition, digital signal processing, pulse modulation, data presentation systems.	4
5	Microprocessors and Microcontrollers: Microcomputer structure, microcontrollers, applications, programmable logic controllers.	8
6	Modeling and System Response: Mathematical models, mechanical, electrical, hydraulic and thermal systems, dynamic response of systems, transfer function and frequency response, closed loop controllers.	9
7	Design and Mechatronics: Input/output systems, computer based modular design, system validation, remote monitoring and control, designing, possible design solutions, case studies.	7
Total		42

11. Suggested Books:

S. No-	Name of Authors / Books / Publisher	Year of Publication /Reprint
1	Bolton, W., "Mechatronics", Longman.	1999
2	Alciatore, D. G. and Histrand, M. B., "Introduction to Mechatronics", Tata McGraw Hill.	2003
3	Shetty, D. and Richard, A.K., "Mechatronics System Design", PWS Pub. Boston.	1997
4	Mahalik, N., "Principles, Concept and Applications: Mechatronics", Tata McGraw.	2003
5	Bishop, R.H. "Mechatronics Handbook", CRC Press.	2002
6	Bolton, W., "Mechatronics: A Multidisciplinary Approach", 4 th Ed., Prentice Hall.	2009

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-565** Course Title: **Smart Materials, Structures and Devices**

2. Contact Hours : L: 3 T: 1 P: 0

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4**

6. Semester: **Spring**

7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge on analysis of smart materials for various applications such as sensors, actuators and controllers with reference to various structures and devices.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Intelligent Materials: Primitive functions of intelligent materials; Intelligence inherent in materials; Materials intelligently harmonizing with humanity; Intelligent biological materials.	2
2	Smart Materials and Structural Systems: Actuator materials; Sensing technologies; Microsensors; Intelligent systems; Hybrid smart materials; Passive sensory smart structures; Reactive actuator-based smart structures; Active sensing and reactive smart structures; Smart skins.	4
3	Electro-Rheological Fluids: Suspensions and electro, rheological fluids; The electro- rheological phenomenon; Charge migration mechanism for the dispersed phase; Electro rheological fluid actuators.	4
4	Piezoelectric Materials: Background; Piezoelectricity; Industrial piezoelectric materials; Smart materials featuring piezoelectric elements.	3
5	Shape Memory Materials: Background on shape memory alloys; Applications of shape memory alloys; Continuum applications: structures and machine systems; Discrete applications; Impediments to applications of shape memory alloys; Shape memory plastics.	4
6	Fiber Optics: Overview; Light propagation in an optical fiber; Embedding optical fibers in fibrous polymeric thermosets; Fiberoptic strain sensors.	3
7	The Piezoelectric Vibrations Absorber Systems: Introduction; The single mode absorber, theory, design solution, extension including viscous modal damping, the electromechanical coupling coefficient, inductance, experimental results; The multimode absorber, derivation of transfer function, design solution, self-tuning absorber, performance function, control scheme.	7
8	Modeling of Shells: Derivation of the basic shell equations, equation of motion, equations for specific geometries and cylindrical shell.	10
9	Modeling of plates and beams: Plate equations and beam equations.	5
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication /Reprint
1	Gandhi, M. V. and Thompson, B. S., "Smart Materials and structures", Chapman & Hall.	1992
2	Banks, H. T., Smith, R. C. and Qang, Y. W., "Smart Material structures: Modeling, Estimation and Control", John Wiley & Sons.	1996
3	Gabbert, U. and Tzou, H. S., "Smart Structures and Structronic System", Kluwer Academic Publishers.	2001
4	Preumont, A., "Vibration Control of Active Structures", Kluwer Academic Publishers.	2002
5	Cheng, F. Y., Jiang, H. and Lou, K., "Smart Structures: Innovative Systems for Seismic Response Control", CRC Press.	2008

Department of Mechanical and Industrial Engineering
M. Tech. (CAD, CAM and Robotics)

I Year

Autumn Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage (%)				
S No	Course No.	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MA-501B	Numerical Analysis	ICC	4	3	1	0	3	--	25	--	25	50	--
2	MI-511B/ MI-511C	Modeling and Simulation	PCC	4	3	1	2/2	3	--	15	15	30	40	--
3	MI-501	Computer Aided Manufacturing	PCC	4	3	1	0	3	--	25	--	25	50	--
4	MI-559	Computer Aided Design	PCC	4	3	1	0	3	--	25	--	25	50	--
5		Open Elective - I	OEC	3/4	--	--	--	3	--	25	--	25	50	--
6	HS-501	Technical Communication (Optional)	---	2	1	0	2	2	--	15	15	30	40	--
Sub Total				19-22										

Spring Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage (%)				
S No	Course No.	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MI-502	Robotics and Control	PCC	4	3	1	2/2	3	--	15	15	30	40	--
2		Program Elective-I	PEC	4	3	1	0	3	--	25	--	25	50	--
3		Program Elective-II	PEC	4	3	1	0	3	--	25	--	25	50	--
4		Program Elective-III	PEC	4	3	1	0	3	--	25	--	25	50	--
5		Open Elective-II	OEC	3/4	-	-	-	-	--	25	--	25	50	--
6	HS-501	Technical Communication (Optional)	---	2	1	0	2	2	--	15	15	30	40	--
Sub Total				19-22										

II Year

Autumn Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage (%)				
S No.	Sub code	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MI-601	Seminar	SEM	2	-	-	-	--	--		--	100	--	--
2	MI-602	Project	RP	4	-	-	-	--	--		--	100	--	--
3	MI-603	Dissertation*	DIS	0	-	-	-	--	--		--	--	25	--
Sub Total				6										

* NOTE: To be continued and grade to be awarded in the next semester.

Spring Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage (%)				
S No.	Sub code	Course Title	Subject Area	Credit	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MI-603	Dissertation (continued from III semester)	DIS	20	-	-	-	--	--	--	--	--	75	--
Sub Total				20										
Total				64-68										

Program Electives for M. Tech. (CAD, CAM & ROBOTICS)

Teaching Scheme					Contact Hrs Per Week			Exam Duration (Hrs)		Relative Weightage (%)				
S No.	Course No.	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MI-500	Instrumentation and Experimental Methods	PEC	4	3	1	0	3	--	25	--	25	50	--
2	MI-515	Manufacturing System Analysis	PEC	4	3	1	0	3	--	25	--	25	50	--
3	MI-516	Artificial Intelligence	PEC	4	3	1	0	3	--	25	--	25	50	--
4	MI-517	Automated Materials Handling Systems	PEC	4	3	1	0	3	--	25	--	25	50	--
5	MI-527	Computational Fluid Dynamics and Heat Transfer	PEC	4	3	1	0	3	--	25	--	25	50	--
6	MI-550	Advanced Machine Design	PEC	4	3	1	0	3	--	25	--	25	50	--
7	MI-551	Dynamics of Mechanical Systems	PEC	4	3	1	0	3	--	25	--	25	50	--
8	MI-554	Computer Aided Mechanism Design	PEC	4	3	1	0	3	--	25	--	25	50	--
9	MI-561	Advanced Mechanical Vibrations	PEC	4	3	1	0	3	--	25	--	25	50	--
10	MI-563	Mechatronics	PEC	4	3	1	0	3	--	25	--	25	50	--
11	MI-565	Smart Materials, Structures, and Devices	PEC	4	3	1	0	3	--	25	--	25	50	--
12	MI-566	Computer Aided Analysis of Mechanical Systems	PEC	4	3	1	0	3	--	25	--	25	50	--
13	MI-567	Computer Graphics	PEC	4	3	1	0	3	--	25	--	25	50	--
14	MI-568	Advanced Robotics	PEC	4	3	1	0	3	--	25	--	25	50	--
15	MI-569	Expert System Design	PEC	4	3	1	0	3	--	25	--	25	50	--
16	MI-575	Product Design and Development	PEC	4	3	1	0	3	--	25	--	25	50	--
17	MI-576	Machine Tool Design and Numerical Control	PEC	4	3	1	0	3	--	25	--	25	50	--
18	MI-577	Industrial Automation	PEC	4	3	1	0	3	--	25	--	25	50	--
19	MI-578	Computer Aided Process Planning	PEC	4	3	1	0	3	--	25	--	25	50	--
20	MI-579	Information Systems and Data Management	PEC	4	3	1	0	3	--	25	--	25	50	--
21	MI-582	Flexible Manufacturing Systems	PEC	4	3	1	0	3	--	25	--	25	50	--
22	MI-584	Operations Research	PEC	4	3	1	0	3	--	25	--	25	50	--

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-511C** Course Title: **Modeling and Simulation**

2. Contact Hours: L: **3** T: **1** P: **2/2**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **15** PRS **15** MTE **30** ETE **40** PRE **0**

5. Credits: **4**

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre – requisite: **Nil**

9. Objective: To introduce concepts, techniques and tools for modeling and simulation of discrete event systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to Modeling: Concept of system, continuous and discrete systems, types of models, time advance mechanisms, components and organizations of a discrete event simulation models, steps in simulation study.	6
2.	Statistical Models in Simulation: Discrete, continuous, Poisson and empirical distributions; Output data analysis for a single system-types of simulation with regard to output analysis, statistical analysis for terminating simulations comparing alternative system configurations, statistical procedures for comparing real world observations with simulation output data, generation of arriving processes,	9
3.	Verification and Validation of Simulation Models: Introduction, guidelines for determining the level of model details, verification of simulation computer programs, techniques for increasing model validity and credibility.	5
4.	Monte Carlo Simulation: Introduction to Monte Carlo simulation, random number generators, and inventory control simulations; Fixed period and fixed quantity system, simulation of queuing problems, applications in queuing models and inventory models.	8
5.	Simulation of Manufacturing and Material Handling Systems: Introduction, objective of simulation in manufacturing, modeling system randomness, sources of randomness, machine down-times, calendar time and busy time approach, models of material handling systems.	8
6.	Case Studies: Use of simulation package to solve of problems related to simulation of queuing systems, simulation of material handling and manufacturing systems.	6
Total		42

11. List of Experiments:

1. Simulation of queuing problems
2. Generation of random numbers
3. Study of input probability distribution functions
4. Simulation of manufacturing systems
5. Simulation of material handling systems

12. Suggested Books:

S. No.	Name of Authors / Books /Publisher	Year of Publication /Reprint
1.	Banks, J. and Carson, J. S., "Discrete Event System Simulation", 5 th Ed., Prentice Hall.	2009
2.	Averill, M. L. and Kelton, W.D., "Simulation Modeling and Analysis", 3 rd Ed., McGraw Hill.	2006
3.	Schwarzenbach, J. and Gill K. F., "System Modeling and Control", 5 th Ed., Edward Arnold.	1995
4.	Carrie, A., "Simulation of Manufacturing Systems", John Wiley and Sons.	1988
5.	Viswanadham, N. and Narahari, Y., "Performance Modeling of Automated Manufacturing System", Prentice Hall.	1992
6.	Kelton, W., Sadowski, R. and Swets, N., "Simulation with Arena", McGraw-Hill	2009

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-501** Course Title: **Computer Aided Manufacturing**
2. Contact Hours : L: 3 T: 1 P: 0
3. Examination Duration (Hrs.) : Theory 3 Practical 0
4. Relative Weightage : CWS 25 PRS 0 MTE 25 ETE 50 PRE 0
5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective: To provide knowledge and details of the means of computer aided manufacturing and various functions supporting the automated manufacturing.
10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Introduction to manufacturing systems and their performance analysis; Introduction to automation; Introduction to computer integrated manufacturing (CIM).	04
2	Numerical Control (NC): Introduction, numerical control – its growth and development, components of NC system, input devices, control systems – point to point, straight cut, and continuous path NC, open loop and closed loop NC systems, NC interpolations – linear, circular, helical, parabolic and cubic interpolation, applications of NC systems, merits and demerits.	10
3	Extensions of NC: Concepts of computer numerical control (CNC), machining center, and direct numerical control (DNC), and their advantages.	06
4	Robotics: Robot anatomy and related attributes, robot control systems – limited sequence, playback with point to point, playback with continuous and intelligent control; End effectors – gripper, tools; Sensors in robotics – tactile sensors, proximity, optical sensors and machine vision; Applications of industrial robots, robot programming.	06
5	Material Handling and Storage: Overview of material handling equipments, automated material handling equipments – AGVs, conveyor systems, performance analysis of material handling systems, automated material storage systems – ASRS and carousel storage, analysis of automated storage systems.	06
6	Manufacturing Support Functions: Introduction to group technology (GT), computer aided process planning (CAPP), material requirement planning MRP (MRP), capacity planning, scheduling etc.	10
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication / Reprint
1	Groover, M. P., "Automation, Production systems and Computer Integrated Manufacturing", 3 rd Ed., Prentice-Hall.	2007
2	Singh, N., "Systems Approach to Computer Integrated Design and Manufacturing", John Wiley & Sons.	1996
3	Chang, T.-C., Wysk, R. A. and Wang, H.-P. "Computer Aided Manufacturing", 3 rd Ed., Prentice Hall.	2005
4	Rembold, U., Nnaji, B. O. and Storr A., "Computer Integrated Manufacturing", Addison Wesley.	1994
5	Besant, C. B. and Lui, C. W. K., "Computer Aided Design and Manufacture", Ellis Horwood Ltd.	1991
6	Rao, P. N., Tiwari, N. K. and Kundra, T.K., "Computer Aided Manufacturing", Tata McGraw Hill.	1993
7	Koren, Y. "Computer Control of Manufacturing Systems", McGraw Hill.	1983
8	Lynch, M., "Computer Numerical Control for Machining", McGraw-Hill.	1992
9	Sava, M. and Pusztai, J., "Computer Numerical Control Programming", Prentice Hall.	1990

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-559** Course Title: **Computer Aided Design**

2. Contact Hours: L: 3 T: 1 P: 0

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: The course aims at providing the basic concepts and elementary tools of CAD.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: The design process, elements of CAD	01
2	Principles of Software Design: Characteristics of good software, data structures, algorithm design, flow chart, coding, top-down programming, modular programming, structural coding, testing of the software.	04
3	Computer Graphics: Graphics display, transformations, visualizations, computer animation.	05
4	3D Modeling and Viewing: Coordinate systems, sketching and sketch planes; Modeling aids and tools; Layers, grids, clipping, arrays, editing.	05
5	Curves Modeling: Analytical and synthetic curves, curve manipulations.	06
6	Surface Modeling: Surface representation and surface analysis, analytical and synthetic surfaces, surface manipulations, NURBS.	06
7	Solid Modeling: Geometry and topology, solid entities, solid representation, fundamental of solid modeling, half spaces, boundary representation, constructive solid geometry, sweeps, solid manipulations.	05
8	Features: Feature entities, feature representation, three dimensional sketching, parametric, relations, constraints, feature manipulation.	02
9	Mass properties: Geometric and mass properties evaluation, assembly modeling, product data exchange	05
10	Optimization technique: Single variable optimization, multi-variable optimization, Johnson's method of optimum design, genetic algorithm.	03
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication / Reprint
1	Zeid, I., "Mastering CAD/CAM", Tata McGraw Hill.	2007
2	Onwubiko, C., "Foundation of Computer Aided Design", West Publishing Company.	1989
3	Hsu, T. R. and Sinha, D. K., "Computer Aided Design: An Integrated Approach", West Publishing Company.	1991
4	Dimarogonas, A. D., "Computer Aided Machine Design", Prentice Hall.	1988
5	Mortenson, M. E., "Geometric Modeling", 3 rd Ed., Industrial Press.	2006

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-502** Course Title: **Robotics and Control**

2. Contact Hours: L: 3 T: 1 P: 0

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To get exposure about basic robot kinematics, dynamics, control and programming.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Definition, structure, classification and specifications of robots, industrial robots.	2
2	Robot Elements and Control: Manipulators, drives, sensors, end effectors, configuration, force/torque relationship, trajectory planning, position control, feedback system, digital control.	5
3	Modeling of Robots: Coordinate frames, mapping and transformation; Direct kinematic model; Inverse kinematics; Manipulator differential motion; Static analysis, Jacobian.	10
4	Manipulator Dynamics: Acceleration of a rigid body, mass distribution, Newton's equation, iterative Newton Euler dynamic formulation, Lagrangian formulation of manipulator dynamics, trajectory planning.	10
5	Linear and Non Linear Control of Manipulators: Control law partitioning, trajectory following control, multi input multi output control systems, Cartesian based control scheme, fuzzy logic control.	10
6	Force Control of manipulators: Hybrid position/force control.	3
7	Robot Programming: Robot programming for manufacturing and other applications, robot integration with CAD and CAM.	2
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication / Reprint
1	Craig, J. J., "Introduction to Robotics: Mechanics & Control", 3 rd Ed., Prentice Hall.	2004
2	Niku, S. B., "Introduction to Robotics: Analysis, Systems, Applications", Prentice Hall.	2001
3	Schilling, R. J., "Fundamentals of Robotics Analysis and Control", Prentice Hall.	1990
4	Mittal, R. K. and Nagrath, I. J., "Robotics and Control", Tata McGraw Hill.	2003
5	Ghosal, A., "Robotics: Fundamental Concepts and Analysis", Oxford University Press.	2006

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-515** Course Title: **Manufacturing Systems Analysis**

2. Contact Hours: L: 3 T: 1 P: 0

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To teach students various tools and techniques used for the performance analysis of manufacturing systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Definitions of manufacturing with input-output model, definition of system, basic problems concerning systems and system design procedure, modes of manufacturing – job/batch/flow and multi-product, small-batch manufacturing.	4
2	System Modeling Issues: Centralized versus distributed control; Real-time vs. discrete event control; Forward vs. backward scheduling approaches with finite/infinite capacity loading; Modeling of absorbing states and deadlocks; Conflicts; Concurrency, and synchronization etc.	8
3	System Modeling Tools and Techniques: Introduction to mathematical modeling, optimization, and simulation; Issues related with deterministic and stochastic models; Continuous and discrete mathematical modeling methods - discrete event, monte carlo method; Basic concepts of Markov chains and processes; The M/M/1 and M/M/m queue; Models of manufacturing systems - including transfer lines and flexible manufacturing systems, introduction to Petri nets.	15
4	Performance Analysis: Transient analysis of manufacturing systems, analysis of a flexible machining center; Product flow analysis; Rank order clustering; Process flow charting; MRPI & II, kanban, OPT, JIT-pull and JIT-push, line of balance, effects of machine failure, set-ups, and other disruptions on system performance; Calculation of performance measures - throughput, in-process inventory, due dates, MTL, capacity, and machine utilization etc.; Critique of high inventory, long lead time systems; Shop floor control issues.	15
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Askin, R. G., and Standridge, C. R., "Modeling and Analysis of Manufacturing Systems", John Wiley & Sons.	1993
2.	Gershwin, S. "Manufacturing Systems Engineering", Prentice-Hall.	1994
3.	Hitomi, K., "Manufacturing Systems Engineering", Taylor & Francis.	1998
4.	Viswanadham N. and Narahari Y. "Performance Modeling of Automated Manufacturing Systems", Prentice-Hall	1992
5.	Hopp, W. J., and Spearman, M. L., "Factory Physics : Foundation of Manufacturing Management", McGraw Hill.	1996
6.	Chang, T.-C., Wysk, R. A. and Wang, H.-P. "Computer Aided Manufacturing", 3 rd Ed., Prentice Hall.	2005

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-516**

Course Title: **Artificial Intelligence**

5. Contact Hours: L: 3 T: 1 P: 0

6. Examination Duration (Hrs.): Theory 3 Practical 0

7. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4

6. Semester: **Spring**

7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: This course is designed to provide basic knowledge of artificial intelligence. The emphasis is on the teaching of various techniques on knowledge representation and search engines with important applications of AI.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Overview of History and Goals of AI: Artificial Intelligence -- Definition, components, scope, and application areas; Turing's test; Review of AI success and failure.	3
2	State Spaces, Production Systems, and Search: State space representation of problems; Problem solving using search; Definition and examples of production systems; Heuristic search techniques i.e. generate-and-test, hill climbing, best-first search, constraint satisfaction and mean-ends analysis.	8
3	Knowledge Representation: Definition of knowledge; Issues in knowledge representation; Procedural vs declarative knowledge and their representation; Predicate logic, production rules, semantic nets, and frames; Meta-knowledge.	9
4	Reasoning and Inference Strategies: Forward vs backward reasoning; Depth first, breadth first, min-max etc.; Non-monotonic reasoning; Symbolic reasoning under uncertainty; Probability and Baye's theorem; Certainty factors, Dempster-Shafer theory; Fuzzy logic etc.	10
5	Expert Systems and their Applications: Justification, structure, knowledge sources; Expert knowledge acquisition; Expert system languages; ES building tools/shells; Applications of AI in CAD, CAPP, process selection, GT, MRP II, adaptive control, robotics, process control, fault diagnosis, failure analysis, etc.	12
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1	Rich, E., Knight, K. and Nair, S. B., "Artificial Intelligence", 3 rd Ed., Tata McGraw Hill.	2010
2	Russell, S. and Norvig, P., "Artificial Intelligence: A Modern Approach", 3 rd Ed., Prentice-Hall.	2009
3	Dean, T. L., Allen, J., and Aloimonos, Y. "Artificial Intelligence: Theory and Practice", Benjamin/Cummings Publishing Company.	1995
4	Genesereth, M. R. and Nilsson, N., "Logical Foundations of Artificial Intelligence", Morgan Kaufmann.	1987

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-517** Course Title: **Automated Materials Handling Systems**

2. Contact Hours: L: **3** T: **1** P: **0**

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4

6. Semester: **Spring**

7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce various automated material handling equipment and their utilization.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction of Material Handling: Overview of MHE, consideration in MHS design, twenty principles of material handling, the unit load concept.	04
2	Material Transport Systems: Industrial trucks, automated guided vehicle systems, monorails and other rail guided vehicles, conveyor systems, cranes and hoists.	06
3	Evaluation and Selection of Material Handling Layout: Design of bins and hoppers – flow patterns, measurement of flow properties, design methods, feeders, dischargers, silos, chutes and gates; Bulk material sampling and weighing systems, blending of bulk materials, transportation interface – rail and water. monitoring and control.	14
4	Analysis of Material Transport Systems: Rate of deliveries, required number of vehicles, economics of material handling systems.	06
5	Automated Storage & Retrieval Systems (AS/RS): Functions of AS/RS, operations of AS/RS, AS/RS components, types of AS/RS, design of an AS/RS, system throughput, size parameters determination of AS/RS.	12
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication / Reprint
1	Allegri, T. H., "Material Handling Principles and Practice", Krieger Publishing Company.	1992
2	Meyers, F. E. and Stephens, M. P. "Manufacturing Facilities Design and Material Handling", Prentice Hall.	2000
3	Adam, N. D., Brown, T. W., Rowland, V. D. and Misenheimer, F. P., "Warehouse & Distribution Automation Handbook", McGraw-Hill.	1996
4	Tompkins, J. A., White, J. A., Bozer, Y. A. and Tanchoco, J. M., "Facilities Planning", 4 th Ed., John Willey & Sons.	2010
5	Sule, D. R., "Manufacturing Facilities-Location, Planning, and Design", 3 rd Ed., CRC Press.	2008

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-566** Course Title: **Computer Aided Analysis of Mechanical Systems**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objectives: To introduce computer-based design tools for analyzing the kinematics and dynamics of mechanical systems.

10. Details of Course:

S. No.	Particulars	Contact Hours
1	Introduction: Introduction to mechanical systems analysis.	2
2	Kinematic Modeling: Modeling the kinematics of mechanical systems; Vector loop methods, vector chain methods.	4
3	Solution of Kinematic Models: Solution of kinematic models for displacements, velocities, accelerations; Direct analytical solutions of position, velocity, acceleration problems; Numerical solution of position problem; Matrix method solutions of velocity and acceleration problems.	8
4	Dynamic Modeling: Modeling the dynamics of mechanical systems; Newton-Euler methods to define dynamic constraints between forces, moments, and accelerations, energy methods to define dynamic constraints between input and output links.	6
5	Solution of Dynamics Models: Solution of inverse dynamics models for joint-link forces and torques, solution of forward dynamics models using numeric integration, model formulation into standard format for solution, Euler's method of integration, Runge-Kutta methods of integration, modeling and analysis of the Trebuchet mechanism.	14
6	Advanced Dynamic Analysis & Simulation: Bond graph modeling of dynamic systems, generation of system equations, causality, and simulation.	8
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1	Norton R., "Design of Machinery", McGraw-Hill	1992
2	Palm W. J., "Introduction to MATLAB 6 for Engineers", McGraw-Hill	2000
3	Nikraves, P. E., "Computer-Aided Analysis of Mechanical Systems", Prentice Hall.	1988
4	Haug, E. J., "Computer Aided Analysis and Optimization of Mechanical System Dynamics", Springer-Verlag.	1984
5	Mukherjee, A., Karmaker, R. and Samantaray, A.K., "Bond Graph in Modeling, Simulation and Fault Identification", I & K International.	2007

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-567** Course Title: **Computer Graphics**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: The course aims is to provide the basics of Computer Graphics needed for CAD/ CAM applications.
10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Role of Computer Graphics in CAD/CAM, configuration of graphic workstations, menu design and Graphical User Interfaces (GUI), customization and parametric programming.	04
2	Geometric Transformations and Projections: Vector representation of geometric entities, homogeneous coordinate systems, fundamentals of 2D and 3D transformations: Reflection, translation, rotation, scaling, and shearing, various types of projections.	08
3	Curves: Modeling planar and space curves, analytical and synthetic approaches, non-parametric and parametric equations.	08
4	Surfaces: Modeling of bi-parametric freedom surfaces, Coons, Bezier, B-spline, and NURBS surfaces, surface manipulation techniques.	08
5	Geometric Modeling: Geometric modeling techniques, wireframe modeling, solid modeling: B-Rep, CSG, hybrid modelers, feature based, parametric and variational modeling.	10
6	Data Structure in Computer Graphics: Introduction to product data standards and data structures, data-base integration for CIM.	04
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1	Rogers, D. F., and Adams, J. A., "Mathematical Elements for Computer Graphics", McGraw Hill.	1989
2	Faux, I. D. and Pratt, M. J., "Computational Geometry for Design and Manufacture", Ellis Horwood Ltd.	1979
3	Mortenson, M. E., "Geometric Modeling", 3 rd Ed., Industrial Press.	2006
4	Zeid, I., "CAD/CAM: Theory and Practice", Tata McGraw Hill.	1998
5	Choi, B. K., "Surface Modeling for CAD/CAM", John Wiley & Sons	1991

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-568**

Course Title: **Advanced Robotics**

5. Contact Hours: **L: 3**

T: 1

P: 0

6. Examination Duration (Hrs.): Theory

3

Practical

0

7. Relative Weightage: CWS

25

PRS

0

MTE

25

ETE

50

PRE

0

5. Credits: **4**

6. Semester: **Spring**

7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of robotic vision systems, robot modeling, trajectory planning, manipulator control, and design and control issues of mobile robots, space robots etc.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Review, laws of robotics, robot anatomy, design and control issues, future prospects.	02
2	Modeling of Robots: Coordinate frames, mapping and transformation; Direct kinematic model, inverse kinematics; Manipulator differential motion; Static analysis; Dynamic modeling; Trajectory planning.	16
3	Control of Manipulators: Manipulator control problem; Linear control schemes; Modeling and simulation; PID control scheme; Force control of robotic manipulators	06
4	Image Processing and Analysis with Vision Systems: Acquisition of images, digital images, image processing techniques, noise reduction, edge detection, image analysis, object recognition by features, application of vision systems	06
5	Fuzzy Logic Control: Crisp values v/s fuzzy values, fuzzy sets: Degrees of membership and truth, fuzzification, fuzzy inference rule base, defuzzification, simulation of fuzzy logic controller, application of fuzzy logic in robotics	04
6	Mobile Robots: Legged and wheeled mobile robots, mobile robot kinematics, sensors for mobile robots, planning and navigation	04
7	Advanced Robots: Modeling and control of space robots, humanoids	04
Total		42

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1	Niku, S. B., "Introduction to Robotics: Analysis, Systems, Applications", Prentice Hall.	2001
2	Angeles, J., "Fundamentals of Robotic Mechanical Systems: Theory, Methods and Algorithms", Springer	2003
3	Craig, J. J., "Introduction to Robotics: Mechanics & Control", Addison Wesley.	1989
4	Siegwart, R., Nourbakhsh, I. R., "Introduction to Autonomous Mobile Robots", MIT Press.	2004
5	Xu, Y. and Kanade, T., "Space Robotics: Dynamics and Control", Kluwer Academic Publishers.	1993

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-569** Course Title: **Expert Systems Design**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To cover concepts, techniques and tools for developing expert systems for various engineering systems.
10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Overview: Evolution and characteristics of knowledge-based systems.	02
2	Introduction to Expert System Languages: CLIPS (C language integrated production system) and JESS (java expert system shell).	06
3	Pattern Matching: Basic and advanced pattern matching techniques.	04
4	Modular Design and Control: Saliency, phases and control facts, modules and execution control	04
5	Knowledge Representation: Productions, semantic nets, schemata, frames, logic and set.	04
6	Methods of Inferences: Inference rules, resolution system, forward and backward chaining.	04
7	Reasoning under Uncertainty: Hubert Dreyfus "From Socrates to Expert Systems: The Limits and Dangers of Computational Rationality" -- CSUS Library video collection, hypothetical reasoning and backward induction, temporal reasoning and Markov chains, uncertainty in inference chains; Probability-based techniques: Objective probability, experimental probability, subjective probability, Bayes' theorem, inexact or heuristic reasoning; Inexact reasoning: uncertainty and rules, certainty factors, Dempster-Shafer theory.	12
8	Design of Expert Systems: Approximate reasoning, fuzzy expert systems.	06
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1	Giarratano, J. C. and Riley, G. D., "Expert Systems: Principles and Programming", 4 th Ed., Course Technology.	2004
2	Gonzalez, A., and Dankel, D., "The Engineering of Knowledge-Based Systems", Prentice Hall.	1994
3	Jackson, P., "Introduction to Expert Systems", 3 rd Ed., Addison Wesley.	1998
4	Akerkar, R. and Sajja, P., "Knowledge-Based Systems", Jones & Bartlett Publishers.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-575** Course Title: **Product Design and Development**

2. Contact Hours: **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To expose the students to the concept of design for X, concurrent engineering, reverse engineering, and rapid prototyping techniques.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Product Design: Traditional and modern design processes; Organization objectives; Innovation, creation, and diffusion techniques; Evaluation of new product ideas – functional, technological, ecological, legal.	06
2	Product Modeling and Reverse Engineering: Wireframe modeling; Surface modeling – boundary representation; Solid modeling – CSG; Concept of reverse engineering.	08
3	Product Data Exchange: Neutral file formats for product data exchange – DXF, IGES, STEP.	06
4	Concurrent Engineering: Concept of concurrent engineering; Design for X; Design for manufacturability (DFM); Design for assemblability (DFA); Design for reliability (DFR); Design for quality (DFQ).	10
5	Rapid Prototyping (RP) Methods: Liquid based RP methods – stereolithography apparatus (SLA), solid ground curing (SGC), solid creation system (SCS), etc.; Solid based RP methods: Fused deposition modeling (FDM), laminated object manufacturing (LOM), etc.; Powder based RP methods– selective laser sintering (SLS), 3D printing (3DP), ballistic particle manufacturing (BPM), etc.	12
Total		42

1 1. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication/ Reprint
1	Andrearsen, M. M., and Hein, L., "Integrated Product Development", Springer.	1987
2	Huang, G. Q., "Design for X: Concurrent Engineering Imperatives", Chapman and Hall.	1996
3	Chitale, A. K. and Gutpa, R. C., "Product Design and Manufacturing", Prentice Hall.	1997
4	Zeid I., "CAD/CAM: Theory and Practice", Tata McGraw Hill.	1998
5	Mortenson, M. E., "Geometric Modeling", 3 rd Ed., Industrial Press.	2006
6	Boothroyd G., Dewhurst P., and Knight, "Product Design for Manufacture and Assembly", 2 nd Ed., Marcel Dekker.	2002
7	Chua, C. K and. Leong, K. F., "Rapid Prototyping: Principles and Applications in Manufacturing", John Wiley & Sons.	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-576** Course Title: **Machine Tool Design and Numerical Control**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce various components of numerically controlled machine tools and their application in automated manufacturing systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Machine Tool Design: General requirements; Electrical and hydraulic drives of machine tools; Layout of gear boxes; Hydraulic, electric and mechanical stepless speed regulations; Design and analysis of guideways; Bed, column, spindle and power screw.	15
2	Numerical Control (NC): Introduction to numerical control; Components of NC systems; Open and close loop NC; Types of numerical control: Point-to-point, straight cut, and continuous path NC; Drives and controls; NC-tape coding standards; Coordinate and positioning systems – Cartesian and polar; Reference zero points; NC interpolations – linear, circular, helical, parabolic and cubic interpolation; Applications of NC systems.	6
3	NC Part Programming Methods: Structure of NC part program; NC word formats; Introduction to G and M codes; Manual programming methods; Computer-assisted programming methods; APT part programming.	10
4	Extensions of NC: Concepts of CNC, machining center, and DNC; Types of CNC systems; Introduction to post processors; Tooling for NC/CNC.	3
5	CNC Part Programming: Tool motion commands; Tool length offset; Cutter diameter compensation command; fixed cycle command; Scaling; rotation; Mirror image; Macros programming etc.	8
Total		42

1 1. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication/ Reprint
1.	Mehta, N. K., "Machine Tool Design and Numerical Control", 2 nd Ed., Tata McGraw Hill.	1996
2.	Koren, Y., "Computer Control of Manufacturing Systems", McGraw Hill.	1983
3.	Rapello, R. G., "Essentials of Numerical Control", Prentice Hall.	1986
4.	Chen, S, and Lin, J., "Computer Numerical Control: From Programming to Networking", Thomson Delmer Learning.	1994
5.	Sava, M., and Pusztai, J., "Computer Numerical Control Programming", Prentice Hall.	1990
6.	Rao, P. N., Tewari, N. K, and Kundra, T. K., "Computer Aided Manufacturing", Tata McGraw Hill	1993
7.	Steve, K. and Gill A., " CNC Technology and Programming", McGraw Hill.	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-577**

Course Title: **Industrial Automation**

2. Contact Hours : **L: 3**

T: 1

P: 0

3. Examination Duration (Hrs.) :

Theory

3

Practical

0

4. Relative Weightage: CWS

25

PRS

0

MTE

25

ETE

50

PRE

0

5. Credits:

4

6. Semester: **Spring**

7. Subject Area: **PEC**

8. Pre – requisite: **Nil**

9. Objective: To introduce the concepts of automation theory and its applications in various fields of manufacturing.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Basic Concepts: Introduction of mechanization and automation, classification and strategies of automation, reasons for and arguments against automation, mechanical, electrical, hydraulic, and pneumatic devices and controls.	6
2.	High Volume Manufacturing: Automated flow lines, types of automatic transfer mechanisms, design and fabrication considerations, analysis of automated flow lines.	6
3.	Assembly Systems: Assembly systems and their types, manual assembly lines and line balancing.	4
4.	Assembly Automation: automated assembly lines and their types, automatic assembly transfer systems, automatic feeding and orienting devices- vibratory and mechanical feeders and their types, orientation of parts, performance and economics of assembly systems, feasibility study for assembly automation.	12
5.	Design for Assembly: Design for manual assembly, design for high-speed automatic assembly, design for robot assembly.	4
6.	Flexible Automation: Introduction of group technology (GT), steps in implementing Group Technology (GT), part families and machine cell formation, introduction of flexible manufacturing systems (FMS).	6

7.	Programmable Automation: Brief introduction of numerical control (NC), computer numerical control (CNC), machining centers, programmable robots, direct numerical control (DNC) and adaptive control.	4
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Groover, M. P., "Automation, Production systems and Computer Integrated Manufacturing", 2 nd Ed., Prentice Hall.	2005
2.	Boothroyd, G., "Assembly Automation and Product Design", 2 nd Ed., Marcel Dekker.	1992
3.	Boothroyd, G., Dewhurst, P. and Knight, W., "Product Design for Manufacture and Assembly", 2 nd Ed., Taylor & Francis.	2002
4.	Boothroyd, G., Poli, C. and Murch, L. E., "Automatic Assembly", Marcel Dekker.	1982
5.	Tergan, V., Andreev, I. and Lieberman, B., "Fundamentals of Industrial Automation", Mir Publishers.	1986

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-578** Course Title: **Computer Aided Process Planning**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge on the integration of design and manufacturing functions leading to the concepts of process planning.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: traditional process planning, product design evaluation, various steps in process planning.	5
2.	Group Technology: Introduction, advantages, part families, classification and coding systems, production flow analysis, design of machine cells.	10
3.	Concepts Related to Process Planning: Machinability data system, cutting condition optimization.	5
4.	Automated Process Planning: Advantages of automated process planning, various approaches to process planning; Variant process planning, its features and different stages, different variant systems; Generative and semi-generative process planning, its features, design strategies, planning, modeling and coding scheme, decision mechanisms; Process capability analysis, intelligent process planning system; Artificial intelligence -- overview and application in process planning; Various recent process planning systems; Case studies.	12
5.	Interfaces of Process Planning: Integrating with loading, scheduling, MRP II, and capacity planning and other shop floor functions.	10
Total		42

11 . Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Chang, T. C. and Wysk, R. A, "An Introduction to Automated Process Planning", Prentice-Hall.	1985
2.	Gallagher, C. C and Knight, W. A., "Group Technology: Production Method in Manufacturing", Ellis Horewood.	1986
3.	Nilsson, N. J., "Principles of Artificial Intelligence", Springer Verlag.	1982
4.	Cornelius, L.T, "Computer Aided and Integrated Manufacturing Systems: Manufacturing Processes", World Scientific Publishing Company.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-579** Course Title: **Information Systems and Data Management**

2. Contact Hours: **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To expose the students to various information systems and to familiarize with data based systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Role of information system, the function of information system, determination of informational need	4
2	Information Processing Concepts: Historical perspective, today's status, systems approach and analysis, concepts of data and information, data collection, data or information, data and information storage, data processing and information generation, transmission of data and information and the information economics of information	10
3	Information System Analysis: Overview of system, management and formal information systems, hierarchical and system approach to information systems design and their applications, tailoring the information system to meet specific information requirements using filtering monitoring, interrogative and external methods.	14
4	Data Base Management System: Introduction to data base concepts, difference between a file system and a data base systems, goals of DBMS including data independence consistency, data security and integrity; DBMS models hierarchical network and relation, data description and query language, physical database design case studies, system R, Ingress, IDMS etc.; Introduction to distributed database, concurrency control bases recovery etc.	14
Total		42

11 . Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication / Reprint
1	Henry Luces C., "Information Systems Concepts for Management", McGraw Hill.	1978
2	Burch, J. G. and Grudnitski, G., "Information Systems Theory and Practice", John Wiley & Sons.	1989
3	Walker, D. W., "Computer Based Information System An Introduction", Pergamon Press.	1989
4	Mark L. Gillenson, "Fundamentals of Database Management Systems", John Wiley & Sons.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-582** Course Title: **Flexible Manufacturing Systems**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.) : Theory 3 Practical 0

4. Relative Weightage : CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre – requisite: **Nil**

9. Objective: To introduce the concepts of flexibilities and its importance in batch manufacturing, various types of FMS configurations and their planning and control.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Definition and classification of manufacturing systems, fundamentals of automated production cycle, need of flexibility, concept of flexibility, various types of flexibility, measures of flexibility.	7
2.	Flexible Manufacturing System (FMS) Type: Introduction of FMS, definition of FMS, types of FMS, applications of FMS, FMS configuration, FMS host operator interface.	10
3.	FMS Planning and Control: Functional requirements of FMS equipments, functions of FMS host computer, host system design, planning, scheduling of FMS, FMS simulation, Databases in FMS, GT in FMS, cell design and layout design, CAPP in FMS.	14
4.	Material handling in FMS: Material handling principles in FMS, applications of robots in FMS.	6
5.	Case Studies: Cases on FMS installation and implementation –acceptance testing and maintenance	5
Total		42

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication /Reprint
1.	Groover, M. P., "Automation, Production System and CIM", 2 nd Ed., Prentice Hall.	2000
2.	Rankey, P., "Design and Operations of FMS", North-Holland Publishing.	1983
3.	Warnecke, H. J. (Ed.), "Flexible Manufacturing System", Springer.	1985
4.	Bonetto, R., "FMS in Practice", North Oxford Academic Publishers.	1988

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-584** Course Title: **Operations Research**

2. Contact Hours : **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.) : Theory: 3 Pra 0

4. Relative Weightage : CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4

6. Semester: **Spring**

7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce various optimization techniques for formulating, solving various industrial problems, develop production and service units as a system.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: definition and scope of OR; Techniques and tools; Model formulation; general methods for solution; Classification of optimization problems; Optimization techniques.	2
2.	Linear Optimization Models: Complex and revised simplex algorithms; Duality theorems, sensitivity analysis; Assignment, transportation and transshipment models; Traveling salesman problem as an assignment problem; Integer and parametric programming; Goal programming.	12
3.	Game Problems: Mini-max criterion and optimal strategy; Two person zero sum game; Games by simplex dominance rules.	6
4.	Waiting Line Problems: Classification of queuing situations; Kendall's notation, Poisson arrival with exponential or Erlang service time distribution; Finite and infinite queues; Optimal service rates; Application of queuing theory to industrial problems.	8
5.	Dynamic Programming: Characteristic of dynamic programming problems (DPPs); Bellman's principle of optimality; Problems with finite number of stages; Use of simplex algorithm for solving DPPs.	6
6.	Non-linear Programming: One dimensional minimization methods; Unconstrained optimization techniques; Optimization techniques-characteristics of a constrained problem; Indirect methods; Search and gradient methods.	8
Total		42

11 - Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication /Reprint
1.	Taha, H. A., "An Introduction to Operations Research", 6 th Ed., Prentice Hall.	2006
2.	Hillier, F. J. and Lieberman, G. J., "Introduction to Operations Research", 7 th Ed., Holden Day.	2001
3.	Phillips, D. T, Ravindran, A. and Solberg, A. A., "Operations Research: Principles and Practice", 2 nd Ed., John Wiley and Sons.	1986
4.	Wagner, H. M., "Principles of OR with Applications to Managerial Decisions", 2 nd Ed., Prentice Hall.	1975
5.	Jensen, P. A, and Bard, J. F., "Operations Research Models and Methods", John Wiley and Sons.	2008

Department of Mechanical and Industrial Engineering

M. Tech. (Production & Industrial Systems Engineering)

I Year

Autumn Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage (%)				
S No	Course No.	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MA-501C	Probability and Statistics	ICC	4	3	1	0	3	--	25	--	25	50	--
2	MI-511C	Modeling and Simulation	PCC	4	3	1	2/2	3	--	15	15	30	40	--
3	MI-570	Operations Management	PCC	4	3	1	0	3	--	25	--	25	50	--
4	MI-571	Quality Management	PCC	4	3	1	0	3	--	25	--	25	50	--
5		Open Elective - I	OEC	3/4	-	-	-	3	--	25	--	25	50	--
6	HS-501	Technical Communication (Optional)	---	2	1	0	2	2	--	15	15	30	40	--
Sub Total				19-22										

Spring Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage (%)				
S No	Course No.	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MI-572	Advanced Manufacturing Processes	PCC	4	3	1	0	3	--	25	--	25	50	--
2		Program Elective-I	PEC	4	3	1	0	3	--	25	--	25	50	--
3		Program Elective-II	PEC	4	3	1	0	3	--	25	--	25	50	--
4		Program Elective-III	PEC	4	3	1	0	3	--	25	--	25	50	--
5		Open Elective-II	OEC	3/4	-	-	-	3	--	25	--	25	50	--
6	HS-501	Technical Communication (Optional)	---	2	1	0	2	2	--	15	15	30	40	--
Sub Total				19-22										

II Year

Autumn Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage (%)				
S No.	Sub code	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MI-601	Seminar	SEM	2	-	-	-	--	--		--	100	--	--
2	MI-602	Project	RP	4	-	-	-	--	--		--	100	--	--
3	MI-603	Dissertation*	DIS	0	-	-	-	--	--		--	--	25	--
Sub Total				6										

* NOTE: To be continued and grade to be awarded in the next semester.

Spring Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage (%)				
S No.	Sub code	Course Title	Subject Area	Credit	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MI-603	Dissertation (continued from III semester)	DIS	20	-	-	-	--	--	--	--	--	75	--
Sub Total				20										
Total				64-68										

Program Electives for M. Tech. (Production & Industrial Systems Engineering)

Teaching Scheme					Contact Hrs Per Week			Exam Duration (Hrs)		Relative Weightage (%)				
S No.	Course No.	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MI-500	Instrumentation and Experimental Methods	PEC	4	3	1	0	3	--	25	--	25	50	--
2	MI-573	Design for Manufacturability	PEC	4	3	1	0	3	--	25	--	25	50	--
3	MI-574	Maintenance Management	PEC	4	3	1	0	3	--	25	--	25	50	--
4	MI-575	Product Design and Development	PEC	4	3	1	0	3	--	25	--	25	50	--
5	MI-576	Machine Tool Design and Numerical Control	PEC	4	3	1	0	3	--	25	--	25	50	--
6	MI-577	Industrial Automation	PEC	4	3	1	0	3	--	25	--	25	50	--
7	MI-578	Computer Aided Process Planning	PEC	4	3	1	0	3	--	25	--	25	50	--
8	MI-579	Information Systems and Data Management	PEC	4	3	1	0	3	--	25	--	25	50	--
9	MI-580	Welding Science	PEC	4	3	1	0	3	--	25	--	25	50	--
10	MI-581	Manufacturing Resources Management	PEC	4	3	1	0	3	--	25	--	25	50	--
11	MI-582	Flexible Manufacturing Systems	PEC	4	3	1	0	3	--	25	--	25	50	--
12	MI-583	Materials Management	PEC	4	3	1	0	3	--	25	--	25	50	--
13	MI-584	Operations Research	PEC	4	3	1	0	3	--	25	--	25	50	--
14	MI-585	Supply Chain Management	PEC	4	3	1	0	3	--	25	--	25	50	--
15	MI-586	Metal Forming	PEC	4	3	1	0	3	--	25	--	25	50	--
16	MI-587	Metal Casting	PEC	4	3	1	0	3	--	25	--	25	50	--
17	MI-588	Non-Traditional Machining Processes	PEC	4	3	1	0	3	--	25	--	25	50	--

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-570** Course Title: **Operations Management**
2. Contact Hours : **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0
4. Relative Weightage : **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0
5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre – requisite: **Nil**
9. Objective: To impart knowledge on various strategic issues of operations management and developing their skills to design and model various facilities of an organization.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Basic concepts of operations and production management, types of manufacturing systems and their characteristics.	4
2.	Product and Process Design: System planning and design, long-range planning, product and process design and technological considerations.	4
3.	Demand Forecasting: Role of demand forecasting in operations decisions; various demand patterns, qualitative and quantitative techniques of demand forecasting.	6
4.	Production Planning and Scheduling: Aggregate production planning, operation scheduling, various scheduling criteria, lot sizing, job shop control; Mutli-stage manufacturing systems, their scheduling and management, capacity planning.	16
5.	Materials Planning: Details of material requirement planning (MRP) and manufacturing resource planning (MRP-II) and their various techniques.	6
6.	Facilities Planning: Plant design, types and considerations in the plant location, plant layout types, design, evaluation, principles and types of material flow, optimum plant layout.	6
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books /Publisher	Year of Publication/ Reprint
1.	Buffa, E. S. and Sarin, R. K., "Modern Production/Operations Management", 8 th Ed., John Wiley & Sons.	2003
2.	Adam, E., Jr. and Ebert, R. E., "Production Operations Management", 5 th Ed., Pearson Education.	1992
3.	Brown, S., Blackmon, K., Cousins, P. and Maylor H., "Operations Management: Policy, Practice, and Performance Improvement", Butterworth-Heinemann.	2001
4.	Dervitsiotis, K. N., "Operations Management", 2 nd Ed., McGraw Hill.	1987
5.	Starr M. K., "Production and Operations Management", Thomson Business Information.	2009
6.	Karjewski, L. J, Ritzman, L. P. and Malhotra, M. K., "Operations Management: Processes & Supply Chains, 9 th Ed., Pearson Education.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-571** Course Title: **Quality Management**

2. Contact Hours : L: **3** T: **1** P: **0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre – requisite: **Nil**

9. Objective: To impart knowledge on various concepts and philosophies of quality management.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Fundamentals of Quality Management : Quality of products, services and total quality control and its impact on the organization; Buyer, producer and market place demand for quality, quality cost and quality system economics; Quality management factors and jobs, system approach for quality management, commitment, leadership and team work.	9
2.	Techniques of Quality Engineering: Quality policy, product reliability and life cycle, safety, product quality and process capability, evaluation of methods, processes and materials, quality cost optimization; Quality planning, implementation and inspection, quality information feedback, corrective actions, Taguchi's philosophy and robust product and process design.	4
3.	Process Control Engineering: Machine and process capability analysis, multi-vary chart, vendor performance and their ratings, mechanization of process for quality.	4
4.	Statistical Quality Control : Review on variables, attributes quantities and their measurements etc; Theory of control charts, brief review on X, R, P, C, charts; Different adaptation of control charts, viz, group control chart, control charts with variable subgroup sizes, moving average and moving range charts, acceptance control charts, charts for trended universe average, CUSUM charts, different control charts.	4
5.	Acceptance Sampling: Acceptance sampling tables, acceptance sampling plans for attributes and variables.	5
6.	Quality Improvement Techniques: Variance concept in manufacturing cycle; Fish bone diagrams; Pareto charts; Just in Time (JIT) - philosophy, evaluation and concept.	6
7.	System Approach and Quality System Establishment: ISO-9000 pre-requisites, different quality systems and their structure, quality policies and	5

	objectives, management responsibility, documentation and methodology of implementation, quality audits and assessment.	
8.	Achieving Total Commitment to Quality: Participative approach and team work, training and motivation; quality circles, their characteristics, objectives and organization structure; Quality circle implementation structures and techniques; Communicating quality commitment to vendors and customers.	5
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books /Publisher	Year of Publication/ Reprint
1.	Jackson, P. and Ashton, D., "Implementing Quality Through ISO-9000", Viva Book Pvt Ltd.	1993
2.	Grant, E. and Lavenworth, R., "Statistical Quality Control", 11 th Ed., McGraw Hill.	1997
3.	Ross, P. J., "Taguchi Techniques For Quality Engineering", 2 nd Ed., McGraw Hill.	1995
4.	Gryna, F., Chua, R. and Defeo, J., "Juran's Quality Planning and Analysis for Enterprise Quality", 5 th Ed., McGraw Hill.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-572** Course Title: **Advanced Manufacturing Processes**

2. Contact Hours: L: **3** T: **1** P: **0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PCC**

8. Pre – requisite: **Nil**

9. Objective: The introduce advancement in machining theory and practices, machining processes, metal forming processes, welding processes and foundry processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Advanced Machining Theory and Practices: Review of orthogonal cutting – mechanisms of chip formation, shear angle relations, theoretical determination of cutting forces; analysis of turning, drilling, and milling operations; mechanics of grinding; dynamometry; thermal aspects of machining; tool wear and extended tool life equation, machinability, economics of machining.	14
2.	Advanced Machining Processes: Introduction, process principle, material removal mechanism, parametric analysis, and applications of processes such as ultrasonic machining (USM), abrasive jet machining (AJM), water jet machining (WJM), abrasive water jet machining (AWJM), electrochemical machining (ECM), electro discharge machining (EDM), electron beam machining (EBM), and laser beam machining (LBM) processes.	14
3.	Advanced Casting Processes: Metal mould casting, continuous casting, squeeze casting, vacuum mould casting, evaporative pattern casting, ceramic shell casting, gating system design.	6
4.	Rapid prototyping (RP): Process chain in RP, layering techniques, steriolithography, fused deposition modeling, laminated object manufacturing, repetitive masking and depositing.	4
5.	Advanced Metal Forming Processes: Details of high energy rate forming (HERF) process, electro-magnetic forming, explosive forming, electro-hydraulic forming, stretch forming, contour roll forming.	4
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books /Publisher	Year of Publication/ Reprint
1.	Bhattacharya, A., "Metal Cutting: Theory and Practices", 2 nd Ed., New Central Book Agency.	1984
2.	Armarego, E. J. A. and Brown, R. H., "Machining of Metals", Prentice Hall.	1969
3.	DeGarmo, E. P., Black J. T. and Kohser, R. A., "Materials and Processes in Manufacturing", 10 th Ed., John Wiley & Sons.	2007
4.	Ghosh, A. and Mallik, A. K., "Manufacturing Science", Affiliated East-West Press.	1985
5.	Benedict, G. F., "Nontraditional Manufacturing Processes", Marcel-Dekker.	1987
6.	Jain, V. K., "Advanced Machining Processes", Allied Publishers.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-573** Course Title: **Design for Manufacturability**

2. Contact Hours : **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.) : **Theory** 3 **Practical** 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre – requisite: **Nil**

9. Objective: To introduce students about inter-relationship between various design, manufacture and assembly related activities.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Introduction to Design for Manufacturability (DFM), fundamentals of manufacturing technology and the interrelationship between design and manufacturing processes. Organizational changes in DFM.	8
2.	Concurrent Engineering: Need for concurrent engineering, industrial practices of concurrent engineering.	8
3.	Automation: Automation of design and manufacturing functions in CIM, computer aided process planning, Design for X, approaches to DFM.	7
4.	Design Knowledge Representation: Design, manufacturing, and re-design considerations, Design and manufacturing knowledge representation.	10
5.	Evaluation of Manufacturability: Evaluation of the manufacturability of a part design, various methods for defining manufacturability index, interpretation of MI value.	9
Total		42

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication/ Reprint
1.	Boothroyd, G., Dewhurst P., and Knight, W., "Product Design for Manufacture and Assembly", 2 nd Ed., Marcel Dekker.	2002
3.	Bralla, J. G., "Design for Manufacturability Handbook", 4 th Ed., McGraw Hill.	1998
4.	Huang, G. Q., "Design for X: Concurrent Engineering Imperatives", Chapman & Hall.	1996
5.	Kusiak, A., "Concurrent Engineering: Automation, Tools, and Techniques", Wiley.	1993

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-574** Course Title: **Maintenance Management**

2. Contact Hours : **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.) : Theory **3** Practical **0**

4. Relative Weightage : CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester : **Spring** 7. Subject area: **PEC**

8. Pre – requisite: **Nil**

9. Objective: To expose students about various policies, strategies, and schedules of maintenance in industries.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Importance of maintenance, objectives, duties, functions and responsibilities of maintenance engineering department, organization and structure of maintenance systems.	4
2.	Maintenance Policies and Planning: Maintenance strategies, advantages and disadvantages of each strategy, planned maintenance procedure, advantage of planned maintenance, scientific maintenance, safety in maintenance.	6
3.	System Reliability: Quantitative estimation of reliability economics of introducing a standby unit into the production system, optimum design configuration of a series/parallel system, breakdown time distribution.	6
4.	Maintenance Activities: Optimal overhaul/repair or replacement policies for equipment subject to breakdown, budgeting and control, production maintenance integration.	4
5.	Replacement Decisions: Economic models block replacement policy, age replacement policy, replacement policies to minimize downtime, economics of preventive maintenance.	8
6.	Maintainability and Availability: Economics of maintainability and reliability, maintainability increment, equipment and mission availability.	8
7.	Maintenance Organization: Computer applications in maintenance management, automatic checkout equipment kits capabilities and limitations, management information system for maintenance.	6
Total		42

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication/ Reprint
1.	Jardine, A. K. S. and Tsang, A. H. C., "Maintenance, Replacement and Reliability", Taylor & Francis.	2005
2.	Dhillon, B. S., "Engineering Maintenance: a Modern Approach", CRC Press.	2002
3.	Kelly, A., "Maintenance Planning and Control", Butterworth-Heinemann.	1983
4.	Niebel, B.W., "Engineering Maintenance Management", Marcel Dekker.	1994
5.	Clifton, R. H., "Principle of Planned Maintenance", McGraw Hill.	1983
6.	Heintzelman, J. E., "Handbook of Maintenance Management", Prentice-Hall.	1987

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-580**

Course Title: **Welding Science**

2. Contact Hours : **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.) : **Theory 3 Practical 0**

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4

6. Semester: **Spring**

7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge on arc welding processes, metal transfer and weldability of metals.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Welding as compared with other fabrication processes, classification of welding processes.	2
2.	Physics of Welding Arc: Welding arc, arc initiation and maintenance, voltage distribution along the arc, cathode and anode drops, arc column, thermionic and non thermionic cathode, theories of cathode and anode mechanisms, arc characteristics, arc efficiency, heat generation at cathode and anode, effect of shielding gas on arc, isotherms of arcs, arc blow.	10
3.	Metal Transfer: Mechanism and types of metal transfer in various arc welding processes, factors controlling melting rate in various welding processes.	4
4.	Welding Power Sources: Basic characteristics of power sources for various arc welding processes, arc length regulation in mechanized welding processes, transformer, rectifier and generators, duty cycle and power factor, static and dynamic characteristics of power sources.	5
5.	Welding Processes: Critical review of MMA, TIG, MIG and CO ₂ welding processes, plasma arc, submerged arc welding, electro- gas and electro-slag welding, resistance welding; Theory and mechanism of solid state welding; Technique and scope of friction welding, diffusion welding, cold pressure welding and ultrasonic welding; Scope and application of electron beam and laser welding processes.	12
6.	Heat Flow in Welding: Calculation of peak temperature, width of heat affected zone, cooling rate and solidification rates, weld thermal cycles, residual stresses and their measurement, weld distortion and its prevention.	4
7.	Weldability of Metals: effects of alloying elements on weldability, welding of plain carbon steel, stainless steel, cast iron and aluminum.	5
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	"Welding Handbook", 7 th Ed., Volumes 1 to 5, American Welding Society.	1982
2.	Houdlecroft, P. T., "Welding Process Technology", Cambridge University Press.	1977
3.	Udin, H., Fruk, F. and Wulff, J., "Welding for Engineers", John Wiley.	1978
4.	Rossi, E., "Welding Technology", Mc-Graw Hill.	1969
5	Baldev, R., "Welding Technology for Engineers", ASM International	2006
6	Bowditch, W.A., Bowditch, K. E., Bowditch, M. A., "Welding Technology Fundamentals", 4 th Ed., Goodheart-Willcox Pub.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-581** Course Title: **Manufacturing Resources Management**

2. Contact Hours : **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.) : **Theory** 3 **Practical** 0

4. Relative Weightage : CWS 25 PRS 0 MTE 25 ETE 50 RE 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce various types of resources in manufacturing systems, their importance and management.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Production as input-output system; Resources of production; Forecasting and resources planning.	5
2.	Material Management: Definition and scope, functions, types of materials; Analytical structure of inventory models; Material requirement planning (MRP); Inventory control systems; Purchase management; Storekeeping and issue of materials; Material handling; Just in Time (JIT) and Kanban systems.	7
3.	Human Resources Management: Objective, function, organizational planning and development, staffing policies and process, training and executive development, wage and salary policies and administration, motivation, employee services, employee record, labor relations, collective bargaining, personnel research.	10
4.	Production Management: Direct and indirect, machines and equipment planning, jigs and tools planning, material handling equipment planning; Planning of land, roads, building, warehouses etc.; General vs special purpose equipment; Economic analysis; Equipment replacement; Capital resources planning; Method of allocation of resources.	10
5.	Production Information Management: Management of production technology, information systems, management information systems (MIS), strategic information system (SIS), information networking, parts oriented production information systems.	10
Total		42

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication /Reprint
1	Hitomi K, "Manufacturing Systems Engineering: A Unified Approach to Manufacturing Technology, Production Management and Industrial Economics", 2 nd Ed., CRC Press.	1996
2	Groover, M. P., "Fundamentals of Modern Manufacturing: Materials, Processes, and Systems", 4 th Ed., Wiley.	2010
3	Dessler, G., "Personnel Management", 4 th Ed., Reston Publishing.	1988
4	Nauhria, R. N. and Prakash, R. "Management of Systems", Wheeler Publishing.	1995
5.	Vollman, T. E., Berry, W. L., Whybark, D. C. and Jacobs, F. R., "Manufacturing Planning and Control Systems", 5 th Ed., McGraw Hill.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-583** Course Title: **Materials Management**

2. Contact Hours: **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4**

6. Semester: **Spring**

7. Subject Area: **PEC**

8. Pre – requisite: **Nil**

9. Objective: To introduce basic concepts of purchasing, supplier management, inventory control, materials planning, materials transportation and distribution.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Operating environment, scope, and issues.	4
2.	Material Requirement Planning: Introduction, bills of material, material requirement plans and planning process.	6
3.	Capacity Management: Definition of capacity, capacity planning, capacity requirement planning, capacity available and required, scheduling order, make span.	6
4.	Production Activity Control: Data requirements, order preparation, scheduling, load leveling, scheduling bottlenecks, production reporting.	6
5.	Purchasing And Forecasting: Establishing specifications, selecting suppliers, price determination, demand management, demand forecasting, principle of forecasting, forecasting techniques, seasonality, tracking the forecast, inventory.	10
6	Inventory fundamentals: Flow of materials, supply and demand pattern, functions of inventories, ABC, VED and FSN system of selective inventory, EOQ, variation of EOQ models, period order quantity, quantity discount.	6
7.	Just In Time (JIT) Manufacturing: JIT philosophy, JIT environment, manufacturing planning and control in JIT environment, MRP, Kanban, and theory of constraints.	4
Total		42

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication /Reprint
1.	Zenz, G. J., "Purchasing and the Management of Materials", 7 th Ed., Wiley.	1993
2.	Bowersox, D. J. and Closs, D. J., "Logistical Management: The Integrated Supply Chain Process", McGraw-Hill.	1996
3.	Leenders, M. R. and Fearon, H. E., "Purchasing and Materials Management", 11 th Ed., Irwin Burr Ridge.	1997
4.	Handfield, R. B. and Nichols, E.L., Jr., "Introduction to Supply Chain Management", Prentice-Hall.	1999
5.	Arnold, J. R. T. and Chapman, S. N., "Introduction to Materials Management", 6 th Ed., Prentice Hall.	2007
6.	McDonald, S. C. "Materials Management: An Executive's Supply Chain Guide", Wiley.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-585** Course Title: **Supply Chain Management**

2. Contact Hours : L: **3** T: **1** P: **0**

3. Examination Duration (Hrs.) : Theory: **3** Practical: **0**

4. Relative Weightage : CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre – requisite: **Nil**

9. Objective: To introduce the strategic role of supply chains, the key strategic drivers of supply chain performance and the analytic methodologies for supply chain network design and analysis.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Understanding supply chain, supply chain performance, supply chain drivers and obstacles.	4
2.	Planning Demand and Supply in a Supply Chain: Demand forecasting in supply chain, aggregate planning in supply chain, planning supply and demand; managing predictable variability, economic order quantity models, reorder point models, multi-echelon inventory systems.	12
3.	Planning and Managing Inventories in a Supply Chain: Managing economies of supply chain, managing uncertainty in a supply chain, determining optimal levels of product availability.	6
4.	Transportation, Network Design and Information Technology: Transportation aspects in a supply chain, facility decision, network design in a supply chain, information technology and its use in supply chain.	10
5.	Coordinating a Supply Chain and the Role of e- Business: Coordination and e-business in a supply chain, financial evaluation in a supply chain.	10
Total		42

11. Suggested Books:

S. No-	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Viswanadham, N., "Analysis of Manufacturing Enterprises", Kluwer Academic Publishers.	2000
2.	Sridhar, T., Ganeshan, R. and Magazine, M. (editors), "Quantitative Models for Supply Chain Management", Kluwer Academic Publishers.	1999
3.	Handfield, R.B. and Nichols E.L.Jr., "Introduction to Supply Chain Management", Prentice Hall.	1999
4.	Viswanadham, N. and Narahari, Y., "Performance Modeling of Automated Manufacturing Systems", Prentice Hall of India.	1998
5.	Simchi-Levi, D., Kaminsky, P. and Simchi-Levi, E., "Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies", 3 rd Ed., McGraw Hill.	2007
6.	Chopra, S. and Meindel, P., "Supply Chain Management: Strategy, Planning, and Operation", 4 th Ed., Prentice Hall of India.	2009
7.	Shapiro, J. F., "Modeling the Supply Chain", 2 nd Ed., South-Western College Pub.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE:

Department of Mechanical and Industrial Engineering

1. Subject Code: **MI-586** Course Title: **Metal Forming**
2. Contact Hours : **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.) : **Theory: 3** **Practical: 0**
4. Relative Weightage : **CWS 25** **PRS 0** **MTE 25** **ETE 50** **PRE 0**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre – requisite: **Nil**
9. Objective: To explain the advanced scientific theoretical aspects of metal forming processes.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Stress/strain, strain-rate characteristics of materials, yield criteria of metals, classification of metal working processes, formability and theory of sheet metal working, friction and lubrication in metal working operation, theories of friction and lubrication, assessment of friction at interface.	9
2.	Process Analysis: Various methods of analyzing the metal working processes (slip-line field theory, upper bound solution, stab methods).	3
3.	Mechanics of Rolling and Forging Processes: Rolling - determination of rolling pressure, roll separating force, driving torque and power, and power loss in bearings; Forging- determination of forces in strip forging and disc forging.	7
4	Mechanics of Drawing and Bending Processes: Drawing - determination of force and power, determination of maximum allowable reduction, deep drawing force analysis, analysis of tube drawing process with fixed and moving mandrel, tandem tube drawing; Bending - determination of work load and spring back.	6
5	Mechanics of Extrusion Processes: Extrusion- determination of work load from stress analysis and energy consideration, power loss, hydrostatic extrusion; Punching and Blanking - mode of metal deformation and failure, two-dimensional deformation model and fracture analysis, determination of working force.	7
6.	Hydrostatic Extrusion: Comparison with conventional extrusion, pressure required to extrude, variables affecting the process.	4
7.	High Speed Forming: Classification, comparison of low and high speed forming operation problems in high speed forming operation, introduction to high forming process such as explosive forming, electrical and mechanical high speed forming techniques.	6
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Bray, S., "Metalworking Tools and Techniques", Crowood Press.	2003
2.	Valberg, H., "Applied Metal Forming, Including FEM Analysis", Cambridge University Press.	2010
3.	Polukhin, V. P., "Mathematical Simulation and Computer Analysis of Thin Strip Rolling Mill", MIR Publishers.	1975
4.	Johnson, W. and Meller, P. B., "Plasticity for Mechanical Engineers", Van Nostrand.	1983
5.	Wagoner, R. H., Chenot, J. L., "Metal Forming Analysis", Cambridge University Press.	2001
6.	Ghosh, A. and Mallik, A. K., "Manufacturing Science", Affiliated East-West.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-587** Course Title: **Metal Casting**
2. Contact Hours : L: **3** T: **1** P: **0**
3. Examination Duration (Hrs.) : Theory: 3 Practical: 0
4. Relative Weightage : CWS 25 PRS 0 MTE 25 ETE 50 PRE 0
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre – requisite: **Nil**
9. Objective: To explain the advanced scientific theoretical aspects of metal casting processes.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Features of casting problem, a survey and scope of foundry industry.	3
2.	Solidification: Solidification of pure metals and alloys, nucleation and growth in alloys, solidification of actual castings, progressive and directional solidification, centerline feeding resistance, rate of solidification, Chvorinov's Rule, electrical analog of solidification problem; Fluidity - measurement of fluidity, effects of various parameters on fluidity	8
3.	Risering and Gating System: Riser design, risering curves, NRL method of riser design, feeding distance, risering of complex casting, risering of alloy other than steel, recent developments in riser design by the application of geometrical programming; Gating systems and their characteristics, the effects of gates on aspiration, turbulence and dross trap, recent trends.	5
4.	Pattern and Casting Design: Pattern design, recent developments in pattern design, materials and construction; Casting design considerations- review of casting design, recent trends.	9
5.	Melting, Molding and Core Making Processes: Selection and control of melting furnaces, boiling, refining and pouring, recent trends in cupola design; Review and critical comparison of various established processes, recent developments e.g. low pressure and ferrous die casting, high pressure molding, full mold process, flaskless molding, hot and cold box molding, ceramic shell molding, V-process, continuous casting, squeeze and pressed casting, Nishiyama process, Shaw process, Anitoch process etc.	6
6.	Internal Stresses, Defects and Surface Finish: Residual stresses, hot tears and cracks in castings, stress relief, defects and their causes and remedies, various parameters affecting surface finish and related defects, e.g. rough casting, sand bum-on, sand bum-in and metal penetration, facing and washes, mold wall	7

	movement, vapor transpoll zones, expansion scabbing etc; Gases in metal-methods of elimination and control of dissolved gases in castings.	
7.	Testing, Inspection and Quality Control: Testing of sand, recent developments e.g. mulling index, moldability index, compactability, deformability; Review of X-ray and gamma ray radiography, magnetic particle, die penetrant and ultrasonic inspection, use of statistical quality control in foundry.	4
	Total	42

11. Suggested Books:

S. No.-	Name of Authors / Books / Publisher	Year of Publication /Reprint
1.	Flinn, R.A., "Fundamentals of Metal Casting", Addison Wesley.	1963
2.	Heine, R. W, Loper, C. R. and Rosenthal, P.C., "Principles of Metal Casting", Tata McGraw-Hill.	1997
3.	Niebel, B.W. and Draper, A. B., "Modern Manufacturing Process Engineering", McGraw Hill.	1990
4.	"ASM Handbook, Volume 15, Casting", ASM International.	2008
5	Beeley, P. R. , "Foundry Technology", Butterworth-Heinemann.	2001
6	Jain, P. L., "Principles of Foundry Technology", Tata McGraw Hill.	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MI-588** Course Title: **Non-Traditional Machining Processes**
2. Contact Hours : **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs.) : Theory: 3 Practical: 0
4. Relative Weightage : CWS 25 PRS 0 MTE 25 ETE 50 PRE 0
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre – requisite: **Nil**
9. Objective: To introduce various non-traditional or Advanced Machining Processes (AMPs).

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Types of advanced manufacturing processes, evolution, need, and classification of advanced machining processes (AMPs).	2
2.	Mechanical Type AMPs: Ultrasonic machining (USM), abrasive jet machining (AJM), water jet machining (WJM), abrasive water jet machining (AWJM) processes - process principle and elements, tool design, mechanism of material removal, parametric analysis, shape and material applications, operational characteristics, limitations.	8
3.	Advanced Fine Finishing Process: Abrasive flow machining (AFM), magnetic abrasive finishing (MAF), magneto rheological abrasive finishing (MRAF) - process principle, process equipment, analysis and modeling of finishing mechanism, parametric analysis, applications.	6
4.	Chemical Type AMPs: Process principle and details of chemical machining (CHM), photo-chemical machining (PCM), and bio-chemical machining (BCM) processes.	4
5.	Electro chemical type AMPs: ECM - process principle, mechanism of material removal, kinematics and dynamics of ECM, tooling design, choice and analysis of process parameters, surface finish and accuracy.	6
6.	Thermal type AMPs: Electrical discharge machining (EDM), laser beam machining (LBM), electron beam machining (EBM), ion beam machining (IBM), plasma arc machining (PAM) processes - working principle, power circuits, mechanism of material removal, process parameters and characteristics, surface finish and accuracy, shape and materials applications, limitations.	8
7.	Derived and Hybrid: AMPs: introduction of processes like rotary ultrasonic machining (RUM), electro stream drilling (ESD), shaped tube electro machining (STEM), wire electro discharge machining (WEDM), electro chemical grinding (ECG), electro chemical honing (ECH), electro chemical deburring (ECDE), and electro-chemical spark machining (ECSM).	6
8.	Miscellaneous Topics: Process selection and process planning for AMPs.	2
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Pande, P. C. and Shan, H. S., "Modern Machining Processes", Tata McGraw-Hill.	1980
2.	Ghosh, A. and Mallik, A. K., "Manufacturing Science", Affiliated East-West Press.	2000
3.	Benedict, G. F., "Nontraditional Manufacturing Processes", Marcel Dekker.	1987
4.	McGeough, J. A., "Advanced Method of Machining", Chapman and Hall.	1988
5.	Mishra, P. K., "Nonconventional Machining", Narosa Publishing House.	2001
6.	Jain, V. K., "Advanced Machining Processes", Allied Publishers.	2002

Department of Mechanical and Industrial Engineering

M. Tech. (Welding Engineering)

I Year

Autumn Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage (%)				
S No	Course No.	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MA-501B	Numerical Analysis	ICC	4	3	1	0	3	--	25	--	25	50	--
2	MI-511C	Modeling and Simulation	PCC	4	3	1	2/2	3	--	15	15	30	40	--
3	MI-590	Theory of Arc Welding Processes	PCC	4	3	1	2/2	3	--	15	15	30	40	--
4	MI-591	Inspection and Quality Control of Weldments	PCC	4	3	1	2/2	3	--	15	15	30	40	--
5		Open Elective - I	OEC	3/4	-	-	-	3	--	25	--	25	50	--
6	HS-501	Technical Communication (Optional)	---	2	1	0	2	2	--	15	15	30	40	--
Sub Total				19-22										

Spring Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage (%)				
S No	Course No.	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MI-592	Design and Analysis of Welded Structures	PCC	4	3	1	2/2	3	--	15	15	30	40	--
2		Program Elective-I	PEC	4	3	1	0	3	--	25	--	25	50	--
3		Program Elective-II	PEC	4	3	1	0	3	--	25	--	25	50	--
4		Program Elective-III	PEC	4	3	1	0	3	--	25	--	25	50	--
5		Open Elective-II	OEC	3/4	-	-	-	3	--	25	--	25	50	--
6	HS-501	Technical Communication (Optional)	---	2	1	0	2	2	--	15	15	30	40	--
Sub Total				19-22										

II Year

Autumn Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage (%)				
S No.	Sub code	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MI-601	Seminar	SEM	2	-	-	-	--	--		--	100	--	--
2	MI-602	Project	RP	4	-	-	-	--	--		--	100	--	--
3	MI-603	Dissertation*	DIS	0	-	-	-	--	--		--	--	25	--
Sub Total				6										

* NOTE: To be continued and grade to be awarded in the next semester.

Spring Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage (%)				
S No.	Sub code	Course Title	Subject Area	Credit	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MI-603	Dissertation (continued from III semester)	DIS	20	-	-	-	--	--	--	--	--	75	--
Sub Total				20										
Total				64-68										

Program Electives for M. Tech. (Welding Engineering)

Teaching Scheme					Contact Hrs Per Week			Exam Duration (Hrs)		Relative Weightage (%)				
S No.	Course No.	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MI-500	Instrumentation and Experimental Methods	PEC	4	3	1	0	3	--	25	--	25	50	--
2	MI-593	Non-Conventional Welding Processes	PEC	4	3	1	0	3	--	25	--	25	50	--
3	MI-594	Safety Aspects of Welded Structures	PEC	4	3	1	0	3	--	25	--	25	50	--
4	MI-595	Failure Analysis of Weld Joints	PEC	4	3	1	0	3	--	25	--	25	50	--
5	MI-596	Automation and Applications of Robots in Welding	PEC	4	3	1	0	3	--	25	--	25	50	--
6	MI-597	Welding Procedures for Specific Applications	PEC	4	3	1	0	3	--	25	--	25	50	--
7	MI-598	Weldability of Metals	PEC	4	3	1	0	3	--	25	--	25	50	--
8	MI-599	Surface Engineering	PEC	4	3	1	0	3	--	25	--	25	50	--

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **Mechanical and Industrial Engineering**

1. Subject Code: **MI-590** Course Title: **Theory of Arc Welding Processes**

2. Contact Hours: L: **3** T: **1** P: **2/2**

3. Examination Duration (Hrs): Theory: **3** Practical: **0**

4. Relative Weightage: CWS **15** PRS **15** MTE **30** ETES **40** PRE **0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To introduce theoretical and practical knowledge about the mechanism of the arc, metal transfer during consumable arc welding, the process and their applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Brief history of welding, classification of welding processes, heat sources and shielding methods; Physics of welding arc, voltage distribution along the arc, thermionic and non-thermionic cathodes, arc characteristics and its relationship with power source, arc efficiency, heat generation, effect of shielding gases on arc, isotherms of arcs, arc blow.	6
2	Metal Transfer: Classification, forces acting on the drop, metal transfer mechanisms, transition current, melting rate, effect of polarity, deposition efficiency, current and voltage oscillograms, high speed films.	3
3	Welding Power Sources: Conventional welding power sources, constructional features, static and dynamic characteristics, duty cycle, influence of inductance on arc and power source characteristics, internal and external regulation, specific power source requirements, special welding power sources.	5
4	Gas Metal Arc Welding Processes: Consumable electrode welding processes. Manual metal arc (MMA) welding: type composition and functions of flux covering, ISI and other international codes for electrodes, concepts of special electrodes, consumables, arc length control in pulsed MIG welding, selection of parameters, self shielded and gas shielded flux cored wire welding.	7
5	Submerged Arc and Electroslag Welding: Specific features, process variables, types and composition of fluxes and their manufacturing, arc length control, significance of flux-metal combination; Electroslag welding- heat generation, principle, wire and consumable guide technique, selection of parameters, nature of fluxes.	8

6	Non Consumable Electrode Welding Processes: Gas tungsten arc welding, electrodes, compositions, shielding gases, arc ignition and maintenance, selection of polarity, arc voltage rectification and remedy, cathode spot and normal mode operations; Plasma arc welding: transferred and non-transferred plasma arc welding, selection of gases, welding parameters, keyhole technique.	6
7	Special Topics: Arc stud welding, application of external magnetic field during welding, gravity welding, surface tension transfer power source, magnetic arc welding.	7
Total		42

11. List of Experiments

1. Effect of welding parameters in SMAW, GMAW and GTAW processes.
2. Comparison of rutile, basic and cellulosic electrodes in MMAW process.
3. Effect of shielding gases on performance of GMAW process.
4. Effect of welding fluxes in submerged arc welding process.
5. Study of optical profile gas cutting.

12. Suggested Books:

S. No.	Name of Author (s)/ Book/ Publisher	Year of Publication/ Reprint
1.	Lancaster J. F., "The Metallurgy of Welding", 6 th Ed., William Andrew Publishing.	1999
2.	"Welding Handbook" Volumes 1, 2 & 3, 9th Ed., American Welding Society.	2001
3.	"Metals Handbook", Vol. 6, ASM International Publication.	1993
4.	"Procedure Handbook of Arc Welding", 14 th Ed., Lincoln Electric Co.	2004
5.	Larry J. and Jeffus L., "Welding Principles and Application", 5 th Ed., Delmer Publication.	2002
6.	Messler R. W., "Principles of Welding (Processes, Physics, Chemistry and Metallurgy)", John Wiley & Sons.	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **Mechanical and Industrial Engineering**

1. Subject Code: **MI-591** Course Title: **Inspection and Quality Control of Weldments**

2. Contact Hours: L: **3** T: **1** P: **2/2**

3. Examination Duration (Hrs): Theory: **3** Practical: **0**

4. Relative Weightage: CWS **15** PRS **15** MTE **30** ETE **40** PRE **0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge of dimensional inspection, destructive testing, NDT methods, WPS and PQR requirements and welder qualification standards.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Types and purposes of weldment testing, important welding terms, symbols for welding and testing.	4
2.	Weld Related Discontinuities: Classification of discontinuities in weldment, occurrence, causes and prevention of discontinuities, location, orientation and extent of discontinuities, method for testing weld and base metal imperfections.	4
3.	Destructive Testing of Welds: Chemical tests, metallographic tests, hardness tests, mechanical test for groove and fillet welds-full section, reduced section and all-weld-metal tensile tests, root, face and side bend tests, fillet weld break tests, fillet weld shear strength test.	8
4.	Non-Destructive Testing (NDT) of Weldments: Visual inspection, dye-penetrant inspection, magnetic particle inspection; Ultrasonic inspection-principle of ultrasonic testing, types of ultrasonic probes, standard blocks for calibration; Radiographic inspection – principle of radiography, X-ray tubes, gamma-ray sources, interpretation of radiographs, defect discernibility, neutron radiography; Eddy current inspection; Proof test, leak tests: NDT AWS (American Welding Society) standards, safety in NDT.	12
5.	Inspection of Weldments: Duties and requirement of an inspector before, during and after welding, codes governing welding inspection, ASME (American Society of Mechanical Engineers) Code.	5
6.	Welding Procedure and Performance Qualifications: Standard procedure	9

	for specification and qualification of welding procedure, operator qualification, standard method of recording of qualification tests, welding procedure specification (WPS), procedure qualification record (PQR) and Welding performance qualification (WPQ).	
	Total	42

List of Experiments:

1. Visual inspection for weld quality
2. Dye-penetrant inspection of surface defects in welded joints
3. Magnetic particle inspection surface defects in welded joints
4. Ultrasonic inspection for assessing sub-surface defects
5. Radiographic inspection of weld joints

11. Suggested Books:

S. No.	Name of Author (s)/ Book/ Publisher	Year of Publication/ Reprint
1.	"Welding Inspection", 3 rd Ed., American Welding Society.	2000
2.	"Welding Hand Book", Vol. 5, 7 th Ed., American Welding Society.	1984
3.	"ASME Code Section IX ", ASME.	1998
4.	"Structural Welding Code – Steel", AWS D1.1:2000 AWS	2000
5.	"Specifications for Welding Procedure & Performance Qualification", ANSI /AWS B2.1:1998	1998
6.	Jeffus, L., "Welding: Principles and Applications", 6 th Ed., Delmar Cengage Learning.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **Mechanical and Industrial Engineering**

1. Subject Code: **MI-592** Course Title: **Design and Analysis of Welded Structures**

2. Contact Hours: L: **3** T: **1** P: **2/2**

3. Examination Duration (Hrs.): Theory: **3** Practical: **0**

4. Relative Weightage: CWS **15** PRS **15** MTE **30** ETE **40** PRE **0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite : **Nil**

9. Objective: To introduce procedure of designing welded joints for static and dynamic load conditions and their analysis.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Introduction to design, engineering properties of steels, weldability of structural steels, carbon equivalent, fatigue and creep properties of welded joints, theories of failures.	7
2.	Weld Joints and Connections: Type of welds and weld joints, description of welds --- terminology, welding symbols, edge preparation, sizing of welds in structure, type of connections in welded structures, combined groove and fillet weld connections.	6
3.	Design for Static Loading: Weld calculations for lap, butt and fillet welds, analysis of connections for direct tension or compression and shear loading conditions, resistance to moment by combined tension and compression	6
4.	Design for Fatigue loading: Introduction to Fatigue, mechanism of fatigue fracture, residual fatigue strength, factors affecting fatigue life, design of welded joints for fatigue loading, fatigue behaviour of hollow section joints, methods for improving the fatigue strength of welded joints, reliability analysis and safety factors applied to fatigue design with reference to fracture toughness.	8
5.	Industrial Applications of Weld Design: Design of tubular structure, circular and rectangular hollow sections under static loading; Introduction to design of weld joint for pressure vessel -- cylindrical and head section; Weld design for automobile applications: chassis and body design; Design of brazed and soldered joints.	8

6-	Heat flow and Residual Stresses in Welds: Heat flow in welding, effect of welding parameters on heat distribution, calculation of peak temperature, weld thermal cycle, cooling rate and solidification time, residual stress distribution, influence of residual stress in static and dynamic loading, introduction to stress corrosion.	7
	Total	42

List of Experiments:

- Study the effect of type of welds on tensile properties of weld joint
- Development of weld thermal cycle during arc welding
- Measurement of residual stress in welded joints
- Measurement of hardness, toughness and fracture toughness of welded joints
- Study stress corrosion cracking behaviour of stainless steel joints

11. **Suggested Books:**

S. No.	Name of Author (s)/ Book/ Publisher	Year of Publication /Reprint
1.	Fuchs, H. O. and Stephen, R I., "Metal Fatigue in Engineering", John Wiley & Sons.	2000
2.	Gray, T. G. F. and Spence, J., "Rational Welding Design", Butterworths.	1992
3.	"Welding Hand Book", Vol. 2 & 3, 9 th Ed., American Welding Society.	2001
4.	Dieter, G., "Mechanical Metallurgy", McGraw Hill.	1988
5.	Messler, R.W. Jr., "Principles of Welding", John Wiley & Sons.	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **Mechanical and Industrial Engineering**

1. Subject Code: **MI - 593** , Course Title: **Non-Conventional Welding Processes**

2. Contact Hours: L: **3** T: **1** P: **0**

3. Examination Duration (Hrs): Theory: **3** Practical: **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester : **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide theoretical and practical details of various non-conventional welding/joining processes and techniques including high energy density welding processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Resistance Welding: Principle of contact resistance, calculation of current, time and voltage for spot welding, choice of electrode material, electrode shapes, shunt current, shop tests for soundness of spot welds, seam, projection, butt and flash welding, selection of welding and other process details, stud welding, power sources for resistance welding, quality of resistance welded joints.	10
2.	High Power Density Welding Processes: Electron beam (EB) welding in different degrees of vacuum, applications; Laser welding, principle of operation, applications.	4
3.	Solid State Welding Processes: Fundamental principles of various non-conventional pressure welding processes and their applications, friction, explosive, diffusion and ultrasonic welding, high frequency resistance/induction welding.	8
4.	Special Topics: Soldering, brazing and braze welding, joining of plastics.	5
5.	Cutting and Surfacing: Plasma and thermal cutting and surfacing operations, parameters, consumables and equipments, arc and gas gouging.	8
6.	Safety Measures in Welding: Various safety measures for conventional and non-conventional welding processes; Gas cylinder colour codes, storage and transportation of gases, protection from fire and explosions; Protection against electric shocks and short circuiting, formation of fumes; Effect of fumes, radiations and noise on welder's health, eye flash, skin burn, heat	7

	exhaustion and other diseases; Protective devices such as exhaust hoods, booths, shields, goggles, screens, clothing and ear covers, safety during welding in confined spaces.	
	Total	42

11. Suggested Books:

S. No.	Name of Author (s)/ Book/ Publisher	Year of Publication /Reprint
1.	"Welding Handbook", Vol. 2 & 3, 9 th Ed., American Welding Society.	2003
2.	"Metals Handbook", Vol. 6, American Society of Metals.	1993
3.	"Procedure Handbook of Arc Welding", Lincoln Electric Co.	2004
4.	Richard, Little L., "Welding and Welding Technology", McGraw Hill.	1976
5.	Tylecote, R. F., "The Solid Phase Welding of Metals", Edward Arnold.	1968

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical and Industrial Engineering**

1. Subject Code: **MI-594** Course Title: **Safety Aspects of Welded Structures**

2. Contact Hours: **L: 3** **T:** **P: 0**

3. Examination Duration (Hrs.) : **Theory: 3** **Practical : 0**

4. Relative Weightage: **CWS 25** **PRS 0** **MTE 25** **ETE 50** **PRE 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre – requisite: **Nil**

9. Objective: To provide knowledge of safety of welded structure primarily in reference to various consequences of stress and strain state, loading conditions and susceptible mode of fracture.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Basics of Safety Concept: Definition of safety, basics and definition of safety concept; Basic mechanism of failure of components, brittle fracture, ductile fracture, collapse fatigue fracture mechanism and representations at sub-microscopic and macroscopic levels through Mohr's Circle; Specific problems of safety related to weldments, definition and safety relevance of weld imperfections.	10
2	Conventional Methods for Safety Analysis: Concepts of strength and toughness of engineering materials, determination and consequences of stress and strain state; Material - stress and strain state embitterment, their reasons and consequences; Effects of notches, stress state in notched component, safety analysis and assessment of notched components using notch theory; Semi quantitative fracture analysis diagrams (Pellim's FAD), limitations of conventional methods.	10
3	Fracture Mechanics: Concepts of stress-strain state of cracked components; Introduction and basic principles of fracture mechanics; Linear elastic fracture mechanics (LEFM); Stress intensity factor, determination of fracture toughness.	6
4	Methods for Safety Analysis: ASTM E 399 method, limitations of LEFM, modified LEFM (ASTM E 1820), general yielding criterion; Plastic limit load calculations (PLLC), principles of Two Criteria Approach (TCA); Failure assessment diagram (CEGB Report R-6); Mechanism of cyclic crack growth; Paris law, modifications of Paris law, effects of temperature and environment; Elastic plastic fracture mechanics (EPFM); Stable crack growth, COD concept (CTOD BS:	8

	5762), R-curve technique, instability diagram.	
5	Application of Safety Concepts to Welded Structures: Material imperfections and stress states in weldments, quality-degradation in welded structures; CODE requirements; Case studies as examples of failures; Design and service requirements for engineering structures fabricated by welding i.e. welded structures.	8
	Total	42

11. Suggested Books:

S.No	Name of Author (s)/ Book/ Publisher	Year of Publication /Reprint
1.	Anderson, T. L., "Fracture Mechanics: Fundamentals and Applications", 3 rd Ed., Taylor & Francis.	2000
2.	Farahmand, B., "Fracture Mechanics of Metals, Composites, Welds and Bolted Joints", Kluwer Academic Publishers.	2000
3.	Broek, D., "Elementary Engineering Fracture Mechanics", Springer-Verlag	1982
4.	Latzko, D. G. H., "Post Yield Fracture Mechanics", 2 nd Ed., Elsevier Applied Science Publication.	1984
5.	Maddox, S. J., "Fatigue of Welded Structures", 2 nd Ed., Woodhead Publishing.	1991
6.	Gurney, T. R., "Fatigue of Welded Structures", Cambridge University Press.	1979
7.	Chell, G. G., "Development of Fracture Mechanics", Elsevier Applied Science Publication.	1979

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical and Industrial Engineering**

1. Subject Code: **MI-595** Course Title: **Failure Analysis of Weld Joints**
2. Contact Hours : L: **3** T: **1** P: **0**
3. Examination Duration (Hrs.) : Theory: **3** Practical : **0**
4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area : **PEC**
8. Pre – requisite: **Nil**
9. Objective: To provide knowledge about the nature of failure of weld joints, failure mode and failure causes, instruments for failure analysis, fracture mechanics approaches, safety of welded structure and weld repairing.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Fundamental Sources of Failure: Deficiencies in design, material and processing errors, improper service condition, residual stresses.	6
2.	General Practice in Failure Analysis: Objective, collection of background data, selection of samples; Selection, cleaning and preservation of fractured surface, identification of mode of failure, approach for failure analysis, ascertaining causes of failure, reporting practice.	9
3.	Preliminary Examination of Fractured Components: Preliminary examination of fractured surface, equipment used for preliminary examination, preservation of failure records.	3
4.	Identification of Mode of Failure: Classification, specific characteristics, distinction between different type of fractures, factors affecting mode of fracture and defects.	5
5.	Analysis of the Causes of Failure: Chemical analysis, optical microscopic examination, use of scanning electron microscope, micro probe analyzer and X-ray diffraction; Correlation of weldment failure of different materials using various welding processes including repair welding	10

6.	Application of Fracture Mechanics Concepts in Failure Analysis: Physical meaning of K_{IC} , J_{IC} and $CTOD (g_c)$ in reference to fracture control process, fracture analysis in the light of fatigue crack growth rate behaviour of material, residual life assessment; Case studies of failure in different components such as heat exchangers, steam power plant equipment, pressure vessel and nuclear reactor etc.	9
Total		42

11. Suggested Books:

S. No.	Name of Author (s)/ Book/ Publisher	Year of Publication /Reprint
1.	Becker, W. T. and Shipley, R. J., "Metals Handbook, Failure Analysis and Prevention", Volume 11, ASM International.	2002
2.	Hutchings, F. R. and Unterweiser, P. M., "Failure Analysis, The British Engineering Technical Report", ASM International.	1981
3.	Bhadeshia, H. K. D. H. and Honeycombe, R. W. K., "Steels: Microstructure and Properties", 3 rd Ed., Butterworth-Heinemann.	2006
4.	"Metals Handbook, Fractography", Volume 12, ASM International.	1992
5.	Das, A. K., "Metallurgy of Failure Analysis", Tata McGraw- Hill.	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER: **Mechanical and Industrial Engineering**

1. Subject Code: **MI-596** Course Title: **Automation and Applications of Robots in Welding**

2. Contact Hours : **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.) : Theory: **3** Practical: **0**

4. Relative Weightage : CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To expose students to various automation devices and robot construction and their application during welding.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Automated Devices for Welding: Concept of manual, mechanized and automated welding, concept of automation in welding, positioners, arc moving devices, welding fixtures and brazing fixtures.	10
2.	Mechanization in Welding: Mechanization of flat / circular joints, mechanization of I beams (arc welding), longitudinal, circumferential submerged arc (SA)-welding (roller- blocks, column booms, flux supports) circular welding joints (rotating tables, positioners), manufacture of longitudinal welded pipes by TIG, plasma and SA welding, spiral welded pipes.	5
3.	Mechanization of Pipe Welding: Butt- welding, Tungsten Inert Gas (TIG)-orbital welding, Metal Inert Gas (MIG) / Metal Active Gas (MAG) -orbital welding, flush butt welding, tube-tube / plate welding.	3
4.	Automation in Welding: Automatic lines for welding, automation of track wheels, automation of weld components in automobile industry.	5
5.	Introduction to Robotics: The concept of robotics, the robot classification, concept of robots, robot arms, devices, sensors, end effectors, robot work volume and robot cell; Robot elements and control-manipulators, drives, sensors, end effectors, configuration, force/torque relationship, trajectory planning, position control, feedback system, digital control	9
6.	Applications of Robots in Welding and Allied Processes: Application of robot in production, exploration and general purpose; Practical application of robots in welding, robots for car body's welding, robots for box fabrication, robots for micro electronic welding and soldering, efficiency of robotics in welding.	10
	Total	42

1 1. Suggested Books:

S. No.	Name of Books/ Authors/ Publisher	Year of Publication/ Reprint
1.	Shimon, Y. N "Industrial Robots Handbook", John Wiley & Sons.	1985
2.	"Procedure Handbook of Arc Welding", Lincoln Electric.	1994
3.	"Welding Hand Book", Vol. 3, 9 th Ed., American Welding Society.	2001
4.	Mittal, R. K. and Nagrath, I. J., "Robotics and Control", Tata McGraw-Hill.	2003
5	Pires, J. N., Loureiro, A. and Bölmsjö, G. "Welding Robots: Technology, System Issues and Application", Springer-Verlag.	2005

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT/CENTER: **Mechanical and Industrial Engineering**

1. Subject Code: **MI-597** Course Title: **Welding Procedures for Specific Applications**
2. Contact Hours : **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.) : **Theory : 3** **Practical: 0**
4. Relative Weightage : CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To provide overview of the welding techniques for joining and repair of structures, to introduce field problems their solving methodology.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Introduction and Economic Consideration: Groove geometry and weld metal deposition rates for different welding processes, welding cost estimation, standard data for cost estimation, comparative cost study for various welding procedures.	6
2.	Welding of Offshore Constructions: Requirement of offshore construction welding, problems in underwater welding, various underwater welding techniques.	6
3.	Welding of Low Temperature Containment Plants: Materials used for cryogenic applications, problems of welding, welding processes and procedures used for cryogenic materials.	6
4.	Welding of Pressure Vessels: Materials used for construction of pressure vessels, processes and procedures for pressure vessels welding, requirement of various codes.	6
5.	Repairing of Castings: Specific problems in repairing of castings of various materials, welding methods used for repairing and reclamation.	6
6.	Micro joining Techniques: Various techniques used for joining of electronic circuitry and other micro joining applications.	6
7.	Corrosion in Weldments: Various types of corrosion, factors affecting corrosion, minimization of susceptibility to corrosion, corrosion testing, stress corrosion cracking	6
Total		42

1.1. Suggested Books:

S.No.	Name of Author (s)/ Book/ Publisher	Year of Publication/ Reprint
1.	Houldcroft, P. T., "Welding Process Technology", Cambridge University Press.	1977
2.	"Developments in Micro joining", TWI, Abbingdon, Cambridge.	1983
3.	"Welding Hand Book" Vol. 3 and 4, 9 th Ed., AWS	2001
4.	"Rules for Construction of Pressure Vessels", ASME	1977
5.	Nixon, J. H., "Underwater Repair Technology", Gulf Professional Publishing	2000
6.	Yahalom, J. and Aladjan, A., "Stress Corrosion Cracking", SN Publishers	1980

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical and Industrial Engineering**

1. Subject Code: **MI-598** Course Title: **Weldability of Metals**

2. Contact Hours : L: **3** T: **1** P: **0**

3. Examination Duration (Hrs.): Theory: **3** Practical: **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6.Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: Nil

9. Objective: To provide the understanding on weldability of metals of commercial importance such as steels, cast iron, aluminum and copper alloys.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Fundamentals: Solidification of weld metal, heat affected zone (HAZ), factors affecting properties of HAZ, gas-metal, slag-metal and solid state reactions in welding and their influence on soundness of weld joint	4
2.	Weldability of Plain Carbon Steels: Various grade of plain-C steels, factors affecting weldability, viz., Carbon content, Mn/S ratio, microstructure of weld and HAZ, gas porosity, causes and prevention of defects in plain-C steel welds.	6
3.	Weldability of Stainless and Heat Resisting Steels: Various types of stainless steels, austenitic, martensitic, ferritic and PH steel, various defects and problems encountered, compositions of filler rods, pre and post weld treatments necessary for successful welding of these grades of steels.	8
4.	Weldability of HSLA Steels: Various grades of high strength low alloy (HSLA) steels, effect of various alloying elements on weldability, factors affecting weld-metal and HAZ Properties, संतुलनसंत जमंतपदह दक लकतवहमद कंठहम, post weld heat treatment of HSLA steels, various grade of tools steels, problems and precautions in their welding.	6
5.	Weldability of Cast Irons: Various grades of cast irons, factors affecting weldability of cast irons, various grades of filler metals for cast iron, precautions in their welding.	6

6.	Weldability of Aluminum Alloys: Important aluminum alloys, softening of HAZ, welding of 2XXX, 6XXX and 7XXX series aluminum alloys; Porosity and solidification cracking and their remedy, welding electrodes/filler metals for various alloys.	6
7.	Weldability of Copper Alloys: Important alloys of copper, effect of various alloying element on weldability, problem in welding of copper alloys due to thermal conductivity, gas absorption and other parameters.	6
	Total	42

11. Suggested Books:

S. No.	Name of Author (s)/ Book/ Publisher	Year of Publication/ Reprint
1.	Lancaster, J. F., "Metallurgy of Welding", Allen & Unwin.	2000
2.	Castro, R. and de Cadenet, J. J., "Welding Metallurgy of Stainless and Heat-resisting Steels", Cambridge University Press.	1975
3.	"Weldability of Metals", Ed. 7, American Welding Society.	1983
4.	Kou, S., "Welding Metallurgy", 2 nd Ed., John Wiley & Sons.	2003
5.	Gene, M., "Welding of Aluminium and Alloys", Wood Head Pub.	2002
6	Hrivnák, I., "Theory of Weldability of Metals and Alloys", Elsevier.	1991

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical and Industrial Engineering**

1. Subject Code: **MI – 599** Course Title: **Surface Engineering**

2. Contact Hours : **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.) : Theory: **3** Practical: **0**

4. Relative Weightage : CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre – requisite: **Nil**

9. Objective: To highlight the different surface degradation phenomena, importance of the surface engineering techniques, their benefits and limitations, and characterization techniques for quality assurance of engineered surfaces.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Concept and importance, classification of surface modification techniques, advantages and their limitations.	3
2	Surface Degradation: Causes, types and consequences of surface degradation; Forms of wear – adhesive, abrasive, surface fatigue, corrosive, fretting and erosive wear; Classical governing laws related to wear, techniques to evaluate the wear damage.	10
3	Materials for Surface Engineering: Materials characteristics, their importance in surface engineering, wear resistant materials, selection of materials for engineering the surfaces for specific applications.	4
4	Coating based Surface Modification Techniques: Principles and application of weld surfacing – SMAW, SAW, GMAW; Thermal spraying – flame spraying, electric arc spraying, plasma spraying, detonation gun spraying and high velocity oxy fuel spraying; Electro deposition and electro less coatings.	8
5	Diffusion based Surface Modification Techniques: Ion implantation, chemical vapour deposition (CVD) and physical vapour deposition (PVD), carburizing, nitriding, plasma nitriding, cyaniding.	4
6	Irradiation based and Laser Assisted Surface Engineering (LASE) Techniques: Laser cladding, alloying, glazing, laser and induction hardening, heat treatment of steel and remelting by laser / TIG; Microwave glazing.	4

7	Coatings Systems: Structure and property relationship of coatings system, coating systems for corrosion and wear protection, new coating concepts including multi-layer structures, functionally gradient materials (FGMs), intermetallic barrier coatings and thermal barrier coating.	5
8	Characterization and Quality Assurance of Engineered Surfaces: Importance, different characterization techniques – physical, mechanical and functional characterizations, surface finish, micro-hardness, strength and tribological characterizations.	4
Total		42

11. Suggested Books:

S.No	Name of Author (s)/ Book/ Publisher	Year of Publication/ Reprint
1.	Burakowski, T. and Wierzchoń, T., "Surface Engineering of Metals: Principles, Equipment, Technologies", CRC Press.	1999
2.	Grainger, S. and Blunt, J. (eds.), "Engineering Coatings - Design and Application", Abington Publishing.	1998
3.	DeGarmo, P. E., Black, J. T. and Kosher, R. A., "Materials and Processes in Manufacturing", 10 th Ed., John Wiley and Sons.	2007
4.	Kalpakjian, V. and Schmid, S. R., "Manufacturing Engineering and Technology", Pearson Education.	2000
5.	Groover, M. P., "Fundamentals of Modern Manufacturing: Materials, Processes, and Systems", 4 th Ed., John Wiley and Sons.	2010

**THE NEW CURRICULUM STRUCTURE AND SYLLABI OF
THE POST GRADUATE PROGRAMMES
(Approved by the Senate in the
34th meeting held on 16th July 2010)**

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Teaching Scheme					Contact Hours/Week			Exam Duration (hrs.)		Relative Weightage (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
Semester – I (Autumn)														
1.	MA-501D	Discrete Mathematics	ICC	4	3	1	0	3	0	25	-	25	50	-
2.	MT-501	Structure of Materials	PCC	4	3	1	0	3	0	25	-	25	50	-
3.	MT-503	Modelling, Simulation and Computer Applications	PCC	4	3	0	2	3	0	15	15	30	40	-
4.	MT-507	Characterization of Materials	PCC	4	3	0	2	3	0	15	15	30	40	-
5.		Open Elective-I	OEC	3/4	---	---	---	---	---	---	---	---	---	---
6.	HS-501	Technical Communication (Optional)		2	1	0	2	2	-	15	15	30	40	-
		Sub Total		19-22										
Semester – II (Spring)														
1.		Program Elective-I	PEC	4	3	1	0	3	0	25	-	25	50	-
2.		Program Elective-II	PEC	4	3	1	0	3	0	25	-	25	50	-
3.		Program Elective-III	PEC	4	3	1	0	3	0	25	-	25	50	-
4.		Program Elective-IV	PEC	4	3	1	0	3	0	25	-	25	50	-
5.		Open Elective-II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (Optional)		2	1	0	2	2	-	15	15	30	40	-
		Sub Total		19-22										

Teaching Scheme					Contact Hours/Week			Exam Duration (hrs.)		Relative Weightage (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
Semester – III (Autumn)														
1.	MT-601	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	MT-602	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	MT-603	Dissertation*	DIS	-	-	-	-	-	-	-	-	-	25	-
		Sub Total		06										
Semester – IV (Spring)														
1.	MT-603	Dissertation (continued from III semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
		Sub Total		20										
		Total		64-68										

Program Electives I-IV (For Industrial Metallurgy Specialization)														
Teaching Scheme					Contact Hours/Week			Exam Duration (hrs.)		Relative Weightage (%)				
S. No.	Subject Code	Course Title	Subject Area	Credit	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1.	MT-510	Advanced Foundry Technology	PEC	4	3	1	0	3	0	25	-	25	50	-
2.	MT-512	Joining of Materials	PEC	4	3	1	0	3	0	25	-	25	50	-
3.	MT-514	Powder Metallurgy	PEC	4	3	1	0	3	0	25	-	25	50	-
4.	MT-516	Principles of Materials Selection	PEC	4	3	1	0	3	0	25	-	25	50	-
5.	MT-518	Theory of Metal Forming	PEC	4	3	1	0	3	0	25	-	25	50	-
6.	MT-520	Inspection and Quality Control	PEC	4	3	1	0	3	0	25	-	25	50	-
7.	MT-522	Composite Materials	PEC	4	3	1	0	3	0	25	-	25	50	-
8.	MT-524	Polymeric Materials	PEC	4	3	1	0	3	0	25	-	25	50	-
9.	MT-526	Failure Analysis	PEC	4	3	1	0	3	0	25	-	25	50	-
10.	MT-528	Tribology of Engineering Materials	PEC	4	3	1	0	3	0	25	-	25	50	-
11.	MT-558	Energy Storage Materials	PEC	4	3	1	0	3	0	25	-	25	50	-

Teaching Scheme					Contact Hours/Week			Exam Duration (hrs.)		Relative Weightage (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
Semester – I (Autuma)														
1.	MA-501D	Discrete Mathematics	ICC	4	3	1	0	3	0	25	-	25	50	-
2.	MT-501	Structure of Materials	PCC	4	3	1	0	3	0	25	-	25	50	-
3.	MT-503	Modelling, Simulation and Computer Applications	PCC	4	3	0	2	3	0	15	15	30	40	-
4.	MT-507	Characterization of Materials	PCC	4	3	0	2	3	0	15	15	30	40	-
5.		Open Elective-I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (Optional)		2	1	0	2	2	-	15	15	30	40	-
		Sub Total		19-22										
Semester – II (Spring)														
1.		Program Elective-I	PEC	4	3	1	0	3	0	25	-	25	50	-
2.		Program Elective-II	PEC	4	3	1	0	3	0	25	-	25	50	-
3.		Program Elective-III	PEC	4	3	1	0	3	0	25	-	25	50	-
4.		Program Elective-IV	PEC	4	3	1	0	3	0	25	-	25	50	-
5.		Open Elective-II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (Optional)		2	1	0	2	2	-	15	15	30	40	-
		Sub Total		19-22										

Teaching Scheme					Contact Hours/Week			Exam Duration (hrs.)		Relative Weightage (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
Semester – III (Autumn)														
1.	MT-601	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	MT-602	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	MT-603	Dissertation*	DIS	-	-	-	-	-	-	-	-	-	25	-
		Sub Total		06										
Semester – IV (Spring)														
1.	MT-603	Dissertation (continued from III semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
		Sub Total		20										
		Total		64-68										

Program Electives I-IV (For Physical Metallurgy Specialization)														
Teaching Scheme					Contact Hours/Week			Exam Duration (hrs.)		Relative Weightage (%)				
S. No.	Subject Code	Course Title	Subject Area	Credit	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1.	MT-506	Metallurgical Thermodynamics and Kinetics	PEC	4	3	1	0	3	0	25	-	25	50	-
2.	MT-508	Phase Transformation	PEC	4	3	1	0	3	0	25	-	25	50	-
3.	MT-516	Principles of Materials Selection	PEC	4	3	1	0	3	0	25	-	25	50	-
4.	MT-530	Nanomaterials and Applications	PEC	4	3	1	0	3	0	25	-	25	50	-
5.	MT-534	Special Steels and Superalloys	PEC	4	3	1	0	3	0	25	-	25	50	-
6.	MT-544	Physical Metallurgy of Light Metals and Alloys	PEC	4	3	1	0	3	0	25	-	25	50	-
7.	MT-546	Metallurgy of Joining	PEC	4	3	1	0	3	0	25	-	25	50	-
8.	MT-548	Diffusion in Solids	PEC	4	3	1	0	3	0	25	-	25	50	-
9.	MT-550	Engineering Applications of Dislocation	PEC	4	3	1	0	3	0	25	-	25	50	-
10.	MT-554	Crystallographic Texture	PEC	4	3	1	0	3	0	25	-	25	50	-
11.	MT-560	Fracture Fatigue and Creep Deformation	PEC	4	3	1	0	3	0	25	-	25	50	-

Teaching Scheme					Contact Hours/Week			Exam Duration (hrs.)		Relative Weightage (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
Semester – I (Autumn)														
1.	MA-501D	Discrete Mathematics	ICC	4	3	1	0	3	0	25	-	25	50	-
2.	MT-501	Structure of Materials	PCC	4	3	1	0	3	0	25	-	25	50	-
3.	MT-503	Modelling, Simulation and Computer Applications	PCC	4	3	0	2	3	0	15	15	30	40	-
4.	MT-507	Characterization of Materials	PCC	4	3	0	2	3	0	15	15	30	40	-
5.		Open Elective-I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (Optional)		2	1	0	2	2	-	15	15	30	40	-
		Sub Total		19-22										
Semester – II (Spring)														
1.		Program Elective-I	PEC	4	3	1	0	3	0	25	-	25	50	-
2.		Program Elective-II	PEC	4	3	1	0	3	0	25	-	25	50	-
3.		Program Elective-III	PEC	4	3	1	0	3	0	25	-	25	50	-
4.		Program Elective-IV	PEC	4	3	1	0	3	0	25	-	25	50	-
5.		Open Elective-II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (Optional)		2	1	0	2	2	-	15	15	30	40	-
		Sub Total		19-22										

Teaching Scheme					Contact Hours/Week			Exam Duration (hrs.)		Relative Weightage (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
Semester – III (Autumn)														
1.	MT-601	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	MT-602	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	MT-603	Dissertation*	DIS	-	-	-	-	-	-	-	-	-	25	-
		Sub Total		06										
Semester – IV (Spring)														
1.	MT-603	Dissertation (continued from III semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
		Sub Total		20										
		Total		64-68										

Program Electives I-IV (For Corrosion Engineering Specialization)														
Teaching Scheme					Contact Hours/Week			Exam Duration (hrs.)		Relative Weightage (%)				
S. No.	Subject Code	Course Title	Subject Area	Credit	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1.	MT-516	Principles of Materials Selection	PEC	4	3	1	0	3	0	25	-	25	50	-
2.	MT-520	Inspection and Quality Control	PEC	4	3	1	0	3	0	25	-	25	50	-
3.	MT-532	Corrosion Protection Methods	PEC	4	3	1	0	3	0	25	-	25	50	-
4.	MT-536	Corrosion Testing	PEC	4	3	1	0	3	0	25	-	25	50	-
5.	MT-538	High Temperature Corrosion	PEC	4	3	1	0	3	0	25	-	25	50	-
6.	MT-540	Corrosion of Metal Joints	PEC	4	3	1	0	3	0	25	-	25	50	-
7.	MT-542	Biomaterials	PEC	4	3	1	0	3	0	25	-	25	50	-
8.	MT-552	Stress Assisted Corrosion	PEC	4	3	1	0	3	0	25	-	25	50	-
9.	MT-556	Surface Engineering and Coating Technology	PEC	4	3	1	0	3	0	25	-	25	50	-

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE :Dept. of Metallurgical and Materials Engineering

1. Subject Code: MT-501 **Course Title:** Structure of Materials

2. Contact Hours: L: 3 T: 1 P: 0

3. Examination Duration (Hrs): **Theory:** 3 **Practical:** 0

4. Relative Weightage: CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0

5. Credits: 4

6. Semester: Autumn

7. Pre-requisite: NIL

8. Subject Area: PCC

9. Objective: To provide knowledge of structure property correlations of different materials.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	Nature of Geometry of Crystals: Atomic arrangements in solids, space lattices, coordination number and effective number of atoms for common crystalline structures: FCC, BCC and HCP, indexing of crystallographic planes and directions.	4
2.	Structure of Ceramics and Polymers: Atomic arrangements in ceramics and polymers, their influence on mechanical properties.	3
3.	Principles of Alloy Formation: Primary and intermediate phases their formation, solid solutions, Hume Rothery rules, electron compounds, normal valency compounds and interstitial compounds.	4
4.	Solidification: Solidification of metals and alloys- equiaxed, dendritic and columnar grains; Coring.	3
5.	Phase Diagrams: Binary equilibrium diagrams involving isomorphous, eutectic, peritectic and monotectic systems, phase rule, lever rule effect of non-equilibrium cooling on structure and distribution of phases.	8
6.	Solid State Transformations: Phase equilibria involving eutectoid and peritectoid transformations, TTT and CCT diagrams, hardenability, Heat Treatment of Ferrous and Non Ferrous Alloys viz., annealing, normalizing, quenching, tempering and precipitation hardening.	8
7.	Diffusion in Solids: Fick's laws of diffusion, Darken's equation, Kirkendall effect and mechanism of diffusion.	4
8.	Important Binary Systems: Cu-Ni, Al-Si, Al-Cu, Pb-Sn, Cu-Zn, Cu-Sn and Fe-C systems, effect of non equilibrium cooling and important alloys belonging to these systems.	8
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors/ Book/ Publisher	Year of Publication/ Reprint
1 .	Avner, S.H., "Introduction to Physical Metallurgy", McGraw Hill	2005
2.	Lakhtin, Y., "Engineering Physical Metallurgy", Mir Publishers	1992
3 .	Hansen, P., "Physical Metallurgy", Cambridge University Press	1987
4.	Gulyaev, A., "Physical Metallurgy", Vol. I and II, Mir Publishers	1980

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE : Dept. of Metallurgical and Materials Engineering

1. Subject Code: MT-503 **Course Title:** Modeling, Simulation and Computer Applications

2. Contact Hours: L: 3 T: 0 P: 2

3. Examination Duration (Hrs): Theory: Practical:

4. Relative Weightage: CWS: PRS: MTE: ETE: PRE:

5. Credits:

6. Semester: Autumn

7. Pre-requisite: NIL

8. Subject Area: PCC

9. Objective : To impart knowledge on modeling with emphasis on metallurgical systems.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	Introduction : System, environment, input and output variables; State variables and their transition; Hierarchy of knowledge about a system; System identification – structure and parameter identification; Deterministic and stochastic systems; Static and Dynamic Systems; Objectives of modelling and simulation	4
2.	Physical Modelling: Dimension analysis, Dimensionless grouping of input and output variables to find empirical relations, similarity criteria and their application to physical models.	5
3.	Modelling of Systems with Known Structure: Review of conservation laws and the governing equation for heat, mass and momentum transfer, Deterministic models – (a) distributed parameter models in terms of partial differential equations and their solutions and (b) lumped parameter models in terms of differential and difference equations, state space models, transfer functions, block diagrams and subsystems, stability of transfer functions, modelling for control, Stochastic models	10
4.	Neural Network Modelling of Systems only with Input-output Database: Neurons, architecture of neural network, knowledge representation, learning algorithm, Multilayer feed forward network and its back propagation learning algorithm, Application to metallurgical systems.	6
5.	Fuzzy logic modelling of systems only with broad expert knowledge: Fuzzy sets, membership functions, fuzzy linguistic variables, 'IF-THEN' rules, Fuzzy Inference systems (FIS) – (i) Mamdani type and (ii) Sugeno (TSK) type, Application to metallurgical systems.	5
6.	Neuro-fuzzy Modelling of Systems with Limited Database: Adaptive neuro-fuzzy inference system (ANFIS), hybrid learning algorithm using MATLAB; Co-active neuro-fuzzy system	4

	(CANFIS)	
7.	Optimization and Design of Systems: Summary of gradient based techniques; Nontraditional optimization techniques – (i) Genetic Algorithm (GA) – coding, GA operators, elitism, application using MATLAB; (ii) Simulated Annealing	4
8.	Simulation of Metallurgical Systems: Monte-Carlo simulation, simulation of solidification and casting, simulation of melt stream disintegration by fluid flow	4
	Total	42

List of Practicals:

1. Introduction to programming with MATLAB
2. Find the response of a lumped variable model expressed in terms of transfer function using MATLAB for inputs of (i) unit step function, (ii) unit impact function and (iii) unit ramp function
3. Use of Simulink in MATLAB for metallurgical problems
4. Use of Neural Network in MATLAB for metallurgical problems
5. Use of FIS and ANFIS in MATLAB for metallurgical problems
6. Develop a computer program to determine the temperature of ingot during its solidification.
7. Develop a computer program to determine the temperature of metal slab during its hot rolling.
8. Develop a computer program for Monte Carlo simulation for grain growth.

1.1. Suggested Books:

Sl. No.	Name of Authors/ Book/ Publisher	Year of Publication/ Reprint
1.	Zeigler, B.P., Praehofer, H. and Kim T.G., "Theory of Modelling and Simulation", 2 nd Edition, Academic Press	2000
2.	Szekely, J.S. and Ray, W.H., "Process optimization with applications metallurgy and chemical engineering", Wiley-Interscience	1973
3.	Ogata, K., "Modern Control Engineering", 3 rd Edition, Prentice Hall of India	2001
4.	Jang, J.S.R., Sun C.T. and Mizutani E., "Neuro-Fuzzy and Soft Computing", 3 rd Edition, Prentice Hall of India	2002
5.	Kuang-O, Y., "Modeling for casting and solidification processing", Marcel Dekker	2002
6.	Irving, W.R., "Continuous casting of steel", Institute of Materials	1993
7.	Pratab, R., "Getting Started with MATLAB", Oxford University Press	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Dept. of Metallurgical and Materials Engineering

1. Subject Code: MT-507 Course Title: Characterization of Materials

2. Contact Hours: L: 3 T: 0 P: 2

3. Examination Duration (Hrs): Theory: 3 Practical: 0

4. Relative Weightage: CWS: 15 PRS: 15 MTE: 30 ETE: 40 PRE: 0

5. Credits: 4

6. Semester: Autumn

7. Pre-requisite: NIL

8. Subject Area: PCC

9. Objective: To familiarise the students with the basic principles related to materials characterization methods.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	X-ray Diffraction and Diffractometry: Stereographic projection, Laue's equation, Bragg's condition of diffraction, structure factor rules, single phase analysis, multi-phase analysis, estimation of particle size and strain, orientation and texture, residual stress.	10
2.	Light Microscopy: Basic principles, estimation of grain size, grain boundary area, volume fraction of second phase.	5
3.	Transmission Electron Microscopy (TEM): Reciprocal space and lattice, Ewald sphere, diffraction from finite crystal, bright and dark field imaging, selected area diffraction, indexing of diffraction patterns, contrast from precipitates, dislocations, and stacking faults.	10
4.	Scanning Electron Microscopy (SEM): Basic principles of scanning electron microscopy, energy dispersive spectroscopy (EDS), wavelength dispersive spectroscopy (WDS), electron backscattered diffraction (EBSD).	6
5.	Thermal analyses techniques: Principles of differential scanning calorimetry (DSC), differential thermal analysis (DTA), Dilatometry, Thermogravimetric analysis (TGA).	6
6.	Instrumental Analysis: Emission spectroscopy, AAS, ICP-MS.	5
	Total	42

List of Practicals:

1. Sample preparation for optical microscopy: estimation of grain size and volume fraction of second phases in brass.
2. Demonstration of X-ray diffraction equipment.
3. Indexing of the powder pattern obtained by XRD.
4. Demonstration of Transmission Electron Microscope.
5. Indexing of the Selected Area Diffraction (SAD) patterns.
6. Demonstration of Scanning Electron Microscope and EDS.
7. Demonstration of DSC technique.

1.1. Suggested Books

S1. No.	Name of Authors/ Book/ Publisher	Year of Publication/ Reprint
1.	Goodhew, P.J., Humphreys, J. and Beanland, R., "Electron Microscopy and Analysis", 3 rd Edition, Taylor and Francis	2001
2.	Cullity, B.D. and Stock, S.R., "Elements of X-Ray Diffraction", 3 rd Edition, Printice Hall	2001
3.	Williams, D. B. and Carter, C. B., "Transmission Electron Microscopy: A Textbook for Materials Science", 2 nd Edition, Springer	2009
4.	Goldstein, J., Newbury, D.E., Joy, D.C., Lyman, C.E., Echlin, P., Lifshin, E., Sawyer, L. and Michael, J.R., "Scanning Electron Microscopy and X-ray Microanalysis", 3 rd Edition, Springer	2003
5.	Speyer, R., "Thermal Analysis of Materials", CRC Press	1993
6.	Dehoff, R.T. and Rhines, F.N., "Quantitative Microscopy", McGraw Hill	1968

Corrected on Sept 7, 2010 after July Senate

Chemistry Department, IITR
M. Tech. (Advanced Chemical Analysis)
COURSE STRUCTURE

**1st Year
Autumn Semester**

Teaching Scheme					Contact Hrs per Week			Exam. Dur. (hr)		Relative Weightage (%)				
S. No	Sub Code	Courses Title	Sub. Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	MA-501 C	Probability and Statistics	ICC	4	3	1	0	3	0	25	-	25	50	-
2	CY-711	Lab-I	PCC	3	0	0	6	0	6	-	15	35	0	50
3	CY-721	Analytical Methods	PCC	3	3	0	0	3	0	15	-	35	50	-
4	CY-731	Characterization Techniques	PCC	3	3	0	0	3	0	15	-	35	50	-
5		Open Elective-I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6	HS-501	Technical Communication (Optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total					16-19									

Spring Semester

Teaching Scheme					Contact Hrs per Week			Exam Durn(hr)		Relative Weightage (%)				
S. No	Subject Code	Courses Title	Sub. Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	CY-712	Lab-II	PCC	3	0	0	6	0	6	-	15	35	-	50
2	CY-722	Chemometrics and Modeling	PCC	4	3	0	2	3	0	25	-	25	50	-
3		Programme Elective I	PEC	4	3	1	0	3	0	25	-	25	50	-
4		Programme Elective II	PEC	4	3	1	0	3	0	25	-	25	50	-
5		Programme Elective III	PEC	4	3	1	0	3	0	25	-	25	50	-
6		Open Elective II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
7	HS-501	Technical Communication (Optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total					22-25									

IITR- Chemistry Department - M.Tech. (Advanced Chemical Analysis)

2 nd Year: (Autumn) the Third Semester														
Teaching Scheme					Contact hr per Week			Exam Durn (hr)		Relative Weightage (%)				
S.No	Subject Code	Courses Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1	CY-801	Seminar	SEM	2	-	-	-	-	-	-			100	
2	CY-802	Project	RP	4	-	-	-	-	-	-			100	
3	CY-803	*Dissertation (To be continued)	DIS	-	-	-	-	-	-	-			25	
Sub Total				06										

2 nd Year: (Spring) the fourth Semester														
Teaching Scheme					Contact hr per Week			Exam Durn (hr)		Relative Weightage (%)				
S.No	Subject Code	Courses Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1	CY-803	Dissertation	DIS	20	-	-	-	-	-	-			75	
Sub Total				20										
Total				64-68										

*Dissertation: To be continued and grade to be awarded in the next semester.

IITR- Chemistry Department - M.Tech. (Advanced Chemical Analysis)
COURSE STRUCTURE

LIST OF PROGRAMME ELECTIVES (PEC)

Teaching Scheme					Contact Hours per Week			Exam Duration (Hrs)		Relative Weight age (%)				
S.No	Subject Code	Courses Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1.	CY-732	Environmental Chemistry	PEC	4	3	1	0	3	0	25	-	25	50	-
2	CY-742	Analysis of Materials	PEC	4	3	1	0	3	0	25	-	25	50	-
3	CY-752	Analysis of Food and Drugs	PEC	4	3	1	0	3	0	25	-	25	50	-
4	CY-762	Drug Design and Action	PEC	4	3	1	0	3	0	25	-	25	50	-
5	CY-772	Analysis of Industrial Polymers	PEC	4	3	1	0	3	0	25	-	25	50	-
6	CY-782	Nuclear Techniques for Analysis and Characterisation	PEC	4	3	1	0	3	0	25	-	25	50	-
7	NT-501	Nanoscale Materials	PEC	4	3	1	0	3	0	25	-	25	50	-
8	NT-532	Supramolecular Chemistry of Nanomaterials	PEC	4	3	1	0	3	0	25	-	25	50	-

INDIAN INSTITUTE OF TECHNOLOGY ROORKEENAME OF DEPTT./ CENTRE: **DEPARTMENT OF CHEMISTRY**1. Subject Code: **CY-711**Course Title: **Lab - I**2. Contact Hours: **L: 0****T: 0****P: 6**

3. Examination Duration (Hrs.):

Theory**0****Practical****6**4. Relative Weightage: **CWS****0****PRS****15****MTE****35****ETE****0****PRE****50**

5. Credits:

36. Semester: **Autumn**7. Subject Area: **PCC**8. Pre-requisite: **Nil**

9. Objective: To develop experimental skills in different methods of characterization.

10. Details of Course:

S. No.	Contents
	List of Experiments:
1.	Simultaneous polarographic determination of two metal ions.
2.	Polarographic estimation of colouring matters in food and dyes.
3.	Use of atomic absorption spectroscopy in the estimation of metal contents in samples.
4.	Experiment based on the use of radiotracers, and radioactivity measurements.
5.	Experiment on separation and estimation of organic compounds using gas chromatograph.
6.	Multi-step synthesis and characterization of pharmaceutical drug.
7.	Analysis of organic components in a mixture by HPLC.

11. Suggested Books:

S. No.	Authors/ Books/ Publisher	Year of Publication/Reprint
1.	Willard H.H. Merritt L.L., Dean J.A. and Settle F.A., "Instrumental Methods of Analysis", 7 th Ed., Wadsworth Publishing Co.	1988
2.	West A.R., "Solid State Chemistry and its Applications", John Wiley & Sons	1988
3.	Arnikar H.J., "Essentials of Nuclear Chemistry", Wiley-Eastern	1990
4.	Skoog D.A., Holler F.J. and Crouch S.R., "Principles of Instrumental Analysis", 6 th Ed., Thomson Brooks	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEENAME OF DEPTT./CENTRE: **DEPARTMENT OF CHEMISTRY**1. Subject Code: **CY-721**Course Title: **Analytical Methods**2. Contact Hours: **L: 3****T: 0****P: 0**

3. Examination Duration (Hrs.):

Theory**3****Practical****0**4. Relative Weight: **CWS****1****15****PRS****0****MTE****35****ETE****50****PRE****0**

5. Credits:

36. Semester: **Autumn**7. Subject Area: **PCC**8. Pre-requisite: **Nil**

9. Objective: To impart advanced knowledge of different methods of analysis as applied in industry and research.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Chromatographic Methods: General principles of chromatography, retention, resolution and separation factor, plate concept, van Deemter equation, chromatographic column and detector characteristics; applications in quantitative analysis-Kovat's index; High Performance Liquid Chromatography (HPLC)- instrumentation, separation columns, detectors, interfacing with Gas Chromatography (GC) and HPLC with mass spectrometry; Reverse phase chromatography; Ion chromatography- its comparison with ion exchange, applications; Inorganic ion exchangers- their classification and application in radioactive waste processing; Affinity chromatography and gel filtration chromatography- basic principles and applications.	12
2.	Electroanalytical Methods and Sensors: Voltametric, coulometric methods; Principle, instrumentation, analytical applications of polarography, pulse and differential pulse polarography, cyclic voltammetry and alternating current cyclic voltammetry, chronopotentiometry, anodic and cathodic stripping voltammetry, microelectrodes, modified electrodes and their analytical applications, electro-separations at controlled potential; Membranes, electroactive materials, membrane potential, selectivity coefficients and their determination, discussion of some important ion and molecule sensors, applications.	12
3.	Nuclear Analytical Methods: Basic principle of methods based on radioactivity measurements, choice of radiotracers, advantages and	12

	limitations; Activation methods- neutron activation methods, principle, classification, methodology, instrumentation, multi-elemental and nondestructive character, interferences, cyclic and derivative activation analysis, typical applications for trace element analysis of various matrices, isotope dilution analysis (IDA) using radiotracers and stable isotopes (ID-MS), basic principle and methodology, limitations, comparison with neutron activation analysis (NAA), substoichiometric IDA; Other radiometric methods using radio-reagents, radiometric titration, radio-chromatography, radioimmunoassay, their advantages and applications; Radio isotopes in diagnosis and therapy.	
4.	Automation in Analysis: Requirements of automation, automatic and automated devices, continuous and discrete analyzers, feedback control loop, on-line analyzer, automated process control, non-destructive automatic analyzer, automation in clinical, environmental analysis and quality control, automated elemental analyzers, laboratory robots.	6
	Total	42

1.1. Suggested Books:

S. No.	Authors/ Books/ Publisher	Year of Publication/Reprint
1.	Willard H.H., Merritt L.L., Dean J.A. and Settle F.A., "Instrumental Methods of Analysis", 7 th Ed., Wardsworth Publishing Co.	1988
2.	Vandecasteele C. and Block C.B., "Modern Methods of Trace Element Determination", John Wiley & Sons	1993
3.	Ehmann W.D. and Vance D.E., "Radiochemistry and Nuclear Methods of Analysis", John Wiley & Sons	1991
4.	Skoog D.A., Holler F.J. and Nieman T.A., "Principles of Instrumental Analysis" 5 th Ed., Harcourt Brace & Company	2006
5.	Meites, L., "Polarographic Techniques", Interscience Publisher,	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF CHEMISTRY**

1. Subject Code: **CY-731** Course Title: **Characterization Techniques**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 15 **PRS** 0 **MTE** 35 **ETE** 50 **PRE** 0

5. Credits: 3 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To impart advanced knowledge of modern techniques of characterization as required in industry and research.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	X-Ray: Nature of X-ray spectra, monochromatization of X-rays; Detection of X-rays – gas ionization detectors, scintillation detectors, solid state ionization detectors; Absorption methods- absorption law, absorption edge analysis, absorption apparatus, applications; X-ray emission spectroscopy- direct methods, X-ray fluorescence methods, fluorescence spectrometer – energy dispersive and wavelength dispersive X-ray spectrometers, applications; X-ray diffraction - elements of repetition, concept of lattice, space groups, crystalline state and different crystal systems, scattering of X-ray by crystals, amplitude and phase of the resultant X-ray diffracted wave, structure factors, experimentation – powdered method, experimental set up, spacing and intensity of diffraction peaks, indexing, unit cell parameters and X-ray density, characterization of crystalline materials; single crystal methods of X-ray diffraction – moving camera methods, X-ray diffractometer, interpretation of diffraction data-geometrical interpretation of Bragg's Law, calculation of structures factors, phasing and indexing of diffraction maxima, electron density maps and structure determination, R-factors, applications.	14
2.	Atomic Spectroscopy: Sources of atomic spectra, principle, instrumentation and applications of atomic absorption atomic emission and atomic fluorescence, radiation sources, atomic absorption with flame and electro thermal atomizers, atomic emission based on flame and electrical excitation, photographic detection, photoelectric detection, inductively coupled plasma atomic emission of data.	8

3.	Surface Spectroscopy: Ion scattering, elastic collisions, depth profiling ion scattering spectrometer; X-ray photoelectron spectroscopy (XPS) – chemical shift, XPS instrumentation, qualitative and quantitative analysis, scanning X-ray photoelectron spectroscopy/ electron spectroscopy for chemical analysis (ESCA), photoelectron spectrum of some simple compounds, scanning electron microscopy (SEM)/ energy dispersive X-ray (EDX)- principles of scanning electron microscopy, electron-specimen interactions, imaging modes of SEM; Elemental analysis by emitted x-rays; Auger electron spectroscopy – principle, instrumentation and applications.	8
4.	Mass Spectroscopy: Principle, instrumentation including different types of ion sources and mass analyzers, resolution, nitrogen rule, ring rule, McLafferty's rearrangement, interpretation of mass spectrum and analytical applications; Hyphenated techniques.	6
5.	Thermal Analyses: General characteristics of thermal methods; Thermogravimetric Analysis (TGA), Differential Thermal Analysis (DTA)-instrumentation, methodology and applications, factors affecting results; Thermometric titrations and their applications; Use of differential scanning calorimetry (DSC) or DTA and TGA in characterization of materials and phases.	6
Total		42

11. Suggested Books:

S. No.	Authors/ Books/ Publisher	Year of Publication/Reprint
1.	Ewing G.W., "Instrumental Methods of Chemical Analysis", McGraw Hill	2006
2.	Willard H.H., Merritt L.L., Dean J.J. and Settle F.A., "Instrumental Methods of Analysis", 7 th Ed., Wardsworth Publishing Co.	1988
3.	Skoog D.A., Holler F.J. and Crouch S.R., "Principles of Instrumental Analysis", 6 th Ed., Thomson Brooks	2007
4.	Mendham J., Denny R.C., Barnes J.D. and Thomas, M., "Vogel's Text Book of Quantitative Inorganic Analysis", Pearson Education.	2000
5.	Fifield F.W. and Kealey D., "Principles and Practice of Analytical Chemistry", Blackwell Science	2000
6.	Meites L., "Polarographic Techniques", Interscience Publisher	2001
7.	West A.R., "Solid State Chemistry and its Applications", John Wiley & Sons	2002

Table: 1 Academic Curriculum for Master of Technology/ P.G. Diploma in

WATER RESOURCES DEVELOPMENT (WRD)

Teaching Scheme					Contact Hours per Week			Exam. Duration (Hrs.)		Relative Weightage (%)				
S.No	SUBJECT CODE	COURSE TITLE	SUBJECT AREA	CREDITS	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1st YEAR I SEMESTER (AUTUMN)														
1.	MA-501C	Probability and Statistics	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	WR-501	Computer Applications	PCC	4	3	-	2	3	-	15	15	30	40	-
3.		Program Core 1 (from List A)	PCC	4	3	1	-	3	-	25	-	25	50	-
4.		Program Core 2 (from List A)	PCC	4	3	1	-	3	-	25	-	25	50	-
5.		Minor Elective I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.		Technical Communication (Optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				19-22										

II SEMESTER (SPRING)														
1.		Major Elective I (As per list B)	PEC	4	-	-	-	-	-	-	-	-	-	-
2.		Major Elective II (As per list B)	PEC	4	-	-	-	-	-	-	-	-	-	-
3.		Major Elective III (As per list B)	PEC	4	-	-	-	-	-	-	-	-	-	-
4.		Major Elective IV (As per list B)	PEC	4	-	-	-	-	-	-	-	-	-	-
5.		Minor Elective II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.		Technical Communication (Optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				19-22										

Note: P.G. Diploma course in WRD shall be of ONE YEAR duration comprising of semesters I and II only, with a minimum credits of 38

2nd YEAR III SEMESTER (AUTUMN)														
1.	WR-601	Seminar	SEM	2	-	-	-	-	-	-	-	100	-	-
2.	WR-602	Project	RP	6	-	-	-	-	-	-	-	100	-	-
3.	WR-603	Dissertation *	DIS	-	-	-	-	-	-	-	-	-	25	-
Sub Total				8										

* to be continued and grade to be awarded in the next semester

IV SEMESTER (SPRING)														
1.	WR-603	Dissertation (continued from 3 rd Semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
Sub Total				20										
Total				64-68										

**List - A: List of Program Core Subjects
For Civil Background**

1.	WR-502	Design of Water Resources Structures	PCC	4	3	1	-	3	-	25	-	25	50	-
2.	WR-503	Water Resources Planning and Management	PCC	4	3	1	-	3	-	25	-	25	50	-

For Electrical Background

1.	WR-531	Hydro Generating Equipment	PCC	4	3	1	-	3	-	25	-	25	50	-
2.	WR-532	Hydropower System Planning	PCC	4	3	1	-	3	-	25	-	25	50	-

For Mechanical Background

1.	WR-551	Design of Hydro Mechanical Equipment	PCC	4	3	1	-	3	-	25	-	25	50	-
2.	WR-552	Construction Planning and Management	PCC	4	3	1	-	3	-	25	-	25	50	-

List – B: Major Electives for Water Resources Development (WRD)

1.	WR-511	System Design Technique	4	3	1	-	3	-	25	-	25	50	-
2.	WR-512	Geotechnical Engineering	4	3	1	-	3	-	25	-	25	50	-
3.	WR-513	Hydropower and Appurtenant Works	4	3	1	-	3	-	25	-	25	50	-
4.	WR-514	Earth and Rockfill Dams	4	3	1	-	3	-	25	-	25	50	-
5.	WR-515	Masonry and Concrete Dams	4	3	1	-	3	-	25	-	25	50	-
6.	WR-516	Irrigation Structures	4	3	1	-	3	-	25	-	25	50	-
7.	WR-517	Rural and Urban Water Supply	4	3	1	-	3	-	25	-	25	50	-
8.	WR-518	River Engineering	4	3	1	-	3	-	25	-	25	50	-
9.	WR-519	Applied Hydrology	4	3	1	-	3	-	25	-	25	50	-
10.	WR-520	Finite Element Methods	4	3	1	-	3	-	25	-	25	50	-
11.	WR-521	Water Resources System Reliability	4	3	1	-	3	-	25	-	25	50	-
12.	WR-522	Environmental Impact Assessment of Water Resource Projects	4	3	1	-	3	-	25	-	25	50	-
13.	WR-523	Groundwater Hydrology	4	3	1	-	3	-	25	-	25	50	-
14.	WR-524	Climate Change and Water Resources	4	3	1	-	3	-	25	-	25	50	-
15.	WR-533	Substation and Transmission line Design	4	3	1	-	3	-	25	-	25	50	-
16.	WR-534	Power System Protection Applications	4	3	1	-	3	-	25	-	25	50	-
17.	WR-535	Installation Maintenance and Testing of Hydro Generating Equipment	4	3	1	-	3	-	25	-	25	50	-
18.	WR-536	Maintenance Management in Power Plants	4	3	1	-	3	-	25	-	25	50	-
19.	WR-537	Power System Management	4	3	1	-	3	-	25	-	25	50	-
20.	WR-538	Electrical Design of Hydro Power Station	4	3	1	-	3	-	25	-	25	50	-
21.	WR-539	Power System Operation and Control	4	3	1	-	3	-	25	-	25	50	-
22.	WR-540	Control and Instrumentation of Hydro Power Plant	4	3	1	-	3	-	25	-	25	50	-
23.	WR-541	Power System Analysis	4	3	1	-	3	-	25	-	25	50	-
24.	WR-542	Power System Reliability	4	3	1	-	3	-	25	-	25	50	-
25.	WR-543	Insulating Systems	4	3	1	-	3	-	25	-	25	50	-
26.	WR-544	Planning and Design of Small Hydro Power Schemes	4	3	1	-	3	-	25	-	25	50	-
27.	WR-553	Welding Engineering	4	3	1	-	3	-	25	-	25	50	-
28.	WR-554	Design of Construction Job Facilities	4	3	1	-	3	-	25	-	25	50	-
29.	WR-555	Construction Plant Machinery	4	3	1	-	3	-	25	-	25	50	-
30.	WR-556	Instrumentation and Control of Hydro Power Plant	4	3	1	-	3	-	25	-	25	50	-
31.	WR-557	Air Conditioning and Ventilation	4	3	1	-	3	-	25	-	25	50	-
32.	WR-558	Construction Techniques	4	3	1	-	3	-	25	-	25	50	-

**Table: 2 Academic Curriculum for Master of Technology/ P.G. Diploma in
IRRIGATION WATER MANAGEMENT (IWM)**

Teaching Scheme					Contact Hours per Week			Exam. Duration (Hrs.)		Relative Weightage (%)				
S.No	SUBJECT CODE	COURSE TITLE	SUBJECT AREA	CREDITS	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1 st YEAR					I SEMESTER (AUTUMN)									
1.	MA-501C	Probability and Statistics	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	WR-501	Computer Applications	PCC	4	3	-	2	3	-	15	15	30	40	-
3.	WR-571	Design of Irrigation Structures and Drainage Works	PCC	4	3	1	-	3	-	25	-	25	50	-
4.	WR-572	Soil and Agronomy	PCC	4	3	1	-	3	-	25	-	25	50	-
5.		Minor Elective I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6		Technical Communication (Optional)	-	2	1	0	2	2	-	15	15	30	40	-
Sub Total				19-22										
					II SEMESTER (SPRING)									
1.		Major Elective I (As per list C)	PEC	4	3	1	-	3	-	25	-	25	50	-
2.		Major Elective II (As per list C)	PEC	4	3	1	-	3	-	25	-	25	50	-
3.		Major Elective III (As per list C)	PEC	4	3	1	-	3	-	25	-	25	50	-
4.		Major Elective IV (As per list C)	PEC	4	3	1	-	3	-	25	-	25	50	-
5.		Minor Elective II	OEC	3/4	3	1	-	3	-	25	-	25	50	-
6		Technical Communication (Optional)	-	2	1	0	2	2	-	15	15	30	40	-
Sub Total				19-22										
Note: P.G. Diploma course in IWM shall be of ONE YEAR duration comprising of semesters I and II only, with a minimum credits of 38														
2 nd YEAR					III SEMESTER (AUTUMN)									
1.	WR-601	Seminar	SEM	2	-	-	-	-	-	-	-	100	-	-
2.	WR-602	Project	RP	6	-	-	-	-	-	-	-	100	-	-
3.	WR-610	Dissertation*	DIS	-	-	-	-	-	-	-	-	-	25	-
Sub Total				8										
* to be continued and grade to be awarded in the next semester														
					IV SEMESTER (SPRING)									
1.	WR-620	Dissertation (contd. From 3 rd Semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
Sub Total				20										
Total				64-68										

List – C: Major Electives for Irrigation Water Management (IWM)

1.	WR-573	Principles and Practice of Irrigation	4	3	1	-	3	-	25	-	25	50	-
2.	WR-574	On Farm Development	4	3	1	-	3	-	25	-	25	50	-
3.	WR-575	Operation Maintenance and Management of Irrigation Systems	4	3	1	-	3	-	25	-	25	50	-
4.	WR-576	Water and Land Laws	4	3	1	-	3	-	25	-	25	50	-
5.	WR-577	Rural Sociology and Irrigation Economics	4	3	1	-	3	-	25	-	25	50	-
6.	WR-578	Evaluation of Irrigation Project	4	3	1	-	3	-	25	-	25	50	-
7.	WR-579	Renewable Energy System Technology	4	3	1	-	3	-	25	-	25	50	-
8.	WR-580	Application of System Techniques in Water Resources	4	3	1	-	3	-	25	-	25	50	-
9.	WR-581	Water Quality Monitoring and Modeling	4	3	1	-	3	-	25	-	25	50	-
10.	WR-582	Theory of Seepage	4	3	1	-	3	-	25	-	25	50	-
11.	WR-583	Remote Sensing and its Application in Agriculture	4	3	1	-	3	-	25	-	25	50	-
12.	WR-584	Cropping System Modeling	4	3	1	-	3	-	25	-	25	50	-
13.	WR-585	Environmental Impact of Irrigated Agriculture	4	3	1	-	3	-	25	-	25	50	-
14.	WR-586	Groundwater Development and Management	4	3	1	-	3	-	25	-	25	50	-
15.	WR-587	Watershed Development and Management	4	3	1	-	3	-	25	-	25	50	-
16.	WR-511	System Design Techniques	4	3	1	-	3	-	25	-	25	50	-

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-501** Course Title: **Computer Applications**

2. Contact Hours: **L: 3 T: 0 P: 2**

3. Examination Duration (Hrs.): **Theory 3 Practical 2**

4. Relative Weightage: **CWS 15 PRS 15 MTE 30 ETE 40 PRE 0**

5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **NIL**

9. Objective: To impart knowledge on computer programming and its application in the water resources data analysis, structures design and its management problems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Algorithms and Flow charts, basics of C++/FORTRAN programming, program construction, Structures- syntax, initialization ,nested structures, enumerated data Loops and Decisions- if, if-else, conditional if, for, do-while, while statements; switch, goto statements, arithmetic and logical operators, incremental and decremental operators, library functions, nested if statements, AND, OR, NOT operators.	8
2.	Functions- declaration, definition, prototype, passing arguments by value and reference, passing structures, overloaded functions, inline functions, default arguments, variable and storage classes, Arrays- one, two and multidimensional arrays, arrays of structures, string arrays	6
3.	Classes and objects-private, public and protected data and member functions, constructors and destructors, overloaded constructors, objects as arguments, returning objects from functions, array of objects, overloaded operators, inheritance	5
4.	Pointers-definition, declaration, initialization, pointers and arrays, new and delete operators, pointer to objects and to pointers, Files-files as class objects, opening and closing of files, opening modes, file pointers and their manipulators, reading from and writing variables	7

	and objects on files.	
5.	Graphics with C++: text and graphics modes, library functions for text and graphic modes.	5
6.	Simulation techniques, advantages, limitations, Monte Carlo simulation, generation of random numbers, Time series analysis applications to water resources structure design and management problems.	8
7.	Use of spreadsheets, data handling in spread sheets, simple and multiple regression, fitting of rating curves, etc.	3
	Total	42

8. List of Practical

1. Program for temperature conversion from one to other by option. (C to F and F to C)
2. Write a program to convert a given large number into year, week and days.
3. To find and print largest of the three or four given integers.
4. Program for making a calculator using IF statements for general functions. (Sum, Diff, Multiply, Div) using SWITCH statements write another program.
5. Program to calculate roots of a quadratic equation.
6. Program to calculate Factorial of a given integer, using FOR, WHILE, DO-WHILE, statements.
7. Program to generate the Fibonacci Series up to desired number of terms, using FOR, WHILE and DO – WHILE statements.
8. Write a program for three given integers to print in ascending or descending order.
9. Program to compute the cosine series and sin series.
10. Write the program to sum the series $1 + X + X^2 + X^3 + \dots + X^N$
11. Write a program to find the sum of the given series :

$$X - X^2/2! + X^3/3! - X^4/4! + X^5/5! - \dots X^N/N!$$
12. Write a program to print the largest number of an array using function.
13. Write a function to generate Fibonacci Series of n numbers, where n is user defined. Use recursive and normal function.
14. Analysis of rainfall data, Computation of runoff etc.
15. Design problems of Canals and other hydraulic structures

11. Suggested Books:

S. No.	Name of Authors /Book/Publisher	Year of Publication/Reprint
1.	Balagurusamy, E., "Object Oriented Programming with C++", Tata McGraw-Hill.	1995
2.	Deitel, H. M. and Deitel, P. J., "C++ How To Program", Pearson Education.	2004
3.	Lafore, R., "Object Oriented Programming in Turbo C++", Galgotia Publication.	2001
4.	Loucks, D.P. and Beek, E.V., "Water Resources Systems Planning and Management- An Introduction to Methods, Models, and Applications", UNESCO.	2005
5.	Nyhoff, L. and Leestma, S., "FORTRAN 90 for Engineers and Scientists" Prentice Hall	1996
6.	Stroustrup, B., "C++ Programming Language", Addison Wesley.	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR- 502** Course Title: **Design of Water Resources Structures**

2. Contact Hours: L: 3 T: 1 P: 0

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre-requisite: **NIL**

9. Objective: To impart knowledge about the design of various water resources structures.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Design of hydraulic structures on permeable foundation including weir and barrage; determination of afflux and discharge intensity; waterway and looseness factor; stilling basin level and length; uplift pressures and exit gradient; floor thickness and protection works.	6
2.	Gravity dams- general features; forces acting on gravity dam; galleries and their functions; stability analysis; roller compacted RCC dams.	6
3.	Earth dams- homogeneous and zoned sections; filter design and stability analysis.	6
4.	Spillways-layout and design of various types of spillways; design of energy dissipaters.	5
5.	Intake Structures-trash racks and their cleaning and handling devices; stoplog arrangements; intake entrance; aeration vent; gate control.	4
6.	Tunnels-classification; rock cover; hydraulic design and supporting systems; concrete lining; portals and plugs; underground cavities.	4
7.	Gates- various types of gates for barrages; spillways; intakes; sluices; structural design considerations for vertical lift and radial gates.	5
8.	Hydro power-function; classification and main components (penstocks, surge tanks, hydro turbines, etc.) of hydro power stations.	6
Total		42

11. Suggested Books:

S.No.	Name of Authors /Book/Publisher	Year of Publication/Reprint
1.	Bickel, J .O., Kuesel, T.R. and King,, E.H., "Tunnel Engineering Handbook", CBS Publishers and Distributors.	2002
2.	Mosoyini, E., "Water Power Development", Nem Chand and Bros.	2009
3.	Singh, B. and Varshney, R.S., "Embankment Dam Engineering", Nem Chand and Bros.	2004
4.	Varshney, R. S., "Hydro Power Structures", N.C. Jain.	2001
5.	Varshney, R. S., "Gates and Valves ", Nem Chand and Bros.	2002
6.	Varshney, R.S., Gupta, S. C. and Gupta, R. L. "Theory and Design of Irrigation Structures", Nem Chand and Bros.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-503** Course Title: **Water Resources Planning and Management**

2. Contact Hours: L: 3 T: 1 P: 0

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: Autumn 7. Subject Area: PCC

8. Pre-requisite: **NIL**

9. Objective: To impart knowledge of planning and managing surface water resources at project and regional levels.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Objectives of water resource development; needs and opportunities; societal goals.	3
2.	Spatial and temporal characteristics of water resources; constraints for its development like non-reversibility; planning region and horizon.	4
3.	Financial analysis of water resources projects; allocation of cost of multipurpose projects; repayment of cost.	8
4.	Demand for drinking water; irrigation, hydropower; navigational; planning for flood control.	6
5.	Characteristics and functions of reservoir; reservoir sedimentation; conservation storage; conflict among uses, Reservoir operation studies - effect on river regime; long term simulation; reliability; resiliency and vulnerability assessment.	8
6.	Ground water evaluation; conjunctive use of surface and ground water.	2
7.	Discounting techniques; benefit cost parameters; estimation of benefits and costs; appraisal criteria; social benefit cost analysis.	4
8.	Basin planning; inter-basin transfer of water.	3
9.	Environmental impacts assessment guidelines and case studies.	4
	Total	42

1. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprint
1.	James, L .D., and Lee, R. R., "Economics of Water Resources Planning", Mc Graw Hill.	1971
2.	Modi, P.N., 'Irrigation, Water Resources and Water Power Engineering', Standard Book Pub., Delhi.	1995
3.	"Guidelines for Preparation of Detail Project Reports of Irrigation and Multipurpose Projects", Ministry of Irrigation, Govt. of India.	2002
4.	Garg, S.K., "Irrigation Engineering and Hydraulic Structure", Khanna Publishers.	2004
5.	Subramanya, K., "Engineering Hydrology", Tata McGraw Hill Publishing Company.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-531** Course Title: **Hydro Generating Equipment**

2. Contact Hours: L: **3** T: **1** P: **0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **NIL**

9. Objective: To impart knowledge on design, construction, acceptance testing and operation of hydro-turbines and generators.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Characteristics and specification of hydro-generators; constructional details- bearings and bearing location; brakes and jacks for hydro-generators.	8
2.	Cooling and ventilation- insulation and temperature limits; fire protection; electrical and mechanical tests; operating limits of hydro generators.	8
3.	Unit transformer and bus duct- excitation system and voltage regulators; excitation requirement; sources; drives; automatic excitation control equipment; typical schemes.	6
4.	Different types of turbines with their constructional details including reversible pump turbines, tubular, bulb and strflow turbines their characteristics and selection.	10
5.	Cavitation and Turbine setting; testing of water turbines at manufacturer's works and at site, model tests.	6
6.	Mechanical governors, electro hydraulic governors, digital governors, pressurized oil system for hydro-turbines.	4
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprint
1.	Brown,G. J., "Hydroelectric Engineering Practice", CBS Publishers.	1984
2.	Kimbark, E.W., "Power system stability- Synhronous Machines" Wiley Interscience, John Wiley and Sons.	1995
3.	Krivchenko, G.I., "Hydraulic Machines, Turbines and Pumps", MIR Publishers.	1986
3.	Raabe, J., "Hydro Power", VDI-Verlag GmbH.	1985
4.	Walker, J.H., " Large A.C. Machines", Bharat Heavy Electricals Ltd.	1979
5.	Mosoyini, E., "Water Power Development", Nem Chand and Brothers.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-532** Course Title: **Hydropower System Planning**

2. Contact Hours: L: **3** T: **1** P: **0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **NIL**

9. Objective: To impart knowledge about the planning of hydropower development in a river basin.

110. Details of Course:

S. No.	Contents	Contact Hours
1.	Sources of energy and status of hydropower-global power scenario; hydropower policies of various countries; principles of hydropower development; components of a hydropower scheme, types of hydro power plants – run-of-river; valley dam; diversion canal plants; high head plants; pumped storage schemes, etc.; power house planning for surface and sub-surface hydropower plants.	10
2.	Rainfall–runoff relationships, flow measurement in rivers and streams, hydrograph analysis, design flood estimation, flow and power duration curves, power potential estimation, prediction of firm and secondary power, load curve, load, capacity, utilization and diversity factors, determination of installed capacity.	10
3.	Diversion structures, different types of dams and their suitability, site selection, intakes, spillways, and energy dissipaters.	6
4.	Water conveyance through penstocks-design criteria and economic diameter of penstock; conduit valves; water hammer.	6
5.	Economics and financial analysis of hydropower projects -time value of money; discount rate; single payment interest factors; uniform series factors; capital recovery factor;effect of inflation; depreciation; return on investment, Benefit cost analysis- Internal rate of return; levllisation; generation cost; energy pricing and tariff principles.	10
Total		42

11. Suggested Books:

Sl. No.	Name of Authors /Book /Publisher	Year of Publication/Reprint
1.	Brown, G.J., "Hydroelectric Engineering Practice", Blackie and Sons.	1958
2.	James, L. D. and Lee, R. R., "Economics of Water Resources Planning", Mc Graw Hill.	1971
3.	Mosoyini, E., "Water Power Development", Nem Chand and Brothers.	2009
4.	Nigam, P.S., "Handbook of Hydroelectric Engineering", Nem Chand and Brothers.	1979
5.	Thuesen, G. J. and Fabrycky, W. J., "Engineering Economy", Prentice Hall.	2008
6.	Varshney, R. S., "Water Power Systems: Planning and Economics", Nem Chand and Brothers.	1990

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Department of Water Resources Development and Management

1. Subject Code: WR-551 Course Title: Design of Hydro Mechanical Equipment

2. Contact Hours: L: 3 T: 1 P: 0

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: Autumn 7. Subject Area: PCC

8. Pre-requisite: NIL

9. Objective: To impart knowledge of hydro-mechanical equipments used in water resources development projects like turbines, pumps, penstocks, gates, valves, and hoists.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Different types of hydro turbines with their constructional details including reversible pump turbines, tubular, bulb and straf flow turbines their characteristics and selection.	6
2.	Pumps for pumping water-characteristics; selection of size and type and constructional features .	8
3.	Gates for different types of spillways; barrages; under sluice and dam outlet, their general features and comparative merits; structural design of radial and vertical lift gates.	10
4.	Different types of hoists for gates- design of rope drum hoist; different types of valves and their selection.	6
5.	Different types of penstock layout- hydraulic and structural design of penstocks.	8
6.	Fabrication, handling, alignment, erection and support arrangement, painting and testing of penstocks.	4
Total		42

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprint
1.	Davis, C. V. and Sorensen, K. E., "Hand book of Applied Hydraulics", Mc Graw Hill.	1969
2.	Nigam, P. S., "Hand book of Hydroelectric Engineering", Nem Chand and Brothers.	1985
3.	Brown, G.J., "Hydroelectric Engineering Practice", Blackie and Sons.	1958
4.	Mosoyini, E., "Water Power Development", Nem Chand and Brothers.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-552** Course Title: **Construction Planning and Management**

2. Contact Hours: L: **3** T: **1** P: **0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **NIL**

9. Objective: To impart knowledge on CPM and PERT applications in construction planning and management of water resources projects.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Problems in planning and control of present day construction-applications of System Design Techniques; advantages and limitations of systems approach.	3
2.	Linear Programming applications like transportation and assignment models.	5
3.	Waiting line models for construction planning and management	4
4.	Inventory Models and Replacement Models in construction planning and management.	8
5	Network systems in project planning; use of CPM in planning scheduling and controlling of construction projects.	4
6	Network development and monitoring of construction projects.	4
7.	Network crashing and time-cost trade off in construction planning and management.	4
8.	Use of different techniques for resource allocation and leveling in construction planning and management.	4
9.	Use of PERT in construction planning- PERT analysis; use of dynamic programming in project evaluation and construction planning and management.	6
	Total	42

11 . Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprint
1-	Punmia, B.C. and Khandelwal, K.K., "Project. Planning and Control with PERT and CPM", Laxmi Publications.	2004
2-	Srinath, L.S., "PERT and CPM, Principles and applications", EastWest Press.	2005
3-	Taha, H.A., "Operations Research- An Introduction", Pearson Education.	2005
4-	Varma, M., "Construction Planning and Management through System Techniques", Metropolitan Book Co.	1985

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-571** Course Title: **Design of Irrigation Structures and Drainage Works**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre-requisite: **NIL**

9. Objective: To impart knowledge on various design aspects of irrigation and drainage works.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Planning and layout of irrigation system: Necessity, advantages and types of irrigation, techniques of water distribution, alignment.	4
2.	Crop water requirement: Duty, delta base period, irrigation efficiencies, consumptive use, net irrigation requirement, frequency of irrigation; canal capacity, rotational delivery, conveyance and seepage losses.	4
3.	Design of lined and unlined channels: Design for clear and sediment laden water, principles of maximum and minimum permissible velocities, theory of sediment transport, regime concept; Kennedy theory; Lacey's theory; economics of canal lining, discharge measuring devices.	8
4.	Design of distributary head regulator and cross regulator: Hydraulic design principles, seepage theory, exit gradient, invert filter, protection works.	8
5.	Design of canal falls/drops: Definition, location and types of canal falls, design principles of vertical drop and fall, Sarda type fall; Glacis type fall; canal escape and their function as safety valve.	6
6.	Water logging: Causes of water logging, types of drainage system, surface drains; layout and design of surface drains their operation and maintenance.	8
6.	Flood control/protection: Design flood and its importance, flood management, structural and non-structural measures	4
Total		42

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprint
1.	Arora, K.R., "Irrigation, Water Power and Water Resources Engineering", Standard Publishers Distributers.	2007
2.	Asawa, G.L., "Irrigation and Water Resources Engineering", New Age International Publishers.	2005
3.	"Design Practices of Open Drainage Channels", ICID Publication	1984
4.	Singh, B., "Fundamentals of Irrigation Engineering", Nem Chand and Brothers.	2005
5.	"Design of Small Canal Structures". U.S.B.R. Publication	1978
6.	Varshney, R.S., Gupta S.C. and Gupta, R.L., "Theory and design of Irrigation Structures". Nem Chand and Brothers.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-572** Course Title: **Soil and Agronomy**

2. Contact Hours: L: 3 T: 1 P: 0

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **NIL**

9. Objective: To impart knowledge of agro-climatic conditions, soil characteristics and cultivation of crops for efficient use of water.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Scenario of agriculture in the world characterization of irrigated and rain-fed agriculture.	4
2.	Crops and plants: Definitions, morphological and physiological features, classification, adaptation and ecology.	4
3.	Agro-climate: Elements of weather, analysis of weather data and agro-climatic classification, biomass production potential assessment and yield estimation.	8
4.	Soils: Physical, chemical and biological properties, Taxonomic classification and characterization.	4
5.	Soil survey for land evaluation: Irrigability and drainability classification, evaluation and productivity assessment of land.	4
6.	Principles and practices of cultivation of crops: Husbandry of cereal, pulses, oilseeds and cash crops; package and practices of crops.	4
7.	Agro Technology Software: Use of computer software like Decision Support System in Agro Technology Transfer (DSSAT) and other crop yield models.	6
8.	Statistical analysis of experimental data: Field experimental techniques; yield estimation and production forecasting.	4
9.	Optimization Techniques: Application of system techniques in crop planning and management.	4
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Book/Publisher	Year of Publication/Reprint
1.	"Hand Book of Agriculture", Indian Council of Agricultural Research (ICAR).	2008
2.	John, R., George, E., and Rashid, A., "Soil and Plant Analysis - Laboratory Manual", Scientific Publishers.	2009
3.	Kakade, J.R., "Agricultural Climatology", Metropolitan Book Company.	1989
4.	Martin, J.H., Leonard, W.H. and Stamp, D.L., "Principles of Field Crop Production", Mcmillan Publishing Company.	1979
5.	Metcalf, D.S. and Elkins, D.M., "Crop Production: Principles and Practices", Mcmillan Publishing Company.	1980

M.Tech. /P.G. Diploma (Surface Water)

I Year

Autumn Semester

Teaching Scheme					Contact Hrs. per Week			Exam. Duration		Relative Weight				
S. No	Sub. Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	MA-501F	Numerical Analysis, Probability and Statistics	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	HY-511	Hydrologic Elements and Analysis	PCC	4	3	1	-	3	-	25	-	25	50	-
3.	HY-512	Computer Applications in Hydrology	PCC	4	2	1	2	2	-	15	15	30	40	-
4.	HY-538	Hydrological Data collection, Processing and Analysis	PCC	4	3	1	2/2	3	-	15	15	30	40	-
5.		Open Elective-I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (Optional)		2	1	0	2	2	-	15	15	30	40	-
Subtotal				19-22										

Spring Semester

Teaching Scheme					Contact Hrs. per Week			Exam. Duration		Relative Weight				
S. No	Sub. Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.		Program Elective-I	PEC	4	-	-	-	-	-	-	-	-	-	-
2.		Program Elective-II	PEC	4	-	-	-	-	-	-	-	-	-	-
3.		Program Elective-III	PEC	4	-	-	-	-	-	-	-	-	-	-
4.		Program Elective-IV	PEC	4	-	-	-	-	-	-	-	-	-	-
5.		Open Elective -II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6	HS-501	Technical Communication (Optional)		2	1	0	2	2	-	15	15	30	40	-
Subtotal				19-22										

Note: P.G. Diploma in Hydrology Shall be of ONE YEAR duration comprising of semester I & II only, with a minimum of 38 credits.

II Year**Autumn Semester**

Teaching Scheme					Contact Hrs. per Week			Exam. Duration		Relative Weight				
S. No	Sub. Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	HY-601	Seminar	SEM	2	-	-	-	-	-	-	-	100	-	-
2.	HY-602	Project	RP	4	-	-	-	-	-	-	-	100	-	-
3.	HY-603	Dissertation*	DIS	-	-	-	-	-	-	-	-	-	25	-
Subtotal				6										

*NOTE: To be continued and grade to be awarded in the next semester.

Spring Semester

Teaching Scheme					Contact Hrs. per Week			Exam. Duration		Relative Weight				
S. No	Sub. Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	HY-603	Dissertation (Contd. From 3 rd Semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
Subtotal				20										
Total				64-68										

List of Electives

Teaching Scheme					Contact Hrs. per Week			Exam. Duration		Relative Weight				
S. No	Sub. Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	HY-518	Water Resources Planning and Management	PEC	4	3	1	0	3	-	25	-	25	50	-
2.	HY-522	Stochastic Hydrology	PEC	4	3	1	0	3	-	25	-	25	50	-
3.	HY-525	System Analysis and Surface Water Planning	PEC	4	3	1	0	3	-	25	-	25	50	-
4.	HY-526	Parametric Hydrology	PEC	4	3	1	2/2	3	-	15	15	30	40	-
5.	HY-543	Flood Forecasting	PEC	4	3	1	0	3	-	25	-	25	50	-
6.	HY-514	Hydrogeology	PEC	4	3	1	2/2	3	-	15	15	30	40	-
7.	HY-524	Geohydrology*	PEC	4	3	1	2/2	3	-	15	15	30	40	-

M.Tech./P.G. Diploma (Ground Water)

I Year

Autumn Semester

Teaching Scheme					Contact Hrs. per Week			Exam. Duration		Relative Weight				
S. No	Sub. Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	MA-501F	Numerical Analysis, Probability and Statistics	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	HY-511	Hydrologic Elements and Analysis	PCC	4	3	1	-	3	-	25	-	25	50	-
3.	HY-512	Computer Applications in Hydrology	PCC	4	2	1	2	2	-	15	15	30	40	-
4.	HY-535	Water Quality and Environment	PCC	4	3	1	2/2	3	-	15	15	30	40	-
5.		Open Elective-I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (Optional)		2	1	0	2	2	-	15	15	30	40	-
Subtotal				19-22										

Spring Semester

Teaching Scheme					Contact Hrs. per Week			Exam. Duration		Relative Weight				
S. No	Sub. Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.		Program Elective-I	PEC	4	-	-	-	-	-	-	-	-	-	-
2.		Program Elective-II	PEC	4	-	-	-	-	-	-	-	-	-	-
3.		Program Elective-III	PEC	4	-	-	-	-	-	-	-	-	-	-
4.		Program Elective-IV	PEC	4	-	-	-	-	-	-	-	-	-	-
5.		Open Elective -II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6	HS-501	Technical Communication (Optional)		2	1	0	2	2	-	15	15	30	40	-
Subtotal				19-22										

Note: P.G. Diploma in Hydrology Shall be of ONE YEAR duration comprising of semester I & II only, with a minimum of 38 credits.

II Year**Autumn Semester**

Teaching Scheme					Contact Hrs. per Week			Exam. Duration		Relative Weight				
S. No	Sub. Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	HY-601	Seminar	SEM	2	-	-	-	-	-	-	-	100	-	-
2.	HY-602	Project	RP	4	-	-	-	-	-	-	-	100	-	-
3.	HY-603	Dissertation*	DIS	-	-	-	-	-	-	-	-	-	25	-
Subtotal				6										

*NOTE: To be continued and grade to be awarded in the next semester.

Spring Semester

Teaching Scheme					Contact Hrs. per Week			Exam. Duration		Relative Weight				
S. No	Sub. Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	HY-603	Dissertation (Contd. From 3 rd Semester)	DIS	20	-	-	-	-	-	100	-	-	-	-
Subtotal				20										
Total				64-68										

List of Electives

Teaching Scheme					Contact Hrs. per Week			Exam. Duration		Relative Weight				
S. No	Sub. Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	HY-527	Ground Water Hydrology	PEC	4	3	1	2/2	3	-	15	15	30	40	-
2.	HY-528	System Analysis and Ground Water System	PEC	4	3	1	2/2	3	-	15	15	30	40	-
3.	HY-529	Geophysical Investigations	PEC	4	3	1	2/2	3	-	15	15	30	40	-
4.	HY-537	Remote Sensing and GIS Applications in Hydrology	PEC	4	3	1	2/2	3	-	15	15	30	40	-
5.	HY-544	Hydrology of Hard Rocks	PEC	4	3	1	0	3	-	25	-	25	50	-
6.	HY-540	Water Resources Economics	PEC	4	3	1	0	3	-	25	-	25	50	-
7.	HY-513	Hydrometeorology	PEC	4	3	1	2/2	3	-	15	15	30	40	-
8.	HY-541	Forest and Agricultural Hydrology	PEC	4	3	1	2/2	3	-	15	15	30	40	-
9.	HY-545	Water Quality Modelling	PEC	4	3	1	2/2	3	-	15	15	30	40	-
10.	HY-546	Hydroinformatics	PEC	4	3	1	2/2	3	-	15	15	30	40	-

M.Tech./P.G. Diploma (Watershed Management)

I Year

Autumn Semester

Teaching Scheme					Contact Hrs. per Week			Exam. Duration		Relative Weight				
S. No	Sub. Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	MA-501F	Numerical Analysis, Probability and Statistics	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	HY-511	Hydrologic Elements and Analysis	PCC	4	3	1	-	3	-	25	-	25	50	-
3.	HY-512	Computer Applications in Hydrology	PCC	4	2	1	2	2	-	15	15	30	40	-
4.	HY-531	Watershed Behavior and Conservation Practices	PCC	4	3	1	-	3	-	25	-	25	50	-
5.		Open Elective-I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (Optional)		2	1	0	2	2	-	15	15	30	40	-
Subtotal				19-22										

Spring Semester

Teaching Scheme					Contact Hrs. per Week			Exam. Duration		Relative Weight				
S. No	Sub. Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.		Program Elective-I	PEC	4	-	-	-	-	-	-	-	-	-	-
2.		Program Elective-II	PEC	4	-	-	-	-	-	-	-	-	-	-
3.		Program Elective-III	PEC	4	-	-	-	-	-	-	-	-	-	-
4.		Program Elective-IV	PEC	4	-	-	-	-	-	-	-	-	-	-
5.		Open Elective -II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6	HS-501	Technical Communication (Optional)		2	1	0	2	2	-	15	15	30	40	-
Subtotal				19-22										

Note: P.G. Diploma in Hydrology Shall be of ONE YEAR duration comprising of semester I & II only, with a minimum of 38 credits.

II Year

Autumn Semester

Teaching Scheme					Contact Hrs. per Week			Exam. Duration		Relative Weight				
S. No	Sub. Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	HY-601	Seminar	SEM	2	-	-	-	-	-	-	-	100	-	-
2.	HY-602	Project	RP	4	-	-	-	-	-	-	-	100	-	-
3.	HY-603	Dissertation*	DIS	-	-	-	-	-	-	-	-	-	25	-
Subtotal				6										

*NOTE: To be continued and grade to be awarded in the next semester.

Spring Semester

Teaching Scheme					Contact Hrs. per Week			Exam. Duration		Relative Weight				
S. No	Sub. Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	HY-603	Dissertation (Contd. From 3 rd Semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
Subtotal				20										
Total				64-68										

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List of Electives

Teaching Scheme					Contact Hrs. per Week			Exam. Duration		Relative Weight				
S. No	Sub. Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	HY-516	Channel and Fluvial Hydraulics	PEC	4	3	1	0	3	-	25	-	25	50	-
2.	HY-530	Planning and Management of Watersheds	PEC	4	3	1	2/2	3	-	15	15	30	40	-
3.	HY-532	System Ecology and Environment Planning	PEC	4	3	1	0	3	-	25	-	25	50	-
4.	HY-537	Remote Sensing and GIS Applications in Hydrology	PEC	4	3	1	2/2	3	-	15	15	30	40	-
5.	HY-547	Geomorphology	PEC	4	3	1	0	3	-	25	-	25	50	-
6.	HY-542	Urban Hydrology	PEC	4	3	1	0	3	-	25	-	25	50	-
7.	HY-539	Nuclear Methods in Hydrology	PEC	4	3	1	2/2	3	-	15	15	30	40	-

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: DEPARTMENT OF HYDROLOGY

1. Subject Code: **HY-511** Course Title: **Hydrologic Elements and Analysis**
2. Contact Hours: L: **3** T: **1** P: **0**
3. Examination Duration (Hrs.): Theory **3** Practical **0**
4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **NIL**
9. Objective: To provide necessary background about various hydrological processes, storages, instrumentation, recording of data and analytical techniques.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Hydrological cycle, storage, water balance.	4
2.	Atmospheric Circulation: Atmospheric circulation patterns, cyclones, typhoons, water vapour, precipitable water.	4
3.	Hydrologic Elements: Precipitation types, measurements, analysis, mean precipitation, depth-area-duration relation, maximum intensity-duration-frequency relation .	6
4.	Evapotranspiration: Evaporation processes, influencing factors, measurement, potential and actual evapotranspiration .	5
5.	Infiltration: Infiltration processes, influencing factors, measurement, infiltration models, infiltration capacity.	4
6.	Hydrometry: Gauge and discharge sites, site suitability, river stage, velocity measurement, area velocity method, tracer techniques.	4
7.	Geomorphology: Stream ordering, linear, areal and relief aspects	2
8.	Runoff: Factor affecting, runoff characteristics of stream, hydrograph-unit hydrograph, S-hydrograph, flow duration curve, flow mass curve, rational and time-area method of runoff computation.	8
9.	Groundwater Hydrology: Types of aquifers, Darcy's Law, well hydraulics.	2
10.	Watershed Management: Watershed management techniques, soil erosion and estimation.	3
	Total	42

11 . Suggested Books:

S. No.	Name of Authors /Books /Publishers	Year of Publication/ Reprint
1.	Chow, V.T., Maidment, D.R. and Mays, L., "Applied Hydrology", McGraw Hill	1988
2.	Singh, V.P., "Elementary Hydrology", Prentice Hall of India	1994
3.	Subramanya, K., "Engineering Hydrology", Tata McGraw Hill	2008
4.	Chow, V.T., "Handbook of Applied Hydrology", McGraw Hill	1964
5.	Hersch, R.W.(Ed.), "Hydrometry: Principles and Practices", Wiley Intersciences	1978
6.	Todd D.K. and Mays L., "Ground Water Hydrology", John Wiley & Sons	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF HYDROLOGY**

1. Subject Code: **HY- 512** Course Title: **Computer Applications in Hydrology**

2. Contact Hours: **L: 2** **T: 1** **P: 2**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage: CWS 155 PRS 15 MTE 30 ETE 40 PRE 0

5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To introduce computer programming and applications in hydrological problems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Number System: Binary and decimal numbers system, integer and floating point representation.	4
2.	Fundamentals: Principle of object oriented programming, introduction to C++, keywords, identifiers, constants, operators, expressions, type conversions.	4
3.	Conditional and Loop Control Structures: if, if...else, switch, while and do...while, for loops.	4
4.	Arrays: Single and multi-dimension arrays, pointers and strings.	2
5.	Functions: Function prototyping and scope, passing parameters to functions including arrays, values return by functions.	4
6.	Object Oriented Programming: Classes, objects, constructors and destructors, type of constructors.	4
7.	MATLAB: Overview and introduction to programming in MATLAB.	4
8.	Introduction to VBA: Overview and programming using VBA in Excel	2
Total		28

List of Practicals:

- Development of programs for statistical analysis of hydrological time series viz rainfall, discharge and temperature etc.
- Development of programs for randomness and trend analysis of hydrological data
- Development of programs for discharge computations using area-velocity methods, time-area methods etc.
- Development of programs for spatial interpolation and areal distribution of hydrological data like rainfall, high frequency groundwater levels etc.
- Development of program using OOP in C++ for systematic data storage and retrieval for a river catchment.
- MATLAB programs for statistical analysis of hydrological time series.
- Programming in VBA for computation of runoff using various methods.
- Development of rating-curve equation for discharge measurement using VBA in Excel.

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Hubbard, S.R., "Schaum's Outline of Programming with C++", McGraw Hill International.	2005
2.	Lafore, R., "Object Oriented Programming in C++", Galgotia Publications	1994
3.	Stallings, W., "Computer Architecture & Organization"; Prentice Hall Inc.	1998
4.	Schildt, H., "The Complete Reference C++", Tata McGraw Hill	2001
5.	Krishnamurthy, E.V. and Sen, S.K., "Programming in MATLAB", East-West Press	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
NAME OF DEPTT./CENTRE: DEPARTMENT OF HYDROLOGY

1. Subject Code: **HY- 531** Course Title: **Watershed Behavior and Conservation Practices**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To teach the impact of land use changes on various hydrological cycle parameters, estimation of peak run off, soil erosion, its measurement and control measures.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Physical elements of a watershed; effects of land use changes on hydrological cycle component- precipitation, interception, evaporation, transpiration, and quality and quantity of runoff .	7
2.	Concept of vegetative management of water yield and quality	3
3.	Watershed experiments, extrapolation of results from representative and experimental basins, regional studies.	4
4.	Inventory techniques for precipitation, runoff, soil, timber, range-land and wild life.	4
5.	Water harvesting techniques, elements, development of modern harvesting techniques.	3
6.	Estimation of peak rate of runoff.	3
7.	Land capability classification; General soil and water conservation practices, land and soil classification, identification of critical areas.	7
8.	Water erosion process, factors affecting erosion, types of erosion, assessment of erosion, universal soil loss equation, control measures for erosion, temporary and permanent measures.	7
9.	Wind erosion and its assessment, vegetative and mechanical control measures.	4
Total		42

11 . Suggested Books:

S- No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Lee, R., "Forest Hydrology", Columbia University Press	1977
2.	Frevert, R.K., Schwab, G.O., Edminster, T.W. and Barnes, K.K., "Soil and Water Conservation Practices", John Wiley & Sons	2003
3.	"Guidelines for Watershed Management", F.A.O. Conservation Guide No.1	1990
4.	Brooks, K.N., Elliott, P.F., Gregerson, H.M. and De Bano, L.F., "Hydrology and Management of Watersheds", Iowa State University Press	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: DEPARTMENT OF HYDROLOGY

1. Subject Code: HY- 535 Course Title: Water Quality and Environment

2. Contact Hours: L: 3 T: 1 P: 2/2

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 15 PRS 15 MTE 30 ETE 40 PRE 0

5. Credits: 4

6. Semester: Autumn

7. Subject Area: PCC

8. Pre-requisite: Nil

9. Objective: To provide basic background for understanding the characteristics environment and skills for assessment and management of its quality.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Overview of Environment, components of environment and their interaction, source and uses of water.	2
2.	Concepts from water, soil and air pollution chemistry; Microbiology and ecology, solutions, electroneutrality, equilibrium, reaction kinetics, microbes in aquatic/terrestrial systems, types and functions, aquatic and terrestrial ecosystems.	8
3.	Introduction to water, soil and air quality concepts, impurities and quality characterization, physical, chemical and biological parameters; Introduction to analytical methods and instruments, field sampling methods, storage and preservation of samples, analytical estimation, analytical quality control and error analysis in laboratories.	10
4.	Movement of pollutants in aquatic/terrestrial environment, water quality issues, transport and transformation processes in surface and groundwater systems, water quality modelling concepts.	8
5.	Mandates and existing monitoring networks of field surface and groundwater organisations, design and review of monitoring networks, evaluation and rationalization of networks, case studies.	5
6.	Analysis and interpretation of quality data, concepts of statistical techniques for data analysis, analysis for correlations, variability,	6

	trends, violations, reporting and graphical presentation of results.	
7.	Legislation and management in environmental quality, water and air quality criteria and standards, national and international perspective.	3
	Total	42

List of Practical:

- Concepts and methods of Gravimetric analysis; Measurement of Total Solids, Total Dissolved Solids, Total Suspended Solids. Measurement of Sulphates and Oil and Grease.
- Concepts and methods of Electrometric analysis; Measurement of EC; Types of sensors and their application in measurement of Flouride, Nitrate and Dissolved Oxygen.
- Concepts and methods of Volumetric and Optical analysis; Measurement of Total Alkalinity, Hardness and its constituents and Chloride; Measurement of Turbidity and Phosphates
- Measurement of Organics viz, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Total Organic Carbon (TOC)
- Introduction to advanced instruments viz. Ion Chromatograph, Gas Chromatograph, Voltammeter

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Kim, Y. J. and Platt, U., "Advanced Environmental Monitoring", Springer	2008
2.	Masters, G.M., "Introduction to Environmental Science and Engineering", Pearson Education	2007
3.	"Standard Methods for Water & Wastewater Analysis", 21 st Edition, APHA	2005
4.	Crompton, T.R., "Soil Analysis: Handbook of Reference Methods", CRC Press	2000
5.	Chapman, D., "Water Quality Assessment", 2 nd Edition, Imprint of Chapman & Hall	1992
6.	Sawyer, C.N., and McCarty, P.L., "Chemistry for Environmental Engineering", 3 rd Edition, McGraw Hill	1987

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF HYDROLOGY**

1. Subject Code : **HY - 538** Course Title : **Hydrological Data Collection, Processing and Analysis**

2. Contact Hours : L: **3** T : **1** P: **2/2**

3. Examination Duration (Hrs) : Theory : **3** Practical: **0**

4. Relative Weightage : CWS: **15** PRS: **15** MTE: **30** ETE: **40** PRE: **0**

5. Credits : **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To introduce various methods for hydrological data collection, processing and analysis.

10. Details of Course:

Sl. No.	Particulars	Contact Hours
1.	Types of hydrometeorological data and their importance, time oriented, space oriented and relational data.	3
2.	Observation of hydrometeorological data - rainfall, temperature, evaporation, discharge and other parameters, observational and instrumental errors and quality control.	5
3.	Storage, transmission and retrieval of data, different formats adopted by IMD, CWC and WMO.	4
4.	Design and optimization of monitoring systems for rainfall, evaporation, gauge and discharge networks and groundwater data monitoring stations.	4
5.	Estimation of missing data in rainfall, runoff and other parameters, record extension for rainfall and runoff data, interpolation and kriging techniques, statistical rainfall-runoff models.	8
6.	Development of stage discharge curves using graphical, physical and analytical methods for various types of streams.	3
7.	Automatic weather stations - types, data storage and retrieval; Automatic water level recorders - types, data storage and retrieval.	4
8.	Analysis of randomness and trends in hydrometeorological data; Computation of statistical parameters and standards errors, components of time series, concepts of short and long term dependence in	6

	hydrometeorological data.	
9.	Estimation of extremes using frequency analysis; Graphical and analytical methods for normal, lognormal and Gumbel distributions.	5
Total		42

List of Practicals:

- Observation of rainfall, temperature and evaporation.
- Observation of groundwater levels in observatory.
- Observation of gauge and discharge in lab/field.
- Demonstration of hydrological processes using Total Hydrologic Station.
- Measurement of infiltration rates.

11. Suggested Books :

Sl. No.	Name of Authors/Books/Publisher	Year of Publication /Reprint
1.	Kottegoda N.T., "Stochastic Water Resources Technology", John Wiley & Sons	1980
2.	Chow V. T., Maidment D. R. and Mays L. W., "Applied Hydrology", McGraw-Hill	1988
3.	Maidment, D.R., "Handbook of Hydrology", McGraw Hill Inc.	1993
4.	Singh V. P., "Elementary Hydrology", Prentice-Hall of India Private	1994
5.	Hornberger G. M., Raffensperger J. P., Woberg P. L and Eshleman K. N., "Elements of Physical Hydrology", The Johns Hopkins University Press	1998
6.	Viessman W. and Lewis G. L., "Introduction to Hydrology", Pearson Education	2007
7.	Subramanya K., "Engineering Hydrology", Tata McGraw Hill Ltd.	2008

Program : M. Tech. (Nanotechnology) at IIT Roorkee
 Year : I

Autumn Semester

Teaching Scheme					Contact Hours Per Week			Exam. Duration		Relative Weight				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	MA-501F	Advanced Mathematics	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	NT- 501	Nanoscale Materials	PCC	4	3		2	3	-	15	15	30	40	-
3.	NT- 511	Nanoscale Modeling and Simulation	PCC	4	3		2	3	-	15	15	30	40	-
4.	MT- 507	Materials Characterization	PCC	4	3	0	2	0	0	15	15	30	40	-
5.	-	Open Elective I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (Optional)	IEC	2	1	0	2	-	-	15	15	30	40	-
Sub total				19/22										

Spring Semester

Teaching Scheme					Contact Hours Per Week			Exam. Duration		Relative Weight				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	-	Program Elective	PEC	4	-	-	-	-	-	-	-	-	-	-
2.	-	Program Elective	PEC	4	-	-	-	-	-	-	-	-	-	-
3.	-	Program Elective	PEC	3/4	-	-	-	-	-	-	-	-	-	-
4.	-	Program Elective	PEC	3/4	-	-	-	-	-	-	-	-	-	-
5.	NT-562	Laboratory Methods (Multidisciplinary Experiments)	PEC	2	0	0	4	-	4	-	15	35	-	50
6.	-	Open Elective - II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
7.	HS-501	Technical Communication (Optional)	IEC	2	1	0	2	-	-	15	15	30	40	-
Sub total				19/24										

Program : M. Tech. (Nanotechnology) at IIT Roorkee
 Year : II

Autumn Semester

Teaching Scheme					Contact Hours Per Week			Exam. Duration		Relative Weight				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	T	P	CW S	PRS	MT E	ETE	PRE
1.	NT-601	Seminar	SEM	2	-	-	-	-	-	-	-	-	-	-
2.	NT-602	Project	RP	4	-	-	-	-	-	-	-	-	-	-
3.	NT-603	Dissertation	DIS	-	-	-	-	-	-	-	-	-	-	-
Sub total				6										

* NOTE : To be continued and grade to be awarded in the next semester.

Spring Semester

Teaching Scheme					Contact Hours Per Week			Exam. Duration		Relative Weight				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	NT - 603	Dissertation	DIS	20	-	-	-	-	-	-	-	-	-	-
Sub total				20										
Total				64/70										

Program Electives														
1.	MT-548	Diffusion in Solids	PEC	3	3	0	0	3	-	15	-	35	50	
2.	NT-502	Structural Analysis of Nanomaterials	PEC	4	3	1	0	3	-	25	-	25	50	
3.	NT-512	Technology of Nanostructured Fabrications	PEC	4	3	1	0	3	-	25	-	25	50	
4.	CY-621	Molecular Spectroscopy	PEC	4	3	1	0	3	-	25	-	25	50	
5.	NT-522	Mechanical Behavior of Nano and Amorphous Materials	PEC	4	3	1	0	3	-	25	-	25	50	
6.	NT-532	Supramolecular Chemistry of Nanomaterials	PEC	4	3	1	0	3	-	25	-	25	50	
7.	NT-542	Nanobiotechnology	PEC	4	3	1	0	3	-	25	-	25	50	
8.	PH-702	Nanomaterials & Technology	PEC	3	3	0	0	3	-	15	-	35	50	
9.	PH-706	Functional Materials and Devices	PEC	3	3	0	0	3	-	15	-	35	50	
10.	NT-552	Physics of Nanomaterials	PEC	3	3	1	0	3	-	25	-	25	50	
11.	MT-506	Metallurgical Thermodynamics & Kinetics	PEC	3	3	0	0	3	-	15	-	35	50	
12.	EC-632N	RF and Microwave MEMS	PEC	3	3	0	0	3	-	15	-	35	50	
13.	EC-642N	Nanoscale Devices and Circuit Design	PEC	3	3	0	0	3	-	15	-	35	50	

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Centre of Nanotechnology

1. Subject Code : NT - 501 Course Title : Nanoscale Materials

2. Contact Hours : L: 3 T: 0 P: 2

3. Examination Duration (Hrs) : Theory : 03 Practicals : 00

4. Relative weightage : CWS : 15 PRS : 15 MTE : 30 ETE : 40

5. Credits : 04 6. Semester : Autumn 7. Pre-requisite : Nil

8. Subject Area : PCC

9. Objectives: To provide knowledge of various concepts related to nanosized materials, their preparation, properties and applications.

10. Details of Course:

S.No.	Contents	Contact Hours
1	Historical Perspective: An overview of natural and classical nanosystems.	2
2	Classification and Nomenclature of Nanomaterials: Nanosized metals and alloys, semiconductors, ceramics - a comparison with respective bulk materials; Organic semiconductors, carbon nanotubes; Zero-, one-, two-, and three dimensional nanostructures – quantum dots, quantum wells, quantum rods, quantum wires, quantum rings; Nanocomposites consisting of organic, inorganic and biomaterials; Self-assembly.	5
3	Synthesis of Nanoparticulates: Nucleation and growth of nanosystems, self-assembly; Physical methods – mechanical milling, laser ablation, sputtering and microwave plasma; Chemical methods – chemical reduction and oxidation, sol-gel processes, photolysis, radiolysis, and metallo-organic chemical vapour deposition; Designing of advanced integrated nanocomposites, functional nanomaterials and nanostructured thin films.	12

4	Novel Properties of Nanomaterials: Size and shape dependent optical, emission, electronic, transport, photonic, refractive index, dielectric, mechanical, magnetic, non-linear optical properties; Catalytic and photocatalytic properties.	9
5	Theories of Nanosized Materials: Transition metal sols, origin of plasmon band, Mie theory, influence of various factors on the plasmon absorption; Quantum confinement in semiconductors – particle in a box like model for quantum dots; Origin of charge on colloidal sols; Zeta potential - DLVO theory; Implications of colloids in making building blocks.	9
6	Applications and Perspectives of Nanomaterials: Development of nanoscale catalysts, photocatalysts, sensitizers, sensors, composites, polymers, ceramics, biomaterials, pharmaceuticals, nanopaints, nanofluids, optical, fluorescent, electronic, magnetic and photonic devices; Future perspectives of nanotechnology in miniaturization of devices and fabrication of value added products.	5
Total		42

List of Experiments:

1. To investigate the optical properties of certain nanosized semiconducting oxides.
2. To synthesize metal nanostructures and investigate their optical behavior.
3. To analyze the thickness, optical transmission and reflectivity of thin film of metal.
4. Synthesis and characterization of carbon nanotubes by cracking of gas mixture using tubular furnace.
5. To work out the charge, zeta potential and size distribution of colloidal solution of nanoparticles using dynamic light scattering method.
6. To determine the elemental contents in nanoalloys using different analytical techniques.

11. Suggested Books:

S.No.	Name of Books/Authors/Publisher	Year of Publication/ Reprints
1	Klabunde, K.J. (Ed.), "Nanoscale Materials in Chemistry", John Wiley & Sons Inc.	2001
2	Nalwa, H.S. (Ed.), "Encyclopedia of Nanoscience and Nanotechnology".	2004
3	Sergeev, G.B., "Nanochemistry", Elsevier, B.V.	2010
4	Schmid, G. (Ed.), "Nanoparticles", Wiley-VCH Verlag GmbH & Co. KgaA.	2004
6	Liz-Marzán, L.M. and Kamat, P.V. (Eds.), "Nanoscale Materials", Kluwer Academic Publishers.	2003
7	Rao, C.N.R., Müller, A. and Cheentham, A.K. (Eds.), "Chemistry of Nanomaterials", Wiley – VCH.	2004
8	Watarai, H., Teramac, N. and Sawad, T., "Interfacial Nanochemistry – Molecular Science and Engineering at Liquid-Liquid Interfaces", Springer.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **Centre of Nanotechnology**

1. Subject Code : **NT - 511** Course Title : **Nanoscale Modeling and Simulation**

2. Contact Hours : **L: 3 T: 0 P: 2**

3. Examination Duration (Hrs) : Theory : **03** Practicals : **00**

4. Relative weightage : CWS : **15** PRS : **15** MTE : **30** ETE : **40**

5. Credits : **04** 6. Semester : **Autumn** 7. Pre-requisite : **Nil**

8. Subject Area : **PCC**

9. Objective: This course would introduce the panoramic views of various approaches used for modeling and simulation of nanomaterials

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Introduction: Definition of a model, modeling in materials science, simulation vs. modeling, simulation techniques for nano, micro, meso and continuum scales; Nanoscale and Microscale - molecular dynamics and Monte Carlo techniques; Data structure and algorithms, computer programming.	10
2.	Statistical Mechanics: Microstate, macrostate, distribution laws, indistinguishable particles, statistical mechanics and thermodynamics laws, Maxwell Boltzmann statistics.	8
3.	Molecular Dynamics: Introduction, interatomic potentials, equations of motion, integration, pair distribution, constraints and free energy; Time correlation functions and spherical densities, velocity autocorrelation functions, time correlation function and relaxation times; Applications in nanomaterials.	12

4.	Monte Carlo Simulation: Principles of equilibrium; Monte Carlo simulation-estimator, importance of sampling, acceptance ratio, continuous time MC; Ising model and metropolis algorithms; Simulation of interfaces, analysis of MC data, out of equilibrium simulation, MC simulation in surface science; Implementation of MC algorithms.	12
Total		42

List of Experiments:

1. Simulation of Ising Model using Metropolis Algorithms.
2. Simulation of Potts Model and its application in studying magnetic properties.
3. *Ab initio* quantum mechanical simulation of CASTEP for electrical, optical and structural properties.
4. Forcefield method GULP: Simulation of thermodynamic, kinetic, and electrical properties.
5. Molecular mechanics based calculation FORCITE of energy and geometry optimization of molecules and periodic systems.
6. Molecular dynamics simulation of thermodynamic and kinetics properties

11. Suggested Books:

S.No.	Name of Author (s) / Book/ Publisher	Year of Publication/ Reprints
1.	Newman, M.E.J. and Barkema, G.T. "Monte Carlo Methods in Statistical Physics", Oxford University Press.	1999
2.	Wolfson, M.M. and Pert, G. J., "An Introduction to Computer Simulation", Oxford Press.	1999
3.	Raabe, D. "Computational Materials Science", Wiley-VCH.	1998
4.	Landau, D.P. and Binder, K., "A Guide to Monte Carlo Simulation in Statistical Physics", Cambridge University Press.	2005
5.	Frenkel, D. and Smith, B. "Understanding Molecular Simulation", Academic Press.	1996

Department of Management Studies

Master of Business Administration (MBA)

Course No.	Course Title	Subject Area	Credit	L	T	P	Exam Dur. (Hrs)		Relative Weightage (%)				
							T	P	CWS	PRS	MTE	ETE	PRE
1 st Year 1 st Semester													
BM-501	Quantitative Techniques for Managers	PCC	3	3	0	0	3	--	15	--	35	50	--
BM-503	Management Processes and Organizational Behaviour	PCC	3	3	0	0	3	--	15	--	35	50	--
BM-505	Managerial Economics	PCC	3	3	0	0	3	--	15	--	35	50	--
BM-507	Business Communication	PCC	3	2	0	2	2	--	15	15	30	40	--
BM-509	Financial Accounting	PCC	3	3	0	0	3	--	15	--	35	50	--
BM-511	Marketing Management	PCC	3	3	0	0	3	--	15	--	35	50	--
BM-513	Business Statistics	PCC	3	3	0	0	3	--	15	--	35	50	--
Sub Total			21										
2 nd Semester													
BM-502	Management Accounting	PCC	2	2	0	0	2	--	15	--	35	50	--
BM-504	Financial Management	PCC	3	3	0	0	3	--	15	--	35	50	--
BM-506	Business Environment	PCC	3	3	0	0	3	--	15	--	35	50	--
BM-508	Human Resource Management	PCC	3	3	0	0	3	--	15	--	35	50	--
BM-510	Marketing Research	PCC	2	2	0	0	2	--	15	--	35	50	--
BM-512	Production and Operations Management	PCC	3	3	0	0	3	--	15	--	35	50	--
BM-514	Technology Management	PCC	2	2	0	0	2	--	15	--	35	50	--
Sub Total			18										
2 nd Year 3 rd Semester													
BM-601	Management Information Systems	PCC	2	2	0	0	2	--	15	--	35	50	--
BM-603	Legal Aspects of Business	PCC	3	3	0	0	3	--	15	--	35	50	--
BM-605	Strategic Management	PCC	3	3	0	0	3	--	15	--	35	50	--
BM-607	Summer Training		0	--	--	--	--	--	--	--	--	--	--
	Elective I	PEC	3	3	0	0	3	--	15	--	35	50	--
	Elective II	PEC	3	3	0	0	3	--	15	--	35	50	--
	Elective III	PEC	3	3	0	0	3	--	15	--	35	50	--
	Elective IV	PEC	3	3	0	0	3	--	15	--	35	50	--
Sub Total			20										

Course No.	Course Title	Subject Area	Credit	L	T	P	Exam Dur. (Hrs)		Relative Weightage (%)				
							T	P	CWS	PRS	MTE	ETE	PRE
2 nd Year		4 th Semester											
BM-602	Project	RP	2	--	--	--	--	--	--	--	--	--	--
	Elective V	PEC	3	3	0	0	3	--	15	--	35	50	--
	Elective VI	PEC	3	3	0	0	3	--	15	--	35	50	--
	Elective VII	PEC	3	3	0	0	3	--	15	--	35	50	--
	Elective VIII	PEC	3	3	0	0	3	--	15	--	35	50	--
	Elective IX	PEC	3	3	0	0	3	--	15	--	35	50	--
Sub Total			17										
TOTAL			76										

Open Electives

S.No.	Subject Code	Subject Name	Credit	L	T	P	Exam Dur. (Hrs)		Relative Weightage (%)				
							T	P	CWS	PRS	MTE	ETE	PRE
1	BM-611	Seminars in Management	3	--	--	--	--	--	--	--	--	--	100
2	BM-612	Knowledge Management	3	3	0	0	3	--	15	--	35	50	--
3	BM-613	Entrepreneurship Development	3	3	0	0	3	--	15	--	35	50	--
4	BM-614	International Business	3	3	0	0	3	--	15	--	35	50	--
5	BM-615	Industrial Waste Management	3	3	0	0	3	--	15	--	35	50	--
6	BM-616	Management of Large Systems	3	3	0	0	3	--	15	--	35	50	--
7	BM-617	Environment Management	3	3	0	0	3	--	15	--	35	50	--
8	BM-618	Advanced Optimization Techniques for Management	3	3	0	0	3	--	15	--	35	50	--
9	BM-619	Basics of Management of Information	3	3	0	0	3	--	15	--	35	50	--
10	BM-620	Soft Computing Techniques for Management	3	3	0	0	3	--	15	--	35	50	--

Note: The students may take two specializations by taking at least 12 credits in each individual specialization out of the 27 credits being offered as electives in the third and fourth semesters of MBA programme. Students can take remaining three credit paper from open electives or any of the specializations offered.

Specialization Electives
(1) Human Resource Management

S.No.	Subject Code	Subject Name	Credit	L	T	P	Exam Dur. (Hrs)		Relative Weightage (%)				
							T	P	CWS	PRS	MTE	ETE	PRE
1	BM-631	Human Resource Planning and Development	3	3	0	0	3	--	15	--	35	50	--
2	BM-632	Organisational Development	3	3	0	0	3	--	15	--	35	50	--
3	BM-633	Labour Legislation and Industrial Relations	3	3	0	0	3	--	15	--	35	50	--
4	BM-634	Career Planning and Performance	3	3	0	0	3	--	15	--	35	50	--
5	BM-635	Management of Training and Talent Development	3	3	0	0	3	--	15	--	35	50	--
6	BM-636	Compensation Management and Reward System	3	3	0	0	3	--	15	--	35	50	--
7	BM-637	Management of Change	3	3	0	0	3	--	15	--	35	50	--
8	BM-638	Managing Innovation and Creativity	3	3	0	0	3	--	15	--	35	50	--
9	BM-639	Management of Self and Interpersonal Dynamics	3	3	0	0	3	--	15	--	35	50	--

(2) Operations Management

S.No.	Subject Code	Subject Name	Credit	L	T	P	Exam Dur. (Hrs)		Relative Weightage (%)				
							T	P	CWS	PRS	MTE	ETE	PRE
1	BM-641	Manufacturing Strategy	3	3	0	0	3	--	15	--	35	50	--
2	BM-642	Computer Integrated Manufacturing	3	3	0	0	3	--	15	--	35	50	--
3	BM-643	Operations Planning and Control Systems	3	3	0	0	3	--	15	--	35	50	--
4	BM-644	Supply Chain Management	3	3	0	0	3	--	15	--	35	50	--
5	BM-645	Total Productive Maintenance	3	3	0	0	3	--	15	--	35	50	--
6	BM-646	Project Management	3	3	0	0	3	--	15	--	35	50	--
7	BM-647	Productivity Management	3	3	0	0	3	--	15	--	35	50	--
8	BM-648	Quality Management	3	3	0	0	3	--	15	--	35	50	--

(3) Information Technology Management

S.No.	Subject Code	Subject Name	Credit	L	T	P	Exam Dur. (Hrs)		Relative Weightage (%)				
							T	P	CWS	PRS	MTE	ETE	PRE
1	BM-651	Management of Information Technology	3	3	0	0	3	--	15	--	35	50	--
2	BM-652	Enterprise Business Applications	3	3	0	0	3	--	15	--	35	50	--
3	BM-653	Information Technology Project Management	3	3	0	0	3	--	15	--	35	50	--
4	BM-654	Software Engineering and Management of Software Development	3	3	0	0	3	--	15	--	35	50	--
5	BM-655	Design of On-Line Systems	3	3	0	0	3	--	15	--	35	50	--
6	BM-656	Decision Support and Experts Systems	3	3	0	0	3	--	15	--	35	50	--
7	BM-657	Business Process Management	3	3	0	0	3	--	15	--	35	50	--
8	BM-658	Electronic Commerce and Electronic Governance	3	3	0	0	3	--	15	--	35	50	--

(4) Marketing Management

S.No.	Subject Code	Subject Name	Credit	L	T	P	Exam Dur. (Hrs)		Relative Weightage (%)				
							T	P	CWS	PRS	MTE	ETE	PRE
1	BM-661	Internet Marketing	3	3	0	0	3	--	15	--	35	50	--
2	BM-662	Consumer Behavior Analysis	3	3	0	0	3	--	15	--	35	50	--
3	BM-663	Product and Brand Management	3	3	0	0	3	--	15	--	35	50	--
4	BM-664	Integrated Marketing Communications	3	3	0	0	3	--	15	--	35	50	--
5	BM-665	Sales and Distribution Management	3	3	0	0	3	--	15	--	35	50	--
6	BM-666	International Marketing	3	3	0	0	3	--	15	--	35	50	--
7	BM-667	Industrial Marketing	3	3	0	0	3	--	15	--	35	50	--
8	BM-668	Services Marketing	3	3	0	0	3	--	15	--	35	50	--

(5) Financial Management

S.No.	Subject Code	Subject Name	Credit	L	T	P	Exam Dur. (Hrs)		Relative Weightage (%)				
							T	P	CWS	PRS	MTE	ETE	PRE
1	BM-671	Quantitative Analysis for Financial Management	3	3	0	0	3	--	15	--	35	50	--
2	BM-672	Working Capital Management	3	3	0	0	3	--	15	--	35	50	--
3	BM-673	Security Analysis and Portfolio Management	3	3	0	0	3	--	15	--	35	50	--
4	BM-674	Indian Financial System	3	3	0	0	3	--	15	--	35	50	--
5	BM-675	International Financial Management	3	3	0	0	3	--	15	--	35	50	--
6	BM-676	Financial Management Control Systems	3	3	0	0	3	--	15	--	35	50	--
7	BM-677	Taxation and Tax Planning	3	3	0	0	3	--	15	--	35	50	--
8	BM-678	Merchant Banking and Financial Services	3	3	0	0	3	--	15	--	35	50	--
9	BM-679	Financial Statement Analysis and Reporting	3	3	0	0	3	--	15	--	35	50	--
10	BM-680	Banking and Bank Finance	3	3	0	0	3	--	15	--	35	50	--

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : DEPARTMENT OF MANAGEMENT STUDIES

1. Subject Code : BM-501 Course Title : Quantitative Techniques for Managers

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.): Theory: 3 Practical: 0

4. Relative Weightage: CWS 15 PRS 0 MTE 35 ETE 50 PRE 0

5. Credits: 3 6. Semester: Autumn

7. Pre-requisite: Nil 8. Subject Area: PCC

9. Objective: To impart knowledge in basic quantitative tools and techniques used in managerial decision making.

10. Details of the Course:

Sl. No.	Contents	Contact hours
1.	Introduction: LP model formulation; the simplex method, special cases, sensitivity analysis.	6
2.	Duality and Post-optimal Analysis: Formulation, economic interpretation, and managerial significance.	4
3.	Integer Programming: Branch and bound method, cutting plane method, introduction to 0-1 programming, site selection problems.	5
4.	Transportation Models: Transportation problems, assignment problems, travelling salesman problems.	4
5.	Game Theory: Optimal solution to two person zero sum games and solution to mixed strategy games.	5
6.	Queuing Theory: Cost related with queuing models, single and multi server models.	5
7.	Simulation: Monte Carlo simulation, random numbers, application in queuing, inventory and marketing problems.	4
8.	Replacement Analysis: Individual and group replacement.	3
9.	Goal Programming: The weights method, the preemptive method.	3
10.	Dynamic programming: Traveling salesmen problem, capital budgeting problems, employment smoothing problems.	4
	Total	42

11 . Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Taha, H. A., Natrajan, A.M., Balasubramanie,P. and Tamilarasi, A. ,“Operations Research”, 8 th Edition, Pearson Prentice Hall	2009
2.	Hillier, F.S. and Lieberman, G.J., “Introduction to Operations Research” 8 th Edition, Tata McGraw-Hill	2009
3.	Wagner, H.M., “Principles of Operations Research”, 2 nd Edition, PHI Learning	1998
4.	Ravindran, A., Phillips, D.T. and Solberg , J.J., “Operations Research Principles and Practice”, 2 nd Edition , John Wiley and Sons	2004
5.	Sharma, J. K., “Operations Research Theory and Applications”, 4 th Edition, Macmillan	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT / CENTRE : DEPARTMENT OF MANAGEMENT STUDIES

1. Subject Code : BM-503 Course Title : Management Processes and Organizational Behavior

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.): Theory: Practical:

4. Relative Weightage: CWS PRS MTE ETE PRE

5. Credits: **6. Semester:** Autumn

7. Pre-requisite: Nil **8. Subject Area:** PCC

9. Objective: To develop an understanding of the basic management concepts and behavior of individuals and group in organizational settings.

10. Details of the Course:

S.No.	Contents	Contact Hours
1.	Managerial processes, functions, skills and roles.	3
2.	Planning and decision making, planning processes, rational model of decision making, individual decision making and problem solving.	6
3.	Organizational design and structure, departmentation, line/staff authority, delegation and decentralization, controlling, process and techniques of control.	6
4.	OB model, perception, personality, leadership, motivation, change management, stress management, conflict management.	6
5.	Values and attitudes, formation of attitudes, job related attitudes and behavior learning in organizations; Motivation, concepts of motivation, behavioral consequences of motivation, organizational conflict and creativity.	6
6.	Interpersonal processes, groups in organizations, formation of groups small and large groups, group dynamics.	4
7.	Leadership approaches, processes and styles.	3
8.	Developing collaboration, power and politics, organizational culture and job involvement practices.	3
9.	Comprehensive case studies.	5
Total		42

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Robbins, S. P. and Sanghi, S., "Organizational Behavior", 13 th Edition, Pearson-Prentice Hall	2009
2.	Parek, U., "Understanding Organizational Behavior", 3 rd Edition, Oxford University Press	2008
3.	Fincham, R. and Rhodes, P., "Principles of Organizational Behavior", 4 th Edition, Oxford University Press	2008
4.	Wehrich, H. and Koontz, H., "Management A Global Prospective, 12 th Edition, Tata McGraw-Hill	2008
5.	Robert, A.B. and Byne, D., "Social Psychology: Understanding Human Interactions", PHI	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : DEPARTMENT OF MANAGEMENT STUDIES

1. Subject Code : BM-505 Course Title : Managerial Economics
2. Contact Hours: L: 3 T: 0 P: 0
3. Examination Duration (Hrs.): Theory: 3 Practical: 0
4. Relative Weightage: CWS 15 PRS 0 MTE 35 ETE 50 PRE 0
5. Credits: 3 6. Semester: Autumn
7. Pre-requisite: Nil 8. Subject Area: PCC
9. Objective : To acquaint the students with various aspects of micro and macro economics.

10. Details of the Course:

S.No.	Contents	Contact Hours
1.	Introduction to managerial economics, nature of micro and macro economics.	2
2.	Theory of demand, demand functions, income and substitution effects.	3
3.	Production and cost- return to scale, cost curves, break even analysis.	4
4.	Theory of firm- profit maximization.	3
5.	Theory of distribution-functional vs personal distribution, micro and macro theories, marginal productivity, marginal revenue product .	4
6.	Market structure- competition, monopoly; oligopoly; non-price competition.	5
7.	National income determination.	2
8.	Aggregate demand function, aggregate demand curve, concept of investment multiplier, multiplier analysis.	5
9.	Business cycles- phases, features and theories.	3
10.	Inflation- meaning, demand pull inflation, cost push inflation, Fisher effect.	3
11.	Monetary and fiscal policies.	3
12.	Exchange rate.	2
13.	International trade- concepts and current scenario.	3
Total		42

11. Suggested Readings:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Mankiw, N.G., "Macroeconomics", 7 th Edition, Worth Publishers	2010
2.	Mankiw, N.G., "Principles of Microeconomics", 5 th Edition, Cengage	2009
3.	Dornbush, R., Fischer, S. and Startz, R., "Macroeconomics, 9 th Edition, McGraw Hill	2004
4.	Sikdar, S., "Principles of Macroeconomics", 9 th Edition, Oxford University Press	2006
5.	Sen, A., "Microeconomics", 2 nd Edition, Oxford University Press	2006
6.	Koutsoyannis, A., "Modern Microeconomics", 2 nd Edition, ELBS Macmillan	1985

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : DEPARTMENT OF MANAGEMENT STUDIES

1. Subject Code : BM-507 Course Title : Business Communication

2. Contact Hours: **L: 2 T: 0 P: 2**

3. Examination Duration (Hrs.): Theory: 2 Practical: 0

4. Relative Weightage: CWS 15 PRS 15 MTE 30 ETE 40 PRE 0

5. Credits: 3 6. Semester: Autumn

7. Pre-requisite: Nil 8. Subject Area: PCC

9. Objective: To acquaint students with the required skills for effective communication in business organisations.

10. Details of the Course:

S. No.	Contents	Contact hours
1.	Introduction, importance, nature, role and process of business communication, perceptions and realities, different forms of communication and their importance including body language, barriers in communication, how to make communication effective, improving listening skills.	5
2.	Writing curriculum vitae, facing interviews, group discussions.	4
3.	Communication with colleagues including brain storming, verbal communication with colleagues and clients and telephonic conversation.	4
4.	Written communication, individual communication-letters and memos, group communication-circulars and notifications, legal communication, agreements, MoUs and negotiations.	4
5.	Preparing business reports, making and presentation of business proposals.	2
6.	Mass communications, newsletters, publicity handouts, instructions and manuals, handling the press.	3
7.	Business etiquette, business presentations and public speaking.	3
8.	Electronic communication, fax, e-mail, internet and multimedia.	3
	Total	28

Practical:

Practical will be done on presentations, mock interviews, report writing, drafting business letters, CV preparation and case studies.

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Hair, D., Friedrich, G.W. and Dixon, L.D., "Strategic Communication: In Business and the Profession", 6 th Edition, Pearson Education	2008
2.	Hudson, R.H., "Business Communication", 5 th Edition, Jaico Publishing House	2006
3.	Lesikar, R.V., Flatley, M.E., Rentz, K. and Pande, N., "Business Communication: Making Connections in a Digital World", 11 th Edition (Special Indian Edition), Tata McGraw-Hill	2009
4.	Lesikar, R.V. and Pettit, J.D., "Business Communication: Theory and Application", 10 th Edition, Richard D. Irwin	2005
5.	Raman, M. and Singh, P., "Business Communication", Oxford University Press	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : DEPARTMENT OF MANAGEMENT STUDIES

1. Subject Code : BM-509 Course Title : Financial Accounting

2. Contact Hours: **L: 3 T: 0 P: 0**

3. Examination Duration (Hrs.): Theory: 3 Practical: 0

4. Relative Weightage: CWS 15 PRS 0 MTE 35 ETE 50 PRE 0

5. Credits: 3 6. Semester: Autumn

7. Pre-requisite: Nil 8. Subject Area: PCC

9. Objective: To acquaint students with the system of collecting, summarising, analysing and reporting information in monetary terms so that interpretation of this information could be used by various stakeholders.

10. Details of the Course:

S. No.	Contents	Contact hours
1.	Introduction to financial accounting, conceptual framework of financial accounting, language of accounting.	3
2.	Accounting conventions and concepts, revenue recognition and measurement, matching of revenues and expenses.	5
3.	Accounting mechanics- basic records, theory and practice of measurement of business income.	4
4.	Financial statements like balance sheet, profit and loss accounts and related concepts.	6
5.	Generally accepted accounting principles.	3
6.	Accounting for tangible and intangible assets, fixed assets and depreciation accounting, inventory valuation, valuation of goodwill.	5
7.	Distinction between revenue and capital expenditures, reserves and surpluses.	2
8.	Legal framework of company accounts, financial statement information.	5
9.	Understanding and analysis of published annual reports, tools and techniques of financial statements analysis.	7
10.	Emerging trends in financial accounting.	2
	Total	42

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Anthony, R. N., Hawkins, D.F. and Merchant, K. A., "Accounting- Text and Cases", 12 th Edition, Special Indian Edition, Tata McGraw-Hill	2007
2.	Belverd, E. N. Jr and Powers, M., "Financial Accounting", 7 th Edition, Houghton Mifflin Company	2006
3.	Bhattacharya, H., "How to Read a Balance Sheet: Adapted to Indian laws and requirements", 2 nd Edition, Oxford and IBH Publishing Company	2008
4.	Bhattacharya, S.K. and Dearden, J., "Accounting for Management, Text and Cases", 2 nd Edition, Vikas Publishing House	2007
5.	Hornrgren, C.T., Sundem, G.L., Elliott, J.A and Philbrick, D., "Introduction to Financial Accounting", 9 th Edition, Prentice Hall International	2009
6.	Narayanaswamy, R., "Financial Accounting: A Managerial Perspective", 3 rd Edition, PHI	2009
7.	Ramachandran, N. and Kakani, R. K., "Financial Accounting for Management", 2 nd Edition, Tata McGraw-Hill	2008
8.	Shah, P., "Basic Financial Accounting for Management", Oxford University Press	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : DEPARTMENT OF MANAGEMENT STUDIES

1. Subject Code : BM-511 Course Title : Marketing Management

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.): Theory: 3 Practical: 0

4. Relative Weightage: CWS 15 PRS 0 MTE 35 ETE 50 PRE 0

5. Credits: 3 6. Semester: Autumn

7. Pre-requisite: Nil 8. Subject Area: PCC

9. Objective: To develop basic conceptual abilities, analytical skills, and knowledge in the field of marketing analysis and planning.

10. Details of the Course:

S. No.	Contents	Contact Hours
1.	Introduction: Understanding marketing management.	2
2.	Developing Marketing Strategies and Plans: Marketing and customer value, corporate, division and business unit strategic planning.	5
3.	Capturing Customer Insights: Scanning the environment, conducting marketing research and forecasting demand.	4
4.	Connecting with Customers: Creating satisfaction, loyalty and analyzing markets, identifying market segments and targets.	5
5.	Building Strong Brands: Dealing with competition, creating brand equity, brand positioning.	6
6.	Shaping the Market Offerings: Designing, developing and managing product, services, and pricing strategies and programs.	5
7.	Delivering Value: Designing and managing integrated marketing channels, retailing, wholesaling and logistics.	5
8.	Communicating Value: Designing and managing integrated marketing communication, mass communications, and personal communications.	5
9.	Creating Long Term Growth: Introducing new market offerings, managing global markets and holistic marketing organization.	5
	Total	42

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Kotler, P., Keller, K L., Koshy, A. and Jha, M., "Marketing Management", 13 th Edition, Pearson Education	2009
2.	Mullins, J., Walker, O. and Harper, B.J., "Marketing Management: A Strategic Decision-Making", 7 th Edition, McGraw-Hill	2009
3.	Etzel, M.J., Walker, B.J., Stanton, W.J. and Pandit, A., "Marketing: Concepts and Cases", 13 th Edition, Tata McGraw-Hill	2006
4.	Kurtz, D. L. and Boone, L.E., "Principles of Marketing", 12 th Edition, Thomson	2006
5.	Winer, R., "Marketing Management", 3 rd Edition, PHI	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: DEPARTMENT OF MANAGEMENT STUDIES

1. **Subject Code :** BM-513 **Course Title :** Business Statistics

2. **Contact Hours:** **L:** 3 **T:** 0 **P:** 0

3. **Examination Duration (Hrs.):** **Theory:** **Practical:**

4. **Relative Weightage:** CWS PRS MTE ETE PRE

5. **Credits:** 6. **Semester:** Autumn

7. **Pre-requisite:** Nil 8. **Subject Area:** PCC

9. **Objective:** To develop knowledge and understanding of some basic statistical techniques and ability for solving business problems.

10. Details of the Course:

S.No.	Contents	Contact Hours
1.	Definition and role of statistics, applications of statistics in managerial decision-making, sampling and sampling methods, sampling and non-sampling errors, central limit theorem, sampling distributions and their characteristics.	4
2.	Statistical decision theory; Introduction, ingredients of decision problem, optimal decisions, decision tree analysis, steps in decision tree analysis and advantages of decision tree approach.	4
3.	Measures of central tendency, mean, median and mode and their implications.	4
4.	Measures of dispersion including range, mean deviation, standard deviation, coefficient of variation.	4
5.	Meaning of correlation, types of correlation - positive correlation, negative correlation, perfect correlation, linear and non-linear correlation.	4
6.	Scatter diagram, Karl Pearson's coefficient of correlation, properties of correlation coefficient.	3
7.	Probable error of correlation coefficient, meaning of multiple and partial correlations; multiple and partial correlation coefficients.	3
8.	Meaning of regression, types of regression, simple and multiple regression.	4
9.	Linear and non-linear regression, statement of regression lines, definition of regression coefficients, properties of regression coefficients.	4
10.	Theory of estimation, testing of hypothesis: Large sample tests, small sample test (t, F, Z test and Chi Square test).	5
11.	Analysis of Variance- one way ANOVA, two way ANOVA.	3
	Total	42

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Levin, R.I. and Rubin, D.S., "Statistics for Management", 7 th Edition, PHI	2010
2.	Anderson, D. R., Sweeney, D.J. and Williams, T. A., "Statistics for Business and Economics", 8 th Edition, Thomson South-Western	2005
3.	Levine, D. M., Krehbiel, T.C., Berenson, M.L. and Viswanathan, P.K., "Business Statistics – A First Course", 4 th Edition, Pearson Education	2009
4.	Gupta, S.P. and Gupta, M.P., "Business Statistics", 15 th Edition, Sultan Chand and Sons	2008
5.	Gupta, S.P., "Statistical Methods", 31 st Edition, Sultan Chand and Sons	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: DEPARTMENT OF MANAGEMENT STUDIES

1. **Subject Code** : BM- 502 **Course Title:** Management Accounting

2. **Contact Hours:** L: 2 T: 0 P: 0

3. **Examination Duration (Hrs.):** **Theory:** 2 **Practical:** 0

4. **Relative Weightage:** CWS 15 PRS 0 MTE 35 ETE 50 PRE 0

5. **Credits:** 2 6. **Semester:** Spring

7. **Pre-requisite:** Nil 8. **Subject Area:** PCC

9. **Objective:** To develop an insight into utilization of financial and cost accounting information for planning, controlling and decision making in the business.

10. Details of the Course:

S.No.	Contents	Contact Hours
1.	Introduction: Nature, scope and tools of management accounting, management accounting vs financial accounting and cost accounting.	2
2.	Cost Accounting: Meaning, scope and classification of costs, absorption costing, cost sheet and cost analysis.	4
3.	Marginal Costing and Cost-Volume-Profit Analysis: Marginal cost equation, contribution, break-even point, P/V ratio and margin of safety, applications of marginal costing and CVP.	3
4.	Preparation of Budgets and Budgetary Control: Types of budgets, components of master budgets, operating budgets, financial budgets, budgeted income statement and balance sheet, sales forecasting and their use in the budgetary process.	4
5.	Standard Costing and Variance Analysis: Establishment of cost centers, types of standards, setting the standards; Material variances, labor variances, overhead variances, sales & profit variances, standard costing and budgetary control- a comparison.	3
6.	Responsibility Accounting: Concept, responsibility centres, goal congruence, managerial efforts and motivation; Controllability and measurement of financial performance, responsibility accounting in service, government and non-profit organizations.	3
7.	Activity Based Costing: Introduction, concept of ABC, cost drivers and cost pools, development of ABC system, allocation of overheads under ABC, traditional Vs ABC approach to designing a costing system.	4
8.	Management Control System: Concept, organizational goals, critical process, key success factors, responsibility centers, measures of performance, balance scorecard, key performance indicators and quality control.	3
9.	Decision involving Alternative Choices: Opportunity, outlay and differential costs; Make or buy, joint product cost, irrelevance of past costs, conflicts between decision making and performance evaluation, influence of income statements on decision making.	2
Total		28

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Horngreen, C.T., Sundem, G.L. and Stratton, W.O., "Introduction to Management Accounting", 13 th Edition, PHI	2007
2.	Bamber, L.S., Braun, K.W. and Harrison, T.W., "Managerial Accounting, Pearson Education	2009
3.	Hansen, D.R. and Mowen, M.M., "Management Accounting", 7 th Edition, Thomson South Western	2005
4.	Khan, M.Y. and Jain, P.K., "Management Accounting", 4 th Edition, Tata McGraw-Hill	2007
5.	Louder, J.G. and Holmen, J.S. "Managerial Accounting", 10 th Edition, Thomson South Western	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : DEPARTMENT OF MANAGEMENT STUDIES

1. **Subject Code : BM-504** **Course Title : Financial Management**

2. **Contact Hours:** **L: 3 T: 0 P: 0**

3. **Examination Duration (Hrs.):** **Theory: 3 Practical: 0**

4. **Relative Weightage:** CWS 15 PRS 0 MTE 35 ETE 50 PRE 0

5. **Credits:** 3 6. **Semester:** Spring

7. **Pre-requisite:** Nil

8. **Subject Area:** PCC

9. **Objective:** To acquaint students with the planning and controlling of the firm's resources with a view to maximize the firm's wealth through the process of increased value of the shares.

10. Details of the Course:

S. No.	Contents	Contact Hours
1.	Time value of money.	4
2.	Valuation of securities.	6
3.	Capital investment decision making, quantification of relevant cash flows.	6
4.	Capital investment decision making, appraisal techniques.	6
5.	Capital investment decision making including projects with unequal lives, issue of tax shields and adjusted net present value (NPV), depreciation bias.	5
6.	Concept of cost of capital.	3
7.	Capital structuring decision, implications of debt funding.	6
8.	Brief overview of working capital computation and funding.	6
	Total	42

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Chandra, P., "Financial Management", 7 th Edition, Tata McGraw-Hill	2009
2.	Van Horne, J.C., "Financial Management and Policy", 12 th Edition, PHI	2009
3.	Khan, M.Y. and Jain, P.K., "Financial Management", 5 th Edition, Tata McGraw-Hill	2008
4.	Pandey, I.M., "Financial Management", 9 th Edition, Vikas Publications	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : DEPARTMENT OF MANAGEMENT STUDIES

1. Subject Code : BM-506 Course Title : Business Environment

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.): Theory: 3 Practical: 0

4. Relative Weightage: CWS 15 PRS 0 MTE 35 ETE 50 PRE 0

5. Credits: 3 6. Semester: Spring

7. Pre-requisite: Nil 8. Subject Area: PCC

9. Objective : To acquaint students with economic, technological, socio-cultural and political environment to enable them to understand the external forces that influence business policies.

10. Details of the Course:

S. No.	Contents	Contact hours
1.	Introduction to business environment, macro economic concepts, consumption, savings, investment, social, cultural, political and technological environment.	4
2.	An overview of planning in India, objectives of economic policy; Nature of economic policies, chronological survey of policy pronouncements and their impact on business.	5
3.	Industrial policy resolutions, IDRA, public-private partnership, privatisation and disinvestment, MSMEs, industrial sickness, Indian Company Law, MRTP, Competition Act.	7
4.	Labour legislation, laws relating to weaker sections, specific industries, trade unions and industrial relations.	3
5.	Business and government relations and government influence on income planning, prices and production policies.	4
6.	Impact of tax and inflation on corporate policy planning; Problem of determining planning horizon; Effect of uncertainties	3
7.	An overview of Indian financial system, financial institutions and financial markets.	4
8.	Societal environment, social responsibility of business, corporate governance, consumerism and consumer protection act, sustainable development.	6
9.	Global environment, impact of global integration, GATT/WTO, MNCs, flow of FDI and FII, FEMA.	6
Total		42

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Aswathappa, K., "Essentials of Business Environment", 10 th Edition, Himalaya Publishing House	2009
2.	Cherunilam, F., "Business Environment-Text and Cases", 19 th Edition. Himalaya Publishing House	2009
3.	Dutt, R. and Sundaram, K.P.M., "Indian Economy", 59 th Edition, S. Chand and Co.	2009
4.	Gopal, N., "Business Environment", 2 nd Edition, Tata McGraw-Hill	2009
5.	Paul, J., "Business Environment-Text and Cases", 2 nd Edition, Tata McGraw-Hill	2007
6.	Saleem, S., "Business Environment", 2 nd Edition, Dorling Kindersley (India)	2010
7.	Worthington, I. and Britton, C., "The Business Environment", 6 th Edition, Pearson Education	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : DEPARTMENT OF MANAGEMENT STUDIES

1. Subject Code : BM-508 Course Title : Human Resource Management

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.): Theory: 3 Practical: 0

4. Relative Weightage: CWS 15 PRS 0 MTE 35 ETE 50 PRE 0
3

5. Credits: 6. Semester: Spring

7. Pre-requisite: Nil 8. Subject Area: PCC

9. Objective: To create an understanding of various facets of managing people and of policies and practices relating to management of human resources.

10. Details of the Course:

S.No.	Contents	Contact Hours
1.	Concepts and perspective on human resource management, role of HRM in a competitive business environment; environment affecting HRM at the enterprise level.	5
2.	HR planning and job analysis recruitment, selection, placement, induction and socialization of the employees.	5
3.	Appraising employee performance and potential evaluation.	3
4.	Manpower training and development.	3
5.	Compensation and reward administration.	3
6.	Introduction to HR accounting, inventory and information systems.	3
7.	Dispute resolution and grievance management, trade unions and their role in collective bargaining.	5
8.	Talent acquisition, talent management.	3
9.	Business environment and workforce adjustments (economic recession/ financial boom), creating high performance systems.	5
10.	HRD, organizational development, career planning and management.	3
11.	International human resource management, empowerment and counseling, innovations in HRM.	4
Total		42

11. Suggested Readings

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Rao, V.S.P., "Human Resource Management", 2 nd Edition, Excel Books	2009
2.	Dessler, G. and Verry, B. "Human Resource Management", 11 th Edition, Pearson Education	2009
3.	Snell, S. and Bohlander, G., "Human Resource Management", Cengage Learning	2009
4.	Decenzo, D. A. and Robbins, S.P, "Human Resource Management", 8 th Edition, John Wiley and Sons	2006
5.	Flippo, E. B., "Personnel Management", 6 th Edition, McGraw Hill	2006
6.	Mondy, R. W. and Noe, R. M., "Human Resource Management", 9 th Edition, Pearson Education	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF MANAGEMENT STUDIES**

1. Subject Code: BM-510

Course Title: Marketing Research

2. Contact Hours: L: 2 T: 0 P: 0

3. Examination Duration (Hrs.): Theory: 2 Practical: 0

4. Relative Weightage: CWS 15 PRS 0 MTE 35 ETE 50 PRE 0

5. Credits: 2 **6. Semester:** Spring

7. Pre-requisite: Nil

8. Subject Area: PCC

9. Objective: To familiarize students with essential elements and tools of the market research process and methodology.

10. Details of the Course:

S. No.	Contents	Contact Hours
1.	Introduction to marketing research and defining marketing research problem.	2
2.	Research design- exploratory, descriptive and causal.	3
3.	Attitude measurement and scaling- fundamental, comparative and noncomparative scaling techniques.	3
4.	Design data collection methods and forms- primary and secondary data, questionnaire and data collection forms.	3
5.	Sampling- design and procedures, determining sample size, non sampling errors.	3
6.	Frequency distribution, cross tabulation, regression, correlation, ANOVA, discriminate analysis.	6
7.	Factor analysis, cluster analysis, multidimensional scaling, correspondence analysis, conjoint analysis.	6
8.	Report preparation and presentation.	2
Total		28

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Malhotra, N., "Marketing Research: An Applied Orientation", 6 th Ed., PHI	2009
2.	Aaker, D. A. Kumar, V., and Day, G.S., "Marketing Research", 10 th Ed., Wiley	2009
3.	Burns, A.C. and Bush, R.F., "Marketing Research", 6 th Ed., PHI	2009
4.	Iacobucci, D. and Churchill, G.A.J., "Marketing Research: Methodological Foundations", 10 th Ed., South-Western College Pub	2009
5.	Zikmund, W.G. and Babin, B.J., "Essentials of Marketing Research", 4 th Ed., South-Western College Pub	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : DEPARTMENT OF MANAGEMENT STUDIES

1. Subject Code : BM-512 Course Title : Production and Operations Management

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.): Theory: Practical:

4. Relative Weightage: CWS PRS MTE ETE PRE

5. Credits: **6. Semester:** Spring

7. Pre-requisite: Nil

8. Subject Area: PCC

9. Objective: To provide a systemic view of operations management and its role in the total enterprise management.

10. Details of the Course:

Sl. No.	Contents	Contact hours
1.	Introduction: System concept and OM systems, role of OM in the enterprise management.	2
2.	Manufacturing Strategy: Concept of product life cycle, manufacturing strategy and competitive advantage.	2
3.	Forecasting Techniques: Approaches, accuracy and control of forecast, computers in forecast.	5
4.	Inventory Models: Static and probabilistic models, inventory control methods.	4
5.	Aggregate Production Planning: Aggregate demand, dimensions of production capacity, mathematical models for aggregate planning; Master production scheduling	6
6.	Material Requirement Planning: Concepts, logic and system parameters, MRPI to MRP II to ERP.	3
7.	Scheduling and Dispatching Rules: Scheduling process-focused manufacturing, scheduling product-focused manufacturing.	3
8.	Facility Location and Layout: Methods of facility location and types of layout.	3
9.	Quality Control: Process capability, six sigma methodology, introduction to TQM and business excellence models.	5
10.	Project Management: project planning, scheduling and controlling.	4
11.	Advanced Manufacturing Technologies: JIT, TOC, lean/ green manufacturing, WCM and safety concepts.	5
	Total	42

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Chase, R.B., Jacobs, R.F., Aquileno, N.J. and Agarwal, N.K., "Operations Management for Competitive Advantage", 11 th Edition, Tata McGraw-Hill	2009
2.	Gaither, N. and Frazier, G., "Operations Management", 9 th Edition, Cengage Learning	2004
3.	Russell, R.S. and Taylor, B.W., "Operations Management", 6 th Edition, John Wiley and Sons	2009
4.	Kachru, U., "Production and Operations Management Text and Cases", Excel Books	2007
5.	Buffa, E. S. and Sarin, R., "Modern Production and Operations Management", 8 th Edition, John Wiley and Sons	2009
6.	Monks, J. G., "Schaum's outline of Operations Management", 2 nd Edition, McGraw Hill	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : DEPARTMENT OF MANAGEMENT STUDIES

1. Subject Code : BM- 514 Course Title : Technology Management

2. Contact Hours: L: 2 T: 0 P: 0

3. Examination Duration (Hrs.): Theory: 2 Practical: 0

4. Relative Weightage: CWS 15 PRS 0 MTE 35 ETE 50 PRE 0

5. Credits: 2 6. Semester: Spring

7. Pre-requisite: Nil 8. Subject Area: PCC

9. Objective: To develop an integrated approach to technology management through life cycle of technology.

10. Details of the Course:

S.No.	Contents	Contact Hours
1.	Process and perspectives of technology management.	3
2.	Scanning, acquisition, assimilation, absorption, business strategy and technology strategy adaptation, critical factors in managing technology, improvement and planning.	5
3.	Technology life cycle and forecasting, technology transfer, technology development: Management of R&D, product design and development, commercialisation of R&D, R&D manufacturing- marketing interface, R&D project management.	5
4.	Technology development and competitiveness, technology and business strategy.	3
5.	Technology innovation and creative transformation in the knowledge age; critical trajectories.	3
6.	Technology entrepreneurship, assessing the need, market dynamics.	4
7.	IPR, technology and role of government; International protocols- treaties, standards; International comparisons of technology management.	5
Total		28

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Khalil, T., "Management of Technology: The Key to Competitiveness and Wealth Creation", International Edition, Tata McGraw-Hill	2009
2.	Langlois, S. L. (Ed.), "Technocrime: Technology, Crime and Social Control", Willan Publishing	2008
3.	Sherif, H. and Khalil, T., "New Direction in Technology Management", Elsevier Publisher	2007
4.	Thamhain, H. J., "Management of Technology: Managing Effectively in Technology Intensive Organisations", 2 nd Ed., John Wiley and Sons	2005
5.	Megantz, R.C., "Technology Management: Developing and Implementing Effective Licensing Programs", John Wiley and Sons	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT / CENTRE : DEPARTMENT OF MANAGEMENT STUDIES

1. Subject Code : BM- 601 Course Title: Management Information Systems

2. Contact Hours: L: 2 T: 0 P: 0

3. Examination Duration (Hrs.): Theory: 2 Practical: 0

4. Relative Weightage: CWS 15 PRS 0 MTE 35 ETE 50 PRE 0

5. Credits: 2 6. Semester: Spring

7. Pre-requisite: Nil 8. Subject Area: PCC

9. Objective: To provide insight into the approaches to information system design, development, operation and maintenance.

10. Details of the Course:

S.No.	Contents	Contact Hours
1.	Overview of digital economy and understanding of business pressures, strategic importance of information management; Definition of management information systems, the role of information systems, types of information systems, components of information systems, information system activities.	5
2.	Building systems, system design life cycle, need and stages in system analysis, system development models, roles of managers, users and designers; Structured Vs object oriented design.	5
3.	Linking information systems with information technology, information technology architecture, managing IT infrastructure, introduction to data centers and networking infrastructure, technologies for information distribution and messaging and publishing; securing IT and business transactions, emerging technologies – sensors and biometrics.	5
4.	Cross Functional e-business Applications, introduction to Enterprise Resource Planning (ERP), customer relationship management (CRM) and supply chain management (SCM), enterprise application integration.	8
5.	Business process reengineering, linking IT strategy to business strategy, business flexibility and IT, security and ethical challenges, managing information technology, outsourcing IT and IS, managing globally integrated organizations, societal implications and the future of IT.	5
Total		28

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	O'Brien, J.A., George, A., Marakas, M. and Behl, R., "Management Information Systems", 9 th Edition, Tata McGraw-Hill	2009
2.	Lucas, H.C., "Information Technology for Management", 7 th Edition, Tata McGraw-Hill	2009
3.	Loudon, K. and Loudon, J., "Management Information Systems", 11 th Edition, Pearson Educations	2010
4.	Murdick, R.G., Ross, J.E. and Clagget, J.R., "Information Systems for Modern Management", 3 rd Edition, PHI	1994
5.	Turban, E. and Volonino, L., "Information Technology for Managers: Improving performance in Digital Economy", 7 th Edition, Wiley India	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : DEPARTMENT OF MANAGEMENT STUDIES

1. Subject Code : BM-603 Course Title : Legal Aspects of Business
2. Contact Hours: L: 3 T: 0 P: 0
3. Examination Duration (Hrs.): Theory: 3 Practical: 0
4. Relative Weightage: CWS 15 PRS 0 MTE 35 ETE 50 PRE 0
5. Credits: 3 6. Semester: Autumn
7. Pre-requisite: Nil 8. Subject Area: PCC
9. Objective: To develop basic understanding of laws related to business.
10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Introduction to Law: Sources and development of law, types of law: Civil, criminal, revenue, personal, labour, environmental.	2
2.	Constitution of India: Basic features, fundamental rights, union and state judiciary, writ jurisdiction, types of writs – habeas corpus, certiorari, mandamus, prohibition, division of power between union and state, public interest litigation.	3
3.	Laws of Contract: Formation of contract, offer, acceptance, revocation of offer and acceptance, essentials of contract, void and voidable contracts, consideration, tender, performance of contract, breach of contract and remedies thereof.	6
4.	Sale of Goods: Essentials of sale, sale and ownership, conditions and warranties, sale by description, sale by general name, caveat emptor, case studies.	3
5.	Negotiable Instruments: Meaning, promissory note, bill of exchange, cheque, parties to a negotiable instrument, negotiation, dishonor and discharge, banker and customer, liability of banker.	3
6.	Company Law : Formation of company, doctrine of ultra virus, indoor management, corporate veil, memorandum and articles of association, prospectus and raising of capital, meetings of companies, directors, foreign companies, winding up.	8
7.	Limited Liability Partnership : Meaning, formation, comparison with other business organizations.	3
8.	Direct Tax: Income tax law, concept of income, exempt incomes, income from business, major tax incentives, MAT.	5
9.	Indirect Tax: Excise duty, incidence, CENVAT, service tax, introduction to GST.	5
10.	Employee Related Legislation : Payment of bonus, gratuity, provident fund.	2

11.	Miscellaneous Laws: Right to information, business and criminal liability, mens rea, classification of offences, structure of courts in India.	2
	Total	42

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication /Reprint
1.	Datey, V.S., "Business and Corporate Laws", Taxmann Publications,	2009
2.	"Corporate Laws", Taxmann Publications	2008
3.	Jain, D.K., "Company Law Ready Reckoner", 8 th Edition, Bharat Law House	2010
4.	Constitution of India	
5.	Bare Acts – Indian Contract Act, Sale of Goods Act, Negotiable Instruments Act	

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : DEPARTMENT OF MANAGEMENT STUDIES

1. Subject Code : BM-605 Course Title : Strategic Management

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.): Theory: 3 Practical: 0

4. Relative Weightage: CWS 15 PRS 0 MTE 35 ETE 50 PRE 0

5. Credits: 3

6. Semester: Autumn

7. Pre-requisite: Nil

8. Subject Area: PCC

9. Objective: To impart knowledge for developing long range strategic plans for any organization.

10. Details of the Course:

S. No.	Contents	Contact Hours
1.	Evolution of strategic management, conceptual foundations of strategy formulation, implementation and evaluation.	4
2.	Vision, mission, goals, objectives and policies.	3
3.	Environmental scanning covering both internal firm environment, and external environment including political, social, cultural, economic and technological issues.	4
4.	Business strategy, low cost strategies, differentiation strategies, strategic business units; Competitive strategies, competitive tactics, market location tactics, offensive tactics and defensive tactics.	6
5.	Cooperative strategies, collusion, strategic alliances, joint ventures, Licensing arrangement, Corporate strategy, growth strategies, stability strategies, downsizing strategies, mergers and acquisitions and the process of due diligence.	7
6.	Corporate parenting strategy, parenting advantage, core competence.	2
7.	Functional strategy, strategic flexibility, strategic marketing, strategic HRM, strategic SCM.	4
8.	Blue ocean strategy and fortune at the bottom of the pyramid capability approach	4
9.	Strategy implementation, balanced scorecard, strategy evaluation, strategic audit.	3
10.	Business strategy, sustainable business practices and management of environment, corporate social responsibility, ethics, values and business, ethics as a strategy.	5
Total		42

11. Suggested Books:

S.No.	Name of the Authors/Book/Publishers	Year of Publication/ Reprint
1.	Hitt, M.A., Hoskisson, R.E. and Ireland R.D., "Management of Strategy" 7 th Edition, South-Western Cengage Publication.	2008
2.	Wheelen, T.L., Hunger, J.D. and Rangarajan, K., "Concepts in Strategic Management and Business Policy", 11 th Edition, Pearson Education	2006
3.	Jauch, L.R. and Glueck, W.F., "Business Policy and Strategic Management", 6 th Edition, Frank Brothers and Co.	2004
4.	Thompson, A.A., Jr., Strickland, A.J. III, and Gamble, J.E., "Crafting and Executing Strategy" 15 th Edition, Tata McGraw-Hill	2006
5.	Sen A., "Development as Freedom", Oxford University Press	2000
6.	Prahalad, C.K., "The Fortune at the bottom of the pyramid", Pearson Education	2006
7.	Kim, W.C. and Mauborgne, R., "The Blue Ocean Strategy", Perseus	2005
8.	Chakraborty, S.K., "Ethics in Management: Vedantic Perspectives", Oxford University Press	2004

**PROPOSED SCHEME OF TEACHING AND EXAMINATION FOR
M. TECH. (Pulp & Paper)**

Teaching Scheme					Contact Hours/Week			Exam Duration (Hrs)		Relative Weightage (%)				
S. No	SUBJECT CODE	COURSE TITLE	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1st YEAR					I Semester (Autumn)									
1	MA-501F	Advanced Mathematics	ICC	4	3	1	0	3	-	25	-	25	50	-
2	PP-521	Modeling & Simulation	PCC	4	3	1	0	3	-	25	-	25	50	-
3*	PP-523A/ PP523B	Essentials of paper manufacture/Transport Phenomena	PCC	4	3	1	0	3	-	25	-	25	50	-
4	PP-525	Design of Control Systems	PCC	4	3	1	0	3	-	25	-	25	50	-
5		Open Elective-I	OEC	3/4										
6		Technical Communication (Optional)	-	2										
Sub Total				19/22										
					II Semester (Spring)									
1	PP-522	Chemical Reactor Analysis & Design	PCC	4	3	1	0	3	-	25	-	25	50	-
2		Programme Elective I	PEC	4	3	1	0	3	-	25	-	25	50	-
3		Programme Elective II	PEC	4	3	1	0	3	-	25	-	25	50	-
4		Programme Elective III	PEC	4	3	1	0	3	-	25	-	25	50	-
5		Open Elective-II	OEC	3/4										
6		Technical Communication (Optional)	-	2										
Sub Total				19/22										
2nd YEAR					III Semester (Autumn)									
1	PP-601	Seminar	SEM	2	-	-	-	-	-	-	-	100	-	-
2	PP-602	Project	RP	4	-	-	-	-	-	-	-	100	-	-
3	PP-603**	Dissertation (Contd. in IV semester)	DIS	0	-	-	-	-	-	-	-	-	25	-
Sub Total				6										
					IV Semester (Spring)									
1	PP-603	Dissertation (Contd. from III Semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
Sub Total				20										
Total				64/68										

* PP523A for students from without Pulp & Paper background

* PP523B for students from Pulp & Paper background.

** To be continued in IV semester but evaluated for 25% weightage in IIIrd semester.

Programme Electives

Teaching Scheme					Contact Hours/Week			Exam Duration (Hrs)		Relative Weightage (%)				
S. No	SUBJECT CODE	COURSE TITLE	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1	PP-530	Advances in Pulping and Bleaching	PEC	4	3	1	0	3	-	25	-	25	50	-
2	PP-531	Advances in Papermaking	PEC	4	3	1	0	3	-	25	-	25	50	-
3	PP-532	Advances in Chemical Recovery	PEC	4	3	1	0	3	-	25	-	25	50	-
4	PP-533	Pulp Mill Calculations	PEC	4	3	1	0	3	-	25	-	25	50	-
5	PP-534	Paper Mill Calculations	PEC	4	3	1	0	3	-	25	-	25	50	-
6	PP-535	System Closure and Sustainable Pulp and Paper Manufacture	PEC	4	3	1	0	3	-	25	-	25	50	-
7	PP-536	Secondary Fiber Processing	PEC	4	3	1	0	3	-	25	-	25	50	-
8	PP-537	Paper Converting	PEC	4	3	1	0	3	-	25	-	25	50	-
9	PP-538	Advances in Stock Preparation	PEC	4	3	1	0	3	-	25	-	25	50	-
10	PP-539	Electrokinetics in Papermaking	PEC	4	3	1	0	3	-	25	-	25	50	-

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PP- 521** Course Title: **Modeling and Simulation**

2. Contact Hours: L: **3** T: **1** P: **0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the concepts of modeling and simulation and their application to industrial processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to process modeling and simulation	3
2.	Fundamentals of modeling techniques, classification of models, physical models, deterministic models and probabilistic models, empirical models; Development of algorithms and flow-charts for solving practical problems.	8
3.	Modeling of processes systems- reactors, bio-reactors, evaporators, separation processes; Examples from pulp and paper, petroleum and petrochemical, sugar and alcohol and food processing.	8
4.	Correlation and regression analysis, least square techniques, design of experiments, full and fractional factorial design, Box-Wilson composite design, Box-Hunter Second order rotatable designs, orthogonal design, mixture design, D-optimal design, Draper Lawrence design, analysis of variance, optimization through statistical model, discrimination and identification of models, validation of models, models in statistical quality-control.	8
5.	Simulation of discrete and continuous system, Monte-Carlo methods, system identification, simulation for econometric models, random number generation methods, application of simulation to industrial problems.	7
6.	Introduction to process simulators-ASPEN PLUS, DYN SIM, g-PROMS, WINGEMS; Application to simulation to industrial processes	8
	Total	42

1 1. Suggested books

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Luyben W. L., "Process Modeling Simulation and Control for Chemical Engineers", 2 nd ed., McGraw Hill.	1990
2.	Babatunde A. O. and Ray W. H., "Process Dynamics, Modeling and Control", Oxford University Press.	1994
3.	Jana A.K., "Process Simulation and Control using ASPEN", Prentice Hall	2009
4.	Denn M.M., "Process Modeling" Longman.	1986
5.	Johnson, R. A. and Wichern, D. W., "Applied Multivariate Statistical Analysis" 5 th ed., Pearson Education.	2002
6.	Edgar, T. F., Himmelblau, D. M. and Lapidus, L. S., "Optimization of Chemical Processes", McGraw Hill.	2001
7.	Levin D.R., "Using Process Simulators in Chemical Engineering- A Multimedia Guide for Core Curriculum", 2 nd ed. Wiley.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PP-523A** Course Title: **Essentials of Paper Manufacture**

2. Contact Hours: L: **3** T: **1** P: **0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To impart basic knowledge of fibrous raw materials, pulping, bleaching, chemical recovery, stock preparation, and paper making operations.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Fibrous Raw Materials: Woody plants and non-woody plants, hardwoods and softwoods, fibers, parenchyma cells, ray tracheids, vessels, cellulose, hemi-cellulose, lignin, ultrastructure of cell wall.	7
2.	Pulping: Debarking, chipping, depithing, screening and cleaning, handling and storage; Chemical and mechanical pulping; Kraft and soda pulping; Batch and continuous digesters and their operations, heating systems, blowing, cold blowing and blow heat recovery system; Kappa number and pulp viscosity.	7
3.	Washing and Bleaching: Mechanisms of washing, washing equipment; Screening and cleaning of pulp; Bleaching of pulp, ECF and TCF bleaching, bleachability and its measurement, brightness and its measurement, brightness reversion.	7
4.	Chemical Recovery: Kraft and soda recovery cycles; Black liquor characterization; Concentration of black liquor, multiple effect evaporators, steam economy; Combustion of black liquor, recovery boiler, fumes recovery; Causticizing, white liquor clarifier and mud washer, lime sludge re-burning	7
5.	Stock Preparation: Mechanism of refining, variables affecting refining, controlling parameters, effect of refining on pulp and paper properties; Internal sizing of paper; Strength additives; Fillers and dyes; Control chemicals at the wet end .	5
6.	Papermaking: Approach flow system, sheet forming, fourdrinier machine, drainage elements, dandy roll, couch roll; Gap formers, hybrid formers; Wet pressing, mechanism of pressing, types of presses, press felts, defects originated in press sections; Drying of paper, steam and condensate handling systems, hoods and hood exhaust; Surface sizing.	6
7.	Paper Properties: Different grades of papers, boards and newsprint, and their specifications; Physical mechanical and optical properties of paper.	3
	Total	42

1.1. Suggested books

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Smook G. A. "Handbook for Pulp and Paper Technologists", 7 th ed., TAPPI Press.	1989
2.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 3: Forest Products Chemistry (Ed. Stenius P.)", Finnish Paper Engineers' Association and TAPPI.	1983
3.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 6B: Chemical Pulping (Eds. Gullichsen, J and Fogelholm, C-J.)", Finnish Paper Engineers' Association and TAPPI.	1999
4.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 8: Papermaking Part 1, Stock Preparation and Wet End (Ed. Paulapuro H.)", Finnish Paper Engineers' Association and TAPPI.	2000
5.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 9: Papermaking Part 2, Drying (Ed. Karlsson M.)", Finnish Paper Engineers' Association and TAPPI.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PP-523B** Course Title: **Transport Phenomena**

2. Contact Hours: **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of momentum, heat and mass transport problems in process industries.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Momentum Transport: Viscosity and the mechanisms of momentum transport shell momentum balances and velocity distributions in laminar flow, equations of change for isothermal systems, velocity distributions with more than one independent variable, velocity distributions in turbulent flow, interphase transport in isothermal systems, macroscopic balances for isothermal flow systems, polymeric liquids.	12
2.	Energy Transport: Thermal conductivity and the mechanisms of energy transport, shell energy balances and temperature distributions in solids and laminar flow, equations of change for non-isothermal systems, temperature distribution with more than one independent variable, temperature distribution in turbulent flow, interphase transport in non-isothermal systems, macroscopic balances for non-isothermal systems energy transport by radiation.	10
3.	Mass Transport: Diffusivity and the mechanism of mass transport, concentration distribution in solids and laminar flow, equations of change for multi-component systems, concentration distribution with more than one independent variable, concentration distributions in turbulent flow, interphase transport in non-isothermal mixtures, macroscopic balances for multi component systems, other mechanisms for mass transport.	20
	Total	42

1 1. Suggested books:

S No.	Name of Authors/Book /Publisher	Year of Publication/Reprint
1.	Bird R.B., Stewart W. E. and Lightfoot E. N., "Transport Phenomena" 2 nd ed., John Wiley.	2003
2.	Geankoplis C.J., "Transport Processes and Unit Operations", 4 th ed., PHI.	2008
3.	Plawsky J. L. "Transport Phenomena Fundamentals" Marcel Dekker	2001
4.	Dean W.M., "Analysis of Transport Phenomena", Oxford University Press.	1998
5.	Leal L.G., "Advanced Transport Phenomena: Fluid Mechanics and Convective Transport Processes", Cambridge University Press.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PP-525**

Course Title: **Design of Control Systems**

2. Contact Hours: **L: 3**

T: 1

P: 0

3. Examination Duration (Hrs.): **Theory**

3

Practical

0

4. Relative Weightage: **CWS**

25

PRS

0

MTE

25

ETE

50

PRE

0

5. Credits:

4

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: The Course covers the details process modeling and application of control systems. The course will also impart knowledge on online control and DCS.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review of dynamic process models- linear and non-linear, lumped and distributed parameter systems; Control of linear systems, review of single-loop feedback control systems.	5
2.	Review of Laplace transform and its applications to control systems, stability and controller tuning.	5
3.	Smith compensator for systems with large dead-time and inverse response, multi-loop control cascade, selective and split-range control, feed-forward control, ratio control, adaptive control, inferential control, internal model control, model predictive control.	8
4.	Multivariable control, controllability and observability, alternative control and configuration, integration and coupling, pairing of control and manipulated variables, tuning of multi-loop control systems; Control of complete plants.	8
5.	Introduction to Z transforms; Digital control- sampling and reconstruction, continuous and discrete-time systems, response and stability; Signal processing and data filtering, tuning of digital PID controllers, direct synthesis for design of controllers.	8
6.	Introduction to control of nonlinear systems and distributed control systems.	4
7.	Case studies of industrial processes.	4
	Total	42

1 1. Suggested books:

S No.	Name of Authors/Book /Publisher	Year of Publication/Reprint
1.	Coughanour D.R., "Process System Analysis and Control", 2 nd ed., McGraw Hill.	1991
2.	Seborg D.E., Edgar T.F. and Mellichamp D.A., "Process Dynamics Control", 2 nd ed., John Wiley.	2008
3.	Stephanopoulos G., "Chemical Process Control- An Introduction to Theory and Practice", PHI.	2008
4.	Luyben W. L., "Process Modeling Simulation and Control for Chemical Engineers", 2 nd ed., McGraw Hill.	1990
5.	Babatunde A. O. and Ray W. H., "Process Dynamics, Modeling and Control", Oxford University press.	1994

BIOTECHNOLOGY
M.Sc. (Biotechnology)

Teaching Scheme					Contact Hrs. per week			Exam. Duration (Hrs.)		Relative weightage (%)				
S.No.	Sub. Code	Course Title	Sub. Area	Crs.	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1st Year					I SEMESTER (AUTUMN)									
1.	MA-500	Foundation Course in Mathematics or	PCC	4	3	1	-	3	-	25	-	25	50	-
	BT-511	Fundamentals of Biology	PCC	4	3	1	-	3	-	25	-	25	50	-
2.	BT-512	Biochemistry	PCC	4	3	1	-	3	-	25	-	25	50	-
3.	BT-513	Biotechnology Laboratory - 1	PCC	4	-	-	8	-	-	-	100	-	-	-
4.	BT-514	Applied Microbiology	PCC	4	3	1	-	3	-	25	-	25	50	-
5.	BT-515	Cell & Molecular Biology	PCC	4	3	1	-	3	-	25	-	25	50	-
6.	BT-550	Computer Applications	ICC	4	3	1	-	3	-	25	-	25	50	-
Sub Total				24										
					II SEMESTER (Spring)									
1.	BT-521	Biophysics	PCC	4	3	1	-	3	-	25	-	25	50	-
2.	BT-522	Immunology & Immunotechnology	PCC	4	3	1	-	3	-	25	-	25	50	-
3.	BT-523	Laboratory-II	PCC	4	-	-	8	-	-	-	100	-	-	-
4.	BT-524	Genetic Engineering	PCC	4	3	1	-	3	-	25	-	25	50	-
5.		Major Elective -I	PEC	4	3	1	-	3	-	25	-	25	50	-
6.		Minor Elective -I	MEC	4	-	-	-	-	-	-	-	-	-	-
SUB TOTAL				24										
2ND YEAR					III SEMESTER (AUTUMN)									
1.	BT-611	Structural Biology	PCC	4	3	1	-	3	-	25	-	25	50	-
2.	BT-612	Seminar & Term Paper	SEM	4	-	-	-	-	-	50	-	50	-	-
3.	BT-613	Laboratory - III	PCC	4	-	-	8	-	-	-	100	-	-	-
4.		Major Elective -II	PEC	4	3	1	-	3	-	25	-	25	50	-
5.		Major Elective -III	PEC	4	3	1	-	3	-	25	-	25	50	-
6.		Minor Elective -II	MEC	4	-	-	-	-	-	-	-	-	-	-
Sub Total				24										
					IV SEMESTER (Spring)									
1.	BT-620	Project	RP	16	-	-	-	-	-	-	-	-	-	-
2.		Major Elective -IV	PEC	4	3	1	-	3	-	25	-	25	50	-
3.														
Sub Total				20										
TOTAL				92										

MAJOR ELECTIVES

1.	BT-601	Cell & Tissue Culture Technology
2.	BT-602	Enzymology & Enzyme Technology
3.	BT-603	Instrumental Methods of Analysis
4.	BT-604	Molecular Carcinogenesis & Therapy
5.	BT-605	Vaccine Development & Production
6.	BT-606	Reproductive Endocrinology & Contraceptive Technology
7.	BT-607	Ecology & Environmental Biotechnology
8.	BT-608	Molecular Diagnostics & Therapeutic Biotechnology
9.	BT-609	Gene Regulation
10.	BT-610	Genomics and Proteomics
11.	BT-614	Bioinformatics
12.	BT-615	General Biology and Microbiology
13.	BT-616	Transgenic Animal Technology

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
NAME OF DEPTT./CENTRE : Department of Biotechnology

1. Subject Code: **BT-511** Course Title: **Fundamentals of Biology**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs.): Theory **3** Practical: **0**
4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisites: **Nil**
9. Objective: To impart knowledge of basic and applied aspects of modern biology.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to general biology, general features of taxonomy, heredity and genetic variation, principles of ecology, origin of life and cell as a living unit.	6
2.	Structure of animal and plant cell; Animal kingdom- unicellular and multicellular organisms; Plant kingdom- lower and higher plants, fundamentals of plant physiology.	6
3.	Basic microbiology, microbes of soil, air and water, microbial technologies for industries and environment.	7
4.	Elementary biochemistry, salient features of biomolecules, enzymes and other tools of biotechnology, tissue culture and diagnostic aids.	7
5.	General concepts of cell biology, cell organelles; Molecular biology: manipulating biomolecules, replication, transcription, translation, genetic engineering, Mendelian and experimental genetics.	8
6.	Digestive, excretory and nervous system in animals, muscular, skeletal, vascular and immune systems; Analytical techniques of modern biology.	8
Total		42

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Roberts, M.B.V., "Biology: A Functional Approach", ELBS.	1987
2.	Elliot, W.H. and Elliot, D.C., "Biochemistry and Molecular Biology", Oxford University Press.	2008
3.	Prentiss, S., "Biotechnology: A New Industrial Revolution", Orbit Publishing.	1984
4.	Swanson, C.P. and Webster P.L., "The Cell", 5 th Edition, Prentice Hall.	2004
5.	Karp, G. "Cell and Molecular Biology", 6 th Edition, John Wiley and Sons.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : Department of Biotechnology

1. Subject Code: **BT-512** Course Title: **Biochemistry**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs.): Theory **3** Practical: **0**
4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisites: **Nil**
9. Objective: To impart knowledge of biochemistry for understanding important aspects of biology.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Molecular design of life; Proteins-level of structure, chemical synthesis, specific binding action and dynamics; Physiological proteins- hemoglobin, myoglobin, collagen.	9
2.	Enzymes classification, kinetics and inhibition of enzymes, enzyme specificity and active site, co-enzymes and allosteric action.	8
3.	Structure and function of carbohydrates and lipids; Nucleic acids- DNA, RNA, properties; Exploring genes-restriction enzymes and ligases, DNA sequencing and chemical synthesis; Glycoproteins and peptidoglycans.	10
4.	Biological transducers and bioenergetics; Carbohydrate metabolism- Glycolysis, citric acid cycle, oxidative phosphorylation, ATP synthase; Co-ordinated control of metabolism.	8
5.	Biosynthesis of purines, pyrimidines; Lipid and steroids, fatty acids.	7
Total		42

11. Suggested Books:

S. No.	Name of Authors/ Book/Publisher	Year of Publication/Reprint
1.	Stryer, L., "Biochemistry", 4 th Edition, W. H. Freeman.	2002
2.	Horton, H.R., Moran, L.A., Ochs R.A., Rawn, J. D. and Scrimgeour, R.S., "Principles of Biochemistry", 3 rd Edition Prentice Hall.	2001
3.	Voet, D. and Voet, J. G., "Biochemistry", 3 rd Edition, John Wiley and Sons.	2004
4.	Nelson, D.L. and Cox, M.M., "Lehninger Principles of Biochemistry", 5 th Edition, W.H. Freeman.	2009
5.	Wilson, K. and Walker, J., "Principles and Techniques of Practical Biochemistry", 5 th Edition, Cambridge University Press.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : Department of Biotechnology

1. Subject Code: **BT-513** Course Title: **Biotechnology Laboratory- I**
2. Contact Hours: L: 0 T: 0 P: 8
3. Examination Duration (Hrs.): Theory Practical:
4. Relative Weightage: CWS PRS MTE ETE PRE
5. Credits:
6. Semester: **Autumn**
7. Subject Area: **PCC**
8. Pre-requisites: **Nil**
9. Objective: To impart practical training in the fields of biochemistry and molecular biology.
10. Details of Course:

S. No.	List List of Experiments
1.	To determine the absorption maxima of two dyes using spectrophotometer; Demonstration of the Beer's law.
2.	To prepare the standard curve for protein estimation and to determine protein concentration by biuret assay and Bradford method.
3.	Determination of ascorbic acid concentration in citrus using 2, 6 dichlorophenol indophenol.
4.	To detect cholesterol in a given unknown sample by TLC.
5.	Ion-exchange chromatography, gel filtration chromatography, affinity chromatography.
6.	Study of enzyme kinetics.
7.	Electrophoretic separation of protein using denaturing polyocrylamide gel.
8.	Gene espresum study using GFP cloning system.
9.	Electrophoretic separation of DNA in agarose gel.
10.	Isolation of RNA from animal tissues.
11.	Estimation of DNA by diphenyl amine.
12.	Estimation of RNA by means of orcinol reaction.

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Sambrook, J. Russel, D., "Molecular Cloning: A Lab Manual" Vol. 3, 3 rd Edition, CSHL Press.	2002
2.	Joshi, R. A., and Saraswat, M., "A Text Book of Practical Biochemistry", B. Jain.	2002
3.	Wilson, K. and Walker, J., "Principles and Techniques of Practical Biochemistry" 5 th Edition, Cambridge University Press.	2000
4.	Mertin, H., "Basic Method for the Biochemical Lab", Springer	2006
5.	Singh S.P., "Practical Manual of Biochemistry", 6 Edition, CBS.	2009
6.	Plummer, D. T., "An Introduction to Practical Biochemistry". 3 rd Edition, Tata McGraw- Hill.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : Department of Biotechnology

1. Subject Code: **BT-514** Course Title: **Applied Microbiology**

2. Contact Hours: L: 3 T: 1 P: 0

3. Examination Duration (Hrs.): Theory **3** Practical: **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisites: **Nil**

9. Objective: To impart knowledge on principles and processes involved in industrial microbiology.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Discovery of microorganisms, morphological and structural organization of microbes, microbial nutrition.	4
2.	Growth kinetics, screening of new metabolites; Strain development-mutation and selection of mutants.	6
3.	Microbial production, structure and biosynthesis of organic acids, amino acids, nucleosides, nucleotides and biofuels.	8
4.	Microbial fermentation -design and types of fermentors, scale up operation and process development, product recovery, down stream processing.	6
5.	Occurrence, structure, biosynthesis, production and regulation of ergot alkaloids, vitamins and antibiotics.	4
6.	Microbial transformations, bioremediation, single cell protein-production from alkanes, methane, methanol, wood, carbohydrates and sewage.	6
7.	Microbial polysaccharides and polyesters, biofertilizers, biopesticides, microbial leaching.	5
8.	Food and beverage fermentation, enzyme and food processing, sweeteners.	3
Total		42

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Glazer, A.N. and Nikaido, H., "Microbial Biotechnology-Fundamentals of Applied Microbiology", Freeman.	2002
2.	Rehm, H. J., and Raad, G., "Biotechnology", Vol. 6 th , VCH Publications.	2004
3.	Prescott, L.M., Harley, J.P. and Klein, D.A., "Microbiology", W. C. Brown Publications.	2002
4.	Smith, J.E., "Biotechnology", 3 rd Edition, Cambridge University Press.	2003
5.	Crueger, W. and Gueger, A., "Biotechnology-A Text Book of Industrial Microbiology", 2 nd Edition, Sinauer Assoc.	

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT-515** Course Title: **Cell and Molecular Biology**

2. Contact Hours: L: 3 T: 1 P: 0

3. Examination Duration (Hrs.): Theory **3** Practical: **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4**

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre-requisites: **Nil**

9. Objective: To impart knowledge of fundamentals of living processes by integrating cell with molecular biology.

10. Details of Course:

S. No.	Particulars	No. of Lecture
1.	Evolution of cell and biological macromolecules, general features of prokaryotic and eukaryotic cells.	2
2.	Structure and function of plasma membrane; Molecular organization of cytoskeleton; Endoplasmic reticulum- structure, role in glycosylation, lipid biosynthesis, intracellular transport and secretion; Golgi apparatus- organization and role in cell secretion; Lysosomes, peroxisomes, glyoxisomes; Nucleus-organization of DNA into chromosomes.	10
3.	Chromosome organization, chromatin structure, complexity of eukaryotic chromosome, cot curve.	4
4.	DNA replication in prokaryote and eukaryotes, enzymes and accessory proteins, telomere replication.	5
5.	Transcription process in prokaryote and eukaryote, Types of RNAs, transcriptional factors, regulation of transcription; RNA processing and RNPs- spliceosome, splicing of mRNA, tRNA and rRNA, Nuclear export and stability of mRNA, gene regulation.	10
6.	Translation Process- genetic code, translation mechanism of prokaryotes and eukaryotes, translational control, post translation modification.	6
7.	Signal transduction, malignant growth, cell differentiation	5
Total		42

11. Suggested Books:

S. No.	Name of Author(s) Book/Publisher.	Year of Publication/ Reprint
1.	Swanson C.P., and Webster P.L., "The Cell", 5 th Edition, Prentice Hall.	2004
2.	Russel, R., "Genetics of Animals", 5 th Edition, Cengage Publication.	2002
1.	Alberts, B., Johnson, A., Laws, J., Raff, M., Robert, K. and Walter, P., "Molecular Biology of the cell", 4 th Edition, Garland Publishing.	2002
2.	Watson, J.D., Baker, T. A., Bell, S. P., Gann, A., Levine, N. and Lovisk, R., "Molecular Biology of the gene", 5 th Edition, Pearson Education.	2004
3.	Lewis, B., "Gene VI", 8 th Edition, John Wiley and Sons	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT-550** Course Title: **Computer Application**
2. Contact Hours: **L: 3 T:1 P:0**
3. Examination Duration (Hrs.): **Theory** 3 **Practical:** 0
4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0
5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **ICC**
8. Pre-requisites: **Nil**
9. Objective: To give basic knowledge in computers, programming and application.
10. Details of Course:

S. No.	Particulars	Contact Hours
1.	Introduction to computers and system software concept. Binary representation of data.	4
2.	Programming fundamentals of C++, control structures, operators, arrays and strings.	12
3.	Object Oriented Programming- Classes, function, overloading, inheritance, containership.	6
4.	Function/ operator overloading and concepts of generic programming.	7
5.	Application with streams and files.	7
6.	Elementary word processing, spreadsheets and database concepts.	6
Total		42

11. Suggested Books:

S. No.	Authors/ Name of Books/Publisher	Year of Publication/Reprint
1.	Robert, L., "Object Oriented Programming in C++", Sams.	2002
2.	Douglas, C., Schmidt, Stephen, D. and Huston, "C++ Programming", Cook Book.	2008
3.	Balaguruswamy, "Object Oriented Programming in C++", Tata McGraw-Hill.	2008
4.	Rajaraman, V., " Fundamentals of Computers", PHI.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : Department of Biotechnology

1. Subject Code: **BT-611** Course Title: **Structural Biology**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs.): Theory **3** Practical: **0**
4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisites: **Nil**
9. Objective: To provide an insight into structural transitions in proteins and nucleic acids and the method of monitoring the equilibrium state as well as kinetics.
10. Details of Course:

S. No.	Particulars	No. of Lecture
1.	Electromagnetic radiation, electronic, rotational & vibrational levels; Ultraviolet-visible spectra – theory, transition dipole moment, extinction coefficient, spectra of biopolymers, hypochromism.	5
2.	Infrared spectra of alpha helix and beta sheets; Optical Rotator Dispersion and Circular Dichroism (ORD-CD) spectra – optical activity, chromophores, Wetlaufer's method; Fluorescent spectroscopy – excitation and emission, quantum yield, fluorophores, probes, resonance energy transfer, application; Raman spectroscopy.	6
3.	Nuclear Magnetic resonance – principle, chemical shift, spin-spin coupling, chemical exchange, paramagnetic probes, ring current effects.	8
4.	Dipolar relaxation, spin lattice (T1) & spin spin relaxation (T2) times, line widths, pulse and fourier transform (FT-NMR), two dimensional NMR techniques, decoupling, Nuclear Overhauser effect (NOE), correlation spectroscopy (COSY) and NOESY; In-vivo NMR, cell and whole body NMR, magnetic resonance imaging (MRI); Solid State NMR –CP-MAS.	9
5.	Electron spin magnetic resonance – hyperfine splitting, membrane studies; X-ray diffraction- reciprocal lattice, phase problem, structure determination; Electron Spray Ionisation Mass • Spectrometry; Conformation equilibrium – partition function, zipper model for helix to coil transition, guest host experiment.	6
6.	Reverse folding of proteins – thermodynamic parameters, intermediates, equilibrium studies, kinetics, three state model, probes, experimental evidence; Structural transitions in nucleic acids, phase diagram of melting, destacking equilibrium, triple helix, structural fluctuations; Bilayer membrane structure, fluidity, flip- flop motion, lateral diffusion, order-disorder transition, relative mobility and micro environment.	8
Total		42

11. Suggested Books:

S. No.	Authors/ Name of Books/Publisher	Year of Publication/Reprint
1.	Glaser, J. A. and Deutscher, M.P., "Introduction to Biophysical Methods for Protein and Nucleic Acid Research", Academic press.	1995
2.	Evans, J. N. S., "Biomolecular NMR spectroscopy", Oxford University Press.	1995
3.	Wuthrich, K., "NMR of Proteins and Nucleic Acids", John Wiley and Sons.	1986
4.	Campbell, I.D. and Dwek, R.A., "Biological spectroscopy", Benjamin Cummings.	1984
5.	Cantor, C.R. and Schimmel, P.R., W.H., "Biophysical chemistry, Part II and III", Freeman.	1980

M.TECH [SOLID STATE ELECTRONIC MATERIALS]

				Teaching Scheme (Hrs./Week)				Exam. Duration (Hrs.)		Relative Weightage (%)				
S. NO.	SUBJECT CODE	COURSE TITLE	SUBJECT AREA	CREDITS	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1st YEAR				I SEMESTER (AUTUMN)										
1.	MA-501F	Numerical Methods, Statistics and Probability	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	PH-701	Laboratory Work	PCC	3	0	-	6	-	6	-	50	-	-	50
3.	PH-703	Semiconductor Materials and Devices	PCC	3	3	-	-	3	-	15	-	35	50	-
4.	PH-705	Characterization of Materials	PCC	3	3	-	-	3	-	15	-	35	50	-
5.	PH-707	Computational Techniques and Programming	PCC	3	2	-	2	2	2	15	15	15	40	15
6.		Open Elective-I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
7.	HS-501	Technical Communication (Optional)		2	-	-	-	-	-	-	-	-	-	-
Sub Total				21/22										
				II SEMESTER (SPRING)										
1.		Program Elective-I	PEC	3	-	-	-	-	-	-	-	-	-	-
2.		Program Elective-II	PEC	3	-	-	-	-	-	-	-	-	-	-
3.		Program Elective-III	PEC	3	-	-	-	-	-	-	-	-	-	-
4.		Program Elective-IV	PEC	3	-	-	-	-	-	-	-	-	-	-
5.		Open Elective-II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (Optional)		2	-	-	-	-	-	-	-	-	-	-
Sub Total				17/18										
2nd YEAR				III SEMESTER (AUTUMN)										
1.	PH-801	Seminar	SEM	2	-	-	-	-	-	-	-	100	-	-
2.	PH-802	Project	RP	4	-	-	-	-	-	-	-	100	-	-
3.	PH-803	Dissertation	DIS	-	-	-	-	-	-	-	-	-	25	-
Sub Total				6										
				IV SEMESTER (SPRING)										
1.	PH-803	Dissertation	DIS	20	-	-	-	-	-	-	-	-	75	-
Sub Total				20										
Total				60/64										
Major Electives														
1.	PH-702	Nanomaterials and Technology	PEC	3	3	-	-	3	-	15	-	35	50	-
2.	PH-704	Quantum Hetrostructures	PEC	3	3	-	-	3	-	15	-	35	50	-
3.	PH-706	Functional Materials and Devices	PEC	3	3	-	-	3	-	15	-	35	50	-
4.	PH-708	Superconducting Materials	PEC	3	3	-	-	3	-	15	-	35	50	-
5.	PH-710	Solid State Devices and Circuits	PEC	3	3	-	-	3	-	15	-	35	50	-
6.	PH-712	Optoelectronics	PEC	3	3	-	-	3	-	15	-	35	50	-
7.	PH-714	Semiconductor Micro Electronic Technology	PEC	3	3	-	-	3	-	15	-	35	50	-
8.	PH-716	Semiconductor Photonics	PEC	3	3	-	-	3	-	15	-	35	50	-
9.	PH-718	Magnetic Materials and Spintronics	PEC	3	3	-	-	3	-	15	-	35	50	-
10.	PH-720	Electronic Instrumentation and Design Techniques	PEC	3	3	-	-	3	-	15	-	35	50	-

*To be continued and grade to be awarded in next semester

HS-501 : Technical Communications a 2-Credit optional course will be run by Humanities and Social Science Department.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-701** Course Title: **Laboratory**

2. Contact Hours: **L: 0 T: 0 P: 6**

3. Examination Duration (Hrs.): **Theory** 0 **Practical** 6

4. Relative Weightage: **CWS** 0 **PRS** 50 **MTE** 0 **ETE** 0 **PRE** 50

5. Credits: 3 6. Semester: **Autumn** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: **To impart practical knowledge in Solid State Electronic Materials**

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Study of variation of resistivity with temperature of metal and highly resistive materials by Four Probe Technique.	14 x 6
2.	Mapping and analysis of the resistivity of large samples (thin films, superconductors) by Four probe Technique.	
3.	To study the temperature dependence of Hall coefficient of n- and p- type semiconductors.	
4.	(a) To measure the dielectric constant and Curie temperature of given ferroelectric samples. (b) To measure the coercive field (E_c), remnant polarization (P_r), Curie temperature (T_c) and spontaneous polarization (P_s) of Barium Titanate (BaTiO_3).	
5.	Thermoluminescence in alkali halides crystals. (a) To produce F centers in the crystal exposing to X-ray /UV source. (b) To determine activation energy of the F-centers by initial rise method.	
6.	Verification of Bragg's law and determination of wavelength/energy spectrum of X-rays.	
7.	Study of solar cell characteristics and to determine open circuit voltage ' V_{oc} ', short circuit current ' I_{sc} ', Efficiency (η), fill factor, spectral characteristics and chopper characteristics.	
8.	To measure the magnetoresistance of semiconductor and analyze the plots of $\Delta R/R$ and log-log plot of $\Delta R/R$ Vs magnetic field.	
9.	To determine the coercivity, saturation magnetization and retentivity of ferromagnetic samples using magnetic hysteresis loop tracer	
10.	To study the temperature dependence of Laser diode characteristics	
11.	To determine transition temperature of given superconducting material and study Meissner effect.	
12.	To measure critical current density of given superconductor and study its field dependence.	

13	To determine the value of Lande's 'g' factor using ESR spectrometer.	
14	To study C-V characteristics of various solid state devices and materials (like p-n junctions and ferroelectric capacitors).	
Total		84

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Melissinos, A.C. and Napolitano, J., "Experiments in Modern Physics", Academic Press.	2003
2.	Sze, S.M., "Semiconductor Devices Physics and Technology", John Wiley and Sons.	2002
3.	Nakra, B.C. and Chaudhary, K.K., "Instrumentation Measurements and Analysis", Tata McGraw Hill.	2002
4.	Sayer, M. and Mansingh, A., "Measurement, Instrumentation and Experiment Design in Physics and Engineering", Prentice Hall.	2000
5.	Runyan, W.R., "Semiconductor Measurements and Instrumentation", McGraw Hill	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-703** Course Title: **Semiconductor Materials and Devices**

2. Contact Hours: **L: 3 T: 0 P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 15 **PRS** 0 **MTE** 35 **ETE** 50 **PRE** 0

5. Credits: 3

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To familiarize with semiconducting materials and devices

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Fundamentals of Semiconductors: Semiconductor materials and their properties, direct and indirect band gap semiconductors, carrier transport, excess carriers, recombination mechanisms, Haynes-Shockley experiment.	12
2.	Junctions: Homo p-n junctions, Hetero p-n junctions, metal-semiconductor contacts, laser diodes, LED.	10
3.	MOS Devices: Ideal MOS diode, inversion layer, threshold voltage, MOS C-V curve, MOSFETS, charge-coupled devices (CCD).	10
4.	Quantum Effect and Hot Electron Devices: resonant tunneling diode, Hot electron HBTs (heterojunction bipolar transmitters), real-space-transfer transistor, Gunn diode, applications.	10
Total		42

11. **Suggested Books:**

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Streetman, B.G., "Solid State Electronic Devices", Prentice Hall.	2007
2.	Sze, S.M., "Semiconductor Devices: Physics and Technology", John Wiley and Sons.	2002
3.	Tyagi, M.S., "Semiconductor Materials and Devices", John Wiley and Sons.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE:

DEPARTMENT OF PHYSICS

1. Subject Code: **PH-705**

Course Title: **Characterization of Materials**

2. Contact Hours: **L: 3**

T: 0

P: 0

3. Examination Duration (Hrs.):

Theory

3

Practical

0

4. Relative Weightage: **CWS**

15

PRS

0

MTE

35

ETE

50

PRE

0

5. Credits:

3

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective:

To introduce various methods of characterization of materials for their structural, electrical, magnetic and optical properties.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Crystal Structure Determination: Brief description of crystal lattices; X-ray diffractometer; Determination of crystal structure using X-ray diffraction	12
2.	Electron Microscopes: Brief description of different microscopes like TEM, SEM, AFM; Modes of operation of microscopes, sample preparation, Interpretation of electron diffraction and determination of crystal structure; morphology of the crystals.	11
3.	Thermal Analysis: Thermogravimetric analysis, Differential thermal analysis and Differential scanning calorimetry and methodology; Determination of phase transitions using these methods.	5
4.	Electrical and Magnetic Property: Measurement of electrical conductivity in different materials- insulators, metals and semiconductors using four probe and Hall effect method. Vibrating Sample Magnetometer (VSM), Superconducting Quantum interference Devices (SQUID)	8
5.	Optical Characterization: Optical characterization of materials using photoluminescence and UV-visible spectroscopy.	3
6.	Chemical Analysis: Brief description to X-ray fluorescence, atomic absorption and electronic spin resonance spectroscopy.	3
Total		42

11. **Suggested Books.**

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Culity, B. D., "Elements of X-ray Diffraction", Addison-Wesley.	2001
2.	Grundy, P. J. and Jones, G. A., "Electron Microscopy in the Study of Materials", Edward Arnold.	1976
3.	Egerton, R. F., "Physical Principles of Electron Microscopy", Springer.	2008
4.	Willard, H. H., Merritt, L. L. and Dean, J. A., "Instrumental Methods of Analysis", CBS publications.	1991
5.	Fultz, B. and Howe, J. M., "Transmission Electron Microscopy and Diffractometry of Materials", Springer.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-707** Course Title: **Computational Techniques and Programming**

2. Contact Hours: **L: 2 T: 0 P: 2**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 2

4. Relative Weightage: **CWS** 10 **PRS** 15 **MTE** 15 **ETE** 30 **PRE** 30

5. Credits: 3 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. **Objective of Course:** To provide the knowledge of computation with suitable mathematical software and its applications to solve the problems of condensed matter physics.

10. **Details of Course:**

S. No.	Contents	Contact Hours
1.	Introduction to mathematical software/language: Concept of programming in FORTRAN/Matlab/Mathematica, input/output, interactive input, loading and saving data, loops, branches and control flow, matrix and array operations, eigenvalues and eigenvectors.	6
2.	Sub programs: Array of dimensional variables, subroutines, sub-programming, functions sub-programming, Advantages of modular programming, built-in functions, scripts, functions, sharing of variables between modules.	5
3.	Graphics: 2D plots, style options, axis control, overlay plots, subplot, histogram, 3D plots, mesh and surface plots, contour plots.	4
4.	Numerical computation: Computer programs for: solving linear system of simultaneous equations, nonlinear algebraic equation, roots of polynomials, curve fitting, polynomial curve fitting, least square curve fitting, interpolation, data analysis and statistics. Numerical integration, Quadrature, Monte-Carlo simulation, ordinary differential equation, first order and second order ODEs, partial differential equation methods (the finite difference method & the finite element method).	13
Total		28

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Pratap, R., "Getting started with MATLAB 7", Oxford University Press.	2006
2.	Gilat, A., "Matlab: An Introduction with Applications", Wiley.	2008
3.	Tao, P., "Computational Physics", Cambridge University Press.	2005
4.	David, P., "Computational Physics", John Wiley & Sons	1973
5.	Wolfram, S., "The Mathematica Book," 5 th Ed., Wolfram Media	2003
6.	Gerald, C. F. and Wheatley, P. O., "Applied Numerical Analysis", 7 th Ed, Addison Wesley	2003

S. No.	List of Experiments
1.	Eigen-value problem: 1-D square potential well
2.	Stochastic methods for multidimensional integrals
3.	Study of systems with chaotic dynamics
4.	Solving Kronig-Penny Model
5.	Study of doping profile in semiconductors
6.	Variation of dielectric constant for composite materials
7.	Calculation of modes of an optical waveguide
8.	Monte-Carlo simulations (Ising Model of magnetism)
9.	Molecular Dynamics Simulations

**M. Tech. Civil Engineering
(Structural Engineering)**

Teaching Scheme					Contact Hours per week			Exam. Duration (Hrs.)		Relative Weightage (%)				
S. No.	Sub. Code	Course Title	Sub. Area	Crs.	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1ST YEAR					I SEMESTER (AUTUMN)									
1.	MA-501B	Numerical Analysis	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	CE-561	Computer Applications in Structural Analysis	PCC	4	3	-	2	3	-	15	15	30	40	-
3.	CE-562	Continuum Mechanics	PCC	4	3	1	-	3	-	25	-	25	50	-
4.	CE-563	Advanced Concrete Design	PCC	4	3	1	-	3	-	25	-	25	50	-
5.		Open Elective – I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				19-22										
					II SEMESTER (SPRING)									
1.		Programme Elective – I	PEC	4	-	-	-	-	-	-	-	-	-	-
2.		Programme Elective – II	PEC	4	-	-	-	-	-	-	-	-	-	-
3.		Programme Elective – III	PEC	4	-	-	-	-	-	-	-	-	-	-
4.		Programme Elective – IV	PEC	4	-	-	-	-	-	-	-	-	-	-
5.		Open Elective – II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				19-22										
2nd YEAR					III SEMESTER (AUTUMN)									
1.	CE-761	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	CE-762	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	CE-760	Dissertation	DIS	0	-	-	-	-	-	-	-	-	25	-
Sub Total				06										
					IV SEMESTER (SPRING)									
1.	CE-760	Dissertation (contd. from III Semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
Sub Total				20										
TOTAL				64-68										

PROGRAMME ELECTIVES														
1.	CE-661	Finite Element Method	PEC	4	3	-	2	3	-	15	15	30	40	-
2.	CE-662	Advanced Steel Design	PEC	4	3	1	-	3	-	25	-	25	50	-
3.	CE-663	Design of Bridge Superstructure	PEC	4	3	-	2	3	-	15	15	30	40	-
4.	CE-664	Design of Bridge Substructure	PEC	4	3	1	-	3	-	25	-	25	50	-
5.	CE-665	Design of Plates and Shells	PEC	4	3	1	-	3	-	25	-	25	50	-
6.	CE-666	Mechanics of Composite Materials	PEC	4	3	1	-	3	-	25	-	25	50	-
7.	CE-667	Structural Optimization and Risk Analysis	PEC	4	3	1	-	3	-	25	-	25	50	-

**M. Tech. Civil Engineering
(Building Technology)**

Teaching Scheme					Contact Hours per week			Exam. Duration (Hrs.)		Relative Weightage (%)				
S. No.	Sub.Code	Course Title	Sub. Area	Crs.	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1ST YEAR					I SEMESTER (AUTUMN)									
1.	MA-501B	Numerical Analysis	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	CE-561	Computer Applications in Structural Analysis	PCC	4	3	-	2	3	-	15	15	30	40	-
3.	CE-512	Analysis and Design for Dynamic Effects	PCC	4	3	1	-	3	-	25	-	25	50	-
4.	CE-513	Analysis and Design of Multistoreyed Buildings	PCC	4	3	1	-	3	-	25	-	25	50	-
5.		Open Elective – I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				19-22										
					II SEMESTER (SPRING)									
1.		Programme Elective – I	PEC	4	-	-	-	-	-	-	-	-	-	-
2.		Programme Elective – II	PEC	4	-	-	-	-	-	-	-	-	-	-
3.		Programme Elective – III	PEC	4	-	-	-	-	-	-	-	-	-	-
4.		Programme Elective – IV	PEC	4	-	-	-	-	-	-	-	-	-	-
5.		Open Elective – II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				19-22										
2nd YEAR					III SEMESTER (AUTUMN)									
1.	CE-711	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	CE-712	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	CE-710	Dissertation	DIS	0	-	-	-	-	-	-	-	-	25	-
Sub Total				06										
					IV SEMESTER (SPRING)									
1.	CE-710	Dissertation (contd. from III Semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
Sub Total				20										
TOTAL				64-68										

PROGRAMME ELECTIVES														
1.	CE-661	Finite Element Method	PEC	4	3	-	2	3	-	15	15	30	40	-
2.	CE-611	Concrete Technology	PEC	4	3	-	2	3	-	15	15	30	40	-
3.	CE-612	Construction Cost Dynamics and Management	PEC	4	3	1	-	3	-	25	-	25	50	-
4.	CE-613	Wind Engineering	PEC	4	3	-	2	3	-	15	15	30	40	-
5.	CE-614	Experimental Stress Analysis	PEC	4	3	-	2	3	-	15	15	30	40	-
6.	CE-615	Evaluation and Retrofitting of Buildings	PEC	4	3	1	-	3	-	25	-	25	50	-
7.	CE-616	Quantitative Methods and Project Financing	PEC	4	3	1	-	3	-	25	-	25	50	-

**M. Tech. Civil Engineering
(Environmental Engineering)**

Teaching Scheme					Contact Hours per week			Exam. Duration (Hrs.)		Relative Weightage (%)				
S. No.	Sub. Code	Course Title	Sub. Area	Crs.	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1ST YEAR					I SEMESTER (AUTUMN)									
1.	MA-501C	Probability and Statistics	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	CE-521	Computer Applications in Environmental Systems	PCC	4	3	1	2/2	3	-	15	15	30	40	-
3.	CE-522	Advanced Water & Wastewater Treatment	PCC	4	3	1	-	3	-	25	-	25	50	-
4.	CE-523	Environmental Chemistry	PCC	5	3	1	2	3	-	15	15	30	40	-
5.		Open Elective – I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				20-23										
II SEMESTER (SPRING)														
1.		Programme Elective – I	PEC	4	-	-	-	-	-	-	-	-	-	-
2.		Programme Elective – II	PEC	4	-	-	-	-	-	-	-	-	-	-
3.		Programme Elective – III	PEC	4	-	-	-	-	-	-	-	-	-	-
4.		Programme Elective – IV	PEC	4	-	-	-	-	-	-	-	-	-	-
5.		Open Elective – II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				19-22										
2nd YEAR					III SEMESTER (AUTUMN)									
1.	CE-721	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	CE-722	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	CE-720	Dissertation	DIS	0	-	-	-	-	-	-	-	-	25	
Sub Total				06										
IV SEMESTER (SPRING)														
1.	CE-720	Dissertation (contd. from III Semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
Sub Total				20										
TOTAL				65-69										

PROGRAMME ELECTIVES														
1.	CE-621	Air Pollution and Control	PEC	4	3	1	2/2	3	-	15	15	30	40	-
2.	CE-622	Water Quality Management	PEC	4	3	1	-	3	-	25	-	25	50	-
3.	CE-623	Solid Waste Management	PEC	4	3	1	2/2	3	-	15	15	30	40	-
4.	CE-624	Environmental Impact and Risk Assessment	PEC	4	3	1	-	3	-	25	-	25	50	-
5.	CE-625	Industrial and Hazardous Waste Management	PEC	4	3	1	-	3	-	25	-	25	50	-
6.	CE-626	Environmental Sanitation and Health	PEC	4	3	1	-	3	-	25	-	25	50	-
7.	CE-627	Environmental Economics and Legislation	PEC	4	3	1	-	3	-	25	-	25	50	-

**M. Tech. Civil Engineering
(Hydraulic Engineering)**

Teaching Scheme					Contact Hours per week			Exam. Duration (Hrs.)		Relative Weightage (%)				
S. No.	Sub. Code	Course Title	Sub. Area	Crs.	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1ST YEAR					I SEMESTER (AUTUMN)									
1.	MA-501E	Optimization Techniques	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	CE-551	Hydrological Modeling and Simulation	PCC	4	3	1	-	3	-	25	-	25	50	-
3.	CE-552	Advanced Fluid Mechanics	PCC	4	3	1	2/2	3	-	15	15	30	40	-
4.	CE-553	Free Surface Flows	PCC	4	3	1	-	3	-	25	-	25	50	-
5.		Open Elective – I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				19-22										
					II SEMESTER (SPRING)									
1.		Programme Elective – I	PEC	4	-	-	-	-	-	-	-	-	-	-
2.		Programme Elective – II	PEC	4	-	-	-	-	-	-	-	-	-	-
3.		Programme Elective – III	PEC	4	-	-	-	-	-	-	-	-	-	-
4.		Programme Elective – IV	PEC	4	-	-	-	-	-	-	-	-	-	-
5.		Open Elective – II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				19-22										
2nd YEAR					III SEMESTER (AUTUMN)									
1.	CE-751	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	CE-752	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	CE-750	Dissertation*	DIS	-	-	-	-	-	-	-	-	-	25	-
Sub Total				6										
					IV SEMESTER (SPRING)									
1.	CE-750	Dissertation (continued from III Semester)	DIS	20									75	
Sub Total				20										
TOTAL				64-68										

*Note: To be continued and grade to be awarded in the next semester.

PROGRAMME ELECTIVES														
1.	CE-651	Fluvial Hydraulics	PEC	4	3	1	-	3	-	25	-	25	50	-
2.	CE-652	Embankment Dams	PEC	4	3	1	-	3	-	25	-	25	50	-
3.	CE-653	Systems Engineering	PEC	4	3	1	-	3	-	25	-	25	50	-
4.	CE-654	Ground Water Engineering	PEC	4	3	1	-	3	-	25	-	25	50	-
5.	CE-655	Water Resources Systems Planning	PEC	4	3	1	-	3	-	25	-	25	50	-
6.	CE-656	Irrigation and Drainage	PEC	4	3	1	-	3	-	25	-	25	50	-
7.	CE-657	Hydro Power Engineering	PEC	4	3	1	-	3	-	25	-	25	50	-
8.	CE-658	Computational Methods in Fluid Mechanics	PEC	4	3	1	-	3	-	25	-	25	50	-

**M. Tech. Civil Engineering
(Computer Aided Design)**

Teaching Scheme					Contact Hours per week			Exam. Duration (Hrs.)		Relative Weightage (%)				
S. No.	Sub. Code	Course Title	Sub. Area	Crs.	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1 ST YEAR					I SEMESTER (AUTUMN)									
1.	MA-501C	Probability and Statistics	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	CE-581	Advanced Programming and Computer Graphics	PCC	4	3	-	2	3	-	15	15	30	40	-
3.	CE-582	Expert Systems, Neural Networks and Fuzzy Systems	PCC	4	3	1	-	3	-	25	-	25	50	-
4.	CE-541	Advanced Numerical Analysis	PCC	4	3	-	2	3	-	15	15	30	40	-
5.		Open Elective – I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				19-22										
II SEMESTER (SPRING)														
1.		Programme Elective – I	PEC	4										
2.		Programme Elective – II	PEC	4										
3.		Programme Elective – III	PEC	4										
4.		Programme Elective – IV	PEC	4										
5.		Open Elective – II	OEC	3/4	*	*	*	*	*	*	*	*	*	*
6.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				19-22										
2nd YEAR					III SEMESTER (AUTUMN)									
1.	CE-781	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	CE-782	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	CE-780	Dissertation	DIS	0	-	-	-	-	-	-	-	-	25	
Sub Total				06										
IV SEMESTER (SPRING)														
1.	CE-780	Dissertation (contd. from III Semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
Sub Total				20										
TOTAL				64-68										

PROGRAMME ELECTIVES

Any four programme electives from any one of Building Technology / Environmental Engineering / Geomatics Engineering / Geotechnical Engineering / Hydraulic Engineering / Structural Engineering / Transportation Engineering disciplines.

Building Technology

1.	CE-661	Finite Element Method	PEC	4	3	-	2	3	-	15	15	30	40	-
2.	CE-611	Concrete Technology	PEC	4	3	-	2	3	-	15	15	30	40	-
3.	CE-612	Construction Cost Dynamics and Management	PEC	4	3	1	-	3	-	25	-	25	50	-
4.	CE-613	Wind Engineering	PEC	4	3	-	2	3	-	15	15	30	40	-
5.	CE-614	Experimental Stress Analysis	PEC	4	3	-	2	3	-	15	15	30	40	-
6.	CE-615	Evaluation and Retrofitting of Buildings	PEC	4	3	1	-	3	-	25	-	25	50	-
7.	CE-616	Quantitative Methods and Project Financing	PEC	4	3	1	-	3	-	25	-	25	50	-

Contd.....

Environmental Engineering														
1.	CE-621	Air Pollution and Control	PEC	4	3	1	2/2	3	-	15	15	30	40	-
2.	CE-622	Water Quality Management	PEC	4	3	1	-	3	-	25	-	25	50	-
3.	CE-623	Solid Waste Management	PEC	4	3	1	2/2	3	-	15	15	30	40	-
4.	CE-624	Environmental Impact and Risk Assessment	PEC	4	3	1	-	3	-	25	-	25	50	-
5.	CE-625	Industrial and Hazardous Waste Management	PEC	4	3	1	-	3	-	25	-	25	50	-
6.	CE-626	Environmental Sanitation and Health	PEC	4	3	1	-	3	-	25	-	25	50	-
7.	CE-627	Environmental Economics and Legislation	PEC	4	3	1	-	3	-	25	-	25	50	-
Geomatics Engineering														
1.	CE-631	Theory and Applications of GIS	PEC	4	3	-	2	3	-	15	15	30	40	-
2.	CE-632	Multi and Hyper Spectral Data Processing Techniques	PEC	4	3	-	2	3	-	15	15	30	40	-
3.	CE-633	Geodesy and GPS Surveying	PEC	4	3	-	2	3	-	15	15	30	40	-
4.	CE-634	Thermal & Microwave Remote Sensing	PEC	4	3	-	2	3	-	15	15	30	40	-
5.	CE-635	Analytical & Digital Photogrammetry	PEC	4	3	-	2	3	-	15	15	30	40	-
6.	CE-636	Remote Sensing for Land Use Analysis and Urban Planning	PEC	4	3	-	2	3	-	15	15	30	40	-
7.	CE-637	Remote Sensing for Water Resources and Hydrology	PEC	4	3	-	2	3	-	15	15	30	40	-
8.	CE-638	Satellite Geodesy	PEC	4	3	-	2	3	-	15	15	30	40	-
9.	CE-639	Geomatics Tools for Disaster Management	PEC	4	3	-	2	3	-	15	15	30	40	-
Geotechnical Engineering														
1.	CE-641	Advanced Foundation Engineering	PEC	4	3	1	2/2	3	-	15	15	30	40	-
2.	CE-642	Stability Analysis of Slopes	PEC	4	3	1	-	3	-	25	-	25	50	-
3.	CE-643	Soil Dynamics and Machine Foundations	PEC	4	3	1	-	3	-	25	-	25	50	-
4.	CE-644	Design of Underground Excavations	PEC	4	3	1	-	3	-	25	-	25	50	-
5.	CE-645	Ground Improvement Engineering	PEC	4	3	1	-	3	-	25	-	25	50	-
6.	CE-646	Foundations on Weak Rocks	PEC	4	3	1	-	3	-	25	-	25	50	-
Hydraulic Engineering														
1.	CE-651	Fluvial Hydraulics	PEC	4	3	1	-	3	-	25	-	25	50	-
2.	CE-652	Embankment Dams	PEC	4	3	1	-	3	-	25	-	25	50	-
3.	CE-653	Systems Engineering	PEC	4	3	1	-	3	-	25	-	25	50	-
4.	CE-654	Ground Water Engineering	PEC	4	3	1	-	3	-	25	-	25	50	-
5.	CE-655	Water Resources Systems Planning	PEC	4	3	1	-	3	-	25	-	25	50	-
6.	CE-656	Irrigation and Drainage	PEC	4	3	1	-	3	-	25	-	25	50	-
7.	CE-657	Hydro Power Engineering	PEC	4	3	1	-	3	-	25	-	25	50	-
8.	CE-658	Computational Methods in Fluid Mechanics	PEC	4	3	1	-	3	-	25	-	25	50	-

Contd.....

Structural Engineering														
1.	CE-661	Finite Element Method	PEC	4	3	-	2	3	-	15	15	30	40	-
2.	CE-662	Advanced Steel Design	PEC	4	3	1	-	3	-	25	-	25	50	-
3.	CE-663	Design of Bridge Superstructure	PEC	4	3	-	2	3	-	15	15	30	40	-
4.	CE-664	Design of Bridge Substructure	PEC	4	3	1	-	3	-	25	-	25	50	-
5.	CE-665	Design of Plates and Shells	PEC	4	3	1	-	3	-	25	-	25	50	-
6.	CE-666	Mechanics of Composite Materials	PEC	4	3	1	-	3	-	25	-	25	50	-
7.	CE-667	Structural Optimization and Risk Analysis	PEC	4	3	1	-	3	-	25	-	25	50	-
Transportation Engineering														
1.	CE-671	Advanced Highway Materials and Construction	PEC	4	3	1	2/2	3	-	15	15	30	40	-
2.	CE-672	Intersection Design and Analysis	PEC	4	3	1	0	3	-	25	-	25	50	-
3.	CE-673	Pavement Evaluation and Management	PEC	4	3	1	0	3	-	25	-	25	50	-
4.	CE-674	Urban Mass Transit Systems	PEC	4	3	1	0	3	-	25	-	25	50	-
5.	CE-675	Highway Geometric Design	PEC	4	3	1	0	3	-	25	-	25	50	-
6.	CE-676	Traffic Flow Theory and Management	PEC	4	3	1	0	3	-	25	-	25	50	-
7.	CE-678	Transportation Systems Analysis	PEC	4	3	1	0	3	-	25	-	25	50	-
8.	CE-679	Traffic Engineering and Transportation Planning	PEC	4	3	1	2/2	3	-	15	15	30	40	-

M. Tech. Civil Engineering
(Geotechnical Engineering)

Teaching Scheme					Contact Hours per week			Exam. Duration (Hrs.)		Relative Weightage (%)				
S. No.	Sub.Code	Course Title	Sub. Area	Crs.	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1ST YEAR					I SEMESTER (AUTUMN)									
1.	MA-501C	Probability and Statistics	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	CE-541	Advanced Numerical Analysis	PCC	4	3	-	2	3	-	15	15	30	40	-
3.	CE-542	Advanced Soil Mechanics	PCC	4	3	1	2/2	3	-	15	15	30	40	-
4.	CE-543	Engineering Behaviour of Rocks	PCC	4	3	1	2/2	3	-	15	15	30	40	-
5.		Open Elective – I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				19-22										
					II SEMESTER (SPRING)									
1.		Programme Elective – I	PEC	4	-	-	-	-	-	-	-	-	-	-
2.		Programme Elective – II	PEC	4	-	-	-	-	-	-	-	-	-	-
3.		Programme Elective – III	PEC	4	-	-	-	-	-	-	-	-	-	-
4.		Programme Elective – IV	PEC	4	-	-	-	-	-	-	-	-	-	-
5.		Open Elective – II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				19-22										
2nd YEAR					III SEMESTER (AUTUMN)									
1.	CE-741	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	CE-742	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	CE-740	Dissertation	DIS	0	-	-	-	-	-	-	-	-	25	-
Sub Total				06										
					IV SEMESTER (SPRING)									
1.	CE-740	Dissertation (contd. from III Semester)		20	-	-	-	-	-	-	-	-	75	-
Sub Total				20										
TOTAL				64-68										

PROGRAMME ELECTIVES

1.	CE-641	Advanced Foundation Engineering	PEC	4	3	1	2/2	3	-	15	15	30	40	-
2.	CE-642	Stability Analysis of Slopes	PEC	4	3	1	-	3	-	25	-	25	50	-
3.	CE-643	Soil Dynamics and Machine Foundations	PEC	4	3	1	-	3	-	25	-	25	50	-
4.	CE-644	Design of Underground Excavations	PEC	4	3	1	-	3	-	25	-	25	50	-
5.	CE-645	Ground Improvement Engineering	PEC	4	3	1	-	3	-	25	-	25	50	-
6.	CE-646	Foundations on Weak Rocks	PEC	4	3	1	-	3	-	25	-	25	50	-

**M. Tech. Civil Engineering
(Transportation Engineering)**

Teaching Scheme					Contact Hours/Week			Exam Duration (hrs.)		Relative Weights (%)				
S. No.	Sub.Code	Course Title	Sub. Area	Crs	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE

1st Year I SEMESTER (AUTUMN)

1.	MA-501C	Probability and Statistics	ICC	4	3	1	0	3	-	25	-	25	50	-
2.	CE-571	Transportation Modeling and Simulation	PCC	4	3	0	2	3	-	15	15	30	40	-
3.	CE-572	Pavement Analysis and Design	PCC	4	3	1	0	3	-	25	-	25	50	-
4.	CE-573	Planning, Design and Construction of Rural Roads	PCC	4	3	1	0	3	-	25	-	25	50	-
5.		Open Elective – I	OEC	3/4	*	*	*	*	*	*	*	*	*	*
6.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub total				19-22										

II SEMESTER (SPRING)

1.		Programme Elective – I	PEC	4										
2.		Programme Elective – II	PEC	4										
3.		Programme Elective – III	PEC	4										
4.		Programme Elective – IV	PEC	4										
5.		Open Elective – II	OEC	*	*	*	*	*	*	*	*	*	*	*
6.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub total				19-22										

2nd Year III SEMESTER (AUTUMN)

1.	CE-771	Seminar	SEM	2									100	
2.	CE-772	Project	RP	4									100	
3.	CE-770	Dissertation*	DIS										25	
Sub Total				6										

IV SEMESTER (SPRING)

1.	CE-770	Dissertation (continued from III semester)	DIS	20									75	
Sub Total				20										
TOTAL				64-68										

* NOTE – To be continued and grade to be awarded in the next semester.

PROGRAMME ELECTIVES:

1.	CE-671	Advanced Highway Materials and Construction	PEC	4	3	1	2/2	3	-	15	15	30	40	-
2.	CE-672	Intersection Design and Analysis	PEC	4	3	1	0	3	-	25	-	25	50	-
3.	CE-673	Pavement Evaluation and Management	PEC	4	3	1	0	3	-	25	-	25	50	-
4.	CE-674	Urban Mass Transit Systems	PEC	4	3	1	0	3	-	25	-	25	50	-
5.	CE-675	Highway Geometric Design	PEC	4	3	1	0	3	-	25	-	25	50	-
6.	CE-676	Traffic Flow Theory and Management	PEC	4	3	1	0	3	-	25	-	25	50	-
7.	CE-678	Transportation Systems Analysis	PEC	4	3	1	0	3	-	25	-	25	50	-
8.	CE-679	Traffic Engineering and Transportation Planning	PEC	4	3	1	2/2	3	-	15	15	30	40	-

**M. Tech. Civil Engineering
(Geomatics Engineering)**

Teaching Scheme					Contact Hours/Week			Exam Duration (hrs.)		Relative Weights (%)				
S-NO.	Sub.Code	Course Title	Sub. Area	Crs.	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
Ist YEAR					I SEMESTER (AUTUMN)									
1.	MA-501E	Optimization Techniques	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	CE-531	Modelling and Analysis of Geo-spatial Data	PCC	4	3	-	3	3	-	15	15	30	40	-
3.	CE-532	Principles of Surveying and Photogrammetry	PCC	4	3	-	3	3	-	15	15	30	40	-
4.	CE-533	Basic Remote Sensing and Digital Image Processing	PCC	4	3	-	3	3	-	15	15	30	40	-
5.	CE-535*	Field Survey Camp	PCC	2	-	-	-	-	-	-	100	-	-	-
6.		Open Elective – I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
7.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				21-24										
* Field Survey Camp of 14 days duration during Winter Vacations.														
					II SEMESTER (SPRING)									
1.		Programme Elective – I	PEC	4	-	-	-	-	-	-	-	-	-	-
2.		Programme Elective – II	PEC	4	-	-	-	-	-	-	-	-	-	-
3.		Programme Elective – III	PEC	4	-	-	-	-	-	-	-	-	-	-
4.		Programme Elective – IV	PEC	4	-	-	-	-	-	-	-	-	-	-
5.		Open Elective – II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (optional)		2	1	0	2	2	-	15	15	30	40	-
Sub Total				19-22										
2nd YEAR					III SEMESTER (AUTUMN)									
1.	CE-731	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	CE-732	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	CE-730	Dissertation	DIS	0	-	-	-	-	-	-	-	-	25	-
Sub Total				06										
					IV SEMESTER (SPRING)									
1.	CE-730	Dissertation (contd. from III semester)	DIS	20									75	
Sub Total				20										
TOTAL				66-70										
P PROGRAMME ELECTIVES														
1.	CE-631	Theory and Applications of GIS	PEC	4	3	-	2	3	-	15	15	30	40	-
2.	CE-632	Multi and Hyper Spectral Data Processing Techniques	PEC	4	3	-	2	3	-	15	15	30	40	-
3.	CE-633	Geodesy and GPS Surveying	PEC	4	3	-	2	3	-	15	15	30	40	-
4.	CE-634	Thermal & Microwave Remote Sensing	PEC	4	3	-	2	3	-	15	15	30	40	-
5.	CE-635	Analytical & Digital Photogrammetry	PEC	4	3	-	2	3	-	15	15	30	40	-
6.	CE-636	Remote Sensing for Land Use Analysis and Urban Planning	PEC	4	3	-	2	3	-	15	15	30	40	-
7.	CE-637	Remote Sensing for Water Resources and Hydrology	PEC	4	3	-	2	3	-	15	15	30	40	-
8.	CE-638	Satellite Geodesy	PEC	4	3	-	2	3	-	15	15	30	40	-
9.	CE-639	Geomatics Tools for Disaster Management	PEC	4	3	-	2	3	-	15	15	30	40	-

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: CE-571

Course Title: Transportation Modelling and Simulation

2. Contact Hours:

L: 3

T: 0

P: 2

3. Examination Duration (Hrs.):

Theory

3

Practical

0

4. Relative Weightage: CWS

15

PRS

15

MTE

30

ETE

40

PRE

0

5. Credits:

4

6. Semester: Autumn

7. Subject Area: PCC

8. Pre-requisite: Nil

9. Objective: To introduce modelling and simulation approaches related to transportation engineering.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Transportation simulation and modelling, decision making, issues in transport modelling, structure of transport models.	4
2.	Multivariate Data Analysis Techniques: Types of data, basic vectors and matrices, sample estimate of centroid, standard deviation, dispersion, variance and covariance, correlation matrices, principal component, factor analysis, manova and cross classification procedure in multivariate data analysis and application to problems in traffic and transportation planning, best fit analysis, distribution analysis.	8
3	Simulation: Elements and attributes, random number generation, pseudo random number generation, cycle repeatability, feedback & evaluation, evaluation of system performance, marginal & corridor simulation, gaming simulation.	6
4.	Data and Spacing: Sampling theory, errors in modelling and forecasting, data collection methods, network and zoning system.	4
5.	Discrete Choice Models: Theoretical framework, specification and functional form of models, statistical estimation and validation of models, binary choice, multinomial and nested logic models, modeling with stated preference data, model aggregation, updating and transferability.	10
6.	Simplified Transport Models: Sketch planning method, model estimation from traffic count.	4
7.	Time Series Analysis of Transportation Problems: Basic components of time series - stationary and non-stationary process, smoothening and decomposition methods, correlation and line spectral diagrams, auto correlations and moving averages, application to transportation problems.	6
	Total	42

List of Experiments:

- i) Modeling of traffic system by linear and non-linear curve fitting
- ii) Fitting of probability distribution for headways and gaps
- iii) Random number generation for sampling households for personal interview survey.
- iv) Stepwise regression analysis for trip generation model
- v) Shortest time estimation of discrete choice models
- vi) Maximum likelihood estimation of discrete choice models
- vii) Forecasting traffic accidents by time series analysis

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Ortuzar de, D.O. and Willumsen, L.G., "Modelling Transport", John Wiley.	1993
2.	Banks, J., Carson, J.S. and Nelson, B.L., "Discrete Event System Simulation", Prentice-Hall.	1998
3.	Ben-Akiva, M. and Lerman, S.R., "Discrete Choice Analysis: Theory and Application to Travel Demand", MIT Press.	1985
4.	Hutchinson, B.G., "Principles of Urban Transport Systems Planning", SCRIPTA Book Company.	1974
5.	Joseph, F.H., Jr., William, C.B., Barry, J.B. and Rolph, E.A., "Multivariate Data Analysis", Prentice Hall.	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code: **CE-572** Course Title: **Pavement Analysis and Design**

2. Contact Hours: **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge on analysis and design of highway pavements.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Components of pavement structure, importance of subgrade soil properties on pavement performance, functions of subgrade, sub-base, base course and wearing course.	6
2.	Stresses in Flexible Pavements: Analysis for stresses in homogeneous masses and layered systems, deflections, shear failures, equivalent wheel and axle loads.	6
3.	Elements in Design of Flexible Pavements: Loading characteristics-static, impact and repeated loads, effects of dual wheels and tandem axles, area of contact and tyre pressure, modulus or California Bearing Ratio (CBR) for different layers, equivalent single wheel load, equivalent stress and equivalent deflection criterion, equivalent wheel load factors, climatic and environmental factors.	6
4.	Design Methods for Flexible Pavements: CBR adopted in various countries, U.S. navy method, triaxial method, Mcleod method, Boussinesq's and Burmister's analysis and design method, triaxial method, design of flexible pavements, IRC method for flexible pavement design.	6
5.	Analysis and Design of Rigid Pavements: Wheel load stresses, liquid and elastic soil subgrade, Westergaard's analysis, Bradbury's approach, Arlington test, Pickett's corner load theory and related charts.	6
6.	Temperature Stresses: Westergaard's and Tomlinson's analysis of warping stresses, combination of stresses due to different causes, effect of temperature variation on rigid pavements.	6
7.	Reinforced Concrete Slabs: Prestressed concrete slabs-general details, design of tie bars and dowel bars.	6
Total		42

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Yoder, E.J. and Witzak, M.W., "Principles of Pavement Design", John Wiley.	1975
2.	O'Flaherty, A.C., "Highways : The Location, Design, Construction and Maintenance of Road Pavements", Elsevier.	2006
3.	Fwa, T.F., "The Hand Book of Highway Engineering", CRC Press Taylor & Francis.	2006
4.	Khanna, S.K. and Justo, C.E.G., "Highway Engineering", Nem Chand Jain & Bros.	2005
5.	Papagiannakis, A.T. and Masad, E.A., "Pavement Design and Materials", John Wiley.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: CE- 573

Course Title: Planning, Design and Construction of Rural Roads

2. Contact Hours:

L: 3

T: 1

P: 0

3. Examination Duration

Theory

3

Practical

0

4. Relative weight

CWS

25

PRS

0

MTE

25

ETE

50

PRE

0

5. Credits:

4

6. Semester: Autumn

7. Subject Area: PCC

8. Prerequisite: NIL

9. Objective: To introduce concepts of planning, geometric design, pavement design, construction and maintenance of rural roads.

10. Details of the Course.

S. No.	Contents	Contact hours
1.	Planning of Rural Roads: Classification of roads, brief introduction to earlier 20 year plans, system's approach, NATPAC model, gravity model, CRRRI model, Facility Based Rural Network Planning (FBRNP) model, concept of PMGSY.	8
2.	Geometric Design: Geometric design standards for rural roads with special reference to PMGSY, hill road standards.	4
3.	Pavement Design: Various pavement design methods for rural roads including flexible and rigid pavements using IRC:SP-20, IRC-72, IRC-37, IRC:SP-62, CRRRI nomograms.	4
4.	Mix Design Methods: CRRRI method, triangular chart method, Fuller's method, Rothfuch method, PI based method.	6
5.	Materials: Conventional materials, marginal and waste materials including fly ash, Granular Blast Furnace Slag (GBFS), Blast Furnace Slag (BFS), Steel Making Slag (SMS), bagasse and Crum Rubber Modified Binder (CRMB), etc.	6
6.	Construction: Low cost techniques for rural road construction, tractor bound technology, special considerations for hill areas; Case studies of waste material utilization in rural roads	6
7.	Drainage: Transverse and longitudinal drainage, design of drains, minor cross drainage works, filter design etc.	4
8.	Maintenance: Type and causes of failures, remedies.	4
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	"Rural Roads Manual", SP-20, IRC.	2002
2.	"Document on Rural Road Development", Vol. I & II, CRRRI.	1990
3.	"PMGSY Operation Manual", NRRDA.	2005
4.	"Specifications for Rural Roads", MoRD, IRC.	2004
5.	Khanna, S.K. and Justo, C.E.G., "Highway Engineering", Nem Chand & Bros.	2004
7.	Kadiyali, L.R., "Traffic Engineering and Transport Planning", Khanna Publishers.	1999
8.	"Quality Assurance Handbook for Rural Roads", NRRDA.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code: **CE- 671** Course Title: **Advanced Highway Materials and Construction**

2. Contact Hours: **L: 3 T: 1 P: 2/2**

3. Examination Duration **Theory** 3 **Practical** 0

4. Relative weight **CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Prerequisite: **NIL**

9. Objective: To introduce the advances in traffic engineering and to make the students conversant with travel demand modeling using four-stage sequential transportation planning.

10. Details of the Course.

S. No.	Contents	Contact hours
1.	Aggregates: Classification, physical and strength characteristics, proportioning of aggregates, aggregate texture and skid resistance, polishing of aggregates.	6
2.	Soil: Classification, structural and constructional problems in soil subgrade, identification and strength tests, soil-moisture movement, sub-soil drainage, soil stabilization	6
3.	Bitumen: Bitumen sources and manufacturing, bitumen constituents, structure and rheology, mechanical and engineering properties of bitumen, tests on bitumen, emulsions – properties, types, modifications, durability of bitumen, adhesion of bitumen, modified bitumen.	10
4.	Bituminous Mixes: Desirable properties of mixes, design of bituminous mixes, tests on bituminous mixes, fillers, theory of fillers and specifications	6
5.	Cement Concrete: Constituents and their requirements, physical, plastic and structural properties of concrete, factors influencing mix design, design of concrete mixes	6
6.	Road Construction: Bituminous road construction procedures and specifications, quality control requirements. concrete road construction: construction methods, quality control requirements, joints in cement concrete pavements, reinforced cement concrete road construction.	8
	Total	42

Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Krebs, R.D. and Walker, R.D., "Highway Materials", McGraw Hill Book Co.	1971
2.	Her Majesty's Stationery Office, "Soil Mechanics for Road Engineers", Ministry of Transport, Road Research Laboratory.	1966
3.	Her Majesty's Stationery Office, "Bituminous Materials in Road Construction", Ministry of Transport, Road Research Laboratory.	1966
4.	Her Majesty's Stationery Office, "Concrete Roads Design and Construction", Ministry of Transport, Road Research Laboratory.	1966
5.	Read, J. And Whiteoak, D., "The Shell Bitumen Handbook", Shell Bitumen, Thomas Telford Publishing.	2003
6.	Relevant IRC and IS Codes.	

List of Practicals:

- Identification tests on soils (attemburg limits); heavy compaction test on subgrade soil
- Triaxial test on pure subgrade soil
- Aggregate polishing and skid resistance test (demonstration); GSB mix design
- Test for aggregate durability; preparation of mix for SDBC
- Elastic recovery test on binder
- Marshall bituminous mix design, rheometer test
- Bitumen viscosity test (rotational viscometer); retained stability test
- Concrete mix design

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code: **CE-672** Course Title: **Intersection Design and Analysis**

2. Contact Hours: **L: 3 T: 1 P: 0**

3. Examination Duration **Theory** **Practical**

4. Relative weightage **CWS** **PRS** **MTE** **ETE** **PRE**

5. Credits: 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Prerequisite: **NIL**

9. Objective of Course: To discuss various methods of design and analysis of different types of road intersections and interchanges.

10. Details of Course

Sl. No.	Contents	Contact hours
1.	Types of intersections, principles of design, types of maneuvers, relative speed, conflict points and area.	6
2.	Intersection geometrics and their influence on design/operation.	3
3.	Operational analysis of two-way and all-way stop controlled intersections and roundabouts by US and Indian methods, mini roundabouts.	6
4.	Analysis of signal controlled intersections by US, British and Swedish methods, delay and its evaluation.	12
5.	Types of signals, Design of signals by Indian, US and British methods, signal coordination.	6
6.	Grade separated intersections and interchanges.	4
7.	Weaving sections and their operational evaluation.	3
8.	Intersection signs, marking and lighting.	2

Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Papacostas, C.S. and Prevedouros, P.D., "Transportation Engineering and Planning", Prentice Hall of India Private Limited.	2001
2.	Mannering, F.L., Walter, P.K. and Scott, S.W., "Principles of Highway Engineering and Traffic Analysis", Wiley India Edition.	2007
3.	Jotin, K.C. and Kent, L.B., "Transportation Engineering", Prentice Hall of India Private Limited.	2006
4.	Flaherty, C.A.O., "Transport Planning and Traffic Engineering", Hodder Headline Group.	1997
5.	Transportation Research Board, "Highway Capacity Manual of US", National Research Council.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code: **CE-673** Course Title: **Pavement Evaluation and Management**

2. Contact Hours: **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge related to evaluation and management with respect to road development.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Pavement Evaluation and Performance: General concept of pavement evaluation, evaluation of pavement performance, evaluation of pavement structural capacity, evaluation of pavement distress, evaluation of pavement safety.	6
2.	Types of Distress: Structural and functional, serviceability, fatigue cracking, pavement deformation and low temperature shrinkage cracking, factors affecting performance, relation between performance and distress.	6
3.	Pavement Evaluation and Measuring Equipments: Functional and structural evaluation, functions parameters such as roughness, distress, rutting, skid resistance etc. structural parameters such as structural capacity, benkelman beam, bump integrator, dynaflect, demonstration of equipments for dynamic testing of pavements, digital ultrasonic concrete tester, pavement skid resistance measuring equipments, fatigue testing equipments.	8
4.	Pavement Overlays: Flexible overlays and determination of overlay thickness. rigid overlays and determination of overlay thickness, design of overlay by benkelman beam and falling weight deflectometer.	8
5.	Design Alternatives – Analysis, Evaluation and Selection: Framework for pavement design, design objectives and constraints, basic structural response models, characterization of physical design inputs, generating alternative pavement design strategies. economic evaluation of alternative pavement design strategies, analysis of alternative design strategies, predicting distress, predicting performance, selection of optimal design strategies.	8
6.	Pavement Management System: Introduction to pavement management system (PMS) & maintenance management system (MMS), construction, maintenance and rehabilitation, feedback data system, examples of working design and management systems, implementation of a pavement management system.	6
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Hass, R., Hudson, W.R. and Zaniewski, J., "Modern Pavement Management", Krieger.	1994
2.	Fwa, T.F., "The Hand Book of Highway Engineering", CRC Press, Taylor & Francies Group.	2006
3.	Shain, M.Y., "Pavement Management for Airports, Roads and Parking Lots", Kluwer Academic Publishers Group.	2004
4.	Khanna, S.K. and Justo, C.E.G., "Highway Engineering", Nem Chand & Bros.	2005
5.	Hudson, W.R., Haas, R. and Uddin, W., "Infrastructure Management", McGraw Hill.	1997
6.	Hass, R. and Hudson, W.R., "Pavement Management System", McGraw Hill Company, Inc.	1978

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code: **CE-674**

Course Title: **Urban Mass Transit Systems**

2. Contact Hours:

L: 3 T: 1 P: 0

3. Examination Duration

Theory 3 **Practical** 0

4. Relative weight CWS 25

PRS 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4

6. Semester: **Spring** 7. Subject Area: **PEC**

8. Prerequisite: **NIL**

9. Objective: To introduce the students to urban mass transit systems, their types, suitability, planning, operation and management aspects.

10. Details of the Course.

S. No.	Contents	Contact hours
1.	Introduction: Mass transit systems, elements / components of transit systems; Urban mass transit systems, types, characteristics, suitability and adaptability of these systems; Evolution of urban transportation.	3
2.	Transit System Planning: Planning needs; Short-range and long-range planning; Planning procedures and methodology, data collection; Medium performance transit systems and high-performance transit systems; Trends in transit planning.	8
3.	Transit Demand Estimation and Evaluation: Transit demand forecasting; Transit mode evaluation; Comparison and selection of most suitable transit mode.	10
4.	Transit System Operations: Basic operational elements; Transit travel characteristics; Transit scheduling; Transit line analysis – planning objectives, geometry, types and their characteristics, capacity of transit lines, system procedures for improving transit line capacity.	9
5.	Transit Networks and System Analysis: Transit networks – types and their characteristics; Transfers in transit networks; System analysis in transit – conceptual models, modeling procedures; Terminal or station location planning – issues, objectives, station spacing decisions.	6
6.	Economics and Financing of Transit Systems: Transit system performance and economic measures; Transit fares – structure, collection and levels; Financing of transit services; Public and private integration of transit services.	6
Total		42

Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Vukan, R.V., "Urban Transit – Operations, Planning and Economics", John Willey and Sons, Inc.	2004
2.	John, W.D. and others, "Metropolitan Transportation Planning", Tata McGraw-Hill Book Company Ltd.	1980
3.	O'Flaherty, C.A., "Transport Planning and Traffic Engineering", Butterworth-Heinemann, Burlington.	2006
4.	Khisty, C.J. and Kent, B.L., "Transportation Engineering", Prentice-Hall of India Pvt Ltd.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: CE-675

Course Title: Highway Geometric Design

2. Contact Hours:

L: 3

T: 1

P: 0

3. Examination Duration (Hrs.):

Theory

3

Practical

0

4. Relative Weightage: CWS

25

PRS

0

MTE

25

ETE

50

PRE

0

5. Credits:

4

6. Semester: Spring

7. Subject Area: PEC

8. Pre-requisite: Nil

9. Objective: To introduce different techniques of highway geometric design.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Design Control and Criteria: Topography and physical features, traffic, impact of vehicular characteristics on road geometrics, speed and safety.	4
2.	Cross-section Elements: Single lane, two lane, four lane, six lane highways, expressways, freeways.	6
3.	Highway Capacity: Two lane, four lane, six lane non-urban highways, urban roads, expressways, freeways, HCM, USA.	8
4.	Sight Distance: Analysis of stopping and passing sight distance, discussion of factors involved, IRC recommendations for measuring sight distance.	4
5.	Horizontal Alignment: Horizontal curve design, maximum curvature, superelevation rates, transition curves, attainment of superelevation, pavement widening, sight distance on horizontal curves.	8
6.	Vertical Alignment: Gradients, compensation of grade at curves, design of climbing lanes, shape of vertical curves, design of summit and valley curves, design of speed breaker, combination of horizontal and vertical alignment.	6
7.	Design of Parking: Demand analysis, parking space configuration and requirements, onstreet and offstreet layout, multilevel parking, automatic/semi-automatic parking structures.	6
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Books / Publisher	Year of Publication/ Reprint
1.	Wright, P.H. and Dixon, K.K., "Highway Engineering", John Wiley & Sons.	2004
2.	Transportation Research Board (TRB), Highways Capacity Manual, National Research Council.	2000
3.	Khisty, C.J. and Lal, B.K., "Transportation Engineering An Introduction", Prentice Hall of India Pvt. Ltd.	2006
4.	Kadiyali, L.R., "Traffic Engineering and Transport Planning", Khanna Publishes.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: CE-676

Course Title: Traffic Flow Theory and Management

2. Contact Hours:

L: 3

T: 1

P: 0

3. Examination Duration (Hrs.):

Theory

3

Practical

0

4. Relative Weightage: CWS

25

PRS

0

MTE

25

ETE

50

PRE

0

5. Credits:

4

6. Semester: Spring

7. Subject Area: PEC

8. Pre-requisite: Nil

9. Objective: To introduce different aspects of traffic flow theory and management approaches.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Components of Traffic Flow System: The vehicle, the driver, the road, driver behaviour, circulation system.	8
2.	Traffic Research and Mathematical Modelling: Probability models, randomness in traffic flow modeling, headways and gaps.	12
3.	Queuing Processes: Queuing theory models for various aspects of traffic flow and operations, single server FIFO system, multiserver FIFO system, case studies.	6
4.	Theories of Traffic Flow: Heat flow analogy, fluid flow analogy, hydrodynamic kinematic theory of flow, shockwaves, bottleneck car following models.	8
5.	Management Techniques: Regulator management, speed control & zoning, traffic segregation, sign design, universal signs.	4
6.	Signalisation: Design-cycle phase, turn-control signal, pedestrian signal, co-ordination of signals, filter signals, area traffic control.	4
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Drew, D.R., "Traffic Flow Theory and Control", McGraw-Hill Book Company.	1968
2.	May, A.D., "Fundamentals of Traffic Flow", Prentice Hall, Inc.	1990
3.	Leutzbach, W., "Introduction to the Theory of Traffic Flow", Springer-Verlag.	1988
4.	Kadiyali, L.R., "Traffic Engineering and Transport Planning", Khanna Publishers.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: CE- 678

Course Title: Transportation Systems Analysis

2. Contact Hours:

L: 3 T: 1 P: 0

3. Examination Duration

Theory 3

Practical 0

4. Relative weight: CWS 25

PRS 0

MTE 25

ETE 50

PRE 0

5. Credits: 4

6. Semester: Spring

7. Subject Area: PEC

8. Prerequisite: NIL

9. Objective: To introduce the students to the analysis of different transportation systems, their components, operations, systems analysis approaches and economics.

10. Details of the Course.

S. No.	Contents	Contact hours
1.	Introduction: Scope of transportation and impact on society; System planning process and problem solving process; Transportation problems.	6
2.	Transportation Technologies: Transportation technologies, suitability and adaptability; Transportation system components; Transportation system characteristics – technological and operational; Path – vehicle interaction; Volume – density relationship for containers.	10
3.	Analysis of Systems: Generation of alternatives; Performance evaluation of system and performance functions; Operational planning and analysis of components; Transportation network analysis and minimum path algorithms; Travel in space and time; Planning for non-motorized transportation; Freight transportation planning–models and methods; Residential location choice models, car-ownership models; Transportation software.	12
4.	Transportation Economics: Transportation demand and supply; equilibrium between supply and demand, transportation system equilibrium; Elasticity – direct and cross; Concept of consumer surplus; Transport demand models – sketch planning, incremental demand model, transportation cost, travel – market equilibrium.	8
5.	Sustainable Transportation Planning: Sustainable transportation – issues and principles; Non-motorized transportation planning; Impact evaluation and impact models.	6
Total		42

Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication/ Reprint
1.	Marvin, L., "Fundamentals of Transportation Systems Analysis", The MIT Press.	1980
2.	Adib, K., "Transportation Demand Analysis", McGraw Hill Inc.	1983
3.	Steenbrink, P.A., "Optimization of Transport Network", John Wiley & Sons.	1974
4.	Konstadinos, G.G., "Transportation System Planning – Methods and Applications", CRC Press.	2002

5.	Khisty, C.J. and Kent, B.L., "Transportation Engineering – An Introduction", Prentice Hall of India Pvt Ltd.	2003
6.	Thomas, A.D. and McFadden, D., "Urban Travel Demand – A Behavioural Analysis", North-Holland Publishing Company.	1975

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: CE- 679

Course Title: Traffic Engineering and Transportation Planning

2. Contact Hours:

L: 3 T: 1 P: 2/2

3. Examination Duration

Theory

3

Practical

0

4. Relative weight:

CWS

15

PRS

15

MTE

30

ETE

40

PRE

0

5. Credits:

4

6. Semester: Spring

7. Subject Area: PEC

8. Prerequisite: NIL

9. Objective: To introduce the advances in traffic engineering and to make the students conversant with travel demand modeling using four-stage sequential transportation planning.

10. Details of the Course.

S. No.	Contents	Contact hours
Traffic Engineering		
1.	Introduction to Traffic Engineering: Elements of traffic engineering, issues for traffic engineers; Travel demand and its patterns; System of facilities; Components of traffic system – road users, vehicles, highways and control devices.	3
2.	Traffic Stream Characteristics and Design: Traffic stream parameters, characteristics of interrupted and uninterrupted flows; Traffic studies – volume studies, speed, travel time and delay studies, parking studies, pedestrian studies; Statistical analysis and design; Capacity analysis concepts – urban streets and rural highways.	12
3.	Miscellaneous: Traffic calming; congestion and road user pricing; Priority movements; Traffic regulations and control systems; Use of intelligent systems and information systems.	5
Transportation Planning		
4.	Introduction to Transportation Planning: Fields of transportation engineering; System-environment ensemble; Transportation planning process; Transportation data and surveys.	3
5.	Four-stage Sequential Planning: Urban transportation planning process; Trip generation, correlation analysis and regression analysis; Trip distribution, growth factor methods and synthetic methods; Modal split models, first generation, second generation, behavioural models; Minimum travel path computations; Trip assignments, route assignment, multiple assignment and network assignment.	15
6.	Land Use-Transportation Planning: Urban forms, mobility and activity hierarchy; Accessibility-based early-era models; Lowery's model and its derivatives; Modern era models.	4
Total		42

Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	William, R.M. and Roger, P.R., "Traffic Engineering", Prentice Hall.	1998
2.	Theodore, M.W., Wilber, S.S. and Fredrick, W.H., "Traffic Engineering", McGraw-Hill Book Company, Inc.	1955
3.	Hobbs, F.D., "Traffic Planning and Engineering", Pergamon Press.	1979
4.	Hutchinson, B.G., "Principles of Urban Transport Systems Planning", Scripta Book Co.	1974
5.	Anthony, J.R., Elizabeth, S.A. and Arnim, H.M., "Survey Methods for Transport Planning", Eucalyptus Press.	1995
6.	Thomas, R., "Traffic Assignment Techniques", Avebury Technical, Aldershot.	1991
7.	O'Flaherty, C.A., ed, "Transport Planning and Traffic Engineering", Butterworth Heinemann, Elsevier.	2006
8.	Khisty, C.J. and Kent, B.L., "Transportation Engineering – An Introduction", Prentice Hall of India Pvt Ltd.	2003

List of Practicals:

- Classified volume count at one location on a national highway
- Spot speed study at a location on a national highway using radar speedometer
- Parking survey at a major off-street parking facility
- Travel time study by a license plate method on a 3 to 4 km stretch of a national highway
- Design and conduct of a personal interview survey
- Step-wise regression analysis using statistical software for trip generations
- Modal split model development using MLE based software
- Assignment of the trips observed between different zones in an area
- Development of a land use – transport plan for a given area

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code: **CE-561** Course Title: **Computer Applications in Structural Analysis**

2. Contact Hours: **L: 3 T: 0 P: 2**

3. Examination Duration (Hrs): **Theory 3 Practical 0**

4. Relative Weightage: **CWS 15 PRS 15 MTE 30 ETE 40 PRE 0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To develop applications of computer methods for structural analysis of linear and nonlinear structural frameworks.

10. Details of the course:

S. No.	Contents	Contact Hours
1.	Need of computer applications in structural analysis, introduction to software packages like STAAD, SAP and MATLAB.	4
2.	Static and kinematic indeterminacy, stiffness and flexibility matrices.	4
3.	Stiffness matrices for prismatic and non prismatic members, solution techniques, substructure analysis techniques.	8
4.	Application to problems of plane truss, space truss, beams, grids, plane frames and space frames subjected to various in-plane / out of plane loadings including effects of temperature change and support displacements.	8
5.	Techniques of nonlinear structural analysis, material and geometric nonlinear problems, incremental and iterative procedures, convergence criteria.	8
6.	Application of software packages such as SAP and STAAD, development of software codes for simple structural analysis problems using MATLAB.	10
Total		42

List of Experiments :

- i) Development of software codes by using MATLAB etc. for the linear analysis of :
 - a. Plane/Space Trusses
 - b. Plane/Space Frames.
- ii) Use of softwares (STAAD and SAP etc.) for the analysis of :
 - a. Plane/Space Trusses
 - b. Plane/Space Frames
 - c. Practical Problems.

1. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Weaver, W., Jr. and Gere, J.M., "Matrix Analysis of Framed Structures", CBS.	2004
2.	McGuire, H.G. and Ziemian, R.D., "Matrix Structural Analysis", John Wiley.	2000
3.	Jain, A.K., "Advanced Structural Analysis with Finite Element and Computer Applications", Nem Chand & Bros.	2006
4.	Wang, C.K., "Intermediate Structural Analysis", McGraw-Hill.	1983
5.	Bansal, R.K., Goel, A.K. and Sharma, M.K., "MATLAB and its Application in Engineering", Pearson.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code: **CE-562** Course Title: **Continuum Mechanics**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs): **Theory** 3 **Practical** 0
4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0
5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective: To develop understanding of analysis of stress and strains, stress-strain relations and elasto-plastic behavior of materials.
10. Details of the course:

S. No.	Contents	Contact Hours
1.	Vector and tensor algebra, linearization and directional derivatives.	3
2.	Stress and equilibrium, analysis for stresses, translational and rotational equilibrium, principal stresses and principal planes in 3D, stress invariants, Cauchy and Kirchhoff stress tensor, deviatoric and volumetric components, work conjugacy, octahedral and Von-Mises stresses.	8
3.	Kinematics, linearized kinematics, strain quadric of Cauchy, principal strains, invariants, equations of compatibility, finite deformation, material (Lagrangian) and spatial (Eulerian) descriptions, deformation gradient, polar decomposition, volume change, distortional component of deformation gradient, area change.	8
4.	Equations of elasticity, Hooke's law, generalized Hooke's law, anisotropic, orthotropic and isotropic elasticity tensor.	7
5.	Plane stress and strain problems, Airy stress functions for two-dimensional problems, Airy stress function in polar coordinates, isotropic hyper elasticity, three-dimensional elasticity.	6
6.	Elasto-plastic behavior of materials; Material yield criteria - Von-Mises, Tresca, Mohr-Coulomb, Ducker-Pager; Isotropic and kinematic hardening, normality principle, plastic flow rule, plastic potential, elasto-plastic stress-strain relations, Prandtl-Rauss equations, Levy-Mises relations, hardening modulus, generalized elasto-plastic stress-strain relations.	10
Total		42

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Sokolnikoff, I.S., "Mathematical Theory of Elasticity", Tata McGraw-Hill.	1956
2.	Timoshenko, S.P. and Goodier, J.N., "Theory of Elasticity", McGraw-Hill.	1993
3.	Chakrabarty, J., "Theory of Plasticity", Elsevier.	2008
4.	Fung, Y.C., "Foundations of Solid Mechanics", Prentice-Hall.	1977

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code: **CE-563** Course Title: **Advanced Concrete Design**
 2. Contact Hours: **L: 3 T: 1 P: 0**
 3. Examination Duration (Hrs): **Theory** 3 **Practical** 0
 4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0
 5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**
 8. Pre-requisite: **Nil**

9. Objective: To develop understanding of nonlinear behavior of concrete elements, ductile detailing and prestressed concrete design.

10. Details of the course:

S. No.	Contents	Contact Hours
1.	Limit state design philosophy, codal recommendations for limit state design, performance based design concept, constitutive modelling of concrete and steel, basic material properties of concrete and steels, fire effects on concrete and concepts of fire severity and fire resistance.	6
2.	Redistribution of moments in continuous span beams, plastic hinge concept, rotation capacity of sections, design of sections.	6
3.	Yield line theory for slabs, equilibrium and virtual work methods.	4
4.	Shrinkage and creep, analysis for stresses in compression and flexural members.	4
5.	Shear wall and coupled shear wall, beam-column joints, detailing for ductility, design consideration for ductility.	6
6.	Limit state design criteria for prestressed concrete members, prestressing of continuous beams, partial and circular prestressing.	6
7.	Strut and tie models, analysis and design of deep beams, design for shear by compression field theory.	6
8.	Application of software such as ABAQUS etc.	4
Total		42

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprints
1.	Klight, J.K. and MacGregor, J.G., "Reinforced Concrete Mechanics and Design", Pearson.	2009
2.	Nilson, A.H., "Design of Concrete Structures", Tata McGraw-Hill.	2005
3.	Jain, A.K., "Reinforced Concrete-Limit State Design", Nem Chand & Bros.	2002
4.	Park, R. and Paulay, T., "Reinforced Concrete Structures", John-Wiley.	1975

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code: **CE-662** Course Title: **Advanced Steel Design**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs): **Theory 3 Practical 0**
4. Relative Weightage: **CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the concepts of stability of components, analysis and design of steel structures and thin walled sections

10 Details of the course:

S. No.	Contents	Contact Hours
1.	Concept of stability, buckling and nonlinear behavior of braces, columns, beam-columns and frames.	8
2.	Lateral instability of beams, local buckling and post buckling behavior of plates.	6
3.	Limit state design and salient features of IS:800 and Eurocode EC3.	2
4.	Behavior and design of cold formed thin walled structures.	8
5.	Bolted, riveted, welded and semi rigid connections including failure modes.	8
6.	Brittle fracture, fatigue and fire effects	6
7.	Example problems on multi-storeyed and pre-engineered steel buildings using softwares such as SAP and STAAD etc.	4
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprints
1.	Arya, A.S. and Ajmani, J.L., "Design of Steel Structures", Nem Chand & Bros.	2004
2.	Englekirk, R., "Steel Structures Controlling Behavior Through Design", John Wiley & Sons.	2003
3.	Subramanian, N., "Design of Steel Structures", Oxford University Press.	2009
4.	Trahair N.S., Bradford, M.A., "The Behavior and Design of Steel Structures to EC3", Taylor & Frances.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code: **CE-663** Course Title: **Design of Bridge Superstructure**
2. Contact Hours: **L: 3 T: 0 P: 2**
3. Examination Duration (Hrs): **Theory** 3 **Practical** 0
4. Relative Weightage: **CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the concepts of analysis and design of bridge superstructure
10. Details of the course:

S. No.	Contents	Contact Hours
1.	Development of bridge form, types of bridges, selection criteria, specification for single, double and multi lane road bridges, IRC and railway loadings, wind and seismic loads.	6
2.	Computer modeling of multi-lane simply supported and continuous bridges and piers, bearing arrangements, application of softwares like SAP etc.	6
3.	Effective width concepts and load distribution in T-beam bridges, grillage analysis, solid and voided slabs, application of softwares like STAAD etc.	6
4.	Analysis and design of multi-lane prestressed concrete T-beam bridge superstructure.	6
5.	Design of box girder bridges and introduction to cable stayed bridges.	4
6.	Analysis of orthotropic steel bridge decks, analysis and design of two-lane steel truss bridge superstructure.	6
7.	Different types of bearings, design of elastomeric bearings.	4
8.	Secondary effects; temperature, shrinkage, creep and construction techniques.	4
Total		42

List of Experiments :

- a. Modeling and analysis of Multi-Lane Simply Supported and continuous Bridges using SAP & STAAD
- b. Application of Microstation / AutoCad in preparation of drawings

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Raina, V.K., "Concrete Bridge Practice: Analysis, Design & Economics", SPD.	1999
2.	Kishna Raju, N., "Prestressed Concrete Bridges", Publishers & Distributors.	2006
3.	Chen, W.F. and Duan, L., "Bridge Engineering", Hand Book, CRC Press.	2000
4.	Bridge Design Specifications, Caltrans.	2004
5.	Seismic Design Criteria, Caltrans.	2006
6.	Bridge Design Manual, Precast/Prestressed Concrete Institute.	2006
7.	Priestley, M.J.N., Seible, F. and Calvi, G.M., "Seismic Design and Retrofit of Bridges", John Wiley & Sons.	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code: **CE-664** Course Title: **Design of Bridge Substructure**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs): **Theory 3 Practical 0**
4. Relative Weightage: **CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the concepts of analysis and design of bridge substructure
10. Details of the course:

S. No.	Contents	Contact Hours
1.	Estimation of design discharge, scour depth, waterway, type and depth of foundation, IRC 78.	4
2.	Piers and abutments for bridges, design loads, uncracked and cracked section analysis, hammerhead and portal-type piers, modeling and design of pier caps, design of wall-type and spill-through abutments, design of seismic restrainers.	8
3.	Deep foundations for bridges, features and characteristics of well foundations, preliminary sizing of a well foundation, analysis of well foundation as per IRC 45, design and detailing of the components of a well foundation, construction issues related to well foundations, tilting and shift.	16
4.	Types of pile foundations, under-reamed and bored cast-in-situ piles, analysis of pile groups for vertical loads, lateral loads and moments, analysis and design of pile caps, construction issues related to pile foundations, IS:2911.	14
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Swaran, S., "Analysis and Design of Substructures", Limit State Design, Oxford & IBH Publishing Co. Pvt. Ltd.	2002
2.	Ponnuswamy, S., "Bridge Engineering", Tata McGraw-Hill.	2006
3.	Rakshit, K.S., "Design and Construction of Highway Bridges", New Central Book Agency.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: **CE-665** Course Title: **Design of Plates and Shells**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs): **Theory 3 Practical 0**
4. Relative Weightage: **CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the concepts of analysis and design of plates and shells, design of cooling towers, silos and bunkers
10. Details of the course:

S. No.	Contents	Contact Hours
1.	Classification of plates, governing equations, boundary conditions, analysis of rectangular and circular plates.	8
2.	Grid floor as orthotropic plate, buckling of plates, design criteria and code specification.	5
3.	Classification of shells, membrane and bending theory for shells of revolution, axisymmetric and non-axisymmetric loadings, buckling of shells.	10
4.	Membrane and bending theory of cylindrical shells, edge beams, doubly curved shells, design of hyperbolic shells.	8
5.	Analysis and design of folded plates.	5
6.	Cooling towers, silos, bunkers, codal specifications, computer applications.	6
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Timoshenko, S.P. and Woinowsky-Krieger, S., "Theory of Plates and Shells", McGraw-Hill.	1959
2.	Reddy, J.N., "Theory and Analysis of Elastic Plates", Taylor & Francis Ltd.	2006
3.	Chatterjee, B.K., "Theory and Design of Concrete Shells", Chapman and Hall.	1988
4.	Kelker, V.S. and Sewell, R.T., "Fundamentals of the Analysis and Design of Shell Structures", Prentice Hall International.	1987

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code: **CE-666** Course Title: **Mechanics of Composite Materials**

2. Contact Hours: **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs): **Theory 3 Practical 0**

4. Relative Weightage: **CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the concepts of mechanics of composite materials and design of laminated composite plates

10. Details of the course:

S. No.	Contents	Contact Hours
1.	Introduction-classification and characteristics of composite materials, basic terminology, uses of fibrous composites.	5
2.	Behavior of lamina stress-strain relationship for anisotropic, orthotropic and isotropic material, transformation of elastic constants, failure criteria for an orthotropic lamina, introduction to micromechanics: law of mixture.	10
3.	Behavior of laminate classical lamination theory, stress-strain relationship for a laminate, extensional, bending and coupling stiffness.	10
4.	Different configurations and corresponding stiffness, strength of laminates, interlaminar stresses, shear deformation theories.	8
5.	Behavior and analysis of laminated plates subjected to bending, buckling and vibrations.	5
6.	Introduction to behavior of thin walled laminated structures and sandwich constructions, examples on practical applications.	4
Total		42

11. Suggested Books:

S. No.	Name of Books /Authors / Publisher	Year of Publication/ Reprint
1.	Jones R. M., "Mechanics of Composite Materials", Taylor & Francis Ltd.	1999
2.	Agarwal, B.D. and Broutman, L.J., "Analysis and Performance of Fiber Composites", John Wiley.	1990
3.	Daniel O. and Ishai I.M., "Engineering Mechanics of Composite Materials", Oxford University Press.	2005
4.	Reddy, J.N. and Miravete, A., "Practical Analysis of Composite Laminates", CRC Press.	1995
5.	Kollar, L.P. and Springer, G.S., "Mechanics of Composite Structures", Cambridge University Press.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF Civil Engineering**

1. Subject Code: **CE-667** Course Title: **Structural Optimization and Risk Analysis**

2. Contact Hours: **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs): **Theory 3 Practical 0**

4. Relative Weightage: **CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the concepts of structural optimization techniques and risk analysis of structures

10. Details of the course:

S. No.	Contents	Contact Hours
1.	General optimization procedures and features of mathematical programming techniques along with risk based constraints.	4
2.	Gradient methods, neural network method, concepts of genetic algorithm and fuzzy logic.	6
3.	Minimum weight and optimum cost considerations in structural design, minimum weight design of trusses.	6
4.	Reliability concepts in engineering, elementary algebra of reliability, safety viewpoints, parallel and series systems, fail safe, component and system reliability, system reliability computations as applicable to structural systems.	9
5.	Classical, special and simulation methods, probabilistic design of simple structural components for specified risk accepted a-priorie.	8
6.	Risk analysis using matrix method along with first order secant moment method, automatic generation of stochastically dominant mechanism of R.C.C. frames, cost effective reliability and optimum risk analysis.	9
Total		42

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication/ Reprint
1.	Tsompanakis, Y., Lagaros, N.D. and Papadrakakis, M., "Structural Design Optimization Considering Uncertainties", Taylor & Francis Group.	2008
2.	Adeli, H., "Advances in Design Optimization", Chapman and Hall.	1994
3.	Kirsch, U., "Optimum Structural Design, Concepts, Methods and Applications", McGraw-Hill.	1990
4.	Rao, S.S., "Optimization Theory and Applications", Wiley Eastern Limited.	1984

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code: **CE-661** Course Title: **Finite Element Method**
2. Contact Hours: **L: 3 T: 0 P: 2**
3. Examination Duration (Hrs): **Theory 3 Practical 0**
4. Relative Weightage: **CWS 15 PRS 15 MTE 30 ETE 40 PRE 0**
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the concepts of finite element analysis of structures, application of finite elements in solid mechanics and structural dynamics
10. Details of the course:

S. No.	Contents	Contact Hours
1.	Basic Concepts, Discretization: Displacement, force and hybrid models, interpolation functions for general element formulations, compatibility and completeness.	3
2.	Polynomial Forms: One dimensional elements, geometric isotropy, triangular elements, rectangular elements, three dimensional elements, isoparametric formulations, axisymmetric elements, numerical integration.	10
3.	Applications in Solid Mechanics: Plane stress/strain, FE formulation, CST, LST, stiffness matrix, load matrix formation rectangular element isoparametric formulation, plate elements and shell elements, three dimensional elements FE formulation, axisymmetric stress analysis, torsion, interface elements, infinite elements.	12
4.	Application in Structural Dynamics and Vibrations: Mass (consistent and diagonal) and damping matrices, modal analysis, time history analysis, explicit direct integration/implicit direct integration and mixed methods.	5
5.	Introduction to Nonlinear Problems: Geometric and material (elasto-plastic), solution methods, Newton-Raphson method, modified Newton-Raphson method, arc method, a problem of geometric nonlinearity.	5
6.	Stationary Principles: Rayleigh Ritz method and interpolation, weighted residual methods and variational methods, numerical errors and convergence.	4
7.	Application of softwares: Such as ABAQUS and ANSYS.	3
Total		42

List of Experiments:

- (i) Development of software codes using MATLAB for the analysis of plane stress/Plane strain problems
- (ii) Introduction to analysis packages (ABAQUS/ANSYS etc.) and their application for the analysis of
 - a. Trusses
 - b. Frames
 - c. Plane stress/plane strain problems
 - d. Plates
 - e. Shells.

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication/ Reprint
1.	Bathe, K.J., "Finite Element Procedures", Prentice-Hall of India Private Limited.	2002
2.	Cook, R.D., Malkus, D.S. and Plesha, M.E., "Concepts and Applications of Finite Element Analysis", John Wiley & Sons.	2007
3.	Zeinkwicz, O.C., "The Finite Element Method", Tata McGraw-Hill.	2005
4.	Reddy, J.N., "An Introduction to Finite element Method", McGraw- Hill.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code : **CE-541** Course Title : **Advanced Numerical Analysis**
2. Contact Hours : L: 3 T: 0 P: 2
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage : CWS 15 PRS 15 MTE 30 ETE 40 PRE 0
5. Credits : 4 6. Semester : **Autumn** 7. Subject Area : **PCC**
8. Pre-requisite : **Nil**
9. Objective: To impart knowledge of various numerical techniques for solving the problems of civil engineering.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Roots of a non-linear equation and roots of n^{th} degree polynomial; Incremental search method, method of successive approximations, Newton's method, bisection method, secant method, Müller's method, synthetic division and Bairstow's method; Convergence study.	10
2.	Solution of Non-homogeneous Linear Algebraic Equations: Gauss elimination method, Choleski's decomposition method, householder method, Gauss-Siedal iterative method.	6
3.	Solution of Non-Linear Algebraic Equations: Method of successive approximation, Newton's method, modified Newton-Raphson method, secant method.	4
4.	Eigen Value Problems: Eigen values and Eigen vectors, reduction of generalized Eigen value problem to the standard Eigen value problem, methods for obtaining Eigen values and Eigen vectors; Polynomial method, vector iteration method, Mises power method and Jacobi method; Application to problems of vibration analysis and buckling analysis.	8
5.	Time Marching Schemes: Solution of dynamic problems in time domain, numerical integration, explicit and implicit methods; Application to problems to portal frames and creep.	4
6.	Solution of Ordinary and Partial Differential Equations: Euler's method, Runge-Kutta method, finite difference method, method of weighted residuals such as collocation, least square and Galerkin's methods; Application to problems of beams and plates on elastic foundation, Laplacian equation for seepage, consolidation equation and laterally loaded piles.	10
Total		42

Laboratory Practicals:

Development of algorithms/codes for different problems such as:

- i) Solution of linear simultaneous equations
- ii) Solution of non-linear simultaneous equations
- iii) Solution of Eigen value problems
- iv) Explicit and implicit integration schemes for solution of problems of creep
- v) Finite difference analysis of problems of:
 - a. Finite beams on elastic foundations
 - b. Plates on elastic foundations
 - c. Laterally loaded piles
 - d. Laplacian and consolidation equations.

1.1. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Chapra, S.C. and Canale, R.P., "Numerical Methods for Engineers", Tata McGraw Hill.	2003
2.	Carnahan, B., Luther, H.A. and Wilkes, J.O., "Applied Numerical Methods", John Wiley.	1969
3.	Heath, M.T., "Scientific Computing : An Introductory Survey", Tata McGraw Hill.	1997
4.	Faires, D.J. and Richard, B., "Numerical Methods", Thomson.	2003
5.	Rajasekaran, S., "Numerical Methods in Science and Engineering", S. Chand.	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code : **CE-542** Course Title : **Advanced Soil Mechanics**
2. Contact Hours : **L: 3 T: 1 P: 2/2**
3. Examination Duration (Hrs.) : **Theory** 3 **Practical** 0
4. Relative Weightage : **CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0
5. Credits : 4
6. Semester : **Autumn**
7. Subject Area : **PCC**
8. Pre-requisite : Nil
9. Objective: To impart advanced knowledge of mechanics governing the behaviour of soils and particulate media.
10. Details of Course :

S. No.	Contents	Contact Hours
1.	Fundamental aspects of soil mechanics, characteristics of soils, particulate nature, weight-volume relationship.	2
2.	Flow of water through soils, permeability, flownets.	2
3.	Theory of elasticity; Plane stress, plane strain and axi-symmetric problems.	5
4.	Pore water pressure, undrained loading, determination of pore water pressure parameters.	5
5.	Consolidation, Terzaghi's 1-D consolidation theory, layered soils, time dependent loading, two dimensional problems, three dimensional consolidation, axisymmetric problems, vertical drains; Creep/secondary consolidation and rheological models; Kelvin, Maxwell, Burgers, generalized Kelvin and generalized Maxwell models.	9
6.	Shear strength, stresses in soils, Mohr's circle, stress paths, UU, CU, CD tests, drained and undrained stress-strain relationships and shear strength.	8
7.	Critical state theory, normal consolidation line, critical state line, Roscoe surface, Hvorslev surface, no tension line.	4
8.	Constitutive laws for soils; Bi-linear, parabolic and hyperbolic models; Mohr-Coulomb, Drucker-Prager and critical state models.	7
Total		42

Laboratory Experiments:

- i) Determination of relative density of sands
- ii) Determination of shear strength parameters of soft clays by vane shear test
- iii) Determination of compression index and coefficient of consolidation of clays by Oedometer test
- iv) Determination of shear strength parameters of cohesionless soils by direct shear test
- v) Determination of shear strength parameters of soils under UU, CU, CD conditions by triaxial compression tests.

1 1. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Das, B.M., "Advanced Soil Mechanics", Taylor & Francis.	1983
2.	Lambe, T.W. and Robert, W.V., "Soil Mechanics", John Wiley.	2000
3.	Craig, R.F., "Soil Mechanics", Chapman & Hall.	1993
4.	Suklje, L., "Rheological Aspects of Soil Mechanics", John Wiley.	1969
5.	Terzaghi, K. and Peck, R.B., "Soil Mechanics in Engineering Practice", John Wiley.	1967
6.	Davis, R.O. and Selvadurai, E.P.S., "Elasticity and Geomechanics", Cambridge University Press.	1995
7.	Atkinson, J.H. and Bransby, P.L., "The Mechanics of Soils : An Introduction to Critical State Soil Mechanics", McGraw Hill.	1978

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code : **CE-543** Course Title : **Engineering Behaviour of Rocks**

2. Contact Hours : **L: 3 T: 1 P: 2/2**

3. Examination Duration (Hrs.) : **Theory 3 Practical 0**

4. Relative Weightage : **CWS 15 PRS 15 MTE 30 ETE 40 PRE 0**

5. Credits : **4** 6. Semester : **Autumn** 7. Subject Area : **PCC**

8. Pre-requisite : **Nil**

9. Objective: To impart knowledge of basic mechanics governing the behaviour of rocks and rock masses.

10. Details of Course :

S. No.	Contents	Contact Hours
1.	Introduction, basic terminology, development of rock mechanics, activities and applications of rock mechanics and rock engineering.	3
2.	Properties of intact rocks; Uniaxial compressive strength (UCS) tests, factors affecting UCS, preparation of test specimens, modes of failure, stress-strain curves, post failure behaviour.	6
3.	Uniaxial tensile strength; Direct methods, indirect methods, miscellaneous methods.	2
4.	Single shear, double shear, punching shear, direct shear and oblique shear tests, triaxial strength tests; Coulomb's theory, Mohr's envelopes and p-q plots.	4
5.	Strength criteria for intact rocks; Coulomb-Navier, Griffith, Mcclintock and Walsh criteria; Empirical failure criteria by Bieniawski, Hoek and Brown, Ramamurthy and Singh and Singh.	8
6.	Geological and geotechnical classification of intact rocks, classification of jointed rocks; Terzaghi, Deere, RQD, RMR and Q systems; Joint factor (J_f) concept, RMI and GSI classification systems; Strength behaviour of jointed rocks.	8
7.	Deformational behaviour of jointed rocks, computation of modulus of deformation through RMR, Q, GSI and J_f ; Constitutive modelling.	7
8.	Flow through jointed rock mass, hydraulic conductivity and flow nets, ground water flow in fractured rocks, field tests for hydraulic conductivity.	4
Total		42

Laboratory Practicals:

- i) Prediction of physical properties for intact rocks
- ii) Determination of uniaxial compression and indirect tensile strength
- iii) Point load strength index tests for uniaxial compressive strength
- iv) Triaxial compression tests on intact rock specimens
- v) Oblique shear test on rock specimen
- vi) Ultrasonic testing of rocks for wave propagation velocity
- vii) Determination of permeability of intact rocks
- viii) Determination of shear strength parameters of rocks from field shear test device
- ix) Prediction of joint wall compressive strength by Schmidt hammer test.

1.1. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication / Reprint
1.	Hudson, J.A. and John, H.P., "Engineering Rock Mechanics - An Introduction to the Principles", Elsevier.	2000
2.	Jaeger, J.C. and Cook, N.G.W., "Fundamentals of Rock Mechanics", Mathew.	1979
3.	Singh, B. and Goel, R.K., "Rock Mass Classification- A Practical Engineering Approach", Elsevier.	2006
4.	Hoek, E., "Practical Rock Engineering", Rock Science.	2000
5.	Ramamurthy, T., "Engineering in Rocks", PHI.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code : **CE-641** Course Title : **Advanced Foundation Engineering**

2. Contact Hours : **L: 3 T: 1 P: 2/2**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 3

4. Relative Weightage : **CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0

5. Credits : 4 6. Semester : **Spring** 7. Subject Area : **PEC**

8. Pre-requisite : **Nil**

9. Objective: To impart knowledge of methods of analysis and design of various foundations.

10. Details of Course :

S. No.	Contents	Contact Hours
1.	Planning of soil exploration for different projects, methods of subsurface exploration, methods of borings along with various penetration tests	5
2.	Shallow foundations, requirements for satisfactory performance of foundations, methods of estimating bearing capacity, settlements of footings and rafts, proportioning of foundations using field test data, IS codes, pressure – settlement characteristics from constitutive laws	6
3.	Pile foundations, methods of estimating load transfer of piles, settlements of pile foundations, pile group capacity and settlement, laterally loaded piles, pile load tests, analytical estimation of load-settlement behaviour of piles, proportioning of pile foundations, lateral and uplift capacity of piles	6
4.	Well foundation, IS and IRC codal provisions, elastic theory and ultimate resistance methods	5
5.	Tunnels and arching in soils, pressure computations around tunnels	4
6.	Open cuts, sheeting and bracing systems in shallow and deep open cuts in different soil types	6
7.	Coffer dams, various types, analysis and design	3
8.	Foundations under uplifting loads	4
9.	Soil-structure interaction	3
Total		42

11. Laboratory Practicals:

Exploratory borings by different methods including auger boring, wash boring, percussion drilling and rotary drilling etc followed by - planning of soil exploration for different projects, standard penetration tests, dynamic cone penetration tests, static cone penetration tests, plate load tests, load tests on piles

1 2. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Bowles, J.E., "Foundation Analysis and Design", Mc-Graw Hill.	1996
2.	Das, B.M., "Principles of Foundation Engineering", PWS Publishing.	1998
3.	Som, N.N. and Das, S.C., "Theory and Practice of Foundation Design", Prentice Hall.	2003
4.	Poulos, H.G. and Davis, F.H., "Pile Foundation Analysis and Design", Wiley and Sons.	1980
5.	Saran, S., "Analysis and Design of Substructures", Oxford and IBH.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code : **CE-642** Course Title: **Stability Analysis of Slopes**
2. Contact Hours : **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0
4. Relative Weightage : **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0
5. Credits : 4 6. Semester : **Spring** 7. Subject Area : **PEC**
8. Pre-requisite : **Nil**
9. Objective: Landslides is a very common phenomenon in hilly regions and results in loss of life and property. The course is designed to identify various modes of failures and study their safety aspects including provision of remedial measures.
10. Details of Course :

S. No.	Contents	Contact Hours
1.	Introduction, classification of natural slopes and excavation failures, slope stability – mechanics of slope failure, failure modes	4
2.	Collection and analysis of geological data, field survey and testing, graphical presentation of geological data and evaluation of potential slope problems	6
3.	Seepage analysis, in-situ permeability tests, two dimensional flow – Laplace equation and it's solution, graphical method, determination of phreatic line, flow nets in homogeneous and zoned earth dams under steady seepage and draw-down conditions, seepage control in earth dams, influence of seepage on slope stability	6
4.	Soil slopes, infinite slope, method of slices, friction circle methods etc., Bishop's modified method, Bishop's rigorous method, Janbu's method, Morgenstern and Price, Spencer's method, stability analysis of dam body during steady seepage	8
5.	Rock slopes, methods of slope stability analysis, plane failure, wedge failure, over toppling failure, Hoek & Bray's charts, three dimensional wedge analysis, seismic considerations, computer programs, use of non-linear failure criterion in rock slope stability analysis	10
6.	Strengthening measures, stabilization of slopes by drainage methods, surface and subsurface drainage, use of synthetic filters, retaining walls, stabilization and strengthening of slopes, shotcreting, rock bolting and rock anchoring	6
7.	Instrumentation and monitoring of slopes, slope movements, warning devices, maintenance of slopes	2
Total		42

1 1. Laboratory Practicals : NIL

1 2. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Hoek, E. and Bray, J.W., "Rock Slope Engineering", Institution of Mining Engineering.	1981
2.	Giani, G.P., "Rock Slope Stability Analysis", A.A. Balkema.	1992
3.	Wyllie, D.C. and Christofer, W.M., "Rock Slope Engineering", Spon Press, Taylor and Francis Group.	2004
4.	Singh, B. and Goel, R.K., "Software for Engineering Control of Landslides and Tunneling Hazards", A.A. Balkema.	2002
5.	Harr, M.E., "Ground Water and Seepage", McGraw Hill.	1962
6.	Chowdhary, R. and Chowdhary, I., "Geotechnical Slope Analysis", CRC Press.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code : **CE-643** Course Title: **Soil Dynamics and Machine Foundations**

2. Contact Hours : **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.): **Theory 3 Practical 0**

4. Relative Weightage : **CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

5. Credits : **4** 6. Semester : **Spring** 7. Subject Area : **PEC**

8. Pre-requisite : **Nil**

9. Objective: To impart to students the basic knowledge in theory of vibrations and behaviour of soils under dynamic loads so that foundations for various types of machines could be designed.

10. Details of Course :

S. No.	Contents	Contact Hours
1.	Theory of vibrations, single, two and multiple degree of freedom systems, vibration isolation, vibration absorbers, vibration measuring instruments.	10
2.	Strength characteristics, factors affecting, philosophy of design of equipments, studies by dynamic tri-axial and oscillatory shear equipments.	6
3.	Liquefaction, mechanism, factors affecting, studies by dynamic tri-axial testing, oscillatory shear box, shake table and blast tests, assessment of liquefaction potential.	6
4.	Dynamic earth pressure, analytical and graphical methods, displacement analysis of retaining walls, seismic stability of slopes : modified Swedish circle and Taylor's method, concept of yield acceleration and evaluation of displacement of embankment.	6
5.	Machine foundations, types and basic requirements, analysis and design of foundations for reciprocating and impact type machines, introduction to the design of T.G. Foundations.	6
6.	Determination of dynamic elastic constants, various methods including block resonance tests, cyclic plate load tests, wave propagation tests, oscillatory shear box test, soil liquefaction test.	8
Total		42

11. Laboratory Practicals : **NIL**

12. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Das, B.M., "Fundamentals of Soil Dynamics", Elsevier.	1983
2.	Kramer, S., "Geotechnical Earthquake Engineering", Pearson.	2008
3.	Prakash, S., "Soil Dynamics", McGraw Hill.	1981
4.	Rao, K.N.S.V., "Vibration Analysis and Foundation Dynamics", Wheeler.	1998
5.	Saran, S., "Soil Dynamics and Machine Foundations", Galgotia.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code : **CE-644** Course Title : **Design of Underground Excavations**

2. Contact Hours : **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.): **Theory 3 Practical 0**

4. Relative Weightage : CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits : **4** 6. Semester : **Spring** 7. Subject Area : **PEC**

8. Pre-requisite : **Nil**

9. Objective: To impart knowledge of methods of analysis and design of underground excavations in rocks and jointed rock masses for hydro-power projects and large underground storages.

10. Details of Course :

S. No.	Contents	Contact Hours
1.	Introduction, planning of and exploration for various underground construction projects.	4
2.	Stereographic projection method, principle and its application in underground excavation design.	4
3.	Elastic stress distribution around tunnels, stress distribution for different shapes and under different in-situ stress conditions, Greenspan method, design principles, multiple openings, openings in laminated rocks, elasto-plastic analysis of tunnels, Daemen's theory.	8
4.	Application of rock mass classification systems, ground conditions in tunneling, analysis of underground openings in squeezing and swelling ground, empirical methods, estimation of elastic modulus and modulus of deformation of rocks; uni-axial jacking / plate jacking tests, radial jacking and Goodman jacking tests, long term behaviour of tunnels and caverns, New Austrian Tunneling Method (NATM), Norwegian Tunneling Method (NTM), construction dewatering.	9
5.	Rock mass-tunnel support interaction analysis, ground response and support reaction curves, Ladanyi's elasto-plastic analysis of tunnels, design of various support systems including concrete and shotcrete linings, steel sets, rock bolting and rock anchoring, combined support systems, estimation of load carrying capacity of rock bolts.	8
6.	In-situ stress, flat jack, hydraulic fracturing and over coring techniques and USBM type drill hole deformation gauge, single and multi-point bore hole extensometers, load cells, pressure cells, etc.	5
7.	Instrumentation and monitoring of underground excavations, during and after construction, various case studies.	4
Total		42

11. Laboratory Practicals : **NIL**

1 2. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication / Reprint
1.	Hoek, E. and Brown, E.T., "Underground Excavations in Rocks", Institute of Mining Engineering.	1983
2.	Obert, L. and Duvall, W.I., "Rock Mechanics and Design of Structures in Rocks", John Wiley & Sons.	1967
3.	Singh, B. and Goel, R.K., "Rock Mass Classification - A Practical Engineering Approach", Elsevier.	2006
4.	Singh, B. and Goel, R.K., "Tunnelling in Weak Rocks", Elsevier.	2006
5.	Ramamurthy, T., "Engineering in Rocks", PHI Learning.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code : **CE-645** Course Title : **Ground Improvement Engineering**

2. Contact Hours : **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage : **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits : 4 6.Semester : **Spring** 7. Subject Area : **PEC**

8. Pre-requisite : **Nil**

9. Objective: To apprise the students about treatment of poor soil conditions for development activities and tell them about state of art in this area by case studies.

10. Details of Course :

S. No.	Contents	Contact Hours
1.	Introduction, typical situations where ground improvement becomes necessary, historical review of methods adopted in practice, current status and the scope in the Indian context.	5
2.	Methods of ground improvement, mechanical compaction, dynamic compaction, impact loading, compaction by blasting, vibro-compaction; pre-compression, dynamic consolidation, design aspects of stone columns, use of admixtures, injection of grouts, design guidelines and quality control, design examples on preloading with sand drains, road designs with geosynthetics.	9
3.	Reinforced earth, basic mechanism, constituent materials and their selection; engineering applications – shallow foundations on reinforced earth, design of reinforced earth retaining walls, reinforced earth embankments structures, wall with reinforced backfill, analysis and design of shallow foundations on reinforced earth.	10
4.	Geotextiles, selection and engineering applications, design examples, stabilisation/improvement of ground using geomembranes, geocells, geonets, geosynthetic walls.	8
5.	Soil nailing, construction of underground structures, landslide controls, deep vertical cuts, contiguous piles.	4
6.	Problematic soils, use of ply soils, improvement of saline soils, improvement of black cotton soils.	6
Total		42

11. Laboratory Practicals : **NIL**

1 2. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Moseley, M.P. and Kirsch K., "Ground Improvement", Spon Press.	2004
2.	Mittal, S., "Ground Improvement Engineering", Vikas Publishing House.	2010
3.	Koerner, R.M., "Designing with Geosynthetics", Prentice Hall.	1990
4.	Saran, S., "Reinforced Soil and Its Engineering Applications", I.K. International.	2005
5.	Rao, G.V., "Geosynthetics – An Introduction", Sai Master Geoenvironmental Services.	2007
6.	Jones, C.J.F.P., "Earth Reinforcement and Soil Structure", Thomas Telford.	1996
7.	Shukla, S.K., Jian-Hua, Y., "Fundamentals of Geosynthetic Engineering", Taylor & Francis.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code : CE-646 Course Title: Foundations on Weak Rocks

2. Contact Hours : L: 3 T: 1 P: 0

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits : 4 6. Semester : Spring 7. Subject Area : PEC

8. Pre-requisite : Nil

9. Objective: This course is designed to impart knowledge for design of foundations of structures in hill regions and methods for treatment of weak foundations to make them stable.

10. Details of Course :

S. No.	Contents	Contact Hours
1.	Engineering properties of weak rocks, different rock mass classification systems, relative merits and demerits.	2
2.	Failure criteria for weak rocks, bi-linear Mohr-Coulomb failure criterion, Hoek and Brown criterion and modified Hoek and Brown failure criterion etc.	2
3.	Effect of structural planes on rock foundations, possible modes of failure of foundations on rocks / rock masses, determination of in-situ shear strength of rocks and rock masses.	4
4.	Requirements for satisfactory performance of foundations, bearing capacity of foundations on rocks and rock masses, allowable bearing pressure of rock foundations using a nonlinear failure criterion, monotonic and cyclic plate load tests.	7
5.	Pressure-settlement characteristics, effect of layering, anisotropy, heterogeneity and in-elasticity.	6
6.	Shallow foundations, shallow foundations on sloping ground, raft foundations, stilt foundations, foundations for suspension bridges, transmission line towers, framed buildings etc, treatment of foundations - open joints, solution cavities, weak seams.	8
7.	Piles in weak rocks, bearing capacity and settlement of piles, piles in stratified rock masses, field load tests on piles in weak rocks, behaviour of bored / driven piles in soft / weathered rocks, case studies.	6
8.	Dam foundations, stability analysis, 3D wedge analysis of abutments of arch dams, dam-foundation interaction problems, influence of discontinuities like faults, fault zones, shear zones, seams etc on stability of dams, seepage below dam foundations etc., treatment of dam foundations- shear keys, dental treatment of faults, seams, grouting of cavities, grout curtains, cable anchors etc.	7
Total		42

1 1. Laboratory Practicals : NIL

1 2. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication / Reprint
1.	Wyllie Duncan C., "Foundations on Rock: Engineering Practice", E&FN Spon, Taylor and Francis.	2005
2.	Singh, B. and Goel, R.K., "Rock Mass Classification - A Practical Engineering Approach", Elsevier.	2006
3.	Hudson, J.A.(Chief Ed.), "Comprehensive Rock Engineering: Principles-Practice and Project", Vols. 1-5, Pergamon Press.	1993
4.	Hoek, E., "Practical Rock Engineering", Rock Science.	2000
5.	Ramamurthy, T., "Engineering in Rocks", PHI Learning.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject code: **CE-551** Course Title: **Hydrological Modelling and Simulation**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs): **Theory 3 Practical 0**
4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0
5. Credits: 4
6. Semester: **Autumn**
7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the fundamentals of modelling and simulation of hydrological and water resources systems.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Hydrologic system and hydrologic budget, fundamental laws of hydrology; Atmospheric water vapor.	3
2.	Hydrologic Inputs: Precipitation and its forms, snowfall and rainfall; Measurement techniques and space-time characteristics.	4
3.	Hydrologic Abstractions: Infiltration, depression storage, evapotranspiration; Measurement techniques, space time characteristics and their modelling.	6
4.	Stream flow: Measurement techniques, space-time characteristics, rating curves.	4
5.	Systems Approach: ERH, DRH, unit hydrograph, IUH, GIUH, Nash and Clark's models, hydrologic routing and flood forecasting.	7
6.	Classification of Models: Deterministic and stochastic, linear and non-linear; black box and grey box models; Physically based, time-invariant and time-variant, steady state models; lumped and distributed parameter state-space models, examples from hydrology/water resources engineering.	4
7.	Regression Analysis: Validation and calibration, comparing model structures, role of historical data, examples from hydrology / water resources engineering.	2
8.	Time Series Analysis: Auto-cross correlation analysis, identification of trend, spectral analysis, smoothening techniques, time series of rainfall and stream flow.	3
9.	Hydrologic Simulation: Random variables, probability density and distribution functions, expectation and standard deviation of discrete and continuous random variables and their functions, covariance and correlation, commonly used theoretical probability distributions, fitting distributions to raw data, Chi-square and Kolmogrov-Smirnov's tests of the goodness of fit, central limit theorem, various algorithms for generation of random numbers, Monte Carlo simulation, synthetic stream flow generation.	9
Total		42

1 1. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Chow, V.T., Maidment, D.R. and Mays, W.L., "Applied Hydrology", McGraw Hill.	1988
2.	Ljung, L., "System Identification Theory for the Users", Prentice Hall.	1999
3.	Ojha, C.S.P., Berndtsson, R. and Bhunya, P., "Engineering Hydrology", Oxford University Press.	2008
4.	Wanielista, M., Kersten, R. and Eaglin, R., "Hydrology", John Wiley.	1997
5.	Daniel, C. and Wood, P.S., "Fitting Equations to Data", John Wiley Interscience.	1980
6.	Law, A.M. and Kelton, W.D., "Simulation Modeling and Analysis", Tata McGraw Hill.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject code: **CE-552** Course Title: **Advanced Fluid Mechanics**
2. Contact Hours: L: 3 T: 1 P: 2/2
3. Examination Duration (Hrs): Theory Practical
4. Relative Weightage: CWS PRS MTE ETE PRE
5. Credits:
6. Semester: **Autumn**
7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge of kinematics of different types of flows and discuss statistics and measurements of turbulence.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Kinematics of Flow: Equation of continuity in cartesian, polar and cylindrical coordinates, rate of deformation, dilation, vorticity.	3
2.	Standard 2D Flow Patterns: Source, sink, doublet and their combinations, construction of flows by superposition, D'Alembert's paradox.	5
3.	Laplace Equation: Solution by graphical and relaxation methods, conformal mapping, solution by separation of variables.	4
4.	Laminar Flow: Derivation of Navier-Stokes equations, exact solutions for flow between parallel plates, Couette flow, flow near a suddenly accelerated plate and an oscillating plate.	8
5.	Boundary Layers: Similarity solutions of boundary layer equations, Falkner-Skan Wedge flows, Karman's momentum integral equations, Karman-Pohlhausen approximate solution, separation in boundary layer under adverse pressure gradient, turbulent boundary layer.	8
6.	Turbulent Flows: Reynolds equations of motion, semi-empirical theories of turbulence, velocity profiles for inner, outer and overlap layers, equilibrium boundary layers.	8
7.	Measurement of Turbulence and Statistical Theory of Turbulence: Isotropic and homogeneous turbulence, probability density functions, correlation coefficients, decay of isotropic turbulence.	6
Total		42

List of Experiments :

- i) To study the surface profile and the total head distribution in a forced vortex flow
- ii) To study the flow behavior in a pipe bend and to calibrate the pipe bend (i.e., bend or elbow meter) for discharge measurement
- iii) To study the boundary layer velocity profile and to determine the exponent in the power law of velocity distribution, boundary layer thickness and displacement thickness
- iv) To study the velocity distribution in an open channel and to estimate the energy and momentum correction factors.
- v) To calibrate a broad-crested weir and study the pressure distribution at the upstream end of the weir.
- vi) To study the characteristics of a hydraulic jump.
- vii) To study the velocity distribution downstream of an expansion (with and without splitter plates) in a channel.

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	White, F.M., "Fluid Mechanics", McGraw-Hill.	1979
2.	Schlichting, H., "Boundary Layer Theory", McGraw-Hill.	1979
3.	Garde, R.J., "Turbulent Flow", Wiley Eastern.	1994
4.	Pope, S. B., "Turbulent Flows", Cambridge University Press.	2000
5.	Rouse, H., "Advanced Mechanics of Fluids", John Wiley.	1959
6.	Ojha, C.S.P., Berndtsson, R. and Chandramouli, P.N., "Fluid Mechanics", Oxford University Press.	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject code: **CE-553** Course Title: **Free Surface Flows**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs): Theory **3** Practical **0**
4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: Nil
9. Objective: To introduce concepts of free surface flow and its applications in flood control, design of drainage ways and water ways.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Free surface flows, velocity distribution, resistance relationships, specific energy and specific force, normal and critical depth computations, governing equation and computation of gradually varied flows.	6
2.	Hydraulic Jump: Elements of hydraulic jump, hydraulic jump in variety of situations including contracting and expanding geometries and rise in floor levels, control of hydraulic jump using baffle walls and cross jets.	6
3.	Supercritical Flows: Flow past deflecting boundaries, oblique shock waves.	4
4.	Spatially Varied Flows: Flows past side weirs, De Marchi equations, design of side weirs, flow past bottom racks, trench weirs and waste water gutters.	6
5.	Aerated Flows: Bulking of flow, mechanism of air entrainments, modelling of aerated flows, development of self-aerated flows, uniform aerated region, aeration over spillway.	6
6.	Stratified Flows: Thermal stratification in water bodies including reservoirs, modelling of stratified flows.	4
7.	Unsteady Flows: St. Venant's equations and their solution using method of characteristics and finite difference schemes; dam break problem, hydraulic flood routing.	6
8.	Channel Transitions: Sub-critical and supercritical.	4
Total		42

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Chow, V.T., "Open Channel Hydraulics", McGraw Hill.	1959
2.	Choudhary, M.H., "Open-Channel Flows", Prentice-Hall.	1994
3.	Ranga Raju, K.G., "Flow Through Open Channels", Tata McGraw Hill.	2003
4.	Chanson, H., "The Hydraulics of Open Channel Flow: An Introduction", Elsevier.	2004
5.	French, R.H., "Open-Channel Hydraulics", McGraw-Hill.	1994
6.	Wood, I.R., "Air entrainment in free-surface flows", Balkema.	1991

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject code: **CE-651** Course Title: **Fluvial Hydraulics**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs): **Theory 3 Practical 0**
4. Relative Weightage: **CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the flow characteristics in an alluvial channel with erodible boundary.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	The sediment problems, properties of sediments, incipient motion of uniform and non-uniform sediments.	8
2.	Bed forms and channel resistance.	5
3.	Bed load and suspended load transport for uniform and non-uniform bed material, total load equations, sediment sampling.	10
4.	Stable channel design and sediment control.	4
5.	Bed level variations, local scour, degradation, aggradation and reservoir sedimentation.	7
6.	Physical and mathematical models.	4
7.	Design of guide bunds and other river training banks.	4
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Garde, R.J., "River Morphology", New International Publishers.	2006
2.	Julien, P.Y., "Erosion and Sedimentation", Cambridge University Press.	1998
3.	Jansen, P.P.H., "Principals of River Engineering", VSSD Publications.	1994
4.	Garde, R.J. and Ranga Raju, K.G., "Mechanics of Sediment Transportation and Alluvial Stream Problems", Wiley Eastern Limited.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject code: **CE-652** Course Title: **Embankment Dams**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs): **Theory 3 Practical 0**
4. Relative Weightage: **CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce types and design of embankment dams and their analysis alongwith construction aspects.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction, advantages of embankment dams, types of embankment dams, safety criteria for design of embankment dams, factors affecting the design of embankment dams.	8
2.	Theoretical analysis of seepage through embankment and its applications, control of seepage through embankment and foundation.	12
3.	Stability analysis including seismic considerations.	12
4.	Rockfill dams.	2
5.	Methods of construction for embankment and salient aspects of construction including construction equipments, instrumentation, field and laboratory tests for quality control, typical problems associated with embankment dams and their possible solutions.	8
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Sherard, J.L. et. al., "Earth and Earth-Rock Dams", John Wiley.	1967
2.	Singh, B., and Varshaney, R.S., "Engineering for Embankment Dams", OIBH.	1995
3.	"Design of Small Dams", USBR Publications, OIBH.	1974
4.	Golze, A.R., "Hand Book of Dam Engineering", OIBH.	1977
5.	Sharma, H.D., "Embankment Dams", India Book House Ltd.	1991
6.	Singh, B., and Sharma, H.D., "Earth and Rockfill Dams", Nem Chand and Brothers.	1976
7.	Cedergren, H.R., "Seepage, Drainage and Flownets", John Wiley.	1967
8.	Peurifoy, R.L., "Construction, Planning, Equipment and Methods", McGrawHill.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject code: **CE-653** Course Title: **Systems Engineering**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs): **Theory 3 Practical 0**
4. Relative Weightage: **CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce basic concepts of systems, system modeling, system synthesis and optimization.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Definitions and components of a system, system control, systems modelling and model development.	10
2.	System synthesis. economic analysis, conflicts and role of optimization in their resolution.	6
3.	Unconstrained optimization – analytical and numerical.	3
4.	Constrained optimization – analytical and numerical.	3
5.	Integer programming.	2
6.	Geometric programming.	2
7.	Linear programming.	10
8.	Dynamic programming.	3
9.	Stochastic programming.	3
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Aguilera, R.J., "Systems Analysis and Design", Prentice Hall.	1973
2.	Ossenbruggen, P. J., "Systems Analysis for Civil Engineering", John Wiley.	1984
3.	de Neufville, R., "Systems Analysis for Engineer", McGraw Hill.	1971
4.	Rao, S.S., "Engineering Optimization – Theory and Practice", New Age International (P) Ltd.	1999
5.	Hamdy, A.T., "Operations Research – An Introduction", Prentice Hall.	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject code: **CE-654** Course Title: **Ground Water Engineering**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs): Theory **3** Practical **0**
4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits: **4**
6. Semester: **Spring**
7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce fundamentals of groundwater hydrology, groundwater assessment and groundwater development.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Definition of groundwater, role of groundwater in hydrological cycle, groundwater bearing formations, classification of aquifers, flow and storage characteristics of aquifers, Darcy's law, anisotropy and heterogeneity.	5
2.	Governing Equations for Groundwater Flow: Dupuit-Forchheimer assumptions, general differential equations governing groundwater flows, analytical solutions.	6
3.	Wells and Well Hydraulics: Different types of wells, construction of wells, steady and unsteady state solutions for confined, unconfined and leaky aquifers, effect of boundaries, method of images, pumping test analysis.	8
4.	Groundwater Conservation: Regional groundwater budget; resource assessment; estimation of recharge, Indian practice, artificial recharge	5
5.	Groundwater Quality: General problem of contamination of groundwater, sources, remedial and preventive measures, seawater intrusion in coastal aquifers.	6
6.	Groundwater Flow Modelling: Role of groundwater flow models, reference to hydraulic, Hele-Shaw and analog models, introduction to numerical modeling.	6
7.	Planning of Groundwater Development: constraints on the development, role of flow models, optimal groundwater development.	6
Total		42

1 1. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Todd, D.K., "Ground Water Hydrology", John Wiley.	1959
2.	Bear, J., "Hydraulics of Ground Water", McGraw.	1979
3.	Bouwer, H., "Ground Water Hydrology", McGraw Hill.	1978
4.	Walton, W.C., "Ground Water Resources Evaluation", McGraw Hill.	1970
5.	Freeze and Cherry, "Ground Water", Prentice Hall.	1979
6.	Driscoll, F.G., "Ground Water and Wells", Johnson Division.	1986
7.	Raghunath, H. M., "Ground Water", New Age International (P) Limited.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject code: **CE-655** Course Title: **Water Resources Systems Planning**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs): **Theory** 3 **Practical** 0
4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0
5. Credits: 4
6. Semester: **Spring**
7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce various aspects of systemic water resource planning and the relevant mathematical tools.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Water resources planning process, multi-objective planning.	3
2.	Evaluation of Water Plans: Basic concepts of engineering economics, welfare economics, economic comparison of alternatives.	4
3.	Water Plan Optimization: Plan formulation, objective functions and constraint, analytical optimization, numerical optimization, linear programming, dynamic programming, simulation, planning under uncertainty.	10
4.	Deterministic River Basin Modeling: Stream flow modeling, estimation of reservoir storage requirements – dead storage, active storage for water supply/irrigation / power generation, flood storage, optimal allocation.	10
5.	Conjunctive Use/Groundwater Management Models: LP based conjunctive use modeling, aquifer response models, link - simulation, embedded, matrix response based models, soft modeling.	10
6.	Water Quality Management Models: Basic water quality modeling, objectives of management, control alternatives, optimal plans.	5
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Hall, W.A. and Dracup, J.A., "Water Resources Systems Engineering", McGraw Hill Book Company.	1970
2.	Loucks, D.P., "Water Resource Systems Planning and Analysis", Prentice Hall.	1981
3.	Maass et al., "Design of Water-Resource Systems", Harvard University Press.	1962
4.	Vedula S. and Mujumdar, P.P., "Water Resources Systems", Tata McGraw Hill.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject code: **CE-656** Course Title: **Irrigation and Drainage**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs): **Theory 3 Practical 0**
4. Relative Weightage: **CWS 25 PRS 3 MTE 25 ETE 50 PRE 0**
5. Credits: 4
6. Semester: **Spring**
7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce concepts of irrigation engineering including drainage and salt balance / leaching aspects.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction, objectives of irrigation, type of irrigation and suitability; selection of irrigation method.	3
2.	Irrigation requirement, water balance, soil water relationships, water storage zone, infiltration.	6
3.	Flow of moisture through root zone, soil physical and chemical properties, crop evaporative and drainage requirements, irrigation efficiency and uniformity.	4
4.	Surface irrigation systems, types of surface systems, basin irrigation, border irrigation, furrow irrigation, field measurement techniques, flow measurement, flumes, weirs, irrigation events, advance, wetting, depletion and recession phases.	7
5.	Infiltration, infiltrometer, ponding methods, soil water, tensiometers, neutron probe, time domain reflectometer, evapotranspiration, crop coefficient, leaf area index, FAO guide lines on evapotranspiration estimation.	6
6.	Fundamentals of surface irrigation hydraulics, continuity equation, momentum equation	3
7.	Hydrodynamic model, zero inertia model, kinematic wave model.	4
8.	Drainage principles, need for drainage, steady state equations, Hooghoudt, Kirkham, Dagan and Ernst equations.	6
9.	Salt balance, water and salt balance of the root zone, salt equilibrium equation and leaching requirement, leaching efficiency.	3
	Total	42

1 1. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Walker, W.R., and Skogerboe, G.V., "Surface Irrigation Theory and Practice", Prentice Hall, INC.	1987
2.	Drainage Principles and Applications, "International Institute for Land Reclamation and Improvement", Wageningen.	1973
3.	Michael, A.M., "Irrigation: Theory and Practice", Vikas Publishing House.	1978
4.	Asawa, G.L., "Irrigation Engineering", New Age International Publishers.	1996
5.	Majumdar, D.K., "Irrigation Water Management", PHI Learning.	2009
6.	Luthin, J.N., "Drainage Engineering", John Wiley.	1966

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject code: **CE-657** Course Title: **Hydro Power Engineering**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs): **Theory** **Practical**
4. Relative Weightage: **CWS** **PRS** **MTE** **ETE** **PRE**
5. Credits:
6. Semester: **Spring**
7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce fundamentals of hydropower, transient analysis and various components of a hydropower plant.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Water Power: Introduction, sources of energy, role of hydropower in a power system.	3
2.	Estimation of Water Power Potential: Flow duration curves of gauge and ungauge streams, load curve, load factor, capacity factor, utilization factor, diversity factor, load duration curve, firm power, secondary power, prediction of load.	7
3.	Types of Hydro-power Plants: Run of river plants, general arrangement of run of river plants, valley dam plants, diversion canal plants, high head diversion plants, storage and pondage, pumped storage power plants.	4
4.	Penstocks: General classification, design criteria, economical diameter, losses, anchor blocks, valves, bends and manifolds.	6
5.	Trash racks: Types, losses, design, stability.	4
6.	Intakes: Types, losses, air entrainment, anti-vortex device, air vent, power channels, forebay, tunnel.	6
7.	Turbines: Introduction, types of turbines, hydraulics of turbines, velocity triangles, draft tubes, cavitation in turbines, turbine model testing, characteristics of turbines.	6
8.	Water Hammer and Surges: Introduction, water hammer, transients caused by turbine, load acceptance and rejection, resonance in penstocks, surge tanks, channel surges.	6
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Dandekar, M.M., and Sharma, K.H., "Water Power Engineering", Vikas Publishing House Pvt Ltd.	2000
2.	Barrows, H.K., "Water Power Engineering", Tata McGraw Hill Publishing Company Ltd.	1943
3.	Varshney, R.S., "Hydro Power Structures", Nem Chand & Bros.	2001
4.	Nigam, P.S., "Hydro Electric Engineering", Nem Chand & Bros.	2001
5.	Choudhary, M.H., "Applied Hydraulic Transients", Van Nostrand Reinhold Company	1987
6.	Streeter, V.L., and Wylie, B., "Fluid Transients", McGraw-Hill Book Company.	1967
7.	Warnick, C.C., "Hydropower Engineering", Prentice-Hall.	1984
8.	Norwegian Institute of Technology: Hydropower Development: Vols. 3, 4, 5 & 6 , Division of Hydraulic Engineering.	1992-93

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject code: **CE-658** , Course Title: **Computational Methods in Fluid Mechanics**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs): **Theory 3 Practical 0**
4. Relative Weightage: **CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**
5. Credits: **4**
6. Semester: **Spring**
7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce various numerical techniques and their applications to transient pipe flow, open channel flow and groundwater flow and contaminant transport.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review of numerical techniques like method of characteristics, finite difference method.	7
2.	Finite element method.	6
3.	Modelling of steady state flow and hydraulic transients in pipes.	6
4.	Modelling of non-uniform, transient spatially varied flows in open channels.	7
5.	Numerical solutions for Navier-Stokes, boundary layer and Reynolds equations.	8
6.	Modelling of groundwater flow and contaminant transport in groundwater.	8
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Anderson, "Computational Fluid Mechanics and Heat Transfer", McGraw Hill.	1984
2.	Chung, T. J., "Finite Element Analysis in Fluid Dynamics", McGraw Hill.	1978
3.	Anderson, & Weessner, "Applied Groundwater Modelling", Academic Press.	1992
4.	Chaudhary, H. M., "Applied Hydraulic Transient", McGraw Hill.	1976
5.	Streeter and Wylie, "Fluid Transients", McGraw Hill.	1976
6.	Smith, G.D., "Numerical Solution of Partial Differential Equations-FDM".	1985

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: **CE-531** Course Title: **Modelling and Analysis of Geo-Spatial Data**
2. Contact Hours: **L: 3 T: 0 P: 3**
3. Examination Duration (Hrs): **Theory** 3 **Practical** 0
4. Relative Weightage: **CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0
5. Credits: 4
6. Semester: **Autumn**
7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective : To introduce various modelling and error analysis techniques for processing of geo-data acquired using geomatics tools.
10. Details of Course :

S. No.	Contents	Contact Hours
1.	Types of Geo-Spatial Data: Ratio, categorical and ordinal data, spatial and non-spatial data, vector and raster data, primary and secondary data; Coordinate transformations - two-dimensional, conformal, affine, projective coordinate transformation and three-dimensional conformal coordinate transformation; Map models and map projection systems.	7
2.	Geo-Spatial Data Structures and Database Management Systems: Data compression models, vector and raster data structures, DBMS and relational DBMS, file formats for various GIS data types, digital remote sensing data-file formats.	6
3.	Measurements and Analysis: Sample versus population, graphical representation of geo-spatial data; Measures of central tendency – mean, median, mode and mean vector; Measures of variation in data - variance covariance and correlation matrices.	4
4.	Errors in Geo-Spatial Data and Error Modelling: Error sources and types of errors – gross, systematic and random errors; Precision, accuracy and uncertainty; Errors in survey and photogrammetric measurements, errors in remote sensing and GIS, propagation of random errors, error propagation in angle and distance measurements; Traverse and triangulation surveys and leveling networks; Propagation of errors in GPS data and GIS data layers.	8
5.	Adjustment Techniques : Stochastic model, functional model, observation equations, systematic formulation of the normal equations using matrices to form the normal equations, least squares solution of nonlinear systems, least squares fit of points to a line or curve, concept of adjustment of errors, least squares adjustment using conditional equations and observation equations.	7
6.	Confidence Intervals and Statistical Testing: Sampling distributions, sampling schemes and sample sizes, confidence interval for the mean, <i>t</i> statistic, confidence interval for a population variance and for the ratio of two population variances; Hypothesis testing, test of hypothesis for the population mean, population variance and ratio of two population variances; Uses of statistical testing in geo-spatial data processing.	5
7.	Uncertainty Modeling of Geo-Spatial Data: Uncertainties in various geo-spatial data, probability, fuzzy set, information and geostatistical theories to model uncertainty; Monte Carlo simulations, error ellipse for uncertainty quantification, computation of error ellipse parameters.	5
Total		42

List of Experiments :

- i) Familiarity with different types of geodata: ratio, categorical and nominal
- ii) Understanding raster and vector data
- iii) Familiarization with various 2D and 3D coordinate transformations and map projection systems.
- iv) Working on a DBMS software for geo-spatial data processing
- v) Introduction to a statistical software such as SPSS for various geo-spatial applications, namely,
 - a. Generation of random error data
 - b. Error modeling
 - c. Least squares adjustment
 - d. Statistical testing
 - e. Uncertainty modeling

11. Suggested Books :

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1	Bossler, J.D., "Manual of Geospatial Science and Technology", Taylor and Francis.	2002
2	Freund, J.E., "Mathematical Statistics", Prentice Hall.	1998
3	Law, A.M. and Kelton, W.D., "Simulation, Modeling and Analysis", Tata McGraw Hill.	2003
4	Mikhail, E.M. and Gracie, G., "Analysis and Adjustment of Survey Measurements", Van Nostrand Reinhold.	1981

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: **CE-532** Course Title: **Principles of Surveying and Photogrammetry**
2. Contact Hours: **L: 3 T: 0 P: 3**
3. Examination Duration (Hrs): Theory **3** Practical **0**
4. Relative Weightage: CWS **15** PRS **15** MTE **30** ETE **40** PRE **0**
5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective : To introduce various concepts of field surveying and photogrammetry.
10. Details of Course :

S. No.	Contents	Contact Hours
1.	Principles of surveying and leveling; Methods of control establishment - traversing, triangulation and trilateration.	3
2.	Surveying measuring, equipment and techniques, distance, height, angles and directions, tacheometric surveying, levelling methods, spirit and trigonometrical leveling, plane table surveys and contouring.	7
3.	Introduction to physical geodesy; Earth-motions, gravity field, size and shape; Atmosphere; Reference coordinate system.	5
4.	Photogrammetry, types of photographs, scale determination, flying height, relief and tilt displacements stereovision, base lining, parallax bar, height determination from stereo-photographs, flight planning.	7
5.	Porro-Koppe reprojection principle, double reprojection, equivalent and calibrated focal length of lens and concept of principal distance; Concepts of orientation-interior, relative and absolute orientation of aerial photographs.	4
6.	Optical, mechanical, graphical and numerical methods of relative orientation, over-correction factors and its determination, model deformations, residual errors and precision of inner and relative orientation, relative orientation in hilly terrain and in difficult areas.	6
7.	Stereo-plotting instruments, 1st, 2nd and 3rd order instruments, general principle of calibration, testing and adjustment of instruments, photogrammetric mapping, basic idea of control requirement and photogrammetric extension of control.	6
8.	Fundamentals of close range photogrammetry, applications in engineering and non-topographic fields.	4
Total		42

List of Experiments :

- i) Introduction to various surveying equipments – level and theodolites
- ii) Level of a profile using auto level
- iii) Determination of coordinates using total station
- iv) Plotting of ground features and contouring using plane table
- v) Determination of scale and flying height of an aerial photograph
- vi) Use of stereo vision test card and base lining of a pair of photographs
- vii) Determination of height using parallax bar and correction contours
- viii) Mapping using sketch master
- ix) Introduction to various types of stereo plotting machines
- x) Interior and relative orientation of a pair of photographs on Wild A8 autograph
- xi) Absolute orientation
- xii) Map plotting using wild A8.

11. Suggested Books :

Sl. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Arora, K.R. Surveying, Vol. 1, 2 & 3. Standard Book House.	2005
2.	Moffitt, F.H. and Mikhail, E.M., "Photogrammetry", Harper and Row.	1992
3.	Wolf, P.R. and Dewitt, B.A., "Elements of Photogrammetry", McGraw-Hill.	2007
4.	Uren, J. and Price, W.F., "Surveying for Engineers", Palgrave Macmillan.	2006
5.	Vanicek, P. and Krokiawasky, "Geodesy; The Concepts", North-Holland.	1986

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: **CE-533** Course Title: **Basic Remote Sensing and Digital Image Processing**
2. Contact Hours: **L: 3 T: 0 P: 3**
3. Examination Duration (Hrs): **Theory 3 Practical 0**
4. Relative Weightage: **CWS 15 PRS 15 MTE 30 ETE 40 PRE 0**
5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective : To introduce the concepts of remote sensing and digital image processing.
10. Details of Course :

S. No.	Contents	Contact Hours
1.	Introduction, sources of energy, electromagnetic spectrum, electromagnetic radiation, reflection, transmission and absorption, black body radiation, Stefan-Boltzmann law, Wein's displacement law, emissivity, Kirchoff's law, thermal emission, Planck's formula.	6
2.	Interaction of EMR with atmosphere, scattering, refraction, absorption, transmission, atmospheric windows, interaction of EMR with earth surface, spectral reflectance curves, radiation calculation.	7
3.	Platforms and sensors, active and passive sensors, PAN, multi and hyper spectral sensors, sensor characteristics, satellite orbit and coverage. Indian remote sensing (IRS) satellite programme.	4
4.	Visual image analysis, image interpretation, elements, keys and aids, basic instrumentation, visual analysis of data in visible, infra-red, thermal and microwave regions.	3
5.	Various data products and their uses, digital image formats, data processing, initial data statistics, histogram and scatter plot.	7
6.	Pre-processing of data, atmospheric, radiometric and geometric corrections.	3
7.	Image enhancement, contrast stretching, histogram techniques, noise removal, low pass, medium pass, high pass and other filters.	7
8.	Basic concepts of digital image analysis, arithmetical operators.	5
Total		42

List of Experiments:

- i) Introduction to different types of remote sensing data products.
- ii) Use of spectrometer for collection of signatures of different earth objects.
- iii) Training of photo interpretation files.
- iv) Visual analysis of a satellite data.
- v) Demonstration of different remote sensing and image processing software.
- vi) Initial statistics extraction.
- vii) Atmospheric correction.
- viii) Geometric correction
- ix) Image enhancement
- x) Image transformation

11. Suggested Books :

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Chandra, A.M. and Ghosh, S.K., "Remote Sensing and Geographical Information System", Narosa.	2006
2.	Gibson, P.J. and Power, C.H., "Introductory Remote Sensing – Digital Image Processing and Applications", Routledge.	2000
3.	Jain, A.K., "Fundamentals of Digital Image Processing", Prentice Hall.	2004
4.	Lillesand, T.M. and R.W. Kiefer, 2000. "Remote Sensing and Image Interpretation", John Wiley.	2000
5.	Mather, P.M., "Computer Processing of Remotely Sensed Images", John Wiley.	1999
6.	Schowengerdt, R.A., "Remote Sensing – Models and Methods for Image Processing", Academic Press.	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: **CE-631** Course Title: **Theory and Applications of GIS**
2. Contact Hours: **L: 3 T: 0 P: 2**
3. Examination Duration (Hrs): **Theory 3 Practical 0**
4. Relative Weightage: **CWS 15 PRS 15 MTE 30 ETE 40 PRE 0**
5. Credits: 4
6. Semester: **Spring**
7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the GIS theory and engineering applications using the existing state-of-the-art GIS software.
10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	Introduction, geographical concepts and terminology, difference between image processing system and GIS, utility of GIS.	4
2.	Various GIS packages and their salient features, essentials components of GIS, data acquisition through scanners and digitizers.	5
3.	Raster and vector data, introduction, descriptions, raster and vector data, raster versus vector, raster to vector conversion, remote sensing data in GIS, topology and spatial relationships, data storage verification and editing.	7
4.	Data preprocessing, georeferencing, data compression and reduction techniques, runlength encoding, interpolation of data, database construction, GIS and the GPS, data output	7
5.	Database structure, hierarchical data, network systems, relational database, database management, data manipulation and analysis.	4
6.	Spatial and mathematical operations in GIS, overlay, query based, measurement and statistical modelling, buffers, spatial analysis, statistical reporting and graphing.	5
7.	Programming languages in GIS, virtual GIS, web GIS.	5
8.	Application of GIS to various natural resources mapping and monitoring and engineering problems.	5
Total		42

List of Experiments:

- a. Demo on various GIS software and their salient features.
- b. Scanning and digitization (on screen).
- c. Registration of various maps and digitization and editing of features.
- d. Database creation and management.
- e. Buffer and overlay analysis.
- f. Map preparation and composition.
- g. Spatial and mathematical operations.
- h. Area and query based analysis
- i. Customized application in GIS.
- j. Web publishing of GIS layers.
- k. 3D GIS.
- l. Demo on various GIS based application.

11. Suggested Books

Sl. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Burrough, P.A. and McDonnel, R.A., "Principles of Geographic Information System", Oxford University Press.	2000
2.	Chrisman, N.R., "Exploring Geographic Information Systems", John Wiley.	2002
3.	Demers, M.N., "Fundamentals of Geographic Information System", Wiley.	2008
4.	Ghosh, S.K. and Chandra, A.M., "Remote Sensing and GIS", Narosa Publishing House.	2008
5.	Lo, C.P. and Young, A.K.W., "Concepts and Techniques of Geographical Information System", Prentice Hall India.	2002
6.	Longley, P.A., Goodchild, M.F., Maguire, D.J. and Rhind, D.W., "Geographic Information Systems And Science", Wiley.	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: **CE-632** Course Title: **Multi and Hyperspectral Data Processing Techniques**
2. Contact Hours: **L: 3 T: 0 P: 2**
3. Examination Duration (Hrs): Theory **3** Practical **0**
4. Relative Weightage: CWS **15** PRS **15** MTE **30** ETE **40** PRE **0**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective : To introduce the concepts of multi and hyper-spectral remote sensing.
10. Details of Course :

Sl. No.	Contents	Contact Hours
1.	Multi and hyperspectral remote sensing data acquisition systems in optical wavelength region, basic principles of data acquisition and measurement in natural scenes, multi and hyperspectral data statistics, digital data file formats.	5
2.	Multi-spectral image pre-processing, noise in multi and hyperspectral systems,. radiometric and geometric processing, calibration and normalization of hyperspectral images, feature and intensity based geometric and image to image registration, methods and models for atmospheric correction.	8
3.	Multi-spectral enhancement techniques, advanced spatial filtering techniques, spatial and frequency domain (e.g., Fourier, wavelets), image fusion techniques.	4
4.	Multi and hyperspectral image compression, feature reduction, feature selection and feature extraction techniques, discriminant analysis, independent component analysis, orthogonal subspace projection, projection pursuit etc.	8
5.	Fundamentals of multi and hyperspectral data analysis, measures for spectral characterization.	3
6.	Application of signal/image processing, statistical and computational pattern recognition and classification algorithms, pixel and sub-pixel level target detection and classification	10
7.	Empirical modelling of biophysical parameters from multi and hyperspectral remote sensing data, applications of multi and hyperspectral remote sensing data in water resources, forestry, earth sciences, resource management and planning, military target detection.	4
Total		42

List of Experiments :

- a. Study of different file formats of multi and hyperspectral remote sensing data
- b. Hands on experience on multi and hyperspectral data processing modules in some image processing systems
- c. Data visualization tools – study of images through 3D visualisers, spectral plots, scatter plots, histograms of images
- d. Use of field spectro-radiometer for creation of spectral libraries for various earth surface features. Understanding of spectral reflectance plots in NIR to SWIR regions.

- e. Implementation of atmospheric models
- f. Feature and intensity based image registration of images
- g. Spatial enhancement of remote sensing images
- h. Data dimensionality reduction using feature selection and feature extraction methods
- i. Advanced pattern recognition algorithms for extraction of information from multi and hyperspectral images
- j. Derivation of biophysical parameters from multi and hyperspectral remote sensing images

11. Suggested Books :

Sl. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Chen, C.H., "Information Processing for Remote Sensing", World Scientific.	1999
2.	Cheng, Chein I., "Hyperspectral Imaging: Techniques for Spectral Detection and Classification", Kluwer Academic.	2003
3.	Landgrebe, D., "Signal Theory Methods in Multi-spectral Remote Sensing", John Wiley.	2003
4.	Richards, John A. and Xiuping, J., "Remote Sensing Digital Image Analysis: An Introduction", Springer-Verlag.	1999
5.	Varshney, P.K. and Arora, Manoj K., "Advanced Image Processing Techniques for Hyperspectral Remote Sensing Data", Springer-Verlag..	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: **CE-633** Course Title: **Geodesy and GPS Surveying**
2. Contact Hours: **L: 3 T: 0 P: 2**
3. Examination Duration (Hrs): Theory **3** Practical **0**
4. Relative Weightage: CWS **15** PRS **15** MTE **30** ETE **40** PRE **0**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective : To introduce the concepts of geodesy and global positioning system.
10. Details of Course :

Sl. No.	Contents	Contact Hours
1	Introduction to geodesy and its development.	2
2	Earth and its size and shape, earth and its motions- annual, spin, precession, nutation, polar motion.	8
3	Earth and its gravity field – anomaly, gravity potential, geoid and deflection to vertical.	5
4	Earth and its atmosphere – physical properties, wave propagation through atmosphere, temporal variations, gravitational field of the atmosphere.	5
5	Introduction to GPS- its components, instruments and processing software, GPS signals, GPS data collection, planning and methods.	7
6	GPS observables- pseudo range and carrier phase, parameter estimations.	6
7	Data handling- cycle slip detection and correction, ambiguity resolution, GPS data processing, errors in GPS data – satellite geometry, multipath errors and corrections, accuracy of GPS data.	7
8	Datum transformation.	2
Total		42

List of Experiments :

- a. Demonstration, hands-on practice and temporary adjustments of a Gravimeter.
- b. Demonstration, hands-on practice and collection of data using navigational GPS receiver. Further, download and process the data using software.
- c. Demonstration, hands-on practice and collection of data using Geodetic GPS receivers. Further, download and process the data using software.
- d. To determine the relative as well as absolute gravity of some stations and along a profile of 100meter at an interval of 5 meter. Find the location of the stations as well as plot the profile using GPS receivers.
- e. To determine the height of a tower using a Gravimeter and verify the result with that by using GPS receiver.
- f. To determine the variations of gravity with elevation. Determine the elevation of the stations using GPS receiver.
- g. To determine the gravity anomaly profile in the IITR campus having absolute locations of the stations using GPS receivers.

11. Suggested Books :

Sl. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Bomford, G. Geodesy. Clarendon Press, Oxford.	1980
2.	Hoffmann-Wellenhoff, B. GPS, "Theory & Practice", Springer.	2001
3.	Leick, A., "GPS Satellite Surveying", John Wiley.	2005
4.	Torge, W., "Geodesy: An Introduction", Walter de Gruyter, Berlin.	1980
5.	Vanicek, P. and Krakiwsky, E.J., "Geodesy: The Concepts", Elsevier.	1986

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: **CE-634** Course Title: **Thermal and Microwave Remote Sensing**
2. Contact Hours: **L: 3 T: 0 P: 2**
3. Examination Duration (Hrs): Theory **3** Practical **0**
4. Relative Weightage: CWS **15** PRS **15** MTE **30** ETE **40** PRE **0**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective : To introduce the concepts of thermal and microwave remote sensing and its various engineering applications.
10. Details of Course :

SL. No.	Contents	Contact Hours
1	Brief review of thermal and microwave remote sensing, their utility, merit and demerits, introduction to spectral characteristics of remote sensing data, optical radiation models, summary of visible to shortwave region models, thermal sensors and their characteristics.	4
2	Thermal infrared region models, radiation components – surface-emitted component, surface-reflectance, atmospheric emitted component, path-emitted component, total at-sensor, emitted radiance, interpretation of thermal images – day and night images, emissivity consideration, thermal inertia considerations. factors affecting analysis of thermal images, data models for thermal image analysis.	7
3	Estimation of land surface temperature from thermal images, application of thermal remote sensing data in crop health monitoring, pollution monitoring, oil spill detection, glaciology, earth sciences, military etc.	3
4	Introduction to microwave remote sensing - active and passive systems, platforms and sensors.	5
5	Passive microwave systems, background, mathematical formulation for microwave radiation and simulation, measurement and analysis of brightness temperature, applications in various fields— oceanography and meteorology.	5
6	Active microwave systems, basic principles of radar, radar equation, resolution, range, phase and angular measurements, microwave scattering and its measurement, relationships between scene and sensor parameters, imaging systems – RAR and SAR, SAR imagery—their characteristics and interpretation, applications in various fields—land use/land cover, soil/rock, hydrology.	10
7	SAR interferometry for DEM generation, differential SAR interferometry for surface displacement studies, applications in land subsidence, landslide movements, glacier movements etc.	5
8	Polarimetry in radar remote sensing, basic equations, propagation of waves and wave polarization. HH, VV, HV and VH polarization data and their applications.	3
Total		42

List of Experiments :

- a. Familiarisation with various thermal and microwave remote sensing data products
- b. Hands on experience on thermal data and microwave data processing modules in an image processing software
- c. Study and collection of emissivity data pertaining to various earth surface features from different sources.
- d. Visual image interpretation of thermal images.
- e. Digital image interpretation of thermal images.
- f. Land surface temperature estimation from thermal images
- g. Study and implementation of brightness temperature estimation models for passive microwave remote sensing data
- h. Study and implementation of backscatter estimation models for active microwave remote sensing data
- i. Visual image interpretation of SAR images.
- j. Digital image interpretation of SAR images.
- k. Use of differential SAR Interferometry for surface displacement studies.

11. Suggested Books :

Sl. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Henderson, F.M. and Anthony, J.L., "Principles and Applications of Imaging Radar, Manual of Remote Sensing", Vol. 2, John Wiley and Sons.	1998
2.	Manual of Remote Sensing, Volumes 1 to 5, American Society of Photogrammetry and Remote Sensing.	2003
3.	Schowengerdt, R.A., "Remote Sensing Models and Methods in Image Processing", Academic Press.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: **CE-635** Course Title: **Analytical and Digital Photogrammetry**

2. Contact Hours: **L: 3 T: 0 P: 2**

3. Examination Duration (Hrs): Theory **3** Practical **0**

4. Relative Weightage: CWS **15** PRS **15** MTE **30** ETE **40** PRE **0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective : To introduce the concepts of analytical and digital photogrammetry.

10. Details of Course :

Sl. No.	Contents	Contact Hours
1	Introduction, historical development from conventional to analytical and digital photogrammetry, applications of analytical and digital photogrammetry.	4
2	Coordinate systems, condition equations, orthogonal transformation matrices and methods of construction, approximate orthogonal matrix, measurement of image coordinates from hard copy and soft copy, instruments.	5
3	Digital images and their properties, direct and indirect methods of acquisition of digital images - CCD, digitizers and photogrammetric scanners, comparative merits, storage and compression of digital imagery, loss of data and image quality, corrections to observed image coordinates.	5
4	Analytical orientation, relative, absolute and exterior orientation methods, analytical plotter and its functioning, automatic image matching techniques - signal based and feature based matching, comparative merits and demerits.	5
5	Digital correlation, least square matching, multipoint matching etc., model formation using digital stereo pairs, automatic generation of DEM, digital orthophotos.	7
6	Digital photogrammetric system - potential, capabilities and characteristics features, design consideration, add-on devices.	6
7	Analytical aerial triangulation, independent model triangulation, strip and block triangulation and adjustment, bundle block adjustment. various applications.	10
Total		42

List of Experiments:

- a. Introduction to digital photogrammetric system.
- b. Preparation of digital photo
- c. Interior orientation.
- d. Relative orientation.
- e. Absolute orientation
- f. 3D model generation
- g. Generation of digital orthophograph.
- h. Aero triangulation on wild A8.

11. Suggested Books :

Sl. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Ghosh, Sanjib K., "Analytical Photogrammetry", Concept Publishing Co.	1987
2.	Manual of Photogrammetry, American Society of Photogrammetry.	1995

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: CE-636 Course Title: **Remote Sensing for Land Use Analysis and Urban Planning**
2. Contact Hours: L: 3 T: 0 P: 2
3. Examination Duration (Hrs): Theory 3 Practical 0
4. Relative Weightage: CWS 15 PRS 15 MTE 30 ETE 40 PRE 0
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: Nil
9. Objective : To introduce the application of remote sensing data in optical and microwave region for preparation of land use land cover maps and their usage in urban planning
10. Details of Course :

Sl. No	Contents	Contact Hours
1	Introduction, land use land cover, definition and its significance in engineering projects, history of land use land cover, modern land use land cover surveys and classification systems, utility of remote sensing data for land use land cover mapping at various scales.	4
2	Land use land cover analysis based on spectral characteristics of remote sensing data - visible, near infrared and shortwave infrared wavelength regions, thermal Infrared regions and active microwave region, high resolution images, various vegetation indices.	8
3	Land use land cover analysis based on spatial characteristics of remote sensing data, utility of IFOV, land parcel sizes, minimum mapping unit, map scale, land use land cover analysis based on temporal characteristics of remote sensing data, temporal resolution of remote sensing data, application based temporal requirements, land use land cover change detection, visual and digital change detection algorithms, principles of land use land cover mapping, visual image interpretation techniques for land use cover map preparation.	8
4	Digital image classification for land use land cover map preparation, per pixel classification, statistical, artificial neural network and other machine learning approaches, object based image classification, concept of mixed pixel, sub pixel classification, linear mixture modeling, fuzzy set based classification, artificial neural network and other machine learning approaches.	9
5	Classification accuracy assessment, accuracy of per pixel and sub-pixel classification, sampling design issues, design of error matrix and fuzzy error matrix, statistical testing.	4
6	Issues in urban and regional planning, objectives and planning processes, data requirements, physical planning and statistical methods, mapping of parcels and individual buildings, utility of land use land cover in urban planning.	4
7	Role of remote sensing and GIS for urban planning, management, and growth assessment, study of cropping pattern and resources, utility/service planning, transportation planning and management, infrastructure planning.	5
Total		42

List of Experiments :

- a. Familiarization with various photographic and digital remote sensing data products used for land use land cover mapping.
- b. Study of spectral reflectance characteristics of various land use land cover features using Spectro-Radiometer.
- c. Preparation of land use land cover classification scheme for an area.
- d. Study of image interpretation elements through image interpretation keys for visual analysis of land use land cover. Preparation of a land cover map from the given FCC. Take minimum mapping unit as 5 mm x 5 mm. Compute areas of various land cover classes mapped using digital planimeter.
- e. Training on image classification module of ERDAS Imagine. Practice for selection of training areas and their quality assessment using histogram and separability analyses.
- f. Comparative assessment of various statistical image classifiers for land use land cover mapping. Practice for selection of testing areas based on different sampling schemes for classification accuracy assessment in ERDAS Imagine.
- g. Preparation of a land use land cover map using back propagation neural network algorithm (use either Matlab, IDRISI or ENVI software).
- h. Preparation of land use land cover map at sub-pixel level using soft classification techniques (use either ERDAS, IDRISI or ENVI software).
- i. Preparation of land parcel and building map from high resolution satellite image.
- j. Development of a computer program to implement an advanced image classification algorithm (e.g., decision tree classifier, evidential reasoning or any other).
- k. Preparation of a land use land cover change detection map using various image change detection algorithms (use either ERDAS, IDRISI or ENVI software).

11. Suggested Books :

Sl. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Campbell, J.B., "Introduction to Remote Sensing", Guilford Press.	2002
2.	Lillesand, T.M. and R.W. Kiefer, 2000, "Remote Sensing and Image Interpretation", John Wiley and Sons.	2000
3.	Mather, P.M., "Computer Processing of Remotely-Sensed Images", John Wiley & Sons.	1999
4.	Rencz, A.B. (Editor-in-Chief), "Remote Sensing for Natural Resource Management and Environmental Modeling, Manual of Remote Sensing", Volume 4, John Wiley and Sons.	2004
5.	Rencz, A.B. (Editor-in-Chief), "Remote Sensing of Human Settlements, Manual of Remote Sensing", Volume 5, John Wiley and Sons.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: CE-637 Course Title: Remote Sensing for Water Resources and Hydrology
2. Contact Hours: L: 3 T: 0 P: 2
3. Examination Duration (Hrs): Theory 3 Practical 0
4. Relative Weightage: CWS 15 PRS 15 MTE 30 ETE 40 PRE 0
5. Credits: 4
6. Semester: Spring
7. Subject Area: PEC
8. Pre-requisite: Nil
9. Objective : To introduce the application of remote sensing in the area of water resources and hydrological modeling.
10. Details of Course :

Sl. No.	Contents	Contact Hours
1	Introduction, importance of water resources and hydrology, components of water resources, hydrological cycle, role of remote sensing.	3
2	Geomorphological analysis of watershed, determination of various geomorphometric parameters, using conventional and remote sensing data, digital elevation model, data input, interpolation techniques, surface generation, assessment of accuracy, extraction of various watershed parameters.	10
3	Hydrological modeling, detailed overview of lumped and conceptual models, data input requirements, process based requirements, extraction of information from remote sensing, soil erosion modeling, different type of erosion models – USLE and MUSLE, extraction of model parameters using remote sensing techniques, soil and water conservation.	12
4	Concepts of irrigation water management, crop water requirements, Irrigation water management and scheduling, performance evaluation of irrigation command areas, performance indicators, mapping of irrigation command areas using temporal remote sensing data.	3
5	Flood plain identification and management, use of remote sensing data products, digital based extraction of flood plain parameters and indices, drought identification and management, conventional approach, data requirements and methods, drought Indices and its assessment using remote sensing data.	6
6	Ground water modeling, conventional approach, types of ground water models, data extraction using remote sensing techniques, management of waterlogged areas, causes and effects of water logging, salinity and alkalinity, reclamation of salt affected soils, role of remote sensing in monitoring and management of waterlogged areas.	6
7	Mapping of snow cover and glaciers, use of normalized difference snow index (NDSI).	2
	Total	42

List of Experiments :

- a. Surface water mapping using satellite data.
- b. Spectral characterization of water using spectro-radiometer.
- c. Comparison of Watershed delineation and morphometric analysis using topographical and satellite data (2 turns)
- d. Delineation of drainage pattern and determination of various basin characteristics.
- e. Digitization of watershed contours and generation of DEM (3 turns)
- f. Extraction of DEM information.
- g. Mapping of flood inundation areas and flood zonation.
- h. Mapping of river bankline using temporal satellite data (2 turns).
- i. Morphological analysis of river system.

11. Suggested Books :

Sl. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Badawy, M., "Application of Remote Sensing and GIS in Geomorphological Studies", Verlag.	2008
2.	Engman, E.T. and Gurney, R.J., "Remote Sensing in Hydrology", Chapman and Hall.	1991
3.	Govardhan, V., "Remote Sensing and Water Management in Command Areas", International Book Distributing Co.	1993
4.	Mekonnen, G. and Houssain, F., "Satellite Rainfall Applications for Surface Hydrology", Springer.	2009
5.	Ramasamy, S.M., "Remote Sensing in Geomorphology", New India Publishing Agency.	2005
6.	Shultz, G.A. and Engman, E.T. (Eds.), "Remote Sensing in Hydrology and Water Management", Springer.	2000
7.	Singh, V.P. and Fiorentino, M., "GIS in Hydrology", Bantam Books.	1996
8.	Singh, V.P., "Computer Model in Watershed Hydrology", Water Resources Publications.	1995
9.	Zhou, Q., Lees, B. and Guo-an, T., "Advances in Digital Terrain Analysis", Springer.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: **CE-638** Course Title: **Satellite Geodesy**
2. Contact Hours: **L: 3 T: 0 P: 2**
3. Examination Duration (Hrs): Theory **3** Practical **0**
4. Relative Weightage: CWS **15** PRS **15** MTE **30** ETE **40** PRE **0**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective : To introduce the concepts of satellite geodesy and its applications in GPS.
10. Details of Course :

Sl. No.	Contents	Contact Hours
1	Introduction: Fundamentals, reference coordinate systems, time, signal propagation.	7
2	Satellite Orbital Motion: Fundamental of celestial mechanics, perturbed satellite motion, orbit determination, satellite orbit and orbital maneuvers.	8
3	Basic Observation Concepts and Geodetic Satellites: Satellite geodesy for parameter estimation, observables and basic concepts, satellites used in geodesy, GNSS systems- GPS, GLONASS, Galileo etc.	9
4	Satellite Altimetry: Basics, satellites and missions, measurements, corrections, data processing and accuracy, determination of mean sea surface.	5
5	Laser Ranging: Systems and components, measurements, corrections, data processing and accuracy, applications.	5
6	Planned Missions and Special Methods: VLBI.	3
7	Applications of Geodetic Satellite Methods: Positioning, gravity field and earth models, navigation, geodynamics.	5
	Total	42

List of Experiments :

- a. Demonstration, hands-on practice and collection of data using Geodetic GPS receivers. Further, download and process the data using commercial software.
- b. Demonstration, hands-on practice and analysis of 7 days GPS data using BERNES software.
- c. Demonstration, hands-on practice and analysis of 7 days GPS data using GAMIT software.
- d. To determine the different orbit and satellite parameters from GPS data.
- e. Process and analyse laser ranging data.
- f. Process and analyse VLBI data.

11. Suggested Books :

Sl. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Kaula, W.A., "Theory of Satellite Geodesy", Dover Pub Inc.	2000
2.	Seeber, G., "Satellite Geodesy, Foundations, Methods and Applications", Walter De Gruyter.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: **CE-639** Course Title: **Geomatics Tools for Disaster Management**
2. Contact Hours: **L: 3 T: 0 P: 2**
3. Examination Duration (Hrs): **Theory** 3 **Practical** 0
4. Relative Weightage: **CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0
5. Credits: 4
6. Semester: **Spring**
7. Subject Area: **PEC**
8. Pre-requisite: **Basic Remote Sensing and Digital Image Processing**
9. Objective : To introduce the applications of remote sensing, GIS and GPS tools for disaster mitigation and management.
10. Details of Course :

Sl. No.	Contents	Contact Hours
1	Introduction to various types of disasters, manmade and natural, earthquakes, volcanoes, landslides, floods, cyclones, tsunamis, anthropogenic, industrial, chemical and environmental, fire etc. stages of a disaster mitigation plan- pre-disaster planning, disaster preparedness, monitoring phase, emergency response or damage assessment, recovery and relief phase.	3
2	Various geomatics tools, total station, GPS, RS, GIS, digital elevation model generation extraction of parameters and their uses.	5
3	Earthquakes, causative factors, hazard assessment, selection of factors, SAR interferometry for estimation of ground displacement, creation of thematic data layers, preparation of seismic hazard zonation maps, regional risk assessment, geomatics tools for risk mitigation plans, case studies, damage assessment.	5
4	Landslides, causative factors, hazard assessment, selection of factors, triggering and non-triggering, creation of thematic data layers, preparation of landslide hazard zonation maps, regional and site specific risk assessments, modeling for risk mitigation plans, case studies	5
5	Cyclones and flooding, cyclone, cyclone related parameters and effects on land and sea, damage assessment, flooding, causes, identification of factors, space-time integration, GIS data layers, flood prone area demarcation, analysis and management, risk assessment, damage assessment, case studies, damage assessment.	4
6	Drought and desertification, types of droughts, factors influencing droughts, identification of variables, development of vegetation index, assessment of land use and ground water level changes, delimiting drought prone areas, processes of desertification, over utilization of water and land resources. GIS data layer creation – management strategies, case studies.	4
7	Anthropogenic disasters, atmospheric disasters, ozone layer depletion, green house/ global warming – acid rain – snow melt – sea level rise – related problems. GIS data layer creation, case studies, marine disasters: oil spill and chemical pollution, coastal erosion and deposition, factor identification, GIS analysis, management strategies. case studies.	5

8	Biodiversity disasters, ecological degradation, nuclear disaster and biodiversity loss, identification of parameters (mapping of forest types, protected areas and natural forests), population extinction – conserving bio-diversity (species and subspecies). soil erosion, coral / mangrove depletion, forest fire-mining, geomatics tools for preparation of ecological degradation maps, erosion maps, deforestation maps etc. GIS in environmental modeling, case studies.	5
9	Forest fire, estimation of forest fire, extent – NBR (normal burnt ratio), use of geomatics tools for monitoring and management, damage assessment.	2
10.	Tsunami, introductory concepts, geomatics tools and systems for monitoring and management, damage assessment.	2
Total		42

List of Experiments :

- Familiarisation with various remote sensing data products at different spectral, spatial and temporal resolutions
- Hands on experience on Total Station
- Hands on experience on GPS.
- Hands on experience on an image processing and GIS software.
- Digitization of Thematic layers.
- Collection of data from different sources for a given natural hazard
- Collection of field data using Total Station and/or GPS survey for the natural hazard selected
- Use of GIS for preparation of thematic data layers for the natural hazard selected
- Use of GIS for hazard zonation using probabilistic or any other method
- Use of GIS for risk zonation and assessment.
- Flood plan mapping using temporal satellite data (pre and post flood).
- Use of Differential SAR Interferometry for surface displacement studies.

11. Suggested Books :

Sl. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Andrew, S., "Environmental Modeling with GIS and Remote Sensing", John Willey and sons.	2002
2.	Ariyabandu, M. and Sahni P. (Eds), "Disaster Risk Reduction in South Asia", Prentice-Hall (India)	2003
3.	Bossler, J.D., "Manual of Geospatial Science and Technology", Taylor and Francis, London	2001
4.	Demers, Michael N., "Fundamentals of Geographic Information Systems", John Willey and sons.	2000
5.	Matthews, J.A., "Natural hazards and Environmental Change", Bill McGuire, Ian Mason.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1.	Subject Code: CE – 521	Course Title: Computer Applications in Environmental Systems									
2.	Contact Hours:	L: 3	T: 1	P: 2/2							
3.	Examination Duration (Hrs.):	Theory	3	Practical	0						
4.	Relative Weightage:	CWS	15	PRS	15	MTE	30	ETE	40	PRE	0
5.	Credits :	4	6. Semester : Autumn		7.		Subject Area: PCC				
8.	Pre-requisite: NIL										
9.	Objective: To develop skills for using computers to analyze, design and control of environmental systems.										

10. Details of the Course:

S.No.	Contents	Contact Hours
1.	Introduction to environmental system design and scope of computer applications in environmental systems.	7
2.	Optimization techniques and software packages.	8
3.	Computer applications in environmental quality modelling (water and air quality modelling), modelling of ecosystems etc.	8
4.	Computer aided analysis and design of water supply systems (water conveyance, distribution grid etc.), water treatment plants, sewerage system and sewage treatment plants.	15
5.	Automation in environmental systems.	4
	Total	42

List of Experiments :

- i) AutoCAD, MATLAB and other softwares
- ii) Application of optimization techniques
- iii) Design problems related to water and wastewater systems.

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Biswas, A.K., "Water Resources: Environmental Planning, Management and Development", McGraw Hill.	2009
2.	Weber, W.J. Jr., "Environmental Systems and Processes – Principles, Modeling and Design", Wiley Interscience.	2001
3.	Metcalf and Eddy, "Wastewater Engineering - Treatment and Reuse", Tata McGraw Hill.	2003
4.	Pielou, E.C., "Mathematical Ecology", John Wiley.	1977
5.	Swamee, P.K. and Sharma, A.K., "Design of Water Supply Pipe Networks", Interscience.	2008
6.	Bansal, R.K., Goel, A.K. and Sharma, M.K., "MATLAB and Its Application in Engineering", Pearson.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: **CE-522**

Course Title: **Advanced Water and Wastewater Treatment**

2. Contact Hours:

L: 3 T: 1

P: 0

3. Examination Duration (Hrs.):

Theory **3**

Practical **0**

4. Relative Weightage: CWS

25

PRS **0**

MTE **25**

ETE **50**

PRE **0**

5. Credits: **4**

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of principles, design and operation of various conventional and advanced processes for treatment of water and wastewater.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to conventional water treatment, rapid mixing, coagulation-flocculation, sedimentation, filtration and disinfection.	7
2.	Natural purification of water, filtration systems for water treatment, membrane systems, microfiltration, nanofiltration, ultrafiltration, reverse osmosis.	6
3.	Ion exchange and demineralization, adsorption, different types of adsorption, adsorption isotherms, adsorption kinetics in batch reactors, breakthrough curve and design of fixed absorber.	3
4.	Disinfection and advanced oxidation processes, advanced disinfection techniques.	3
5.	Removal of nitrate, fluoride, iron, manganese, arsenic etc. from water.	3
6.	Introduction to conventional aerobic and anaerobic methods of sewage treatment i.e. OP, RB, ASP TF, UASB etc.	7
7.	Wastewater treatment for carbon and nitrogen removal, biological nitrification and denitrification, activated sludge process design for nutrient removal, process operation, food to microorganism ratio (F/M), mean cell residence time, oxygen requirement.	4
8.	Biological and chemical phosphorous removal, process design and operation.	2
9.	Biomembrane processes for wastewater treatment, types of membrane bioreactors, design, operation and maintenance.	3
10.	Downstream wastewater treatment for reuse and recycle, need for downstream processing, guidelines for wastewater recycling, small and package plants for water and wastewater treatment.	4
Total		42

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication / Reprint
1.	"Wastewater Engineering – Treatment and Reuse", Metcalf and Eddy, Tata McGraw Hill.	2003
2.	Droste, R.L., "Theory and Practice of Water and Wastewater Treatment", John Wiley.	1997
3.	Vigneswaran, S. and Visvanathan, C., "Water Treatment Processes : Simple Options", CRC.	1995
4.	Davis, M.L. and Cornwell, D.A., "Introduction to Environmental Engineering", McGraw Hill.	2008
5.	Nazaroff, W.W. and Alvarez-Cohen, L., "Environmental Engineering Science", John Wiley.	2004
6.	Hammer, M.J. and Hammer, M.J. Jr., "Water and Wastewater Technology", PHL.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: CE-523

Course Title: Environmental Chemistry

2. Contact Hours:

L: 3

T: 1

P: 2

3. Examination Duration (Hrs.):

Theory 3

Practical 0

4. Relative Weightage: CWS

15

PRS

15

MTE

30

ETE

40

PRE

0

5. Credits: 5

6. Semester: Autumn

7. Subject Area: PCC

8. Pre-requisite: Nil

9. Objective: To develop understanding of environmental interactions and measurement of water and wastewater quality parameters.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction and Scope: Air-water, water-sediment / soil and air – water – sediment interactions, physical water quality parameters.	5
2.	Chemistry of Natural Water: Reaction stoichiometry, basic concepts from equilibrium chemistry, acid-base reactions, solubility of salts (soil chemistry) and related water quality parameters.	14
3.	Nutrients and Organic Impurities in Water: Oxidation-reduction reactions, water and wastewater quality parameters (ORP, BOD, COD, TOC etc.).	9
4.	Biochemical Reactions in Water and Wastewater: Reaction kinetics, sludge production, methane output, oxygen requirement etc.	5
5.	Heavy Metals: In water, complex formation, metal speciation.	2
6.	Air Chemistry: General concepts of air chemistry, stratospheric and tropospheric chemistry.	7
	Total	42

List of Experiments :

- i) Determination of pH, conductivity, TS, TDS, turbidity, total coliform, fecal coliform
- ii) Determination of major ions : Ca^{++} , Mg^{++} , Na^+ , HCO_3^- , Cl^- , SO_4^{--} , checking correctness of analysis, (ion balance, TDS – EC ratio), determination of saturation Index and CCPP
- iii) Determination of nutrients, BOD, COD, TOC, UV-absorbance, K_{ow}
- iv) Determination of residual Cl_2 , available Cl_2 and chlorine demand
- v) Analysis of trace metals in water and wastewater.

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication / Reprint
1.	Sawyer, C.N., McCarty P.L. and Parkin, G.F., "Chemistry for Environmental Engineering and Science", Tata McGraw Hill.	2003
2.	Davis, M.L. and Cornwell, D.A., "Introduction to Environmental Engineering", McGraw Hill.	2008
3.	Masters, G.M. and Ela, W.P., "Introduction to Environmental Engineering and Science", PHI.	2008
4.	Baird, C., "Environmental Chemistry", W.H. Freeman.	1999
5.	Stumm, S.W. and Morgan, J.J., "Aquatic Chemistry", John Wiley.	1981
6.	"Standard Methods for the Examination of Water and Wastewater", APHA, AWWA and WEF.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: **CE-581**

Course Title: **Advanced Programming and Computer Graphics**

2. Contact Hours:

L: 3

T: 0

P: 2

3. Examination Duration (Hrs.):

Theory **3**

Practical **0**

4. Relative Weightage: CWS **15**

PRS **15**

MTE **30**

ETE **40**

PRE **0**

5. Credits : **4**

6. Semester : **Autumn**

7. Subject Area: **PCC**

8. Pre-requisite: **NIL**

9. Objective : To develop understanding of the C++ programming language and introduce the basic principles of computer graphics.

10. Details of the Course

S. No.	Contents	Contact hours
1.	Introduction: Overview of programming languages and styles.	2
2.	The C Programming Language: Fundamental data types and declarations, operators, expressions and statements; Functions, pointers and arrays, structures and unions, input and output.	7
3.	The C++ Programming Language: Linkage conventions, namespaces, classes; Inheritance, polymorphism; Generic programming, exceptions, streams; Standard template library.	20
4.	Computer Graphics: Introduction and applications, graphics user interface; Point and line scan conversion.	5
5.	Transformations: 2-D and 3-D geometrical transformations, 2D clipping.	3
6.	The C Graphics Functions: Overview of AutoCAD and / or Microstation; Computer graphics applications.	5
Total		42

Laboratory Practicals:

Coding in C++ for the following:

- i) Mathematical procedures
- ii) Multidimensional arrays
- iii) List, stack and queue
- iv) Text processing
- v) Class for matrices
- vi) Inheritance
- vii) Polymorphism
- viii) Generic class
- ix) Class for graphics procedures
- x) Standard template library

11. Suggested Books

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Kernighan, B.W. and Ritchie, D.M., "The C Programming Language", Prentice Hall.	1988
2.	Stroustrup, B., "The C++ Programming Language", Addison Wesley.	2000
3.	Ellis, M.A. and Stroustrup, B., "The Annotated C++ Reference Manual", Pearson.	2007
4.	Foley, J.D., van Dam, A., Feiner, S.K. and Hughes, J.F., "Computer Graphics Principles and Practice", Pearson.	1996
5.	Xiang, Z. and Plastock, R.A., "Computer Graphics", Tata McGraw Hill Schaum's Outlines Series.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: **CE-582**

Course Title: **Expert Systems, Neural Networks and Fuzzy Systems**

2. Contact Hours:

L: 3 T: 1 P: 0

3. Examination Duration (Hrs.):

Theory **3** Practical **0**

4. Relative Weightage: CWS **25**

PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits : **4**

6. Semester : **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **NIL**

9. Objective : To introduce the basics of artificial intelligence and its applications in civil engineering.

10. Details of the Course:

S.No.	Contents	Contact Hours
1.	Introduction: Artificial Intelligence (AI), Expert System (ES), Fuzzy System (FS), Artificial Neural Networks (ANN).	2
2.	Expert Systems: Introduction; Knowledge acquisition – learning models, machine learning; Knowledge representation – symbolic logic, graphs, frames, related structures; Inference engine – searching, matching and control strategies; Reasoning under uncertainty – probabilistic and Dempster – Shafer's theories, fuzzy theory, neural network.	10
3.	Neural Networks: Introduction; Basic concepts of neural networks; Classification models-association, optimization and self organization models; Neural network learning-back propagating, radial basis function network, ART network, genetic algorithm; Knowledge based neural networks-rule based, training, decision-tree based, constitutive based.	12
4.	Fuzzy Systems: Fuzzy set theory, membership functions, parameters of fuzzy sets, properties of fuzzy sets, operations on fuzzy sets, fuzzy relations, fuzzy crisp conversions, fuzzy arithmetic, fuzzy logic.	5
5.	Fuzzy Expert Systems: Neuro - fuzzy computing – integration methods, mathematical formulation; Adaptive fuzzy system – neuro fuzzy learning system.	5
6.	Application: AI Techniques as applied to civil engineering problems.	6
	Total	40

11. Suggested Books:

S.No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Patterson, D.W., "Introduction to Artificial Intelligence and Expert Systems", PHI.	1992
2.	Li Min, F., "Neural Networks in Computer Intelligence", McGraw-Hill.	1994
3.	Kosko, B., "Neural Network and Fuzzy Systems", PHI	2000
4.	Klir, G.J. and Yuan, B., "Fuzzy Sets and Fuzzy Logic - Theory and Application", PHI.	1992
5.	Rao, V. and Rao, H., "C++ Neural Networks and Fuzzy Logic", BPB Publication.	2000
6.	Zimmermann, H.J., "Fuzzy Set Theory and its Applications", Allied Publishers.	1996
7.	Frenzel, L.E., "Crash Course in Artificial Intelligence and Expert Systems", H.W. Sams and Co.	1987

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code : CE-541 Course Title : Advanced Numerical Analysis
2. Contact Hours : L: 3 T: 0 P: 2
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage : CWS 15 PRS 15 MTE 30 ETE 40 PRE 0
5. Credits : 4
6. Semester : Autumn
7. Subject Area : PCC
8. Pre-requisite : Nil
9. Objective: To impart knowledge of various numerical techniques for solving the problems of civil engineering.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Roots of a non-linear equation and roots of n^{th} degree polynomial; Incremental search method, method of successive approximations, Newton's method, bisection method, secant method, Müller's method, synthetic division and Bairstow's method; Convergence study.	10
2.	Solution of Non-homogeneous Linear Algebraic Equations: Gauss elimination method, Choleski's decomposition method, householder method, Gauss-Siedal iterative method.	6
3.	Solution of Non-Linear Algebraic Equations: Method of successive approximation, Newton's method, modified Newton-Raphson method, secant method.	4
4.	Eigen Value Problems: Eigen values and Eigen vectors, reduction of generalized Eigen value problem to the standard Eigen value problem, methods for obtaining Eigen values and Eigen vectors; Polynomial method, vector iteration method, Mises power method and Jacobi method; Application to problems of vibration analysis and buckling analysis.	8
5.	Time Marching Schemes: Solution of dynamic problems in time domain, numerical integration, explicit and implicit methods; Application to problems to portal frames and creep.	4
6.	Solution of Ordinary and Partial Differential Equations: Euler's method, Runge-Kutta method, finite difference method, method of weighted residuals such as collocation, least square and Galerkin's methods; Application to problems of beams and plates on elastic foundation, Laplacian equation for seepage, consolidation equation and laterally loaded piles.	10
Total		42

Laboratory Practicals:

Development of algorithms/codes for different problems such as:

- i) Solution of linear simultaneous equations
- ii) Solution of non-linear simultaneous equations
- iii) Solution of Eigen value problems
- iv) Explicit and implicit integration schemes for solution of problems of creep
- v) Finite difference analysis of problems of:
 - a. Finite beams on elastic foundations
 - b. Plates on elastic foundations
 - c. Laterally loaded piles
 - d. Laplacian and consolidation equations.

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Chapra, S.C. and Canale, R.P., "Numerical Methods for Engineers", Tata McGraw Hill.	2003
2.	Carnahan, B., Luther, H.A. and Wilkes, J.O., "Applied Numerical Methods", John Wiley.	1969
3.	Heath, M.T., "Scientific Computing : An Introductory Survey", Tata McGraw Hill.	1997
4.	Faires, D.J. and Richard, B., "Numerical Methods", Thomson.	2003
5.	Rajasekaran, S., "Numerical Methods in Science and Engineering", S. Chand.	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code: **CE-512** Course Title: **Analysis and Design for Dynamic Effects**

2. Contact Hours: **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs): **Theory 3 Practical 0**

4. Relative Weightage: **CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the concepts of structural dynamics, earthquake resistant design and to impart understanding of various codal provisions.

10. Details of the course:

S. No.	Contents	Contact Hours
1.	Single Degree of Freedom (SDOF) systems; free and forced vibrations, damped and undamped systems.	6
2.	Duhamel integral, Rayleigh method, Green's function, Fourier series, elastic response spectra.	6
3.	Time history analysis of SDOF system, Newmark method and Wilson-θ method, convergence criteria.	5
4.	Multi degree of freedom systems, lumped and consistent mass matrix, application to multistorey buildings, SRSS and CQC mode superposition techniques.	7
5.	Vibration of continuous systems including axial effects, introduction to inelastic response spectra, ductile detailing, design specification in IS:1893, IS:13920 and IS:875 (pt 3).	6
6.	Analysis of buildings and towers for wind loads by static and dynamic methods, design specifications in IS:875.	5
7.	Active and passive control systems.	3
8.	Application to dynamic analysis using software packages like SAP2000 and STAAD.	4
Total		42

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Clough, R.W. and Penzien, J., "Dynamics of Structures", McGraw-Hill.	2008
2.	Chopra, A.K., "Dynamics of Structures", Pearson.	2006
3.	Agarwal, P. and Shrikhande, M., "Earthquake Resistant Design of Structures", PHI.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code: **CE-561** Course Title: **Computer Applications in Structural Analysis**
2. Contact Hours: **L: 3 T: 0 P: 2**
3. Examination Duration (Hrs): **Theory 3 Practical 0**
4. Relative Weightage: **CWS 15 PRS 15 MTE 30 ETE 40 PRE 0**
5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective: To develop the application of computer software for structural analysis of linear and nonlinear problems.
10. Details of the course:

S. No.	Contents	Contact Hours
1.	Need of computer applications in structural analysis, introduction to software packages like STAAD, SAP and MATLAB.	4
2.	Static and kinematic indeterminacy, stiffness and flexibility matrices.	4
3.	Stiffness matrices for prismatic and non prismatic members, solution techniques, substructure analysis techniques.	8
4.	Application to plane truss, space truss, beams, grids, plane frames and space frames subjected to various in-plane / out of plane loadings including effects of temperature change and support displacements.	8
5.	Techniques of nonlinear structural analysis, material and geometric nonlinear problems, incremental and iterative procedures, convergence criteria.	8
6.	Application of software packages such as SAP and STAAD, development of software codes for simple structural analysis problems using MATLAB.	10
Total		42

List of Experiments :

- i) Development of software codes by using MATLAB etc. for the linear analysis of :
 - a. Plane/Space Trusses
 - b. Plane/Space Frames.
- ii) Use of softwares (STAAD and SAP etc.) for the analysis of :
 - a. Plane/Space Trusses
 - b. Plane/Space Frames
 - c. Practical Problems.

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Weaver, W., Jr. and Gere, J.M., "Matrix Analysis of Framed Structures", CBS.	2004
2.	McGuire, H.G. and Ziemian, R.D., "Matrix Structural Analysis", John Wiley.	2000
3.	Jain, A.K., "Advanced Structural Analysis with Finite Element and Computer Applications", Nem Chand & Bros.	2006
4.	Wang, C.K., "Intermediate Structural Analysis", McGraw-Hill.	1983
5.	Bansal, R.K., Goel, A.K. and Sharma, M.K., "MATLAB and its Application in Engineering", Pearson.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: **CE-513**

Course Title: **Analysis and Design of Multistoreyed Buildings**

2. Contact Hours:

L: 3 T: 1 P: 0

3. Examination Duration (Hrs):

Theory **3** Practical **0**

4. Relative Weightage: CWS **25**

PRS **0**

MTE **25**

ETE **50**

PRE **0**

5. Credits: **4**

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of analysis and design of tall buildings subjected to different loading conditions and detailing of various components

10. Details of the course:

S. No.	Contents	Contact Hours
1.	Performance based design philosophy, structural systems for multistoreyed buildings, gravity and lateral loads on buildings, analysis of multistoreyed frames.	8
2.	Analysis of asymmetric buildings – mass irregularity in plan and elevation, analysis for torsion in buildings.	4
3.	Behavior of framed tube system, tube-in-tube system, bundled tube system, simplified analytical models for symmetrical tubular structures.	6
4.	Design of buildings with shear walls and coupled-shear walls, design specifications in IS codes.	7
5.	Design and detailing of various members and beam-column joints for ductility, design specifications in IS codes.	6
6.	Design of raft and pile foundations, design specifications in IS codes.	5
7.	Application of software packages such as MS-Excel, ETABS and SAFE.	6
Total		42

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Jain, A.K., "Reinforced Concrete-Limit State Design", Nem Chand & Bros.	2002
2.	James, K.K. and Gregor, J.G.M., "Reinforced Concrete Mechanics and Design", Pearson.	2009
3.	Arthur, H.N., "Design of Concrete Structures", Tata McGraw-Hill.	2005
4.	Park, R. and Paulay, T., "Reinforced Concrete Structures", John-Wiley.	1975

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: **CE-611** Course Title: **Concrete Technology**
2. Contact Hours: **L: 3 T: 0 P: 2**
3. Examination Duration (Hrs): **Theory 3 Practical 0**
4. Relative Weightage: **CWS 15 PRS 15 MTE 30 ETE 40 PRE 0**
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: Nil
9. Objective: To introduce the understanding of different ingredients required for making concrete, properties of fresh and hardened concrete as well as mix design and testing of concrete
10. Details of the course:

S. No.	Contents	Contact Hours
1.	Ingredients of Concrete: Review of cements including blended cements, manufacture, chemical composition, aggregates; Review of types; Elementary mineralogy and petrology; Sampling and testing.	8
2.	Admixtures: Review of types and classification, chemical admixtures, mineral admixtures, effects on properties of concretes.	4
3.	Fresh-concrete: Rheology of mortars and concretes; Workability, segregation and bleeding, theory and principles governing transportation, placing, compaction and curing of concrete, plastic settlement and plastic shrinkage, exothermic characteristics; Early age thermal movements, strength development, maturity, hot and cold weather concreting.	8
4.	Properties of Hardened Concrete: Strength, deformation, elasticity, creep, drying shrinkage and other volume changes, thermal properties, durability.	8
5.	Concrete Mix Design: The process of mix selection, factors governing the selection of mix proportions, combining aggregates to obtain specified grading, statistical quality control.	8
6.	Special Concretes: Lightweight concrete, no-fines concrete, high performance concrete, high density and radiation-shielding concrete, polymer concrete, fiber-reinforced concrete, self compacting concrete, roller compacted concrete, high volume fly ash concrete, ready mixed concrete.	6
Total		42

List of Experiments :

- a. To determine the properties of fresh concrete namely workability, yield, temperature, air content etc.
- b. Concrete mix design of high strength concrete, self compacting concrete etc.
- c. To determine the properties of hardened concrete namely compressive strength, flexural strength, stress-strain behavior, modulus of elasticity and creep & shrinkage.
- d. To determine the transport properties of hardened concrete namely water permeability, chloride permeability etc.

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Neville, A.M., "Properties of Concrete", Prentice Hall.	1995
2.	Mehta, P.K. Paulo, M.J.M., "Concrete Micro Structures, Properties and Materials", Prentice Hall Inc. & McGraw-Hill.	2005
3.	Orchard, D.F., "Concrete Technology", Vol. I-II, Applied Science.	1979
4.	Shetty, M.S., "Concrete Technology: Theory and Practice", S. Chand & Company Ltd.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: CE-612	Course Title: Construction Cost Dynamics and Management
2. Contact Hours:	L: 3 T: 1 P: 0
3. Examination Duration (Hrs):	Theory 3 Practical 0
4. Relative Weightage: CWS 25	PRS 0 MTE 25 ETE 50 PRE 0
5. Credits: 4	6. Semester: Spring 7. Subject Area: PEC
8. Pre-requisite: Nil	
9. Objective: To introduce the scheduling and planning of a project and network techniques	

10. Details of the course:

S. No.	Contents	Contact Hours
1.	Building construction industry, specific features.	3
2.	Elements of engineering economics, time value of money, compounding components of cost, criteria for cost comparison, cost indices.	8
3.	Planning, effect of plan shape and storey heights.	1
4.	Probabilistic concepts, uncertainty, probability models, minimization of expected costs, applications to site planning, bidding, reliability analysis.	11
5.	Introduction to network techniques LOB, CPM, PERT, time, cost and material scheduling, cash flow diagrams.	6
6.	Resources leveling and allocation, application to mass housing, statistical methods for decision making under uncertainty, balancing the risk and cost effectiveness of decisions.	6
7.	Application of construction management softwares like Construct SIM and Primavera etc.	7
Total		42

11. Suggested Books:

S. No.	Name of Books/Authors/Publisher	Year of Publication/ Reprints
1.	Adeli, H. and Karim, A., "Construction Scheduling, Cost Optimization and Management", Taylor & Francis.	2001
2.	Jaggar, D., Ross, A., Smith, J. and Love, P., "Building Design Cost Management", Blackwell Science Ltd.	2000
3.	Harris, F., McCaffer, R. and Fotwe, F.E., "Modern Construction Management", Wiley-Blackwell.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: **CE-613**

Course Title: **Wind Engineering**

2. Contact Hours:

L: 3 T: 0 P: 2

3. Examination Duration (Hrs):

Theory 3

Practical 0

4. Relative Weightage: **CWS 15**

PRS 15

MTE 30

ETE 40

PRE 0

5. Credits: **4**

6. Semester: **Spring**

7. Subject Area: **PEC**

8. Pre-requisite: **CE-512**

9. Objective: To introduce the wind effects on buildings, chimneys, towers and bridges and wind tunnel instrumentation for the measurement of flow parameters

9. Details of the course:

S. No.	Contents	Contact Hours
1.	Atmospheric pressure and gradient wind, wind climate and structure, peak 3-sec, 10 min and hourly mean wind speeds, low cycle energy and large scale pressure systems, wind energy and turbulence.	7
2.	Spectral Distribution and Boundary Layer (ABL) & its characteristics, aerodynamics of bluff bodies, vortex shedding and associated unsteady along and across wind forces, extreme winds, correlation and spectral function.	8
3.	Random vibration theory, narrow and wide band random processes, response of SDF in the frequency domain to random excitation, application to MDF systems, experimental procedures for response studies, wind tunnel and its salient features, ABL simulation.	11
4.	Basic wind tunnel instrumentation for the measurement of flow parameters, forces, displacements and strains, use of statistical methods for the analysis of measured data and its interpretation, procedures for along wind and across wind forces.	8
5.	Wind effects on buildings, chimneys, towers and bridges, pressure coefficients and internal pressures, case studies, IS-875-III & Euro code.	8
Total		42

List of Experiments :

- a. Measurement of base shear and moment in tall structures.
- b. Measurement of pressure distribution on building models.
- c. Measurement of strains in aero-elastic models.
- d. Study of interference effects.
- e. Study of the effects of openings in walls.

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprints
1.	Liu, H., "Wind Engineering A Hand Book for Structural Engineers", Prentice-Hall India Pvt. Ltd.	1991
2.	Meroney, R.N. and Bienkiewicz, B., "Computational Wind Engineering", Elsevier Science.	1997
3.	Simiu, E. and Seaman, R.H., "Wind Effect on Structures", John Wiley & Sons.	1996
4.	McDonald, J., "Wind Loading on Buildings", Applied Science Publishers Ltd.	1984
5.	Sean, P., "Wind Forces in Engineering", Pergamon Press.	1978

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: **CE-615**

Course Title: **Evaluation and Retrofitting of Buildings**

2. Contact Hours:

L: 3 T: 1 P: 0

3. Examination Duration (Hrs):

Theory 3

Practical 0

4. Relative Weightage: **CWS** 25

PRS 0

MTE 25

ETE 50

PRE 0

5. Credits: 4

6. Semester: **Spring**

7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the application of different techniques for evaluation and retrofitting of buildings

10. Details of the course:

S. No.	Contents	Contact Hours
1.	Deterioration of concrete buildings, embedded metal corrosion, disintegration mechanisms, moisture effects, thermal effects, structural effects, faulty construction	6
2.	Evaluation of concrete buildings, visual investigation, destructive testing systems, non-destructive testing techniques, semi-destructive testing techniques, chemical testing.	8
3.	Structural health monitoring, vibration based monitoring technique, smart materials and sensors	4
4.	Surface repair and retrofitting techniques, strategy & design, selection of repair materials, surface preparation, bonding repair materials to existing concrete, placement methods.	8
5.	Strengthening techniques, strengthening techniques, beam shear capacity strengthening, shear transfer strengthening between members, column strengthening, flexural strengthening, and crack stabilization.	9
6.	Seismic rehabilitation of existing buildings, seismic vulnerability and strategies for seismic retrofit.	7
Total		42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprints
1.	Emmons, P.H., "Concrete Repair and Maintenance Illustrated", Galgotia Publications Pvt. Ltd.	2001
2.	Bungey, S., Lillard, G. and Grantham, M.G., "Testing of Concrete in Structures", Taylor and Francis.	2001
3.	Malhotra, V.M. and Carino, N.J., Handbook on Non-destructive Testing of Concrete, CRC Press.	2004
4.	Bohni, H., "Corrosion in Concrete Structures", CRC Press.	2005
5.	FEMA 273; NEHRP Guidelines for the Seismic Rehabilitation of Buildings.	1997
6.	ATC- 40: Seismic Evaluation and Retrofit of Concrete Buildings, Vol. 1 & 2.	1997
7.	Priestley, M.J.N., Seible, F. and Calvi, G.M., "Seismic Design and Retrofit of Bridges", John Wiley & Sons.	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: **CE-616**

Course Title: **Quantitative Methods and Project Financing**

2. Contact Hours:

L: 3 T: 1 P: 0

3. Examination Duration (Hrs):

Theory **3** Practical **0**

4. Relative Weightage: CWS **25**

PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4**

6. Semester: **Spring**

7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the quantitative methods and project financing in Civil Engineering.

10. Details of the course:

S. No.	Contents	Contact Hours
1.	Working capital needs, sources, procedures, practices in construction business.	4
2.	Long term financing.	2
3.	Working of financial institute in India and abroad.	3
4.	Self financing, stock exchange.	3
5.	Types of securities, borrowings debentures.	2
6.	Understanding of financial statements and their analysis, like balance sheet, profit and loss account, rate analysis fund flow analysis, statement of changes in financial position.	9
7.	Corporate reporting practices in India.	2
8.	Introduction, meaning, importance and development of value analysis techniques, life cycle costing: maintenance and operating costs, energy and utility costs, cost of insurance, anticipated future income growth, effect of facilities on productivity, present and future trends in real estate.	10
9.	Sampling and sampling distributions, testing hypothesis: one sample test, testing hypothesis: two sample test, simple regression and correlations.	7
Total		42

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication/ Reprints
1.	Goodpasture, J.C., "Quantitative Methods in Project Management", J. Ross Publishing, Inc.	2003
2.	Kerzner, H., "Project Management: A Systems Approach to Planning, Scheduling and Controlling", Wiley.	2009
3.	Wysocki, R.K., "Effective Project Management", John Wiley & Sons.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: **CE-661**

Course Title: **Finite Element Method**

2. Contact Hours:

L: 3 T: 0 P: 2

3. Examination Duration (Hrs):

Theory 3 Practical 0

4. Relative Weightage: **CWS 15**

PRS 15 MTE 30 ETE 40 PRE 0

5. Credits: 4

6. Semester: **Spring**

7. Subject Area: **PEC**

8. Pre-requisite: Nil

9. Objective: To introduce the concept of finite element analysis of structures, application of finite elements in solid mechanics and structural dynamics

10. Details of the course:

S. No.	Contents	Contact Hours
1.	Basic Concepts, Discretization: Displacement, force and hybrid models, interpolation functions for general element formulations, compatibility and completeness.	3
2.	Polynomial Forms: One dimensional elements, geometric isotropy, triangular elements, rectangular elements, three dimensional elements, isoparametric formulations, axisymmetric elements, numerical integration.	10
3.	Applications in Solid Mechanics: Plane stress/strain, FE formulation, CST, LST, stiffness matrix, load matrix formation rectangular element isoparametric formulation, plate elements and shell elements; three dimensional elements FE formulation; Axisymmetric stress analysis, torsion, interface elements, infinite elements.	12
4.	Application in Structural Dynamics and Vibrations: Mass (consistent and diagonal) and damping matrices, modal analysis, time history analysis, explicit direct integration/implicit direct integration and mixed methods.	5
5.	Introduction to Nonlinear Problems: Geometric and material (elasto-plastic), solution methods; Newton-Raphson method, modified Newton-Raphson method, arc method, a problem of geometric nonlinearity.	5
6.	Stationary principles: Rayleigh Ritz method and interpolation; Weighted residual methods and variational methods, numerical errors and convergence.	4
7.	Application of Software: Such as ABAQUS and ANSYS.	3
	Total	42

List of Experiments :

- a. Development of software codes using MATLAB etc. for the analysis of plane stress/ plane strain problems
- b. Introduction to analysis packages (ABAQUS/ANSYS etc.) and their application for the analysis of :
 - a. Trusses
 - b. Frames
 - c. Plane stress/plane strain problems
 - d. Plates
 - e. Shells

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication/ Reprint
1.	Bathe, K.J., "Finite Element Procedures", Prentice-Hall of India Private Limited.	2002
2.	Cook, R.D., Malkus, D.S. and Plesha M.E., "Concepts and Applications of Finite Element Analysis", John Wiley & Sons.	2007
3.	Zeinkwicz, O.C., "The Finite element Method", Tata McGraw-Hill.	2005
4.	Reddy, J.N., "An introduction to Finite element Method", McGraw-Hill.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE:

DEPARTMENT OF CIVIL ENGINEERING

1. Subject Code: CE-614

Course Title: Experimental Stress Analysis

2. Contact Hours:

L: 3

T: 0

P: 2

3. Examination Duration (Hrs):

Theory 3

Practical 0

4. Relative Weightage: CWS 15

PRS 15

MTE 30

ETE 40

PRE 0

5. Credits: 4

6. Semester: Spring

7. Subject Area: PEC

8. Pre-requisite: Nil

9. Objective: To introduce the principles of various measuring devices for stress and strain analysis

10. Details of the course:

S. No.	Contents	Contact Hours
1.	Strain Measurement: Strain gauges-theory of resistance strain gauges, basic types and constructions, gauge configurations and their uses, gauge materials and requirements, mounting techniques, strain gauge circuitry, reduction of strain gauge data, special applications such as high temperature, fatigue and creep.	8
2.	Displacement Measurement: Mechanical dial gauges, linear variable differential transformers, linear resistance potentiometers.	6
3.	Stresses and Force Measurements: Load cells-types and sizes, embedded stress meters and plugs, proving rings.	4
4.	Temperature Measurements: Thermo-couples and thermistors, thermistor type thermometers.	4
5.	Vibration Measurement: Vibration pickups for measuring displacements, velocities and accelerations-principles of operations, phase distortions, sensitivity, practical applications.	4
6.	Photoelasticity: Photoelastic theory, photoelastic equipment, photoelastic model materials, reduction of photoelastic data, extrapolation to the prototype, practical applications.	8
7.	Smart Materials: Characteristics, piezoelectric materials, shape memory alloys, self healing materials, practical applications.	4
8.	Measurement Devices: UPV method, radar and dynamic response testing, radiography and radiometry, infrared thermography, X-Ray diffraction, SEM techniques.	4
Total		42

List of Experiments :

Experiments using strain gauges

- a. Measurement of strain, temperature and pressure effects
- b. Experiments using vibration meter and acceleration pickup
- c. Experiments using photoelastic bench
- d. Experiments using NDT techniques

11. Suggested Books:

S. No.	Name of Authors Books / Books / Publisher	Year of

		Publication/ Reprint
1.	Dally, J.W. and Riley, W.F., "Experimental Stress Analysis", McGraw-Hill..	1991
2.	Sabmis, G.J. et al., "Structural Modeling and Experimental Techniques", Prentice-Hall.	1983
3.	Bungey, J.H. and Millard, S.G., "Testing of Concrete in Structures", Blackie Academic & Professional.	2008
4.	Encyclopedia of Smart Materials, John Wiley & Sons.	2010

M.Tech. (Electrical Engineering)
(Instrumentation and Signal Processing)

I Year

Autumn Semester

Teaching Scheme															
S. No.	Sub Code	Course Title	Sub Area	Credits	Contact Hrs. Per Week			Exam. Duration		Relative Weight					
					L	T	P	T	P	CWS	PRS	MTE	ETE	PRE	
1.	MA-501F	Numerical Analysis, Probability and Statistics	ICC	4	3	1	0	3	-	-	25	-	25	50	-
2.	EE-521	Advanced Industrial and Electronic Instrumentation	PCC	4	3	1	2/2	3	-	-	15	15	30	40	-
3.	EE-520	Digital Signal and Image Processing	PCC	4	3	1	2/2	3	-	-	15	15	30	40	-
4.	EE-532	Intelligent Sensors and Instrumentation	PCC	4	3	1	0	3	-	-	25	-	25	50	-
5.		Open Elective-I	OEC	3/4	-	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (Optional)	IEC	2	1	0	2	2	-	-	15	15	30	40	-
				Subtotal	19-22										

Spring Semester

Teaching Scheme					Contact Hrs. Per Week	Exam. Duration		Relative Weight						
S. No.	Sub Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	EE-502	Modelling, Simulation and Evolutionary Techniques	PCC	4	3	0	2	3	-	15	15	30	40	-
2.		Program Elective-I	PEC	4	-	-	-	-	-	-	-	-	-	-
3.		Program Elective-II	PEC	4	-	-	-	-	-	-	-	-	-	-
4.		Program Elective-III	PEC	4	-	-	-	-	-	-	-	-	-	-
5.		Open Elective-II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6	HS-501	Technical Communication (Optional)	IEC	2	1	0	2	2	-	15	15	30	40	-
Subtotal				19-22										

II Year
Autumn Semester

Teaching Scheme					Contact Hrs. Per Week	Exam. Duration			Relative Weight						
S. No.	Sub Code	Course Title	Sub Area	Credits		L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	EE-601	Seminar	SEM	2	-	-	-	-	-	-	-	-	-	100	-
2.	EE-602	Project	RP	4	-	-	-	-	-	-	-	-	-	100	-
3.	EE-603	Dissertation *	DIS	-	-	-	-	-	-	-	-	-	-	25	-
Subtotal				6											

***NOTE:** To be continued and grade to be awarded in the next semester.

Spring Semester

Teaching Scheme														
S. No.	Sub Code	Course Title	Sub Area	Credits	Contact Hrs. Per Week			Exam. Duration		Relative Weight				
					L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	EE-603	Dissertation (contd. From III semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
Subtotal				20										
Total				64-68										

List of Electives (Instrumentation and Signal Processing)

Teaching Scheme					Contact Hrs. Per Week			Exam. Duration		Relative Weight				
S. No.	Sub Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	EE-522	Biomedical Instrumentation	PEC	4	3	1	0	3	-	25	-	25	50	-
2.	EE-523	Process Instrumentation and Control	PEC	4	3	1	0	3	-	25	-	25	50	-
3.	EE-524	Telemetry and SCADA	PEC	4	3	1	0	3	-	25	-	25	50	-
4.	EE-525	Measurement Errors and Statistical Analysis	PEC	4	3	1	0	3	-	25	-	25	50	-
5	EE-526	Bioelectric Signals and Processing	PEC	4	3	1	0	3	-	25	-	25	50	-
6	EE-527	Computer Applications in Medicine	PEC	4	3	1	0	3	-	25	-	25	50	-
7	EE-528	Virtual Instrumentation	PEC	4	3	1	0	3	-	25	-	25	50	-
8	EE-529	Medical Imaging	PEC	4	3	1	0	3	-	25	-	25	50	-
9	EE-530	Power System Instrumentation	PEC	4	3	1	0	3	-	25	-	25	50	-
10	EE-531	Ultrasonic and Laser Instrumentation	PEC	4	3	1	0	3	-	25	-	25	50	-
11	EE-533	Advances in Signal and Image Processing	PEC	4	3	1	0	3	-	25	-	25	50	-

M.Tech. (Electrical Engineering)
(Electric Drives and Power Electronics)

I Year

Autumn Semester

Teaching Scheme					Contact Hrs. Per Week			Exam. Duration		Relative Weight				
S. No.	Sub Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	MA-501F	Numerical Analysis, Probability and Statistics	ICC	4	3	1	0	3	-	25	-	25	50	-
2.	EE-540	Advanced Power Electronics	PCC	4	3	1	2/2	3	-	15	15	30	40	-
3.	EE-541	Power Electronic Controlled Electric Drives	PCC	4	3	1	2/2	3	-	15	15	30	40	-
4.	EE-542	Analysis of Electrical Machines	PCC	4	3	1	0	3	-	25	-	25	50	-
5.		Open Elective-I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6	HS-501	Technical Communication (Optional)	IEC	2	2	0	2	2	-	15	15	30	40	-
Subtotal				19-22										

Spring Semester

Teaching Scheme														
S. No.	Sub Code	Course Title	Sub Area	Credits	Contact Hrs. Per Week			Exam. Duration		Relative Weight				
					L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	EE-502	Modelling, Simulation and Evolutionary Techniques	PCC	4	3	0	2	3	-	15	15	30	40	-
2.		Program Elective-I	PEC	4	-	-	-	-	-	-	-	-	-	-
3.		Program Elective-II	PEC	4	-	-	-	-	-	-	-	-	-	-
4.		Program Elective-III	PEC	4	-	-	-	-	-	-	-	-	-	-
5.		Open Elective-II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6	HS-501	Technical Communication (Optional)	IEC	2	1	0	2	2	-	15	15	30	40	-
Subtotal				19-22										

II Year
Autumn Semester

Teaching Scheme														
S. No.	Sub Code	Course Title	Sub Area	Credits	Contact Hrs. Per Week			Exam. Duration			Relative Weight			
					L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	EE-601	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	EE-602	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	EE-603	Dissertation*	DIS	-	-	-	-	-	-	-	-	-	25	-
Subtotal				6										

***NOTE:** To be continued and grade to be awarded in the next semester.

Spring Semester

Teaching Scheme														
S. No.	Sub Code	Course Title	Sub Area	Credits	Contact Hrs. Per Week			Exam. Duration		Relative Weight				
					L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	EE-603	Dissertation (contd. From III semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
Subtotal				20										
Total				64-68										

List of Electives (Electric Drives and Power Electronics)

Teaching Scheme					Contact Hrs. Per Week			Exam. Duration		Relative Weight				
S. No.	Sub Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	EE-543	Advanced Electric Drives	PEC	4	3	1	2/2	3	-	15	15	30	40	-
2.	EE-544	Microprocessor Controlled Electric Drives	PEC	4	3	0	2	3	-	15	15	30	40	-
3.	EE-545	Embedded Controllers and Applications	PEC	4	3	0	2	3	-	15	15	30	40	-
4	EE-546	Design of Electric Drives	PEC	4	3	1	0	3	-	25	-	25	50	-
5	EE-547	Instrumentation in Electric Drives	PEC	4	3	1	0	3	-	25	-	25	50	-
6	EE-548	Drive System in Electric Traction	PEC	4	3	1	0	3	-	25	-	25	50	-
7	EE-549	Control Techniques in Power Electronics for AC Drives	PEC	4	3	0	2	3	-	15	15	30	40	-
8	EE-550	Pulse Width Modulation for Power Converters	PEC	4	3	1	0	3	-	25	-	25	50	-
9	EE-551	Enhanced Power Quality AC/DC Converters	PEC	4	3	0	2	3	-	15	15	30	40	-
10	EE-552	Switched Mode Power Supply	PEC	4	3	1	0	3	-	25	-	25	50	-
11	EE-553	Power Quality Improvement Techniques	PEC	4	3	0	2	3	-	15	15	30	40	-
12	EE-554	FACTS Devices	PEC	4	3	1	0	3	-	25	-	25	50	-
13	EE-555	CAD of Power Apparatus	PEC	4	3	1	0	3	-	25	-	25	50	-
14	EE-556	Selected Topics in Machines and Transformers	PEC	4	3	0	2	3	-	15	15	30	40	-
15	EE-557	Synchronous Machines and System Stability	PEC	4	3	1	0	3	-	25	-	25	50	-
16	EE-558	Special Machines	PEC	4	3	1	0	3	-	25	-	25	50	-
17	EE-567	HVDC Systems	PEC	4	3	1	0	3	-	25	-	25	50	-

M.Tech. (Electrical Engineering)
(Power System Engineering)

I Year
Autumn Semester

Teaching Scheme					Contact Hrs. Per Week			Exam. Duration		Relative Weight				
S. No.	Sub Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	MA-501F	Numerical Analysis, Probability and Statistics	ICC	4	3	1	0	3	-	25	-	25	50	-
2.	EE-560	Computer Aided Power System Analysis	PCC	4	3	0	2	3	-	15	15	30	40	-
3.	EE-561	EHVAC and DC Transmission	PCC	4	3	1	0	3	-	25	-	25	50	-
4.	EE-562	Power System Operation and Control	PCC	4	3	1	0	3	-	25	-	25	50	-
5.		Open Elective-I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6	HS-501	Technical Communication (Optional)	IEC	2	1	0	2	2	-	15	15	30	40	-
Subtotal				19-22										

Spring Semester

Teaching Scheme										Contact Hrs. Per Week		Exam. Duration		Relative Weight				
S. No.	Sub Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE				
1.	EE-502	Modelling, Simulation and Evolutionary Techniques	PCC	4	3	0	2	3	-	15	15	30	40	-				
2.		Program Elective-I	PEC	4	-	-	-	-	-	-	-	-	-	-				
3.		Program Elective-II	PEC	4	-	-	-	-	-	-	-	-	-	-				
4.		Program Elective-III	PEC	4	-	-	-	-	-	-	-	-	-	-				
5.		Open Elective-II	OEC	3/4	-	-	-	-	-	-	-	-	-	-				
6	HS-501	Technical Communication (Optional)	IEC	2	1	0	2	2	-	15	15	30	40	-				
Subtotal				19-22														

II Year

Autumn Semester

Teaching Scheme													
Contact Hrs. Per Week					Exam. Duration		Relative Weight						
S. No.	Sub Code	Course Title	Sub Area	Credits	L	T	P	CWS	PRS	MTE	ETE	PRE	
1.	EE-601	Seminar	SEM	2	-	-	-	-	-	-	100	-	
2.	EE-602	Project	RP	4	-	-	-	-	-	-	100	-	
3.	EE-603	Dissertation*	DIS	-	-	-	-	-	-	-	25	-	
Subtotal				6									

*NOTE: To be continued and grade to be awarded in the next semester.

Spring Semester

Spring semester														
Teaching Scheme														
S. No.	Sub Code	Course Title	Sub Area	Credits	Contact Hrs. Per Week			Exam. Duration		Relative Weight				
					L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	EE-603	Dissertation (contd. From III semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
			Subtotal	20										
			Total	64-68										

List of Electives (Power System Engineering)

Teaching Scheme					Contact Hrs. Per Week			Exam. Duration		Relative Weight				
S. No.	Sub Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	EE-563	Flexible AC Transmission Systems	PEC	4	3	1	0	3	-	25	-	25	50	-
2.	EE-564	High Voltage Techniques	PEC	4	3	1	0	3	-	25	-	25	50	-
3.	EE-565	Power System Planning	PEC	4	3	1	0	3	-	25	-	25	50	-
4	EE-566	Power System Harmonics	PEC	4	3	1	0	3	-	25	-	25	50	-
5	EE-567	HVDC Systems	PEC	4	3	1	0	3	-	25	-	25	50	-
6	EE-568	Power System Reliability	PEC	4	3	1	0	3	-	25	-	25	50	-
7	EE-569	Relaying and Switchgear	PEC	4	3	1	2	3	-	15	15	30	40	-
8	EE-570	Distribution System Automation	PEC	4	3	1	0	3	-	25	-	25	50	-
9	EE-571	Wind Energy	PEC	4	3	1	0	3	-	25	-	25	50	-
10	EE-572	Digital Protection of Power System	PEC	4	3	1	0	3	-	25	-	25	50	-
11	EE-553	Power Quality Improvement Techniques	PEC	4	3	0	2	3	-	15	15	30	40	-
12	EE-554	FACTS Devices	PEC	4	3	0	2	3	-	15	15	30	40	-
13	EE-573	Power System Dynamics	PEC	4	3	0	2	3	-	15	15	30	40	-
14	EE-574	Distribution System Analysis and Operation	PEC	4	3	0	2	3	-	15	15	30	40	-

M.Tech. (Electrical Engineering)
(Systems and Control)

I Year
Autumn Semester

Teaching Scheme														Relative Weight						
Autumn semester														Exam. Duration		Contact Hrs. Per Week				
S. No.	Sub Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE						
1.	MA-501F	Numerical Analysis, Probability and Statistics	ICC	4	3	1	0	3	-	25	-	25	50	-						
2.	EE-580	Principles of Systems Engineering	PCC	4	3	1	0	3	-	25	-	25	50	-						
3.	EE-581	Advanced Control Systems	PCC	4	3	1	2/2	3	-	15	15	30	40	-						
4.	EE-582	Operations Research	PCC	4	3	1	2/2	3	-	15	15	30	40	-						
5.		Open Elective-I	OEC	3/4	-	-	-	-	-	-	-	-	-	-						
6	HS-501	Technical Communication (Optional)	IEC	2	1	0	2	2	-	15	15	30	40	-						
Subtotal				19-22																

Spring Semester

Teaching Scheme														
Spring semester														
S. No.	Sub Code	Course Title	Sub Area	Credits	Contact Hrs. Per Week			Exam. Duration		Relative Weight				
					L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	EE-502	Modelling, Simulation and Evolutionary Techniques	PCC	4	3	0	2	3	-	15	15	30	40	-
2.		Program Elective-I	PEC	4	-	-	-	-	-	-	-	-	-	-
3.		Program Elective-II	PEC	4	-	-	-	-	-	-	-	-	-	-
4.		Program Elective-III	PEC	4	-	-	-	-	-	-	-	-	-	-
5.		Open Elective-II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6	HS-501	Technical Communication (Optional)	IEC	2	1	0	2	2	-	15	15	30	40	-
Subtotal				19-22										

II Year
Autumn Semester

Teaching Scheme					Contact Hrs. Per Week			Exam. Duration		Relative Weight				
S. No.	Sub Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	EE-601	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	EE-602	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	EE-603	Dissertation*	DIS	-	-	-	-	-	-	-	-	-	25	-
Subtotal				6										

*NOTE: To be continued and grade to be awarded in the next semester.

Spring Semester

Teaching Scheme					Contact Hrs. Per Week			Exam. Duration		Relative Weight				
S. No.	Sub Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	EE-603	Dissertation (contd. From III semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
Subtotal				20										
Total				64-68										

List of Electives (Systems and Control)

Teaching Scheme					Contact Hrs. Per Week			Exam. Duration		Relative Weight				
S. No.	Sub Code	Course Title	Sub Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	EE-583	Stochastic Systems	PEC	4	3	1	0	3	-	25	-	25	50	
2.	EE-584	Optimal Systems	PEC	4	3	1	0	3	-	25	-	25	50	
3.	EE-585	Advanced Computer Controlled Systems	PEC	4	3	1	0	3	-	25	-	25	50	
4	EE-586	Data Management	PEC	4	3	0	2	3	-	15	15	30	40	-
5	EE-587	Data Structures	PEC	4	3	0	2	3	-	15	15	30	40	-
6	EE-588	Large Scale Systems	PEC	4	3	1	0	3	-	25	-	25		
7	EE-589	Advanced Microprocessor and Applications	PEC	4	3	0	2	3	-	15	15	30	40	-
8	EE-590	Modelling of Industrial Processes	PEC	4	3	1	0	3	-	25	-	25	50	
9	EE-591	System Reliability	PEC	4	3	1	0	3	-	25	-	25	50	
10	EE-592	Reliability Testing and Prediction	PEC	4	3	1	0	3	-	25	-	25	50	
11	EE-593	Graph Theory and Applications	PEC	4	3	0	2	3	-	15	15	30	40	-

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **Department of Electrical Engineering**

1. Subject Code: **EE-521** Course Title: **Advanced Industrial and Electronic Instrumentation**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0

5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **NIL**

9. Objective: To impart knowledge about the principle, construction and characteristics of transducers used in industry for the measurement of various physical quantities, including the signal conditioners needed with these transducers.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Measurement of Displacement and Strain: Resistive, inductive and capacitive transducers for displacement; Wire, metal film and semiconductor strain gauges; Wheatstone-bridge circuit with one, two and four active elements, temperature compensation.	4
2.	Measurement of Speed and Torque: Electro-magnetic and photoelectric tachometers; Torque shaft, strain-gauge, electromagnetic and radio type torque meters.	4
3.	Measurement of Force and Pressure: Column, ring and cantilever-beam type load cells; Elastic elements for pressure sensing; Using displacement sensors and strain gauges with elastic elements.	3
4.	Measurement of Temperature: Resistance temperature detector, NTC and PTC thermistors, Seebeck effect, thermocouple and thermopile.	3
5.	Vibration Measurement: Importance of vibration measurement, frequency range of vibrations; Absolute displacement, velocity and acceleration pick-ups; Mass-spring-damper system as absolute acceleration to relative displacement converter; Strain gauge and piezoelectric type acceleration pickups.	3
6.	Smart transducers: Introduction, smart sensors and systems, case studies-humidity sensor, pressure sensor	3
7.	Intelligent Instrumentation Systems: Components of intelligent instrumentation systems, systems on chip, typical examples.	4
8.	Analog Electronic Instruments & Measurements: Electronic wattmeter and energy meter, a.c. and d.c. current probes, AF and RF	8

	power measurement, audio and radio frequency measurement.	
9.	Signal Generators, Analyzers and Recorders: Function generators, signal synthesizers, spectrum analyzer, logic analyzer; graphical recorders, FM magnetic recorder.	6
10.	Digital Measuring Instruments: Digital counter-timer and frequency meter, digital voltmeter and multimeter, digital storage oscilloscope.	4
	Total	42

Details of Experiments: The objective of the experimental work is give the students a practical knowledge of the construction, working, testing and application of some advanced type of industrial transducer, transducer based measurement systems and advanced electronic instruments.

A set of experiments will be given on the measurement systems involving more recent types of transducers for the measurement of industrial parameters. Another set of experiments will be meant to familiarize the students with advanced electronic instruments such as digital storage oscilloscope, signal synthesizer and analyzer, spectrum and logic analyzers.

11. Suggested Books:

S.No.	Name of Authors /Book / Publisher	Year of Publication/ Reprint
1.	Docbelin E.O., "Measurement Systems: Application and Design", McGraw Hill	1975
2.	Rangan C.S., Sarma G.R. and Mani V.S.V., "Instrumentation Devices and Systems", Tata McGraw-Hill	1983
3.	Barney G.C., "Intelligent Instrumentation: Microprocessor Applications in Measurement and Control", Prentice Hall of India	1992
4.	Helfrick A. D. and Cooper William D., "Modern Electronic Instrumentation and Measurement Techniques", Prentice Hall of India	1996
5.	Stanley W. and Smith R. F.M., "Student Reference Manual for Electronic Laboratories", Prentice Hall of India	1994
6.	Nakra B.C. and Chaaudhary K .K., "Instrumwentation, Measurement and Analysis", 2 nd ed., Tata Mc Graw Hill	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **Department of Electrical Engineering**

1. Subject Code: **EE-520** Course Title: **Digital Signal and Image Processing**
2. Contact Hours: **L: 3** **T: 1** **P: 2/2**
3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0
4. Relative Weightage: **CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0
5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **NIL**
9. Objective: To familiarize the students with the concepts of 1-D and 2-D signals, design of 1-D and 2-D filters, 1-D and 2-D power spectrum and various aspects of image processing.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Signal processing overview; Image processing basics; Fundamental signals (1-D and 2-D); Classification of systems; Characteristics of LTI/LSI systems.	4
2.	Fourier Analysis: Discrete-time Fourier analysis; Sampling theory; Discrete Fourier transform; Fast Fourier transform; 2-D extensions.	5
3.	z-Transform and Digital Filters : z-transform, Inverse z-transform; Causality and stability; Linear phase concept, Linear filtering; 2-D extensions.	5
4.	Filter Design: Filter structures; FIR filter design; IIR filter design; 2-D FIR and IIR filter design.	7
5.	Digital Image Fundamentals: Human visual system and visual perception; Image sensing and acquisition Image file types; Pixel representation and spatial relationship.	3
6.	Image Enhancement and Restoration: Contrast modification and stretching; Histogram equalization; Unsharp masking; Homomorphic processing; Interpolation; Mean and median filtering; Concepts of least square and Wiener filtering.	7

S. No.	Contents	Contact Hours
7.	Image Segmentation: Thresholding; Edge based segmentation; Region growing; Watershed transform.	5
8.	Image Compression: Fundamentals of image compression; Loss-less compression techniques; Lossy compression techniques.	6
	Total	42

Details of Experiments: The experiments will have two categories. Under DSP, experiments related to development of software for design and performance study of different filters, frequency spectrum analysis will be performed. Under DIP students will be asked to get acquainted with image processing tool box of MATLAB and they will be assigned mini projects with some specific task.

11. Suggested Books:

S.No.	Name of Authors /Book / Publisher	Year of Publication/ Reprint
1	Gonzalez R. C. and Woods R. C., "Digital Image Processing", 2 nd Ed., Pearson Education.	2007
2.	Jain A. K., "Fundamentals of Digital Image Processing", Prentice Hall.	2007
3.	Mitra S. K., "Digital Signal Processing : A Computer Based Approach", Tata Mc Graw Hill	2008
4.	Bose T., "Digital Signal and Image Processing", Wiley Eastern.	2008
5.	Sonaka M., Hlavac V. and Boyle R., "Image Processing, Analysis and Machine Vision", 2 nd Ed., Cengage Learning.	2008
6.	Oppenheim <u>A. V and Schafer R.W.</u> , "Discrete Time Signal Processing", Prentice Hall.	1975

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **Department of Electrical Engineering**

1. Subject Code: **EE- 532** Course Title: **Intelligent Sensors and Instrumentation**

2. Contact Hours **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre- requisite: **NIL**

9. Objective: To familiarize students with the state of art of smart, intelligent and network sensors, and instrumentation systems and their design.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review: Sensor, actuator and transducer; Classification of sensors on the basis of energy source and type of output signals; Signal conditioning; Meaning and types of smart sensors.	4
2.	Smart Sensor Technologies: Thick-film, thin-film and monolithic IC technologies and their use in making smart sensors; Bulk and surface micromachining technologies, wafer bonding, LIGA process, plasma etching, and their use in making smart sensors; Examples.	5
3.	MEMS Sensors: Concept and methods of making MEMS devices, sensors and actuators; Examples.	2
4.	Intelligent and Network Sensors: Concept and architecture of intelligent sensors; Concept and architecture of network sensors; Examples.	2
5.	Sensor Networking: 7-Layer OSI model of communication system, device-level networks, introduction to protocols and technologies for wired and wireless LANs; Ethernet, RS-485 and Foundation Fieldbus protocols; Wi-Fi; Zigbee and Bluetooth protocols; Concept of adhoc networks; Smart Transducer Interface Standard IEEE 1451.	12
6.	Intelligent Instrumentation: Introduction meaning and advantages; Microprocessor application techniques; I/O techniques; Interfacing of I/O devices; Examples.	12
7.	Future Trends: Neurosensors; Biosensors; Nano technology; Softcomputing techniques in instrumentation.	5
	Total	42

11. Suggested Books:

S.No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Barney G., "Intelligent Instrumentation", Prentice-Hall International Edition	1988
2.	Yamasaki H., "Intelligent Sensors", Elsevier Eastern Limited.	1996
3.	Frank R., "Understanding Smart Sensors", Artech House Publishers.	2000
4.	Ramon P. A. and Webster J. G., "Sensors and Signal Conditioning" 2nd Ed., John Wiley and Sons.	2001
5.	Fraden J., "Handbook of Modern Sensors: Physics, Design and Applications", AIP press.	2003
6	Feng Z. and Leonidas G., "Wireless Sensor Networks", Elsevier Eastern Limited.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-540** Course Title: **Advanced Power Electronics**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weight: **CWS** **15** **PRS** **15** **MTE** **30** **ETE** **40** **PRE** **0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective:

To impart knowledge of modern semiconductor devices and their applications in power electronic controllers for rectification, inversion and frequency conversion with improved performance.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Review of SCR, driving circuits and protection; Modern semiconductor devices: MOSFET, GTO, IGBT, GTO, SIT, SITH, MCT, their operating characteristics; Heat sink design.	3
2.	Three-phase converters, effect of load and source impedances; Dual converter, twelve-step converter, multi-pulse converters.	5
3.	PWM converter, power factor improvement techniques.	5
4.	Voltage and current commutated choppers, dc-dc converters: buck converter, boost converter, Cuk converter.	4
5.	Three-phase ac regulators, operation with resistive load.	3
6.	Single-phase and three-phase cyclo-converters; Matrix converters.	2
7.	Review of line commutated and forced commutated inverters, three-phase voltage source inverters, voltage and frequency control.	2
8.	Harmonic reduction techniques, PWM inverters, space vector modulation.	6
9.	Multi-level inverters, advantages, configurations: Diode clamped, flying capacitor and cascade multi-level inverters, applications.	3
10.	Current source inverters, commutation circuits, transient voltage suppressing techniques.	3
11.	DC link resonant converters, operation and control.	3
12.	MATLAB simulation of power electronic converters.	3
	Total	42

Details of Experiments:

The experiments related to controlled rectifiers, AC controllers, chopper control of DC motor drive, PWM VSI, V/f control of three-phase induction motor and closed loop control of DC motor drive will be performed.

11. Suggested Books:

S.No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Dubey G. K., Doradla S. R., Joshi A. and Sinha R. M. K., "Thyristorised Power Controllers", New Age International.	2008
2.	Mohan N., Underland T.M. and Robbins W.P., "Power Electronics – Converters, Applications and Design", 3 rd Ed., Wiley.	2008
3.	Bose B.K., "Power Electronics and Variable Frequency Drives – Technology and Applications", IEEE Press, Standard Publisher.	2001
4.	Lander C. W., "Power Electronics", 3 rd Ed., McGraw-Hill International Book Company.	2007
5.	Rashid M., "Power Electronics- Circuits, Devices and Applications", 3 rd Ed., Pearson Education.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-541** Course Title: **Power Electronic Controlled Electric Drives**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weight: **CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0

5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective:

To familiarize with the concepts of electric drives and to provide in-depth knowledge of power converters fed DC and AC drives.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Introduction: Definition of electric drive, types of load; Speed-torque characteristic of driven unit/loads, motors, steady state and transient stability of drives; Classification and components of load torque; Selection of motor power capacity for different duty cycles.	3
2.	Speed Control of Motors: Review of braking and speed control of dc motor and induction motor, multi-quadrant operation, loss minimization in adjustable speed drives.	3
3.	Converter fed DC Drives: Principle of operation of converter fed separately excited dc motor drives, operation of dc drive under continuous and discontinuous armature current, armature voltage and current waveforms, effect of free wheeling diode, analysis and performance evaluation, expression for speed-torque characteristic; Dual converter fed dc drives, MATLAB simulation.	6
4.	Chopper fed DC Drives: Principle of operation, control techniques, steady state analysis of time ratio control and current limit control, closed loop control of dc drives; Current control techniques, mathematical model of chopper fed dc drive, stability analysis.	5
5.	Inverter fed AC Drives: Constant V/f controlled induction motors, controlled current and controlled slip operations; Variable frequency controlled induction motor drives; PWM inverter drives, operation of closed loop slip-speed controlled VSI and CSI fed ac drives, multi-quadrant operation, MATLAB simulation.	6

S.No.	Contents	Contact Hours
6.	Slip Power Controlled AC Drives: Static rotor resistance control, static Kramer drive.	4
7.	Stability Analysis: Mathematical modeling of induction motor drives, transient response and stability analysis.	5
8.	Advanced Control Techniques: Adaptive control, field oriented control of induction motor drives.	5
9.	Synchronous Motor Drives: Adjustable frequency operations, voltage fed and current fed self controlled drives.	5
	Total	42

Details of Experiments: The experiments related to closed loop control of controlled converter fed DC motor, braking of Dc motor, VSI fed induction motor speed control, braking of three-phase induction motor and field oriented control of induction motor drive will be performed.

11. Suggested Books:

S. No.	Name of Authors /Book / Publisher	Year of Publication/ Reprint
1.	Murphy J. M. D. and Turnbull F. G., "Power Electronics Control of AC Motors", Pregamon Press.	1990
2.	Bose B. K., "Power Electronics and Variable Frequency Drives", IEEE Press, Standard Publisher.	2001
3.	Dubey G. K., "Power Semiconductor Controlled Drives", Prentice-Hall.	2001
4.	Dubey G. K., "Fundamentals of Electric Drives", 2 nd Ed., Narosa Publishing House.	2007
5.	Krishnan R., "Electric Motor Drives – Modeling, Analysis and Control", Prentice Hall of India.	2007
6.	Mohan N., Undeland T.M. and Robbins W.P., "Power Electronics- Converters, Applications and Design", 3 rd Ed., Wiley.	2008
7.	Pillai S. K., "A First Course in Electric Drives", 2 nd Ed., New Age International.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-542** Course Title: **Analysis of Electrical Machines**

2. Contact Hours: **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.): **Theory 3 Practical 0**

4. Relative Weight: **CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective:

The objective of the course is to present a general theory of rotating electrical machines applicable to all normal types of machines and to all conditions of operation.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Generalized transformations, physical model, different reference frame, primitive machine, dynamic variable, formulation of dynamic equations of a generalized machine in arbitrary reference frame.	10
2.	Analysis of induction machines, space vector, induction motor modeling in arbitrary reference frame and in field oriented frame, performance analysis in terms of torque, speed and current response.	12
3.	Analysis of synchronous machine, modeling, operational impedances, time constants, torque expression, asynchronous damping.	8
4.	Steady state and transient performance, phasor diagram and power angle characteristics.	6
5.	Symmetrical and asymmetrical short circuit analysis, measurement of reactances and time constants.	6
Total		42

11. Suggested Books:

S. No.	Name of Authors /Book / Publishers	Year of Publication/ Reprint
1.	Concordia C, "Synchronous Machines-Theory and Performance", Wiley.	1989
2.	Kimbark E.W, "Power System Stability: Synchronous Machines", Vol.3, Cover Publication.	1976
3.	Adkins B and Harley R.G, "The Generalized Theory of Alternating Current Machines", Chapman and Hall.	1979
4.	Leonard W, "Control of Electrical Drives", 3 rd Edition. Springer	2002
5.	Murphy J.M.D and Turnbull F.G., "Power Electronics Control of AC Motors", Pergamon Press.	1988

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-560** Course Title: **Computer Aided Power System Analysis**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weight: **CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0

5. Credits: 4

6. Semester: **Autumn**

7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective:

To familiarize with the computer aided methods for power system analysis

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Sparsity Techniques: Storage of sparse matrix, Sparsity directed inversion methods and parallel inversions	5
2.	Load Flow with HVDC Link: Balanced AC load flow, DC system model, incorporation of control equations, inverter operation, unified and sequential solution techniques.	7
3.	Three-phase Load Flow: load flow equations, solution techniques-Gauss-Seidal, Newton Raphson methods and fast decoupled method; Three-phase AC-DC load flow	5
4.	Short Circuit Studies for Unbalanced Network: Z-bus building algorithm; Derivation of fault admittance matrices, three-phase model of transmission lines- series and shunt impedance, mutually coupled three-phase lines, transformer modeling, sequence components, analysis of unbalance faults, open circuit fault, three-phase model of synchronous machine.	10
5.	State Estimation and Bad Data Processing: State estimation of linear and nonlinear systems, Pseudo-measurements, recursive and weighted least square estimation method, detection and identification of bad measurements, network observability.	6
6.	Reactive Power Allocation and Scheduling: Sources of reactive power, reactive power capability curve, FACT devices, modeling of reactive power allocation problem, solution techniques.	6
7.	Parallel Processors: Concepts of parallel computing.	3
	Total	42

Details of Experiments: The objective of the laboratory work is to give the students an exposure towards real time simulation of practical power systems. This may include (a) load flow studies (b) short circuit studies and (c) reactive power allocation.

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Abur A. and Exposito A. G., Power System State Estimation: Theory & Implementation, Marcel Dekkar	2004
2.	Arrillaga J. and Watson N.R. ., " Computer Modelling of Electrical Power Systems, John Wiley & Sons	2003
3.	Wood A. J. and Wollenberg B.F., " Power Generation, Operation and Control, John Wiley & Sons	2003
4.	Chakraborty A. and Halder S., "Power System Analysis Operation and Control, Prentice Hall of India	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-561** Course Title: **EHV AC & DC TRANSMISSION**

2. Contact Hours: L: **3** T: **1** P: **0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weight: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **NIL**

9. Objective: To provide an in-depth understanding of different aspects of extra high voltage ac and dc transmission system design and analysis.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	EHVAC Transmission System: Sequence impedance calculation, calculation of transmission line parameters and sequence impedances for lines with ground returns, lines with bundle conductors and ground returns, sequence networks for various three phase transformer connections.	12
2.	Corona: Basic phenomenon and calculation of voltage gradient of conductors, power loss, audible noise and radio interference due to corona, electrostatic field of EHV lines.	6
3.	EHV Transmission Line: Introduction, concepts of design	3
4.	Reactive Power Compensation: Basic concepts of reactive power compensation, principles of series and shunt compensation; Improvement of system performance due to reactive power compensation.	5
5.	HVDC Transmission System: Brief history of HVDC transmission system, comparison with EHVAC transmission, analysis of converter circuits for HVDC transmission, HVDC control system: CIA, CC and CEA control, analysis of faults in HVDC converters, basic concepts of multi-terminal HVDC system.	16
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Begamudre R. D., "Extra High Voltage AC Transmission Engineering", 3rd Ed., New Age International Private Limited.	2008
2.	Hingorani N. G. and Gyugyi L., "Understanding FACTS", IEEE Press, Standard Publishers Distributors.	2001
3.	Miller T. J. E., "Reactive Power Control in Electric Systems", John Wiley and Sons.	1982
4.	Sood V. K. "HVDC and FACTS Controller", Springer.	2004
5.	Arrilaga J., "High Voltage Direct Current Transmission", 2nd Ed., IET Publications.	1998
6.	Padiyar K. R., "HVDC Power Transmission System", New Age International Private Limited.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT ./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-562** Course Title: **Power System Operation and Control**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weight: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **NIL**

9. Objective: To familiarize about the basic aspects of power system operation and control strategies that help in operating the system in an economic and secure state.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Characteristics of Power Generating Units: Characteristics of steam units and their variations, hydro-electric units	2
2.	Economic Dispatch of Thermal Units: Problem of economic dispatch with and without line losses; Solution methods-Lambda-iteration technique, gradient search, Newton's method, optimal power flow method.	8
3.	Unit Commitment: Unit commitment problem; Thermal and hydro constraints; Solution methods- priority-list, dynamic programming, lambda relaxation.	5
4.	Hydro-Thermal Coordination: Scheduling problems, scheduling energy, short-term hydro-thermal scheduling problem solution by gradient method, pumped storage hydro-plant scheduling.	6
5.	Production Cost Models: Probabilistic production cost computations	4
6.	Control of Generation: Generator model, load model, prime-mover-model, governor model, tie-line model, automatic generation control of single area, inter-connected areas	5
7.	Interchange of Power and Energy: Economy interchange between interconnected utilities, types of interchange, power pools, transmission effects and issues	3
8.	Power System Security: Contingency analysis methods, contingency selection	4
9.	Reactive Power Control: Reactive power and voltage collapse, factors affecting voltage stability, reactive compensation methods	5
Total		42

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Wood A. J., and Wollenberg B.F., "Power Generation Operation and Control", Second Edition, John Wiley and Sons	2003
2.	Nagrath I.J. and Kothari D. P., "Power System Engineering", Tata Mcgraw Hill	2007
3.	Chakraborty A. and Halder S., "Power System Analysis Operation and Control, Prentice Hall of India	2006
4.	Kothari D. P. and Dhillon J.S., "Power System Optimization", Prentice Hall of India	2009
5.	Miller T. J. E., "Reactive Power Control in Electric System", Wiley India	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./ CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-580** Course Title: **Principles of Systems Engineering**
2. Contact Hours: L: **3** T: **1** P: **0**
3. Examination Duration(Hrs.): Theory Practical
4. Related Weightage: CWS PRS MTE ETE PRE
5. Credits: 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **NIL**
9. Objective: To provide a background for system engineering concepts, modeling methodologies and various analysis techniques.

10. Details of Course :

S. No.	Contents	Contact Hours
1.	Systems models and their classifications, principles used in modeling of systems, objectives of constructing models.	4
2.	Necessity for model reduction, reduced order modeling problem in time and frequency domain, application of reduced order models, algebraic reduction methods, reduction methods in time and frequency domain, stable reduction methods, models of discrete systems.	14
3.	System simulation, advantages and disadvantages, steps in simulation study, techniques of simulation, continuous system simulation.	4
4.	Probability concepts, sample space, probability distributions, random signals, characterization of random variables, statistical averages of random variables, discrete and continuous random variables, density and distribution functions, properties of cumulative distribution and probability density function, joint distribution functions.	10
5.	Stochastic process, classification of random process, response of linear systems to random inputs, auto correlation and cross correlation function, power spectral density.	6
6.	Basic principles of system reliability and failures, component reliability and hazard model, bath tub curve, series and parallel systems, reliability of complex systems.	4
	Total	42

11. Suggested Books:

Sr. No.	Name of Books/Authors/Publishers	Year of Publication
1.	Gordon G., "System Simulation", PHI	1978
2.	Jamshidi M. O., "Large Scale Systems Modeling and Control", Series Volume-9, North Holland	1983
3.	Mahmud M. S. and Singh M. G., " Large Scale Systems Modelling", Volume -3, Pergmon Press	1981
4.	Peebles Z. P. Jr., "Probability, Random Variables and Random Signal Principles", 4 th Ed., Tata McGraw Hill	2002
5.	Papoulis A., " Probability and Statistics", PHI	1990

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE- 581** Course Title: **Advanced Control Systems**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weight: **CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0

5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **NIL**

9. Objective: To introduce advanced control methods for linear and nonlinear systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: State space model of dynamical system in continuous time and discrete time; Solution of continuous time state equation-similarity transformation; Cayley Hamilton approach and inverse Laplace approach; Solution of discrete time state equation.	6
2.	Controllability and Observability: General concepts, controllability and observability test for continuous time and discrete time system; test for continuous and discrete time systems; Stabilizability and detectability- definition and tests; Loss of controllability and observability due to sampling; Controllable and observable canonical forms.	8
3.	Nonlinear Control Systems: Nonlinear models, equilibrium points, linearization of nonlinear models, separable nonlinearities; Describing function analysis, describing function of common nonlinearities; Stability analysis by describing function method; Phase plane analysis of nonlinear systems; Bang-Bang control system; Feedback linearization.	10
4.	Stability Analysis: Stability concepts, stability definition in the sense of Lyapunov; Stability of continuous and discrete time linear systems; Stability of nonlinear systems; Lyapunov stability and instability theorems; Lyapunov's direct method for continuous and discrete time systems; Lyapunov function for nonlinear systems.	8
5.	Controller/Observer Design: Pole placement technique; Ackerman's approach and linear quadratic regulator for continuous time and discrete time systems; Sliding mode control; H-infinity control; Full order and reduced order observer designs.	10
Total		42

Details of Experiments: In laboratory work, students will learn about the real-time implementation of controller, controller design for linear and non-linear system using Simulink and stability analysis of a given system by different advance techniques.

11. Suggested Books:

S. No-	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Stefani, R.T., Shahuian B., Sawant C.J. and , Hostetter G. H., "Design of Feedback Control Systems", Oxford University Press	2001
2.	Kailath T., "Linear Systems", Prentice Hall	1996
3.	Khalil, H., "Nonlinear Systems", 3rd Ed., Macmillan	2002
4.	Slotine, J.J. and Li. W.P., "Applied Nonlinear Control", Prentice-Hall	1991
5.	Vidyasagar M., "Nonlinear Systems Analysis", 2nd Ed., Prentice Hall	1992

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE- 582** Course Title: **Operations Research**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weight: **CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0

5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **NIL**

9. Objective: To introduce with foundations of operations research methodology and tools.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Linear Programming: Graphical LP solution, simplex method, Big M method, two phase method, degeneracy, alternate optima, unbounded optimal solutions, infeasible solutions, duality and sensitivity analysis- dual simplex method, primal dual computations.	10
2.	Transportation Problems: Determination of starting solution, iterative computations of algorithm, assignment problems- Hungarian method & its simplex explanation.	5
3.	Integer Programming: Branch and bound method, zero-one implicit enumeration algorithm, cutting plane algorithm.	5
4.	Probabilistic Decision Making: Decision making under risk, probabilistic dynamic programming.	5
5.	Inventory Models: Static EOQ models, EOQ with price breaks, multi-item EOQ with storage limitation, dynamic EOQ models.	5
6.	Game Theory: Optimal solution of two person zero sum game, solution of mixed strategy games.	4
7.	Queueing Theory: Role of exponential distribution, pure birth and death models, generalized Poission queueing model, specialized Poission queues.	4
8.	Project Scheduling by CPM/PERT: Network representations, critical path computations, construction of time schedule.	4
	Total	42

Details of Experiments: In the laboratory work students will work on linear programming and optimization packages to solve various operation research problems.

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Taha H.A., "Operations Research", 8 th Ed., Prentice Hall of India	2009
2.	Ignizio J. P., "Linear Programming in Single and Multiple Objecting Systems", Prentice Hall of India	1982
3.	Bazaraa M.S. and Jarvis J.J., "Programming and Network Flows", John Willy & Sons.	1977
4.	Sen R. P., " Operations Research: Algorithms and Applications", 1 st Ed., Prentice Hall of India	2009

Department of Electrical Engineering
IIT Roorkee

Corrections in the subject numbers in the light of UG/IDD approved electives

Approved Course Number by Senate	Subject Name	New Numbers Proposed
EE-523	Intelligent Sensors and Instrumentation	EE-532*
EE-524	Process Instrumentation and Control	EE-523*
EE-534	Telemetry and SCADA	EE-524*
EE-530	Power System Instrumentation	EE-530*
EE-537	Biomedical Instrumentation	EE-522*

*These numbers are already approved by the senate for UG/IDD electives.

Corrections in the subject numbers in the light of few subjects being dropped

Approved Course Number by Senate	Subject Name	New Numbers Proposed
EE-522	Digital Signal and Image Processing	EE-520
EE-533	Measurement Errors and Statistical Analysis	EE-525
EE-526	Bioelectric Signals and Processing	EE-526
EE-527	Computer Applications in Medicine	EE-527
EE-535	Virtual Instrumentation	EE-528
EE-536	Medical Imaging	EE-529
EE-531	Ultrasonic and Laser Instrumentation	EE-531
EE-532	Advances in Signal and Image Processing	EE-533