सीनेट की 36वीं बैठक का कार्यवृत्त

MINUTES OF THE 36TH MEETING OF THE SENATE

13 एवं 27 दिसम्बर 2010
13TH & 27TH DECEMBER 2010

भारतीय प्रौद्योगिकी संस्थान रूड़की
रूड़की – 247 667 (भारत)
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
ROORKEE – 247 667 (INDIA)

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

Minutes of the 36th Meeting of the Senate held on 13th December 2010 in the Senate Hall of the Institute.

I N D E X

Minutes of the 36th meeting of the Senate held on 13.12.2010 and adjourned meeting held on 27.12.2010 in the Senate Hall of the Institute.

The following were present:-

1.	Prof. S.C. Saxena, Director	-Chairman
2.	Prof. S.Y. Kulkarni	(Architecture & Planning)
3.	Prof. (Mrs) Pushplata	(Architecture & Planning)
4.	Prof. R.P. Singh	(Biotechnology)
5.	Prof. I.M. Mishra	(Chemical Engineering)
6.	Prof. Surendra Kumar	(Chemical Engineering)
7.	Prof. Bikash Mohanty	(Chemical Engineering)
8.	Prof. Shri Chand	(Chemical Engineering)
9.	Prof. I.D. Mall	(Chemical Engineering)
10.	Prof. Vijay Kumar Agarwal	(Chemical Engineering)
11.	Prof. G. Bhattacharjee	(Chemistry)
12.	Prof. Kamaluddin	(Chemistry)
13.	Prof. V.K.Gupta	(Chemistry)
14.	Prof. Anil Kumar	(Chemistry)
15.	Prof. (Mrs) Mala Nath	(Chemistry)
16.	Prof. U.P. Singh	(Chemistry)
17.	Prof. M.R.Maurya	(Chemistry)
18.	Prof. S.S. Jain	(Civil Engineering)
19.	Prof. M.N. Viladkar	(Civil Engineering)
20.	Prof. S.K. Ghosh	(Civil Engineering)
21.	Prof. M.Parida	(Civil Engineering)
22.	Prof. Praveen Kumar	(Civil Engineering)
23.	Prof. N.K. Samadhiya	(Civil Engineering)
24.	Prof. D.K. Paul	(Earthquake Engineering)
25.	Prof. Ashwini Kumar	(Earthquake Engineering)
26.	Prof. H.R. Wason	(Earthquake Engineering)
27.	Prof. Ashok Kumar	(Earthquake Engineering)
28.	Prof. H. Sinvhal	(Earth Sciences)
29.	Prof. V.N. Singh	(Earth Sciences)
30.	Prof. A.K. Pachauri	(Earth Sciences)
31.	Prof. P.K. Gupta	(Earth Sciences)
32.	Prof. A.K. Saraf	(Earth Sciences)
33.	Prof. J.D. Sharma	(Electrical Engineering)
34.	Prof. H.O. Gupta	(Electrical Engineering)
35.	Prof. S.P. Gupta	(Electrical Engineering)
36.	Prof. Pramod Agarwal	(Electrical Engineering)
37.	Prof. S.P. Singh	(Electrical Engineering)
38.	Prof. S.P. Srivastava	(Electrical Engineering)
39.	Prof. R.S. Anand	(Electrical Engineering)
40.	Prof. S.N. Sinha	(Electronics & Computer Engg.)
41.	Prof. Padam Kumar	(Electronics & Computer Engg.)
42.	Prof. M.J. Nigam	(Electronics & Computer Engg.)
43.	Prof. N.K.Goel	(Hydrology)

21 JAN 2011

44.	Prof. M.C. Bansal	(Paper Technology)
45.	Prof. V.K. Nangia	(Management Studies)
46.	Prof. G.S. Srivastava	(Mathematics)
47.	Prof. (Mrs) Rama Bhargava	(Mathematics)
48.	Prof. Y.K. Gupta	(Mathematics)
49.	Prof. Pradeep Kumar	(Mechanical & Industrial Engg.)
50.	Prof. Satish C. Sharma	(Mechanical & Industrial Engg.)
51.	Prof. P.K. Jain	(Mechanical & Industrial Engg.)
52.	Prof. Dinesh Kumar	(Mechanical & Industrial Engg.)
53.	Prof. B.K.Gandhi	(Mechanical & Industrial Engg.)
54.	Prof. Ravi Kumar	(Mechanical & Industrial Engg.)
55.	Prof. P.K. Ghosh	(Metallurgical & Materials Engg.)
56.	Prof. S.K. Nath	(Metallurgical & Materials Engg.)
57.	Prof. Surendra Singh	(Metallurgical & Materials Engg.)
58.	Prof. Anjan Sil	(Metallurgical &Materials Engg.)
59.	Prof. Ishwar Singh	(Physics)
60.	Prof. Ravindra Nath	(Physics)
61.	Prof. G.S. Singh	(Physics)
62.	Prof. D. Das	(WRD&M)
63.	Prof. S.K. Tripathi	(WRD&M)
64.	Prof. M.L. Kansal	(WRD&M)
65.	Prof. Deepak Khare	(WRD&M)
66.	Dr. Arun Kumar,Head, AHEC	
67.	Mr. Yogendra Singh, Librarian	
68.	Dr. Sunil Singhal, Chief Warden, Cautley Bhawan & Scientist AHEC.	
69.	Dr. K.L. Yadav, Associate Professor, Department of Physics	
70.	Dr. C.B. Majumdar, Associate Professor, Department of Chemical Engg.	
71.	Mr. Prashant Garg, Offtg. Registrar	- Secretary (13.12.2010)
72.	Dr. ShyamNarayan, Offtg. Registrar	- Secretary (27.12.2010)

The Chairman (Director) welcomed the members to the 36th Meeting of the Senate. The Chairman (Director) stated that the meeting was convened to consider the syllabi of PG Courses (Spring Semester) under new PG programme. He also informed the house that Mr. Abhay Kumar Kumpawat F/O Mr. Vivek Kumpawat pointed out that due to lack of quorum, all the decisions taken by the Senate in its meeting held on 16th June 2010 are illegitimate/unauthorized in which his son's plea of one year extension was rejected. In view of this, the agenda of the 33rd meeting of the Senate held on 16.6.2010, is to be reconsidered during this meeting. The case of Mr. Vivek Kumpawat is also included in the agenda of the said meeting.

Due to lack of the quorum, the Chairman (Director) ruled that the meeting is adjourned for want of quorum; the meeting was again convened at 3.30 P.M. on the same day.

Accordingly, the Senate again met at 3.30 PM at the same venue, and the members present were assumed to represent the quorum.

21 JAN 2011

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

1. Prof. Karmeshu, New Delhi
2. Prof. B.D. Indu, Department of Physics
3. Prof. M. Perumal, Department of Hydrology
4. Prof. Manoj Arora, Department of Civil Engineering
5. Prof. Vinod Kumar, Department of Electrical Engineering

The Agenda was then taken up:

Item No.36.1.1: To confirm the minutes of the 34th meeting of the Senate held on 16.7.2010 and 35th Meeting held on 8.11.2010.

The minutes of the 34th meeting of the Senate held on 16.7.2010 and the 35th meeting held on 8.11.2010, respectively, were confirmed.

Item No.36.1.2: To receive a report on the actions taken to implement the decisions taken by the Senate in its 34th meeting held on 16th July 2010 and 35th meeting held on 8.11.2010.

The Senate noted that the required actions have been taken on the decisions taken by the Senate in its 34th meeting held on 16.7.2010 and the 35th meeting held on 8.11.2010, respectively.

Item No.36.2.1: To consider admitting GATE qualified candidates working against various projects to allow them to pursue Part Time M. Tech.

As discussed and recommended by the Board of Studies, the Senate decided that the GATE qualified candidate be considered for admission in a PG programme, as per his eligibility, as Part Time PG student and also simultaneously appointed as Project Fellow/JRF in a project provided the remaining duration of the project must be at least one & a half year. In case, the project is completed before the completion of his PG programme, he may be reappointed as project fellow/JRF in some other project. In case no other project is available for the candidate, the Institute may provide the assistantship for the remaining period not exceeding one year and his/her part time status be changed to full time with the approval of the Dean (Academic Studies) on the recommendation of the DAC of the department. Such admissions for PG programmes and simultaneous appointment in research

21 JAN 2011

projects be coordinated by PG Admission Office alongwith regular PG admissions.

Item No.36.2.2: To consider the syllabi of PG Courses (Spring Semester) under new PG programme.

As considered and recommended by the Board of Studies, the Senate decided that the syllabi of PG Courses (Spring Semester) in respect of the under-mentioned departments be approved:

Sl. No.	Name of Department	Appendix
(a)	Biotechnology	Appendix-A
(b)	Chemistry	Appendix-B
(c)	Civil Engineering	Appendix-C
(d)	Management Studies	Appendix-D
(e)	Water Resource Development & Management	Appendix-E
(f)	Physics	Appendix-F
(g)	Hydrology	Appendix-G
(h)	Center for Nano Technology	Appendix-H
(i)	Metallurgical and Materials Engineering	Appendix-I
(j)	Pulp and Paper Technology	Appendix-J
(k)	Electrical Engineering	Appendix-K

Item No.36.2.3: To consider offering admission to additional 10% candidates in all Master's degree courses in Science Departments for which the admissions are made through JAM.

The Senate decided that admission to additional 10% candidates be offered in all Master's degree courses in Science Departments for which the admissions are made through JAM so that if there is a vacancy due to some of the candidates not joining a programme or leaving it just after registration the same is filled by the candidate admitted in addition to the normal sanctioned strength.

Item No.36.2.4: To consider the syllabi of following subjects of B.Arch. II year Spring Semester 2010-2011 onwards.

As considered and recommended by the Board of Studies, the Senate decided that the syllabi of the following subjects of B.Arch. II year Spring Semester for 2010-2011 onwards be approved:

1. AR-202: Architectural Design III
2. AR-204: Building Construction III

21 JAN 2011

3. AR-206: History of Architecture-I
4. CE-292: Theory of Structures-I

The Senate further approved the under-mentioned Electives of the present B.Arch. 3rd and B.Arch. 4th year Spring Semester:

1. AR-308: Fire Protection and Security Systems
2. AR-312: History of Modern Architecture
3. AR-316: Acoustics and Lighting
4. AR-414: Futuristic Architecture

The detailed syllabi are appended at **Appendix 'L'.**

Item No.36.2.5: To consider the structure of three years Part time M.Tech./ MBA programs to be started from Spring Semester 2010-2011 at Greater Noida Extension Centre.

At the outset, Prof. H.O. Gupta, Dean Academic Studies briefed the house about the structures of three years Part Time M.Tech/ MBA programmes at Greater Noida Extension Centre. He stated that Prof. P.K. Jain, Coordinator- Academic, Greater Noida Extension Centre vide their letter No. GNEC/ dated 02.12.2010 intimated that three departments are interested to run the programme.

The Senate after deliberation decided that a paper be prepared in light of the discussions held in the meeting of the Senate by the Dean Academic Studies & Prof. P.K. Jain, Coordinator-Academic, Greater Noida Extension Centre. The paper, so prepared, be first placed before the Board of Studies (BOS) and then placed before the Senate for consideration.

Item No. 36.2.6: To re-consider the agenda of the 33rd meeting of the Senate held on 16.6.2010:

The Senate decided that the earlier decisions taken by the Senate in its 33rd meeting held on 16.6.2010 in respect of all the items, which were placed before the said meeting, be reiterated.

21 JAN 2011

Item No. 36.3.1: Reported the nomination of two Senators to the Students Affairs Council (SAC) for a period of two years w.e.f. 1.12.2010.

Noted that the Director (Chairman, Senate) on behalf of the Senate has nominated the under-mentioned two Senators to the Students Affairs Council (SAC) for a period of two years w.e.f. 1.12.2010:

(a) Prof. M.R. Maurya, Department of Chemistry
(b) Prof. Mahendra Singh, Department Civil Engineering

Item No. 36.3.2: Reported the acceptance of a proposal for the Institution of "Shri Reghuraj Behari Mathur Cash Prizes" of Rs.20,000/- p.a. each for a female student who has obtained highest CGPA amongst female students in B.Tech. I year, Civil Engineering, and another one for a male student who has obtained highest CGPA amongst male students in B.Tech. I year, Civil Engineering.

Noted that the Director (Chairman, Senate) on behalf of the Senate has approved the proposal for the Institution of "Shri Reghuraj Behari Mathur Cash Prizes" of Rs.20,000/- p.a. each for a female student who has obtained highest CGPA amongst female students in B.Tech. I year, Civil Engineering, and another one for a male student who has obtained highest CGPA amongst male students in B.Tech. I year, Civil Engineering.

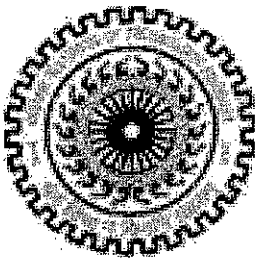
The meeting ended with a vote of thanks to the Chair.

21 JAN 2011

Appendix-A
Item No.SENATE/36.2.2

M.Tech. Syllabus

(Spring Semester)



Department of Biotechnology
Indian Institute of Technology Roorkee
Roorkee – 247 667

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			1 SEMESTER (AUTUMN)											
1.	MA-500	Foundation Course in Mathematics	PCC	4	3	1	-	3	-	25	-	25	50	-
		or												
	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-521** Course Title: **Biophysics**

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

3. Examination Duration (Hrs.): **Theory** [3] **Practical:** [--]

4. Relative Weightage: **CWS** [25] **PRS** [--] **MTE** [25] **ETE** [50] **PRE** [--]

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

8. Pre-requisites: **Nil**

9. Objective: To impart knowledge on conformational analysis of biomolymers based on concepts of thermodynamics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Properties of amino acids, polarity, discrimination function; Primary structure- cross links, sequence comparison, mutant proteins; Secondary structure,- α helix, β sheet, β turns, poly pro helices; Prediction method, tertiary structure, packing density.	9
2.	Conformational analysis, Φ Ψ angles, Ramachandran plot; Energy terms – vand der waal's, repulsive (non bonded), dipolar (bonded), torsional; Results of energy calculations, experimentally observed values of Φ Ψ angles; Hydrogen bonding, hydrophobic interactions, ionic interactions, disulphide bonds.	9
3.	Nucleic acids – composition, glycosidic bond rotation, backbone torsional angles and steric hindrance, sugar ring congormations, psuedorotation, C3' endo, C2'endo and their energies; Polymorphism in DNA – A, B, Z family of structures, super helical forms; Base pairing – Hoogstein, Waston-Crick, energetics, electronic complementarity; Base stacking – preferences and energetics, role of solvent, intercalation.	10
4.	Structure of t-RNA molecule, model of tertiary interactions; Levels of structures in polysaccharides, peptidoglycan in bacteria & animal cell; Helix to coil transition, molecular mechanism, thermodynamic model.	8
5.	Micelle stability in membrane; Membrane equilibrium – osmotic pressure, Donnan effect., pH across membrane and membrane potential.	6
	Total	42

11. Suggested Books:

S. No.	Authors/ Name of Books/Publisher	Year of Publication/Reprint
1.	Sinden, R.R., "DNA structure and function", Academic Press	1994
2.	Blackburn, G.M. and Giat, M.J., "Nucleic acids in chemistry and biology", IRL press.	20005
3.	Cantor, C.R. and Schimmel P.R., "Biophysical chemistry Part-I and Part-III", WH Freeman.	1986
4.	Govil, G. and Hosur, R.V., "Conformation of biological molecules NMR, Vol. 20", Springer Verlag.	1982
5.	Hoppe, W., Lohmann, W., Merklad, H. and Ziegler, H. "Biophysics", Springer Verlag.	1981
6.	Schulz, G.E.and Schirmer, R.H., "Principles of protein structure", Springer Verlag.	1989

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT-523** Course Title: **Laboratory - II**

2. Contact Hours: **L**: 0 **T**: 0 **P** : 8

3. Examination Duration (Hrs.): **Theory** [--] **Practical:** [--]

4. Relative Weightage: **CWS** [--] **PRS** [100] **MTE** [--] **ETE** [--] **PRE** [--]

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

8. Pre-requisites: **Nil**

9. Objective: The student is expected to develop skills and experience essential for understanding the integrated complexity of the structure and function of living cells and molecules.

10. Details of Course:

List of Practicals:

S. No.	Contents
1.	Preparation and sterilization of culture media.
2.	Isolation of bacteria from different sources (soil, water, air).
3.	Characterization of the isolated bacteria obtained form different source samples.
4.	Identification of isolated bacterial calories using microscopic & staining techniques.
5.	To plot a growth curve of isolated bacterial strain.
6.	To carry out bacterial transformation conjugation and transduction using gene transfer methods.
7.	To prepare a survival curve for the given bacterial culture using germicidal UV radiation as a mutagen.
8.	To carry out Ame's test for detection of a possible chemical carcinogen.

11. Suggested Books:

S. No.	Authors/ Name of Books/Publisher	Year of Publication/Reprint
1.	William, M., O'Leary, "Practical handbook of microbiology", CRC Press.	1989
2.	Albert, B., John H. H., "Practical bacteriology, microbiology and serum therapy (medical and veterinary)", Green.	1913
3.	Roy, D. and Cullimore, "Practical manual of groundwater microbiology:, CRC Press.	2008
4.	Goldman E., Lorrence, H. "Greenpractical handbook of microbiology", CRC Press.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT-523A** Course Title: **Laboratory - II**
2. Contact Hours: **L**: 0 **T**: 0 **P** : 8
3. Examination Duration (Hrs.): **Theory** [--] **Practical:** [--]
4. Relative Weightage: **CWS** [--] **PRS** [100] **MTE** [--] **ETE** [--] **PRE** [--]
5. Credits: [4] 6. Semester: **Spring** 7. Subject Area: **PCC**
8. Pre-requisites: **Nil**
9. Objective: The student is expected to develop skills and experience essential for understanding the integrated complexity of the structure and function of living cells and molecules.
10. Details of Course:

List of Practicals:

S. No.	Contents
1.	Preparation and sterilization of culture media.
2.	Isolation of bacteria from soil
3.	Isolation of extreme halophiles
4.	Preparation of minimal media for isolation of bacteria from industrial samples provided (pesticide degradation in this case).
4	Isolation of the microorganisms from the given sample using single colony isolation method.
5.	Gram staining of the isolated colonies along with positive control strains
6	Spore staining of the isolated colonies along with positive control strains.
7	To plot a growth curve of isolated bacterial colony from halophile & pesticide degrading strains
8.	Isolation of genomic DNA from single purified colony.
9.	Quantification of genomic DNA by UV spectrophotometer
10	Isolation of plasmid DNA from the given bacterial strain.
11	Quantification of plasmid DNA by UV spectrophotometer
12	Agarose gel electrophoresis of the genomic DNA along with suitable DNA marker.
13	Agarose gel electrophoresis of the plasmid DNA along with suitable DNA marker.
14	Genomic DNA digestion with Sau3A for genomic DNA library construction.
15	Restriction digestion of the plasmid DNA
16	Analysis of the digested DNA fragments by agarose electrophoresis.
17	Gel purification of genomic and plasmid DNA fragments from agarose gel by gel extraction kit.
18	Ligation of the vector and a genomic DNA fragment containing cohesive ends.
19	Chemical Competent cell preparation of *E.coli* DH5α.
20	Transformation of ligated product in *E.coli* DH5α.
21	Screening of transformed colonies by BamHI digestion.
22	Identification of pesticide degrading gene from constructed library.
23	Screening of halophile library for industrial enzymes.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT-524** Course Title: **Genetic Engineering**

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

3. Examination Duration (Hrs.): **Theory** [3] **Practical:** [--]

4. Relative Weightage: **CWS** [25] **PRS** [--] **MTE** [25] **ETE** [50] **PRE** [--]

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of various techniques employed in the field of genetic engineering and its applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction and historical background	2
2.	Cloning vectors for E. coli- plasmids, lambda phage vectors, cosmids and single stranded DNA phage vectors; Cloning vectors for organisms other than E. coli.	8
3.	Purification of DNA from living cells; Manipulation of purified DNA; Introduction of DNA into living cells.	4
4.	Gel electrophoresis of DNA, recovery of DNA from gels; Extraction, purification and analysis of mRNA from eukaryotic cells	6
5.	Construction and analysis of genomics and cDNA libraries; Preparation of DNA and RNA probes; Synthetic oligonucleotide probes.; The polymerase chain reaction; Site directed mutagenesis.	8
6.	Expression of cloned genes in E. coli, expression of cloned genes in cultured mammalian cells, detection and analysis of proteins expressed from cloned genes	7
7.	Genetic manipulation of higher animals and plants; Application of genetic engineering; Possible risks and safety aspects of genetic engineering.	7
	Total	42

11. Suggested Books:

S. No.	Authors/ Name of Books/Publisher	Year of Publication/Reprint
1.	Sambrook, J., Fritsch, E.F., and Maniatis, T., " Molecular cloning : A laboratory Manual" , Cold Spring Harbor Laboratory.	2001
2.	Brown, T.A., "Gene Cloning and DNA Analysis", Blackwell Science.	2001
3.	Winnacker, E.L., "From Genes to Clones: An Introduction to Gene Technology", VCH.	1989
4.	Old, R.W. and Primrose S.B., "Principles of Gene Manipulation" , Blackwell Scientific Publication.	1999
5	Gupta, P.K., "Biotechnology and Genomics", Rastogi Publications.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT-601** Course Title: **Cell & Tissue Culture Technology**

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

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

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

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

8. Pre-requisites: **Nil**

9. Objective: To give an overview of plant and animal tissue culture techniques and potential applications in generating products for the present day society.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to basic principles; Laboratory requirements for setting up cell/tissue culture facility	5
2.	Techniques of cell culture – batch, batch fed and continuous cultures design of media, cytotoxicity and viability assays; Cell separation techniques, flow cytometry and fluorescence associated cell sorting; Role of enzymes / isozymes in culture	10
3.	Characterization of cell lines, cryo-preservation and cell banking; Primary, secondary cultures and scale up operations	5
4.	In situ hybridization; Hybridoma technology; Industrial products of animal cell culture.	5
5.	Elements of plant tissue culture; Protoplast technologies- isolation and culture, protoplast fusion ; Somatic cell genetics, gene transfer techniques, transgenic plants.	7
6.	Somoclonal variation, practical applications of variability in tissue culture; Anthers and pollen cultures, techniques and prospects.	5
7.	Culture techniques for crop improvement; Natural products from plant cell culture	5
	Total	42

11. Suggested Books:

S. No.	Authors/ Name of Books/Publisher	Year of Publication/Reprint
1.	Freshney, R.I., "Animal Cell Culture – A Practical Approach", IRL Press.	2004
2.	Dixon, R.A., "Plant Cell Culture – A Practical Approach", IRL Press.	2002
3.	Lanza, R.P., Langer, R. and Vacanti, J., "Principles of Tissue Engineering", Academic Press.	2007
4.	Atala, A., and Lanza, R., "Methods of Tissue Engineering", Academic Press.	2001
5.	Bhojwani, S.S., and Razdan, M.K., "Plant Tissue Culture – Theory and Practice" Elsevier.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT-602** Course Title: **Enzymology and Enzyme technology**

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

3. Examination Duration (Hrs.): **Theory** [3] **Practical:** [--]

4. Relative Weightage: **CWS** [25] **PRS** [--] **MTE** [25] **ETE** [50] **PRE** [--]

5. Credits: [4] 6. Semester: **Both** 7. Subject Area: **PEC**

8. Pre-requisites: **Nil**

9. Objective: To impart knowledge of fundamental principles of enzyme catalysis and applications of enzyme technology.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction and classification; Structure of enzymes- active site structure determination, identification of binding and catalytic sites, trapping of enzyme substrate complex.	8
2.	Extraction, purification , assay and analysis of enzymes	3
3.	Catalysis and kinetics, factors affecting rates of reaction; Kinetics of single substrate enzyme catalysed reactions, Michaelis- Menton equation, Briggs- Haldane modification, Lineweaver- Burk plot, Kinetics of multisubstrate enzyme catalysed reactions, ping-pong, random order and compulsory order mechanisms; Enzyme inhibition – competitive, uncompetitive and non competitive inhibition, substrate inhibition, allosteric and irreversible inhibition.	12
4.	Investigation of reaction mechanisms- steady and non-steady state methods; Monomeric enzymes- serine proteases, oligomeric enzymes, lactate dehydrogenase and lactose synthase; Mechanism of enzyme catalysis: metals and coenzymes.	7
5.	Binding of ligands to proteins, cooperativity, allosteric enzymes and metabolic regulation, sub-cellular compartmentalization.	5
6.	Clinical aspects of enzymes, plasma enzymes, inborn errors of metabolism, enzymes as reagents, large scale production and purification of enzymes; Immobilized enzymes- preparation and application; Application of enzymes and enzymes technology.	7
	Total	42

11. Suggested Books:

S. No.	Authors/ Name of Books/Publisher	Year of Publication/Reprint
1.	Chaplin, M.F. and Bucke, C., "Enzyme technology," Cambridge University Press.	1992
2.	Palmer, T., "Understanding Enzymes", Prentice Hall.	1985
3.	Boyer, P.D., "The Enzymes V", , Academic Press	1992
4.	Buchholz, K., Kasche, V. and Bornscheuer, U. T., "Biocatalysts and Enzyme Technology", Wiley-VCH.	2005
5.	Shanmugam, S., "Enzyme Technology", I. K. International.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT-603** Course Title: **Instrumental methods of analysis**

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

3. Examination Duration (Hrs.): **Theory** [3] **Practical:** [--]

4. Relative Weightage: **CWS** [25] **PRS** [--] **MTE** [25] **ETE** [50] **PRE** [--]

5. Credits: [4] 6. Semester: **Both** 7. Subject Area: **PEC**

8. Pre-requisites: **Nil**

9. Objective: To impart knowledge of advanced analytical techniques in modern biology.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Microscopy-phase contrast, fluorescence, Polarization scanning and transmission electron microscopy.	6
2.	Radioactive tracer techniques, autoradiography, Cerenkov radiation, liquid scintillation counting, radio immunological assays.	7
3.	Gel filtration, ion-exchange, affinity chromatography, HPLC and gas chromatography.	7
4.	Electrophoresis, denaturing and non-denaturing gels, isoelectric focusing, pulsed-field gel electrophoresis and immuno-electrophoresis.	8
5.	Dialysis, microfiltration, sedimentation, ultra centrifugation and hydrodynamic methods	8
6.	Automated methods of DNA and peptide synthesis	3
7.	Atomic absorption and plasma emission spectroscopy	3
	Total	42

11. Suggested Books:

S. No.	Authors/ Name of Books/Publisher	Year of Publication/ Reprint
1.	Pungor, E., "A Practical Guid to Instrumental Analysis", CRC Press.	1995
2.	Rickwood, D. and Hames, B.D., "HPLC, Gel Elctrophoresis, Oligonucleotide Synthesis, Soild Phase Peptide Synthesis, The Practical Approach Series", IRL Press.	1994
3.	Glasel, J.A. and Deutscher, M.P., "Introduction to Biophysical Method for Protein and Nucleic Acid Research", Academic press.	1995
4.	Campbell, I.D., and Dwek, R.A., "Biological spectroscopy", Benjamin Cummins.	1984
5.	Wilson, K. and Walker, J., "Principles and Techniques of Practical Biochemistry" 5th edition, Cambridge University Press.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT-604** Course Title: **Molecular Carcinogenesis & Therapy**
2. Contact Hours: **L**: 3 **T**: 1 **P**: 0
3. Examination Duration (Hrs.): **Theory** [3] **Practical:** [--]
4. Relative Weightage: **CWS** [25] **PRS** [--] **MTE** [25] **ETE** [50] **PRE** [--]
5. Credits: [4] 6. Semester: **Both** 7. Subject Area: **PEC**
8. Pre-requisite : **Nil**
9. Objective: To impart knowledge of various factors that induces carcinogenesis and strategies for combating cancer.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to carcinogenesis, origin of cell line, normal and transformed cell lines, growth requirements, cell cycle, mutation in proliferating cells.	8
2.	Growth factors, regulation of cell proliferation PDGF, IGF & EGF receptor interaction, secondary message, erythropoietin, TCGF	6
3.	Characteristic feature of cancer cells, loss of normal cellular affinities, cytoskeletal changes, differential expression of genes, factor affecting carcinogenesis, chemical carcinogens, tumor promoters, viruses, DNA & RNA tumor viruses	8
4.	Role of large T antigen, oncogen carrying retro viruses, molecular features of oncogenes, human cancer genes: H-ras, K-ras and N-ras genes, chromosomal abnormalities in human tumors: abl and myc protooncogene, retinoblastoma gene 1	8
5.	Human cancer viruses- EB virus, Hepatitis B virus, HTLV, Papiloma virus, Cervical carcinoma	4
6.	Primary screening of anti tumor compounds, chemo therapy of Hodgkin's disease, lymphosarcoma & bronchiogenic carcinoma, cancer gene therapy and vaccines, future prospects.	8
	Total	42

11. Suggested Books:

S. No.	Authors/ Name of Books/Publisher	Year of Publication
1.	Vande, G. F., Levine A. J., Topp, W. C. and Watson, J. D. "Cancer Cell: Oncogenes and Viral Gene", Cold spring Harbor.	1985
2.	Franks, L. M. Teich, N.M., "Introduction to Cellular and Molecular Biology of Cancer", Oxford University Press.	1997
3.	Larionow, L. "Cancer Chemotherapy", Pergamon Press.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT-605** Course Title: **Vaccine Development & Production**

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

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

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

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

9. Pre-requisite : **Nil**

10. Objective: To provides an in depth view of the various factors and designs used for vaccine research.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction, immune mechanism and effector system antigens, cell surface antigens.	6
2.	Rationale for vaccine production, whole organism and sub unit vaccines, recombinant vaccines, vector vaccine, design of a sub unit vaccine for Hepatitis B- virus, Vaccinia virus as vector for recombinant live vaccines.	10
3.	Factors affecting vaccine production, non toxic immunogenic analogs of toxins, pertussis toxin, approaches for the development of attenuated virus strains.	9
4.	Designing vaccines for Herpis and Polio virus, bacterial virulence as strategy for developing vaccines, design of vaccines for cholera, streptococcal infection and for other intracellular (bacterial & protozoan) parasites.	9
5.	Design of peptide vaccines, monoclonal antibodies as biotherapeutic agents, immunological adjuvants	8
	Total	42

11. Suggested Books:

S. No.	Authors/ Name of Books/Publisher	Year of Publication/Reprint
1.	Bittle, J.L. and Murphy, E.A., "Vaccine Biotechnology", Academic Press.	2002
2.	Cryps, S.J., "Immunotherapy and Vaccine", VCH Publ.	2003
3.	Chanock, R.M, "Vaccine 92; Modern Approaches to New Vaccines.	1992
4.	Manuel, J.T.C., Griffiths, B. and José, L.P. M., "Animal Cell Technology: From Vaccines to Genetic Medicine", Springer.	1996
5.	"Vaccines: Preventing Disease and Protecting Health", World Health Organization.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT-606** Course Title: **Reproductive Endocrinology & Contraceptive Technology**

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

3. Examination Duration (Hrs.): **Theory** [3] **Practical:** [--]

4. Relative Weightage: **CWS** [25] **PRS** [--] **MTE** [25] **ETE** [50] **PRE** [--]

5. Credits: [4] 6. Semester: **Both** 7. Subject Area: **PEC**

11. Pre-requisite : **Nil**

12. Objective: To provide understanding of reproductive processes and the technologies that can regulate fertility.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to endocrinology, endocrine glands and hormones, neuroendocrine integration	4
2.	Biosynthesis of steroid and peptide hormones, mechanism of hormone action; Hypothalamo- pituitary- gonad axis and feedback regulation; Testis- sertoli and leydig cells, spermatogenesis; Male accessory sex tissue- epididymis, vas deferens, seminal vesicle, prostate.	10
3.	Puberty- development of primary and secondary sex tissues and their endocrine control; Menstrual cycle- changes in reproductive tract and hormones involved; Pregnancy- placenta, physiology and hormones in gestation, mammary glands and lactation	10
4.	Reproductive behavior and seasonal regulation of reproduction, gametes and fertilization, cloning, in vitro fertilization and embryo transfer	8
5.	Natural methods of contraception, safe periods and general awareness, contraception by barriers and surgical intervention, oral and injectables, implants, intrauterine and other devices, Immunocontraception and future prospects	10
	Total	42

11. Suggested Books:

S. No.	Authors/ Name of Books/Publisher	Year of Publication/Reprint
1.	Knobil, E. and Neil, J.D., "The physiology of reproduction, Vol. I and II", Raven Press.	2000
2.	Bentley, P.J., "Comparative Vertebrate Endocrinology", Cambridge University Press.	2004
3.	Hatcher, R.A., Rinehart, W., Blackburn, R. and Geller, J.S., "The Essentials of Contraceptive Technology Population information program centre for communication program", John's Hopkins university and World health organization.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Biotechnology Department

1. Subject Code: **BT-607** Course Title: **Ecology & Environmental Biotechnology**

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

3. Examination Duration (Hrs.): **Theory** [3] **Practical:** [--]

4. Relative Weightage: **CWS** [25] **PRS** [--] **MTE** [25] **ETE** [50] **PRE** [--]

5. Credits: [4] 6. Semester: **Both** 7. Subject Area: **PEC**

8. Pre-requisite : **Nil**

9. Objective : To introduce applications of biotechnology to environmental conservation and management.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to environment, concept and scope	3
2.	Ecological principle, ecosystem approach, system analysis in ecology	4
3.	Population ecology- structure and dynamics; Biotic communities- species diversity, development and evolution; Human ecology- ecological imbalances caused due to human activities, water pollution, air pollution, noise pollution, conservation of natural recourses, control policies, act and legislation	10
4.	Waste water management- objective, waste water flow, waste water treatment methods, physical unit operation, chemical unit process and biological unit processes, anaerobic and pond system	9
5.	Solid waste management- organization and management, quality and quantity of solid waste, industrial and hazardous solid wastes, collection haulage, compositing, incineration and disposal	8
6.	Introduction to biosensors- types and application; Bioremediation- onsite and offsite	8
	Total	42

11. Suggested Books:

S. No.	Authors/ Name of Books/Publisher	Year of Publication/Reprint
1.	Metcalf and Eddy, "Wastes Water Engineering, Treatment and Disposal" , McGraw Hill	2000
2.	Evans, G.M., and Furlong J.C., "Environmental Biotechnology Theory and Application", John Wiley and Sons	2003
3.	Bhide, A.D., and Sundaresan, B.B., "Solid Waste Management in Developing Countries", INSDOC.	1998
4.	Lee, C.C., Shun Dar Lin, " Handbook of environmental Engineering Calculation", 2nd Edition , McGraw Hill.	2007
5.	Rickwood, D. and Hames, B.D., "Biosensors: A practical Approach", IRL Press.	1990

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT-608** Course Title: **Molecular diagnostic and Therapeutic Biotechnology**

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

3. Examination Duration (Hrs.): **Theory** [ ] **Practical:** [--]

4. Relative Weightage: **CWS** [25] **PRS** [--] **MTE** [25] **ETE** [50] **PRE** [--]

5. Credits: [4] 6. Semester: **Both** 7. Subject Area: **PEC**

10. Pre-requisite : **Nil**

11. Objective: To provide knowledge and concepts of modern diagnostics & therapeutics biotechnology.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Immunological diagnostic procedures: enzyme linked immunosorbant assay, radioimmunoassay, dot and slot blot assay, detection of cytoskeleton proteins, immunochemistry of blood and bone marrow, immunosenor technology.	7
2.	Monoclonal antibodies as therapeutic agent: Prevention of rejection of transplant orgons, treatment of bacterial infection and leukemia, HLA typing, transplantation.	5
3.	Genetically engineered immunotherapeutic agents: Fusion protein, production of antibodies in E. coli, purification and application, chemically linked monoclonal antibodies, human monoclonal antibodies, hybrid human-mouse monoclonal antibodies, catalytic antibodies.	7
4.	DNA diagnostic system: Hybridization probes, diagnosis of malaria and other diseases, non isotopic hybridization procedure, detection of mRNA by in situ hybridization, hapten lebeling of nucleic acid probes.	6
5.	Molecular basis of multidrug resistance (MDR): In cancer, leishamania, candida and other diseases, a comparative view.	4
6.	Molecular diagnosis of genetic diseases: PCR application in genetic and diseases diagnosis, PCR/OLA procedure, mulation at different site within one gene, DNA fingerprinting (new genetic tests) application.	6
7.	Ribozymes: Synthesis *in vitro* application *in vivo*, clinical potentials of ribozymes.	3
8.	Genetherapy: Positional cloning, getting closer to diseases causing genes, genes based medicines, genetic immunization, human somatic cell gene therapy, *ex-vivo* and *in-vivo* gene therapy, antisense therapy, germline gene therapy, future and fears, HIV therapy.	4
	Total	42

11. Suggested Books:

S. No.	Authors/ Name of Books/Publisher	Year of Publication/Reprint
1.	Buckingham, L. and Maribeth, L.F., " Molecualr Diagnostics: Fundamentals, Methods and Clinical Application", F.A. Davis.	2007
2.	David, B., Edward, A. and Carl. B., "Fundamentals of Molecular Diagnostics", W.B. Saunders.	2007
3.	Gardy, W.W., Nakumura, R.M. and Kieche, F.L., "Molecular Diagnostic: Techniques and Application", Academic Press.	2009
4.	Mausaaum, D., Prasad, G.B.KS., and Bisen, P.S.,"Molecular Diagnostics: Prospect and Possibilities", Springer	2010
5.	Blum, H.E., LU, C.H.,"Molecuar Diagnostics and Gene Therphy" Springer.	2009
6.	Maulik, S. and Patel, P.,"Molecular Biotechnology: Therapeutic and Stratgies", Humana Press.	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT-609** Course Title: **Gene Regulation**

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

3. Examination Duration (Hrs.): **Theory** [3] **Practical:** [--]

4. Relative Weightage: **CWS** [25] **PRS** [--] **MTE** [25] **ETE** [50] **PRE** [--]

5. Credits: [4] 6. Semester: **Both** 7. Subject Area: **PEC**

8. Pre-requisites: **Nil**

9. Objective: To provide information about the various mechanisms of gene regulation in bacteriphages, bacteria and eukaryotes.

10. Details of Course:

S. No.	Particulars	No. of Lecture
1.	Transcriptional regulation in Bacteria; Translational and post-translational regulation in bacteria	8
2.	Gene regulation in bacteriophage life cycle	3
3.	Tissue specific expression of proteins and messenger RNAs; Gene regulation by DNA loss, amplification and rearrangement	7
4.	Gene regulation at transcription in eukaryotes; Post- transcriptional regulation in eukaryotes	8
5.	Transcriptional control –chromatin structure, DNA sequence elements, transcriptional factors.	9
6.	Gene regulation and cancer	3
7.	Application and future propects of gene regulation studies	4
	Total	42

11. Suggested Books:

S. No.	Authors/ Name of Books/Publisher	Year of Publication/Reprint
1.	Latchman, D. S., "Gene Regulation: An Eukaryotic Perspective", 2nd, Ed., Chapman and Hall.	2003
2.	Booker, R. J., "Genetics: Analysis and principles", Addison Wesley Longman.	1996
3.	Lewis B., "Genes VI", Oxford University Press.	2010
4.	Jun, M.A., "Gene Expression and Regulation", Springer Verlag.	2005
5.	Jeffery, W., "Post Transcriptional Gene Regulation", Humana Press.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT./CENTRE: **Department of Biotechnology**

1. Subject Code: **BT-610** Course Title: **Genomics and Proteomics**

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

3. Examination Duration (Hrs.): **Theory** [3] **Practical:** [--]

4. Relative Weightage: **CWS** [25] **PRS** [--] **MTE** [25] **ETE** [50] **PRE** [--]

5. Credits: [4] 6. Semester: **Both** 7. Subject Area: **PEC**

8. Pre-requisites: **Nil**

9. Objective: To impart in-depth knowledge regarding use of various molecular biology and bioinformatics tools to study the complete genome and proteome of an organism.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Genome evolution and organization in prokaryotes and eukaryotes.	3
2.	Genome sequencing, basics, strategies and methodology, databases and sequence comparisons.	7
3.	Comparative genomics, functional genomics, expression sequence tags (ESTs), serial analysis of gene expression (SAGE) and targeting induced local lesions in genome (TILLING).	7
4.	Microarrays technology- Principles and applications, transcriptome analysis and SNPs determination.	3
5.	Allele mining and single nucteotide polymorphisms (SNPs).	3
6.	Proteomics- Introduction, proteomics and proteome, protein databases; Tools of proteomics- Analytical protein and peptide separations, high throughput proteome analysis with 2D-IEF, protein digestion techniques, mass spectrometry.	9
7.	Peptide sequencing analysis by tandem mass spectrometry data, mass-finger printing, protein–protein interactions.	6
8.	Application of genomics and proteomics- mining genome proteomes, protein expression profiles, mapping protein modifications, new directions.	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Books/Authors/Publisher	Year of Publication/Reprint
1.	Campbell, A. M. and Heyer, L. J., "Discovering Genomics, Proteomics and Bioinformatics", Benjamin Cummings Publication.	**2003**
2.	Pevsner, J., "Bioinformatics and Functional Genomics", John Wiley & Sons.	**2003**
3.	Botwell, D. and Sambrook, J., "DNA Microarrays: Molecular Cloning Manual", Cold Spring Harbor Lab. Press.	**2002**
4.	Hunt, S. P. and Liversey, F. J., "Functional Genomics: A Practical Approach", Oxford University Press.	**2001**
5.	Pennington, S. and Dunn, P. J., "Proteomics: From Protein Sequence to Function", Springer Verlag.	**2001**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT-614** Course Title: **Bioinformatics**

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

3. Examination Duration (Hrs.): **Theory** [3] **Practical:** [--]

4. Relative Weightage: **CWS** [25] **PRS** [--] **MTE** [25] **ETE** [50] **PRE** [--]

5. Credits: [4] 6. Semester: **Both** 7. Subject Area: **PEC**

8. Pre-requisites: **Nil**

9. Objective: To expose student to the rapidly growing field of Bio-informatics through data mining and computational approach.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to Bioinformatics, NCBI, Protein Data Bank and data retrieval.	6
2.	European Bioinformatics Institute database search; Understanding EXPASY server; European Molecular Biology server.	7
3.	Introduction to Sequence comparison, global and multiple sequence alignment, Multiple sequence alignment using FASTA, Sequence alignment using CLUSTALW, BLAST and PSI BLAST.	9
4.	Introduction to 3-dimensional protein structure, superposition of molecules, RMS deviation, classification family of proteins and fold, SCOP, MSD.	10
5.	Introduction of Homology modeling, homology modeling using MOE and HYPERCHEM.	10
	Total	42

11. Suggested Books:

S. No.	Authors/ Name of Books/Publisher	Year of Publication/Reprint
1.	Higgins, D. and Taylor, W., "Bioinformatics – Sequence, Structure and Databanks" , Oxford University Press.	2003
2.	Lacroix, Z. and Critchlow, T., "Bioinformatics – Managing Scientific Data", Morgan Kaufmann Publishers.	2003
3.	Bourne, E.,P. and Weissig H., "Structural Bioinformatics"' John Wiley and Sons.	2003
4.	Campbell, A.M., and Heyer, I.J., "Discovering Genomics, Proteomics and Bioinformatics"' Benjamin Cummings.	2003
5.	Mount D.W., "Bioinformatics – Sequence and Genome Analysis" Cold Spring Harbor Lab. Press.	2001
6.	Pevsner, J., "Bioinformatics and Functional Geonomics"' John Wiley & Sons.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Biotechnology Department

1. Subject Code: **BT-615** Course Title: **General Biology and Microbiology**

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

3. Examination Duration (Hrs.): **Theory** 03 **Practical:** --

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

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

8. Pre-requisites: **Nil**

9. Objective: To give an over view of basic and applied aspects of general biology and microbiology to students with physics and mathematics background at graduate level.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to general biology, origin and evolution of life cell as a living unit, cell structure and function, heredity and genetic variation; Nomenclature and taxonomy	6
2.	Elementary biochemistry, salient feature of biomolecules, enzymes and other tools of biotechnology.	6
3.	Micro- organism, discovery and diversity, prokaryotic cell.	5
4.	Microbial energetic, biosynthesis and nutrition, autotrophic way of life, growth, macromolecular synthesis.	7
5.	Micro-organism in its environment, microbiology of air, soil and water.	5
6.	Bacteria and viruses, bacteriophages, animal and plant viruses, structure, replication and quantification.	7
7.	Structure and diversity of algae, protozoa and rotifers.	6
	Total	42

11. Suggested Books:

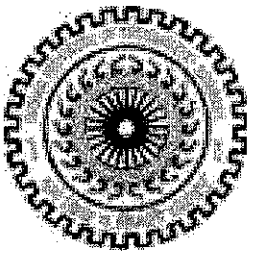
S. No.	Authors/ Name of Books/Publisher	Year of Publication/Reprint
1.	Roberts, M. B. V. and Ingram, N., "Biology", Thornes & Nelson Publication.	2001
2.	Harley, L. M., Klein, J. P., Brown, W. C., "Microbiology", Prescott Publication.	1996
3.	Smith, J. E., "Biotechnology" , Cambridge University Press.	1996
4.	Walker, J. M. and Rapley, R., "Molecular Biology and Biotechnology" , Royal Society of Chemistry.	2003
5.	Stryer, L., "Biochemistry"' W .H Freeman.	2000

After senate Dec 13, 10 corrected on Jan. 10, 2010

Appendix-B
Item No.SENATE/36.2.2

M.Tech. Syllabus

(Spring Semester)



Department of Chemistry
Indian Institute of Technology Roorkee
Roorkee – 247 667

After senate Dec 13, 10 corrected on Jan. 10, 2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF CHEMISTRY**

1. Subject Code: **CY-712** Course Title: **Lab - II**

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: **3** 6. Semester: **Spring** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To develop experimental skills in modern methods of characterization.

10. Details of Course:

S. No.	Contents
	List of Practicals
1.	Use of IR spectroscopy in determination of the purity of commercial samples by compressed disc.
2.	Thermal decomposition studies of inorganic compounds and polymers
3.	Magnetic measurements by vibrating sample magnetometer (VSM).
4.	Powdered x-ray diffraction pattern of a cubic/tetragonal system and indexing of the pattern (a) Determination of unit cell parameter. (b) Determination of number of molecules in a unit cell.
5.	Identification of materials in a solid mixture by powder x-ray diffraction pattern.

11. Suggested Books:

S. No.	Authors/ Book/ Publisher	Year of Publication/Reprint
1.	Radd M. and Palmer R. "Structure Determination by X-ray Crystallography", 4th Ed., Springer.	**2003**
2.	Willard H.H., Merritt L.L., Dean J.J. and Settle F.A., "Instrumental Methods of Analysis", 7th Ed., Wadsworth Publishing Co.	**1988**
3.	Skoog D.A., Holler F.J. and Crouch S.R., "Principles of Instrumental Analysis", 6th Ed., Thomson Brooks.	**2007**
4.	Ewing G.W., "Instrumental Methods of Chemical Analysis", 5th Ed., McGraw-Hill.	**2006**

After senate Dec 13, 10 corrected on Jan. 10, 2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF CHEMISTRY**

1. Subject Code: **CY-722** Course Title: **Chemometrics and Modelling**

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 import knowledge of modern methods of reducing and analyzing chemical data.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Fundamentals, probability and statistics:** Representation of simultaneous equations in matrix form, scalars, vectors and matrices; The matrix inverse, eigenvalues and eigenvectors, false negatives, false positives and power in testing of means; Regression (linear and nonlinear regression, curve fitting of chemical models, chemical calibration to concentration and properties, signal processing (digital filters, derivative filters, noise, Fourier transforms).	**14**
2.	**Treatment of Data:** Sources of error, precision and accuracy, propagation of errors (random errors, systematic errors, correlated errors), distributions (binomial distribution, sampling of solids, Poisson distribution, shot noise, gaussian distribution, chi-squared distribution, Student t distribution, confidence intervals), hypothesis testing (t-test, types of errors, paired t-test, F-test, chi-squared test, Q-test), simple analysis of variance and experimental design (one-way, two-way with and without replicates, randomized and blocked designs).	**14**
3.	**Computational methods:** Introduction to digital computers, representation of numbers, errors in floating point representation; Algorithms, syntax of one higher level language suitable for scientific computations (C or Fortran)- declarations, assignment statement, input/ output statements, control structures for selection and iteration, functions, array data structure, selected numerical methods for data analysis and treatment, writing and implementation of simple programs and one individually assigned programming project.	**14**
	Total	**42**

After senate Dec 13, 10 corrected on Jan. 10, 2010

List of Practicals:

I. Writing C program using input and output statements

II. Writing C program to demonstrate the concept of scope of variables

III. Writing C program involving functions

IV. C program for analysis of errors

V. C program for least square analysis

VI. Geometry optimization of small molecules using Gaussian 09 program

VII. Calculation of IR frequencies of sample using Gaussian 09 program

VIII. Computation of excitation energies for small molecules using Gaussian 09 program

IX. Conformational analysis using molecular modeling

X. C programming projects involving chemical calculations

Suggested Books:

S. No.	Authors/ Book/ Publisher	Year of Publication/Reprint
1.	Balagurusamy E., "Programming in ANSIC", Tata McGraw-Hill.	2004
2.	Anderson R.L., "Practical Statistics for Analytical Chemists", John Wiley.	1970
3.	Brereton R.G., "Applied Chemometrics for Scientists", John Wiley.	2007
4.	Goyal M., "Comprehensive Computer Based Numerical and Statistical Techniques", Laxmi Publications (P) Ltd.	2006
5.	Miller J.N. and Miller J.C., "Statistics and Chemometrics for Analytical Chemistry", Pearson Education Limited	2005

After senate Dec 13, 10 corrected on Jan. 10, 2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemistry**

1. Subject Code: **CY-732** Course Title: **Environmental Chemistry**

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 environment chemistry.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Chemistry and the Environment:** Environment segments, ecosystem and natural cycles of the environment, chemical and photochemical reactions in the atmosphere, ozone chemistry, oxides of sulphur and nitrogen, organic compounds, green house effect and global warming, acid rain, environmental fate of pollutants, biological activity, biodegradation of carbohydrates, fats and oil, proteins, detergents, pesticides.	9
2.	**Chemical Toxicology:** Toxic chemicals in the environment, toxic effects, biochemical effects of arsenic, cadmium, lead, mercury, copper, chromium; Biochemical effects of some gaseous pollutants, cyanide, pesticides, asbestos.	6
3.	**Pollution:** Air pollutants, air quality standards, sampling and analysis, air pollution control, noise pollution, injurious effects of noise.	3
4.	**Water Quality:** Water quality parameters and standards, turbidity, color, pH, acidity, solids, hardness, chlorides, residual chlorine, sulfates, fluorides, phosphates, iron, manganese, nitrogen, DO, BOD, COD, grease, volatile acids, analytical techniques in water analysis, soil pollution.	9
5.	**Wastewater Treatment:** Primary treatment, equalization, neutralization, proportioning, sedimentation, oil stripping of volatile organic, biological treatment process, lagoons, activated sludge process, trickling filtration, anaerobic decomposition, sludge handling and treatment process.	9
6.	**Adsorption and Oxidation Processes:** Theory of adsorption, ion exchange process, chemical oxidation, advanced oxidation process, miscellaneous treatment processes.	6
	Total	42

After senate Dec 13, 10 corrected on Jan. 10, 2010

Suggested Books:

S. No.	Authors/ Book/ Publisher	Year of Publication/Reprint
1.	De A.K., "Environmental Chemistry", 7th Ed. New Age International (P) Ltd.	2010
2.	Sawyer C.N., "Chemistry for Environmental Engineering", 4th Ed., McGraw, Inc.	1994
3.	Metcalf E., "Wastewater Engineering", 3rd Ed., McGraw Hill Inc.	1991
4.	Manahan S.E., "Environmental Chemistry", 8th Ed., CRC Press.	2005
5.	Masters G.M., "Introduction to Environmental Engineering and Science", Prentice Hall of India Pvt. Ltd.	1998
6.	Khopkar S.M., "Environmental Pollution Analysis", New Age International (P) Ltd.	2008

After senate Dec 13, 10 corrected on Jan. 10, 2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemistry**

1. Subject Code: **CY-742** Course Title: **Analysis 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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide advanced knowledge of chemistry of engineering materials and their analysis.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Steel, Ferro and Non-Ferro Alloys:** Analysis of major constituents such as combined and uncombined carbon and silicon; Analysis of various metals present in steel, ferrochrome, ferromanganese, ferrovanadium, ferromolybdenum and ferrotungsten; Systematic determination of various metal ions in non-ferro alloys, analysis of major constituents in brasses, bronzes, gun metal and white metal.	10
2.	**Analysis of Constituents of Mortar and Concrete:** Classification of cements, various constituents of cement; Analysis of Portland cement with reference to insoluble residue, total silica, sesquioxides, iron, lime and manganese.	6
3.	**Analysis of Paints:** Identification of thinner, vehicle and their analysis, classification of pigments, analysis of various constituents in different pigments, varnishes, catalyzed coating and metal manganese.	6
4.	**Oils, Lubricants and Greases:** Testing of lubricating and allied oils with reference to viscosity and viscosity index, cloud and pour points, flash and fire points, aniline points, neutralization number, total acid number, Koettsdoerfer number and iodine value; Mechanical stability of greases, determination of penetration number and dropping point of grease, analysis and characterization of petroleum products.	10
5.	**Detergents:** Various constituents of detergents, quantitative analysis of anionic, cationic, amphoteric, ampholytic and zwitterionic surfactants; Determination and identification of major organic components such as	10

	sodium carboxymethyl cellulose, NTA, EDTA, organic bleaches and inorganic constituents; Analysis of soap products.	
	Total	**42**

Suggested Books:

S. No.	Authors/ Book/ Publisher	Year of Publication/Reprint
1.	Agarwal B.C. and Jain S.P., "Metallurgical Analysis", Khanna Publications.	1996
2.	Virmani O.P. and Narula A.K., "Applied Chemistry: Theory and Practice", New Age International Publishers.	2001
3.	Longman G.F. "The Analysis of Detergents and Detergent Products", John Wiley and Sons.	2000

After senate Dec 13, 10 corrected on Jan. 10, 2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemistry**

1. Subject Code: **CY-752** Course Title: **Analysis of Food and Drugs**

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 composition and analysis of foods and drugs.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Analysis of Basic Constituents of Food:** Moisture in case of dry, wet, moist food, oils, fats and fatty emulsions in case of fatty foods, volatile oil in case of spices, fibre determination in fibre containing food such as cereal, bread, spice (to determine quality of spices), protein in all kinds of food; Ash-determination of sulfated ash, water soluble ash and siliceous matter in vegetables, spices, sugars in fruit juices and soft drinks, acidity and volatile acidity, pH value.	10
2.	**Analysis of Preservatives, Colouring Matter and Contaminants:** Determination of SO_2, benzoic acid, hydroxyl benzoates, nitrites, nitrates used as preservatives; Analysis of antioxidants in fats, such as BHT, BHA and gallates, coloring matter in soft drinks, alcoholic drinks, jam-jelly, sweets, contaminants- analysis of mercury, arsenic and trace elements.	8
3.	**Analysis of Drugs and Pharmaceuticals:** General pharmacology, qualitative aspects of drug action, receptors, role of absorption of drugs, routes for administration and elimination of drugs, gram positive and gram negative bacteria, 5-HT receptors and drugs action on 5-HT, non steroidal anti-inflammatory drugs. Analysis of chloramphenicol, chloroquine, phosphate, beta-methasone, amylobarbitone, analgin, ampicilline, ascorbic acid, aspirin and paracetamol.	14
4.	**Forensic Analysis of Common Poisons:** Poisoning due to arsenic, lead, cadmium, mercury and cyanide, general analytical approach; Case studies-death due to fire, explosions, drug overdose case; Alcohol- effects of alcohol, analysis of body fluid samples for alcohol, analysis of breath for alcohol. analysis of body fluids- biological evidence, blood analysis, DNA analysis.	10
	Total	**42**

After senate Dec 13, 10 corrected on Jan. 10, 2010

Suggested Books:

S. No.	Authors/ Book/ Publisher	Year of Publication/Reprint
1.	Pearson D., "Lab Techniques in Food Analysis", Butter Worth and Co. Ltd.	2003
2.	Mayer L.H., "Food Chemistry", The AVI Publishing Co.	2005
3.	Mac Leod A.J., "Instrumental Methods of Food Analysis", Elec Science.	1975
4.	ISI Handbook of Food Analysis. Indian Standards Institution.	2000
5.	Rang H.P., Dale M.M. and Ritter J.M., "Pharmacology", Churchill Livingstone.	1996
6	George C, Thomas M and Pearmain H, "Aids to the Analysis of Foods and Drugs", 4th Ed., Bibliobazar, LLC, Bibliolife.	2003
7.	Pearmain T.H. and Moor C.G., "The Analysis of Foods and Drugs", Balliere, Tindall and Cox.	2007

After senate Dec 13, 10 corrected on Jan. 10, 2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemistry**

1. Subject Code: **CY-762** Course Title: **Drug Design and Action**

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 the design of drugs and their mode of action.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Drug Design Concepts**: Stereochemistry, formation of salts, solubility of drugs, importance of water solubility, structure activity relationships (SARs), quantitative structure activity relationships (QSARs), liphophilicity and stereo-electronic effects; Computer aided design and combinatorial methods, encoding methods, combinatorial synthesis in solution, screening and deconvolution.	**10**
2.	**Drugs and Their Action:** Sources of drugs, classification of drugs, routes of administration, pharmaceutical phase, pharmacokinetic phase, bioavailability of a drug and pharmacodynamic phase.	**4**
3.	**Examples of Drug Action:** Concept of antibiotics, membranes-types, transport across membranes, drugs that disrupt membranes, enzymes-biological catalysis enzyme kinetics, enzyme inhibition, design of enzyme inhibitors, reversible inhibitors, transition state inhibitors, irreversible inhibitors; Receptors and messengers – types, ligand responses, ligand-receptor interactions, binding affinity, designing receptor based drugs-agonists and antagonists; Drugs that target nucleic acids, nucleic acid synthesis, inhibitors.	**14**
4.	**Drug Metabolism**: Phase I and phase II metabolic reactions.	**2**
5.	**Drug Synthesis**: Importance of chiral drugs, asymmetry in synthesis – creation of stereospecific centers, methods of asymmetric synthesis and disconnection approach, enantiomeric separation and characterization methods, drugs based on steroid, non-steroid, substituted benzene ring, five and six membered heterocycles.	**12**
	Total	**42**

After senate Dec 13, 10 corrected on Jan. 10, 2010

Suggested Books:

S. No.	Authors/ Book/ Publisher	Year of Publication/Reprint
1.	Thomas G., "Fundamentals of Medicinal Chemistry", John Wiley and Sons.	2003
2.	Lednicer D., "Strategies for Organic Drug Synthesis and Design", Wiley-Interscience, John Wiley and Sons.	1988
3.	Dugas H., "Bio Organic Chemistry, A.Chemical approach to enzyme action", 2nd Ed., Springer – Verlag.	1989
4.	Roth H. J. Kleemann A., "Pharmaceutical chemistry", Vol.1, Drug Synthesis.	2001
5.	Berger A., "Medicinal chemistry", Vol 1 and 2, Wiley Interscience.	1990

After senate Dec 13, 10 corrected on Jan. 10, 2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemistry**

1. Subject Code: **CY-772** Course Title: **Analysis of Industrial Polymers**

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 polymer chemistry and analysis of industrial polymers.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction of Polymers:** Classification of polymers, homopolymers, copolymers, graft copolymers and their characteristic properties in reference to technological and industrial applications.	6
2.	**Thermal and Spectral Methods of Analysis of Polymers:** Applications of DSC, DTA, TG methods for analysis of homopolymers, copolymers, polymer blends and composites; Application of IR , NMR, X-ray diffraction neutron scattering, SEM and TEM techniques for analysis of polymers; Viscosimetry for the analysis of molecular mass and molecular dimension of polymer coils.	12
3.	**Mechanical Behavior of Polymers:** Analysis of mechanical properties such as tensile, polymers shear and flexural strengths.	6
4.	**Polymers for Advance Technologies:** Testing of polymers for electrical and electronic applications; Analysis of optical properties of polymers in presence of coloring agents, effects of radiation on stability of polymers.	6
5.	**Reinforced and Multi-component Polymers:** Analysis of fillers, antioxidants, stabilizers, plasticizers, fire retardants, pigments and other additives in industrial polymers using modern methods of analysis.	6
6.	**Commercial and Industrial Polymers:** Polymer liquid crystals, polymeric foams, polymer blends, thermosets and thermoplasts, biodegradable polymers, ion exchangers, engineering plastics and conducting polymers.	6
		42

After senate Dec 13, 10 corrected on Jan. 10, 2010

Suggested Books:

S. No.	Authors/ Book/ Publisher	Year of Publication/Reprint
1.	Billmeyer Jr. F.W., "Text Book of Polymer Science", 3rd Ed., Wiley-Interscience.	1994
2.	Fried J.R., "Polymer Science and Technology", Prentice-Hall.	2002
3.	Seymeur R.B. and Carraher Jr. C.E., "Polymer Chemistry", Marcel Dekker.	1981
4.	Dyson R.N., "Specialty Polymer", Chapman and Hall.	1987
5.	Ku C.C., Liepins R., "Electrical Properties of Polymers", Hanser Publications.	1987
6.	Morgoles J M., "Conducting Polymers and Plastics", Chapman-Hall.	1989

After senate Dec 13, 10 corrected on Jan. 10, 2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemistry**

1. Subject Code: **CY-782** Course Title: **Nuclear Techniques for Analysis and Characterisation**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart in-depth knowledge on nuclear techniques for analysis and characterization of materials.

10. Details of Course:

Sl. No.	Particulars	Contact Hours
1	**Basic Radiochemistry:** Types of radioactivity, decay methods, radioactive equilibrium, choice and production of radio nuclides, interaction of radiation with matter.	6
2	**Nuclear Detector:** Properties of a detector, gas filled counters, scintillation and semiconductor detectors, clover detectors.	4
3	**Applications of Radioactivity:** Isotope dilution analysis, radioimmunoassay, radiochemical methods for determining biological activity, radiopharmaceutical, neutron activation analysis.	8
4	**Ion Beam Analysis and Micro-analysis:** Proton Induced X-ray Emission (PIXE), Rutherford Backscattering Spectrometry (RBS), nuclear reactions analysis. Nuclear Microprobe- μ-PIXE, μ-RBS, scanning transmission ion microscopy (STIM); Comparison with other microprobes- electron microprobe, synchrotron based μ-XRF	10
5	**Applications of Ion Beam Analysis:** Quantitative elemental imaging, applications to biomedical science, geological science, materials science, toxicology, single cell irradiation, proton beam writing for nanostructure fabrications.	14
	Total	42

After senate Dec 13, 10 corrected on Jan. 10, 2010

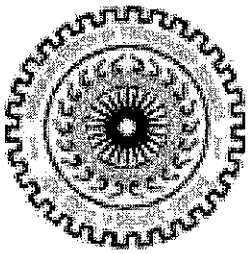
Recommended Books:

S. No	**Authors/Book/Publisher**	**Year of Publication /Reprint**
1	Ehmann W.D. and Vance D.E., "Radiochemistry and Nuclear Methods of Analysis", John Wiley and Sons.	**1991**
2	Sood, D.D., Reddy A.V.R. and Ramamoorthy N., "Fundamentals of Radiochemistry" Indian Association of Nuclear Chemists and Allied Scientists.	**2004**
3	Johansson S.A.E., Campbell J.L. and Malmqvist K.G. (Eds), "Particle Induced X-Ray Emission Spectrometry, (Chemical Analysis: A series of monographs on Analytical Chemistry and Applications)", Wiley Interscience.	**1995**
4	Meyer J.W. and Rimini, E., "Ion Beam Handbook for Material Analysis" Academic Press.	**1987**

Appendix-C
Item No.SENATE/36.2.2

M.Tech. Syllabus

(Spring Semester)



Department of Civil Engineering
Indian Institute of Technology Roorkee
Roorkee – 247 667

M. Tech. (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.	MA501B	Numerical Analysis	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	CE561	Computer Applications in Structural Analysis	PCC	4	3	-	2	3	-	15	15	30	40	-
3.	CE562	Continuum Mechanics	PCC	4	3	1	-	3	-	25	-	25	50	-
4.	CE563	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.	CE761	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	CE762	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	CE760	Dissertation	DIS	0	-	-	-	-	-	-	-	-	25	
		Sub Total		**06**										
			IV SEMESTER (SPRING)											
1.	CE760	Dissertation (contd. from III Semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
		Sub Total		**20**										
		TOTAL		**64-68**										

PROGRAMME ELECTIVES														
1.	CE661	Finite Element Method	PEC	4	3	-	2	3	-	15	15	30	40	-
2.	CE662	Advanced Steel Design	PEC	4	3	1	-	3	-	25	-	25	50	-
3.	CE663	Design of Bridge Superstructure	PEC	4	3	-	2	3	-	15	15	30	40	-
4.	CE664	Design of Bridge Substructure	PEC	4	3	1	-	3	-	25	-	25	50	-
5.	CE665	Design of Plates and Shells	PEC	4	3	1	-	3	-	25	-	25	50	-
6.	CE666	Mechanics of Composite Materials	PEC	4	3	1	-	3	-	25	-	25	50	-
7.	CE667	Structural Optimization and Risk Analysis	PEC	4	3	1	-	3	-	25	-	25	50	-

M. Tech. (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.	MA501B	Numerical Analysis	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	CE561	Computer Applications in Structural Analysis	PCC	4	3	-	2	3	-	15	15	30	40	-
3.	CE512	Analysis and Design for Dynamic Effects	PCC	4	3	1	-	3	-	25	-	25	50	-
4.	CE513	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.	CE711	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	CE712	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	CE710	Dissertation	DIS	0	-	-	-	-	-	-	-	-	25	
		Sub Total		**06**										
			IV SEMESTER (SPRING)											
1.	CE710	Dissertation (contd. from III Semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
		Sub Total		**20**										
		TOTAL		**66-68**										

PROGRAMME ELECTIVES														
1.	CE661	Finite Element Method	PEC	4	3	-	2	3	-	15	15	30	40	-
2.	CE611	Concrete Technology	PEC	4	3	-	2	3	-	15	15	30	40	-
3.	CE612	Construction Cost Dynamics and Management	PEC	4	3	1	-	3	-	25	-	25	50	-
4.	CE613	Wind Engineering	PEC	4	3	-	2	3	-	15	15	30	40	-
5.	CE614	Experimental Stress Analysis	PEC	4	3	-	2	3	-	15	15	30	40	-
6.	CE615	Evaluation and Retrofitting of Buildings	PEC	4	3	1	-	3	-	25	-	25	50	-

M. Tech. (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.	MA501C	Probability and Statistics	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	CE521	Computer Applications in Environmental Systems	PCC	4	3	1	2/2	3	-	15	15	30	40	-
3.	CE522	Advanced Water & Wastewater Treatment	PCC	4	3	1	-	3	-	25	-	25	50	-
4.	CE523	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.	CE721	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	CE722	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	CE720	Dissertation	DIS	0	-	-	-	-	-	-	-	-	25	
		Sub Total		**06**										
				IV SEMESTER (SPRING)										
1.	CE720	Dissertation (contd. from III Semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
		Sub Total		**20**										
		TOTAL		**65-69**										

PROGRAMME ELECTIVES														
1.	CE621	Air Pollution and Control	PEC	4	3	1	2/2	3	-	15	15	30	40	-
2.	CE622	Water Quality Management	PEC	4	3	1	-	3	-	25	-	25	50	-
3.	CE623	Solid Waste Management	PEC	4	3	1	2/2	3	-	15	15	30	40	-
4.	CE624	Environmental Impact and Risk Assessment	PEC	4	3	1	-	3	-	25	-	25	50	-
5.	CE625	Industrial and Hazardous Waste Management	PEC	4	3	1	-	3	-	25	-	25	50	-
6.	CE626	Environmental Sanitation and Health	PEC	4	3	1	-	3	-	25	-	25	50	-
7.	CE627	Environmental Economics and Legislation	PEC	4	3	1	-	3	-	25	-	25	50	-

M. Tech. (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.	MA501E	Optimization Techniques	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	CE551	Hydrological Modeling and Simulation	PCC	4	3	1	-	3	-	25	-	25	50	-
3.	CE552	Advanced Fluid Mechanics	PCC	4	3	1	2/2	3	-	15	15	30	40	-
4.	CE553	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.	CE751	Seminar	SEM	2									100	
2.	CE752	Project	RP	4									100	
3.	CE750	Dissertation	DIS	0									25	
Sub Total				**06**										
IV SEMESTER (SPRING)														
1.	CE750	Dissertation (contd. from III Semester)	DIS	20									75	
Sub Total				**20**										
TOTAL				**64-68**										

PROGRAMME ELECTIVES

1.	CE651	Fluvial Hydraulics	PEC	4	3	1	-	3	-	25	-	25	50	-
2.	CE652	Embankment Dams	PEC	4	3	1	-	3	-	25	-	25	50	-
3.	CE653	Systems Engineering	PEC	4	3	1	-	3	-	25	-	25	50	-
4.	CE654	Ground Water Engineering	PEC	4	3	1	-	3	-	25	-	25	50	-
5.	CE655	Water Resources Systems Planning	PEC	4	3	1	-	3	-	25	-	25	50	-
6.	CE656	Irrigation and Drainage	PEC	4	3	1	-	3	-	25	-	25	50	-
7.	CE657	Hydro Power Engineering	PEC	4	3	1	-	3	-	25	-	25	50	-
8.	CE658	Computational Methods in Fluid Mechanics		4	3	1	-	3	-	25	-	25	50	-

M. Tech. (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
1ST YEAR			**I SEMESTER (AUTUMN)**											
1.	MA501C	Probability and Statistics	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	CE581	Advanced Programming and Computer Graphics	PCC	4	3	-	2	3	-	15	15	30	40	-
3.	CE582	Expert Systems, Neural Networks and Fuzzy Systems	PCC	4	3	1	-	3	-	25	-	25	50	-
4.	CE541	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.	CE781	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	CE782	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	CE780	Dissertation	DIS	0	-	-	-	-	-	-	-	-	25	
		Sub Total		**06**										
			IV SEMESTER (SPRING)											
1.	CE780	Dissertation (contd. from III Semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
		Sub Total		**20**										
		TOTAL		**64-68**										

PROGRAMME ELECTIVES			
1.			Any four Programme Electives from any one of Building Technology / Environmental Engineering / Geomatics Engineering / Geotechnical Engineering / Hydraulics Engineering / Structural Engineering / Transportation Engineering disciplines.
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			

M. Tech. (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.	MA501 C	Probability and Statistics	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	CE541	Advanced Numerical Analysis	PCC	4	3	-	2	3	-	15	15	30	40	-
3.	CE542	Advanced Soil Mechanics	PCC	4	3	1	2/2	3	-	15	15	30	40	-
4.	CE543	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.	CE741	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	CE742	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	CE740	Dissertation	DIS	0	-	-	-	-	-	-	-	-	25	
		Sub Total		**06**										
					IV SEMESTER (SPRING)									
1.	CE740	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. (Transportation Engineering)

Teaching Scheme					Contact Hours/Week			Exam Duration (hrs.)		Relative Weights (%)				
S. No.	Subject 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.	CE-	Programme Elective – I	PEC	4										
2.	CE-	Programme Elective – II	PEC	4										
3.	CE-	Programme Elective – III	PEC	4										
4.	CE-	Programme Elective – IV	PEC	4										
5.	CE-	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-677	**Airport Planning and Design**	PEC	4	3	1	0	**3**	-	25	-	25	50	-
8.	CE-678	Transportation Systems Analysis	PEC	4	3	1	0	**3**	-	25	-	25	50	-
9.	CE-679	Traffic Engineering and Transportation Planning	PEC	4	3	1	2/2	**3**	-	15	15	30	40	-

M. Tech. (Geomatics Engineering)

Teaching Scheme					Contact Hours/Week			Exam Duration (hrs.)		Relative Weights (%)				
S. No.	Subject 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	-	2	3	-	15	15	30	40	-
3.	CE-532	Principles of Surveying and Photogrammetry	PCC	6*	3	-	2	3	-	15	15	30	40	-
4.	CE-533	Basic Remote Sensing and Digital Image Processing	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 * includes 2 credits of Field Survey Camp with PRS of 25% for 14 days during Winter Vacations				**21-24**										
					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.	CE731	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	CE732	Project	RP	4	-	-	-	-	-	-	-	-	100	-
3.	CE730	Dissertation	DIS	0	-	-	-	-	-	-	-	-	25	-
Sub Total				**06**										
					IV SEMESTER (SPRING)									
1.	CE730	Dissertation (contd. from III semester)	DIS	20									75	
Sub Total				**20**										
TOTAL				**66-70**										
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 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 and its applications to solid mechanics, structural dynamics, geomechanics and field problems.

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, iso-parametric formulations, axi-symmetric elements, numerical integration.	10
3.	Plane stress/strain problems, FE formulation, CST, LST, stiffness matrix, load matrix formation, rectangular elements, iso-parametric formulation, plate and shell elements, three dimensional elements, axi-symmetric stress analysis, torsion, interface elements, infinite elements.	12
4.	Applications to problems of vibrations and structural dynamics, mass (consistent and diagonal) and damping matrices, modal analysis, time history analysis, explicit direct integration/implicit direct integration and mixed methods.	6
5.	Introduction to nonlinear problems, geometric and material non-linearities, elasto-plastic analysis, solution methods - Newton-Raphson method, modified Newton-Raphson method, arc method, problems of geometric nonlinearity.	6
6.	Stationary principles, Rayleigh-Ritz method and interpolation, weighted residual methods and variational methods, numerical errors and convergence.	5
	Total	**42**

List of Practicals :

i) Development of computer programs for the analysis of plane stress/Plane strain problems
ii) Introduction to analysis packages (ABAQUS/ANSYS etc.) and their application to the analysis of :
    a. Trusses
    b. Frames
    c. Plane stress/plane strain problems
    d. Plates
    e. Shells

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Bathe, K.J., "Finite Element Procedures", Prentice-Hall of India.	2002
2.	Cook, R.D., Malkus, D.S. and Plesha, M.E., "Concepts and Applications of Finite Element Analysis", John Wiley.	2007
3.	Zienkiewicz, 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 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 of multi-storeyed and pre-engineered steel buildings using available software packages.	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
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.	2003
3.	Subramanian, N., "Design of Steel Structures" Oxford University Press.	2009
4.	Trahair, N. S. and Bradford, M.A., "The Behavior and Design of Steel Structures to EC3", Taylor & Francis.	2008
5.	Punmia, B.C., Jain, A.K. and Jain, A.K., "Design of Steel Structures", Laxmi Publications.	2010
6.	Duggal, S.K., "Design of Steel Structures", Tata McGraw Hill.	2009

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 available software.	6
3.	Effective width concepts and load distribution in T-beam bridges, grillage analysis, solid and voided slabs, application of STAAD.	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 Practicals :

Modeling and analysis of multi-lane simply supported and continuous bridges using SAP & STAAD and application of Microstation / AutoCAD in preparation of drawings

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Krishna Raju, N., "Prestressed Concrete Bridges", CBS.	2009
2.	Chen, W.F. and Duan, L., "Bridge Engineering Hand Book", CRC Press.	2000
3.	"Bridge Design Specifications", California Department of Transportation (CALTRANS).	2004
4.	"Seismic Design Criteria", California Department of Transportation (CALTRANS).	2006
5.	"Bridge Design Manual", Precast/Prestressed Concrete Institute, Chicago	2006
6.	Priestley, M.J.N., Seible, F. and Calvi, G.M., "Seismic Design and Retrofit of Bridges", John Wiley.	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: Analysis, design and detailing of bridge substructures.
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 recommendations.	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.	6
3.	**Design of Abutment Foundations :** Selection of foundation type, preliminary proportioning, analysis and design of pile and well foundations.	6
4.	**Deep Foundations for Bridges:** Features and characteristics of deep foundations, preliminary sizing of a deep foundation, IRC-78 recommendations.	6
5.	**Analysis and Design of Well Foundations:** Analysis as per IRC-45, design and detailing of components, construction issues, tilting and shift.	8
6.	**Types of Pile Foundations:** Bored cast-in-situ piles, cast-in-situ and pre-cast driven piles, under-reamed piles.	4
7.	**Analysis and Design of Pile Foundations:** Analysis of pile groups for vertical loads, lateral loads and moments, analysis and design of pile caps, construction issues, IS:2911 recommendations.	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Book/Publisher	Year of Publication/ Reprint
1.	Saran, S., "Analysis and Design of Substructures, Limit State Design", Oxford & IBH.	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
4.	Victor, D., "Essentials of Bridge Engineering", Oxford & IBH.	2004
5.	Singh, V., "Wells and Caissons", Nem Chand Jain & Bros.	1981

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 codal specifications.	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/Book/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.	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.	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 materials, 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 stiffnesses, 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, practical applications.	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Jones, R. M., "Mechanics of Composite Materials", Taylor & Francis.	1999
2.	Agarwal, B. D. and Broutman, L. J., "Analysis and Performance of Fiber Composites", John Wiley.	1990
3.	Daniel, I.M. and Ishai, O., "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-priori.	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 Authors/Book/Publisher	Year of Publication/ Reprint
1.	Tsompanakis, Y., Lagaros, N.D. and Papadrakakis, M., "Structural Design Optimization Considering Uncertainties", Taylor & Francis.	2008
2.	Adeli, H., "Advances in Design Optimization", Chapman and Hall.	1994
3.	Kirsch, U., "Optimum Structural Design : Concepts, Methods and Applications", Mc Graw-Hill.	1990
4.	Rao, S.S., "Optimization Theory and Applications", John Wiley.	2009

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, effect 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:** 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, no-fines, high performance, high density and radiation-shielding, polymer, fiber-reinforced, self compacting, roller compacted, high volume fly ash, ready mixed concretes.	6
	Total	**42**

List of Practicals :

i) To determine the properties of fresh concrete, namely workability, yield, temperature, air content etc.
ii) Mix design of high strength concrete, self compacting concrete etc.
iii) To determine the properties of hardened concrete, namely compressive strength, flexural strength, stress-strain behavior, modulus of elasticity, creep and shrinkage.
iv) To determine the transport properties of hardened concrete, namely water permeability, chloride permeability etc.

11. Suggested Books:

S. No.	Name of Authors / Book /Publisher	Year of Publication/ Reprint
1.	Neville, A.M., "Properties of Concrete", Prentice Hall.	1995
2.	Mehta, P. K., Monteiro, Paulo J.M., "Concrete Micro Structures, Properties and Materials", Prentice Hall & 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 & Co.	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 impart knowledge of scheduling and planning of a construction project and network techniques.

10. Details of the course:

S. No.	Contents	Contact Hours
1.	Building construction industry, specific features, Planning, effect of plan shape and storey heights.	4
2.	Elements of engineering economics, time value of money, compounding components of cost, criteria for cost comparison, cost indices.	8
3.	Probabilistic concepts, uncertainty, probability models, minimization of expected costs, applications to site planning, bidding, reliability analysis.	11
4.	Introduction to network techniques, LOB, CPM, PERT, time, cost and material scheduling, cash flow diagrams.	6
5.	Resources leveling and allocation, application to mass housing, statistical methods for decision making under uncertainty, balancing the risk and cost effectiveness of decisions.	6
6.	Application of Construct SIM and Primavera and other packages. Case studies of 2-3 buildings including time as well as resource scheduling.	7
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Frank, H. and Ronald, M., "Modern Construction Management", Black Well Publishing.	2002
2.	Graham, M.W., "Managing Construction Projects", Blaskwell Publishing.	2002
3.	Adeli, H. and Karim, A., "Construction Scheduling, Cost Optimization and Management", Taylor & Francis.	2001
4.	Jaggar, D., Ross, A., Smith, J. and Love, P., "Building Design and Cost Management", Blackwell Science.	2000
5.	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: **Nil**

9. Objective: To impart knowledge of wind effects on buildings, chimneys, towers and bridges, and wind tunnel instrumentation for the measurement of flow parameters.

10. 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 Atmospheric Boundary Layer (ABL) and 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 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 Practicals :

i) Measurement of base shear and moment in tall structures
ii) Measurement of pressure distribution on building models
iii) Measurement of strains in aero-elastic models
iv) Study of interference effects
v) Study of the effects of openings in walls

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Liu, H., "Wind Engineering - A Hand Book for Structural Engineers", Prentice-Hall.	1991
2.	Meroney, R.N. and Bienkiewicz, B., "Computational Wind Engineering", Elsevier Science.	1997
3.	Simiu, E. and Scanlan, R.H., "Wind Effects on Structures", John Wiley.	2008
4.	Mcdonald, J., "Wind Loading on Buildings", Applied Science.	1984
5.	Sean, P., "Wind Forces in Engineering", Pergamon Press.	1978
6.	Holmes, J.D., "Wind Loading on Structures", Spon Press, U.K.	2001

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 of structures.

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, strain indicators, 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 (LVDT), 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, equipment and 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, Scanning Electron Microscope (SEM) techniques.	4
	Total	**42**

List of Practicals :

i) Measurement of strain, temperature and pressure effects
ii) Experiments using vibration meter and acceleration pickup
iii) Experiments using photoelastic bench
iv) Experiments using NDT techniques

11. Suggested Books:

S. No.	Name of Authors/Book/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.	Srinivasan, A.V. and McFarland, D.M., "Smart Structures : Analysis and Design", Cambridge University Press.	2010

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 impart knowledge 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, construction defects.	6
2.	**Evaluation of Concrete Buildings:** Visual investigation, destructive testing systems, non-destructive testing techniques, semi-destructive testing techniques, chemical testing.	8
3.	**Monitoring of Structures:** Structural health monitoring, vibration based monitoring techniques, smart materials and sensors.	4
4.	**Surface Repair & Retrofitting Techniques:** Strategy & design, selection of repair materials, surface preparation, bonding repair materials to existing concrete, placement methods.	8
5.	**Strengthening Techniques:** Beam shear capacity strengthening, shear transfer strengthening between members, column strengthening, flexural strengthening and crack stabilization.	9
6.	**Rehabilitation and Retrofitting:** Seismic rehabilitation of existing buildings, seismic vulnerability and strategies for retrofit.	7
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Emmons, P.H., "Concrete Repair and Maintenance Illustrated", Galgotia.	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.	FEMA 273; NEHRP Guidelines for Seismic Rehabilitation of Buildings.	1997
5.	ATC:40: Seismic Evaluation and Retrofit of Concrete Buildings, Vol. 1 & 2.	1997
6.	Priestley, M.J.N., Seible, F. and Calvi, G.M., "Seismic Design and Retrofit of Bridges", John Wiley.	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 impart knowledge of various quantitative methods and project financing in Civil Engineering.
10. Details of the course:

S. No.	Contents	Contact Hours
1.	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
2.	Sampling and sampling distributions, testing hypothesis, one sample test, two sample test, simple regression analysis and correlations.	7
3.	Understanding of financial statements and their analysis, balance sheet, profit and loss account, rate analysis, fund flow analysis, statement of changes in financial position.	9
4.	Corporate reporting practices in India.	2
5.	Working capital needs, sources, procedures and practices in construction business, application to civil engineering projects.	4
6.	Long term financing.	2
7.	Working of financial institutes in India and abroad.	3
8.	Stock exchange, types of securities, borrowings, debentures.	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Goodpasture, J.C., "Quantitative Methods in Project Management", J. Ross Publishing.	2003
2.	Kerzner, H., "Project Management: A Systems Approach to Planning, Scheduling and Controlling", John Wiley.	2009
3.	Wysocki, R.K., "Effective Project Management", John Wiley.	2002
4.	Graham, M.W., "Managing Construction Projects", Blackwell Publishing.	2002
5.	Frank, H. and Ronald, M., "Modern Construction Management", Blackwell Publishing.	2002
6.	Chandra, P., "Financial Management Theory and Practice", Tata Mc Graw Hill.	2009
7.	Khan, M.Y. and Jain, P.K., "Finance Management", Tata Mc Graw Hill.	2009

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 and its applications to solid mechanics, structural dynamics, geomechanics and field problems.
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, iso-parametric formulations, axi-symmetric elements, numerical integration.	10
3.	Plane stress/strain problems, FE formulation, CST, LST, stiffness matrix, load matrix formation, rectangular elements, iso-parametric formulation, plate and shell elements, three dimensional elements, axi-symmetric stress analysis, torsion, interface elements, infinite elements.	12
4.	Applications to problems of vibrations and structural dynamics, mass (consistent and diagonal) and damping matrices, modal analysis, time history analysis, explicit direct integration/implicit direct integration and mixed methods.	6
5.	Introduction to nonlinear problems, geometric and material non-linearities, elasto-plastic analysis, solution methods - Newton-Raphson method, modified Newton-Raphson method, arc method, problems of geometric nonlinearity.	6
6.	Stationary principles, Rayleigh-Ritz method and interpolation, weighted residual methods and variational methods, numerical errors and convergence.	5
	Total	**42**

List of Practicals :

i) Development of computer programs for the analysis of plane stress/Plane strain problems
ii) Introduction to analysis packages (ABAQUS/ANSYS etc.) and their application to the analysis of :
    a. Trusses
    b. Frames
    c. Plane stress/plane strain problems
    d. Plates
    e. Shells

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Bathe, K.J., "Finite Element Procedures", Prentice-Hall of India.	2002
2.	Cook, R.D., Malkus, D.S. and Plesha, M.E., "Concepts and Applications of Finite Element Analysis", John Wiley.	2007
3.	Zienkiewicz, 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 621** Course Title: **Air Pollution and Control**
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: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge of causes and effects of air pollution and their controlling mechanisms.

10. Details of the Course:

S. No.	Contents	Contact Hours
1.	Introduction and scope, emission sources, stationary and mobile sources, types of air pollutants (criteria for air pollutants, air toxics, green house gases and noise), effects of pollutants on humans, materials and plants.	6
2.	Introduction to transport, dispersion and transformation of pollutants in air, plume rise, effect of buildings and topography on dispersion of air pollutants.	7
3.	Monitoring of indoor and ambient air quality, emission inventory, air pollution dispersion models, point, line and area source models, receptor modeling, stochastic models, compartment/box model.	7
4.	Carrying capacity of air sheds, local, regional and global issues of air pollution, summer and winter smog, acid rain and climate change.	7
5.	Air pollution control techniques, equipments and their design, design of stacks, control of particulate matter and gaseous pollutants.	7
6.	Air pollution emission standards, air quality standards, control laws, regulations and legislations - national and international, technology and policy options for controlling air pollution, economics of air pollution control, case studies.	8
	Total	**42**

List of Practicals :

i) Tailpipe emission measurements
ii) Stack emission measurements
iii) Sampling and analysis of SO_2, NO_2, SPM, and RSPM
iv) Measurements of CO and HC
v) Measurements of noise

11. Suggested Books:

S. No.	Name of Authors/Book/ Publisher	Year of Publication/ Reprint
1	Wark, K., Warner, C.F., and Davis, W.T., "Air Pollution: Its Origin and Control", Addison-Wesley Longman.	1998
2	Boubel, R.W., Fox, D.L., Turner, D.B., Stern, A.C., "Fundamentals of Air Pollution", Academic Press.	2005
3	Seinfeld, J.H., Pandis, S.N., "Atmospheric Chemistry and Physics", John Wiley.	2006
4	Stern, A.C., "Fundamentals of Air Pollution", Academic Press.	1984
5	Lodge, J.P. (Ed.), "Methods of Air Sampling and Analysis", CRC Press.	1988

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject code: **CE 622** Course Title: **Water 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: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To impart understanding of various aspects related to quality, pollution and remediation of natural water resources

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Source and nature of water pollution, strategy for water quality management, water quality standards, laws and regulations.	02
2.	**Rivers and Streams:** River hydrology and river pollution, spills and continuous discharge of residual material from point and non-point sources, initial mixing, oxygen demanding wastewaters, nutrients Streeter-Phelps model and other models, effect of bacteria (indicator bacteria, pathogens and viruses, restoration and management strategy).	13
3.	**Lakes and Reservoirs:** Physical and hydrologic characteristics, natural processes, water quality models (completely mixed, vertical, two dimensional), eutrophication, phyloplantation models, phyloplantation – nutrient – DO relationships, restoration and management strategy.	13
4.	**Ground Water:** Introduction, natural ground water quality, sources and ground water pollution, transport processes (sorption, decay and other processes), transport models for instantaneous and continuous point sources and non-point sources, non-aqueous phase liquids, remediation strategy.	08
5.	**Wetlands and Watersheds:** Introduction, natural and constructed wetlands, wetland hydrology, water generated pollutant loads, urban and agricultural watersheds, air shields.	04
6.	**Estuaries, Bays and Harbors:** Estuarine hydrology, tides and tidal currents, water quality in estuaries, water quality models.	02
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprints
1.	Thomann, R.V., Mueller, J.A., "Principles of Surface Water Quality Modelling and Control", Harper and Row Publishers.	1987
2.	Chin, D.A., "Water Quality Engineering in Natural Systems", Wiley – Interscience.	2006
3.	Masters, G.M. and Ela, W., "Introduction to Environmental Engineering and Science", PHI Learning.	2008
4.	Tchobanoglous, G. and Schroeder, E.D., "Water Quality", Addison–Wesley.	1985
5.	Chopra, S.C., "Surface Water Quality Modelling", McGraw Hill.	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject code: **CE 623** Course Title: **Solid Waste Management**
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: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge of planning of municipal solid waste management systems for environmental health and sustainable development.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Development of Solid Waste Management (SWM), issues in SWM, integrated SWM, legislations and regulations.	3
2.	**Sources and Types of Solid Waste:** Residential, commercial and industrial wastes, waste generation, sampling and analysis.	4
3.	**Collection and Transport:** On-site management (handling, storage and processing), collection services, analysis of collection system, route optimization, separation and transformation, transfer and transport.	11
4.	**Biodegradation of Solid Waste:** Composting, vermi-composting, digestion, thermal conversion technologies.	6
5.	**Disposal of Solid Waste:** Sanitary landfilling, gas and leachete movement and control, design of landfills, natural attenuation and containment landfills, closure of landfills, environmental monitoring.	8
6.	**Environmental Impact Assessment:** EIA of landfills and other treatment methods.	2
7.	**Resource Recovery:** Recovery, recycle and reuse-material, energy recovery processes and operations, SWM during disaster.	4
8.	**Case Studies:** Solid waste management practices in India.	4
	Total	**42**

List of Practicals :

Practicals related to Solid Waste Characterization, Biodegradation and measurement of end products.

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1	Tchobanoglous G., Theisen, H. and Vigil, S., "Integrated Solid Waste Management: Engineering Principles and Management Issues", McGraw Hill.	1993
2	CPHEEO "Manual of Solid Waste Management", GOI Publication.	2001
3	Bagchi, A., "Design of Landfills and Integrated Solid Waste Management", John Wiley.	2004
4	Kreith, F. and Tchobanoglous, G., "Handbook of Solid Waste Management", McGraw Hill.	2002
5	Ramchandra, T.V., "Management of Municipal Solid Waste", TERI Publications.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code: **CE – 624** Course Title: **Environmental Impact and Risk Assessment**
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 develop understanding of the environment and impact on it due to various projects and actions.

10. Details of the Course

S.No.	Contents	Contact Hours
1.	Introduction to environmental impact assessment, definitions, need in decision making.	2
2.	Elements of environmental impact assessment, guidelines of Ministry of Environment and Forest, GOI.	2
3.	Environmental impact assessment techniques and methodologies, checklists, matrices, network, geographic information system and computer applications.	5
4.	Environmental indices and standards.	2
5.	Assessment of impact on bio-geo-physico-chemical environment- flora and fauna, air, water and land.	5
6.	Assessment of impact on aesthetics, cultural and socio-economic environment.	4
7.	Decision methods, public participation in environmental decision making.	2
8.	Environmental impact statement and its review.	3
9.	Environmental impact assessment - case studies.	4
10.	Environmental audits.	2
11.	Environmental risk assessment – hazard identification, exposure, dose response, risk characterization and risk evaluation.	5
12.	Environmental risk management – cost benefit analysis, utility theory and decision making, mitigation measures.	4
13.	Environmental risk assessment – case studies.	2
	Total	**42**

11. Suggested Books

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Jain, R.K., Urban, L.V. and Stacey, G.S., "Environmental Impact Analysis", van Nostrand Reinhold.	2003
2.	Canter, L.W., "Environmental Impact Assessment", McGraw Hill.	2006
3.	Lerche, I. and Paleologos, E.K. "Environmental Risk Analysis", McGraw Hill.	2001
4.	Glasson, J., Therivel, R. C. "Introduction to Environmental Impact Assessment", Taylor & Francis.	2005
5.	Carroll, B., Turpin, T., "Environmental Impact Assessment Handbook", Thomas Telford.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject Code: **CE – 625** Course Title: **Industrial and Hazardous Waste 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-requisites: **Nil**

9. Objective: To develop understanding of industrial and hazardous waste management practices.

10. Details of the Course

S.No.	Contents	Contact Hours
1.	Introduction, industrial waste surveys, sampling and characterization	4
2.	Waste management strategies and programs, waste minimization, end-of-pipe treatment and disposal, waste management options hierarchy	3
3.	Green technologies, zero waste discharge units, environmentally balanced industrial complex	3
4.	ISO 9000 and 14000 series of standards for environmental management	3
5.	Waste treatment technologies, common effluent treatment plants, co-disposal with municipal waste	5
6.	Case studies of distilleries, pulp and paper, tannery, sugar, textile, steel, oil refineries, chemicals and industrial complexes	9
7.	Introduction and classification of hazardous wastes, storage and handling requirements, onsite and offsite emergency preparedness planning, hazardous waste management rules	5
8.	Hazardous wastes stabilization and solidification	4
9.	Hazardous waste disposal practices, incineration, land-filling, underground disposal	3
10.	Site remediation	3
	Total	**42**

11. Suggested Books

S.No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Nemerow, N.L., "Industrial Waste Management", McGraw Hill.	2007
2.	Eckenfelder, W.W., "Industrial Water Pollution Control", McGraw Hill.	2004
3.	LaGrega, M.D., Buckingham, P.L. and Evans, J.C., "Hazardous Waste Management", McGraw Hill.	1994
4.	Liu, O.H.F., and Liptak, B.G., "Solid and Hazardous Waste Management", Lewis Publishers.	2000
5.	Wentz, C.A., "Hazardous Waste Management", McGraw Hill.	1995

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject code: **CE 626** Course Title: **Environmental Sanitation and Health**
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-requisites: **Nil**
9. Objective: To develop an understanding of water borne diseases, health and sanitation problems and strategic planning for remediation.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Global situation of water supply and sanitation, safe water 2000, national, rural and urban sanitation policy.	4
2.	Characteristics of human excreta, pollution caused by excreta, pathogenic microorganisms, epidemiology of pathogens.	4
3.	Occurrence and features of waterborne and airborne diseases, preventive methodology.	4
4.	Low cost technologies for drinking water treatment, physical and chemical, disinfection, solar disinfection, chlorination and emerging techniques.	8
5.	Design of low cost toilets, small scale sewage and/or septage treatment systems - onsite and offsite.	8
6.	Organic waste management, recycling and reuse, composting and vermi-composting.	4
7.	Household Centered Environmental Sanitation (HCES) model, concept of zone, provisional guidelines.	3
8.	Introduction of Material Flux Analyses (MFA) on environmental sanitation-concept of MFA, case studies.	3
9.	Hygiene education and integrated approach to health and sanitation, emergency water supply and sanitation during disaster.	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1	Park, K., "Preventive and Social Medicines", Banarasidas Bhanot Publishers.	2002
2	WHO: "Guidelines for Drinking Water Quality", World Health Organization.	1996
3	"Wastewater Engineering", Metcalf & Eddy, Inc.	2003
4	WHO: "Guidelines for The Safe Use of Wastewater, Excreta and Greywater", World Health Organization.	2006
5	Crites, R. and Tchobanoglous, G., "Small and Decentralized Wastewater Management Systems", McGraw Hill.	1997
6	Lens, P., Zeeman, G. and Lettinga, G., "Decentralized Sanitation and Reuse: Concepts, Systems and Implementation", IWA Publishing.	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject code: **CE 627** Course Title: **Environmental Economics and Legislation**
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 economic aspects of environmental problems, environmental legislations and policy tools.
10. Details of the Course:

S. No.	Contents	Contact Hours
1	Introduction and scope, renewable and non-renewable resources depletion, economic principles, (optimal trade-offs, marginal benefits, willingness to pay, limits to growth etc.), environmental economic analysis, environmental and health risks, life cycle assessment.	7
2	Environmental policy instruments, public and environmental goods and externalities, valuation of environmental goods, negative externality and market failure.	6
3	Uncertainty, sustainable development and irreversibility in environmental policy (public participation, equity, sunk cost benefit, etc.), cost-benefit analysis and other tools to evaluate environmental policies.	7
4	Point and non-point sources, emission charges and permits in practice, technological changes and pollution control.	6
5	Environmental acts and legislations (national and international), environmental management systems (e.g. ISO 14000) and their certification processes, command and control regulations, inspection and fines.	6
6	Voluntary regulations, incentive-based strategies, taxes and subsidies, and marketable permits for pollution control.	2
7	Economics of climate change, co-benefits of environmental quality management, health risk and climate change, global pollutants and international environmental agreements, stratospheric ozone depletion and Montreal protocol, global warming and Kyoto and other protocols.	8
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1	Hanley, N., Shogren, J. F. and White, B., "Environmental Economics in Theory and Practice", Oxford University Press.	1997
2	Kolstad, C. D., "Environmental Economics", Oxford University Press.	2003
3	Tietenberg, T., "Environmental and Natural Resource Economics", Addison Wesley Longman.	2000
4	Robb, C.A.R., Palmer, A., "International Environmental Law Reports", Cambridge University Press.	2005

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 impart knowledge of the flow characteristics in an alluvial channel with erodible boundary.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Sediment problems, origin and properties of sediments, fundamental and bulk properties of sediments, incipient motion of uniform, non-uniform, cohesionless and cohesive sediments.	8
2.	Regimes of flow, ripples and dunes, antidunes, prediction and importance of regimes of flow, resistance to flow and velocity distribution in alluvial channels.	5
3.	Bed load and suspended load transport for uniform and non-uniform cohesionless and cohesive sediments, total load equations, sediment sampling.	10
4.	Stable channel design, stable channels carrying clear water in coarse non-cohesive material, stable channels carrying sediment-laden water in alluvial bed channels, sediment control by sediment ejectors and sediment extractors.	4
5.	Bed level variations, local scour, degradation, aggradation and reservoir sedimentation, soil erosion and sediment yield, methods of soil conservation.	7
6.	Physical models for alluvial river processes, mathematical models for alluvial river processes: 1D, 2D and 3D mathematical models, model data requirement and their applications.	4
7.	River training for sediment control, river training for bank protection by way of guide bunds and spur dikes	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Garde, R.J., "River Morphology", New Age International.	2006
2.	Julien, P.Y., "Erosion and Sedimentation", University Press, Cambridge.	2010
3.	Jansen, P.P.H., "Principle of River Engineering", VSSD Publications.	1994
4.	Garde, R.J. and Ranga Raju, K.G., "Mechanics of Sediment Transportation and Alluvial Stream Problems", New Age International (P) Ltd.	2006
5.	Graf, W.H., and Altinaker, M.S., "Fluvial Hydraulics : Flow and Transport Processes in Channels of Simple Geometry", West Sussex, U.K.	1998
6.	Dingman, S.L., "Fluvial Hydraulics", Oxford University Press.	2009

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 impart knowledge of methods of design of embankment dams and methods of analysis along with construction aspects.
10. Details of Course:

S. No.	Contents	Contact Hours
1	Types and advantages of embankment dams, factors affecting stability, criteria for design.	8
2	Theoretical analysis of seepage through embankments and its applications, governing equation, flow nets, Kozeny's solution, Casagrande's method, Scheffernak and Interson's solutions, anisotropic seepage, control of seepage through embankments and foundations, selection of core material, core thickness, location of core, slanting core, horizontal drainage, rock toe, chimney drains and transition filter.	12
3	Stability analysis, effective and total stress approaches, method of slices, Fellenins and simplified Bishop's method, graphical methods, May modified method, Taylor modified Swedish method, location of critical slip circle, wedge analysis.	12
4	Rockfill dams with impervious membranes, rockfill dams with earth cores, general characteristics, materials for rockfill dams, foundations for rockfill dams, Gilboy's method of stability check.	2
5	Methods of construction of embankments and salient aspects of construction including 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/Book/Publisher	Year of Publication/ Reprint
1.	Sherard, J. L., "Earth and Earth-Rock Dams", John Wiley.	1967
2.	Singh, B. and Varshney R. S., "Engineering for Embankment Dams", OIBH.	1995
3.	"Design of Small Dams", USBR Publications, OIBH.	1974
4.	Singh, B. and Sharma, H.D., "Earth and Rockfill Dams", Nem Chand & Bros.	1976
5.	Cedergren, H. R., "Seepage, Drainage and Flownets", John Wiley	1967
6.	Peurifoy, R. L., "Construction, Planning, Equipment and Methods", McGraw Hill.	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 modelling, synthesis and optimization.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Fundamentals of Systemic Approach :** Definitions of a system, system components, classification including linear, non-linear, time-invariant, time variant systems, system synthesis, role of optimization.	4
2.	**Linear Programming :** Graphical solution, formulation of primal, Simplex method, formulation of dual and dual simplex methods, relationship between primal and dual, sensitivity analysis.	8
3.	**Non-Linear Programming :** Analytical methods, Kuhn-Tucker conditions numerical unconstrained optimization, direct search methods, descent methods, one dimensional minimization, constrained optimization, direct and indirect methods, interior and exterior penalty function methods, sequential unconstrained minimization technique.	8
4.	**Dynamic Programming :** Characteristics of dynamic programming problems, solution, Bellman's principle of optimality, multiple state variables.	5
5.	**Queing System :** Generalized Poisson queing model, steady state measures of performance.	3
6.	**Non-Traditional Optimization Methods :** Genetic Algorithms, Simulated annealing, etc.	3
7.	**Stochastic Programming :** Probability distributions, generation of random numbers, central limit theorem, inverse transform theorem, Monte-Carlo simulations.	4
8.	**Application to Civil Engineering Problems :** Basic concepts for random variable and stochastic fields, stochastic and nonlinear programming problems.	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/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 Neufrille, R., "Systems Analysis for Engineer", McGraw Hill.	1971
4.	Rao, S. S., "Engineering Optimization–Theory and Practice", New Age International.	1999
5.	Hamdy A. T., "Operations Research–An Introduction", Prentice Hall.	1997
6.	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 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 the fundamentals of ground water hydrology, ground water assessment and ground water development.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction :** Definition of ground water, role of ground water in hydrological cycle, ground water bearing formations, classification of aquifers, flow and storage characteristics of aquifers, Darcy's law, anisotropy and heterogeneity.	5
2.	**Governing Equations for Ground water Flow:** Dupuit-Forchheimer assumptions, general differential equations governing ground water 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.	**Ground water Conservation:** Regional ground water budget, resource assessment, estimation of recharge, artificial recharge, Rain water harvesting; Indian practices.	5
5.	**Ground water Quality:** General problem of contamination of ground water, sources, remedial and preventive measures, seawater intrusion in coastal aquifers.	6
6.	**Ground water Flow Modelling:** Role of ground water flow models, reference to hydraulics, Hele Shaw and analog models, introduction to numerical modeling.	6
7.	**Planning of Ground water Development:** Constraints on the development, role of flow models, optimal ground water development.	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Todd, D. K., "Ground Water Hydrology", John Wiley.	1959
2.	Jacob B., "Hydraulics of Ground Water", McGraw Hill.	1979
3.	Bouwer, H., "Ground Water Hydrology", McGraw Hill.	1978
4.	Walton, W. C., "Ground Water Resources Evaluation", McGraw Hill.	1970
5.	Driscoll, F. G., "Ground Water and Wells", Johnson Division.	1986
6.	Raghunath, H. M., "Ground Water", New Age International.	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 water resource system 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 constraints, analytical and numerical optimization, linear programming, dynamic programming, simulation, planning under uncertainty.	10
4.	**Deterministic River Basin Modeling:** Stream flow modelling, estimation of reservoir storage requirements, dead storage, active storage for water supply/ irrigation/ power generation, flood storage, optimal allocation.	10
5.	**Conjunctive Use / Ground Water Management Models:** Linear programming 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/Book/Publisher	Year of Publication/ Reprint
1.	Hall, W.A. and Dracup, J.A., "Water Resources Systems Engineering", McGraw Hill.	1970
2.	Loucks, D.P., "Water Resource Systems Planning and Analysis", Prentice Hall.	1981
3.	Maass, A., "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:** 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 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**: Flow through root zone, physical and chemical properties of soils, 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, evapo-transpiration, crop coefficient, leaf area index, FAO guidelines on evapo-transpiration estimation.	6
6.	**Fundamentals of Surface Irrigation Hydraulics:** Continuity equation, momentum equation.	3
7.	**Modelling Aspects:** 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**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Walker, W. R. and Skogerboe, G. V., "Surface Irrigation Theory and Practice", Prentice Hall.	1987
2.	Ritzema, H.P., "Drainage Principles and Applications", International Institute for Land Reclamation and Improvement, Netherlands.	1973
3.	Michael, A. M., "Irrigation: Theory and Practice", Vikas Publishing.	1978
4.	Asawa, G. L., "Irrigation Engineering", New Age International.	1996
5.	Majumdar, D.K., "Irrigation Water Management", PHI Learning.	2009

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:** 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 fundamentals of hydro power, transient analysis and various components of a hydropower plant.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Water Power:** 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-the-river plants, general arrangement, 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 and 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/Book/Publisher	Year of Publication/ Reprint
1.	Dandekar, M.M. and Sharma, K.H., "Water Power Engineering", Vikas Publishing.	2000
2.	Varshney, R.S., "Hydro Power Structures", Nem Chand & Bros.	2001
3.	Nigam,P.S., "Hydro Electric Engineering", Nem Chand & Bros.	2001
4.	Choudhary, M.H., "Applied Hydraulic Transients", Van Nostrand Reinhold.	1987
5.	Warnick, C.C., "Hydro Power Engineering", Prentice-Hall.	1984
6.	"Hydropower Development", Norwegian Institute of Technology, Vols. 3-6.	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, ground water flow and contaminant transport.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Differential Equations :** Ordinary and partial differential equations, parabolic, elliptic and hyperbolic equations, initial and boundary conditions.	5
2.	**Finite Difference Method :** Taylor's series approximation of derivatives, forward, backward and central difference approximations, truncation and round-off errors, explicit and implicit schemes, Crank-Nicholson approximation, solution of matrix equations, application to one dimensional problems.	10
3.	**Finite Element Method :** Weighted residual approach, Galerkin method, weak form, shape functions, two dimensional triangular and rectangular elements, serendipity elements, applications.	8
4.	**Method of Characteristics :** Characteristic equations, wave propagation, forward and backward characteristics, application to fluid transients.	7
5.	**Numerical Solutions of Open Channel Flow Problems :** Gradually, spatially varied flows.	4
6.	**Numerical Solution of Flow and Transport Problems :** Numerical solution of ground water flow and contaminant transport, advection dispersion equation.	4
7.	**Numerical Solution of Laminar and Turbulent Flows :** Numerical solution of Navier-Stocks and Reynolds equations.	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Anderson, D.A., Tannehill, J.C. and Pletcher, R.H., "Computational Fluid Mechanics and Heat Transfer", McGraw Hill.	1984
2.	Chung, T. J., "Finite Element Analysis in Fluid Dynamics", McGraw Hill.	1978
3.	Anderson, M.P. and Weessner, W.W., "Applied Ground water Modelling", Academic Press.	1992
4.	Chaudhary, H. M., "Applied Hydraulic Transient", McGraw Hill.	1976
5.	Streeter, V.L. and Wylie, E.B., "Fluid Transients", McGraw Hill.	1976
6.	Smith, G. D., "Numerical Solution of Partial Differential Equations– FDM", Oxford.	1985

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: 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 impart knowledge of advanced methods of analysis and design of shallow and deep 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 dynamic cone, standard penetration and static penetration tests.	5
2.	**Shallow Foundations :** Requirements for satisfactory performance of foundations, methods of estimating bearing capacity, settlements of footings and rafts, codal provisions, pressure-settlement characteristics from constitutive laws, proportioning of shallow foundations.	6
3.	**Pile Foundations:** Methods of estimating load transfer of piles, settlements of pile foundations, pile group capacity and settlement, laterally loaded piles, proportioning of pile foundations.	6
4.	**Well/Caisson Foundations :** IS and IRC codal provisions, elastic theory and ultimate resistance methods for load carrying capacity of caissons.	5
5.	**Tunnels and Arching in Soils:** Pressure computations around tunnels through soft ground.	4
6.	**Open Cuts :** Stability of deep excavations, 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 Uplift Loads :** Prediction of swelling potential of expansive soils, estimation of uplift pressure on foundations, design considerations, underreamed piles, prediction of uplift capacity.	4
9.	**Soil-Structure Interaction :** Introduction of phenomenon, prediction of spring constants, beams and plates on elastic foundation,.	3
	Total	**42**

List of Practicals :

i) Exploratory Borings by different methods including auger boring, wash boring, percussion drilling and rotary drilling etc.
ii) Planning of soil exploration for different projects
iii) Standard penetration, dynamic cone penetration and static cone penetration tests
iv) Plate load tests

11. Suggested Books :

S. No.	Name of Authors/Book/ 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", John Wiley.	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 : To introduce various modes of failure of both soil and rock slopes and their stability 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, Bishop's modified, Bishop's rigorous, Janbu's, Morgenstern and Price, and Spencer's methods, seismic consideration, 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, 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, synthetic filters, retaining walls, strengthening of slopes, shotcreting, rock bolting and rock anchoring, bio-engineering methods.	6
7.	**Instrumentation and Monitoring of Slopes:** Slope movements, warning devices, slope indicators, inclinometers, tension crack meters, sliding wire deformation measuring instruments, maintenance of slopes.	2
	Total	**42**

11. Suggested Books :

S. No.	Name of Authors/Book/ 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" Taylor and Francis.	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 introduce theory of vibrations, behaviour of soils under dynamic loads and design of machine foundations.
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 :** Influencing factors, philosophy of design of equipments, behaviour under tri-axial and oscillatory shear conditions.	6
3.	**Liquefaction :** Mechanism, influencing factors, 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 turbo generator 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. Suggested Books :

S. No.	Name of Authors/Book/ 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, N.S.V. Kameswara, "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 introduce methods of analysis and design of underground excavations in rocks and jointed rock masses with special reference to tunnels, shafts and caverns.
10. Details of Course :

S. No.	Contents	Contact Hours
1.	**Introduction** : Planning of exploration for various underground construction projects.	4
2.	**Stereographic Projection Method** : Principle and preparation of stereo nets for various geological conditions, application in underground excavation design.	4
3.	**Elastic Stress Distribution Around Tunnels** : Stress distribution around tunnels of 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** : Prediction by flat jack, hydraulic fracturing, over coring techniques and United States Bureau of Mines (USBM) type drill hole deformation gauge, analysis of test data.	5
7.	**Instrumentation and Monitoring of Underground Excavations** : Single and multi-point bore hole extensometers, load cells, pressure cells, etc., tape extensometers, various case studies.	4
	Total	**42**

11. Suggested Books :

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Hoek, E. and 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.	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 impart knowledge of different methods for treatment of poor soils for various Civil Engineering projects.
10. Details of Course :

S. No.	Contents	Contact Hours
1.	**Introduction :** Typical situations requiring ground improvement, historical review of methods adopted in practice, current status and scope in the global context.	5
2.	**Densification of Soils :** Mechanical compaction, dynamic compaction, impact loading, compaction by blasting, vibro-compaction, pre-compression, dynamic consolidation, soil fracturing and injection of grouts, equipments for ground improvement.	7
3.	**Deep Foundations :** Design aspects of stone columns e.g. critical length, diameter, spacing, layout, contiguous piles, examples of pre-loading with sand drains, band drains, skirt walls; Material selection.	7
4.	**Geotextiles :** Selection and engineering applications, design examples, stabilisation/improvement of ground using geomembranes, geocells, geonets and geosynthetic walls, road designs with geosynthetics.	7
5.	**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, retaining walls with reinforced backfill.	8
6.	**Soil Nailing :** Need and basic concept of soil nailing, application to problems of vertical cuts and landslide control.	3
7.	**Problematic Soils :** Black cotton soils, Kaoline, saline soils, types of admixtures, improvement of problematic soils by admixtures, use of ply soils.	5
Total		**42**

11. Suggested Books :

S. No.	Name of Authors/Book/ Publisher	Year of Publication/ Reprint
1.	Moseley, M.P. and Kirsch K., "Ground Improvement", Taylor and Francis.	2004
2.	Mittal, S., "Ground Improvement Engineering", Vikas Publishing.	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 Geo-environmental.	2007
6.	Jones, C.J.F.P., "Earth Reinforcement and Soil Structure", Thomas Telford.	1996

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 : To impart knowledge of various methods for design of foundations of structures on jointed rock masses and treatment of weak foundations.
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, Hoek and Brown and modified Hoek and Brown failure criteria etc.	3
3.	**Effect of Structural Weakness 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 :** Theories for prediction of 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.	3
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 etc.	9
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, treatment of dam foundations with shear keys, dental treatment of faults and seams, grouting of cavities, grout curtains, cable anchors etc.	8
Total		**42**

11. Suggested Books :

S. No.	Name of Authors/Book/ Publisher	Year of Publication/ Reprint
1.	Wyllie D.C., "Foundations on Rocks : Engineering Practice", Taylor and Francis.	2005
2.	Singh, B. and Goel, R.K., "Rock Mass Classification- A Practical Engineering Approach", Elsevier.	2006
3.	Hudson, J.A., "Comprehensive Rock Engineering: Principles-Practice & Project," Vols. 1-5, Pergamon.	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 671** Course Title: **Advanced Highway Materials and Construction**
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: **PEC**
8. Pre-requisite: **Nil**
9. Objective : To impart advanced knowledge in highway materials and construction related to highway development.
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, subsoil drainage, soil stabilization.	6
3	**Bitumen:** Bitumen sources and manufacturing, bitumen constituents, structure and rheology, mechanical and engineering properties, tests, emulsion properties, types, modifications, durability of bitumen, adhesion of bitumen, modified bitumen.	10
4	**Bituminous Mixes:** Desirable properties, design, fillers, theory 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**

List of Practicals :

i) Identification tests on soils (Atterburg limits); Heavy compaction test on subgrade soil
ii) Triaxial test on pure subgrade soil
iii) Aggregate polishing and skid resistance test (demonstration); GSB mix design
iv) Test for aggregate durability; Preparation of mix for SDBC
v) Elastic recovery test on binder
vi) Marshall Bituminous Mix design, Rheometer test
vii)Bitumen viscosity test (Rotational viscometer); Retained stability test
viii) Concrete Mix design

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1	Krebs, R.D. and Walker, R.D., "Highway Materials", McGraw Hill.	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", Thomas Telford.	2003
6	IRC and IS codes : i) IRC:44-2008, "Guidelines for Cement Concrete Mix Design for Pavement". ii) IRC:SP:42-1994, "Guidelines for Load Drainage". iii) HRBSR:01-2000, "State of the Art : Lime – Soil Stabilisation". iv) MORT&H-2001, "Specifications for Road & Bridge Work". v) MORT&H-2001, "Manual for Construction & Supervision of Bituminous Work". vi) IS:2386, Reaffirmed 2007 Part 1 to 8, Methods of Tests for Aggregate for Concrete. vii) IS:73-2006, Paving Bituminous – Specifications. viii) IS:317-2004, Bitumen Emulsion for Roads & Allied Applications – Specification. ix) IS:8887-2004, Bitumen Emulsion for Road (Cationic Tests) – Specification.	

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **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 (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 methods of design and analysis of different types of road intersections and interchanges.

10. Details of the Course :

S. 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 at intersections 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, relevant IRC codes.	2
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1	Papacostas, C.S. and Prevedouros, P.D.,"Transportation Engineering and Planning", Prentice Hall.	2001
2	Mannering, F.L., Kilareski, W.P. and Washburn, S.S., "Principles of Highway Engineering and Traffic Analysis", John Wiley.	2007
3	Khisty, J. and Lall, B.K., "Transportation Engineering", Prentice Hall of India.	2006
4	Flaherty, C.A.P., "Transport Planning and Traffic Engineering", Hodder Headline.	1997
5.	"Highway Capacity Manual of US", Transportation Research Board, Washington D.C.	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 impart knowledge related to evaluation and management for road development.
10. Details of the Course:

S. No.	Contents	Contact Hours
1.	**Introduction :** General concept of pavement evaluation, evaluation of pavement performance, pavement structural capacity, pavement distress and 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, functional 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.	**Overlay Design Alternatives, Analysis, Evaluation and Selection:** Framework for pavement overlay design, design objectives and constraints, basic structural response models, characterization of physical design inputs, generating alternative pavement design strategies, economic evaluation, alternative pavement overlay design strategies - analysis of alternative overlay design strategies, predicting distress and performance, selection of optimal overlay design strategies.	8
6.	**Pavement Management System:** Introduction, 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/Book/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.	2006
3	Shain, M.Y., "Pavement Management for Airports, Roads and Parking Lots", Kluwer.	2004
4	Khanna, S.K. and Justo, C.E.G., "Highway Engineering", Nem Chand and 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.	1978

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **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 (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 planning, operation and management of urban mass transit systems.

10. Details of the Course:

S. No.	Contents	Contact hours
1	**Introduction:** Mass transit systems-elements and components; Urban mass transit systems-types, characteristics, suitability and adaptability; Evolution of urban transportation.	3
2	**Transit System Planning:** Planning needs, short-range and long-range planning, planning procedures and methodology, Medium-performance and high-performance transit systems, Trends in transit planning.	8
3	**Transit Travel Demand:** Data requirements and collection techniques, Methods – O & D Surveys, transit stop surveys, on-transit surveys, attitudinal surveys, analysis of data and estimation of demand, transit demand forecasting, demand patterns, evaluation, comparison and selection of transit modes.	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**

11. Suggested Books:

S. No.	Name of Authors/Book/ Publisher	Year of Publication/ Reprint
1	Vuchic, V.R., "Urban Transit–Operations, Planning and Economics", John Wiley.	1990
2	Dickey, J.W., "Metropolitan Transportation Planning", Tata McGraw-Hill.	1980
3	O'Flaherty, C.A., "Transport Planning and Traffic Engineering", Butterworth-Heinemann.	2006
4	Khisty, C.J. and Lall, B.K., "Transportation Engineering" Prentice-Hall.	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 aspects of highway geometric design.

10. Details of the 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, Highway Capacity Manual (HCM).	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, super-elevation rates, transition curves, attainment of super-elevation, 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, on-street and off-street layout, multilevel parking, automatic/semi-automatic parking structures.	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Wright, P.H. and Dixon, K.K., "Highway Engineering", John Wiley.	2004
2.	Transportation Research Board (TRB), "Highways Capacity Manual", National Research Council, Washington D.C.	2000
3.	Khisty, C.J. and Lal, B.K., "Transportation Engineering-An Introduction", Prentice Hall.	2006
4.	Kadiyali, L.R., "Traffic Engineering and Transport Planning", Khanna Publishers.	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 the Course:

S. No.	Contents	Contact Hours
1.	**Components of Traffic Flow System:** Vehicle – Driver – Road System, Static Characteristics of Vehicle, Vehicle Dynamics, Nonuniform acceleration theory, impact and collision, human factor engineering, driver behaviour, driver error, perception-reaction time model, road geometrics, vertical & horizontal alignment.	6
2.	**Traffic Characteristics :** Microscopic flow characteristics, macroscopic flow & characteristics, microscopic speed characteristics, macroscopic speed characteristics, microscopic density characteristics, macroscopic density characteristics.	8
3.	**Continuous Variables & Mathematical Modelling:** Moment – generating function, Normal distribution, development of traffic variables, Negative exponential distribution, Erlang distribution, Pearson Type I & Type III distributions.	6
4.	**Queueing Processes :** Single channel, finite queues, waiting times, multiple channels, moving queues, Markov process, Queueing service rate, non-exponential distribution.	4
5.	**Deterministic Relationships:** Curve fitting, boundary-condition approach, heat flow analogy, fluid-flow analogy, moving-vehicle method, shock waves, bottleneck – control, approach, stream measurements, system models.	6
6.	**Traffic Management & Control Devices:** Longitudinal markings, transverse markings, word & symbol markings, intersection markings, object markers and delineators, traffic signs, traffic control signals, pedestrian signals, urban traffic control system.	6
7.	**Arterial Design and Management :** Kramer's concept, Arterial performance, Signal spacing in planning context, access management, one-way streets and networks, special –use lanes and streets, transit vehicles on urban streets, special signalization issues.	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Drew, D.R., "Traffic Flow Theory and Control", McGraw-Hill.	1968
2.	May, A.D., "Fundamentals of Traffic Flow", Prentice Hall.	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 DEPTT/CENTRE: **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 (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 transportation systems including technologies, systems analysis and economics.

10. Details of the Course:

S. No.	Contents	Contact hours
1	**Introduction:** Scope of transportation and impacts on society, system planning process and problem solving process, transportation problems.	6
2	**Transportation Technologies:** Types of technologies, their suitability and adaptability, transportation system components 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, transportation system analysis softwares.	10
4	**Transportation Economics:** Demand and supply, equilibrium between supply and demand, elasticity-direct and cross, concept of consumer surplus, transport demand models-sketch planning, incremental demand model, transportation cost, travel-market equilibrium, vehicle ownership and vehicle ownership models.	8
5	**Sustainable Transportation Planning:** Sustainable transportation – issues and principles, non-motorized transportation planning, freight transportation planning models and methods, residential location choice models, impact evaluation and impact models.	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1	Manheim, M.L., "Fundamentals of Transportation Systems Analysis", MIT Press.	1980
2	Kanafani, A., "Transportation Demand Analysis", McGraw Hill.	1983
3	Steenbrink, P.A., "Optimization of Transport Network", John Wiley.	1974
4	Goulias, K.G., "Transportation System Planning-Methods and Applications", CRC Press.	2002
5	Khisty, C.J. and Lall, B.K., "Transportation Engineering-An Introduction", Prentice Hall.	2003
6	Domencich, T.A. and McFadden, D., "Urban Travel Demand-A Behavioural Analysis", North-Holland Publishing.	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **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 (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 impart knowledge of advances in traffic engineering and travel demand modelling using four-stage sequential transportation planning.

10. Details of the Course :

S. No.	Contents	Contact hours
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	**Traffic Management:** Traffic calming, congestion and road user pricing, priority movements, traffic regulations and control systems, use of intelligent systems and information systems.	5
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 and second generation, behavioural models, minimum travel path computations, trip and route assignments, multiple and network assignments.	15
6	**Landuse-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**

List of Practicals :

i) Classified volume count at one location on a national Highway
ii) Spot speed study at a location on a National Highway using Radar speedometer
iii) Parking survey at a major off-street parking facility
iv) Travel time study by a license plate method on a 3 to 4 km stretch of a national Highway
v) Design and conduct of a personal interview survey
vi) Step-wise regression analysis using statistical software for trip generations
vii)Modal split model development using MLE based software
viii) Assignment of the trips observed between different zones in an area
ix) Development of a land use – transport plan for a given area

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1	Mcshane, W.R. and Roess, R.P., "Traffic Engineering", Prentice Hall.	1998
2	Watson, T.M., Smith, W.S. and Hurd, F.W., "Traffic Engineering", McGraw-Hill.	1955
3	Hobbs, F.D., "Traffic Planning and Engineering", Pergamon.	1979
4	Hutchinson, B.G., "Principles of Urban Transport Systems Planning", Scripta Book Co.	1974
5	Richardson, A.J., Ampt, E.S. and Meyburg, A.H., "Survey Methods for Transport Planning", Eucalyptus.	1995
6	Thomas, R., "Traffic Assignment Techniques", Aldershot.	1991
7	O'Flaherty, C.A., "Transport Planning and Traffic Engineering", Elsevier.	2006

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 GIS theory and its engineering applications.
10. Details of Course:

S. 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, essential components of GIS, data acquisition through scanners and digitizers.	5
3	Raster versus vector, raster and vector data, raster to vector conversion, remote sensing data in GIS, topology and spatial relationships, data storage verification and editing.	7
4	Data pre-processing, geo-referencing, data compression and reduction techniques, run-length encoding, interpolation of data, database construction.	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 and query based measurement and statistical modeling, buffers, spatial analysis, statistical reporting and graphing.	5
7	Programming languauges in GIS, virtual GIS, web GIS.	5
8	Application of GIS to various natural resources mapping, monitoring and engineering problems.	5
	Total	**42**

List of Practicals :

i) Demonstration on various GIS software and their salient features.
ii) Scanning and digitization (on screen).
iii) Registration of various maps and digitization and editing of features.
iv) Database creation and management.
v) Buffer and overlay analysis.
vi) Map preparation and composition.
vii) Spatial and mathematical operations.
viii) Area and query based analysis
ix) Customized application in GIS.
x) Web publishing of GIS layers.
xi) 3D GIS.
xii) Demonstration on various GIS based application.

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1	Burrough, P.A. and Mc Donnel, 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", John Wiley.	2008
4	Ghosh, S.K. and Chandra, A.M., "Remote Sensing and GIS", Narosa Publishing.	2008
5	Lo, C.P. and Young, A.K.W., "Concepts and Techniques of Geographical Information System", Prentice Hall.	2002
6	Longley, P. A, Goodchild, M.F., Maguire, D.J. and Rhind, D.W., "Geographic Information Systems and Science", John Wiley.	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject code: **CE 632** Course Title: **Multi and Hyper Spectral 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 data processing and analysis
10. Details of Course :

S. No.	Contents	Contact Hours
1	Multi and hyper spectral remote sensing data acquisition systems in optical wavelength region, basic principles of data acquisition and measurement in natural scenes, multi and hyper spectral data statistics, digital data file formats.	5
2	Multi spectral image pre-processing, noise in multi and hyper spectral systems, radiometric and geometric processing, calibration and normalization of hyper spectral 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 and wavelets), image fusion techniques.	4
4	Multi and hyper spectral 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 hyper spectral 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 hyper spectral remote sensing data, applications of multi and hyper spectral remote sensing data in water resources, forestry, earth sciences, resource management and planning, military target detection etc.	4
	Total	**42**

List of Practicals :

i) Study of different file formats of multi and hyper spectral remote sensing data
ii) Hands on experience on multi and hyper spectral data processing modules in some image processing systems
iii) Data visualization tools – study of images through 3D visualisers, spectral plots, scatter plots, histograms of images
iv) 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.
v) Implementation of atmospheric models

vi) Feature and intensity based image registration of images
vii) Spatial enhancement of remote sensing images
viii) Data dimensionality reduction using feature selection and feature extraction methods
ix) Advanced pattern recognition algorithms for extraction of information from multi and hyper spectral images
x) Derivation of biophysical parameters from multi and hyper spectral remote sensing images

11. Suggested Books :

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Chen, C.H., "Information Processing for Remote Sensing", World Scientific.	1999
2.	Cheng, C.I., "Hyper Spectral Imaging: Techniques for Spectral Detection and Classification", Kluwer Academy.	2003
3.	Landgrebe, D., "Signal Theory Methods in Multi Spectral Remote Sensing", John Wiley.	2003
4.	Richards, J.A. and Xiuping, J., "Remote Sensing Digital Image Analysis: An Introduction", Springer-Verlag.	1999
5.	Varshney, P.K. and Arora, M. K., "Advanced Image Processing Techniques for Hyper Spectral 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 :

S. No.	Contents	Contact Hours
1	Introduction to geodesy and its development.	2
2	Earth & its motions – annual motion, spin, precision, nutation, free nutation, polar motion and spin velocity variations; Earth & its size and shape – actual shape, groid, biaxial ellipsoid and other mathematical figures of earth.	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	Fundamentals of GPS – different segments, observation principle, signal structures and navigational data, orbit determination and its representation, GPS receivers, data collection methods, planning.	7
6	GPS observables & Data processing, software for GPS data processing, Parameter estimation – Linear combination, concepts of parameterization, ambiguity resolution.	6
7	Data Handling; Cycle slip, RINEX, Errors in GPS data and its minimization methods, Geometry of satellite & its significance, Accuracy estimation, Differential GPS, Data transformation.	9
	Total	**42**

List of Practicals :

i) Demonstration, hands-on practice and temporary adjustments of a Gravimeter.
ii) Demonstration, hands-on practice and collection of data using navigational GPS receiver.
iii) Demonstration, hands-on practice and collection of data using Geodetic GPS receivers.
iv) To determine the relative as well as absolute gravity of some stations and along a profile.
v) To determine the height of a tower using Gravimeter and verify the result with that by using GPS receiver.
vi) To determine the variations of gravity with elevation. Determine the elevation of the stations using GPS receiver.
vii) To determine the gravity anomaly profile in the IITR campus having absolute locations of the stations using GPS receivers.

11. Suggested Books :

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Bomford, G., "Geodesy", Clarendon Press.	1980
2.	Hoffmann-Wellenhoff, B., Lichtenegger, H., Collins, J., "GPS Theory & Practice", Springer.	2001
3.	Leick, A., "GPS Satellite Surveying", John Wiley.	2005
4.	Torge, W., "Geodesy: An Introduction", Walter de Gruyter.	1980
5.	Vanicek, Peter 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 impart knowledge of thermal and microwave remote sensing and its various engineering applications.

10. Details of Course :

S. No.	Contents	Contact Hours
1	Brief review of thermal and microwave remote sensing, their utility, merits 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, emmissivity 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, mathematical formulation for microwave radiation and simulation, measurement, analysis of brightness temperature, applications in oceanography and meteorology.	10
5	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, application to land use/land cover, soil/rock, hydrology.	10
6	SAR interferometry for DEM generation, differential SAR interferometry for surface displacement studies, applications in land subsidence, landslide movements, glacier movements etc.	5
7	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 Practicals :

i) Familiarisation with various thermal and microwave remote sensing data products
ii) Hands on experience on thermal data and microwave data processing modules in an image processing software
iii) Study and collection of emmissivity data pertaining to various earth surface features from different sources.
iv) Visual image interpretation of thermal images.
v) Digital image interpretation of thermal images.
vi) Land surface temperature estimation from thermal images
vii) Study and implementation of brightness temperature estimation models for passive microwave remote sensing data
viii) Study and implementation of backscatter estimation models for active microwave remote sensing data
ix) Visual image interpretation of SAR images.
x) Digital image interpretation of SAR images.
xi) Use of Differential SAR Interferometry for surface displacement studies.

11. Suggested Books :

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Woodhouse, J.H., "Introduction of Microwave Remote Sensing", Taylor & Francis.	2006
2.	Elachi, C. and J.V. Zyl, "Introduction to the Physics and Techniques of Remote Sensing", 2nd Ed., Wiley Interscience.	2006
3.	Henderson, F.M. and Anthony, J.L., "Principles and Applications of Imaging Radar', Manual of Remote Sensing, Vol. 2. John Wiley.	1998
4.	"Manual of Remote Sensing", Vol. 1 to 5, American Society of Photogrammetry and Remote Sensing.	2003
5.	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: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge of the concepts of analytical and digital photogrammetry followed by their engineering applications.
10. Details of Course :

S. No.	Contents	Contact Hours
1	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 hardcopy and softcopy, 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 characteristic 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 Practicals :

i) Introduction to Digital Photogrammetric System.
ii) Preparation of Digital Photo
iii) Interior Orientation.
iv) Relative Orientation.
v) Absolute Orientation
vi) 3D Model generation
vii) Generation of Digital orthophotograph.
viii) Aero triangulation on WILD A8.

11. Suggested Books :

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Ghosh, S. K., "Analytical Photogrammetry", Concept Publishing.	1987
2.	Manual of Photogrammetry, American Society of Photogrammetry.	1995
3.	Kasser, M. and Yves, Egels, "Digital Photogrammetrey", Taylor & Francis.	2002
4.	Mikhail, E.M., "Introduction to Modern Photogrammetry", John Wiley.	2001
5.	Konecny, G., "Geoinformations : Remote Sensing, Photogrammetry & Geographical Information Systems", Taylor & Francis.	2003

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 impart knowledge of 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 :

S. No	Contents	Contact Hours
1	Introduction, land use land cover - definition and its significance in engineering projects, history, modern surveys and classification systems, utility of remote sensing data 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, utility of various 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.	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 and 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	Urban and regional planning - objectives and issues, planning processes, data requirements, physical planning and statistical methods, mapping of parcels and individual buildings, utility of land use land cover maps 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 Practicals :

i) Familiarization with various photographic and digital remote sensing data products used for land use land cover mapping.
ii) Study of spectral reflectance characteristics of various land use land cover features using Spectro-Radiometer.
iii) Preparation of land use land cover classification scheme for an area.
iv) 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.
v) Training on image classification. Practice for selection of training areas and their quality assessment using histogram and separability analyses.
vi) 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.
vii) Preparation of a land use land cover map using back propagation neural network algorithm.
viii) Preparation of land use land cover map at sub-pixel level using soft classification techniques.
ix) Preparation of land parcel and building map from high resolution satellite image.
x) Development of a computer program to implement an advanced image classification algorithm (e.g., decision tree classifier, evidential reasoning or any other).
xi) Preparation of a land use land cover change detection map using various image change detection algorithms.

11. Suggested Books :

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Campbell, J. B., "Introduction to Remote Sensing", Guilford Press.	2002
2.	Lillesand, T.M. and Kiefer, R.W., "Remote Sensing and Image Interpretation", John Wiley.	2000
3.	Mather, P. M., "Computer Processing of Remotely Sensed Images", John Wiley.	1999
4.	Rencz, A.B., "Remote Sensing for Natural Resource Management and Environmental Modeling", Manual of Remote Sensing, Vol. 4. John Wiley.	2004
5.	Rencz, A.B., "Remote Sensing of Human Settlements", Manual of Remote Sensing, Vol. 5. John Wiley.	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 impart knowledge of remote sensing in the area of water resources and hydrological modelling.
10. Details of Course :

S. 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 modelling, detailed overview of lumped and conceptual models, data input requirements, process based requirements, extraction of information from remote sensing, soil erosion modeling, different types of erosion models - USLE and MUSLE, extraction of model parameters using remote sensing techniques.	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 Practicals :

i) Surface water mapping using satellite data.
ii) Spectral characterization of water using spectro-radiometer.
iii) Comparison of Watershed delineation and morphometric analysis using topographical and satellite data (2 turns)
iv) Delineation of drainage pattern and determination of various basin characteristics.
v) Digitization of watershed contours and generation of DEM.
vi) Extraction of DEM information.
vii) Mapping of flood inundation areas and flood zonation.
viii)Mapping of river bankline using temporal satellite data.
ix) Morphological analysis of river system.

11. Suggested Books :

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Engman, E.T. and Gurney, R.J., "Remote Sensing in Hydrology", Chapman and Hall.	1991
2.	Govardhan, V., "Remote Sensing and Water Management in Command Areas", International Book Distributing Co.	1993
3.	Mekonnen, G. and Houssain, F., "Satellite Rainfall Applications for Surface Hydrology", Springer.	2009
4.	Shultz, G.A. and Engman, E.T., "Remote Sensing in Hydrology and Water Management", Springer.	2000
5.	Singh, V.P. and Fiorentino, M., "GIS in Hydrology", Bantam Books.	1996
6.	Zhou, Q., Lees, B. and Tang, G., "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 :

S. No.	Contents	Contact Hours
1	**Introduction:** Reference Coordinate Systems – Cartesian system & its transformation, Conventional inertial system & frames in gravity field of the earth, Ellipsoid system, WGS 84 system, time-sidereal time, UT, atomic time, etc. Clock & frequency standard; Signal propagation – fundamentals, structure and divisions of atmosphere, signal propagation through atmosphere.	7
2	**Satellite Orbital Motion:** Fundamental of Celestical Mechanics – Keplerian motion, Newtonian mechanics, Orbit Geometry and oribit motion, Purturbed satellite motion–representation of perturbed oribital motion, disturbed motion due to earth's anomalous gravity field, other perturbations, implications of perturbationa, Orbit determination–integration of undisturbed orbit, integration of the per-curbed orbit, orbit representation, satellite orbits and constellation basis, sum-synchronous, geostationary and transfer orbits.	8
3	**Basic Observation Concepts and Geodetic Satellites used in Geodesy :** Satellite geodesy as a parameter estimation problem, observables and basic concepts determination of directions, range–differences, range–rate, satellite altimetry, interferometric measurements; Satellite used in Geodesy-basic consideration, some selected satellites, satellite sub-systems, planned satellites and missions.	9
4	**Laser Ranging:** Introduction, laser ranging systems and components – laser oscillators, other system components, fixed & transportable laser systems, corrections; Data processing & accuracy; Applications of satellite laser ranging–parameter estimation, earth's gravity field, position and position changes, earth's rotation and polar motion, lunar laser ranging, speciborne laser.	5
5	**Satellite Altimetry:** Basics, satellites and missions, measurements, corrections and accuracy–geometry, data generation, corrections & error budget, determination of mean sea surface; Application–geoid & gravity field, geophysical interpretation.	5
6	**Planned Missions and Special Methods:** Very long baseline interferometry (VLBI) – basics, observation equation, error budget, applications, Interferometric Synthetic Aperture Radar (InSAR) basics, SAR, InSAR, Differential radar interferometry.	3
7	**Applications of Geodetic Satellite Methods**: Positioning, gravity fields and earth models; Navigation; Geodynamics; Combined space geodetic techniques.	5
	Total	**42**

List of Practicals :

i) Demonstration, hands-on practice and collection of data using Geodetic GPS receivers. Further, download and process the data using commercial software.
ii) Demonstration, hands-on practice and analysis of 7 days GPS data.
iii) To determine the different orbit and satellite parameters from GPS data.
iv) Process and analyse laser ranging data.
v) Process and analyse VLBI data.

11. Suggested Books :

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Kaula, W.A., "Theory of Satellite Geodesy", Dover Pub.	2000
2.	Seeber, G., "Satellite Geodesy: Foundations, Methods and Applications", Walter De Gruyter.	2006
3.	Beutler, G., Mervart, L. and Verdun, A., "Methods of Celestical Mechanics", Physical, Mathematical and Numerical Principles, Vol. I & II, Springer-Verlag.	2005
4.	Fan, H., "Theoretical Geodesy", KTH, Stockholm.	2004

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: **Nil**
9. Objective : To introduce the applications of remote sensing, GIS and GPS tools for disaster mitigation and management.
10. Details of Course :

S. No.	Contents	Contact Hours
1	**Introduction:** Types of disasters; 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 and digital elevation model generation, extraction of parameters and their uses.	5
3	**Earthquakes and Landslides:** Causative factors, hazard assessment, selection of factors, SAR, interferometry for estimation of ground displacement, creation of thematic data layers, preparation of seismic and landslide hazard zonation maps, regional and site specific risk assessment, geomatics tools for risk mitigation plans, case studies, damage assessment.	10
4	**Cyclones, Floods and Tsunami**: Cyclone related parameters and effects on land and sea, damage assessment; causes of floods, identification of factors, space-time integration, GIS data layers, flood prone area demarcation, analysis and management, risk assessment, damage assessment, case studies; concept of tsunamis, geomatics tools and systems for monitoring and management; damage assessment.	6
5	**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
6	**Anthropogenic Disasters:** Ozone layer depletion, green house/global warming, acid rain, snow melt, sea level rise, related problems; GIS data layer creation, case studies.	5
7	**Marine, Biodiversity and Forest Disasters:** Oil spill and chemical pollution, coastal erosion and deposition, factor identification, GIS analysis, management strategies, case studies, 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; Forest Fire, Estimation, extent, NBR (Normal Burnt Ratio), use of geomatics tools for monitoring and management, damage assessment.	9
	Total	**42**

List of Practicals :

i) Familiarisation with various remote sensing data products at different spectral, spatial and temporal resolutions
ii) Hands on experience on Total Station
iii) Hands on experience on GPS.
iv) Hands on experience on an image processing and GIS software.
v) Digitization of Thematic layers.
vi) Collection of data from different sources for a given natural hazard
vii) Collection of field data using Total Station and/or GPS survey for the natural hazard selected
viii) Use of GIS for preparation of thematic data layers for the natural hazard selected
ix) Use of GIS for hazard zonation using probabilistic or any other method
x) Use of GIS for risk zonation and assessment.
xi) Flood plan mapping using temporal satellite data (pre and post flood).
xii) Use of Differential SAR Interferometry for surface displacement studies.

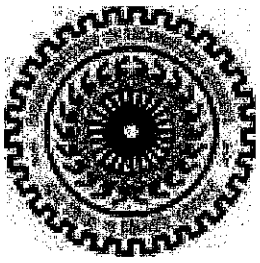
11. Suggested Books :

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Andrew, S., "Environmental Modeling with GIS and Remote Sensing", John Wiley.	2002
2.	Ariyabandu, M. and Sahni P., "Disaster Risk Reduction in South Asia", Prentice-Hall.	2003
3.	Bossler, J.D., "Manual of Geospatial Science and Technology", Taylor and Francis.	2001
4.	Demers, M.N., "Fundamentals of Geographic Information Systems", John Wiley.	2000
5.	Matthews, J.A., "Natural Hazards and Environmental Change", Bill McGuire.	2002

Appendix-D
Item No.SENATE/36.2.2

M.Tech. Syllabus

(Spring Semester)



Department of Management Studies
Indian Institute of Technology Roorkee
Roorkee – 247 667

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
1st Year	**1st 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**										
	2nd 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**										
2nd Year	**3rd 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
2nd Year	**4th 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-612** **Course Title :** **Knowledge 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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. **Objective:** To impart knowledge on various aspects of knowledge management and exposure to knowledge creation, storage and distribution practices in India and abroad.

10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	Introduction to Knowledge Management, distinction between data, information and knowledge	3
2.	Concept of knowledge creation, intellectual capital creation, human capital, customer capital and organizational capital	5
3.	Socio-cultural aspects and organizational aspects, tacit and explicit knowledge, knowledge organization, group formation and team conversion as a social mechanism	5
4.	Knowledge storage and distribution, KM tools, data warehouse, data mining, knowledge management evaluation and valuation of knowledge	5
5.	Knowledge sharing practices and barriers, knowledge sharing proficiencies – the key to barriers to adoption of organizational memories: lessons from industry	3
6.	Knowledge culture, culture process, culture and knowledge, trust and KM, the human factor in KM culture, peer-to-peer knowledge, developing and sustaining methods of knowledge culture	4
7.	Knowledge initiative, knowledge strategic issues in knowledge management, identifying and transferring internal best practices	5
8.	Knowledge commerce combining data from existing company sources, architecture and experiences, commercialization- the next phase of KM, the convergence of electronic business and KM	4
9.	KM in Indian organizations and MNC, sharing tacit knowledge, case studies of companies such as Volvo, Tata Steel, Eicher Motors, General Motors, knowledge window at WIPRO, knowledge currency at TCS	4
10.	Learning organizations and organizational learning, alternative strategies for leveraging the knowledge asset, system and processes of learning organization	4
	Total	**42**

11. Suggested Readings:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Raman, T., "Knowledge Management", Excel Books	2004
2.	Warrier, S., " Knowledge Management", Vikas Publishing House	2007
3.	Barnes, S., "Knowledge Management Systems: Theory & Practice", Thomson Learning Press	2002
4.	Maier, R., "Knowledge Management System", Springer	2002
5.	Tiwana, A., "Knowledge Management Tool Kit", Pearson Education	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM- 613** **Course Title : Entrepreneurship Development**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC
9. **Objective:** To introduce various capabilities and issues in developing entrepreneurship.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Entrepreneurs- challenging the unknown, evolution and entrepreneurship, environment for entrepreneurship, new trends in entrepreneurship research, innovation, growth and survival	6
2.	Financial institutions and source of funding new ventures, search for capital, debt versus equity, venture capital market, types of investors	4
3.	Corporate entrepreneurship, entrepreneurial mind set in organizations, nature of corporate entrepreneurship, idea generation and innovation, corporate entrepreneurship strategy, developing team and individual managers for corporate entrepreneurship	6
4.	Pathway to new venture for entrepreneur, creating new venture, acquiring, franchising, franchise law, managing growth and ending the venture	5
5.	International entrepreneurship identifying opportunities and problems, SWOT analysis, international, multinational and global ventures, financial and legal issues for international entrepreneurship	4
6.	Entrepreneurs in small business enterprises, small business- concept and need, stages in small business development, distinctive feature of small business	4
7.	Intellectual Property Rights (IPR) and related issues- understanding IP, IP protection- patents, copyrights, trademark, trade secrets, IT and IP protection	4
8.	Entrepreneurship and legal aspects- understanding legal structure for entrepreneurial venture, sole proprietorship, partnership, corporations, limited liabilities companies, government policies and environmental issues	5
9.	SMEs and technology, data base management system, intranet and internet, IT and Entrepreneurship	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Norman, M. S., "Essentials of Entrepreneurship and Small Business Management", 6th Edition, Prentice Hall of India	2010
2.	Steve, M. and Carolin, G., "Entrepreneurship: Starting and Operating a new Business", 2nd Edition, Prentice Hall of India	2009
3.	Donald, F.K., "Entrepreneurship: Theory, Process, and Practice", 8th Edition, South Western College Publications	2008
4.	Peggy, A. L. and Charles, R. K., "Entrepreneurship", 4th Edition , Prentice Hall of India	2006
5.	Poornima, M.C., "Entrepreneurship and Small Business Enterprises", Pearson Education	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code: BM-614** **Course Title: International 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:** Both

7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. **Objective:** To familiarize students with international trade and investment, global monetary system, strategies and structure of IB.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Overview of international business	2
2.	**Comparative environmental frameworks:** Cultural, political, legal, and economic environment facing business	7
3.	**Theories and institutions of trade and investment:** International trade theory, government influence of trade, regional economic integration and cooperative agreements, factor mobility and FDI	7
4.	**World financial environment:** Foreign exchange market, determination of exchange rates	6
5.	**Dynamics of international business-government relationships:** Government policy and plan for FDI, IB negotiation and diplomacy	6
6.	**Operations:** Country evaluation and selection, collaborative and control strategies	7
7.	**Managing business functions:** Marketing, export and import strategies, global manufacturing and supply chain, finance and human resource management	7
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Book/ Publisher	Year of Publication/ Reprint
1.	Hill, C.W.L., "International Business", 8th Edition, McGraw-Hill	2010
2.	Ball, D., Geringer, M., Minor, M. and McNett, J., "International Business: The Challenge of Global Competition", 12th Edition, McGraw-Hill	2009
3.	Griffin, R. and Pustay, M., "International Business", 6th Edition, Prentice-Hall	2009
4.	Wild, J.J., Wild, K.L. and Han, J.C.Y., " International Business: The Challenges of Globalization", 6th Edition, Prentice-Hall	2009
5.	Daniels, J., Radebaugh, L., and Sullivan, D., "International Business", 12th Edition, Prentice-Hall	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-615** **Course Title :** **Industrial Waste 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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. **Objective:** To introduce current ecological and environmental problems of industrial waste and its management.

10. **Details of Course:**

S. No.	Contents	Contact hours
1.	Introduction- category of waste, evolution waste management, history of waste management, recent waste management initiatives	4
2.	Onsite handling- storage and processing, collection of solid wastes, transfer and transport, solid waste control and management	4
3.	Solid waste- definition and categories of solid waste, municipal solid waste, industrial solid waste, medicinal solid waste, hazardous waste, mining and agriculture waste, construction debris, disposal of solid wastes and residual matter, hazardous wastes management	5
4.	Management in transfer and transport of solid waste, management in processing and in materials and energy recovery	3
5.	Management of the disposal of "no alternative" option, plan development, selection and implementation	3
6.	Case studies, public information programs, statistical analysis of solid waste-techniques and procedures, process instrumentation and control, project procurement	5
7.	Typical cost data and cost-estimating waste water, introduction, water pollution and their sources, waste water sampling, flow measurement, estimation options, sampling and methods of sampling, sampling procedure and techniques	6
8.	Management of waste waters, Planning and managing industrial waste water treatment, Treatment technology, management of waste water disposal systems, waste water treatability assessment, batch test, bench-scale reactor test, physical and chemical test	6
9.	Meteorology and air pollution; micro and macro- meteorology, wind rose, atmosphere and air pollutants management of air pollution, management policies for pollution prevention and waste minimization, transfer of technology between plants	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Pichte, J., "Waste Management Practices: Municipal Hazardous and Industrial", CRC Press	2005
2.	Tchobanoglous, G. and Kreith, F.,"Hand book of Solid Waste management", 2nd Edition, Tata McGraw Hill	2002
3.	Blackman, W. C., "Basic Hazardous Waste Management", 3rd Edition, CRC Press	2001
4.	LaGrega, M., Buckingham, P., Evans, J., "Hazardous waste management" , 2nd Edition, McGraw Hill	2001
5.	Vanatta, B., "Guide for Industrial Waste Management", Diane Publishing Co.	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM- 616** **Course Title :** **Management of Large Systems**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC
9. **Objective:** To understand the nature and problems related to large systems and their management.
10. **Details of Course:**

S. No.	Contents	Contact Hours
1.	System- definition and concept, characteristics of system, categories of system, system approach, current environment and challenges	3
2.	Change paradigms of systems, need for system engineering, system analysis and system science, system architecture, system engineering management plan	3
3.	Large system configuration, hierarchy of large system, open and feedback system, system life cycle, managing large system risk	3
4.	Large system types- infrastructure, energy, transport and telecommunication, development of large systems, testing throughout system development	3
5.	Features and management of large systems, project approach, strategy planning, operations, co-ordination and control of large systems, investment planning and financing, valuation of capital source, cost estimation methods and work cost breakdown structure, corporate social responsibility and social cost benefit analysis, system administration and system management	10
6.	Managing technology, technology transfer for large systems, environmental impacts of large systems, regulatory and legal issues related to large systems	4
7.	Human resource management and large systems, creating proper climate, leadership characteristics, need of individuals, staffing the organization, training and development	4
8.	Optimizing learning systems, developing the learning system requirement, operational requirement analysis, performance requirement formulation and validation	4
9.	Simulation and modeling- IT based methods, system organics and applications, modeling throughout system development and management, tradeoff analysis	4
10.	Organization for large systems, developing the organizational structure, stakeholder management, customer organization and function, producer organization and function, supplier organization and function	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Jamshidi, M., "Systems of System Engineering", Wiley Inter science	2008
2.	Haraway, M., "Large Scale Incident Management", Delmer Cengage Learning	2008
3.	Sage, A.P. and Armstrong, J.E., "Introduction to system Engineering" Wiley Inter science	2000
4.	Khalil, T., "Management of Technology: The Key to Competitiveness and Wealth Creation", Tata McGraw Hill	2009
5.	Dessler, G. and Biju, V., "Human Resource Management" , 11th Edition, Pearson Education	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM- 617** **Course Title :** **Environment 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:** Both

7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. **Objective:** To introduce current environmental problems and their management.

10. **Details of Course:**

S. No.	Contents	Contact hours
1.	**Introduction to environmental and ecological system:** Level of organization, classification and different ecological systems, elements of ecosystem, productivity and its determination	3
2.	**Tropic level:** Tropic chains and food web, factors affecting the growth of ecosystem	4
3.	**General pollution:** Classification of pollutants, sources and emissions of pollutant, adverse effects of pollutants on flora and fauna, status of environmental degradation	5
4.	**Environmental quality:** Air and water quality criteria, goals and standards	5
5.	**Air pollution:** Importance of micro meteorology in air pollution, selection, evaluation and application of control devices at source, general equipment used for control of particulate and gaseous pollutants	5
6.	**Solid waste management:** Evaluation and physico-chemical characterization and handling, mechanical, thermal and biological processing of solid wastes, regeneration and recycling	5
7.	**Noise pollution:** Noise control criteria, engineering aspects of noise control, gas/liquid purging, heavy-duty machine drive/crushing, grinding and compressions/pumping equipment	5
8.	**Philosophy of waste management:** Environmental impact assessment with respect to air, water, land, socio economic aspect and cross media analysis	5
9.	**Case studies:** Beyond greening, strategies for sustainable world, business case for climate protection, regulation and economic model for meeting pollution reduction goals, capturing the free trade while protecting the environment	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Pathak ,A. and Bhagat, R., "International Management: Managing in a Diverse and Dynamic Environment", 2nd Edition, Tata McGraw Hill	2009
2.	Charles, J. K., "Ecology: the experimental analysis of distribution and abundance", 6th Edition, Benjamin-Cummins Pearson	2008
3.	Townsend, C.R. and Begon, M.H., "Essential of Ecology", 3rd Edition, Wiley-Blackwell Publishers	2008
4.	Pepper, I.L., Charles, P.G. and Mark, L.B., "Environmental and Pollution Science", 2nd Edition, Academic Press	2006
5.	Tchobanoglous, G., and Kreith, F., "Hand book of Solid Waste Management",2nd Edition, Tata McGraw Hill	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM- 618 Course Title: Advanced Optimization Techniques for 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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC
9. **Objective:** To impart knowledge of the advanced techniques of optimization with emphasis on application to business problems.

10. Details of Course:

S. No.	Contents	Contact hours
1.	Concepts of vector spaces, normed spaces, pre-Hilbert and Hilbert spaces	6
2.	Basic notions of distance, topologies, convexity, projections, orthogonalization	6
3.	Convergence and approximation, normal equations and Fourier series based approximation of functions	6
4.	Least squares estimation and applications	6
5.	Elementary optimization of functionals using calculus of variations	6
6.	Global and local constrained optimization using Lagrange multipliers	6
7.	Newton's approximation method, descent methods, gradient methods	6
	Total	42

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Luenberger, D. G., "Optimization by Vector Space Methods', John Wiley	1997
2.	Sundaram, R. K., 'A first course in optimization theory", Cambridge University Press	1996
3.	Taha, H. A., "Operations Research: An Introduction", 9th Edition, Pearson Education	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-619** **Course Title : Basics of Management of Information**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC
9. **Objective:** To impart knowledge of classical information theory relevant to management.

10. Details of Course:

S. No.	Contents	Contact hours
1.	Introduction to information, measures of information, concept of entropy and its variants, mutual information	6
2.	Basic inequalities of information theory	6
3.	Information channels and channel capacity, computation of channel capacity in simple cases	6
4.	Information in relation to stochastic processes, conditional random variables, Gaussian channels	6
5.	Elements of network information theory , multiple user Gaussian channels	6
6.	Information theory in financial management such as Kuhn Tucker characterization of portfolios, asymptotic optimality of portfolios	6
7.	Concept of universal portfolios.	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Cover and Thomas, "Elements of Information Theory", 2nd Edition, Wiley	2006
2.	Reza F. M., "An Introduction to Information Theory", Dover Publications	1994
3.	Krippendorff, K., "Information Theory: Structural Models for Qualitative Data", SAGE Publications	1986

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-620** **Course Title : Soft Computing Techniques for 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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC
9. **Objective:** To introduce basic soft computing techniques for managerial decision making.
10. **Details of Course:**

S. No.	Contents	Contact hours
1.	Soft computing constituents and conventional artificial intelligence	6
2.	Introduction to fuzzy mathematics, basic definitions and terminology, set-theoretic operations, membership function-formulation and parameterization	6
3.	Fuzzy union, intersection, and complement, extension principle and fuzzy relations, fuzzy if-then rules, fuzzy reasoning	6
4.	Application of fuzzy logic in business decision making	6
5.	Basics of genetic algorithms, simulated annealing, random search	6
6.	Downhill simplex search, swarm intelligence, genetic programming	6
7.	Fundamentals of neural networks and elementary applications to management decision making problems	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Jang, J.S.R. and Sun, C.T., Mizutani E., "Neuro-fuzzy and Soft Computing", Prentice Hall of India	2004
2.	Rajasekaran, S., Pai,G.A. and Vijaylakshmi, "Neural Networks, Fuzzy Logic, and Genetic Algorithms", Prentice Hall of India	2004
3.	Aliev, R.A., Fazlollahi , B. and Rashad R.A., "Soft Computing and its Applications in Business and Economics", Springer	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM- 631** **Course Title: Human Resource Planning and Development**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. **Objective:** To impart knowledge of human resource planning (HRP), deployment and development issues in organizations.

10. **Details of Course:**

S. No.	Contents	Contact hours
1.	Manpower planning- introduction and objectives, labor market analysis and labor supply, process , challenges, responsibility of HRP; Organizational human resource planning, stock taking, identifying gap, source of manpower for organization, how to attract talent: planning and strategies	6
2.	Work force flow mapping-age and grade distribution mapping, career management, career counseling, career stages, career anchors, career planning Vs human resource planning, career development, organizational career development, preparing incumbent for future assignment, Succession planning and management, career planning Vs succession planning	6
3.	Models and techniques of manpower demand and supply forecasting, staffing table, markov analysis, skills inventory, replacement chart	4
4.	Recruitment-concept, constraint and challenge, situational audit for recruitment, source of recruitment, methods of recruitment, internet as source of recruitment, evaluation of the source of recruitment, recruitment policies and procedures, recruitment-Indian experience	6
5.	Behavioral factors in human resource planning, wastage analysis, retention, redeployment and exit strategies, exit interview and diary writing, job analysis- job task, job duty, job responsibility, process of job analysis, competency approach to job analysis, position analysis questionnaire, management position description questionnaire, behavioral factors in job analysis, job description, job specification, job evaluation- concept, process and methods, ranking method, classification method, factor comparison method, point method, role analysis and negotiation	8

6.	HR challenges in IT industry, technology and human resource planning and development	2
7.	Human resource development, evolution and history of human resource development, HRD matrix, HRD Vs HRM, human resource development subsystems, principles of human resource development, HRD in Indian industry, HRD survey, TQM and HRD strategies, HRD in strategic organizations, HRD climate	4
8.	Human resource information system, significance of HRIS Human resource valuation and accounting, accounting techniques for human resource, human capital management, human capital valuation: methods and models for valuation, human capital valuation in manufacturing and service industry	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Bernadin, H. J., "Human Resource Management", 4th Edition, McGraw Hill	2010
2.	Bhattacharya, D.K., " Human Resource Research Methods", Oxford University Press	2007
3.	Snell, B., "Human Resource Management', Thomson India	2007
4.	Armstrong, M., " A Handbook of Human Resource Management Practices", 10th Edition, Kogan Page Publishers	2006
5.	Burack, E.H. and Mathys, J., " Human Resource Planning: A Pragmatic Approach to Manpower Staffing and Development", 4th Edition, Brace-Park Press	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-632** **Course Title :** **Organizational Development**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. Objective: To impart knowledge of processes of organization development and tools and techniques for change and development.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Understanding organization, approaches, typology; Organization development (OD)- characteristics, historical perspective and evolution, emerging issues of work organization, value and assumptions in OD	6
2.	Organizational change, process, forces, resistance to change, overcoming and minimizing resistance to change, change and human resource, organizational culture and climate as change agent, strategies for effective change, models of change, change and transition management, organizational growth, systematic approach to change, effective change management	9
3.	Model of OD action research, Action research and intervention model, action research as a process, features of action research, OD interventions, selection of OD intervention, classification and type of OD intervention-interpersonal interventions, team development interventions, intergroup development interventions	8
4.	Organization and implementation of OD process, diagnostic strategies and skills-process of diagnosis, diagnosis model, diagnostic skills, client consultants relations in OD, power politics and ethics in OD	7
5.	OD in Indian industries, future prospects, organizational learning, approaches to organizational learning, knowledge management and OD, knowledge workers as change agents	6
6.	OD and technology- use of IT for selecting, implementing, and analyzing OD intervention, intranet and internet for OD, significance of database management system in organizational development, human resource information system and OD	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Thomas G. C. and Christopher G. W., "Organization Development and Change" , 9th Edition , South Western College Publication	2008
2.	Hatch, M.J., "Organization Theory, 2nd Edition, Oxford University Press	2006
3.	Daft, R.L., "Organization Theory and Design", 8th Edition, Thompson Learning	2004
4.	French, W.L. and Bell, C.H., "Organization Development: Behavioral Science Interventions for Organization Improvement", 6th Edition, Prentice Hall of India	1999
5.	Sorensen, P.F., Head, T.C., Yaeger, T. and Cooperrider, D. , "Global and International Organization Development' , Stipes Publishing L.L.C.	2004
6.	Wendell, L., French, B. and Robert A. Z., "Organization Development and Transformation", 6th Edition, Tata McGraw Hill	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-633** **Course Title : Labor Legislation and Industrial Relations**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. **Objective:** To introduce Indian industrial relations systems necessary for managing industrial relations and to impart knowledge of labor laws.

10. **Details of Course:**

S. No.	Contents	Contact Hours
1.	Industrial relations (IR) system, concept and structure, status of actors and their inter-relationships, trade unions and their growth, organization, formation, rivalry, leadership, multiplicity political affiliation, recognition	6
2.	Grievance handling, disciplinary proceedings, standing orders, domestic inquiry, contemporary issues in IR	8
3.	Factories act, 1948; Trade unions act, 1926; Industrial disputes act, 1947; Industrial employment (standing orders) act, 1946	8
4.	Payment of wages act, 1936; Minimum wages act, 1948; Payment of bonus act, 1965; Employees' provident fund	8
5.	Workmen's compensation act, 1923; Employee's state insurance act, 1948; Payment of gratuity act, 1972	8
6.	Industrial relations and organizational development; HRD approach to industrial relation, contemporary issues in Industrial Relation, industrial dispute and industrial conflict, dispute handling machinery in India	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	John R. C., "Principles of Labor Legislation", General Books	2009
2.	Mamroia, C.B. and Mamaroia,S., "Labour welfare, Social Security and Industrial peace in India", Kitab Mahal	2007
3.	Harper, M.C., "Labor Laws: cases, Material and Problems", 6th Edition , Aspen Publishers	2007
4.	Harry, K., and Kochan, T., "An introduction to Industrial relation and Collective bargaining", 3rd Edition, Tata McGraw Hill	2003
5.	Sinha, P.R.N. and Priyadarshini, S.,"Industrial relation, Trade Unions and Labor Legislation", Pearson Education	2003
6.	Deery, S., Plowman, D., Walsh, J. and Brown, M., "Industrial relation : A contemporary Analysis", Tata McGraw Hill	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM- 634** **Course Title :** **Career Planning and Performance**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC
9. **Objective:** To develop skills for career planning and development.

10. Details of Course

S.No.	Contents	Contact Hours
1.	Concept of career, stages, choices, anchors, development, development programs, counseling, patching, human resources aspects	10
2.	Career information systems (CIS), management and supervisory development, organizational assessment programs- assessment centers	8
3.	Psychological testing, training, special groups issues, development of different career stages, career development problems and issues	8
4.	Performance audit and its rationale, appraisal systems, rating scales, human errors in ratings, employees' participation in appraisal process	8
5.	Frequency of appraisals, appraisal counseling, analyzing existing appraisal system, designing new appraisal system	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Rao, V.S.P., "Human Resource Management", 2nd Edition, Excel Books	2009
2.	Dessler, G. "Human Resource Management", 11th Edition , Pearson Education,	2009
3.	Herman, A., "Performance Planning", 2nd Edition, Pearson Education	2009
4.	Flippo, E.B., "Personnel Management", 6th Edition, McGraw Hill	2006
5.	Peel, "Career Development and Planning", Tata McGraw Hill	1992

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM- 635** **Course Title :** **Management of Training and Talent Development**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. **Objective:** To provide an understanding of role of training in the HRD and training systems and processes.

10. **Details of Course:**

S. No.	Contents	Contact hours
1.	Introduction to employee training, factors influencing training, training investment leaders, role, responsibility, competencies, positions and challenges of training managers, cost effective training model, designing effective training, strategic training, training department- models of organizing training department, faculty model, customer model, matrix model, corporate university model, business embedded model, globalization and training practices in Indian organizations, outsourcing of training	8
2.	Organization and management of training function, organizational culture and climate and training, Transfer of training	4
3.	Training needs assessment and action research, methods used for need assessment, process of need assessment- organizational analysis, person analysis, task analysis, competency model of need assessment, scope of need assessment	6
4.	Employee development, approach to employee development- formal education, assessment, job experience, interpersonal relationships, development planning process, organizational strategies for employee development, return on employee investment	6
5.	Learning; theories and program design, E-Learning and use of technology in training, E-learning and employee development, developing effective online learning, blended learning, use of technologies for training delivery, training for virtual work arrangements, computer based training, sharing of intellectual capital through information technologies	6
6.	Training methods and techniques, presentation methods- lecturer and audiovisual techniques, hands on methods: on the job training, simulations, case studies, business games, role plays, behavior modeling,	6

	group building methods, adventure methods, team training, action learning, selecting a training method	
7.	Training evaluation, evaluation practices, evaluation designs, future of training and development, special issues in training and employee development, partnership with local community, business environment and training and development, training issues related to internal environment of organizations	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Raymond, A. N. and Kodwani, A.D., " Employee Training and Development", 4th Edition, Tata McGraw Hill	2008
2.	Pareek , U., "Training instruments in HRD and OD", Tata McGraw Hill	2008
3.	Mustsuddi, I.," Essentials of HRM", New Age International	2010
4.	Dhar, U. and Dhar, S., "Management Education and Training", 2nd Edition, Excel Books	2008
5.	Desimone, R.L., Werner, J. M. and Harris, D.M., "Human Resource Development", 3rd Edition ,Thomson Publications	2003
6.	Rao, T.V., " Future of HRD", Macmillan Books	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM- 636** **Course Title: Compensation Management and Reward Systems**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC
9. **Objective:** To develop understanding of rewarding systems for human resources.
10. **Details of Course:**

S. No.	Contents	Contact hours
1.	Compensation management, objectives of compensation planning, components of pay structure in India, economic theory related to compensation management, wage and salary administration, principles of wage administration, wage policy in India, factors influencing compensation level	6
2.	Internal and external equity in compensation systems, determination of inter and intra industry compensation, wage differential, techniques for wage differential, compensation practices of MNCs, strategic compensation systems	6
3.	Understanding tools used in designing, improving and implementing compensation packages, skill competency and knowledge based pay, incentive compensation program design, reward system management, advantages and disadvantages of reward system, essential of sound reward system	6
4.	Managerial compensation, Compensation designs for specific type of human resource such as directors, CEO, CFO, Senior Managers, R& D staff	4
5.	Components of compensation packages such as fringe benefits, incentives, bonus, and retirement plans, pay for performance systems, incentive plans, individual incentive plans, team based incentive plans, organization based incentive plans	6
6.	Statutory provisions governing different components of reward systems, minimum wages act 1948, the payment of wages act 1936, payment of bonus act 1965	8

7.	Working of different institutions related to reward system like wage board, pay commissions, adjudication of wage disputes, compensation administration and technology	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Berger, L. and Berger, D., "Handbook of Compensation" 5th Edition, Tata McGraw Hill	2008
2.	Milkovich, G. and Newman, J., "Compensation" 9th Edition, McGraw-Hill/ Irwin	2007
3.	Mondy, R., Wayne, N. and Robert M. "Human Resource Management", 9th Edition, Pearson Education	2006
4.	Henderson, R.I., "Compensation Management in a Knowledge-Based World" 10th Edition, Prentice Hall	2005
5.	Gupta, A., "Wage and Salary Administration in India", Anmol Publications	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-637** **Course Title :** **Management of Change**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC
9. **Objective:** To understand various aspects of change management process and methodologies.

10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	Forces of change, planning for change, change agents and champions, resistance to change, managing organizational change; Organization development (OD) and transformation	6
2.	Types of change- cultural, strategic, structural, process and technological changes	4
3.	Transformational leadership, learning organizations	4
4.	OD interventions, creativity and innovation	3
5.	Cross role of visioning and leadership, change mechanisms, functional linkages.	4
6.	Teams and teamwork; empowerment and participative management collaboration and intrapreneurship, knowledge based organization.	6
7.	TQM, business process reengineering , simultaneous engineering, small group activities, self managed teams, QFD, workplace innovations, lean organization, kaizen, pokayoke	7
8.	Implementing organizational change, diffusion of change, management of change projects, evaluation of impacts, building and sustaining changing organizations	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	John, H., "Theories and Practices of Change Management", 2nd Edition, Palgrave Macmillan	2007
2.	Sharma, R., "Change Management: Concept and Applications", Tata McGraw Hill	2006
3.	Michal, B., "Strategic Organizational Change", 2nd Edition, Practitioner Press International	2006
4.	Richard, L., "Managing Change and Transition", Harvard Business School	2003
5.	Harrington, H., Conner, D. and Horney, N., "Project Change Management", Tata McGraw Hill	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-638** **Course Title : Managing Innovation and Creativity**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC
9. **Objective:** To impart knowledge of management of creativity and organizational innovations.

10. Details of Course

S.No.	Contents	Contact Hours
1.	Creativity, process, determinants, skills, creative thinking, nature and characteristics of creativity, innovation incremental and radical innovation, innovation in process, service innovation, case studies- GE-success story of innovation, BBC's walking with Dinosaurs, an innovative leader- a case of apple	10
2.	Stages in creative thinking, creative decisions, training in creative problem solving, taping the ideas of customers, learning from lead users	6
3.	Creativity and leadership, opportunity recognition, develop and innovation friendly culture, apply portfolio thinking, organizing team creativity and innovation and harvest ideas	5
4.	Creativity and entrepreneurship, creativity and organizational innovations, establish strategic direction, improve the idea to commercialization, creation of an ambidextrous organization, developing self creativity	7
5.	Channeling creativity in organizations, managing creativity, creativity and innovation, handling creative groups, enriching the organization and workforce, time pressure and creativity	7
6.	Cultural innovation, innovation-group style, creativity and organizational innovations	7
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Constatine, P., and Dowsan ,M.B., "Managing Change Creativity and Innovation", Sage Publications	2009
2.	Estrin, J., " Losing the Innovation Gap: Reigniting the Spark of Creativity in a Global Economy", Tata McGraw Hill	2008
3.	Sawyer, R. K., "Explaining creativity: The science of human innovation" Oxford University Press	2006
4.	Biech , E., " Creativity and Innovation", Tata McGraw Hill	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-639 Course Title : Management of Self and Interpersonal Dynamics**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC
9. **Objective:** To impart knowledge on managing oneself and the conflicts while working with others in an organization.
10. **Details of Course:**

S. No.	Contents	Contact Hours
1.	Exploring the self- capabilities, orientation, time management, johari window self assessment-strength and weaknesses	8
2.	Conflict- introduction and concept, new view to conflict, approaches to conflict handling, ingredients of conflict, conflict partnership process, cognitive aspect of conflict, emotional side of conflict	8
3.	Transactional analysis, exchange relationship, inputs and outcomes of relationships, relevance of inputs and outcomes	5
4.	Resource allocation norms, dynamics of role stress, role stress and burnout, role stress and coping, career goals and paths, career planning and knowing others	7
5.	Conflict, intra-individual conflict, interpersonal conflict, resolving conflict, techniques and methods to resolve conflict, essentials of conflict resolution, develop mutual benefits agreements	7
6.	Interpersonal dynamics and relationship, team conflict competence, organizational conflict competence	5
7.	Self and organizational culture, culture and conflict management, organizational leader and conflict management	2
	Total	**42**

11. Suggested Books

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Kavitha, G. , "Occupational Stress and Coping Strategies", Discovery Publishing House	2009
2.	Pastonjee, D.M. and Pareek, U., "Studies in Stress and Its Management", Oxford Publications	1999
3.	Robbins S.P., " Organizational Behavior" , 13th Edition, Pearson-Prentice Hall	2009
4.	Fincham, R.and Rhodes, P., "Principles of Organizational Behavior", 4th Edition, Oxford University Press	2008
5.	Baron, R. A. and Byne, D., "Social Psychology: Understanding Human Interactions", 10th Edition, Prentice Hall	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./ CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-641** **Course Title : Manufacturing Strategy**

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:** Both

7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. **Objective:** To provide a strategic perspective of manufacturing function and its role in competitive strategy of an enterprise.

10. **Details of Course:**

S. No.	Contents	Contact hours
1.	Strategic issues in manufacturing, developing a manufacturing strategy-principles and concepts	4
2.	Order winners and qualifiers- basic characteristics, specific dimensions	3
3.	Issues in new product development, strategic importance, types of new product development, process of new product development, CAD, modular design, product profiling	6
4.	Manufacturing investment, process choice and strategy.	3
5.	Developing a manufacturing strategy- methodology	5
6.	Process choice- overview, business implications, hybrid processes, technology strategy	5
7.	Focused manufacturing- principles and concepts, trade offs in focused manufacturing.	4
8.	Focus methodology, origins of existing plants, moving to focused plants, focus regression Vs focus progression, focused plants outcome	5
9.	Managing the supply chain	3
10.	Manufacturing infrastructure development, World class strategic manufacturing- concepts, cases, development	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Hill, T. and Hill, A., "Manufacturing Operations Strategy Text and Cases", 3rd Edition, Palgrave MacMillan	2009
2.	Brown, S., "Strategic Manufacturing for Competitive Advantage", 2nd Edition, Prentice Hall	1996
3.	Todd, J., "World Class Manufacturing", 2nd Edition, McGraw- Hill	2008
4.	Schonberger, R.J., "World Class Manufacturing: The Lessons of Simplicity Applied", 3rd Edition, The Free Press	2008
5.	Slack, N. and Lewis, M., "Operations Strategy", 2nd Edition, Pearson Education	2009
6.	Sahay, B.S., Saxena, K.B. C. and Kumar, A., "World Class Manufacturing- A Strategic Perspective", Macmillan	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM - 642** **Course Title : Computer Integrated Manufacturing**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC
9. **Objective:** To impart knowledge of computer integrated manufacturing systems.
10. **Details of Course**:

S. No.	Contents	Contact hours
1.	Evolution and stages of automated manufacturing systems, history of manufacturing, the product cycle, manufacturing automation, economies of scale and scope	6
2.	Computer controlled machines, numerically controlled machines, pallets and fixtures, constituents of machine centres, automated inspection systems	6
3.	Plant layout, process layout- computerized layout techniques, SLP, product layout- assembly line, splitting task, flexible and U shaped line layout, group technology	5
4.	Flexible manufacturing systems, architecture, automated work piece flow, automated assembly systems	7
5.	Performance measures- operational measurements throughput, inventory, operating expenses	3
6.	Computer based control systems- networking, automation protocol, database management system	5
7.	Computerized process planning and scheduling in flexible manufacturing	5
8.	Economic justification of CIMS- financial measurements such as net profit, return on investment (ROI), cash flow and implementation issues	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Grover, M.; "Automation, Production Systems and Computer Integrated Manufacturing", 3rd Edition, Prentice Hall of India	2009
2.	Talavage, J., "Flexible Manufacturing Systems: Design, Analysis and Simulation (Manufacturing Engineering and Materials Processing)", CRC Press	1987
3.	Weatherall, A.; "Computer Integrated Manufacturing", 2nd Edition, Butterworths and Co.	1992
4.	Kraebber, H. W. and Rehq, J. A., "Computer Integrated Manufacturing", 3rd Edition, Prentice Hall	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM - 643** **Course Title : Operations Planning and Control Systems**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC
9. **Objective:** To impart knowledge of advanced concepts of operational planning and control.
10. **Details of Course:**

S. No.	Contents	Contact hours
1.	Operations planning as a system, current status of operating system, factors affecting domestic and international productivity, manufacturing and service system	6
2.	Aggregate planning of production, varying use of work force, use of overtime, varying inventory level, accepting back orders, subcontracting, changing existing capacity	6
3.	Materials requirement planning- dependent Vs independent demand, bill of materials, time phasing, lot sizing, manufacturing resource planning, distribution requirement planning	6
4.	Scheduling- overview of operations scheduling, scheduling and control functions, scheduling in high intermediate low volume systems, order release; Dispatching; Personnel scheduling	6
5.	Shop floor control, loading and assignment, sequencing, lead time control, expediting, status control, input and output control	6
6.	Just-in-time planning and control systems, tie-up with suppliers, pull type movement of materials, low cost set up time, continuous improvement	6
7.	Computer based planning and control systems, computer aided design, computer aided manufacturing, flexible manufacturing system, automated guided vehicles, automated storage and retrieval system, computer communication	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Stephen, N. and Chapman, "Fundamentals of Production Planning and Control", Pearson Education	2007
2.	Khalid, S., "Manufacturing Resource Planning (MRP II) with Introduction to ERP, SCM, and CRM", Tata McGraw Hill	2002
3.	Wight, O.; "MRPII: Unlocking America's Productivity Potential", Wiley	1995
4.	Narasimhan, S.L., McLeavey, D.W. and Billington, P.J.,"Production Planning and Inventory Control", 2nd Edition, Prentice Hall of India	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-644** **Course Title : Supply Chain 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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC
9. **Objective:** To provide a comprehensive view of Supply Chain Management (SCM) function in enterprises.
10. **Details of Course:**

S. No.	Contents	Contact hours
1.	Meaning and evolution of SCM, environmental factors and changing nature of competition, SCM as a philosophy, cycle view, process view	4
2.	Supply chain design, competitive and SC strategies, achieving strategic fit, SC and value chain, parameters for SC performance	4
3.	SC drivers and metrics, framework for structuring drivers, facilities, inventory, transportation, information, sourcing, pricing	4
4.	Demand forecasting in a SC, aggregate planning and inventory management, planning supply and demand in a SC, managing predictable variability	5
5.	Transportation in a supply chain, role, modes of transportation, infrastructure and policies	4
6.	Sourcing decisions in supply chain- in-house or outsource, 3PL and 4 PL, supplier scoring and assessment	4
7.	Pricing and revenue management in supply chain- multiple customer segments, perishable assets, seasonal demand	4
8.	Warehouse management and operation, location and networking	3
9.	Supply chain quality, supplier relationships and the quality management function	3
10.	Supply chain coordination and performance, IT and SCM	3
11.	International logistics and supply chain	2
12.	Decision support and optimization models for LSCM	2
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication / Reprint
1.	Chopra, S., Meindl, P. and Kalra, D.V., "Supply Chain Management Strategy, Planning and Operation", 3rd Edition, Pearson Prentice Hall	2009
2.	Kachru, U., "Exploring the Supply Chain theory and practice", Excel Books	2009
3.	Bowesox, D.J. and Closs, D.J., "Logistical Management: The Integrated Supply Chain Process", Tata McGraw Hill	2008
4.	Deshmukh, S.G. and Mohanty, R.P., "Supply Chain Management Theories and Practices", 2nd Edition, Biztantra	2008
5.	Coyle, J.J., Bardi, E.J. and Lanley, C.J. Jr., "The Management of Business Logistics A Supply Chain Perspective", 7th Edition, Thomson South Western	2003
6.	Shapiro, J.F., "Modelling The Supply Chain", 2nd Edition, Duxbury Press	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-645** **Course Title : Total Productive Maintenance**

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:** Both

7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. **Objective:** To understand the principles and practices of maintenance management and related issues of safety and reliability.

10. **Details of Course:**

S. No.	Contents	Contact hours
1.	Role of maintenance function, fundamental concepts in safety system and maintenance management, types of maintenance systems	4
2.	Organising for safety and maintenance management, maintenance systems and procedures	4
3.	System failure analysis, models of system reliability and failure analysis	5
4.	Decision models for maintenance, planning and allocation of maintenance effort in breakdown, preventive and predictive maintenance	5
5.	Replacement and repair analysis, spares inventory management	4
6.	Manpower planning, scheduling and allocation in maintenance, condition monitoring	4
7.	Maintenance cost analysis and cost management, total productive maintenance	4
8.	Maintenance standards, budgeting, performance analysis and control	4
9.	Management of industrial safety, scheduling of major overhaul and shut downs	4
10.	Maintenance management information systems	4
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Venkataraman, K., "Maintenance Engineering and Management", 2nd Edition, Prentice Hall of India	2009
2.	Higgins, L. and Morrow, L.,"Maintenance Engineering Hand Book", McGraw-Hill	1977
3.	Wireman, T., "Total Productive Maintenance", 2nd Ed., Industrial Press	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM- 646** **Course Title : Project 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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC
9. **Objective:** To provide an integrative approach to management of projects, detailing the concepts of various phases of the Project life cycle.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Definition of projects, project life cycle / phases, stakeholders, organization and skills	4
2.	Role of project manager, conflicts in projects and resolution, project objectives / processes	4
3.	Proposal engineering management, project feasibility and appraisal	5
4.	Project cost estimation and control, project financing and managing cash flows; risk analysis in project	8
5.	Project structuring, planning and scheduling, resource scheduling and allocation, project acceleration, network approach, PERT/CPM, PERT/COST, GERT, simulation of networks	10
6.	Project monitoring systems, line of balance	3
7.	Contract management and structuring	4
8.	Project management in production, services and construction industries	4
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors /Book/ Publisher	Year of Publication / Reprint
1.	Chandra, P., "Projects-Planning, Analysis, Financing, Implementation and Control",5th Ed., Tata McGraw Hill	2002
2.	Maylor, H., "Project Management", 2nd Ed., Pitman Publication	2000
3.	Ghattas, R.G. and Mc Kee, S.L., "Practical Project Management", Pearson Education Asia	2001
4.	Pinto, P.K., "Project Management", Pearson Education	2009
5.	Wyzocki, R.K. and McGary R., "Effective Project Management', Wiley	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-647** **Course Title : Productivity 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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC
9. **Objective:** To provide a total organisational approach to productivity management.

10. **Details of Course:**

S. No.	Contents	Contact hours
1.	Overview of productivity and productivity improvement	3
2.	Conceptual framework of productivity measurement	5
3.	Productivity measurement in manufacturing sector	5
4.	Productivity measurement models, historical perspective, production function models, financial ratios, production based models, product oriented models, surrogate models, economic utility models, models based on system approach	5
5.	PO-P application, productivity measurement in service sector	5
6.	Interfacing productivity with other factors such as quality, flexibility and innovation	4
7.	Japanese approaches for high productivity management systems	5
8.	Techniques of productivity improvement, work analysis, value analysis	5
9.	Behavioural techniques, job design, organisation learning, incentive and reward systems, waste elimination	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Premvrat, Sardana, G.D. and Sahay, B.S., "Productivity Management: A systems Approach", Narosa Publishing House	1998
2.	Schaffer, R., "Managing Productivity", Jaico Publishing House	2001
3.	Schonberger, R., "Japanese Manufacturing Techniques: nine hidden lessons in simplicity", The Free Press	1982
4.	Premvrat, Sardana, G.D. and Sahay, B.S., "Productivity Measurement for Business Excellence", Narosa Publishing House	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM – 648** **Course Title** : **Quality 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:** Both

7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. **Objective:** To introduce various concepts and philosophies of quality management.

10. **Details of Course:**

S. No.	Contents	Contact hours
1.	Basic concepts and definition of quality, characteristics of quality leaders, role of TQM leaders, strategic planning and decision making	4
2.	Customer satisfaction, service quality, customer retention	3
3.	Motivation and its tools, performance appraisal and benefits of employee involvement	2
4.	Continuous process improvement, improvement strategies, PDSA cycle, Kaizen, reengineering, six sigma	4
5.	Principles of customer/ supplier relationship, sourcing, selection, certification of suppliers	3
6.	Strategies of performance measurement, cost of quality, and awards related to quality	3
7.	Benchmarking, process, planning, pitfalls and criticism of benchmarking, role of IT in quality	4
8.	Quality management systems (ISO 9000 series), environment management systems (ISO 14000 series)	4
9.	Quality function deployment, quality by design and various communication models	5
10.	Statistical process control, various tools and their application, acceptance sampling	3
11.	Methods of experimental design and taguchi method	7
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Besterfield, D.H., Michna, C.B., Besterfield, G.H. and Sacre, M.B., "Total Quality Management", 9th Ed., Pearson Prentice Hall	2009
2.	Juran, J. M. and Gryna, Jr. F.M., "Quality Planning and Analysis", 5th Ed., Tata McGraw Hill	2005
3.	Ronald, G.D., "Quality Function Deployment Linking a Company with its Customers", ASQ Quality Press	1993
4.	Howard, G., Oppenheim, A., Oppenheim, R. and David L., "Quality Management", 3rd Ed., Tata McGraw Hill	2008
5.	Marash, I. and Block, M. , "Integrating ISO 14001 into a Quality Management System", Tata McGraw Hill	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM 651** **Course Title : Management of Information Technology**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. **Objective:** To impart knowledge on use of information technology for achieving organisational goals.

10. Details of Course:

S. No.	Contents	Contact hours
1.	**IT strategy context and content:** Linking IT and business strategy, soft aspects of IT - relating IT and organizational structure, leadership and culture, role of chief information officer, chief technology officer and IT managers, IT for internal effectiveness, IT for inter-organisational linkages	6
2.	**IT strategy formulation:** IT strategy components, strategy formulation techniques and models, nolan's stage model and revised models for Nolan's stages, critical success factors, scenario analysis, linkage analysis, enterprise modeling	8
3.	**Investment decisions in a high velocity environment:** Information economics and ROI, IT-enabled business process redesign	4
4.	**Enterprise architecture:** Enterprise architecture framework – TOGAF, ZACHMAN	5
5.	**Basics of enterprise computing:** Centralization and decentralization, data center, networks, monitoring, security, standards, IT governance	7
6.	**Risk and compliance in the global enterprise:** Basics of Information Technology Infrastructure Library (ITIL), managing IT outsourcing, managing legacy systems	4
7.	**Emerging technologies:** Overview of specific emerging technologies, cloud computing, semantic web, global collaboration and tools	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Turban, E., McLean, E. and Wetherbe J., "Information Technology for Management, Transforming Organizations in the Digital Economy", 6th Edition, John Wiley	2008
2.	Kulkarni,P. and Chandle,P., 'IT Strategy for Business", Oxford University Press	2008
3.	Chew,E.K. and Gottschalk,P., "Information Technology Strategy and Management Best Practices", IGI Global	2009
4.	Applegate,L.M., Austin,R.D. and McFarian,F.W., "Corporate Information Strategy and Management", Tata McGraw Hill	2007
5.	Dubey,S.S., "IT Strategy and Management", Prentice Hall of India	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-652** **Course Title : Enterprise Business Applications**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. Objective: To impart knowledge on various aspects relating to selection, implementation and management of enterprise.

10. Details of Course:

S. No.	Contents	Contact hours
1.	**Introduction:** Enterprise wide information system applications, cross functional framework, introduction to concept of enterprise resource planning, supply chain management, customer relationship management, product life cycle management and enterprise performance management	4
2.	**Enterprise resource planning:** Introduction, historical development, modules such as financials, manufacturing, maintenance, procurement, HRM, inventory	9
3.	**Management of ERP projects:** ERP platform and vendor selection methods, ERP project management, management of issues in ERP projects	7
4.	**Supply chain management systems:** Nature and concept of supply chain management, IT support to supply chain management – EDI, data warehousing, RFID, SCM packages and functionalities including supply chain planning, warehousing, logistics and transportation, order management, price management, global trade management and optimization	7
5.	**Customer relationship management systems:** Defining CRM, sales force automation, partnership relationship management, e-CRM technologies and applications, popular CRM packages and functionalities like sales, marketing and loyalty, contact center and service, self service and e-billing, partner relationship management	7
6.	**Implementation methodologies:** Deployment models, support models (onsite and offsite), upgrade and patch management, risk management, data migration strategy, training strategy and customization management	6
7.	**Enterprise application integration:** Overview of EAI, integration of various enterprise applications	2
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Leon, A., "Enterprise Resource Planning", Tata McGraw Hill	2008
2.	Olson, D., "Managerial Issues of Enterprise Resource Planning Systems", Tata McGraw Hill	2004
3.	Paul, G., "CRM at the speed of light", 3rd Edition, Tata McGraw Hill	2007
4.	Rangarajan, N., "Supply Chain Management", Tata McGraw Hill	2009
5.	Monk, E. and Wagner, B., "Concepts in Enterprise Resource Planning", 3rd Edition, Cengage Learning	2009
6.	Goldenberg, B.J., "CRM in real time: Empowering Customer Relationships", Information Today	2008
7.	Linthicum, D.S., "Enterprise Application Integration", Addison Wesley	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-653 Course Title : Information Technology Project 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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC
9. **Objective:** To provide an insight into the life cycle of an IT project highlighting specific and unique requirements of IT projects.
10. **Details of Course:**

Sl. No.	Contents	Contact hours
1.	**Characteristics of IT programs and projects:** Difference between IT and business projects, specific requirements of IT projects, success of IT projects - why projects fail, typical large projects - issues and challenges, program and project life cycle	6
2.	**Pre-project activities:** Vision, objectives and goals, estimation pricing models, proposal preparation	3
3.	**Project framework:** Project processes, IT project planning, phases and stages, critical considerations for the project	4
4.	**Project execution:** Management of multivendor projects, project and vendors structure, service level agreements and contracts finalization	6
5.	**Project implementation:** Project kickoff and nodal teams, deliverable mapping and development/customization, project reviews and sign-off, stakeholder liaison mechanisms	8
6.	**Solution Review:** Solution review stages, proof of concept, scope changes, risk management, change management and user adoption challenges	6
7.	**Project infrastructure and readiness:** Legacy systems integration, infrastructure requirements, emerging options and models	4
8.	**Project roll out:** Checklists, pilots, training, handover, project closure, feedback	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Marchewka, J.T., "Information Technology Project Management", Wiley	2006
2.	Kelkar, S.A., "Information Technology Project Management", Prentice Hall	2005
3.	Taylor,J., "Managing Information Technology Projects, Applying Project Management Strategies to Software, Hardware and Integration Initiatives", AMACOM books	2004
4.	Schwalbe,K., "Information Technology Project Management", 6th Edition, Cengage Learning	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM 654** **Course Title : Software Engineering and Management of Software Development**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. **Objective:** To provide insight into software project and product development and the importance of software engineering tools and techniques.

10. **Details of Course:**

S. No.	Contents	Contact hours
1.	Introduction to software products, characteristics of software products and projects, software processes, various models of software development life cycle, process visibility and deliverables	6
2.	Introduction to systems engineering and systems architecture, introduction to project management	2
3.	Requirements engineering- analysis, definition, and specification, prototyping	4
4.	Software design process, architectural and user interface design, function oriented design, object oriented design, detailed design, verification and validation	8
5.	Software cost estimation, software testing, configuration management and version control, software maintenance, reverse engineering and software reengineering	8
6.	Product development, evaluating opportunities , domain expertise, sales and marketing cycle, proposal preparation effort estimation, system development metrics, *a priori* ROI analysis	8
7.	Project teams and work breakdown structure, project planning and tracking, quality management and process improvement	4
8.	Service oriented architecture	2
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Pressman, R.S., "Software Engineering", 7th Ed., McGraw Hill	2009
2.	Sommerville, I., "Software Engineering", 8th Ed., Pearson Education	2007
3.	Jalote, P., "An Integrated Approach to Software Engineering", 3rd Ed., Narosa Publishing House	2010
4.	Gopalaswamy, R., "Managing Global Software Projects", McGraw Hill	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM- 655** **Course Title : Design of On-Line Systems**

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:** Both

7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. **Objective:** To impart working knowledge of online systems and new technologies which are driving changes in the online systems domain.

10. **Details of Course:**

S. No.	Contents	Contact hours
1.	**Introduction:** Various online systems and technologies including service oriented architecture, cloud computing, business and social networking, e-commerce, e-payments, mobile computing and mobile applications, business models of online systems	6
2.	**Service oriented architecture:** Principles, web services approach, SOA and web services protocols, SOA Concepts, SOA definitions, service contract, SOA and network management architecture	3
3.	**Cloud computing:** Characteristics, types, comparisons, architecture, key features, layers, deployment models, privacy and compliance issues, open standards in cloud computing	4
4.	**Social networking:** History, social impacts, structure, emerging trends in social networking, social networking hosting services, business models, issues concerning to privacy, potential for misuse, social networking in government, business, education and medical field	8
5.	**Mobile computing:** Types of mobile computing, different applications of mobile computing, application of mobile computing in different industries, technical and other limitation of mobile computing	8
6.	**Electronic commerce:** History, early development of e-commerce, timeline, various business applications like email, enterprise content management, instant messaging, newsgroups, online shopping, online banking, online office suites, payment systems, shopping carts, teleconferencing and e-ticketing, commercial and government regulations, electronic forms	8
7.	**Enterprise dashboards and analytics:** Types of enterprise dashboards interface designing, history, benefits of digital dashboards, corporate performance	5

	management, data mining, and enterprise manufacturing intelligence, applications, challenges and competing on analytics	
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Bhasker, B. , "Electronic Commerce: Framework, Technologies and Applications", 3rd Ed., Tata McGraw Hill	2008
2.	Shuen, A., "Web 2.0 – A Strategy Guide", Shroff/ O'Reilly Media	2008
3.	Velte, T., Velte, A., and Elsenpeter, R.C. , "Cloud Computing a Practical Approach" McGraw- Hill	2009
4.	Jeff, J., "What Would Google Do", Harper Collins Publishers	2009
5.	Schneider, G.P., "E commerce – Strategy, Technology and Implementation", Course Technology	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM 656** **Course Title : Decision Support and Expert Systems**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. Objective: To impart knowledge of developing decision support systems and expert systems for management.

10. Details of Course:

S. No.	Contents	Contact hours
1.	**Managers and decisions**: decision making contexts (certainty, risk and uncertainty), computers and decisions; Decision support systems (DSS) concepts, decision modeling	8
2.	**Decision Support Framework**: Structured, semistructured unstructured decisions, bounded rational decision making phases - intelligence, alternative generation, choice, feedback, overview of available technologies	3
3.	**Modeling and analysis**: Different types of models (analog, mental heuristic and statistical models), decision tree, spreadsheet based systems, quantitative system modeling	9
4.	**Designing a DSS** – Approach and methodologies, tools - statistical and simulation modeling, sensitivity analysis, scenario analysis, monitoring and controls, optimization and search methods - heuristic methods, and evolutionary algorithms, GUI design, visual interactive systems, evaluating the effectiveness of a DSS	8
5.	**Intelligent systems**: Knowledge based systems, knowledge engineering, knowledge capture	4
6.	**Application** : Expert and AI systems, neural network systems, intelligent systems over the web	4
7.	**Implementing DSS:** Strategies for implementing and maintaining management support systems	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Turban, E., Jay, E. A. and Liang, T.P., "Decision Support Systems and Intelligent Systems"7th Ed., Prentice Hall	2004
2.	Marakas,G.M., "Decision Support Systems in the 21st Century", 2nd Ed., Prentice Hall	2008
3.	Janakiraman, V.S. and Sarukesi, K., "Decision Support Systems" 6th Ed., Prentice Hall	2006
4.	Burstein, F.and Holsapple, C. W. (Eds.), "Handbook on Decision Support Systems 2", Springer	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-657** **Course Title : Business Process 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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. **Objective:** To provide an understanding of business performance, linkages to processes towards managing business and unlocking value in the activity chain.

10. Details of Course:

S. No.	Contents	Contact hours
1.	**Introduction:** Organization strategy, structure, closed-loop process linking strategy to execution, role of IT in performance management, planning and management reporting	3
2.	**Business performance management and measurement:** Overview of BPM methodologies, six sigma, balanced scorecard, management by objectives	4
3.	**Process engineering:** Business activity management, process study, authority and responsibility, critical success factors, process maturity	3
4.	**Process design:** Process modeling and innovation, workflow automation, collaborative processes, document and content management systems, collaboration tools, group support systems	9
5.	**Process control and Governance:** Process metrics, rollout challenges of new processes, mechanisms for process governance	6
6.	**Business intelligence** Data warehousing, data mining, business analytics, balanced score card implementation	5
7.	**Knowledge management(KM):** Introduction, distinction between data, information and knowledge, knowledge creation, evolution of knowledge management, models of knowledge management, coding of knowledge, data mining	6
8.	**The KM process:** Strategic issues in knowledge management, knowledge management ROI and evaluation, valuation of intellectual capital, human factors, socio-cultural and organizational aspects, relationship with technological components, the knowledge organization and knowledge distribution	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Chang, J.F., "Business Process Management Systems" Auerbach Publications	2006
2.	Havey, M., "Essential Business Process Modelling", Shroff/o'reilly	2005
3.	Kahn, R.N., "Understanding workflow automation: A guide to enhancing customer loyalty", Prentice Hall	2004
4.	Jeston, J. and Nelis, J., "Management by Process – A Roadmap to Sustainable Business Process Management", Elsevier	2008
5.	Debowski, S., "Knowledge Management" Wiley India	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM 658** **Course Title : Electronic Commerce and e-Governance**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. **Objective:** To impart knowledge of various aspects of electronic commerce and electronic governance.

10. **Details of Course:**

Sl. No.	Contents	Contact hours
1.	Introduction to e-commerce- meaning and definition, frameworks such as EDI, WAN, www, intranets, business models, formulating an e-commerce strategy, sector strategies, e-branding	7
2.	E-commerce technologies- search engines and directories, infrastructure in e-commerce (ISPS, local loops, backbone), bottlenecks, overall selection considerations	6
3.	Architecture of internet model, technologies such as HTML, XML, WML, java applets, java servlets, browsers, payment systems and security	3
4.	E-commerce management, content management, infrastructure management, security policy, web hosting service models, types of hosting accounts, cyber laws and other legal issues including ethics, malpractices and torts, website management tools, market valuation of website, generation of traffic on website; M-commerce	6
5.	Introduction to E-governance- governance and e-governance, concepts, government reforms and government process reengineering, government information systems, design of e-governance projects	5
6.	Social cost benefit analysis of investment in IT projects, project appraisal techniques, UNIDO approach, world bank methods	4
7.	Management of e-governance initiatives, business models for e-governance – public private partnership models, change management, people management and technology tools for e-governance projects	6
8.	IT infrastructure management, security and legal challenges	3
9.	Indian experience in e-governance, critical sectors mission mode projects, success stories	2
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Loudon, K., "E-Commerce" 5th Ed., Prentice Hall	2009
2.	Bajaj, K.K. and Nag, D., "E-commerce: The Cutting Edge of Business", Tata McGraw Hill	2009
3.	Satyanarayana, J., "e-Government: The Science of the Possible" Prentice Hall of India	2004
4.	Bhatnagar, S., "E-Government: From Vision to Implementation", Sage Publications	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-661** **Course Title : Internet Marketing**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. Objective: To acquaint students with Internet technologies for use of marketing, selling and distribution of goods and services.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**The Online Environment:** The impact of internet on society and business, online buying behavior, online marketing objectives	6
2.	**The B2C Online Presence**: Introduction, niche marketing, comparison shopping engines	5
3.	**The B2B Online Presence:** Introduction, e-marketplaces, online auctions	5
4.	**Online Advertising:** Objectives and management, search engine advertising, network advertising	5
5.	**Permission Marketing:** Introduction, RSS feeds, personalization and mobile marketing	5
6.	**Social Media Marketing:** Introduction, consumer generated content, viral marketing	6
7.	**New product development and Online market research**: On line pricing strategies and tactics	6
8.	**The Internet as part of the Integrated Marketing Strategy:** Introduction, integrated online marketing	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Book/ Publishers	Year of Publication
1.	Jason, M., "Principles of Internet Marketing: New Tools and Methods for Web Developers", Cengage Learning	2010
2.	Wilson, R. F., 'Planning Your Internet Marketing Strategy", Wiley,	2001
3.	Hanson, W., "Principles of Internet Marketing," , South Western Publishing Co.	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code: BM-662** **Course Title: Consumer Behaviour Analysis**

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:** Both

7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. Objective: To develop an understanding of the consumer decision making process and its application in marketing functions of firms

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Consumer behavior:** Introduction, nature, scope, understanding consumers and market segments	5
2.	**Environmental influences on consumer behavior I:** Culture, cross-cultural understanding of consumer behaviour, subcultures, the nature of subculture, social class, the process of social stratification, social class and consumer behavior, social groups, group properties	7
3.	**Environmental influences on consumer behavior II:** Family, family life cycle, family purchase decisions, personal influence and diffusion of innovations, opinion leaders in marketing, marketing implications of personal influence	6
4.	**Individual determinants of consumer behavior I:** Personality and self- concept, personality theories and applications, personality and marketing	7
5.	**Individual determinants of consumer behavior II:** Motivation and involvement, the nature and role of motives, classifying motives, information processing, learning and memory, attitudes, characteristics and functions of attitude, attitude theories and models	6
6.	**Consumer decision processes:** Problem recognition, search and evaluation, purchasing processes, post-purchase behavior	6
7.	**Additional Dimensions:** Modeling and researching consumer behavior, organizational buyer behavior	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Book/ Publishers	Year of Publication
1.	Schiffman, L. and Kanuk, L., "Consumer Behavior", 10th Ed., Prentice Hall	2009
2.	Solomon, M.R., "Consumer Behavior", 9th Ed., Prentice Hall	2010
3.	Graham, G., "Critical Thinking in Consumer Behavior: Cases and Experiential Exercises", 2nd Ed., Prentice Hall	2009
4.	Blackwell, R.D., Miniard, P.W. and Engel, J.F., "Consumer Behavior", 10th Ed., South-Western College	2005
5.	Assael, H., "Consumer Behavior: A Strategic Approach", South-Western College	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code: BM-663 Course Title: Product and Brand 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:** Both

7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. **Objective:** To impart knowledge on complexities of a company's market offer and Product and Brand management.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Role of product management in contemporary marketing environment	3
2.	Product strategy and integration with marketing mix elements, impact of product strategy on marketing mix elements and marketing process, supply chain system including cost and competition considerations	5
3.	Product planning and marketing planning, understanding the relationship with respect to objectives of marketing departments involved and interdepartmental considerations	5
4.	Category planning and evaluation, category attractiveness analysis, competitors analysis, customers analysis, market potential and sales forecasting	5
5.	Introduction to product and offerings, developing product strategy, role of technology, inventions and innovations, pricing and brand development considerations	5
6.	Understanding innovation and new product development, keeping pace with market expectations, understanding of customers, future market development and global market scenario	5
7.	Taking innovation to markets, propelling market share and growth through innovation, brand development, integrated marketing communication and strategic choices	4
8.	Branding as a concept, brand creation principles, relevance of brand development, brand evolution and growth, branding and brand development strategies	5
9.	Building global brands, integrating brand strengths with globalized marketing perspective, customer orientation, awareness and buying behavior process	5
	Total	**42**

11. Suggested Books:

S.No.	Name of the Authors/ Book/Publisher	Year of Publication/ Reprint
1.	Donald, R. L. and Russell, S. W., " Product Management" , 3rd Ed., Tata McGraw Hill	2002
2.	Kotler, P., Keller, K., Koshi, A. and Jha, M., "Marketing Management" 13th Ed., Pearson	2009
3.	Wheelwright, S. C. and Clark, K. B., "Revolutionizing Product Development: Quantum Leaps in speed efficiency and quality", Free Press	1992
4.	Trott, P., "Innovation Management and New Product Development", 4th Ed., Prentice Hall	2008
5.	Kapferer, J. N., "Strategic Brand management : New Approaches to Creating and Evaluating Brand Equity", 2nd Ed, Kogan Page	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-664 Course Title Integrated Marketing Communication**

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:** Both

7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. Objective: To impart knowledge on integrated role of marketing communications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	IMC objectives and strategy, role in marketing process, associated perspectives	3
2.	Determining the promotions mix, elements, interrelationship, application, relevant combination	4
3.	Advertising concept, role, functions, setting advertising objectives, methods, associated factors, setting advertising budget, developing campaigns, message and channel design, evaluation and monitoring	12
4.	Direct marketing/database marketing, role, functions, application and comparative advantages	4
5.	Personal selling-role, functions, integration with advertising and sales promotion	4
6.	Sales promotion-role, functions, integration with advertising and personal selling, PR and media management	4
7.	On-line /interactive promotion- relevance in the present and future sales and marketing scenario	4
8.	Legal and ethical considerations of promotional strategies, role of media agencies, government marketers other stake holders in defining and redefining Integrated marketing communication	4
9.	Implementation and evaluation of marketing communication, process, feedback, reanalysis and refinement	3
	Total	42

11. Suggested Books:

S.No.	Name of the Authors/ Book/Publishers	Year of Publication/ Reprint
1.	O'Guinn,T., Allen, C., Semenik, R.J., "Advertising Management" Cengage Learning	2009
2.	Clow, K. E. and Baack, D., "Integrated Advertising, promotion and Marketing Communications", 2nd Edition, Pearson Prentice Hall	2008
3.	Smith, P. R., " Marketing Communications- An integrated approach"', 2nd Ed., Kogan page Publication	2004
4.	Iane, R.W., King, W. K., Russell, T.J. and Keeppner's "Advertising Procedure", 16th Ed., Pearson Education	2005
5.	George, E. B. and Michael, A. B. ," Advertising and Promotions, An Integrated Marketing Communications Perspective", 6th Ed., McGraw Hill	2003
6.	Kotler, P., Keller, K., Koshi, A. and Jha, M., Marketing Management 13th Ed., Pearson'	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-665** **Course Title : Sales and Distribution 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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. Objective: To impart knowledge of sales and distribution channel management in coherence with complete supply chain management system.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Nature, scope and process of sales management, relevance integration with product management and integrated marketing communication	4
2.	Recruiting, selecting, training and development of sales force and sales organization, evaluation of sales personnel	6
3.	Compensation and motivation of sales personnel, impact on the sales practices and sales achievements	3
4.	Designing territories and allocating sales efforts, associated strategic advantages and disadvantages	4
5.	Managing major accounts, role of major accounts versus average business accounts and approach towards the balance of efforts associated with the same	5
6.	Sales budgeting, sales forecasting and control, approaches, techniques, role as a sales and marketing performance measurement tool and strategic marketing tool	5
7.	Importance of distribution management in competitive business environment, associated strategies and techniques	3
8.	Marketing channels – roles, structures, functions and relationships with the elements of marketing mix	4
9.	Managing distribution channels, channel design and planning and associated models, strategies and the role of strategies in business enhancement and growth	5
10.	Physical distribution management – transportation and warehousing	3
	Total	**42**

11. Suggested Books:

S.No.	Name of the Authors/ Book/Publisher	Year of Publication/ Reprint
1.	Jeff, T., Earl, D. H. and Robert, C. E. " Sales Management" Prentice Hall	2008
2.	Still, R.R., Cundiff, E.W. and Govoni, N.A.P., "Sales Management", 5th Ed., Prentice-Hall	1988
3.	Kotler, P., Keller, K., Koshi, A. and Jha, M., "Marketing Management" , 13th Ed., Pearson	2009
4.	Jobber, D., Lancaster, G., "Selling and Sales Management", 5th Ed., Prentice Hall	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-666** **Course Title : International Marketing**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. Objective: To acquaint students with environmental procedural, institutional and decision aspects of international marketing with emphasize on global nature of marketing.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Globalization:** Globalization imperative, globalization of markets, evolution of global marketing	5
2.	**Global marketing environment I:** Global economic environment, country competitiveness, evolution of cooperative global trade agreements, financial environment, foreign exchange and foreign exchange rates	5
3.	**Global marketing environment II:** Elements of culture, culture and the marketing mix, political environment and legal environment, international law and local legal requirements, issues transcending national boundaries	5
4.	**Developing competitive marketing strategies I:** Global marketing research, market size assessment, segmentation and positioning, international market segmentation approaches, segmentation scenarios, international positioning strategies	5
5.	**Developing competitive marketing strategies II:** Global marketing strategies, regionalization of global marketing strategy, market-entry strategies, strategic alliances, exit strategies, global sourcing strategies, value chain and functional interfaces, procurement and types of sourcing strategies	5
6.	**Global marketing strategy development I:** New product development, global product strategies, multinational diffusion, managing products and services, global branding strategies, managing multinational product lines, global marketing of services, global pricing, transfer pricing, price coordination	5
7.	**Global marketing strategy development II:** , Global distribution and logistics, free trade zones, global retailing, communication for global markets, creative strategy, global media decisions, sales management, export and import management	6
8.	**Managing global operations:** Planning, organizing, and control of global marketing operations, using internet for global marketing	6
	Total	42

11. Suggested Books:

S. No.	Name of Authors/ Book/ Publishers	Year of Publication/ Reprint
1.	Keegan, W. J. and Green, M., " Global Marketing", 6th Ed., Prentice-Hall	2010
2.	Kotabe, M. and Helsen ,K., "Global marketing Management", 5th Ed., Wiley	2010
3.	Czinkota, M.R. and Ronkainen, I. A., "International Marketing", 9th Ed., South-Western College	2009
4.	Lee, K. and Carter, S., " Global Marketing Management", 2nd Ed., Oxford University Press	2009
5.	Johansson, J., "Global Marketing: Foreign Entry, Local Marketing, and Global Management", 5th Ed., McGraw Hill	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF MANAGEMENT STUDIES**

1. Subject Code: BM-667 **Course Title: Industrial 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:** Both

7. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective: To impart knowledge of the realities of industrial market place, cross-functional decision-making processes, supply chain management, e-commerce and related areas.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Dimensions of industrial marketing:** Nature and environment of industrial marketing, understanding of industrial markets	4
2.	**Organizational buying and buyer behavior:** Nature of industrial buying, dynamics of industrial buying behavior	6
3.	**Strategy formulation in the industrial markets:** Strategic planning process, assessing market opportunities, industrial market segmentation, target marketing, and positioning	7
4.	**Formulating product planning:** Developing product strategy, strategic innovation and new product development	6
5.	**Formulating channel strategy:** Channel participants, logistics, distribution and customer service	6
6.	**Formulating marketing communication planning:** Developing the industrial sales force, planning, organization, and controlling the selling function, managing advertising, sales promotion and publicity strategy	7
7.	**Formulating pricing policies:** Price determinants, pricing decision analysis	6
	Total	42

11. Suggested Books:

S. No.	Name of Authors/ Book/ Publisher	Year of Publication/ Reprint
1.	Hutt, M.D. and Speh, T.W., "Business Marketing Management: B2B", 10th Ed., South-Western College	2009
2.	Brennan, R., Canning, L.E. and McDowell, R., " Business-to-Business Marketing", Sage Publications	2007
3.	Coe, J., "The Fundamentals of Business-to-Business Sales and Marketing", McGraw-Hill	2003
4.	Morris, M.H., Pitt, L. and Honeycutt, E. D., "Business-to-Business Marketing: A Strategic Approach", 3rd Ed., Sage Publications	2001
5.	Reeder, R.R., Brierty, E.D, and Reeder, B. H., "Industrial Marketing: Analysis, Planning, and Control", 2nd Ed., Prentice-Hall	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-668** **Course Title : Services Marketing**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. Objective: To impart knowledge of special needs of marketing of services.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Characteristics of services compared to goods, services marketing mix	4
2.	**Focusing on the customer:** Consumer behavior in services, consumer experience, post purchase evaluation, customer expectations, factors influencing customer expectations, customer perceptions, service quality, service encounters	8
3.	**Customer requirement analysis:** Marketing research for services, customer relationship management and service recovery	6
4.	**Service design and standards:** Service development, design and standards, physical evidence and servicescape	6
5.	**Delivering services:** Employees' and customers' roles in service delivery, delivering services through intermediaries and electronic channels, managing demand and capacity	6
6.	**Managing service promises:** Managing integrated marketing communications and pricing of services	6
7.	**Economic and financial impact of service:** Customer retention, balanced performance scorecard, strategy maps	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Book/ Publisher	Year of Publication/ Reprint
1.	Schultz, M. and Doerr, J., "Professional Services Marketing", Wiley,	2009
2.	Lovelock, C. and Wirtz, J., "Essentials of Services Marketing", Pearson Education	2008
3.	Zeithaml, V. A., Bitner, M.J., Gremler, D. D. and Pandit, A., "Services Marketing", 4th Ed., Tata McGraw Hill	2008
4.	Gronroos, C., "Service Management and Marketing", 3rd Ed., Wiley,	2007
5.	Hoffman, K.D. and Bateson, J.E.G., "Services Marketing", 3rd Ed., Cengage Learning	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-671** **Course Title : Quantitative Analysis for 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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC
9. **Objective:** To impart knowledge of the contemporary mathematical framework for financial management.

10. Details of Course:

S. No.	Contents	Contact hours
1.	Relevance of probabilistic concepts in financial markets, moments, conditional expectations, binomial, normal and poisons distributions, attributes of lognormal distribution, relevance of lognormal distribution in financial modeling	9
2.	Markov processes and their relevance, convergence of random variables	3
3.	Differentiation in stochastic environment, integration in stochastic environment, the ITO integral	6
4.	Discrete time and continuous time martingales, uses of martingales in asset pricing	6
5.	Option pricing models- binomial models, the black-scholes model, simple applications and variants of the black-scholes model	6
6.	Warrants and option pricing theory, overview of pricing in incomplete markets	6
7.	Sensitivity analysis of options, delta hedging, relationship between Delta Δ , Vega ν, Theta Θ, Rho ρ	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Hull, J.C., "Options, Futures, and Other Derivatives", 7th Ed., Prentice Hall	2009
2.	Neftci, S.N., "Introduction to the Mathematics of Financial Derivatives",2nd Ed., Academic Press	2000
3.	Cerny, A., "Mathematical Techniques in Finance : Tools for Incomplete Markets", 2nd Ed., Princeton University Press	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM- 672** **Course Title : Working Capital 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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC
9. **Objectives of Course:** To acquaint the students with various aspects of management of current assets and current liabilities in the firms for effective decision making.

10. Details of the Course:

S. No.	Contents	Contact Hours
1.	Working capital management, meaning, concepts, classification and importance of working capital, objectives of working capital, factors determining working capital requirements, working capital approaches	6
2.	Assessment and forecasting of working capital requirement, working capital financing, determining the working capital financing mix	6
3.	New trends in financing of working capital by banks, recommendations of Tandon committee report, Chore committee report, major recommendations of Marathe committee report, Chakravarty committee report and Kannan committee report	6
4.	Management and nature of cash, motives of holding cash, cash management, managing cash flows, determining optimum cash balance, cash management models, Baumol model, Miller-Orr model, Stone model, Investment of surplus funds	6
5.	Receivables management, meaning of receivables, cost of maintaining receivables, factors influencing receivables, formation and execution of credit policy	7
6.	Inventory management, meaning and nature of inventory, purpose and benefits of holding inventory, risk and cost of holding inventory, inventory management - tools, techniques, objective and meaning, determining stock levels and safety stocks	7
7.	Management of payables, meaning, objectives and dimensions of payables management	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Bhattacharya, H., "Working Capital Management",2nd Ed., Prentice Hall of India	2009
2.	Mathur, S. B, "Working Capital Management and Control: Principles and Practice", New Age	2003
3.	Bhalla, V.K., "Working Capital Management: Text and Cases", 4th Ed., Anmol Publications	2007
4.	Hampton, J.J. and Wagner, C.L. "Working Capital Management", 4th Ed., John Wiley	2007
5.	Pandey, I.M., "Financial Management", 9th Ed., Vikas Publications	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-673** **Course Title : Security Analysis and Portfolio 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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC
9. **Objective:** To provide a comprehensive knowledge of security analysis and portfolio management for investment decisions.

10. **Details of Course:**

S. No.	Contents	Contact hours
1.	Risk-return analysis in investment decisions, measures of risk and return	3
2.	Portfolio optimization in the mean variance framework – two security case	6
3.	Portfolio optimization in the mean variance framework – multi security case	6
4.	Single index model and arbitrage pricing model	4
5.	Capital asset pricing model and its variants	6
6.	Portfolio performance appraisal	3
7.	Efficient market hypotheses	3
8.	Fixed income portfolio management and concept of duration, immunization and key rates	5
9.	Equity analysis and valuation – asset, income and cash flow basis, brief overview of fundamental analysis	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Chandra, P., "The Investment Game, How to Win", Tata McGraw Hill	1993
2.	Reilly, F.K., "Investment Analysis and Portfolio Management", 5th Ed., Dryden	1997
3.	Pike, R. and Bill, N., "Corporate Finance and Investment., Decisions and Strategies", , 5th Ed, Prentice Hall	2006
4.	Fisher, D.E. and Jordan, R.J. " Security Analysis and Portfolio Management",.6th Ed., Prentice Hall	1996
5.	Elton, E.J., Gruber, M.J., Brown S.J. and Goetzman, W., "Modern Portfolio Theory and Investment Analysis", 6th Ed., Wiley	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-674** **Course Title : Indian Financial System**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. **Objective:** To acquaint students with the organisation, operations and growth of the financial system in India.

10. **Details of Course:**

S. No.	Contents	Contact hours
1.	Nature and role of financial system, Indian Financial System, an overview	4
2.	Reserve Bank of India-history, structure and growth, Monetary Policy, evaluation	4
3.	Commercial Banks and Co-operative Banks- history, structure and growth	3
4.	Call Money Market, Treasury Bills Market, Commercial Bills Market, Markets for Commercial Paper and Certificate of Deposits, Discount Market, Market for Financial Guarantees, level and structure of interest rates, interest rates in India	5
5.	Non Banking Financial Companies	2
6.	National Bank for Agriculture and Rural Development, Deposit Insurance and Credit Guarantee Corporation, Export Credit Guarantee Corporation, Export-Import Bank of India	3
7.	Specialized financial institutions like Power Finance Corporation, Indian Railway Finance Corporation, Unit Trust of India, Insurance companies	5
8.	Financial instruments- equity, debt, mutual funds	3
9.	Securities and Exchange Board of India- origin, structure and growth	2
10.	Capital Markets and other institutional arrangements of Capital Markets like SHCIL, NSE, BSE, scams in Indian Financial Markets	6
11.	International dimensions of financial markets, integration of Indian financial system with global financial system, global financial crisis	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Bhole, L.M. and Mahakud, J., "Financial Institutions and Markets: Structure, Growth and Innovations", 5th Ed., Tata McGraw Hill	2009
2.	Burton, M. and Brown, B., "The Financial System and the Economy", 5th Ed., Prentice Hall of India	2009
3.	Desai, V., "Fundamentals of the Indian Financial System", 6th Ed., Himalaya Publishing House	2008
4.	Gomez, C., "Financial Markets, Institutions and Financial Services", Prentice Hall of India	2008
5.	Gurusamy, S., "Indian Financial System", 2nd Ed., Tata McGraw Hill	2009
6.	Kohn, M., "Financial Institutions and Markets", Oxford University Press	2007
7.	Pathak, B. V., "The Indian Financial System-Markets, Institutions and Services", 2nd Ed., Pearson Education	2008
8.	Srivastava, R.M. and Nigam, D., "Management of Indian Financial Institutions", 8th Ed., Himalaya Publishing House	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM – 675** **Course Title : International 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:** Both

7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. Objective: To provide students with an overall view of international financial system and the way multinational corporations.

10. Details of Course:

S. No.	Contents	Contact hours
1.	Exposure and risk – concept, types and measurement	6
2.	Concept of arbitrage between spot markets	4
3.	Spot v forward markets and the parity principles	5
4.	Hedging and exposure/risk management- instruments and strategies	6
5.	Hedging and speculations with options	6
6.	Hedging with futures and forwards	6
7.	Swaps – applications and pricing	5
8.	Management of operating exposure	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Shapiro, A.C., "Multinational Financial Management", 8th Edition, Allynand Bacon,	2006
2.	Levi, M., "International Financial Management and the International Economy", 4th Edition, Routledge	2005
3.	Buckley, A., "Multinational Finance", 5th Edition, Pearson	2006
4.	Apte, P.G., "International Financial Management", Tata McGraw-Hill	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-676** **Course Title: Financial Management Control Systems**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC
9. **Objective:** To impart knowledge of process of evaluating, monitoring, and controlling the various sub units of the organization.

10. Details of Course:

S. No.	Contents	Contact hours
1.	Framework for planning and control, goal and strategies	3
2.	Structure of control mechanism, various forms of organizational structure and their relevance to the control systems	3
3.	Responsibility centres and control centers, revenue centres, cost centre; profit centre and investment centre	5
4.	Traditional and contemporary measures of performance return on investment, residual income	6
5.	Key variables as control indicators, information system as support to management control	5
6.	Transfer pricing as a tool for management control, international transfer pricing	4
7.	Budget as an instrument of control, analysis of budget variances for control action	5
8.	Management control in non-profit organisations, projects, development programme	6
9.	Management control in multinational corporations and services organizations	3
10.	Mathematical models for management control	2
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Anthony, R.N. and Govindrajan, V., "Management Control Systems", 12th Edition, Tata McGraw Hill	2007
2.	Sharma, S., "Management Control Systems, Text and Cases", Tata McGraw Hill	2007
3.	Mohanty,B., "Management Control System: Implementation and Administration", McMillan	1979
4.	Merchant, K. A. and Stede, W. V. D., "Management Control Systems: Performance Measurement, Evaluation and Incentives", 2nd Edition, Prentice Hall	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-677** **Course Title : Taxation and Tax Planning**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. Objective: To provide knowledge of various taxes, mainly direct taxes and taxation and their implication for business.

10. Details of Course:

S. No.	Contents	Contact hours
1.	Basic concepts, sources of tax laws, act and rules, administrative instructions issued by CBDT, annual finance acts	2
2.	Income tax definitions, concept of income, heads of income	3
3.	Residential status and tax liability, scope of total income, concept of permanent establishment, business connection in India, taxability of BPO units	3
4.	Exempt incomes	2
5.	Income from salary, scope, allowances and perquisites, deductions from salary	3
6.	Income from house property, coverage and deductions	2
7.	Income from business and profession, express allowances and disallowances, tax incentives on R &D expenses, depreciation allowance, method of accounting	5
8.	Income from capital gains, concept of capital asset and transfer, short term and long term capital assets, exemptions	3
9.	Income from other sources	2
10.	Set off and carry forward of losses, tax planning	2
11.	Deductions under chapter VI A, incentives to infrastructure sector, hotels, etc	3
12.	Taxation of companies, MAT, calculation of book profits, credit for MAT	3
13.	Assessment of Income including reassessment, appeals, rectification and revisions, ITAT, reference to High Court and Supreme Court	3
14.	Tax Deduction at Source	3
15.	International taxation, transfer pricing, double taxation avoidance agreements	3
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Singhania, V.K. and Singhania, K. "Direct Taxes Law and Practice", Taxmann Publications	2010
2.	"Income Tax Act", Pocket Edition, Taxmann Publications	
3.	Ahuja, G. and Gupta, R., "Direct Taxes Ready Reckoner(with tax planning)", 10th Ed., Bharat Law House	2009
4.	Mehrotra, H.C., "Practical Problems In Income Tax", Sahitya Bhawan Publications	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-678** **Course Title : Merchant Banking and Financial Services**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. Objective: To acquaint the students with various aspects relating to legal, procedural and evaluatory framework for fee and fund based financial services.

10. Details of Course:

S. No.	Contents	Contact hours
1.	Capital Market- introduction, history, growth and structure of Capital Market	5
2.	Various types of markets, instruments and issues	5
3.	Regulatory framework, Securities and Exchange Board of India (SEBI)	3
4.	Merchant banking- nature and scope	2
5.	Market intermediaries for issues, merchant bankers, registrar and share transfer agents, underwriters, bankers to issue, debenture trustees, stock brokers and sub brokers and depository services	7
6.	Role of merchant banker, pre and post issue management, advisory role, role in corporate restructuring, mergers, amalgamations, takeovers and joint ventures	10
7.	Credit rating, lease finance, hire purchase, loan syndication, bill discounting, factoring and forfeiting and venture capital	10
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Machiraju, H.R., "Merchant Banking", 4th Edition, New Age	2010
2.	Fabozzi, F. J., Franco Modigliani, "Capital Markets – Institutions and Instruments", 4th Edition , Prentice Hall of India	2009
3.	Clifford, G., "Financial Markets, Institutions and Financial Services", Prentice Hall of India	2009
4.	Gurusamy, S., "Merchant Banking and Financial Services", 3rd Edition, Tata McGraw-Hill	2009
5.	Christopher, V., "Financial Institutions, Instruments and Markets", 6th Edition ,Tata McGraw-Hill	2009
6.	Khan, M. Y., "Financial Services", 5th Edition, Tata McGraw-Hill	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-679** **Course Title : Financial Statement Analysis and Reporting**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. **Objective:** To impart knowledge of tools, techniques and approaches for financial statement analysis based on qualitative and quantitative information.

10. **Details of Course:**

S. No.	Contents	Contact hours
1.	**Introduction:** Economy, industry, company analysis	3
2.	**Annual Report:** Content of annual report, quality of financial reporting, reporting regulation in India for different types of entities, directors' report and auditor's report	5
3.	**Understanding Financial Statements:** Nature, objectives, uses, limitations and stakeholders of financial statements , balance sheet and income statement as per Indian Companies Act 1956	8
4.	**Financial Statement Analysis:** Sources of information, tools and techniques of financial statement analysis	9
5.	**Ratio Analysis:** Nature, importance and types of ratios, Dupont analysis	4
6.	**Distress analysis:** Need for corporate failure analysis, concepts on sickness, distress, failure and insolvency, stages, signals and symptoms of financial distress	2
7.	**Reporting:** Report preparation of financial statement analysis	2
8.	**Combinations and Consolidation:** Types of business combinations, consolidated financial statements, intercompany transactions and profit confirmations, minority interest, consolidated net income and consolidated retained earnings, changes in ownership	5
9.	**Ethical issues in financial reporting:** Window dressing, recent scandals in financial reporting	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Ormiston, Aileen, Fraser and Lyn, M., "Understanding Financial Statements", 9th Edition ,Prentice Hall of India	2010
2.	Sinha, G., "Financial Statement Analysis", Prentice Hall of India	2009
3.	Narayanaswamy, R., "Financial Accounting – A Managerial Perspective", 3rd Edition , Prentice Hall of India	2009
4.	Subramanyam, K. R. and John, J.W., "Financial Statement Analysis", 10th Edition, Tata McGraw Hill	2008
5.	Penman, S.H., "Financial Statement Analysis and Security Valuation", 2nd Edition, Tata McGraw Hill	2006
6.	Erich, A. H., "Techniques of Financial Analysis: A Guide to Value Creation", 11th Edition ,Tata McGraw Hill	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF MANAGEMENT STUDIES**

1. **Subject Code : BM-680** **Course Title : Banking and Bank Finance**
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:** Both
7. **Pre-requisite:** Nil **8. Subject Area:** PEC

9. **Objective:** To apprise students with basic understanding of Financial System, Banking and Bank Finance.

10. **Details of Course:**

S. No.	Contents	Contact hours
1.	Introduction;Trade, commerce, business, barter system, origin of money, medium of exchange, role of money in economy, structure of financial system, instruments, institutions and markets, growth perspectives of financial system in India since 1947	4
2.	Bank; Origin, nature and history, structure of banking, central bank – functions, role and organization structure, instruments of central banking (RBI) policy – bank rate, CRR, SLR and open market operations	4
3.	Commercial banking; Deposits, credit offering, forms of advances and types of credit, letter of credit, deferred payments, guarantees, charging of securities, hypothecation, pledge, mortgage, lien and set-off	7
4.	Development banking; Nature and types, participation in economic development, role of IDBI, IFCI, SIDBI, ICICI, SHCL, DFHI, NHB, SFCs, EXIM Bank and ECGC	6
5.	Rural banking; History, structure and growth, role of NABARD in agriculture and rural development	4
6.	Role of banks in financial market, Merchant banking, bankers to issue, investment banking, asset management, portfolio management, depositary and stock broking services	8
7.	Changing scenario in banking sector; Core banking, universal banking, retail banking, housing finance, technology, virtual banking, e-banking, credit cards and ECS	5
8.	Financial upheavals; Scams, frauds, global financial crisis and its effect	4
	Total	**42**

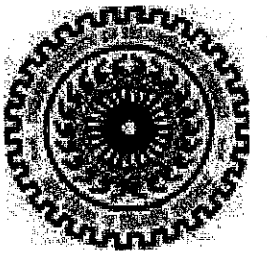
11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Sethi, J. and Bhatia, N., "Elements of Banking and Insurance", Prentice Hall of India	2009
2.	Gurusamy, S., "Indian Financial System", 2nd Edition, Tata McGraw-Hill	2009
3.	Christopher, V., "Financial Institutions, Instruments and Markets", 6th Edition, Tata McGraw- Hill	2009
4.	Clifford, G., "Financial Markets, Institutions and Financial Services", Prentice Hall of India	2009
5.	Khan, M. Y., "Financial Services", 5th Edition, Tata McGraw- Hill	2007

Appendix-E
Item No.SENATE/36.2.2

M.Tech. Syllabus

(Spring Semester)



Department of Water Resource Development & Management
Indian Institute of Technology Roorkee
Roorkee – 247 667

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
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.	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	PEC	4	3	1	-	3	-	25	-	25	50	-
2.		Major Elective II	PEC	4	3	1	-	3	-	25	-	25	50	-
3.		Major Elective III	PEC	4	3	1	-	3	-	25	-	25	50	-
4.		Major Elective IV	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*														
2nd 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 3rd Semester)	DIS	20	-	-	-	-	-	-	-	-	75	-
		Sub Total		**20**										
		Total		**64-68**										

PROGRAMME ELECTIVES

1.	WR-511	System Design Techniques	PEC	4	3	1	-	3	-	25	-	25	50	-
2.	WR-573	Principles and Practices of Irrigation	PEC	4	3	1	-	3	-	25	-	25	50	-
3.	WR-574	On Farm Development	PEC	4	3	1	-	3	-	25	-	25	50	-
4.	WR-575	Operation, Maintenance and Management of Irrigation Systems	PEC	4	3	1	-	3	-	25	-	25	50	-
5.	WR-576	Water and Land Laws	PEC	4	3	1	-	3	-	25	-	25	50	-
6.	WR-577	Rural Sociology and Irrigation Economics	PEC	4	3	1	-	3	-	25	-	25	50	-
7.	WR-578	Evaluation of Irrigation Project	PEC	4	3	1	-	3	-	25	-	25	50	-
8.	WR-579	Renewable Energy System Technology	PEC	4	3	1	-	3	-	25	-	25	50	-
9.	WR-581	Water Quality Monitoring and Modeling	PEC	4	3	1	-	3	-	25	-	25	50	-
10.	WR-582	Theory of Seepage	PEC	4	3	1	-	3	-	25	-	25	50	-
11.	WR-583	Remote Sensing and GIS Applications in Agriculture	PEC	4	3	1	-	3	-	25	-	25	50	-
12.	WR-584	Cropping System Modeling	PEC	4	3	1	-	3	-	25	-	25	50	-
13.	WR-585	Environmental Impact of Irrigated Agriculture	PEC	4	3	1	-	3	-	25	-	25	50	-
14.	WR-586	Groundwater Development and Management	PEC	4	3	1	-	3	-	25	-	25	50	-
15.	WR-587	Watershed Development and Management	PEC	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-511** Course Title: **System Design 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 the system design techniques and applications to water resources systems analysis, design and management.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**System concepts:** Boundary, environment, input, output and constraints; Open and closed systems; System modeling, water resources systems, issues in system application; Operation research approach to system analysis	4
2.	**Linear programming:** Model formulation, graphical method, simplex procedure- two phase, big-M, dual simplex, primal-dual simplex, modified simplex procedures; Upper bounded solutions, sensitivity analysis	8
3.	**Transportation problems:** Basic feasible solution techniques, testing for optimal solution; Integer and mixed integer problems, assignment problems, applications for efficient water resources management	8
4.	**Non linear programming (NLP):** Separable and convex programming problems, quadratic programming, unconstrained and constrained NLP problems, chance constrained programming, method of calculus, search techniques	6
5.	**Dynamic programming:** Optimality principle, deterministic and stochastic dynamic programming, application to water resources problems	8
6.	**Decision making:** Value and utility concepts, goal programming, decision theory and decision trees, decision making under risk and uncertainty, theory of games; Multi criteria decision making- distance based and compromise techniques	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprint
1.	Jain, S. K. and Singh, V. P., "Water Resources Planning and Management", Elsevier.	2003
2.	Loucks, D.P., Stedinger, J.R. and Haith, D.A., "Water Resources Systems Planning and Analysis", Prentice Hall.	1981
3.	Ravindran, A., Philips, D.T. and Solberg, J.J., "Operation Research- Principles and Practice", Second Edition, John Wiley.	2000
4.	Rao, S.S. "Optimization - Theory and Applications", Wiley Eastern.	1984
5.	Sharma, J.K., "Operations Research", Macmillan.	1997
6.	Taha, H.A., "Operation Research - An Introduction", PHI.	2002
7.	Wurbs, R.A. and James, W.P., "Water Resources Engineering", PHI .	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-573** Course Title: **Principles and Practices of Irrigation**

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 principles of irrigation and irrigation practices.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction, basic definitions and approach, water resources and its status, problems of irrigation development	4
2.	Soil water plant atmosphere relationship, monitoring of crop water stress and soil moisture, water uptake and release in the atmosphere and root zone, consumptive use determination from field and Lysimetric experiments	8
3.	Rainfall-runoff analysis, water availability assessment, infiltration, hydraulic conductivity and water balance study	8
4.	Approaches of estimating reference crop evapotranspiration, crop coefficient; Effective rainfall, net irrigation requirement, gross irrigation requirement, project irrigation requirement; Preparation of water demand sheet	4
5.	Crop growth stages; Soil moisture depletion; Miscellaneous uses of irrigation	6
6.	Basin, border, furrow, sprinkler and drip irrigation and their design procedures; Evaluation of irrigation performance; Irrigation pumps; Automation in irrigation	8
7.	Water quality testing, classification, treatment and management; Groundwater quality contamination, effluent and wastewater use in agriculture	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publishers	Year of Publication /Reprint
1.	Asawa, G.L., "Irrigation and Water Resources Engineering", New Age International Publishers.	2006
2.	FAO, "Crop Water Requirements", FAO Irrigation and Drainage Paper No. 24.	1992
3.	Jensen, M.E., "Design and Operation of Farm Irrigation System", American Society of Agricultural Engineers.	1981
4.	Majumdar, D.K., "Irrigation Water Management Principles and Practices", Prentice Hall.	2000
5.	Michael, A.M., "Irrigation Theory and Practice', Vikas Publishing House	2008
6.	Garg, S. K., "Irrigation Engineering and Hydraulic Structures", Khanna Publishers.	2004
7.	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-574** Course Title: **On Farm 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 impart knowledge on the watershed level development of the canal commands.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction, techno-economic and environmental issues of canal commands; Command area development programme- Objectives and approach	4
2.	On Farm Development Planning- Delineation of watershed, land acquisition, delineation of farm roads, field channels, field drains and escapes; Land leveling, shaping and earth work estimation	7
3.	Identification and reclamation of waterlogged and salt-affected lands through cultural, chemical and engineering practices	4
4.	Water distribution practices in India and other neighboring countries in canal, tube well, small storage and diversion structures; On farm system design- Modernization and rehabilitation of water-courses and their structures	8
5.	Agricultural extension- Farmer's organization, leadership development and linking farmers- with agriculture, irrigation and financing; Rural and infrastructural development agencies	4
6.	Participatory irrigation management- Irrigation management transfer, responsibility of irrigation department and farmers' organization, constitution, laws and bye laws, social, economic and environmental control of water users' society	6
7.	Runoff recycling, planning mixed use of fresh and effluent water in agriculture	3
8.	Conjunctive use planning- Use of surface and ground water to improve water productivity, safeguard against land degradation and environmental protection; Sub surface drainage- Layout and Design	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publishers	Year of Publication /Reprint
1.	Jensen, M.E., "Design and Operation of Farm Irrigation System", American Society of Agricultural Engineers.	1981
2.	Michael, A.M., "Irrigation Theory and Practice', Vikas Publishing House	2008
3.	Murthy, V.V.N., "Land and Water Management Engineering", Kalayani Pubishers.	1998
4.	Garg, S. K., "Irrigation Engineering and Hydraulic Structures", Khanna Publishers.	2004
5.	Singh, B., "Fundamentals of Irrigation Engineering", 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-575** Course Title: **Operation, Maintenance and Management of Irrigation 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 knowledge on operation, maintenance and management of irrgation systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Definition of terms, elements of organizational management; Comparative analysis of irrigation organization, organizational change mechanism	4
2.	Maintenance problems- physical and social phenomena, examples; Maintenance types- essential, structural, catch up, preventive and normal; Budget control and accountability development of maintenance program	5
3.	Maintenance practices- catchment protection to check soil erosion, headworks; Maintenance of channels, structures, communication and ancillary works; Maintenance of tertiary systems and drains	5
4.	Diagnostic analysis of operation and maintenance of a canal system; Purpose, planning, field work, walk-through survey, field experiments, report preparation and presentation	8
5.	Reservoir and canal operation- reservoir operation rules for flood control and water supply; Canal capacity, discharge measurement, water allowance, water distribution, planning and sharing in water deficit	6
6.	Automatic regulation of canal operation- concept of automation, hardware and software requirements, gate discharge, pool volume control; Algorithm for canal operation	4
7.	Information management- geographic information system based record keeping and analysis, information flow and feedback	6
8.	Water charges, revenue recovery and performance budgeting	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books /Publishers	Year of Publication /Reprint
1.	MOWR, GOI, "Guidelines for Farmers Participation in Water Management', Command Area Development and Water Management Division.	1987
2.	INCID, "Guide for Preparation of Plans of Operation and Maintenance of Irrigation Systems in India".	1994
3.	INCID, "Guidelines for Irrigation Performance Evaluations".	2005
4.	Modi, P.N., "Irrigation Water Resources and Water Power Engineering", Standard Book House.	1995
5.	Garg, S.K., "Irrigation Engineering and Hydraulic Structures", Khanna Publishers.	2004
6.	Singh, B., "Fundamentals of Irrigation Engineering", 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- 576** Course Title: **Water and Land Laws**
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: 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **NIL**
9. Objective: To impart knowledge on laws pertaining to water and land use for sustainable agricultural production.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Water laws in India**: Basic concepts of resource economics applied to water resource management, fugitive nature of water resources, common property rights; Constitutional right, surface and ground water use regulations	8
2.	**National policies:** Agriculture, water, forest and science policies; North India canal and drainage act	6
3.	**Land laws in India:** Legal aspects of land ownership, inheritance, disputes and their resolution	6
4.	**Environmental protection act:** Rules and regulation, effluent disposal and pollution control laws	6
5.	**Water rights:** Comparative analysis of surface and subsurface water rights, legal procedures for establishment of water rights, groundwater legal issues, group versus individual rights	6
6.	**Water disputes and their resolution:** Interstate, inter-basin and trans-boundary disputes; Conflict resolution, development of accountability mechanism	6
7.	**Organizational setup:** Water boards and authorities; Case studies of users' interactions with government agencies	4
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors /Book /Publishers	Year of Publication/ Reprint
1.	Indian Council of Agricultural Research, "Hand Book of Agriculture" , Govt. of India.	2008
2.	Joseph, L. S., "Water Laws Planning and Policy", Bobbs Meril.	1968
3.	Luis, V. C., "Management and Law for Water Resources", Water Resources Publication.	1977
4.	Ministry of Agriculture, "National Agricultural Policy", Govt. of India.	2000
5.	Ministry of Environment and Forest, "National Forest Policy", Govt. of India.	1992
6.	Ministry of Health and Family Welfare, "National Health Policy", Govt. of India.	2002
7.	Ministry of Water Resources, "National Water Policy", Govt. of India.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR- 577** Course Title: **Rural Sociology and Irrigation Economics**

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 socio-economic groups and their role in economic use of irrigation water.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Rural sociology:** Elements of rural sociology, social structure and their interaction, moral values, irrigation for social service and rural development,	6
2.	**Social structure:** Rural psychology, leadership, communication and motivation for effective governance	4
3.	**Panchayati raj act:** Panchayati raj institution and rural development programs	6
4.	**Social upliftment:** Social conflicts and their resolution, role of NGOs and women in irrigation management	6
5.	**Principles of economics:** Definitions, basic concepts of water resource economics, analysis and project planning for irrigation management	4
6.	**Farm accounting:** Production response, functions of irrigation application	6
7	**Pricing of water:** Socio-economic aspects, time-value of money, determination of demand; Pricing policy- guidelines and estimation	6
8	**Socio-economic surveys:** Principles and guidelines	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publishers	Year of Publication/Reprint
1.	Bhattacharya, S.N., "Rural Development in India and Other Developing Countries", Metropolitan.	1983
2.	Indian Council of Agricultural Research, "Hand Book of Agriculture", Govt. of India.	2008
3.	James, L. D. and Lee, R. R., "Economics of Water Resources Planning", McGraw Hill.	1971
4.	Stevenson, V., "Social Change", Prentice Hall.	1989

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR- 578** Course Title: **Evaluation of Irrigation Projects**
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 evaluation of irrigation projects for their performance improvement.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Need for evaluation of irrigation projects; Principles of system diagnosis, health of an irrigation system for its functioning	4
2	**Cropping system:** Cropping pattern, cultivation techniques, crop diversification, intensification and rotation; Yield estimation	6
3	**Performance evaluation:** Benchmarking, guidelines and procedures for command area project evaluation	8
4	**Water productivity:** Modern concepts, economics, limits and opportunities for improvement, management of floods and droughts	6
5	**On farm system:** Field level assessment of efficiencies, efficient use of rain water	6
6	**Main system:** Basic concepts of irrigation systems, system boundaries, interaction between environment and system, system deficiency	6
7	**Socio-economic:** Social structure, per capita income, livelihood improvement	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publishers	Year of Publication/Reprint
1.	David, J., Molden, R., Sakthivadivel, C., Perry, J. and Charlotte de F., "Indicators for Comparing Performance of Irrigated Agricultural Systems", International Water Management Institute.	1998
2.	Hector, M. and Martin, B., "Guidelines for Benchmarking Performance in Irrigation and Drainage", Food and Agricultural Organisation.	2001
3.	ICID, "Benchmarking of Irrigation and Drainage Projects", International Commission on Irrigation and Drainage.	2004
4.	Yoder, R., "Identification and Utilization of Farm Resources in Irrigation Development", Cornell University Press.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR- 579** Course Title: **Renewable Energy System Technology**

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 renewable energy harnessing technologies.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Renewable energy:** Definition, history, current state-of-the-art, future use and penetration of renewable energy technologies; Types of renewable energy sources - Solar radiation, tidal and waves, hydro cycle, geothermal	3
2.	**Solar thermal energy conversion technologies:** Nature of solar radiation; Insolation; Measurements and estimation; Physical principles of conversion of solar radiation into heat; Flat plate collectors, energy balance equation and collector efficiency, concentrating collectors and flat plate collectors, solar thermal electric power generation	6
3.	**Solar photo voltaic systems:** System components and configurations, cells, modules, and arrays, batteries, charge controllers, inverters, system sizing, mechanical integration, electrical integration, utility interconnection	3
4.	**Wind energy:** Wind characteristics, data analysis and resource estimation; Wind turbine energy prediction; Measurement of wind velocity and direction; Wind turbine configurations- drag and lift types; Magnus effect in wind turbines; Vortex wind machines; Electric generators for wind turbine application; Power converter, auxiliary equipment; Wind turbine control; Wind turbine sitting considerations; System economics; Environmental aspects and impacts	5
5.	**Tidal power:** Tidal phenomena, historical background, basic aspects of tidal power development and tide mills; Tidal power project components;	5

	Design considerations- Selection of tidal power sites, feasible tidal range, preliminary design and productivity considerations; Tidal barrier construction techniques- dikes, types of float in modules, concrete caissons	
6.	**Bio mass energy:** Biomass conversion technologies, generation, bio-digestion; Classification of biogas plants– floating drum type and fixed dome type; Thermal gasification of biomass; Biomass gasifiers; Gasification process, application of gasifiers for electricity generation; Pyrolysis and alcohol fuels	7
7.	**Other renewable energy sources:** Wave energy and ocean thermal energy conversion technologies; Geothermal energy sources, geothermal exploitation, prime-movers for geothermal energy conversion system, material selection for geothermal power plants, flashed steam and total flow concept	6
8.	**Applications**: Application to micro-irrigation, rural water supply, water and waste water treatment, special conditions of preference – off grid and remote areas; cost effectiveness, use of software	7
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books /Publishers	Year of Publication
1.	Messenger, R.A. and Ventre, J., "Photovoltaic System Engineering," CRC Press.	2003
2.	Peuser, F. A., Remmers, Karl-Heinz and Schnauss, M., "Solar Thermal Systems: Successful Planning and Construction", Solar Press.	2009
3.	Rai, G.D., "Non conventional Energy Sources," Khanna Publishers.	2001
4.	Rosa, A.V. Da, "Fundamentals of Renewable Energy Processes", Elsevier.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-581** Course Title: **Water Quality Monitoring and Modelling**
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 water quality modelling and monitoring of water bodies.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Water quality parameters:** Physical, chemical and biological parameters of natural water bodies like lake, river and estuary; Water quality standards, Eutrophication; Sources of pollution, mass bathing impacts, waste load allocation	9
2.	**Water quality monitoring:** Physical, chemical and biological monitoring of rivers; Guidelines for sample size and location of monitoring stations, Sample analysis	8
3.	**Modelling:** Characteristics of point and non-point sources of pollution; Solution of diffusion and dispersion problems; Water quality models, case studies	9
4.	**Water purification:** Physical, chemical and biological processes, response of streams to biodegradable organic waste; Engineered systems for water and waste water purification	8
5.	**Groundwater quality:** Parameters; Sources of salinity, short and long term monitoring; Remedial and preventive measures	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books /Publishers	Year of Publication
1.	Biswas, A. K., "Models for Water Quality Management", Mc Graw Hill.	1981
2.	Chapra, S. C., "Surface Water Quality Modeling", Waveland Press.	2008
3.	David, A. Chin, "Water Quality Engineering in Natural Systems", Wiley Interscience.	2006
4.	Loucks, D. P., Stedinger, J. R. and Haith, D. A., "Water Resource Systems Planning and Analysis", PH.	1981
5.	Orlob, G. T., "Mathematical Modelling of Water Quality- Streams, Lakes, and Reservoirs", John Wiley.	1983
6.	Thomn, R. V. and Mueller, J. A., "Principles of Surface Water Quality Modelling", Harper and Row Publishers.	1987
7.	Zhen, G. J., "Hydrodynamics and Water Quality- Modelling Rivers, Lakes and Estuaries", John Wiley.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-582** Course Title: **Theory of Seepage**
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 seepage theory applicable to water resources projects.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Fundamentals, characteristics and boundary conditions of groundwater flow; Darcy's law; General hydrodynamic equations; Flownet	6
2	Application of Dupuit theory; Basic consideration; Two dimensional flow; Free surface subject to infiltration and evaporation; Radial flow in fully penetrating well	6
3	Conformal mapping and special mapping techniques; Application of mapping function; Fundamentals of solution of two dimensional flow problems by conformal mapping; Bilinear transformation	6
4	Unconfined flow through earthen structures and its seepage analysis; Unconfined flow around cutoffs; Earth structure with a cutoff wall and with horizontal drain; Rockfill dams with central core and seepage analysis	8
5	Confined flow, methods of solving confined flow problems; Hydraulic structure on surface of finite depth of porous media; Inclined sheet pile; Finite lower impervious boundary; Depressed structure on a permeable base of infinite extent; Double-wall sheet-pile cofferdam	8
6	Seepage from small water bodies, reservoirs and canals; Seepage towards well- steady and unsteady flows; Stream-aquifer interaction	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publishers	Year of Publication/Reprint
1.	Bear, J., "Dynamics of Fluids in Porous Media" McGraw Hill.	1972
2.	Bear., J. "Hydraulics of Groundwater" McGraw Hill.	1979
3.	Harr, M.E., "Groundwater and Seepage", McGraw Hill.	1990
4.	Reddi, L. N., "Seepage in Soils-Principles and Applications' John Wiley.	2005
5.	Walton, W.C. "Groundwater Resources Evaluation" McGraw Hill.	1970

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-583** Course Title: **Remote Sensing and GIS Applications in Agriculture**

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 applications of remote sensing and GIS techniques in agriculture and water resources management.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction, history of remote sensing, sensors, platforms and their characteristics; Satellite data products	6
2.	Principles of remote sensing and data analysis, electromagnetic spectrum, atmospheric effects, energy interaction with earth surface features, basic interaction mechanism of soil, vegetation and water	8
3.	Image interpretation virtual and digital; Image rectification, image enhancement, image classification and accuracy assessment, use of image processing software	8
3.	Geographical information system (GIS), definition, essential components of GIS, spatial data structure- raster and vector, spatial and non-spatial relationship, geographic database concepts and analysis, GIS packages and salient features	8
4.	Use of remote sensing and GIS techniques in agriculture, vegetation cover mapping, crop acreage estimation and disease detection	4
5.	Application of remote sensing and GIS for estimation of surface and groundwater irrigation potential, erosion hazard assessment, water quality assessment, flood inundation mapping and modeling; Drought monitoring; performance evaluation of irrigation commands; Selection of site for artificial recharge, agricultural management and planning	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books /Publishers	Year of Publication
1.	Burrough, P. A., "Principles of Geographic Information System for Land Resources Assessment", Clarendom Press.	1998
2.	Chandra, A.M. and Ghosh, S.K., "Remote Sensing and Geographic Information System", Narosa Publishers.	2007
3.	Jensen, J.R. "Remote Sensing of the Environment an Earth Resources Perspective", Pearson Education.	2003
4.	Lillesand, T. M. and Kiefer, R. W., "Remote Sensing and Image Interpretation", Fourth Edition, John Wiley.	2000
5.	Curan, P.J., "Principles of Remote Sensing", English Language Book Society, Longman.	1983

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR- 584** Course Title: **Cropping System 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: To impart knowledge on decision making in agro-techniques for crop cultivation.
10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Need of crop modeling, crop modeling, advanced crop cultivation techniques	4
2	**Constraint analysis:** Crop, soil and hydrological constraints, analysis of problems, remedies for optimal crop yield	4
3	**Agricultural lands problems:** Land and water degradation problems due to use of fertilizers, water and agro-chemicals	6
4	**Crop diversification:** Need, process and forms; Crop intensification, intensive cropping systems	4
5	**Systems approach:** Use of linear programming in crop planning and management	6
6	**Crop models:** Use of CROPWAT for yield estimation, water uptake and nitrogen uptake forecasting	6
7	**Decision support system (DSS):** Basic concepts, development of DSS for agro-technology transfer	6
8	**Remote Sensing & GIS application:** Introduction to remote sensing & GIS and application for yield forecasting	6
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Book /Publishers	Year of Publication/Reprint
1.	IBSNAT, "Decision Support System in Agrotechnology Transfer", International Benchmark Sites Network for Agrotechnology Transfer.	2004
2.	National Bureau of Soil Survey, "Agro-Climate Regional Planning in India", Indian Council of Agriculture and Research, Vol.1-2.	2004
3.	Thornily J.M. and Johnson, I.R., "Plant and Crop Modeling", Scientific Publication.	2009
4	Lillesand, T. M. and Kiefer, R. W., "Remote Sensing and Image Interpretation", Fourth Edition, John Wiley.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Managemer**

1. Subject Code: **WR- 585** Course Title: **Environmental Impact of Irrigated Agriculture**

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 environmental implications of intensive irrigated agriculture.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction**: Definition, basic environmental issues in irrigated agriculture, scope	4
2	**Ecology**: Flora and fauna in irrigated areas, soil and water-borne pathogens of crops and trees, fertility and productivity of lands	6
3	**Ecological adaptation:** Competition, adaptation and adoption of crop and weeds under variable soil moisture condition	4
4	**Nutrient and water balance**: Organic carbon, major and micronutrient requirements of crops and soils, nutrient and water use efficiency; Model studies in nutrient and water balance studies	6
5	**Soil, water and plant chemical analysis:** Collection of samples, preparation of standard solution and analysis; Use of advance techniques for chemical analysis	4
6	**Climatologically changes in irrigated areas:** Soil degradation; Crop extinction; Human and animal diseases	6
7	**Microclimate**: Micro environment study of field crops, instrumentation for microclimatic study	4
7	**Field studies:** Project work on field observation, recording of data and statistical analysis	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publishers	Year of Publication/Reprint
1.	Dougherty, T.C. and Hall, A. W., "Environmental Impact Assessment of Irrigation and Drainage Programme", FAO Irrigation and Drainage Paper.	1995
2.	Shiva, V., "Sustainable Agriculture and Food Security", Sage Publishers.	2002
3.	Wainwright, J., "Environmental Modeling Finding Simplicity and Complicity", John Wiley.	2004
4.	Jaiswal, P.C., "Soil, Plant and Water Analysis", Kalyani Publishers.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-586** Course Title: **Groundwater Development 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 impart knowledge on groundwater development and management for irrigation water management.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Use of groundwater and its impact on irrigation water management; Hydrologic properties of water bearing formation, occurrence, storage and distribution of groundwater; Use of groundwater zone maps; Groundwater resource assessment and budget	8
2	Surface investigations of groundwater; Well hydraulics- steady and unsteady flows; Water wells- test holes and well logs; Design, construction and development of shallow and deep wells, design of screen and gravel packs	8
3	Pumps and their selection, installation and testing of pumps; Monitoring and maintenance of wells, causes of failure	6
4	Ground water conservation and artificial recharge, sustained yield, water balance equation; Ground-water and surface-water interaction, interference of wells; Watershed conservation measures in irrigation commands	8
5	Groundwater flow parameter estimation; Groundwater simulation and conjunctive use models, comparative analysis for management of conjunctive use system	6
6	Groundwater quality- agricultural sources of pollution, causes and monitoring; Technical, socio-economic and organizational aspects of groundwater management	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publishers	Year of Publication/Reprint
1.	Bear, J., "Hydraulics of Groundwater", McGraw Hill.	1979
2	Karanth, K. R., "Groundwater Assessment, Development and Management", Tata McGraw Hill.	1987
3.	Rastogi, A.K., "Numerical Groundwater Hydrology", Penram International.	2007
4.	Raghunath, H.M., "Groundwater", New Age International.	2007
5.	Sharma, H.D. and Chawla, A.S., "Manual on Ground Water and Tube Wells", Central Board of Irrigation and Power.	1977
6.	Sterrett, R.J., "Groundwater and Wells", Smyth Companies.	2008
7.	Todd, D. K and Mays, L.W. "Groundwater Hydrology", John Wiley.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-587** Course Title: **Watershed Development 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 impart knowledge of watershed components, processes and management for soil and water conservation.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Components of watershed and need of watershed management; Principal factors influencing watershed operations; Delineation of watersheds; Engineering surveys; Data requirement	4
2.	Watershed hydrology, water resources assessment in watershed, hydrological cycle; Surface water assessment- rainfall-runoff analysis; Groundwater assessment, infiltration and its measurement	8
3.	Watershed Behavior- Physical elements of watershed, effects of land use changes on hydrological cycle components, watershed experiments	4
4.	Land capability classification; Erosion process- factors affecting erosion, types of erosion, soil erosion models	6
5.	Engineering measures for soil and water conservation- Contour bunding, graded bunding, bench terracing, land leveling and grading; Small storage structures- Types and design data requirement, loose boulder dams, gabions, check dams and their design criteria	8
6.	Rainwater harvesting, direct and indirect methods, filter design, planning and design; Layout and execution; Impact assessment, operation and maintenance issues	6
7.	Watershed management plan- Methodology of planning a watershed, identification of watershed problems, socio-economic issues including application of Remote sensing and GIS in watershed management	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publishers	Year of Publication/Reprint
1.	Das, G., "Hydrology and Soil Conservation Engineering", Prentice Hall.	2002
2.	Debarry, P. A., "Watershed: Processes, Assessment and Management", John Wiley.	2004
3.	Lyon, J. G., "GIS for Water Resources and Watershed Management", Taylor and Francis.	2003
4.	Schwab, G.O., Fangmeier, D.D., Elliot, W. J., Frevert, R. K., "Soil and Water Conservation Engineering", John Wiley.	2002
5.	Suresh, R., "Soil and Water Conservation Engineering", Standard Publishers.	2006
6.	Tideman, E.M., "Watershed Management", Omega Scientific Publisher.	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	PCC	4	3	1	-	3	-	25	-	25	50	-
4.		Program Core 2	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	PEC	4	-	-	-	-	-	-	-	-	-	-
2.		Major Elective II	PEC	4	-	-	-	-	-	-	-	-	-	-
3.		Major Elective III	PEC	4	-	-	-	-	-	-	-	-	-	-
4.		Major Elective IV	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 3rd Semester)	DIS	20	-	-	-	-	-	-	-		75	
		Sub Total		**20**										
		Total		**64-68**										

PROGRAMME 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

PROGRAMME ELECTIVES

1.	WR-511	System Design Techniques	PEC	4	3	1	-	3	-	25	-	25	50	-
2.	WR-512	Geotechnical Engineering	PEC	4	3	1	-	3	-	25	-	25	50	-
3.	WR-513	Hydropower and Appurtenant Works	PEC	4	3	1	-	3	-	25	-	25	50	-
4.	WR-514	Earth and Rockfill Dams	PEC	4	3	1	-	3	-	25	-	25	50	-
5.	WR-515	Masonry and Concrete Dams	PEC	4	3	1	-	3	-	25	-	25	50	-
6.	WR-516	Irrigation Structures	PEC	4	3	1	-	3	-	25	-	25	50	-
7.	WR-517	Rural and Urban Water Supply	PEC	4	3	1	-	3	-	25	-	25	50	-
8.	WR-518	River Engineering	PEC	4	3	1	-	3	-	25	-	25	50	-
9.	WR-519	Applied Hydrology	PEC	4	3	1	-	3	-	25	-	25	50	-
10.	WR-520	Finite Element Methods	PEC	4	3	1	-	3	-	25	-	25	50	-
11.	WR-521	Water Resources System Reliability	PEC	4	3	1	-	3	-	25	-	25	50	-
12.	WR-522	Environmental Impact Assessment of Water Resource Projects	PEC	4	3	1	-	3	-	25	-	25	50	-
13.	WR-523	Groundwater Hydrology	PEC	4	3	1	-	3	-	25	-	25	50	-
14.	WR-524	Climate Change and Water Resources	PEC	4	3	1	-	3	-	25	-	25	50	-
15.	WR-533	Substation and Transmission line Design	PEC	4	3	1	-	3	-	25	-	25	50	-
16.	WR-534	Power System Protection Applications	PEC	4	3	1	-	3	-	25	-	25	50	-
17.	WR-535	Installation Maintenance and Testing of Hydro Generating Equipment	PEC	4	3	1	-	3	-	25	-	25	50	-
18.	WR-536	Maintenance Management in Power Plants	PEC	4	3	1	-	3	-	25	-	25	50	-
19.	WR-537	Power System Management	PEC	4	3	1	-	3	-	25	-	25	50	-
20.	WR-538	Electrical Design of Hydro Power Station	PEC	4	3	1	-	3	-	25	-	25	50	-
21.	WR-539	Power System Operation and Control	PEC	4	3	1	-	3	-	25	-	25	50	-
22.	WR-540	Control and Instrumentation of Hydro Power Plant	PEC	4	3	1	-	3	-	25	-	25	50	-
23.	WR-541	Power System Analysis	PEC	4	3	1	-	3	-	25	-	25	50	-
24.	WR-542	Power System Reliability	PEC	4	3	1	-	3	-	25	-	25	50	-
25.	WR-543	Insulating Systems	PEC	4	3	1	-	3	-	25	-	25	50	-
26.	WR-544	Planning and Design of Small Hydro Power Schemes	PEC	4	3	1	-	3	-	25	-	25	50	-
27.	WR-554	Design of Construction Job Facilities	PEC	4	3	1	-	3	-	25	-	25	50	-
28.	WR-555	Construction Plant Machinery	PEC	4	3	1	-	3	-	25	-	25	50	-
29.	WR-557	Air Conditioning and Ventilation	PEC	4	3	1	-	3	-	25	-	25	50	-
30.	WR-558	Construction Techniques	PEC	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-511** Course Title: **System Design 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 the system design techniques and applications to water resources systems analysis, design and management.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**System concepts:** Boundary, environment, input, output and constraints; Open and closed systems; System modeling, water resources systems, issues in system application; Operation research approach to system analysis	4
2.	**Linear programming:** Model formulation, graphical method, simplex procedure- two phase, big-M, dual simplex, primal-dual simplex, modified simplex procedures; Upper bounded solutions, sensitivity analysis	8
3.	**Transportation problems:** Basic feasible solution techniques, testing for optimal solution; Integer and mixed integer problems, assignment problems, applications for efficient water resources management	8
4.	**Non linear programming (NLP):** Separable and convex programming problems, quadratic programming, unconstrained and constrained NLP problems, chance constrained programming, method of calculus, search techniques	6
5.	**Dynamic programming:** Optimality principle, deterministic and stochastic dynamic programming, application to water resources problems	8
6.	**Decision making:** Value and utility concepts, goal programming, decision theory and decision trees, decision making under risk and uncertainty, theory of games; Multi criteria decision making- distance based and compromise techniques	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprint
1.	Jain, S. K. and Singh, V. P., "Water Resources Planning and Management", Elsevier.	2003
2.	Loucks, D.P., Stedinger, J.R. and Haith, D.A., "Water Resources Systems Planning and Analysis", Prentice Hall.	1981
3.	Ravindran, A., Philips, D.T. and Solberg, J.J., "Operation Research- Principles and Practice", Second Edition, John Wiley.	2000
4.	Rao, S.S. "Optimization - Theory and Applications", Wiley Eastern.	1984
5.	Sharma, J.K., "Operations Research", Macmillan.	1997
6.	Taha, H.A., "Operation Research - An Introduction", PHI.	2002
7.	Wurbs, R.A. and James, W.P., "Water Resources Engineering", PHI .	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-512** Course Title: **Geotechnical 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 impart knowledge on theory and analysis of soil mechanics for design of water resources structures, compaction and consolidation.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Composition and classification of soil:** Importance of soil mechanics in water resources applications; Textural properties and their determination; Identification and classification of soils	4
2.	**Seepage analysis:** Flow net; Theory of seepage and analysis; Quick-sand phenomenon and seepage forces	5
3.	**Compressibility and consolidation:** Compressibility of soil; Terzaghi's theory of consolidation; Secondary consolidation	6
4.	**Shear strength of soils:** Friction; Mohr's circle; Strength theories for soils; Pore pressure parameters; Shearing characteristics of sand and clay	5
5.	**Stability of earth slopes:** Earth pressures; Stability of retaining walls; Bearing capacity; settlement analysis	4
6.	**Foundation**– Types of shallow foundation, foundation on nonuniform soils; Deep foundation; Design and construction of pile foundation	6
7.	**Engineering geology:** Classifications and properties of rocks, folds, faults, joints; Unconformities and their bearing on engineering structures; Geophysical and geological explorations for various engineering projects	6
8.	**Rock mechanics:** Theories of failure and strength of rock masses; Geological investigations of dams, reservoirs and tunnels; Design of rock anchors and cables for slopes, dam abutments and foundation	8
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Krynine, M. G. and Judd, W. R., "Principles of Engineering Geology and Geotechnics", McGraw Hills.	1957
2.	Obert, L. and Duvall, W.I., "Rock Mechanics and Design of Structure in Rock", John Wiley.	1967
3.	Punmia, B.C., "Soil Mechanics and Foundation", Standard Book House.	1981
4.	Terzagi, K., "Theoretical Soil Mechanics", John Wiley.	1943
5.	Venkatramaiah, C., "Geotechnical Engineering", New Age International	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-513** Course Title: **Hydropower and Appurtenant 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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **NIL**

9. Objective: To impart knowledge on various types of hydroelectric power stations and other related appurtenant works.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Surface hydro power stations**: Basic functional features and typical general arrangements; Classification of surface power houses, vertical sub-divisions, type of super structures; Overall layout, preliminary dimensions of various components, main floor levels	6
2.	**Arrangement at various floors:** Details of auxiliary equipment, arrangement at various floors, joints, collection of data, design and indexing of loads	6
3.	**Stability analysis of powerhouse:** Stability of substructures, intermediate structures and superstructures	6
2.	**Underground power stations**: Number and size of cavities, their location and alignment, auxillary equipments and their arrangement, supporting arrangements for roof and sides, design considerations, design of gantary girder column	6
3.	**Tunnels and shafts:** High head pressure tunnels and shafts, design considerations, design of concrete lining and steel liner, pre- stressed concrete lining, grouting and drainage	6
4.	**Surge tanks**: Characteristics and suitability of various types of surge tanks like simple, restricted orifice and differential types, criteria for design and stability, hydraulic design	4

5.	**Penstocks:** Water hammer phenomenon, velocity and pressure waves, estimation of over-pressures by arithmetic integration and by use of charts and curves, effects of over pressure on governing of turbines; Forces acting on penstock pipe lines and preliminary design of steel penstocks, fabrication and testing of penstocks; Design of anchors, piers and saddles	6
6.	**Switchyard**: Equipments in the switchyard and their layout, design of foundation	2
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Brown, Gutherie, "Hydroelectric Engineering Practice", Blackie and Sons.	1958
2.	Mosoyni, E., "Eater Power Development", Nem Chand and Brothers.	2009
3.	Nigam, P.S., "Handbook of Hydroelectric Engineering", Nem Chand and Brothers.	1979
4.	Varshney, R. S., "Hydro Power Structures", Nem Chand and Brothers.	2001
5.	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-514** Course Title: **Earth and Rock Fill 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 impart knowledge on design and analysis of earth and rock fill dams.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Materials properties of soils:** Pore pressure parameters; Hilf Bishop method; Shear strength of soils; Mohr Coulomb failure criterion; Factors contributing to slope failure	4
2.	**Design criteria:** Types of earth dams; Design considerations- Freeboard calculations, dam section, upstream slope protection; Design considerations in earthquake regions; Filter design; Causes of damage and failure, typical case studies.	6
3.	**Seepage control:** Control of seepage through earth dam on pervious soil foundation and on impervious base; Cutoff trench; Sheet pile; Alluvial grouting; Slurry trench; Horizontal upstream blanket; Relief wells; Loading berm; Treatment of rock foundations and grouting	8
4	**Stability analysis:** Total and effective stress methods of analysis; Standard method of slices, Simplified Bishop method; Wedge method; Stability conditions during construction, full reservoir and reservoir drawdown	8
5	**Analysis of dam:** Introduction to finite element method (FEM); FEM analysis of dams; Nonlinearity in soils	4
6	**Rockfill dam:** Considerations favouring choice of a rockfill dam; Principles of design; Selection of materials; Stability analysis by wedge method, Different types of impervious cores and their locations; Different types of face members; Settlement in rock fill dams; Procedure for placement and compaction of rock fill	5

7	**Instrumentation in earth dams:** Measurements of deformations, pore pressures; Quality control; Foundation preparation and treatment; Quality control of materials and control of moisture, laying and compaction; Tests for quality control; Diversion during construction	7
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprint
1	Abramson, L.W., Lee, T.S., Sharma, S. and Boyce, G.M., "Slope Stability and Stabilization Method", John Wiley.	1996
2	Creager, W. P., Justin J.D. and Hinds, "Engineering for dams", Wiley Eastern.	1968
3	Hirschfeld, R.C. and Poulos, S.J., "Embankment Dam Engineering - Casagrande Volume" , John Wiley.	1973
4	Sherard, J.L., Woodward, R.J., Gizienski, S.F. and Clevenger, W.A., "Earth and Earth-Rock Dams", John Wiley.	1963
5	Singh, B. and Sharma, H.D., "Earth and Rock Fill Dams", Sarita Prakashan.	1976
6	Singh, B. and Varshney, R.S., "Embankment Dam Engineering", Nem Chand and Brothers.	2004
7	Department of Interior, "Design of Small Dams", United States Bureau of Reclamation.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-515** Course Title: **Masonry and Concrete 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 impart knowledge on design and analysis of masonry and concrete dams.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Selection of site for different types of dams, selection of materials, layout of works; Properties of concrete as related to dams	4
2.	**Gravity Dams:** Forces acting on a dam including uplift and wave forces; Design criteria for stability; Determination of dam profile; Computation of stresses by gravity analysis; Elastic analysis by finite element method and structural modelling techniques; Seismic design and analysis; Determination of internal stresses	8
3.	**Foundation treatment:** Preparation of foundation including consolidation; Curtain grouting and treatment of faults and weak zones; Foundation cutoffs and drainage arrangements; Layout and location of spillway; Powerhouse and other appurtenances	5
4.	**Stressed and their management:** Stresses around openings; Design of galleries in dams; Temperature stresses and methods of temperature control; Joints and seals	7
5.	**Instrumentation and maintenance aspects:** Instrumentation and analysis of data; Deterioration of concrete in dams and remedial measures	6
6.	**Hollow and buttress dams:** Principles of hollow gravity dams; Stability criteria and determination of internal stresses	6
7.	**Arch dams:** Classification, principles of layout and factors affecting layout; Theories for arch dam analysis	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Creager, W. P., Justin J.D. and Hinds, "Engineering for Dams", Wiley Eastern.	1968
2.	Golze, A.R., "Handbook of Dam Engineering", Van Nostrand Reinhold.	1977
3	Sharma, H.D., "Concrete Dams", CBIP Publication.	1998
4	Department of Interior, "Design of Gravity Dams", United States Bureau of Reclamation.	1976
5	Department of Interior, "Design of Arch Dams", United States Bureau of Reclamation.	1977
6	Varshney, R.S., "Concrete Dams", Oxford and IBH Publishing.	1977

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-516** Course Title: **Irrigation 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: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **NIL**
9. Objective: To impart knowledge on the design of various irrigation structures.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Site selection and investigations for diversion works; Hydraulics of flow over weirs/under sluices; Hydraulic jump, seepage theory, Khosla theory, scour depth estimation, critical exit gradient	8
2.	Design flood estimation; Types and design of energy dissipaters; protection works, transitions	6
3.	Components of barrage- waterway, undersluice/weir, glacis, stilling basin and appurtenance works, cutoff, u/s and d/s protection works; Hydraulic design of barrage; Head regulator; Cross regulator	8
4.	Types of cross drainage works; Design aspects of aqueducts, siphon aqueducts, super-passage, siphon	6
5.	Concept of sediment removal, fall velocity, difference between sediment exclusion and ejection devices, design aspects of sediment excluder and sediment ejector	6
6.	Types of loads and their combinations; Structural design of raft foundation, piers, abutments, and retaining walls	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Singh, B., "Fundamentals of Irrigation Engineering", Nem Chand and Brothers.	2005
2.	Varshney, R.S., Gupta, S.C. and Gupta, R.L., "Theory and Design of Irrigation Structures", Nem Chand and Brothers.	2005
3.	Asawa, G.L., "Irrigation and Water Resources Engineering", New Age International.	2005
4.	Arora, K.R., "Irrigation, Water Power and Water Resources Engineering", Standard Publishers Distributers.	2007
5.	Garg, S.K. "Irrigation Engineering and Hydraulic Structures", Khanna Publishers.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-517** Course Title: **Rural and Urban Water Supply**
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 for planning, design, operation and maintenance of water supply schemes for rural and urban areas.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Planning and preparation of water supply schemes for rural and urban areas; Issues in water supply for hilly and coastal regions, regional and national perspective; Water pricing	6
2.	**Water Demand**: Population forecasting, assessment of domestic, fire, industrial and public demands, demand management	4
3.	**Water Supply Sources:** Surface and sub-surface, selection, protection, contamination protection zone, estimating potential yield and sustainability; Design of wells	8
4.	**Water Quality:** Drinking water quality parameters, comparison of international and national codes, physical and chemical treatment processes, disinfection and appropriate technologies for water treatment	9
5.	**Components of Intake Works:** Sizing water mains, pumps for water supply, pumping station, pipe appurtenances, pipe materials, laying of pipes, design of water distribution network and allied works.	6
6.	**Water Distribution Networks:** Flow through pipes, equivalent pipes, solving pipe network flow problems, use of computer software for network analysis	9
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Garg, S. K, "Water Supply Engineering", Khanna Publishers.	2008
2.	Jeppson, R., "Analysis of Flow in Pipe Networks", Ann Arbor Science.	1976
3.	Mays, L.W., "Urban Water Supply Handbook", McGraw Hill.	2002
4.	Ministry of Urban Development, "Manual on Water Supply and Treatment", CPHEEO, Government of India.	1999
5.	Peavy, H.S. and Rowe, D.R. and Tchobanoglous, G., "Environmental Engineering", McGraw Hill.	1985
6.	Qasim, S. R., Motley, E. M. and Zhu, G., "Water works engineering -Planning, design, and operation", PHI.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-518** Course Title: **River 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: The impart knowledge of river mechanics and various river management techniques.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Sediment Transport Processes:** Incipient motion of sediment particles; Regimes of flow; Resistance to flow and velocity distribution in alluvial streams; transport of bed, suspended and total load	8
2.	**River Morphology:** Plan form variations and river channel pattern; Meandering and braided stream characteristics; River equilibrium, river dynamics and adjustments to stream power	8
3.	**River Training Techniques:** Principles of stabilisation and rectification of rivers, river bank stability analysis, spur / groyne, stream bank armouring, guide banks, submerged vanes, porcupine and jack jetty systems, gabions; Bandalling, surface and bottom panels	8
4.	**Inland Navigation Channel Development:** Fairway dimensions and maintenance, canalization, navigation locks and terminals	5
5.	**River Models:** Mathematical modelling - types, mathematical formulation, numerical procedures, calibration and validation; Scale modelling – types, principles of similitude and dimensional analysis, model verification, limitations	8
6.	**Flood Management and Remote Sensing Applications:** Flood control planning, flood plain zoning and other non – structural measures, use of satellite imageries and topo sheets for DEM generation for flood plain zone mapping	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/ Reprints
1.	Blazejewski, R., Pilarczyk, K.W, and Przedwojski, B., "River Training Techniques: Fundamentals, Techniques and Applications", A. A. Balkema, Rotterdam.	1995
2.	Cunge, J. A., et. al., "Practical Aspects of Computational River Hydraulics", Pitman Advance Pub. Program.	1980
3.	Garde, R. J. and Rangaraju, K. G., "Mechanics of Sediment Transportation and Alluvial Stream Problems", New Age International (P) Ltd. Revised Reprint 3rd Edition.	2006
4.	Jansen, P. P., et. al., "Principles of River Engineering"; Pitman Publishing Co.	1979
5.	Julien, Pierre, Y., "River Mechanics", Cambridge University Press.	2002
6.	Peterson, Margaret, S., "River Engineering"; Prentice Hall.	1986
7.	Shen, H. W., "Modeling of Rivers", John Wiley and Sons.	1979

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-519** Course Title: **Applied Hydrology**
2. Contact Hours: **L: 3** **T: 1** **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 hydrologic aspects of investigations, planning, design and operations of river valley projects.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Hydrologic design requirements, hydrologic cycle, classification of processes and models	4
2.	**Hydrologic Data:** Observation and collection; Processing - supplementing, consistency checking, corrections and presentation	7
3.	**Frequency Analysis:** Probability distributions, statistical analysis, return period of flood and storm, outliers, regional flood frequency, confidence interval and goodness of fit	8
4.	**Rainfall runoff models:** Empirical, conceptual and physical; Unit hydrograph; Decisions with inadequate hydrologic data	8
5.	**Hydrologic Design:** Design criteria, dependable yield, design storm, design flood estimation, reservoir and channel routing	8
6.	**Flood Forecasting:** Travel time, correlation, telemetry, gage and discharge forecasting	4
7.	**Elements of Groundwater Hydrology:** Ground water recharge, ground water balance, aquifer properties	3
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Chow, V.T., Maidment, D. R. and Mays, L. W., "Applied Hydrology", Tata McGraw Hill.	1988
2.	Mishra, S.K. and Singh, V.P., "Soil Conservation Service-Curve Number Methodology", Kluwer Publication.	2003
3.	Mutreja, K. N., "Applied Hydrology" Tata McGraw Hill.	1986
4.	Subramanya, K., "Engineering Hydrology", Tata McGraw Hill.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-520** Course Title: **Finite Element Method**

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 fundamentals and applications of finite element method and its application to engineering problems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Finite difference method (FDM), finite element method (FEM), advantages of FEM over FDM and matrix algebra.	4
2.	**Basics of FEM:** Steps, formulation of element equations, shape functions for triangular elements, load and strain displacements, stress strain relations, variational principles	6
3.	**Weighted Residual Methods:** Collocation, sub-domain, Galerkin's and least square	4
4	**Shape Functions:** Linear elements, element equations, iso-parametric elements, Hermite polynomial, Jacobian matrix, numerical integration, two dimensional, Lagrangian, triangular and trapezoidal elements	8
5	**Solution Techniques:** Axisymetric problems - element equations, stiffness matrix, boundary conditions; Direct and Iterative methods, band solver and frontal solution techniques	8
6	**Applications of FEM:** Heat flow problems in one, two and three dimensions; Beams and trusses; Dams and seepage problems	8
7	**Software Applications:** Case studies, data preparation, processing and result reporting for field problems	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1	Desai, C. S., and Abel, J.E., "Introduction to Finite Element Method" , Van Nostrand Reinhold Company.	1972
2	Desai, C.S., and Christian, J.T., "Numerical Methods in Geotechnical Engineering", Mc Graw Hill.	1977
3	Hinton , E. and Owen, D.R. J., "Finite Element Programming", Academic Press.	1977
4	Norrie, D.H.; De Vries, G., "Introduction to Finite Element Analysis", Academic Press.	1978
5	Segerlind, L.J., "Applied Finite Element Analysis", John Wiley and Sons.	1976
6	Tirupathi, R. Chandrupatla and Belegundu, Ashok D. "Introduction to Finite Elements in Engineering", Pearson Education.	2002
7	Zienkiewicz, O.C., "The Finite Element Method", McGraw Hill.	1973

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-522** Course Title: **Environmental Impact Assessment of Water Resources Projects**

2. Contact Hours: **L: 3** **T: 1** **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: 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **NIL**

9. Objective: To impart knowledge on environmental aspects of river valley projects and methods for impact assessment and management.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Human concern; Need for environmental impact assessment (EIA); Requirements and levels of EIA; Potential impacts of water resource development projects	6
2.	**EIA Procedure:** Screening, baseline data, scoping, terms of reference (TOR)	4
3.	**Environmental Clearance:** Guidelines, acts and legislations, codes and country practices	4
4.	**Environmental flow:** River as habitat, downstream direct and indirect uses, criteria and methods of assessment	4
5.	**Soil and Water Quality Management:** Effect of project development on soil and water quality, water logging, soil salinity, and contamination, remedial measures	5
6.	**Rehabilitation:** Submergence effects, rehabilitation guidelines, planning, and procedures	4
7.	**Monitoring:** Parameters to be monitored, frequency of monitoring, reporting procedures	4
8.	**Remote Sensing and GIS Applications:** Monitoring of land use changes, digital elevation model (DEM), assessment of land degradation, catchment area treatment plan	6
9.	**Simulation Exercises and Case Studies**	5
	Total	42

11. Suggested Books:

S.No.	Name of Authors /Book /Publisher	Year of Publication/ Reprints
1.	Govt. of India, "Environmental Impact Assessment of Development Projects", Ministry of Environment and Forests.	1989
2.	Canter, L. W., "Environmental Impact Assessment", McGraw Hill.	1996
3.	Govt. of India, "EIA Notification 2006", Ministry of Environment and Forest.	2006
4.	Bureau of Indian Standards, "Parameters for EIA of Water resources Project", IS 5442:2004.	2004
5.	Burrough, P. A., "Principles of Geographic Information System for Land Resources Assessment" Clarendom Press.	1998
6.	Chandra, A.M. and Ghosh, S.K., "Remote Sensing and Geographic Information System". Narosa Publishers	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-523** Course Title: **Groundwater Hydrology**

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 groundwater behavior, characteristics and its hydrology.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Occurrence of groundwater sources; Groundwater bearing formations; Classification of aquifers; Flow and storage characteristics of aquifer; Hydrologic budget	4
2.	**Groundwater movement:** Darcy's law; Hydraulic conductivity and its determination; Anisotropy and heterogeneity; Groundwater flow rates and directions, governing equations for groundwater flow; Analytical solutions, general flow equation; Unsteady flow	6
3.	**Well hydraulics:** Steady unidirectional and radial flow; Unsteady radial flow in confined and unconfined aquifers; Leaky aquifer; Determination of aquifer parameters; Pumping tests and analysis; Well flow near different boundaries; Multiple well systems; Interference of wells	6
4.	**Groundwater wells:** Types and features of each type of wells; Well development, yield test	4
5.	**Groundwater quality:** Indian and international standards; Pollution of groundwater and possible sources; Remedial and preventive measures	4
6.	**Groundwater flow modeling:** Need of groundwater flow models; numerical modeling, 2D and 3D groundwater flow models; MODLFOW and its application	6

7.	**Conjunctive use planning:** Planning of groundwater development; Conjunctive use models, constraints, application in water resources management	6
8.	**Groundwater conservation:** Regional groundwater budget; Resource assessment; Estimation of recharge; Artificial recharge; Rainwater harvesting	6
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Bear J., "Hydraulics of Groundwater" McGraw Hill.	1979
2.	Delleur, J.W., "The Handbook of Groundwater Engineering", Springer Verlag	1998
3.	Rastogi, A.K., "Numerical Groundwater Hydrology", Penram International	2007
4.	Todd, D. K. and Mays L.W., "Groundwater Hydrology", John Wiley.	2005
5.	Walton, W.C. "Groundwater Resources Evaluation" McGraw Hill.	1970

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-524** Course Title: **Climate Change and Water Resources**

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 concepts of climate change and impact assessment of climate change on water resources.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to atmospheric science; Earth, its atmospheric cycle and its relation with climate; Green house gas and climate change; Earth and green house effect; Past climate change; Lessons from history; Present and future climate changes	7
2.	Ecological effect on freshwater systems- surface water, ground water and glaciers; Agriculture; Marine environment; Causes, human dimension- impact of human settlement and infrastructure, environmental quality	8
3.	Analysis for climatic change assessment, statistical analysis of long-term meteorological and hydrological data; Trend analysis	8
4.	Available climatic models such as GCM; Hydrologic models such as SWAT and Mike11; Downscaling of GCM to regional/local scales	8
5.	Mitigation- capture of sequester carbon emissions, reducing global warming, renewable energy technologies, efficient use of energy	6
6.	Policy, laws, economics, benefits and costs of mitigating climate change, international cooperation	5
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Dowden, M., "Climate Change and Sustainable Development-Law, Policy and Practice", EG-Books.	2008
2.	Hardy, J.T., "Climate Change-Causes, Effect and Solutions", John Wiley.	2003
3.	Las, D.S., "Climatology", Sharda Pustak Bhawan.	2005
4.	Mirza, M.M.Q. and Ahmed, Q.K., "Climate Change and Water Resources in South Asia", A.A. Balkema Publishers, Taylor and Francis Group.	2005
5.	Rohil, V.R. and Vega, A.J., "Climatology", Jones and Bartlett.	2008
6.	Schubert, R., Hammerschmidt, G. and Scheu, H., "Climate Change as a Security Risk", Earthscan.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-533** Course Title: **Substation and Transmission Line 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 planning and design of EHV lines, substation, their equipment characteristics and specifications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Transmission system planning including selection of voltage, AC and DC transmission systems, number of circuits	4
2.	Travelling waves, lightning phenomenon, lightning and switching surges, surge wave shapes over voltages in power systems- types lightning, switching and temporary control of over voltage, statistical characteristics of over voltage; Flashover characteristics of rods gaps and insulators	8
3.	Characteristics of lightning arresters and protective devices, selection of lightning arresters, insulation coordination, location of protective devices, direct stroke protection, protection of transformers, surge protection of generators	6
4.	Electrical design of overhead lines, choice of conductor, voltage regulation, losses, charging KVA requirements; Surge impedance loading; Stability considerations; Corona and radio interference characteristics	6
5.	Survey of transmission lines, plotting of profiles, planning and locating line supports; Inductive coordination between power and communication lines; Series and shunt compensation	6
6.	Design of various HV and EHV substations, switching and busbar schemes, typical layouts, oil and compressed air systems	4

7.	Power transformers- specification, types, rating electrical characteristic, insulation temperature rise	4
8.	Circuit breakers- types, ratings, electrical characteristics	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Begamudre, R.D., "EHV AC Transmission Engineering", New Age International.	2006
2.	Edison Electric Institute, "EHV Transmission Line Reference Book", General Electric.	1968
3.	EPRI., "Transmission Line Reference Book : 345 KV and Above", Wiley Eastern.	1990
4.	Gupta, P.V. and Satnam, P.S., "Substation Design and Equipment", Dhanpat Rai.	1983
5.	Pabla, A.S., "Electric Power Distribution", Tata McGraw-Hill	2004
6.	Bayliss, C.R., and Hardy, B.J., "Transmission and Distribution Electrical Engineering", Elsevier India.	2009
7.	McDonald, J.D., (Ed), "Electric Power Substation Engineering", CRC Press.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-534** Course Title: **Power System Protection 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 impart knowledge on power system protection applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Principles of power system protection application	2
2.	Current and voltage transformers– characteristics and application	6
3.	Electro-mechanical, static and microprocessor-based relays	6
4.	Electrical protection of generators and generator transformers	6
5.	Protection of transformers for electrical and incipient faults	4
6.	Different types of electrical protection applicable to bus zones	4
7.	Protection of transmission lines by over current, pilot-wire, distance and with carrier application	8
8.	Protection of single phase and three phase motors- induction and synchronous types; Protection of reactors, capacitor banks and industrial power systems	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	GEC Measurements, "Protective Relays - Application Guide"', General Electric.	1987
2.	Patra, S.P., Basu, S.K. and Choudhuri, S., "Power System Protection", Oxford and IBH Publishing.	1983
3.	Rao, T.S.M., "Power System Protection– Static Relays", McGraw Hill.	1981
4.	Mason, C.R., "The Art and Science of Protective Relaying", Wiley Eastern.	1984
5.	Blackburn, J.L., Domin, T.J., "Protective Relaying Principles and Applications", CRC Press.	2007
6.	Anderson, P.M., "Power System Protection", McGraw Hill.	1999
7.	Hewitson, L., Brown, M. and Ramesh, B., "Practical Power Systems Protection", Newnes.	2005
8.	Singh, R.P., "Digital Power System Protection", Prentice-Hall.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-535** Course Title: **Installation, Maintenance and Testing of 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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **NIL**

9. Objective: To impart knowledge on erection and commissioning of hydro turbine, generator and transformers in hydropower projects.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Basic components of hydro turbines, pre-requisite for erection of hydro turbine, erection of under water parts, concreting of embedded parts, erection of internal parts for Francis, Kaplan, Deriaz and Pelton turbines (vertical type), erection precision	10
2.	Erection of vertical large generator	4
3.	Hydraulic model testing of hydro turbines and on-site testing	4
4.	Pre-commissioning and commissioning tests on generator	6
5.	Erection of large power transformers, commissioning tests and preventive maintenance tests of solid and liquid insulation, reconditioning and reclaiming methods of insulating oil	4
6.	Preventive maintenance testing of generator insulation	4
7.	Routine and preventive maintenance and capital maintenance of hydro turbines and generators	4
8.	Testing of protective relays, over current, impedance and directional relays	4
9.	Preventive maintenance and its scheduling, maintenance of records, record keeping and analysis	2
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Carr, L. H. A., "The Testing of Electrical Machines", The Book Centre.	1963
2.	Walker, J. H., "Large AC Machines – Design, Manufacture, and Operation", BHEL.	1979
3.	Kerszenbaum, I., "Inspection of Large Synchronous Machines", IEEE Press.	1996
4.	Gill, P., "Electrical Power Equipment Maintenance and Testing", CRC Press.	2009
5.	Clemen, D.M., "Hydro Plant Electrical Systems", Penn Well.	1999
6.	Agarwal, K.C., "Electrical Power Engineering Reference and Applications Handbook", Knowledge Books.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-536** Course Title: **Maintenance Management in Power Plants**

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 policies and schedules of maintenance and strategies for power plant equipments.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Importance of maintenance, objectives, functions, maintenance management strategies for hydro power stations and their organization.	4
2.	Maintenance policies and planning- maintenance strategies and their advantages and disadvantages, planned maintenance procedure, advantage of planned maintenance, scientific maintenance, safety in maintenance	8
3.	Maintenance activities- optimal overhaul, repair or replacement policies for equipments subjected to breakdown, budgeting and control, production maintenance integration	8
4.	Replacement decisions- economic models, replacement policy, economics of preventive maintenance	8
5.	Maintainability and availability- economics of maintainability and reliability, maintainability increment, equipment availability	8
6.	Management information systems for maintenance	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Clifton, R.H., "Principle of Planned Maintenance", McGraw Hill.	1983
2.	Cunningham, C.E., "Applied Maintainability Engineering", John Wiley.	1972
3.	Enthory, K., "Maintenance Planning and Control", EWP.	1984
4.	Heintzelman, "The Complete Handbook of Maintenance Management", Prentice Hall.	1976
5.	Morse, P.M., "Queues, Inventories and Maintenance", Wiley.	1958

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-537** Course Title: **Power System 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 on the organization and management of power utilities.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Management and its goals- management processes, managerial skills and performance, policy and objectives of a power utility; electricity industry and market- main concerns of electric utilities, performance of electric utilities, power sector changes	8
2.	Financial accounting of utility- balance sheet, income statement, accounting for depreciation, interest charges during construction, financial performance analysis	4
3.	Investment proposal- interest and compounding, measure of price- public and private perspective, internal rate of return and pay-back period	4
4.	Cost of generation, levellisation of cost of generation; Tariff for electricity- objectives, traditional approach, long-run marginal costs, general principles of tariff design	6
5.	Dynamic, spot and real time pricing strategy, bidding strategies	4
6.	Concepts and methods of demand side management (DSM)- load control, energy efficiency, load management, DSM planning, design, marketing, customer incentives	4
7.	Fundamentals of deregulation- privatization and deregulation, necessity for restructuring the power industry, necessity of unbundling of generation, transmission and distribution	4

8.	Components of restructured systems, independent system operators, functions and responsibilities, trading arrangements (pool, bilateral and multilateral), open access transmission system	4
9.	Different models of deregulation- Indian model, UK model, California model, Australian and New Zealand models, Japan model, Thailand model	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Bartol, K.M. and Martin, D. C., "Management" McGraw Hill.	1994
2.	Gellings, C.W. and Chamberlain, J.H., "Demand side Management : Concepts and Methods," Fairmont Press.	1988
3.	Lai, L.L., "Power System Restructuring and Deregulation," John Wiley.	2001
4.	Levy, H. and Sarnat, M., "Capital Investment and Financial Decissions," Prentice Hall.	1994
5.	Shahidehpur,M. and Alomoush, M., "Restructured Electrical Power Systems, Operation, Trading and Volatility," Marcel Dekker.	2001
6.	Stickney, C.P. and Weil, R.L., "Financial Accounting", Dryden Press.	1994
7.	Stoft, S., "Power System Economics: Designing Market for Electricity," IEEE Press, Wiley –Interscience.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-538** Course Title: **Electrical Design of Hydro Power Stations**

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: **WH-511**

9. Objective: To impart knowledge on the design criteria and principles of electrical system design of hydroelectric stations.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Selection of turbine and generating equipment for conventional, small hydro and pumped storage stations	4
2.	Types of pumping schemes- sources of power for pumping, starting of reversible units, pumped storage plant operation in the system, economics, choice of site, choice of plant	4
3.	Design and dimensional parameters of the turbine and generators; Cavitation and turbine setting	6
4.	Planning and layout of electrical equipment in a conventional, small hydro and pumped storage stations- case studies; Turbine governing, speed and pressure regulation, relief valves, frequency control	8
5.	Auxiliary power supply system design and equipment, power and control cables and their ratings	4
6.	Auxiliary system design and equipment for DC system and batteries, lighting system, grounding system, control and annunciation system and internal communication system	8
7.	Auxiliary system design involving air conditioning and ventilation system, lubricating oil system, fire protection system, power house crane and drainage and dewatering systems	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Brown, J. G., "Hydro-electric Engineering Practice, Vols. I - III", CBS Publishers.	1984
2.	Bureau of Indian Standards, Indian Standards Specifications and Guidelines (Relevant) on the equipment and systems.	Latest edition
3.	Prasad, M., Arora, J.K., Mathur, G.N. and Kanjia, V.K.,"Manual on Earthing of AC power Systems," Central Board of Irrigation and Power.	2007
4.	ASME Hydro Power Technical Committee, "The Guide to Hydropower Mechanical Design", Penn Well.	1996
5.	DiLaura, D., Houser, Mistrick, R. and Steffy, G., (Ede.), "The IES Lighting Handbook", IES.	2011
6.	Agarwal, K.C., "Electrical Power Engineering Reference and Applications Handbook", Knowledge Books.	2007
7.	Clemen, D.M., "Hydro Plant Electrical Systems", HCI Publications.	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-539** 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 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 judicious power system operation and control.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Modelling of generator, load, prime-mover, governor and excitation system	6
2.	Modelling of governor and excitation system	4
3.	Probabilistic methods for generation planning	4
4.	Unit commitment- spinning reserve, thermal unit constraint, hydro constraints and solution methods	4
5.	Long-term and short-term hydro-generation scheduling	4
6.	Hydro-thermal scheduling- problem formulation and solution	4
7.	Interchange evaluation- economy, capacity, diversity emergency power, inadvertent power exchange, energy banking	4
8.	Power pools- energy broker system, centralized economic dispatch of a power pool, allocating pool savings	4
9.	Power system security evaluation, factors affecting power system security, contingency analysis	4
10.	Power system state estimation- maximum likelihood weighted least squares estimation, detection and identification of bad data, application of power system state measurement	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Cohn, N., "Control of Generation and Power flow on Interconnected Systems", Wiley.	1966
2.	El-Hawary, M.E. and Christensen, G.S., "Optimal Economic Operation of Electric Power Systems", Academic.	1979
3.	Kirchmeyer, L.K., "Economic Operation of Power Systems", Wiley.	1958
4.	Kothari, D.P, "Power System Engineering", Tata-McGraw Hill.	2008
5.	Sterling, M.J.H., "Power System Control", Peregrinus.	1978
6.	Wood, A.J., Woolenberg, Bruce, F., "Power Generation Operation and Control", John Wiley.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-540** Course Title: **Control and Instrumentation of Hydro Power Plant**

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 imparting knowledge on control and instrumentation of hydro power plants.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Essentials of measurement, implementation and scope of instrumentation; Performance characteristics, accuracy, response time, reliability and availability, types of equipment	6
2.	Measurement techniques and instruments for temperature, pressure, level, flow, speed, vibration, electric power and power factor measurement	10
3.	Strip-chart and X-Y recorders of galvanometric and servo types- magnetic recorder; FM recording technique; Indicating and display devices	4
4.	Control room instrumentation- design factors and validation, operator interface and ergonomics, computer based displays	4
5.	DC, AC pulse and digital telemetry, signal transmission media	8
6.	Automation schemes in hydro-electric power plants for start and stop operation	4
7.	Elements and functions of SCADA system, automatic controllers closed loop control; On-off, proportional, PI and PID controllers, pneumatic and electronic controllers, automatic controllers in hydro-electric plant	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Jervis, M.W. (Ed.),"Power Station Instrumentation," Butterworth Hienemann.	1993
2.	Johnson, C.D., "Process Control Instrumentation Technology," John Wiley.	1977
3.	Rangan, C.S., Sarma, G.R. and Mani, V.S.N., "Instrumentation Devices and System", Tata Mc-Graw Hill.	1983
4.	Cegrell,T., "Power System Control Technology", Prentice Hall.	1986
5.	Littler, D.J., Davies, E.J., Johnson, H.E., Kirkhy, F., Myerscough, P.B. and Wright, W., "Modern Power Station Practice (Vol. F)", ASM International.	2008
6.	Bolton, W., "Instrumentation and Control Systems", Newnes	2004
7.	Northrop, R.B., "Introduction to Instrumentation and Measurements", CRC Press.	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-541** Course Title: **Power System 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 impart knowledge on power systems analysis.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Complex power in balanced transmission lines, per unit system, constant impedance representation of the loads, three winding transformers, autotransformers, delta-wye and wye - delta transformations	4
2.	Disturbance of normal operating conditions, fault types and their analysis, symmetrical components, sequence networks balanced three phase faults at no load and full load, analysis of unbalanced faults, application of current limiting reactors	4
3.	Load flow analysis, Gauss iterative method, Gauss-Seidel iterative method and its applications; Y_{bus}, application of acceleration factors, application of Gauss-Seidel method Z_{bus}; Newton - Raphson method and its applications in rectangular coordinates and polar coordinates; Decoupled load flow method, fast decoupled load flow method, DC load flow method	10
4.	Linear models of the synchronous machine, steady-state equations and phasor diagrams, initial conditions for a multi-machine system, analog and digital simulation of synchronous machine	10
5.	Excitation systems- control configuration, response, state-space description, computer representation, typical system constants, effect of excitation on generator performance	4
6.	Speed governing, modeling of governing system for hydro turbines	4
7.	Modeling of hydraulic turbine prime movers, conduits, surge tanks and penstocks, hydraulic system equations, hydraulic system transfer function, block diagram for a hydro system	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Anderson, P.M. and Fouad, A.A., "Power System Control and Stability", Wiley Interscience.	2003
2.	Gonen, T., "Modern Power System Analysis", Wiley.	1998
3.	Nagrath, I.J. and Kothari, D.P., "Power System Engineering", Tata McGraw-Hill.	1994
4.	Nagrath, I.J. and Kothari, D.P., "Modern Power System Analysis", Tata McGraw-Hill.	1994
5.	Murty, P.S.R., "Power System Operation and Control", Tata McGraw-Hill.	1984
6.	Kundur, P., "Power System Stability and Control", McGraw Hill.	1994
7.	Das, J.C., "Power System Analysis", Marcel Dekker.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-542** Course Title: **Power System Reliability**

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 reliability techniques used for design and planning of power systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Basic probability theory, binomial distribution, Poisson distribution, normal distribution, adequacy and security evaluation	4
2.	Basic reliability concepts- general reliability function, exponential distribution, mean time to failure, series and parallel systems, Markov and continuous Markov processes, recursive techniques; Other Markov applications- simple series and parallel system models	4
3.	Component reliability- non-repairable components, hazard models, components with preventive maintenance, repairable components, ideal repair, ideal repair and preventive maintenance, repairable components, normal repair and preventive maintenance	4
3.	Static generating capacity reliability evaluation-capacity outage probability tables, the loss of load probability method, load forecast uncertainty, the loss of energy probability method, frequency and duration approach	6
4.	Spinning generating capacity reliability evaluation-spinning capacity evaluation, load forecast uncertainty, derated capacity levels	4
5.	Transmission system reliability evaluation-average interruption rate method, frequency and duration method, stormy and normal weather effects, Markov process approach, system studies	4
6.	Composite system reliability evaluation- service quality criterion, conditional	4

	probability approach, simple system application, two-plant single load systems, two-plant two load systems, networked system approach	
7.	Interconnected system generating capacity reliability evaluation- probability array for two systems, loss of load approach, reliability evaluation in more than two systems, interconnection benefits	4
8.	Direct current transmission system reliability evaluation- system failure modes, loss of load approach, frequency and duration approach, Spare valve assessment, multiple bridge equivalents	4
9.	Assessment of reliability worth- interruption cost for commercial users, industrial users, residential users and interruption energy assessment rate	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Billinton, R. and Allan, R.N., "Reliability Assessment of Large Electric Power System", Kluwer Academic.	1988
2.	Billinton, R., Ringlee, R.J. and Wood, A.J., "Power System Reliability Calculations", The MIT Press.	1978
3.	Endrenyi, J., "Reliability Modeling in Electric Power Systems", John Wiley.	1979
4.	Elmakais, D., "New Computational Methods in Power System Reliability", Springer – Verlag.	2008
5.	Billinton, R. and Allon, R.N., "Reliability Evaluation of Power Systems", Springer.	2006
6.	Pansini, A., "Transmission Line Reliability and Security", Marcel Dekker.	2004
7.	Brown, R., "Electric Power Distribution Reliability", Marcel Dekker.	2002
8.	Chawdhury, A.A. and Koval, D.O., "Power Distribution System Reliability – Practical Methods and Applications", John Wiley.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-543** Course Title: **Insulating 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 knowledge on insulating systems and their characteristics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Electrical conduction of dielectrics, volume resistance, electrical conduction in metals, semi-conductors and dielectric, band theory of solids, ionic and molionic electrical conduction of dielectrics, electrical condition of gases, dependence of resistivity of dielectric on various factors, surface conduction of dielectrics	6
2.	Polarization of dielectrics, relationship between capacitance and resistance of an insulator, polar and non-polar dielectric, polarization, dependence of permittivity on various factors, electric fields in non-homogeneous dielectrics, mechanical forces in dielectric	6
3.	Dielectric losses, basic definitions and equations, dependence of tan delta on various factors, dielectric losses under non-sinusoidal voltage	4
4.	Breakdown of dielectrics, breakdown of gaseous, liquid, solid dielectrics	4
5.	Non-linear dielectrics, ferroelectrics, capacitors with a barrier layer, piezoelectrics; Properties of dielectrics, wetting thermal and radiation properties	4
6.	Insulation of power transformers, construction of the insulation of power transformers, transient processes in transformer windings, internal protection of transformers, testing of transformer insulation	4

7.	Insulation of high voltage rotating machines and its construction, puncture voltages of the insulation of rotating machines, methods of elimination of corona in the insulation of rotating machines, transient phenomena in windings of electrical machines, testing of the insulating systems	4
8.	Insulation of high voltage power cables, types and construction, oil fuel cables, testing of cable insulations, insulation of power condensers, paper impregnated condenser insulation	3
9.	Preventive testing of insulation, measurement of tan delta and capacitance, partial discharges and methods of its detection, preventive testing of bushings, suspension and post insulators, preventive testing of transformer insulation, preventive testing of insulation rotating machines, preventive testing of cables with viscous impregnation	7
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Razevig, D.V. and Chourasia, M.P., "High Voltage Engineering", Khanna Publishers.	1978
2.	Tareev, B., "Physics of Dielectric Materials", English Translation, Mir Publishers.	1979
3.	Stone, G.C., Boulter, E.A., Culbert, I. and Dhirani, H., "Electrical Insulation for Rotating Machines", Wiley Interscience.	2004
4.	Malik, N.H., Al-arainy, A.A. and Qureshi, M.I., "Electrical Insulation in Power Systems", Taylor & Francis.	1997
5.	Arora, R. and Mosch, W., "High Voltage and Electrical Insulation Engineering", Wiley.	2011
6.	James, R. and Su, Q., "Condition Assessment of High Voltage Insulation in Power Equipment", The Institution of Engineering & Technology.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-544** Course Title: **Planning and Design of Small Hydro Power Scheme**

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 planning and design of small hydro power schemes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Small hydro definition and country status, government policy for renewable energy development including small hydro, basic components of a small hydro scheme	4
2.	Hydrology, regional flow duration models, rainfall-runoff modeling for small catchments, flow duration, considerations for environmental flow	4
3.	Planning and design of diversion, intake, desilting and water conductor system	8
3.	Types of turbines for small hydro, their characteristics, construction and selection of turbine	6
4.	Synchronous and induction generators– characteristic, specification and application	4
5.	Power evacuation system, design, control systems	4
6.	Planning and design of auxiliary systems– cooling water, drainage and dewatering, ventilation and lighting	3
7.	Protection of synchronous and induction generators, protection of transformer and transformer feeder	3
8.	Economic and financial analysis of small hydro projects	3
9.	Case Studies– low, medium and high head small hydro projects	3
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Masonyi, E., "Water Power Development , Vol.I, and Vol.II, Part A and B", Nem Chand and Brothers.	2009
2.	Nigam, P.S., "Hand Book of Hydro Electric Engineering", Nem Chand and Brothers.	1985
3.	USBR, " Design of Small Dams," SBS.	2006
4.	Fritz, J.J., "Small and Mini Hydropower Systems", McGraw Hill.	1984
5.	Bureau of Indian Standards, Indian Standards Specifications and Guidelines (Relevant) on the Equipment and Systems.	Latest Edition
6.	Singh, A.N., Parasuraman, M.P., Tyagi, S.P., Ghose, D.P. and Ajwani, M.G., "Manual on Planning and Design of Small Hydroelectric Schemes", CBIP.	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-554** Course Title: **Design of Construction Job Facilities**

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 different facilities required for construction of water resources development projects and their design.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Requirements of material handling, mechanization of material movements on construction for construction sites for handling of earth and concrete	3
2.	Belt and bucket conveyors, bucket elevators, screw conveyors and calculations for sizes and capacities of conveyors including design of principal components	8
3.	Selection of type and design of pneumatic conveyors for conveying bulk cement	4
4.	Hoisting equipment and its design and selection for different working conditions	4
5.	Selection of type and design of cable-ways for aerial transportation and placement of concrete	5
6.	Design of compressed air and water supply system on construction projects; Estimating construct ion power requirements	6
7.	Design and layout of plant for production of aggregates including scalping crushing screening, washing, stockpiling and reclaiming	8
8.	Planning for shop services; base and field workshops; layouts for workshops and principal workshop equipment; equipment for structural fabrication.	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Author /Book /Publisher	Year of Publication/Reprints
1.	Havers, J.A. and Stubbs, F. Jr., "Handbook of Heavy Construction", 2nd Edition, McGraw-Hill.	1971
2.	**Peurifoy, R.L., Schexnayder, C.J., Shapira, A. and Schmitt, R., "Construction Planning, Equipment, and Methods", Tata McGraw Hill.**	2010
3.	Peurifoy, R.L., Schexnayder, C.J. and Aviad, S., "Construction Planning, Equipment and Methods", Mcgraw-Hill Series in Civil Engineering.	2002
4.	Varma, M., Construction Equipment and its Planning and Application, 3rd Edition, Metropolitan.	1983

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-555** Course Title: **Construction Plant Machinery**
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 construction equipment and machinery for water resources development projects.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Mechanized nature of modern construction and responsibilities of mechanical engineers on construction projects, functional classification of construction equipment; Different types of prime movers, power ratings, power available, useable power, power requirements	8
2.	Grade-ability and pull ability, analysis of combined influence of rolling resistance and traction on ability to negotiate grade and ability to pull trailing load by track-mounted and wheel-mounted construction equipment	8
3.	Analysis and application of different types of planetary, hydraulic and hybrid transmissions for track-mounted and wheel-mounted construction equipment	6
4.	Analysis and application of different types of mechanical, hydraulic, electric and hybrid controls for steering and braking of track-mounted and wheel-mounted construction equipment	6
5.	Equipment specifications and procurement procedures, old versus new and indigenous versus imported equipment; Performance computations and production estimates	6
6	Sizing, matching and efficient utilization for optimal production of principal construction plant and machinery	4
7	Cost accounting, maintaining records and preventive maintenance of construction plant and machinery	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Author /Book /Publisher	Year of Publication/Reprints
1.	Nunnally, S. W., "Construction Planning, Equipment, and Methods", Eighth edition, Pearson.	2010
2.	**Peurifoy, R.L., Schexnayder, C.J., Shapira, A. and Schmitt, R., "Construction Planning, Equipment, and Methods", Tata McGraw Hill.**	2010
3.	Varma, M., "Construction Equipment and its Planning and Application", Metropolitan.	1983
4.	Wong, J.Y., "Theory of Ground Vehicles", John Wiley.	1978

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-557** 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 impart knowledge on various aspects of air-conditioning and ventilation systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Types of air-conditioning systems, design conditions, heat transfer coefficients for indoor and outdoor conditions	8
2.	**Load Estimation:** Refrigeration and air conditioning load estimation, heat gains through structures	8
3.	**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.	8
4.	**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
5.	**Air-conditioning and ventilation ducts:** Layout and design	8
6.	**Others:** Refrigerants; System noise and its control, Environmental issues; Controls for air conditioning and ventilation systems	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Arora, C.P., "Refrigeration and Air conditioning", Tata-McGrawHill.	1998
2.	ASHRAE, "ASHRAE Handbooks", ASHRAE.	2006
3.	Howell, Ronald, H., Sauer, Harry J. and Coad, William J., "Principles of Heating, Ventilating, and Air Conditioning: A Textbook with Design", American Society of Heating, Refrigerating, and Air-Conditioning Engineers.	2010
4.	Tobias, H. , and Otto, K., "Air Conditioning Systems: Performance, Environment and Energy Factors", Nova Science Pub.	2010
5.	William, M. J., William, C. W., Eugene, S. and John, A. T., "Refrigeration and Air Conditioning Technology", Delmar Pub..	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WR-558** Course Title: **Construction 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 aspects of construction techniques for water resources development projects.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Construction planning, job and resource planning, construction scheduling, mechanization in heavy construction, construction plant and its functional classification	4
2.	Selection of type, size and number of construction equipment and techniques for excavation at borrow-pits, transportation from borrow-pits to fill sites, placement, compaction, and quality control for construction of embankments and earth and rockfill dams	6
3.	Selection of type, size and number of construction equipment and techniques for manufacture, transportation, cooling, placement and quality control of concrete for construction of concrete dams/spillways/other structures	8
4.	Selection of type, size and number of construction equipment and techniques for tunneling and underground powerhouses in squeezing, weak, moderate and sound strata	6
5.	Flood frequencies for design of river diversion works, techniques for river diversion, economical height of coffer dams and diameter of diversion tunnels; Different techniques for dewatering, design of pumping and well-point dewatering systems	6
6.	Foundation treatment of concrete and earth dams; Consolidation and curtain grouting, dental treatment and cutoff trenches	6
7.	Equipment and techniques for aggregate recovery, processing and conveyance; Construction utility services	6
	Total	**42**

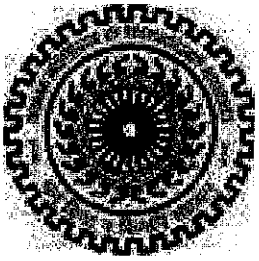
11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/ Reprints
1.	Nunnally, S. W., "Construction Planning, Equipment, and Methods", Eighth edition, Pearson.	2010
2.	**Peurifoy, R.L., Schexnayder, C.J., Shapira, A. and Schmitt, R., "Construction Planning, Equipment, and Methods" Tata McGraw Hill.**	2010
3.	Sharma, S.C., "Construction Equipment and its Management", Khanna Publishers.	2007
4.	Varma, M., "Construction Equipment and its Planning and Application", Metropolitan.	1983

APPENDIX 'F'
Item No.SENATE/36.2.2

M.Tech. Syllabus

(Spring Semester)



Department of Physics
Indian Institute of Technology Roorkee
Roorkee – 247 667

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-702** Course Title: **Nanomaterials and Technology**
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. Subject Area: **PEC**

8. Pre-requisite: **NIL**

9. **Objective of Course:** To impart knowledge of nanomaterials and technology

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Physics of Low-dimensional Materials:** An overview of quantum mechanical concepts related to low dimensional systems, classifications of quantum confined systems, electrons and holes in quantum wells, electronic wave functions, energy sub-bands and density of electronic states in quantum wells, quantum wires and quantum dots	10
2.	**Synthesis and Characterization of Nanomaterials:** various top down and bottom up approaches for synthesis of nanomaterials, overview of thin film technology for nanotechnology applications, physical vapour deposition and chemical vapour deposition techniques, synthesis of zero, one dimensional and two dimensional nano structures, characterization of nano materials using XRD, AFM, STM, FESEM and SQUID	12
3.	**Properties of Nano Materials:** Phenomena and properties at nanoscale, mechanical/frictional, optical, electrical and magnetic properties	08
4.	**Nanofabrication and Device Applications**: Miniaturization of electrical and electronic devices, Moore's law, nanofabrication using lithography techniques-electron beam lithography, X-ray lithography, soft nanolithography and dip pen nanolithography; electronic devices based on nanostructures, single electron transistor, future of silicon computer technology, heat dissipation and Rapid Single Flux Quantum (RSFQ) technology, quantum dot lasers, superconducting Josephson junctions, energy storage and fuel cells	12
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/Reprint
1.	Edelstein A. A. and Cammarata R .C., "Nanomaterials-Synthesis, Properties and Applications", Institute of Physics Publishing, London	**1998**
2.	Nalwa H.S., "Handbook of Nanostructured Materials and Nanotechnology", Vols. 1-5, Academic Press	**2000**
3.	Benedek G., Milani P. and Ralchenko V. G., "Nanostructured Carbon for advanced Applications", Kluwer Academic Publishers	**2001**
4.	Dresselhaus M.S., Dresselhaus G. and Eklund P., "Science of Fullerenes and Nanotubes", Academic Press	**1996**
5.	Wilson M, Kannangawa K, Smith G, Simmons M and Raguse B., "Nanotechnology: Basic Science and Emerging Technologies", Chapman and Hall	**2002**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-704** Course Title: **Quantum Heterostructures**

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. Subject Area: **PEC**

8. Pre-requisite: **NIL**

9. **Objective of Course:** To impart knowledge of size-quantization in nanosystems and semiconductor heterostructure quantum devices

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Electrons in Quantum Confined Systems:** Density of states function in quantum wells, quantum wires, quantum dots and super lattices, coupling of quantum wells, Type-I and Type-II heterostructures	10
2.	**Electron Transport in nanostructures:** Parallel and perpendicular transport in quantum structures, linear electron transport, hot electron transport, real space transfer of hot electrons	08
3.	**Quantum Tunneling:** Single and double barrier cases, resonant tunneling, resonant tunnel diode characteristics and mechanisms, resonant tunnel transistors	08
4.	**Heterostructure Devices:** Super lattices and ballistic-injection devices, Block oscillations, Wannier-Stark energy ladder, single electron transfer and Coulomb blockade, velocity modulation interference transistors (vmt)	08
5.	**Quantum Optical Devices:** Quantum well lasers, multiple quantum well lasers, cascade lasers, optical modulators and quantum well photodetectors	08
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/Reprint
1.	Mitin V.V., Kochelap V. A. and Stroscio M. A., "Quantum Heterostructures: Microelectronics and Optoelectronic Devices", Cambridge University Press	1999
2.	Ferry D.K. and Goodnick S.M., "Transport in Nanostructures", Cambridge University Press	1997
3.	Shik A., "Quantum Wells: Physics and Electronics of Two-Dimensional Systems", World Scientific	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-706** Course Title: **Functional 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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **NIL**

9. **Objective of Course:** To impart knowledge of functional materials and devices

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Scope of functional ceramics, classification according to their different functions, electrical and electronic conduction in ceramics, defect chemistry, ionic conductivity, ceramic electrolytes and fast ion conductors, ceramic insulators; Ceramic Capacitors, piezoelectric, ferroelectric and electro optic ceramics - material systems, processing and fabrication	10
2.	Electroceramic thin film technology, materials and deposition methods, application of thin films in microelectronics and microsystems; Multilayer ceramic technology- processing of multi layer ceramics, sintering of multilayer structure, low temperature co-fired glass ceramics	10
3.	Smart functional role of the materials in devices which depends on their electrical, optical and thermal properties, smart transducers, optical fibers, optical coatings, liquid crystal displays, optical storage devices, ruby laser, solar cell, ceramic insulators, Peltier cooler	8
4.	Ceramic sensors and resistors- classification, operating principles of different sensors, preparation and applications; Positive and negative temperature coefficient ceramic thermistors, gas, humidity and pressure sensors, ZnO-varistors technology, varistor microstructure and fabrication, Varistor application	7
5.	Ceramic membranes- classifications, material requirements, preparation and applications, special glass and glass ceramics for defence applications	7
	Total	42

11. Suggested Books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/Reprint
1.	Buchanan R. C., "Ceramic Materials for Electronics", 3rd Ed, Marcel Dekker, NY	2004
2.	Moulson A. J. and Herbert J. M., "Electroceramics: Materials, Properties and Applications", Wiley; 2nd Ed.	2003
3.	Bachs H. and Krause D., "Low Thermal Expansion Glass Ceramics", Springer	2005
4.	Setter N., "Electroceramic based MEMS: Fabrication Technology and Applications", Springer	2005
5.	Nenov T. G., Yordanov S. P. and Nenov N., "Ceramic Sensors: Technology and Applications", CRC Press	1996
6.	Wang Z. L., Wang W. Z. L. and Kang Z. C., "Functional and Smart Material", Springer	1998
7.	Jaffe B., Cook W. R., Jaffe H. and Jaffe H. L. C., "Piezoelectric Ceramics", R.A.N Publishers	1990

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-708** Course Title: **Superconducting 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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **NIL**

9. **Objective of Course:** To impart knowledge of superconductivity and superconducting materials

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Characteristic Properties of Superconducting Materials and Basic Theories:** Zero resistance, Meissner effect, critical magnetic field, critical current density, Type-I and Type-II superconductors, isotope effect, flux quantization, thermal properties of superconductors, heat capacity, thermal conductivity, energy gap, London's equations, outline of Ginzberg Landau theory, outline of BCS theory	10
2.	**Superconducting Materials:** Superconducting elements, binary alloys and compounds, organic superconductors, high-T_c cuprate superconductors, C_{60} based superconductors, MgB_2 superconductor, Fe-based superconductors	7
3.	**Processing and Characterization of High T_c Materials:** Various techniques of synthesis of HTSC phase of cuprate superconductors in bulk, thin films, single crystals and tape/wires forms, various techniques of electrical, magnetic and structural characterizations of HTSC materials	8
4.	**Critical Current of Type-II Superconductors:** Mixed state, stable and metastable states, the Abriksov lattice, flux flow, flux pinning, flux creep, irreversible properties, depairing critical current, hysteresis cycle- Bean model, effects of grain boundaries on J_c in high-T_c superconductors	6
5.	**Josephson Effects:** Tunnel effect, NIN, NIS and SIS junctions, dc and ac Josephson effect, dc and rf SQUIDS	6
6.	**Technology and Applications:** Large scale and high current applications of superconductors, Superconducting Electronics and film applications	5
	Total	42

11. Suggested Books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/Reprint
1.	Kittel C., "Introduction to Solid State Physics" John Willey	**1996**
2.	Rose-Innes A. C. and Rhoderich E. H., "Introduction to superconductivity", Pergamon Press	**1969**
3.	Ramakrishnan T.V. and Rao C.N.R., "Superconductivity Today", Pergamon Press.	**1992**
4.	Michel C. and Davor P., "Introduction to Superconductivity and High Tc Materials", World Scientific	**1992**
5.	Burns G., "High Temperature Superconductivity – An Introduction", Academic Press	**1991**
6.	Kresin V.Z. and Wolf S.A., "Fundamentals of Superconductivity", Plenum Press	**1990**
7.	Tinkham M., "Introduction to Superconductivity", Dover Publications	**2004**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-710** Course Title: **Solid State Devices and Circuits**

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. Subject Area: **PEC**

8. Pre-requisite: **NIL**

9. **Objective of Course:** To impart knowledge of semiconductor devices and circuits

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Carrier injection across pn-junction, derivation of ideal pn-diode current equation, capacitances and resistances in pn-diode, diode equivalent circuit, Doping profiles in BJTs; low-frequency BJT-model; base-transit time and high frequency limitations of BJT; hybrid-model; Ebers – Moll model and charge-control analysis, time-variation of stored charge in pn-junctions, reverse recovery transient, turn-on and turn-off transients in BJT	10
2.	Conduction mechanism in JFET, operating principles of MOSFETs (NMOS and PMOS), MOSFET – current – voltage relationships; NMOS- inverter; CMOS- structure and its properties, CMOS – as circuit element	10
3.	FET – biasing, cascaded amplifiers and different coupling methods, bandwidth of cascaded amplifiers, emitter follower, source follower and Darlington – pair; cascade configuration, amplifier response to pulse, band width requirement for pulse amplification, power transistor	10
4.	Positive and Negative feedback- effects of negative feedback on amplifier input and output resistances, voltage-series, current-series, current-shunt and voltage-shunt feedback, feedback and amplifier stability, gain and phase margins, conditions for oscillations, resonant circuit oscillators; circuit requirement for oscillations, oscillator analysis, crystal oscillator	12
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/Reprint
1.	Streetman B.G. and Banerjee S., "Solid State Electronic Devices", 6 Ed. Prentice Hall	**2006**
2.	Millman J., Halkias C. and Satyabrata J., "Electronic Devices and Circuits", McGraw Hill	**2007**
3.	Tyagi M.S., "Introduction to Semiconductor Material and Devices", John Wiley	**1991**
4.	Schilling D., Belove C., Apelewicz T. and Saccardi R., "Electronic Circuits: Discrete and Integrated", Tata McGraw Hill	**2002**
5.	Nagrath I.J., "Electronics: Analog and Digital", Prentice Hall	**2004**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-712** Course Title: **Optoelectronics**

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. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: **To impart knowledge of photons and semiconductors physics of optoelectronic devices**

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Interaction of photons with atoms, spontaneous emission, stimulated emission and absorption, line broadening, the laser amplifier, theory of laser oscillation, characteristics of laser output, characteristics of common lasers	6
2.	Semiconductors- energy bands and charge carriers, binary, ternary and quaternary semiconductors, generation, recombination and injection processes, junctions, hetrojunctions, quantum wells, superlattices, interaction of photons with electrons and holes, band-to-band absorption and emission, rates of absorption and emission, refractive index	8
3.	Light emitting diodes, injection electroluminescence, LED characteristics, semiconductor laser amplifier, gain, pumping, hetrostructures, semicunductor injection lasers, amplification, feedback and oscillation, power, spectral distribution, mode selection, characteristics of typical semiconductor lasers, quantum well lasers	8
4.	Properties of semiconductor photodetectors, quantum efficiency, responsivity, response time, Photoconductors- photodiodes, p-n and p-i-n photodiode, hetrostructure photodiodes, array detectors, avalanche photodiodes, noise in photodetectors	7
5.	Principles of electron optics, Pockels and Kerr effects, electro-optic modulators and switches, scanners, directional couplers, spatial light modulators, electro-optics of anisotropic media and liquid crystals, photorefractive materials	6
6.	Integrated optic planar waveguides, mechanism of light guidance, integrated optic components, directional coupler, optical fiber, step-index, graded-index, single-mode fibers, optical fiber components, fused fiber coupler, fiber Bragg gratings, long-period fiber gratings, sources for optical transmitters, detectors for optical receivers, fiber-optic systems	7
	Total	42

11. Suggested Books:

S. No.	Authors/Name of Books/Publisher	Year of Publication
1.	Saleh B. E. A. and Teich M. C., "Fundamentals of Photonics", John Wiley and Sons, Inc.	1991
2.	Ghatak A. and Thyagarajan K., "Optical Electronics", Cambridge University Press	2003
3.	Yariv A, "Quantum Electronics", 3 Ed., John Wiley and Sons	1988
4.	Streetman B.G. and Banerjee S., "Solid State Electronic Devices", 6 Ed. Prentice Hall	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-714** Course Title: **Semiconductor Micro-Electronic Technology**

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. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. **Objective:** To impart knowledge of physics of semiconductor devices and their fabrication technologies.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Crystal Growth and Epitaxy:** Single crystal growth techniques of Silicon and GaAs, epitaxial growth techniques, structures and defects in epitaxial layers, thermal oxidation of silicon including the Deal-Grove model	10
2.	**Film Formation:** Vacuum science, vacuum technology and basic physics of a plasma, thermal oxidation of Si, deposition of SiO_2 film by CVD technique	7
3.	**Lithography:** Optical and nonoptical lithography, electron beam lithography, X-ray lithography, etching techniques- wet and dry etch processes including reactive ion and high density plasma etching	8
4.	**Impurity Doping:** Impurity diffusion in semiconductors, diffusion mechanisms, and rapid thermal processes, diffusion process, diffusion equation, diffusion profiles, evaluation of diffused layers, ion implantation- range of implanted ions, ion distribution, ion stopping, ion channeling, implant damage and annealing	9
5.	**Integrated devices:** Fabrication of active and passive components in an integrated circuit, bipolar, MOSFET and MESFET technologies	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/Reprint
1.	Sze S.M., "Semiconductor Devices: Physics and Technology", John Wiley and Sons	2002
2.	Streetman B.G. and Banerjee S., "Solid State Electronic Devices", 6 Ed. Prentice Hall	2006
3.	Gandhi S.K., "VLSI Fabrication Principles", John Wiley and Sons	1994
4.	Nagchoudhuri D., "Microelectronic Devices", Pearson	2001
5.	Jaeger R. C., "Introduction to Microelectronic Fabrication", 2nd Ed., Prentice Hall	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Physics**

1. Subject Code: **PH-716** Course Title: **Semiconductor Photonics**

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. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of optical processes in semiconductors

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Fundamental Optical Processes:** Fundamental absorption, exciton absorption, relationship between optical constants, radiative transitions, non-radiative recombination	04
2.	**Maxwell Equations:** Photons and density of states, Maxwell equations, electromagnetic radiation in vacuum and matter, photons and related aspects of quantum mechanics and dispersion relations	03
3.	**Interaction of Light with Matter:** Laws of refraction, reflection, transmission at the interface and Fresnel formula, Febry Perot modes, birefringence and dichorism, optical activity	03
4.	**The Concept of Polariton:** Polaritons as new quasi particles, dispersion relation of polaritons, common optical properties of polaritons, surface polaritons	07
5.	**Cavity Polaritons to Photonic Crystals:** Cavity polaritons, photonic crystals and photonic band gap structure, metamaterials	07
6.	**Excitons and Biexcitons:** Frenkel excitons, correction to the simple exciton model, biexcitons, bound exciton complexes, exciton in disordered systems	04
7.	**Optical Properties of Phonons:** Phonons in bulk semiconductors, reflection spectra, Raman scattering, phonon polaritons, Brillouin scattering, surface phonon polaritons	05
8.	**Optical Properties of Plasmons:** Surface plasmons, Plasmon phonon mixed states	04
9.	**Optoelectronic Devices:** light emitting diodes, different types of laser diodes, detectors	05
	Total	42

11. Suggested Books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/Reprint
1.	Pankove J. I., "Optical Processes in Semiconductors", Prentice Hall	1971
2.	Klingshirn C. F. , "Semiconductor Optics", Springer	2007
3.	Rogach, A., "Semiconductor Nanocrystal Quantum Dots", Springer	2008
4.	Reed G. T., "Silicon Photonics: An Introduction", John Wiley and Sons	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-718** Course Title: **Magnetic Materials and Spintronics**

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. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. **Objective of Course:** To impart knowledge of magnetic materials and spintronics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Review of theories of dia-, para- and Ferromagnetism:** Langevin diamagnetism, Langevin paramagnetism of insulators, Pauli paramagnetism of metals, Curie-Weiss theory of ferromagnetism exchange integral; Ferrimagnetism- Theory of antiferro- and ferrimagnetism, ferrimagnetic oxides, ferrites and iron garnets, crystal and magnetic structure of these oxides	10
2.	**Magnetic Domain Structure:** The concept of magnetic domain, domain wall, magnetostatic energy, magnetic anisotropy, pair model of magnetism, anisotropy coercive force and hystersis, magnetostriction, mechanism of magnetostriction; Measurement of magnetic quantities- measurement of magnetic field strength, magnetization, magnetostriction and magnetic anisotropy	10
3.	**Magnetic Materials and Applications**: Materials for permanent magnets, permalloy, rare earth permanent magnets, fine particle magnets, precipitation hardened alloy, oriented anisotropic alloys, soft magnetic materials, iron-silicon alloys, iron-nickel alloys, ferrites, electromagnetic properties, microwave applications, magneto optical properties and devices, magnetic materials for switching applications, magnetic bubbles, magnetic garnets, materials for recording tape	12
4.	**Spintronics:** Spin-polarized transport and magneto resistive effect spin injection and optical orientation, generation of spin polarization, spintronic devices and applications, F/I/S tunneling, F/I/F tunneling, spin transistors, spin field-effect transistors.	10
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/Reprint
1.	Chikazumi S., "Physics of Magnetism", Oxford University Press	2002
2.	Tebble R.S. and Craik D.J., "Magnetic Materials", John Wiley and Sons	1969
3.	Smit, J., "Magnetic Properties of Materials", McGraw Hill	1971
4.	Dragoman M. and Dragoman D., "Nanoelectronics Principles and Devices", 2 Ed., Artech House Publishers	2008
5.	Cullity B.D. and Graham C.D. "Introduction to Magnetic Materials", IEEE Computer Society Press	2008
6.	Bandyopadhyay S., "Introduction to Spintronics", CRC Press	2008
7.	Shinjo T., "Nanomagnetism and Spintronics", Elsevier	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-720** Course Title: **Electronic Instrumentation and Design 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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. **Objective of Course:** To impart knowledge of complex systems and design techniques.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Overview:** Systems and mathematical modeling	2
2.	**Complex Systems:** Algebra of Fuzzy sets and relations, artificial neural networks, genetic algorithms, complex systems and Zadeh's principle	6
3.	**Discrete Mathematics:** Partially ordered sets, boolean algebra, isomorphism of boolean algebra to power set, statement calculus, predicate calculus, knowledge representation in intelligent systems	6
4.	**Measurement Systems:** Static performance order of instruments, dynamic performance, response of system to step, pulse and sinusoidal inputs in time and Laplace domains, design examples	7
5.	**Control Systems:** The terminology and block diagrams, transfer functions, stability, PID controller, design examples, fuzzy control systems	7
6.	**Digital Systems:** Discrete signals, sampling theorem, design of large combinational logic circuits, synchronous and asynchronous sequential networks, design of counters, design of generalized counters as controllers, timing consideration in design, Mealy machine, Moore machine, algorithm state machine, ASM charts based design of digital systems	14
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/Reprint
1.	Kolman B., Busby R. C., Ross S. C. and Rehman N., "Discrete Mathematical Structures" Pearson Education	2008
2.	Doebelin E.O., "Measurement Systems", 5 Ed., Tata McGraw Hill,	2008
3.	Hsu H.P., "Signal & Systems", Tata McGraw Hill	2004
4.	Ross T.J., "Fuzzy Sets with Engineering Application", McGraw Hill	1997
5.	Kuo B. "Automatic Control Systems", Prentice Hall	2008
6.	Givone D. D., "Digital Principle and Design", Tata McGraw Hill	2002

APPENDIX 'G'
Item No.SENATE/36.2.2

M.Tech Syllabus

(Surface Water, Ground Water & Watershed Management)

Department of Hydrology
Indian Institute of Technology Roorkee
Roorkee – 247 667

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department /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 Book Company	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.	Linsley, R.K., Kohler, M.A., and Paulhus, J.L.H., "Hydrology for Engineers", McGraw Hill	1982
6.	Herschy, R.W.(Ed.), "Hydrometry: Principles and Practices", Wiley Intersciences	1978
7.	Mays, L.W., "Water Resources Engineering", John Wiley & Sons	2001
8.	Todd D.K. and Mays L., "Ground Water Hydrology", John Wiley & Sons	2005
9.	Frevert R.K., Schwab G.O., Edminister, T.W. and Barnes, K.K., "Soil and Water Conservation Practices", John Wiley & Sons	1990

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department /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 [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: The objective is to introduce computer programming using 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	5
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	3
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
	Total	**28**

List of Practicals:

i. Development of programs for statistical analysis of hydrological time series viz rainfall, discharge and temperature etc.
ii. Development of programs for randomness and trend analysis of hydrological data.
iii. Development of programs for discharge computations using area-velocity methods, time-area methods etc.
iv. Development of programs for spatial interpolation and areal distribution of hydrological data like rainfall, high frequency groundwater levels etc.
v. Development of program using OOP in C++ for systematic data storage and retrieval for a river catchment.
vi. MATLAB programs for statistical analysis for hydrological time series.
vii. Programming in VBA for computation of runoff using various methods.
viii. 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 the Department /Centre: **Department of Hydrology**

1. Subject Code: **HY- 513** Course Title: **Hydrometeorology**

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: **Both**

7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the fundamental physical principles of atmospheric science

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Atmosphere:** General circulation, composition and structure of atmosphere, role of meteorology in hydrology	4
2.	**Precipitation Process**: Adiabatic process, stability and instability of atmosphere	3
3.	**Atmospheric Thermodynamics:** Equation of state, Dalton's of partial pressure, Poisson's law, equivalent potential temperature, concept of air parcel, virtual temperature, dry adiabatic and saturated adiabatic lapse rates, hydrostatic equilibrium equation, dispersion of air pollutants	6
4.	**Clouds**: Classification, formation and characteristics	4
5.	**Climate**: Preparation of climatological norms, climate classification; Preparation, analysis and interpretation of weather forecast	6
6.	**Monsoon**: Monsoon circulation, monsoon troughs, monsoon depression and tropical cyclones	4
7.	**Instrumentation:** Hydrometeorological instrumentation, observations, use of radar and satellites in hydrology	4
8.	**Storm Analysis**: Storm selection, storm maximization probable maximum precipitation, meteorological homogeneity, storm transposition	5
9.	**Climate Change:** General circulation models, regional climate models, scenario generation, and dynamic and statistical downscaling	6
	Total	**42**

List of Practicals:

i. Setup of Hydrometerology Lab and equipments.
ii. Observation of Hydrometerology parameters.
    - Temperature
    - Wind direction
    - Rainfall
    - Evaporation
    - Humidity
    - Solar radiation
    - Atmospheric pressure
iii. Compilation and Processing of Hydrometerology data.

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Berry I.A., "Handbook of Meteorology", McGraw Hill	1973
2.	Donn , W., "Meteorology", Mc Graw Hill	1975
3.	Wallace, J.M. and Hubbs, P.V., "Atmospheric science – An Introductory Survey", Academic Press	1977
4.	"Manual for Estimation Probable Maximum Precipitation", World Meteorological Organization, Operational Hydrology Report	1986
5.	"Damage Potential of Tropical Cyclones", Technical Report, India Meteorology Department.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Hydrology**

1. Subject Code: **HY- 514** Course Title: **Hydrogeology**

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: **Both**

7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the basic geological concepts in occurrence and movement of groundwater.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Hydrogeology and its scope, hydrologic cycle and its relation to groundwater, classification of natural waters, merits and demerits of groundwater, age of groundwater, basic geology	4
2.	**Classification of Aquifers:** Hydrological classification of geological materials, types of aquifers, geological formations as aquifers	4
3.	**Hydraulic Properties of Aquifers and Related Materials:** Porosity and its estimation, factors controlling porosity, hydraulic conductivity and methods of its estimation, transmissivity, storativity, specific yield leakage factor, hydraulic resistance and specific capacity	4
4.	**Occurrence and Movement of Groundwater:** Geological controls in occurrence and movement of groundwater, role of land forms, geological structures, stratigraphic and sedimentation controls, geographic distribution of aquifer materials	4
5.	**Methods of Groundwater Exploration**: Geomorphological and geological techniques, hydrological techniques, remote sensing and its application in groundwater targeting, indicators of groundwater, use of geophysical techniques in pinpointing water well locations	5
6.	**Drilling Techniques:** Methods of shallow well drilling, percussion, hydraulic rotary, reverse rotary and down the hole hammer techniques	3
7.	**Ground Water in Different Geological Formations:** Hydrogeology of crystalline rocks, volcanic rocks, clastic and carbonates rocks and	6

	unindurated sedimentary formations, ground water quality in various geological formations.	
8.	**Preparation of Hydrogeological Maps:** Geologic and hydrogeological maps, field methods of hydrgeological mapping, representation of hydrogeological data on geological maps	4
9.	**Ground Water in Regions of Climatic Extremes:** Occurrence and movement of groundwater in Arid and semi-arid regions and in glacial regions, groundwater management and quality in different regions	4
10.	**Hydrogeological Divisions of India:** Groundwater provinces of India and their hydrogeological features, aquifer characteristics and yield of wells, management of groundwater	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Davis, S. and Dewiest, R.J.M., "Hydrogeology", John Wiley & Sons	1966
2.	Fletcher, F.W., "Basic Hydrogeologic Methods", Technomic Publishing Company	1997
3.	Karanth, K.R., "Hydrogeology", McGraw Hill	1989
4.	Singhal, B.B.S. and Gupta, R.P., "Applied Hydrogeology of Fractured Rocks", Kluwer Publishers	1999
5.	Soliman, M. M., La Moreaux, P.E., Memon, B.A. , Assad, F.A. and La Moreaux, J.W., "Environmental Hydrogeology", Lewis Publishers	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKE

NAME OF DEPTT./CENTRE: **Department of Hydrology**

1. Subject Code: **HY- 516** Course Title: **Channel and 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: The objective is to introduce the fundamentals of hydraulics of open channel flow and fluvial hydraulics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Review of fundamentals of hydraulics, hydrostatics and hydrodynamics	3
2.	**Energy Depth Relationships:** Open channel flow, basic features, uniform flow, critical flow, specific energy, specific energy diagram, flow transitions, momentum principles, hydraulic jumps and computer assisted calculations	8
3.	**Gradually-Varied Flow Theory:** Steady state gradually varied flow, governing differential equation, characteristics and classification; step methods, direct integration method, graphical integration method of water surface profiles, computer oriented algorithms	8
4.	**Unsteady Flow:** Transient gradually varied flow, Saint Venant's equations, simplified hydraulic routing methods- diffusion wave theory, kinematic wave theory, approximate convection–diffusion equations, overland flow theory, computer oriented algorithms	8
5.	**Fluvial Hydraulics:** Introduction, bed forms, incipient condition, sediment load-bed, suspended and total loads, field measurements	8
6.	**Design of Channels:** Regime channels, design of stable channels-critical tractive force approach	4
7.	**Softwares:** Overview of hydraulic modeling softwares	3
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Chow, V.T., "Open Channel Hydraulics", Mc Graw Hill	1959
2.	Garde, R.J. and Rangaraju, K.G., "Mechanics of Sediment Transportation and Alluvial Stream Problems", New Age International	2000
3.	Ranga Raju, K.G., "Flow Through Open Channels", Tata-Mc Graw Hill Publisher Company Ltd.	2009
4.	Subramanya, K., "Flow in Open Channels", Tata-Mc Graw Hill Publisher Company Ltd.	2009
5.	Henderson, F.M., "Open Channel Flow", Macmillan Publishing Company, Inc.	1966
6.	Chanson, H., "The Hydraulics of Open Channel Flow: An Introduction", Elsevier-Butterworth-Heinemann Company	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Hydrology**

1. Subject Code: **HY- 518** 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: **Both**

7. Subject Area: **PEC** 8. Pre-requisite: **Nil**

9. Objective: To introduce the principles of water resources planning and management including engineering and economic aspects.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Principles of water resources planning and management	2
2.	**Reservoir Capacity and Yield:** Finding reservoir capacity and yield using mass curves	3
3.	**Flow-duration Curve:** Determination of flows of various dependabilities using Ranking method and Class interval method	3
4.	**Reservoir Sediment Distribution:** Sediment distribution using empirical area reduction method and area increment method	2
5.	**Conjunctive Water-use Planning:** Combined use of surface and groundwater	3
6.	**Reservoir Operation and Flood Routing:** Reservoir routing using Pul's method for flood control, reservoir operation using SOP and Zoning methods	5
7.	**Integrated River-basin Development:** Inter basin river water transfers - modeling for trans-boundary river basins in India, river water disputes - modeling of various Indian river water disputes using reservoir yield models, environmental aspects of water resources projects	9
8.	**Cost-benefit Analysis**: Mathematics of finance, discounting technique; Financial analysis	5
9.	**Reservoir Planning:** single purpose reservoir and multipurpose reservoir	4
10.	**Software Application:** Some useful softwares for planning water resources projects	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Goodman, A.S., "Principles of Water Resources Planning", Prentice Hall Inc	1984
2.	James, L.D. and Lee, R.R., "Economics of Water Resources Planning", Mc Graw Hill	1971
3.	Warnic, C.C., "Hydropower Engineering", Prentice Hall Inc	1984
4.	Wood, A.J. and Wollenberg, B.F., "Power Generation, Operation and Control", John Wiley & Sons	2003
5.	Mays, L.W., "Water Resources Engineering", John Wiley & Sons	2007
6.	Mays, L.W., "Water Resources Handbook", McGraw-Hill	1996
7.	Mays, L.W., "Water Resources Sustainability", McGraw Hill	2007
8.	Stephenson, D., "Water Resources Management", A.A. Balkema Publishers	2003
9.	Dandekar, M.M., and Sharma, K.N., "Water Power Engineering", Vikas Publishing House	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Hydrology**

1. Subject Code : **HY - 522** Course Title : **Stochastic Hydrology**

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 probability and stochastic models for the modelling of hydrologic processes and the basic tools required for forecasting, simulation and frequency prediction.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Definition, objectives, components and importance of time series analysis	4
2.	Analysis for trends and periodicity using non-parametric and parametric tests, peridogram, and, P_{max} and P_{min} test for selection of significant harmonics; Tests for short term and long term dependence	8
3.	Application of AR, MA, ARMA, ARIMA models in data generation and forecasting	5
4.	Synthetic data generation using Thomas Fiering models, transition probability matrix method and multisite models	5
5.	Simple and multiple linear regression, artificial neural network for regression	4
6.	At site, at site regional and regional frequency analysis; graphical and analytical methods for normal lognormal Gumbel GEV and generalized logistic distributions, Index flood method and L moments based methods, Goodness of fit tests like Chi square, K-S test and L moments based tests	8
7.	Analysis of low flows, forecasting of low and high flows, graphical and analytical methods, models adopted by Central Water Commission	5
8.	Auto correlation and spectral analysis, range and storage analysis	3
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors/Books/Publisher	Year of Publication
1	Box G. P. and Jenkins G.M., "Time Series Analysis: Forecasting and Control", Holden Day Publisher	1976
2	Clarke R.T., "Mathematical models in Hydrology", FAO Publication no. 19	1973
3	Hosking J. R. M. and Wallis J. R., "Regional Frequency Analysis: An Approach Based on L-Moments", Cambridge University Press	2005
4	Haan C.T., "Statistical Methods in Hydrology", The lowa State University Press	1977
5	Kottegoda N.T., "Stochastic Water Resources Technology", John Wiley & Sons	1980
6	Maidment, D.R., "Handbook of Hydrology", Mc Graw Hill Inc	1993
7	"Manual on Flood Forecasting", River Management Wing, Central Water Commission, India	1989
8	Reddy P.J., "Stochastic Hydrology", Laxmi Publications Ltd	1987
9.	Salas J.D., Delleur J.W., Yevjevich V. and Lane W.L., "Applied Modeling of Hydrologic Time Series", Water Resources Publications	1980
10.	Yevjevich, V., "Stochastic Processes in Hydrology", Water Resources Publications	1972

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Hydrology**

1. Subject Code: **HY- 524** Course Title: **Geohydrology**

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: **Both**

7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide concepts of basic hydrogeology, exploration for groundwater, well hydraulics and groundwater management.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Basics:** Introduction and scope of geohydrology and hydrogeology, merits and demerits of groundwater, hydrological cycle and its relation to groundwater, hydrological classification of geological materials	2
2.	**Geological Influences on Groundwater Occurrence and Movement:** Control of geomorphologic land forms, geological structures, stratigraphy and sedimentation, geographic distribution of aquifer materials	4
3.	**Aquifer types and Hydraulic Properties of Aquifers:** Porosity and hydraulic conductivity and their estimation, Darcy law, transmissivity, storativity, hydraulic resistance, leakage factor, specific capacity	4
4.	**Occurrence and Movement of Groundwater in Different Geologic Formations:** Hydrogeology of crystalline, volcanic rocks, consolidated sedimentary and carbonate rocks and unindurated sedimentary formations	4
5.	**Methods of Ground Water Exploration:** Geological, Hydrological and remote sensing techniques of investigating and targeting groundwater, geophysical resistivity & seismic methods for pinpointing well locations, role of electromagnetic and magnetic methods in groundwater targetting	7
6.	**Aquifer Type:** Flow of groundwater in ditches tapping different types of aquifers under confined unconfined, and leaky confined conditions	3
7.	**Groundwater Flow:** Steady and unsteady flow of groundwater to wells	2
8.	**Pumping Test data Analysis:** Interpretation of test pumping data, Thiem's equilibrium method of analysis of groundwater flow in confined aquifers	6

	tapped by wells, methods of analysis of test pumping data of unsteady groundwater flow in confined and semiconfined aquifers, use of type curves, evaluation of aquifer boundary, multiple well systems	
9.	**Groundwater Budgeting and Management:** Methods of evaluating rainfall recharge and stage of groundwater development; Management of groundwater by conjunctive use	4
10.	**Groundwater Recharge:** Methods of artificial groundwater recharge, induced recharge of groundwater and rainwater harvesting	2
11.	**Well Design and Development:** Methods of well design, development, artificial gravel pack and Natural gravel pack wells, methods of well development	2
12.	**Saline Water Intrusion:** Sea water intrusion in coastal aquifers and its abatement	2
	Total	**42**

List of Practicals:

i. Lab Verification of Darcy Law.
ii. Lab Demo of groundwater flow in unconfined aquifers.
iii. Unsteady state flow in ditches.

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Davis, S.N. and Dewiest, R.J.M.,"Hydrogeology", John Wiley	1966
2.	Freeze, R.A. and Cherry, J., "Groundwater", Prentice Hall	1979
3.	Karanth, K.R., "Hydrogeology", McGraw Hill	1989
4.	Kruseman and de Ridder, "Analysis and Evaluation of pumping test data" ILRI publication No. 47, The Netherlands.	1990
5.	Soliman, M.M., Lamoreaux, P.E., Memon, B., Assad, F.A. and Lamoreaux, J.W. "Environmental Hydrogeology", Lewis Publishers	1998
6.	Todd, D.K. and Mays, L.W., "Groundwater Hydrology", John Wiley	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Hydrology**

1. Subject Code: **HY- 525** Course Title: **Systems Analysis and Surface Water 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: **Both**
7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce system analysis techniques including linear, dynamic and non-linear programming and simulation of water resources systems.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Systems analysis concepts	2
2.	**Linear Programming:** Graphical method, simplex method, , dual of linear programming, multipurpose reservoir planning (Single reservoir application, multi reservoir application), reservoir yield model (Complete models, implicit stochastic model)	9
3.	Application of softwares for system analysis	6
4.	**Dynamic Programming:** Bellman's principle, water allocation to different water users, distribution of canal water to different users	5
5.	**Reservoir Planning:** Single reservoir and multi reservoir applications using controlled output DP model and controlled inventory DP model	6
6.	Use of uncontrolled inventory DP model for water import, capacity expansion and sequencing, unit commitment,	6
7.	**Nonlinear Programming:** Unconstrained and constrained nonlinear programming , Kuhn- Tucker conditions	4
8.	**System Simulations:** Simulation techniques, reservoir planning	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Chaturvedi M.C., "Water Resources System Planning and Management", Tata McGraw Hill	1987
2.	Hall W.A. and Dracup J.A., "Water Resources Systems Engineering", McGraw Hill	1970
3.	Loucks D.P., "Water Resources System Planning and Analysis", Prentice Hall	1981
4.	Ravindran A. "Operations Research Principles and Practice", John Wiley	2000
5.	Rao S.S., "Optimization Theory and Practice", Wiley Eastern Ltd	1985
6.	Vedula, S., and Mujumdar, P.P., "Water Resources Systems", Tata McGraw Hill	2005
7.	Jain, S.K and Singh, V.P., "Water Resources Systems Planning and Management", Elsevier	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Hydrology**

1. Subject Code: **HY- 526** Course Title: **Parametric Hydrology**

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: **HY-511 or equivalent**

9. Objective: To introduce the hydrological systems theory using conceptual models and physical processes modeling.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Systems Concept**: Nature of systems approach, systems terminology, types of systems linear time invariant systems nonlinear systems	2
2.	**Hydrological Systems**: The hydrological cycle as a system, unit hydrograph methods, identification of hydrological systems, simulation of hydrological systems	2
3.	**Linear Conceptual Models of Direct Runoff**: Conceptual models such as Nash, Dooge, Muskingum models; Comparison of conceptual models, generalized linear system models and their limiting forms	8
4.	**Calibration of Conceptual Models**: Use of moment matching, effect of data errors of conceptual models, fitting one-parameter models, two and three parameters models, regional data analysis	6
5.	**Physically Based Surface Flow Models**: Overland flow models, channel routing models - multilinear models, simplified hydraulic model, V-catchment model	8
6.	**Nonlinear Deterministic Models**: Nonlinearity in hydrology, problem of overland flow, linearization of nonlinear systems using multi-linear systems, nonlinear black-box analysis, simplified physically based models	8
7.	**Watershed Models:** Necessity for modeling, modeling philosophy, modeling protocol, event based hydrological models, continuous simulation models	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Chow, V.T. , "Handbook of Applied Hydrology: A Compendium of Water Resources Technology", McGraw Hill	1964
2.	Singh, V.P., "Hydrologic Systems; Rainfall Runoff Modelling", Vol. I, Prentice Hall	1988
3.	Singh, V.P., "Hydrologic Systems; Rainfall Runoff Modelling" Vol. II, Prentice Hall	1989
4.	Dooge, J.C.I., and O'Kane, J.P., "Deterministic Methods in Systems Hydrology", A.A. Balkema	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Hydrology**

1. Subject Code: **HY- 527** Course Title: **Groundwater Hydrology**

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: **Both**

7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To develop an overall comprehension of principles, methods and practices of well hydraulics and concepts of groundwater management.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Scope of groundwater hydrology and its historical development. Darcy's law of groundwater flow in porous media and its validity; Review of aquifer properties and well hydraulics, methods of estimation of hydraulic conductivity	5
2.	Groundwater flow in ditches and galleries tapping confined, leaky confined and unconfined aquifers	5
3.	Analysis of pumping test data of confined, semi confined and unconfined aquifers, groundwater flow in partially penetrated aquifers, aquifers having finite boundaries; Anisotropic aquifers tapped by large diameter wells; Multiple well systems	10
4.	Evaluation of well loss parameters by step drawdown tests, Jacob and Rorabavgh method; Estimation of specific capacity of wells	4
5.	Development of drilled wells and well design; Artificial gravel pack and natural gravel pack wells, evaluation of entrance velocity and its significance in well design	5
6.	Groundwater budgeting and assessment, Groundwater Estimation Committee methodology, evaluation of stages of groundwater development	3
7.	Methods of artificial groundwater recharge, induced recharge and rain water harvesting	3
8.	Groundwater management in conjunctive use, alternate basin yields	2
9.	Seawater intrusion in coastal aquifers and its abatement	3
10.	Groundwater legislation in India and case histories	2
	Total	**42**

List of Practicals:

i. Lab Verification of Darcy Law.
ii. Lab Demo of groundwater flow in unconfined aquifers.
iii. Unsteady state flow in ditches.

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Freeze, R.A. and Cherry, J., "Groundwater", Prentice Hall	1979
2.	Karanth, K.R., "Groundwater-Assessment, Development and Management", McGraw Hill Publishing Company	1987
3.	Kruseman, G.P. and Deridder, N.A., "Analysis and Evaluation of Pumping Test Data", ILRI Publication No. 47, The Netherland	1991
4.	Schwartz, F.W. and Zhang, H., "Fundamentals of Groundwater", John Wiley & Sons	2003
5.	Todd D.K. and Mays, L.W., "Groundwater Hydrology", John Wiley & Sons	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Hydrology**

1. Subject Code: **HY- 528** Course Title: **System Analysis and Groundwater System**

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 tools of systems analysis and their role in planning of groundwater development under various conditions and constraints.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Systems Concepts**: System components and constraints	2
2.	**Linear Programming**: Graphical method, simplex and dual simplex methods	8
3.	**Dynamic Programming**: Principle of optimality, recursive equation representation, tabular method	3
4.	**Nonlinear Programming**: Classical optimization techniques, constrained and unconstrained nonlinear algorithms, Lagrange multiplier method and Kuhn-Tucker conditions	4
5.	**Numerical Modelling of Groundwater Flow**: Review of differential equations, finite difference approach, one-dimensional flow solution using explicit and implicit methods, Thomas algorithm, Crank-Nicolson method, ADI method for two-dimensional flow modeling, inverse modeling, stream-aquifer interaction	12
6.	**Planning of Groundwater Development**: Water balance, assessment of recharge, utilizable recharge, Indian practices, constraints on groundwater development, feasibility check by groundwater flow modelling, optimal groundwater developments, planning of groundwater development in canal command areas-conjunctive use models, planning of groundwater development in coastal aquifers	11
7.	**Groundwater Models**: Introduction to softwares such as MODFLOW	2
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Remson, I., Hornberger, G.M. and Molz, F.J., "Numerical Methods in Subsurface Hydrology", Wiley-Interscience	1971
2.	Srinath, L.S, "Linear Programming: Principles and Applications", Affiliated East –West Press	1982
3.	Schwartz, F.W. and Zang, H., "Fundamentals of Ground Water", John Wiley	2003
4.	Ravindran, A., "Operations Research Principles and Practice", John Wiley	2000
5.	Vedula, S., and Mujumdar, P.P., "Water Resources Systems", Tata Mc Graw Hill	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Hydrology**

1. Subject Code: **HY- 529** Course Title: **Geophysical Investigations**
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: **Both**
7. Subject Area: **PEC**
8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of geophysical techniques in groundwater exploration.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Overview of geophysical techniques and their applications in groundwater exploration	3
2.	Electrical resistivity methods for groundwater investigation; Principles, electric-potential distribution in homogenous half space; Apparent resistivity for common electrode configurations, current flow in horizontally stratified earth, Vertical electrical sounding; Electrical resistivity profiling and tomography; Inversion of Wenner and Schlumberger apparent resistivity field data by partial curve matching and Direct methods, correlation of interpreted resistivity data with local geology, summation of resistivity in geoelectric section, Dar Zarrouk parameters; Estimation of Transmissivity and Hydraulic conductivity from resistivity data	14
3.	Very Low Frequency (VLF), Ground Penetration Radar (GPR) methods in groundwater exploration, use of TDEM method in groundwater exploration	8
4.	Induced polarisation method and its application in groundwater exploration of sandy zones in alluvial regions	3
5.	Seismic refraction method for evaluation of bedrock investigation; Applications in groundwater prospecting and limitations	4
6.	Magnetic and gravity methods in groundwater targetting, applications and their limitations	3
7.	Geophysical well logging and its applications in evaluation of aquifers, normal and lateral resistivity, self potential, natural gamma, neutron gamma and other logs, estimation of aquifer properties and groundwater quality from geophysical logs	5
8.	Case studies	2
	Total	**42**

List of Practicals:

i. Conduct of electrical resistivity profiling (in field).
ii. Conduct of Wenner electrical sounding (in field).
iii. Conduct of SCHLUMBERGER resistivity sounding.
iv. Demo & use of TDEM instrument for electromagnetic survey for groundwater investigation.
v. Demo of VLF instrument for groundwater targeting.
vi. Demo of Electrical logger for recording SP & resistivity logs.

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Keller, G.V. and Frischkhnechdt, F.C., "Electrical Methods in Geophysical Prospecting", Pergamon Press	1966
2.	Bhattacharya, P.K and Patra, H.P. "Direct Current Geoelectric Sounding: Principles and Interpretation", Elsevier	1968
3.	Parasnis, D.S., "Principles of Applied Geophysics", Chapman & Hall	1997
4.	Key, W.S., "Practical Guide to Borchole Geophysics in Environmental Investigations", Levis Publishers	1997
5.	Nath, S.K., Patra, H.P. and Shahid, S., "Geophysical Prospecting for Groundwater", Oxford and IBH	2000
6.	Ellis, D.V. and Singer, J.M., "Well logging for Earth Scientists, Springer-Verlag"	2007
7.	Zhdanov, M.S., "Geophysical hydromagnetic theory and Methods, Elsevier	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Hydrology**

1. Subject Code: **HY-530** Course Title: **Planning and Management of Watersheds**
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 about planning of watershed projects using system concepts and economic considerations.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Principles of watershed management, objectives of planning watershed projects, watershed delineation, determination of priority critical areas, hydrological soil survey, land use survey and land suitability analysis, concepts of land use planning	4
2.	**Economic Aspects:** Basic frame work of economic analysis, steps in economic analysis, discounting factors and discounting techniques; Project economics–pattern of financing and credit and economic evaluation	6
3.	**Systems Concepts:** System components and constraints	2
4.	**Linear Programming:** Graphical method, simplex method, duality and dual simplex method	8
5.	**Nonlinear programming:** Classical optimization techniques, constrained and unconstrained non linear algorithms, Lagrange's function, Kuhn- Tucker conditions	7
6.	**Dynamic Programming:** Principle of optimality, recursive equation representation, tabular method	5
7.	**Multiple Use Concept:** Watershed resources management with multiple use concept	2
8.	**Modelling and Simulation Techniques:** Model taxonomy, model formulation, watershed simulation models, concept of integrated watershed modeling	6
9.	**Watershed Monitoring**: Watershed monitoring and impact assessment	2
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books /Publishers	Year of Publication/ Reprint
1.	Dantzig, G.B., "Linear Programming and Extensions", Princeton University Press, Princeton	1963
2.	Hall, W.A. and Dracup, J.A., "Water Resources Systems Engineering", Mc Graw Hill	1970
3.	Vajda, S., "Theory of Linear and Non-linear Programming", Longman	1974
4.	Vedula, S., and Mujumdar, P.P., "Water Resources Systems", Tata Mc Graw Hill	2005
5.	Jain, S.K. and Singh, V.P., "Water Resources Systems Planning and Management", Elsevier	2006

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 processes, 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	3
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
10.	Objective and general soil and water conservation practices, land and soil classification, identification of critical areas	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., Ffolliott, 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- 532** Course Title: **System Ecology and Environment 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 basic principles of ecology for planning sustainable development.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Environment components and communities, scope of ecology, concepts of integrative level and environmental planning, propelling issues and problem definition in planning, projection of human population growth and related demands	6
2.	Description of environmental setting and indicators, assessment of physical environment; Geologic, hydrologic climatic and ecological considerations; Biogeochemical cycles and biodiversity, resources and their classification, equitable use and conservation	6
3.	National and International legislation on environmental planning; Introduction to various acts (Water, Air and Wild life), network and role of agencies involved at various stages of planning and implementation	6
4.	Assessment of natural and manmade hazards, carrying capacity analysis, air, water and soil pollution, sources and impacts, vulnerability analysis, hazard, risk and uncertainty	7
5.	Environmental modeling and simulation process, prediction and scenario projection, introduction and application of appropriate air and water pollution models	6
6.	Impact assessment and decision support perspective, planning and decision support, impact assessment methodologies, conflict resolution, mitigation of hazards	6
7.	Case studies related to environmental planning and management	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Eccleston, C.. H., "NEPA and Environmental Planning", CRC Press	2008
2.	Adolf, E. and Vili, T. D., "Air, Water and Soil Quality Modelling for Risk and Impact Assessment", Springer	2007
3.	Edward J. K., "Concepts of Ecology", 4th Ed., Pearson Education	2007
4.	"Pollution Control Acts, Rules and Modifications", Central Pollution Control Board, India	2006
5.	Lein, J. K., "Integrated Environmental Planning", Blackwell Publishing	2003
6.	Robert, L. F., (Ed), "Handbook of Water Sensitive Planning and Design", CRC Press	2002
7.	Liu, D. H.F., Liptak, B. G. and Boris, P. A., "Environmental Engineer's Handbook", Lewis Publishers	1997
8.	Canter, L. W., "Environmental Impact Assessment", McGraw Hill	1996
9.	Odum E.P., "Ecology", Oxford & IBH Publishing Company	1975

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: This course provides basic background for understanding the Characteristis of 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, trends, violations, reporting and graphical presentation of results	6
7.	Legislation and management in environmental quality, water and air quality criteria and standards, national and international perspective	3
	Total	**42**

List of Practicals:

i. Concepts and methods of Gravimetric analysis; Measurement of Total Solids, Total Dissolved Solids, Total Suspended Soilds. Measurement of Sulphates and Oil and Grease.
ii. Concepts and methods of Electrometric analysis; Measurement of EC; Types of sensors and their application in measurement of Flouride, Nitrate and Dissolved Oxygen.
iii. Concepts and methods of Volumetric and Optical analysis; Measurement of Total Alkalinity, Hardness and its constituents and Chloride; Measurement of Turbidity and Phosphates.
iv. Measurement of Organics viz, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Total Organic Carbon (TOC).
v. Introduction to advanced instruments viz. Ion Chromatrograph, Gas Chromatograph, Voltmeter.

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Kim, Y. J. and Plat U., "Advanced Environmental Monitoring", Springer	2008
2.	Master, G.M., "Introduction of Environmental Science and Engineering", Pearson Education	2007
3.	"Standard Methods for Water & Wastewater Analysis", 21st Edition, APHA	2005
4.	Crompton, T.R., "Soil Analysis: Handbook of Reference Methods", CRC Press	2000
5.	Chapman, D., "Water Quality Assessment", 2nd Edition, Imprint of Chapman & Hall	1992
6.	Sawyer, C.N., and McCarty, P.L., "Chemistry for Environmental Engineering", 3rd Edition, McGraw Hill	1987

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Hydrology**

1. Subject Code: **HY- 537** Course Title: **Remote Sensing and GIS Applications in Hydrology**

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: **Both**

7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the fundamentals of Remote Sensing and geographical information systems (GIS) and their applications in hydrology.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to Principle of Remote Sensing**: Definition, active and passive remote sensing, aerial and space platforms	2
2.	**Electromagnetic Radiation**: EMR interaction with atmosphere, atmospheric windows and their significance, interaction with earth surface materials, specular and diffuse reflection surfaces, spectral reflectance curves and spectral signature, spectral reflectance curves of water, soil and vegetation	8
3.	**Satellite Programs and Sensors:** Classification, description of multi spectral scanning – along and across track scanners, satellite sensors , resolution types, description of sensors in Landsat, SPOT, IRS series	4
4.	**Satellite Image Interpretation:** Basic principles of image interpretation, visual interpretation, elements of image interpretation, digital image processing, supervised and unsupervised classification	6
5.	**Introduction to GIS**: Components, data types – spatial, attribute and metadata, raster and vector data, and their comparison, data abstraction, maps and map scale	3
6.	**Coordinate System:** Datum, geographical coordinate system, projected coordinate system and their need, basic projection types, polyconic and UTM projections	4

7.	**Data Input and Editing:** Raster and vector data formats, georeferencing, data input using scanner and on-screen digitization, input using xy data, data editing, attribute data	2
8.	**Spatial Analysis**: Reclassification, overlaying, buffering, unions, intersections; DEM, DEM analysis, contour and cut-fill analysis, process modeling using GIS, IDW, spline and kriging, interpolation techniques	6
9.	**GPS and Keyhole Markup Language:** Introduction to global positioning system and KML format	2
10.	**Remote Sensing and GIS Applications:** LULC Classification, flood plain mapping and zoning, ground water studies, erosion sedimentation studies, watershed and drainage delineation	5
	Total	**42**

List of Practicals:

i. Introduction to Image Processing software.
ii. Introduction to various types of remote sensing data.
iii. Introduction to image enhancement and classification techniques.
iv. Mapping and monitoring of water bodies using remote sensing data.
v. Preparation of LULC map and its application for runoff computation using SCS method.
vi. Introduction to GIS software and understanding of GIS data and data formats.
vii. Scanning, georeferencing and digitization of water bodies from maps/toposheets.
viii. Preparation of groundwater contours and surfaces using groundwater wells data.
ix. Delineation of watershed and drainage pattern using digital elevation models.
x. Land suitability analysis for dams/check dams etc using remote sensing and GIS.
xi. River shifting studies using remote sensing data and GIS.
xii. Flood plain zoning and mapping using remote sensing and GIS.

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Lillesand, T.M. and Kieffer, "Remote Sensing and Image Interpretation", - 4th Reprint, Joh Wiley and Sons	2004
2.	Jensen, J.R., "Introductory Digital Image Processing: A Remote Sensing Perspective", 2nd Edition. Prentice Hall	1996
3.	Schowengerdt, R.A., "Remote Sensing Models and Methods for Image Processing", 3rd Edition, Academic Press	2007
4.	DeMers, M.N., "Fundamentals of Geographical Information Systems", 3rd Edition, John Wiley & Sons	2009
5.	Chang, K, "Introduction to Geographical Systems", 4th Edition, Tata McGraw-Hill	2008

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: The objective is to present the details of various methods for hydro-meteorological data collection, processing and analysis.

10. Details of Course:

S. No.	Contents	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 hydrometeorological data	6
9.	Estimation of extremes using frequency analysis; Graphical and analytical methods for normal, lognormal and Gumbel distributions	5
	Total	42

List of Practicals:

i. Observation of rainfall, temperature and evaporation.
ii. Observation of groundwater levels in observatory.
iii. Observation of gauge and discharge in lab/field.
iv. Demonstration of hydrological processes using Total Hydrologic Station.
v. Measurement of infiltration rates.

11. Suggested Books :

S. 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 Ltd.	1994
5	Gupta R.S., "Hydrology and Hydraulic Systems", Prentice Hall	1997
6	Hornberger G. M., Raffensperger J. P., Woberg P. L and Eshleman K. N., "Elements of Physical Hydrology", The Johns Hopkins University Press	1998
7	Viessman W. and Lewis G. L., "Introduction to Hydrology", Pearson Education	2007
8	Subramanya K., "Engineering Hydrology", Tata McGraw Hill Ltd.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Hydrology**

1. Subject Code: **HY- 539** Course Title: **Nuclear Methods in Hydrology**
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: **Both**
7. Subject Area: **PEC**
8. Pre-requisite: **Nil**

9. Objective: To introduce the basic concepts of isotopes, their detection and their applications in hydrology.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Isotopes-classification and characteristics, law of radioactivity, radio isotopes, basic principles of absorption and scattering of alphs and beta particles, gamma rays and neutrons	6
2.	Principles of detection of radioactive isotopes and stable isotopes, neutron moisture probe, high and low level beta counters, sample preparation units for dating of groundwater, sediment dating instruments – IRMS and TIMS, etc.	4
3.	Environmental isotopes and their variations in groundwater, surface water, snow and ice and precipitation including abundance, fractionation and water sampling procedures, etc.	5
4.	Isotope applications to hydrology as tracers: recharge to groundwater, environmental isotopes, discharge of mountainous rivers, seepage and leakage water bodies and geochemical applications, snow and glacier melt runoff estimation, aquifer-aquifer interaction	7
5.	Isotopes application of sealed sources; soil moisture variation and recharge to groundwater, snow and glacier met equivalent, suspended sediment concentration, estimation of soil and groundwater flow parameters	6
6.	Sediment and groundwater dating techniques, sedimentation in water bodies, soil erosion, water balance and dynamics of lakes and aquifer dynamics	8
7.	Isotopes for the study of inter-relation of hydrological elements and interconnection of water bodies, surface water and groundwater interaction, separation of hydrograph components, etc.	6
	Total	**42**

List of Practicals:

i. Dating of groundwater.
ii. Measurement of stable isotopes in water.
iii. Dating of sediments for sedimentation in water bodies.
iv. Estimation of groundwater recharge.

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Gupta S.K., "Modern hydrology and sustainable water development"	2010
2.	Rao S.M., "Practical Isotope Hydrology"	2006
3.	Mook W.G., "Introduction to isotope hydrology"	2005
4.	Cook P. and Herezeg A.L. (Eds), "Environmental Tracers in Subsurface Hydrology", Kluwer Academic Publishers, 529 p	2000
5.	Kendall, C. and McDonnell, J.J. (Eds), "Isotope Tracers in Catchment Hydrology", Elsevier Science, Amsterdam, 839 p	1998
6.	Mazor E., "Chemical and isotopic groundwater hydrology", 2nd Ed. Marcel Dekkar In (pub.)	1997
7.	Clark I.D., and Fritz P. "Environmental Isotopes in Hydrogeology", CRS Press: Boca Raton, 328 pp	1997
8.	"Guide Book on Nuclear Techniques, in hydrology", TEC_DOC 91/2, IAEA, Vienna.	1983

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Hydrology**

1. Subject Code: **HY- 540** Course Title: **Water Resources Economics**

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: **Both**

7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the concepts of water resources economics for optimal design of water resource projects.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Project evaluation, Benfit-cost measurement; Discounting factors: single payment factor, uniform annual series factors, uniform gradient series etc.	4
2.	**Discounting Techniques:** Present worth, annual cost, cost benefit ratio and internal rate of return methods	4
3.	**Cost Estimation:** Investigation cost, project cost	2
4.	**Economic Planning of Project Purpose:** Irrigation benefit at farmers level and at project level, hydropower benefits using alternate cost method, benefits from floods control measures (crops and urban floods)	8
5.	**Graphical Optimization:** Cost-benefit, marginal analysis.	3
6.	**Systems Applications:** Basics of linear programming, basics of dynamic programming.	6
7.	**Multiobjective and Multipurpose Analysis:** Weighing method, method of constraints, goal programming, surrogate worth trade-off method	7
8.	**Economic and Financial Analysis:** Economic feasibility, financial feasibility, cost allocation to different water uses in a multipurpose reservoir	4
9.	**Case Studies:** Single purpose projects, multi purpose projects	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	James, L.D. and Lee, R.R., "Water Resources Economics", McGraw Hill, Inc.	1971
2.	Goodman, A.S., "Principles of Water Resources Planning", Prentice Hall Inc.	1984
3.	Warnic, C.C., "Hydropower Engineering", Prentice Hall Inc.	1984
4.	Stephen M., "Introduction to the Economics of Water Resources: An International Perspective", Rowman and Littltfield, Inc.	1997
5.	Griffin, R.C., "Water Resources Economics: The Analysis of Scarcity", Policies and Projects, The MIT Press	2006
6.	Jeffrey J., Jack H. and Jeffrey M., "Water Resources Economics: Theory, Institutions and Applications", Routledge Publishers	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Hydrology**

1. Subject Code: **HY-541** Course Title: **Forests and Agricultural Hydrology**

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: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce various hydrological processes, problems and methods related to forested and agricultural land.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Forest ecosystem, role of forest components in hydrological modification, influence of forests on hydrologic processes, soil-water relationship	5
2.	**Deterioration of Watersheds**: Causes, influence on water resources and water quality	2
3.	**Experimental Watershed study**: Single watershed, paired watershed, replicated watershed, upstream-downstream approaches, experimental plots, regional analysis, watershed simulation	5
4.	**Typical Problems of Agricultural Lands**: Soil salinity and alkalinity, salt balance, leaching requirement, waterlogging, causes and remediation	2
5.	**Runoff:** Estimation of runoff from forested and agricultural watersheds, determination of peak run-off rate, forest-flood relationship, SCS-CN method of runoff estimation, forest practices and water quantity	5
6.	**Irrigation Methods:** Irrigation water requirement, factors affecting irrigation requirement, duty-delta relationship, methods of determining duty of water, surface method of irrigation – border, check basin, furrow; Sub-surface method of irrigation, sprinkler irrigation, trickle irrigation	8
7.	**Irrigation Efficiency**: Factors affecting irrigation efficiency, water conveyance efficiency, application efficiency, water storage efficiency, project efficiency	4
8.	**Agricultural Drainage:** Types of drainage problems, drainage investigations, classes of drainage, classification of drainage methods – surface drainage systems, sub-surface drainage systems, hydrologic and hydraulic design of drainage systems	6

9.	**Snowmelt Runoff Estimation:** Snowmelt theory - energy balance, energy sources and behavior of snowmelt; Modeling snowmelt – energy balance approach, degree-day method; Snowmelt indexes, effect of snowpack condition on runoff	4
10.	**Vegetated Outlets and Water Courses**: Grassed waterways design, maintenance	1
	Total	**42**

List of Practicals:

i. Soil moisture profiling.
ii. Infiltration experiments.
iii. Rainfall runoff simulation on model catchment.
iv. Evaporation measurement.
v. Hydraulic conductivity measurements.

11. Suggested Books:

S. No.	Name of Authors /Books /Publishers	Year of Publication/ Reprint
1.	Lee, R., "Forest Hydrology", Columbia University Press.	1977
2.	Mingteh C., "Forest Hydrology: An Introduction to Water and Forests", CRC Press	2006
3.	Hewlett, J.D., "Principles of Forest Hydrology", The University of Georgia Press, Athens, GA.	1982
4.	Grey D.M. and Male, D. H., "Hand Book of Snow", Permaman Press,	1981
5.	Michael A.M., "Irrigation, Theory and Practices", Vikas Publishing House Pvt. Ltd.	2008
6.	Israelson, O.W., "Irrigation Principles and Practices", John Wiley	
7.	Luthin, J.N., "Drainage Engineering", Wiley Eastern	1970

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Hydrology**

1. Subject Code: **HY- 542** Course Title: **Urban Hydrology**

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: **Both**

7. Subject Area: **PEC**

8. Pre-requisite: Nil

9. Objective: To study the process of urbanization and its influence on urban hydrological processes and urban water supply system.

10. Details of Course:p

S. No.	Contents	Contact Hours
1.	Urbanization, planning, land use, consequences for rainfall-runoff and groundwater Urban water 'cycle', processes, flooding, infiltration, groundwater, urban streams and rivers.	4
2.	Rainfall analysis, IDF curves, profiles/hyetographs, Chicago, antecedent conditions Urban runoff, source control, lag time, empirical methods, SCS method, time-area diagram, linear reservoir.	6
3.	GIS, remote sensing and data management.	5
4.	Water supply and distribution, demand, supply from surface and groundwater, treatment, quality control, leakage, groundwater.	4
5.	Surface channel and pipe network drainage, waste and storm water, infiltration, Rational method for design, time of concentration, return period of rainfall and design, return period of flooding (from rainfall).	5
6.	Simulation of drainage network performance, brief hydraulic concepts, related simulation softwares, levels of service, rehabilitation, damage costs.	5
7.	Urban flood management, runoff from adjacent catchments and overflows from rivers, flood flows through urban areas, flash flooding, flood forecasting, warning, sociological issues, 2D flow modeling (simple with easy to use software).	8
8.	Use of storage for flood control, ponds/basins, use of public open spaces for flood storage, over ground flow paths, flood resilience of public/private buildings, roads and railways.	3
9.	Rain water harvesting, codes of practice.	2
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Lazaro, T.R. "Urban Hydrology: A Multidisciplinary Perspective", Ann Arbor Science Publishers Inc.	1979
2.	Chow, V.T., "Applied Hydrology", Mc Graw Hill	1988
3.	Akan, O.S., "Urban Stormwater Hydrology", CRC Press	1993
4.	James, W., "Advances in Modeling the Management of Stormwater Impacts", CRC Press	1997
5.	Twort, A.C. and Ratnayaka, D.D., "Water Supply", 5th Edition, Butterworth-Heinemann	2001
6.	Debo,T.N and Reese, A., "Municipal Stormwater Management", 2nd Edition, CRC Press	2002
7.	Shamsi, U.M., "GIS Applications for Water, Wastewater, and Stormwater Systems", CRC Press	2005
8.	Iyyer, M.J., "Urban Water Supply and Sanitation - A Management Perspective", ICFAI University Press	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Hydrology**

1. Subject Code : **HY-543** Course Title: **Flood Forecasting**

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: **Both**

7. Subject Area : **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the details of various methods of flood estimation, forecasting and control.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Definitions, objectives and importance of flood estimation and real time forecasting; Classification of hydrological forecasts	3
2.	Flood estimation and forecasting methods, statistical and deterministic approaches, basic concepts and formulations	5
3.	Hydrological data collection; Site selection and installation of instruments, river monitoring and raingauge networks design, automatic weather stations and G and D station; Data transmission	8
4.	Meteorological forecasting and quantitative precipitation forecasting	3
5.	Graphical and statistical models for flood forecasting adopted by CWC and other operational models; Case studies	6
6.	Unit hydrograph and Soil conservation service – curve number based deterministic models for flood forecasting; Antoregrenive (AR), Moving Average (MA), Antoregrenive moving average (ARMA) models: basic concepts, formulations and updating of parameters using adaptive filter models	7
7.	Physically based models for flood forecasting; Fundamentals and overview of operational model	4
8.	Calibration and validation of forecasts, dissemination of forecast, Early warning system	6
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/Books/Publisher	Year of Publication/ Reprint
1.	Abraham, B. and Ledolter, J., "Statistical Methods for Forecasting", John Wiley & Sons	2005
2.	"Hydrological Forecasting Practices, Operational Hydrology", World Meteorological Organization, Report No. 6	1975
3.	Kottegoda N.T., "Stochastic Water Resources Technology", John Wiley & Sons	1980
4.	Maidment, D.R., "Handbook of Hydrology", McGraw Hill	1993
5.	"Manual on Flood Forecasting, Central Flood Forecasting Organisation", Central Water Commission, India	1980
6.	"Manual on Flood Forecasting, River Management Wing", Central Water Commission, India	1989
7.	Montgomery, D.C., Jennings, C.L. and Kulahci M., "Introduction to Time Series Analysis and Forecasting", John Wiley & Sons	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Hydrology**

1. Subject Code: **HY- 544** Course Title: **Hydrogeology of Hard 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: **Both**
7. Subject Area: **PEC**
8. Pre-requisite: Nil
9. Objective: To introduce the principles of groundwater occurrence and movement in fractured heterogeneous geological formations.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Geographical distribution of consolidated geological formations in India	2
2.	Groundwater occurrence in crystalline rocks, hydraulic properties of fractured rock formations, porosity and hydraulic conductivity, Darcy's law and Cubic's law, groundwater flow in fractured rocks, flow models	6
3.	Hydrogeology of volcanic rocks and karstic formations, development of lava vesicles and nature of groundwater flow, development of cavernous zones in carbonate rocks and groundwater movement, hydraulic parameters of volcanic and karstic aquifers.	3
4.	Estimation of hydraulic parameters of fractured aquifers-relationship of permeability with depth, slug tests; Interpretation of pumping test data of wells; Fractured anisotropic aquifers, equivalent porous medium models, double porosity models, and discrete fracture models, Streltsova –Adams method and Warren and Roots method for interpretation of pumping test data	8
5.	Interpretation of pumping test data of large diameter wells in hard rocks, Papadopulous and Cooper method, and Boulton and Strelsova method	6
6.	Estimation of well characteristics by Jacob and Rorabaugh methods, step draw down tests; Evaluation of minimum spacing of wells by different approaches	5
7.	Groundwater assessment in hardrock areas; Evaluation of rainfall recharge and CGWB methodology of groundwater resources estimation, its limitations; Stage of groundwater development	3
8.	Quality of groundwater in fractured crystalline and karstic aquifers, rock-	3

	water interaction and implications for groundwater geochemistry	
9.	Artificial groundwater recharge in fractured aquifers, applicability of various methods of managed aquifer recharge, rainwater harvesting	3
10.	Groundwater legislation and implications in implementation, Case studies	3
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Freeze, R.A.,and Cherry, J., "Groundwater", Prentice Hall Inc	1979
2.	Kruseman, G.P., & Deridder, N.A., "Analysis and Evaluation of Pumping Test Data", 2nd Edition, ILRI Publication No. 47	1990
3.	Ahmed, S., Jayakumar, R. and Salih, A. (Eds.) "Groundwater Dynamics in Hardrock Aquifers", Capital Publishing Company	2007
4.	Singhal, B.B.S., and Gupta, R.P., "Applied Hydrogeology of Fractured Rocks", Kluwer Publishers	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Hydrology**

1. Subject Code: **HY- 545** Course Title: **Water Quality Modeling**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0
4. Relative Weightage: **CWS** 25 **PRS** **MTE** 25 **ETE** 50 **PRE** 0
5. Credits: 4
6. Semester: **Both**
7. Subject Area: **PEC**
8. Pre-requisite: Nil

9. Objective: To provide basic understanding of the cause and effect relationships of various processes in the aquatic environment for its subsequent management.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Review of Water Quality:** Concept, characterization and assessment, water quality issues in surface and groundwater bodies, monitoring and analysis protocol	5
2.	**Modeling:** Concept and process, classification and selection of models, spatial and temporal resolutions	3
3.	**Mathematical Framework and Solution Techniques:** Overview of differential and partial differential equations, analytical and numerical solutions, error and sensitivity analysis	4
4.	**Hydrodynamic Processes and Parameters in Surface and Groundwater Bodies:** Laws of conservation, advection and dispersion, mass balance equation, governing equations in Cartesian and curvilinear coordinates, initial and boundary conditions	6
5.	**Fate and Transport of Pollutants in Aquatic Environment:** Point and nonpoint sources of pollutants, sedimentation, degradation, decay, sorption processes and their kinetics, processes and governing equations for water quality variables (dissolved oxygen, biochemical oxygen demand, pathogens, nutrients and algae etc.)	6
6.	**Data Concerns:** Model needs, review of available monitoring networks, design of new networks, rationalization, field collection, storage and transportation of samples	4
7.	**Available Water Quality Models**: Introduction to QUAL2E, WASP, MODFLOW AGNPS and other models; Model frame work, process equations, solution techniques, boundary conditions, data formats, calibration and	10

	validation schedule, error analysis, TMDL concept and application; Case studies	
8.	**Water Quality Management:** Systems engineering concepts. design of experiments, available methods, applications to the polluted environment	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication/ Reprint
1.	Zhen-Gang Ji, "Hydrodynamics and Water Quality", Modelling Rivers, Lakes, Estuaries, John Wiley & Sons	2008
2.	Novotny, V., "Water Quality: Diffuse Pollution and Watershed Management", John Wiley & Sons	2003
3.	Wu Seng Lung, "Water Quality Modelling for Wasteload Allocation and TMDLs", John Wiley & Sons	2001
4.	Mervin D., Palmer, "Water Quality Modelling, A Guide to Effective Practice", World Bank Publication	2001
5.	Chapra, S. C., "Surface Water Quality Modelling", McGraw Hill	1997
6.	Thomann, R.V. and Mueller, "Principles of Surface Water Quality Modelling and Control", Prentice Hall	1997
7.	James A., "An Introduction to Water Quality Modelling", 2nd Edition, John Wiley & Sons	1993
8.	Jorgensen, S.E. "Application of Ecological Modelling in Environmental Management", Part A & B, Elsevier	1983
9.	Fried, J.J., "Groundwater Pollution: Theory, Methodology: Modelling and Practical Rules", Elsevier	1975

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Hydrology**

1. Subject Code: **HY- 546** Course Title: **Hydroinformatics**

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: **PEC**

8. Pre-requisite: **HY-512 or equivalent**

9. Objective: To introduce emerging techniques and tools developed in information and communication technology (ICT) field for applications in hydrology.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to hydroinformatics and overview of emerging techniques	2
2.	HTML, XML, Internet and their use for information display	4
3.	Databases design and connectivity	5
4.	Introduction to information systems, decision support system, spatial decision support systems, web-based information system, expert systems	6
5.	Data mining, artificial neural networks and their application in hydrology	6
6.	Introduction to fuzzy logic and applications	5
7.	Application of ANN and fuzzy logic using software like MATLAB	6
8.	Application of hydrological models (HEC-RAS, HEC-HMS and MIKE-11)	8
	Total	**42**

List of Practicals:

i. Introduction to HTML and application of Imagemaps tags for developing web based hydrological information systems.
ii. Connectivity to hydrological databases using ADO and ASPs
iii. Application of DSS being developed under Hydrological Project by MoEF
iv. Introduction to MATLAB and application of ANN and fuzzy logic for rainfall runoff modeling using MATLAB
v. Application of Hydrological modeling software HEC-RAS and HEC-HMS

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Ross, T.J., "Fuzzy Logic with Engineering Application", 2nd Edition, John Wiley & Sons	2004
2.	Witten, I.H., and Frank E, "Data Mining", Morgan Kaufmann Publishers	2000
3.	Mallach, E.G., "Decision Support System and Data Warehouses Systems", Tata McGraw Hill	2000
4.	Babovic, V and Larsem, L.C., "Hydroinformatics '98", AA Balkema	1998
5.	Rao, V.B. and Rao, H.V., "Neural Network and Fuzzy Logic", BPB Publications	1996
6.	Fu, L., "Neural Networks and Fuzy Logic", Mc Graw-Hill Inc	1994

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Hydrology**

1. Subject Code: **HY- 547** Course Title: **Geomorphology**
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: **Both**
7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the principles of natural processes active in shaping earth land forms and to explain mechanisms of their formation.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Scope, relation of geomorphology with hydrological sciences, geomorphic cycle and processes, theory of uniformitarianism and controls of geomorphological features, geological time scale and age of earth	4
2.	**Rock Weathering and soils:** Mechanical and chemical weathering processes; Formation of soil and relation with rock weathering; Influence of geologic structure and climate on rock weathering	5
3.	**Streams:** Hydrologic cycle, types of streams, equations describing flow and distribution of suspended sediments, erosional features, concept of grade and cycle of erosion, stream deposits and fluvial landforms, channel patterns and influence of slope, discharge and bed characteristics; Quantitative drainage basin analysis and relationships between morphometric and hydraulic variables; Geomorphologic instantaneous unit hydrograph, channel changes with time.	8
4.	**Hill Slopes and Mass Wasting:** Slope processes, forms and profiles, classification of mass wasting, role of water in mass wasting	3
5.	**Deserts and Wind Deposition:** Erosion, transportation and deposition by wind, desert land forms, cycle of erosion	3
6.	**Karst Topography and its Hydrology:** Process of karstification, karstic land forms and characterstics, hydrologic aspects of karstic rocks and their influence on rivers	4
7.	**Oceans and Coastal Deposits:** Introduction and basic definitions, phenomenon of reflection, refraction and breaking of waves, coastal erosion and coastal deposits, classification of shore lines, cycle of development of shorelines, coastal land forms, protection of coasts	4

8.	**Glacial and Fluvioglacial Deposits:** Types of glaciers, growth and movement of a glacier, work of glaciers, glacial landforms, characteristics of fluvioglacial deposits	4
9.	**Geomorphic subdivision of Indian subcontinent**: Geomorphic evolution, peninsula and extra peninsula, Gangetic plain, physiographic features of Himalayas and Indian glaciers, rivers and lakes of peninsula and extrapeninsula and their geological action; Volcanic activity in the Andaman arc	7
	Total	**42**

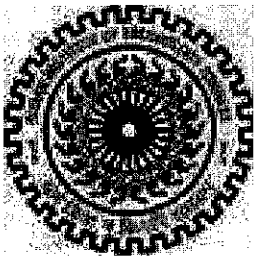
11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1.	Bloom, A.L., "Geomorphology: A Systematic Analysis of Late Cenozoic Landforms", Prentice Hall of India	1979
2.	Brass, R.L., "Hydrology – An Introduction to Hydrologic Science", Addison-Wesley	1990
3.	Chow, V.T., "Handbook of Applied Hydrology", McGraw Hill	1964
4.	Hugget, R., Fundamental of Geomorphology	2007
5.	Leopold, L. B., Wolman, M. G. and Millar, J. P., "Fluvial Processes in Geomorphology", W. Freeman	1964
6.	Ritter, D.F., Kochel, R.C. Miller, J.R., "Process Geomorphology", Waveland Press	2006
7.	Singh, V.P., "Hydrologic Systems", Watershed Modelling (Vol.2)	1988
8.	Thornbury, W.D., "Principles of Geomorphology", Balkema	1995

Appendix-H

M.Tech. Syllabus

(Spring Semester)



Centre for Nano Technology
Indian Institute of Technology Roorkee
Roorkee – 247 667

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	PCC	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**	**CWS**	**PRS**	**MTE**	**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 Nanostructrued 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 Nanomaterials	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 - 502** Course Title : **Structural Analysis of Nanomaterials**
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**
5. Credits : **4** 6. Semester : **Spring** 7. Pre-requisite : **Nil**
8. Subject Area : **PEC**
9. Objectives: To impart the knowledge on structural aspects of nanomaterials.
10. **Details of Course:**

S. No.	Contents	Contact Hours
1.	**Introduction:** Phase, Gibb's phase rule, phase diagram; Unary, binary and ternary systems; Lever rule, microstructures during cooling, structural magic number rule, crystal formation, X-ray diffraction by the crystalline phase.	4
2.	**Qualitative and Quantitative Analysis:** Basic principles, Hanawalt method, examples of phase analysis single phase and phase mixtures, analysis of unknown phase mixtures, practical difficulties. Atom fraction and weight fraction, factors that control absolute and relative X- Ray intensities; Single phase - Chemical analysis by parameter measurement, principle and application of this method; Multiple phase - Basic principles, methods like external standard method, direct comparison method and internal standard method, precautions for precise measurements, practical difficulties.	8
3.	**Phase-Diagram and Precise Parameter Determinations:** General principles; Solid solutions - Interstitial, substitutional, random, ordered and defect; Determination of the type of solid solutions by XRD, determination of solvus curves for binary and ternary systems using disappearing-phase method and parametric method, precautions, practical difficulties; Cameras used for parameter measurements: Debye-Scherrer, back-reflection focusing , pinhole; Diffractometer; Ways of analysis- method of least squares, Cohen's method, calibration method.	6
4.	**Structure of Polycrystalline Aggregates and Order-Disorder Transformations:** Crystal size - Grain size, particle size; Crystal perfection; Texture of wire, sheet and rod; Long-range order, detection of super-lattice lines, short-range order and clustering.	7
5.	**Determination of Crystal Structure and Orientation of Single Crystals:** Indexing patterns of cubic and noncubic crystals, determination of the number of atoms and their positions in a unit cell, zone, pole and trace, stereographic projections of diffracted spots, Wulff net, angle between poles and traces, rotation of the poles around axes; Methods for determining crystal orientation - Laue methods, Method of determining orientation- Greninger chart, Leonhardt chart , Diffractometer method; Relative orientation of precipitates and matrix.	7

6.	**Stress Measurement:** Introduction, applied stress and residual stress, uniaxial stress, biaxial stress, experimental technique using pinhole camera and diffractometer, applications.	4
7.	**Other Structural Studies of Nanomaterials:** Reciprocal Lattice, Ewald's Sphere and its application, principles of emerging nanoscale X-ray techniques such as small angle X-ray scattering and X-ray absorption fine structure (XAFS), electron and neutron diffraction techniques and their applications to nanomaterials.	6
	Total	42

11. **Suggested Books:**

S.No.	Name of Author (s) / Book/ Publisher	Year of Publication/ Reprints
1.	Cullity, B. D., Stock, S.R. and Stock, S. ,"Elements of X-ray Diffraction, 3rd Edition", Prentice Hall.	2001
2.	Phillips, R., "Crystals, Defects and Microstructures", Cambridge University Press.	2001
3.	Wang, Z.L. ,"Characterization of Nanophase Materials", Wiley-VCH.	2000
4	Graef, M. De. and McHenry, M.E. ,"An Introduction to Crystallography, Diffraction and Symmetry", Cambridge University Press.	2007
5	Allen, S.M. and Thomas, E.L., "The Structure of Materials: MIT Series in Materials Science and Engineering" , John Wiley and Sons.	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **Centre of Nanotechnology**

1. Subject Code : **NT - 512** Course Title : **Technology of Nanostructured Fabrications**
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**
5. Credits : **4** 6. Semester : **Spring** 7. Pre-requisite : **Nil**
8. Subject Area : **PEC**
9. Objectives: The objective of this course is to impart knowledge on thin film technology to fabricate nanoelectronic, optical and magnetic data storage devices.
10. **Details of Course:**

S. No.	Contents	Contact Hours
1.	**Introduction to Nanostructures:** Overview of thin film technology for various nanotechnology applications, miniaturization of electrical and electronic devices, Moore's law; Epitaxial growth of thin films, homoepitaxy and heteroepitaxy; Lattice misfit and imperfections, thin film superlattice.	6
2.	**Production of Nanolayers**: Ultrahigh vacuum technology for the production of nanolayers; Thermal evaporation; Sputtering, molecular beam epitaxy (MBE) and pulsed laser deposition (PLD), chemical vapour deposition (CVD).	11
3.	**Introduction to Lithographic Techniques:** Optical lithography; X-ray lithography, electron beam lithography, proton beam writing, focussed ion beam lithography, nanoimprinting and soft nanolithography, dip pen nanolithography.	12
4.	**Applications and emerging techonologies:** Thin films for micro- and nanoelelctronics, MEMS, NEMS, growth and properties of semiconducting nanowires using topdown and bottom up approaches and their applications in electronics devices, mechanical, chemical and biochemical sensing applications; Solar cells, fuel cells, superconducting and GMR devices, gas sensors.	13
	Total	**42**

11. **Suggested Books:**

S. No.	Name of Books/Authors/Publisher	Year of Publication/ Reprints
1.	Fahrner,W.R., "Nanotechnology and Nanoelectronics", Springer.	2005
2.	Waits, R.K., "Thin Film Deposition and Patterning", American Vacuum Society.	1998
3.	Tu, K.N., Mayer, J.W. and Feldman, L.C., "Electronic Thin Film Science for Electrical Engineers and Materials Scientists", American Vacuum Society.	1992
4.	Poole, C.P., "Introduction to Nanotechnology", John Wiley & Sons.	2003
5.	Ohring, M., "Materials Science of Thin Films", Academic Press.	2002
6.	Callister, Jr. D., "Materials Science and Engineering: An Introduction 6th Edition", William John Wiley & Sons.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **Centre of Nanotechnology**

1. Subject Code : **NT - 522** Course Title : **Mechanical Behaviour of Nanomaterials**
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**
5. Credits : **4** 6. Semester : **Spring** 7. Pre-requisite : **Nil**
8. Subject Area : **PEC**
9. Objectives: To provide an understanding of the mechanical behaviour of crystalline and amorphous nanomaterials.
10. **Details of the Course:**

S. No.	Contents	Contact Hours
1.	**Introduction:** Difference between nanocrystalline materials and bulk materials, deformed solid-state nanostructures, peculiarities in the structures of nanocrystalline materials- structural and induced defects.	4
2.	**Dislocations in Materials:** Introduction to dislocation, disclinations, desperations; Isotropic and anisotropic stress fields; Energies of dislocations, stability of dislocation in crystal structure, interaction between dislocations, impurities, microparticles.	7
3.	**Yield Stress of Nanocrystalline Materials:** Rule of mixture approach to yield stress, key mechanisms to plastic deformation - lattice dislocation motion, evolution of grain boundary defect structures, comparison between deformation mechanisms and effect of a grain size distribution, grain boundary sliding and triple junction migration, triple junction diffusion, and abnormal Hall-Petch effect dependence.	6
4	**Localization of Plastic flow in Nanocrystalline Materials:** Concepts of cellular dislocation - nucleation and kinetics of cellular dislocation, concepts of grain boundary dislocation, transformation of grain boundary dislocations at triple junctions; Strengthening and softening under super plastic deformation.	7
5	**Rotational Plastic Deformation in Crystalline and Amorphous nanomaterials:** Generation and development of misorientation bands – misorientation bands in metals under large deformation, models for disclination configuration at grain boundary junction, propagation of misorientation bands, motion of grain boundary disclinations – crossover from grain boundary sliding to rotational deformation; Plastic deformation of amorphous materials.	8

6	**Disclination and Amorphization at grain boundaries:** Splitting of triple junction disclination and amorphization of the triple junction – energy of wedge disclination in a cylinder, necessary condition for splitting, microcrack initiation at an amorphised triple junction, nanocrack generation at a wedge disclination.	7
7	**Nanoindentation technique:** Principles and measurement of elastic and plastic properties of nanomaterials.	3
	Total	**42**

11. **Suggested Books:**

S. No.	Name of Books/Authors/Publisher	Year of Publication/ Reprints
1.	Zehetbauer, M. J. and Zhu, Y.T., "Bulk Nanostructured Materials", Wiley WCH.	2008
2.	Gutkin, Y., Ovid'ko, I.A. and Gutkin, M.,"Plastic Deformation in Nanocrystalline Materials" Springer.	2004
3.	Courtney, T. ,"Mechanical Behavior of Materials (Material Science/metallurgy Series)", McGraw Hill.	1999
4.	Fischer Cripps, A.C. ,"Nanoindentation" , Springer.	2002
5.	Hull, D. and Bacon, D.J. , "Introduction to Dislocation, Fourth Edition", Butterworth-Heinemann.	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **Centre of Nanotechnology**

1. Subject Code : **NT - 532** Course Title : **Supramolecular Chemistry of Nanomaterials**
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**
5. Credits : **4** 6. Semester : **Spring** 7. Pre-requisite : **Nil**
8. Subject Area : **PEC**
9. Objectives: This course will impart knowledge of supramolecular interactions in natural systems, self-assembly and synthetic nanodevices.
10. **Details of Course**:

S.No.	Contents	Contact Hours
1.	**Introduction**: Inspiration, history and definitions; Molecular forces - role of non-covalent interactions in supramolecular chemistry, difference with molecular and supermolecular system; Kinetics and thermodynamics of supramolecular assemblies.	5
2.	**Molecular structures:** Natural and artificial ionophores and receptors - cyclodextrins, zeolites, cucurbiturils, crown ethers, calixarenes and porphyrins based systems; Synthesis of receptors for cations, anions, and neutral molecules; Non-covalent synthesis - synthesis of macrocycles; metal containing molecular geometries.	8
3.	**Molecular recognition:** Bio-materials and bioinspiration (protein folding, assembly and structure, protein misfolding and diseases), biomemetics and nanotechnology.	7
4.	**Synthesis and fabrication:** 'Top-down' vs. 'bottom-up' approaches, self-assembly and core-shell systems, microspheres, microporous and mesoporous materials.	8
5.	**Applications of self-assembled nanomaterials:** Self-assembled molecular structures, molecular scale machines - mechanical rotors, gears, brakes, and molecular switches; Self-assembling block copolymers, self-assembly of large building blocks, nanorods, nanotubes, and nanowires; Nano-imaging and nano-drugs.	14
	Total	42

11. **Suggested Books:**

S. No.	Name of Books/Authors/Publisher	Year of Publication/ Reprints
1.	Pradeep, T., "Nano: The Essentials", Tata McGrawHill.	2007
2.	Ozin, G. and Arsenault, A., "Nanochemistry - A Chemical Approach to Nanomaterials", RSC.	2005
3.	Cao, G., "Nanostructures and Nanomaterials - Synthesis, Properties and Applications", Imperial College Press.	2004
4.	Gomez-Romero, P. and Sanchez, C., "Functional Hybrid Materials, Wiley-VCH", Weinheim.	2004
5.	Balzani, V., Venturi, M. and Credi, A., "Molecular Devices and Machines - A Journey into the Nanoworld", Wiley-VCH, Weinheim.	2003
6.	Steed, J.W., Turner, D.R. and Wallace, K.J., "Core Concepts in Supramolecular Chemistry and Nanochemistry", John Wiley & Sons Ltd.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **Centre of Nanotechnology**

1. Subject Code : **NT - 542** Course Title : **Nanobiotechnology**
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**
5. Credits : **4** 6. Semester : **Spring** 7. Pre-requisite : **Nil**
8. Subject Area : **PEC**
9. Objectives: To impart the knowledge of nanoscale biological molecules and their integration to macromolecules.
10. **Details of Course:**

S. No.	Contents	Contact Hours
1	**Overview of nanobiotechnology:** Historical perspective of integration of biology, chemistry and material science; Opportunities and promises of nanobiotechnology.	2
2	**Biological molecules and their analysis:** Complexity and size of biological molecules – DNA, RNA, proteins and carbohydrates; Biochemical analyses, electrophoretic and chromatographic analyses - basic principles and applications.	6
3	**Single molecule approaches in biotechnology:** Fluorescence spectroscopy - Fluorescent probes for analysis of proteins and nucleic acids; Labeling of proteins and nucleic acids by various fluorescent dyes; Molecular beacons and applications.	4
4	**Microbiology and nanotechnology:** Prokaryotic complexity and size distribution; Bacterial cell-to-cell communication, quorum sensing, chemotaxis; Microbial production of inorganic nanoparticles; Gold nanoparticles for imaging and therapy.	8
5	**Miniaturized medical devices:** Overview of smart devices for medical field, miniaturised devices for drug delivery, advantages of miniaturised devices – lab on chip concept; Epipen, intelligent pill, wobbling gels.	6
6	**Nanomaterials in biotechnology:** Nanoparticles, carbon nanotubes, fullerenes, nanofibres, quantum dots and buckyballs interface with biological macromolecules; Biological perspectives of nanomaterials – impact of nanomaterials in biological processes, tolerance by immune systems and toxicity; Nucleic acid engineering - modifications of DNA for nanotechnological applications, nanostrutured assembly using DNA.	7
7	**Chemical biology:** Small molecules as antibiotics – mode of action, chemical genetics, nanotechnology and high throughput screening for drug discovery.	3

8	**Applications of nanobiotechnology:** Nano-biosensing - biosensors and nanobiosensors, design and types of nanobiosensors.; DNA aptamers for nano-biosensing and drug discovery; Nanomedicine – an overview of impact of nanotechnology in health and medicine; Promising applications of nanomedicine - recent concepts; Implantable devices, dendrimers-polymers for drug delivery, targeted drug delivery for cancer and other diseases; Synthetic biology - self assembly of nucleic acids into nanostructures, nanomotors and nanoengines based on nucleic acids.	6
	Total	**42**

11. **Suggested Books:**

S. No.	Name of Books/Authors/Publisher	Year of Publication/ Reprints
1.	Berg, J.M., Tymoczko, J.L. and Stryer, L., "Biochemistry", 6th Ed., W. H. Freeman and Company.	2006
2.	Goodsell, D.S. , "Bionanotechnology: Lessons from Nature", Wiley Press.	2004
3.	Niemeyer, C. M. and Mirkin, C. A. (Editor), "Nanobiotechnology: Concepts, Applications and Perspectives", Wiley Press.	2004
4.	Labhasehwar, V. and Leslie-Pelecky, D.L. (Editor), "Biomedical Applications of Nanotechnology", Wiley Press.	2007
5.	Klussman, S., "The Aptamer Handbook: Functional Oligonucleotides and their Applications", Wiley- VCH Press.	2006
6.	Poulter, R. L., Adams, J., Knowler, T. and Leader, D. P., "The Biochemistry of the Nucleic Acids", Springer-Verlag.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **Centre of Nanotechnology**

1. Subject Code : **NT - 552** Course Title : **Physics of Nanomaterials**
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**
5. Credits : **4** 6. Semester : **Spring** 7. Pre-requisite : **Nil**
8. Subject Area : **PEC**
9. Objectives: This course is aimed at providing physics of nanomaterials.
10. **Details of Course**:

S. No.	Contents	Contact Hours
1	**Introduction:** Quantum mechanical concepts related to low-dimensional systems, e. g. wave-particle duality, de-Broglie wavelength, quantum confinement, time-dependent and time-independent Schrodinger equation, particle in box, a free particle.	5
2	**Concepts related to Electronic Structure:** Three-dimensional and two-dimensional direct lattice, packing fraction, reciprocal lattice, Brillouin zones, diffraction from 2D structures, free – electron approximation, periodic boundary conditions, allowed k values, Fermi energy, density of electronic states for one-, two-, and three- dimensional electron gas, energy bands, direct- and indirect band gap semiconductors, lattice matching, effective mass, variation of energy bands with alloy composition and its exploitation for devices.	12
3	**Hetrostructures and electron states:** Heterojunctions – Type - I and Type - II heterostructures, classification of quantum confined systems, electrons and holes in quantum wells, electronic wavefunctions, energy sub-bands and density of electronic states in quantum wells, quantum wires, and quantum dots, effective mass mismatch in heterostructures, coupling between quantum wells, superlattices, wavefunctions and density of states for superlattices, excitons in bulk, in quantum structures and in heterostructures, the unit cell for quantum well, quantum wire and quantum dots.	12
4	**Nanoclusters and nanoparticles:** Introduction, particle shape and the surface, collective surface area, porosity, spherical cluster approximation, metal nanoclusters - magic numbers, geometric structures, electronic structure, bulk to nanotransition, magnetic clusters; Semiconducting nanoparticles; Rare-gas and molecular clusters.	6
5	**Carbon nanostructures:** Introduction to carbon molecules and clusters, structure of C_{60} and its crystal, small and large fullerenes and other Buckyballs, carbon nanotubes and their electronic structure.	5

6	**Bulk nanostructured materials:** Solid disordered nanostructures, nanostructured crystals, photonic crystals.	2
	Total	42

11. **Suggested Books:**

S. No.	Name of Books/Authors/Publisher	Year of Publication/ Reprints
1.	Hornyak, G.L., Dutta, J., Tibbals, H.F. and Rao, A.K., "Introduction to Nanoscience", CRC Press.	2008
2.	Mitin, V.V., Kochelap, V.A. and Stroscio, M.A. "Quantum Heterostructures: Microelectronics and Optoelectronics", Cambridge University Press.	1999
3.	Poole, Jr. C.P. and Owens, F.J. "Introduction to Nanotechnology", Wiley India.	2006
4	Pradeep, T., "Nano: The essentials", Tata McGraw Hills.	2007
5	Streetman, B.G. and Banerje e, S., "Solid State Electronic Devices", Prentice Hall of India.	2001
6	Harrison, P., "Quantum Wells, Wires, and Dots: Theoretical and Computational Physics" John Wiley.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **Centre of Nanotechnology**

1. Subject Code : **NT - 562** Course Title : **Laboratory Methods**
2. Contact Hours : **L: 0** **T: 0** **P: 4**
3. Examination Duration (Hrs) : Theory : **0** Practical : **4**
4. Relative weightage : CWS : **0** PRS : **50** MTE : **0** ETE : **50**
5. Credits : **2** 6. Semester : **Spring** 7. Pre-requisite : **Nil**
8. Subject Area : **PCC**
9. Objectives: This course is intended to provide an experimental training in multidisciplinary areas of nanotechnology.

10: **List of Experiments**

1 To study the size quantization effects in semiconducting nanosystems using optical and emission tools.

2 To study the forming characteristics of nanograined microstructure by mechanical alloying using high energy planetary ball mill.

3 To study the annealing behavior of nanopowders using microwave furnace under controlled environment.

4 Synthesis of nanocoating by electroless technique and to study the morphology of coatings.

5 To study the dielectric constant variation of ferroelectric ceramics - PZT with tempereature and frequency.

6 To study the dilectric variation of ferroelectric ceramics - $BaTiO_3$ with tempereature and frequency.

7 To study the imprint effect in ferroelectric ceramics.

8 To study the dielectric polarization of PZT with electric field.

9 To study the CV characteristics of diodes to extract doping profile.

10 To study CV characteristics of MOSFETs to extract surface states.

11 Native agarose-gel electrophoresis for DNA.

12 Quantification of DNA oligonucleotides using UV-spectrophotometer.

11. **Suggested Books :**

S. No.	Name of Books/Authors/Publisher	Year of Publication/ Reprints
1.	Bharat Bhushan (Editor), "Springer Handbook of Nanotechnology", Springer Science International Edition	2007
2.	Nalwa, H.S., "Encyclopedia of Nanoscience and Nanotechnology", American Scientific Publishers.	2004
3.	Berg, J.M., Tymoczko, J.L. and Stryer, L. "Biochemistry, 6th Ed." W. H. Freeman and Company.	2006

Appendix-I
Item No.SENATE/36.2.2

M.Tech. Syllabus

(Spring Semester)

Department of Metallurgical & Materials Engineering
Indian Institute of Technology Roorkee
Roorkee – 247 667

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 (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 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 : Metallurgical and Materials Engineering

1. Subject Code: MT-506 **Course Title**: Metallurgical Thermodynamics and Kinetics

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 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. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective

To impart knowledge of the principles of thermodynamics and kinetics related to chemical reactions and equilibrium

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	**Introduction:** System, first law, reversible process, second law, irreversible process, entropy, enthalpy, free energy	6
2	**Solution Thermodynamics:** Gibbs–Duhem equations, regular solutions, quasi-chemical theory, Maxwell equations, Thermodynamics of electrochemical cells	9
3	**Equilibrium phase diagram:** Equilibrium criteria, fugacity and its determination, Activity, Phase rule, Free-energy – Composition diagram	9
4	**Experimental techniques:** Calorimetric methods like isoperibol, isothermal and adiabatic calorimetry, chemical equilibrium based methods, electromotive force based methods.	9
5	**Kinetics:** order and molecularity of reaction, reaction rate determination, Arrhenius equation and activation energy, homogeneous and heterogeneous reactions, collision theory, unimolecular and bimolecular gas-solid reaction, adsorption, phase-boundary and diffusion controlled reactions	9
	Total	**42**

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications/ Reprint
1	Gaskell D.R., Introduction to Metallurgical Thermodynamics, 3rd edition, McGraw Hill	1995
2	Ghosh A., Textbook of Materials and Metallurgical Thermodynamics, Prentice-Hall of India	2003
3	Kubaschewski O., Evans E.L. and Alcock C.B., Metallurgical Thermochemistry, Volume 1, 4th edition, Pergamon Press	1967
4	Upadhayaya G.S. and Dube R.K., Problems in Metallurgical Thermodynamics and Kinetics, Pergamon Press	1985
5	Moore J.J., Chemical Metallurgy, Butterworths	1981
6	Laidler K.J., Chemical Kinetics, McGraw Hill	1987

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-508 **Course Title**: Phase Transformations

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 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. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective

To introduce the fundamentals of phase transformations in metal and alloys.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	**Introduction :** Types and classification of phase transformations, thermodynamic basis of phase transformation, introduction to concept of Gibbs free energy, entropy and enthalpy	2
2	**Thermodynamics and phase diagram:** Equilibrium in a closed system, effect of temperature and composition, order of transformation, fluctuations, stable unstable and metastable state, single component systems, binary solutions and binary phase diagrams	5
3	**Structural defects:** Surface free energy, interfaces in solids; boundaries in single phase solids, coherent, semicoherent and incoherent interfaces and interface migration	5
4	**Empirical transformations kinetics:** Atomic mechanism of diffusion, rate of atomic processes, empirical rate equation, determination of activation energy	5
5	**Liquid solid transformation:** Introduction, nucleation, rate of nucleation, growth, eutectic solidification, crystallization, cellular and dendritic solidification	9
6	**Diffusional transformations in solids:** Polymorphic transformations, massive transformations, order-disorder transformations, recrystallisation, precipitation, pearlitic reaction, cellular transformation, particle coarsening	9
7	**Spinodal decompositions:** Points of inflexion, solubility differences	2
8	**Martensitic transformations:** Thermodynamic of martensitic transformation, phenomenological theory of martensite crystallography (PTMC), effect of composition and temperature	5
	Total	**42**

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications
1	Porter D.A. and Easterling K.E., Phase Transformations in Metals and Alloys, II edition, Taylor and Francis	2004
2	Jena A.K. and Chaturvedi M.C., Phase Transformations in Materials, Prentice Hall	1992
3	Burke J., The Kinetics of Phase Transformations in Metals, Pergamon Press	1996
4	Phase Transformation in Materials, Editor G. Kostoz, Wiley-VCH Verlag	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-510 **Course Title:** Advanced Foundry Technology

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical:** 0 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. Pre-requisite: Nil

8. Subject Area: PEC

9. Objective:

To impart knowledge of the concepts of solidification of metals and alloys, and casting techniques

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction:** Metal solidification principle, conventional method, advantages and limitations; Classification of foundries, different sections of a foundry and lay out, foundry industries in India, export scenario of foundry sector, future of foundry industries	5
2	**Solidification of metals:** Mechanism of nucleation and growth, solidification of pure metals, solidification of alloys- constitutional super-cooling, dendritic growth, defect formation in real crystals, segregation- classification and mechanism	5
3	**Gating and risering:** Gating design, gas aspiration, gating systems, directional solidification, shrinkage in castings, Chvorinov equation, solidification modulus- thumb rules and other methods in practice to estimate solidification modulus of different castings, riser design, riser efficiency, riser size estimation, riser location	6
4	**Fluidity of metals:** Methods of measuring fluidity, factors influencing fluidity	2
5	**Special casting processes:** Resin bonded sand molding process, carbon dioxide-sodium silicate sand molding process, centrifugal casting process, gravity die casting and pressure die casting processes	6
6	**Salient features in casting of metals:** Melting and casting practice for- gray cast iron, malleable iron, ductile/nodular iron, steel castings, Al-alloy casting, Mg-alloy castings, Cu-alloy castings	6
7	**Casting defects:** Types of defects-identification, reasons and their remedies	4

8	**Inspection and quality control in castings:** Inspection methods; NDT methods in inspection and quality control of ferrous and nonferrous castings- principles, methods and applications	5
9	**Case studies:** Applications of software in design of mould, die and castings	3
		42

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Mukherjee P. C., Fundamentals of Metal Casting Technology, Oxford & IBH Publishing	1979
2	Wlodawer R., Directional Solidification of Steel Castings, Pergamon Press	1966
3	Tefanescus S. and Michael D., Science and Engineering of Casting Solidification, 2nd edition, Springer	2010
4	Chakrabarti A. K., Casting Technology and Cast Alloys, Printice-Hall	2005
5	Foundry Industries in India-March 2010, Komal Publication	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-512 **Course Title:** Joining of Materials

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical:** 0 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. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective:

To impart the knowledge of joining different metallic and non-metallic materials

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction:** Arc welding, electrical resistance welding, solid state welding, welding consumables, brazing and soldering, mechanical joining, adhesive joining	6
2	**Thermal and mechanical effects of joining**: Isotherm and thermal cycle, fusion and solidification, heat affected zone, microstructure, fastening, riveting, clinching, distortion and residual stresses in different joints	7
3	**Joining of ferrous and non ferrous metals**: Plain carbon structural steels, high strength low alloy steels, alloy steels, cast iron, stainless steels, aluminium alloys, copper alloys, titanium alloys, nickel alloys, characterization, defects and remedial measures	10
5	**Joining of non metallic materials**: Structural polymers, structural ceramics, composites, defects and remedial measures	5
6	**Joining of dissimilar materials**: Structural steel-stainless steel, aluminium-copper, metal-polymer, metal-ceramic, microstructure, defects and remedial measures	6
7	**Quality assessment of joint**: Inspection, mechanical testing, non-destructive testing, standards and codes for joint testing and qualification of joints	8
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publications/ Reprint
1	Larry J., Welding Principles and Applications, 4th Ed., Delmar Publishers	1999
2	Cornu J., Advanced Welding Systems: Consumable Electrode Processes, IFS Publications	1988
3	Koichi M., Analysis of Welded Structures, Pergamon Press.	1980
4	DeGarmo P.E., Black J.T. and Kohser R.A., Materials and Processes in Manufacturing, 8th Ed., Prentice-Hall India	2000
5	Parmer R.S., Welding Engineering and Technology, Khanna Publishers	1997
6	Mittal K.L. and Pizzi A., Adhesion Promotion Techniques, Marcel Dekker	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-514 **Course Title**: Powder Metallurgy

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

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

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

5. Credits: 0 4 **6 Semesters:** Spring

7. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective:
To introduce the concepts of powder metallurgy with special reference to recent development of powder metallurgy products

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction:** Scope, limitations in making components, application of powder metallurgy	3
2	**Powder production:** Production methods like physical, chemical, mechanical methods; Single fluid atomization like rotating electrode atomization, roller atomization, rotating disc atomization; Two fluid atomization like gas atomization, water atomization, oil atomization etc. Reduction methods, carbonyl process, hydride-dehydride process, electrolytic method	8
3	**Powder characterization:** Particle size and Size distribution using sieving, sedimentation method, Andreasen pipette method, size distribution functions like normal distribution, log-normal distribution, Rosin-Rammler distribution, particle shape, shape factors, specific surface area of powder, flow rate, tap density, apparent density, compressibility, pyrophoricity, explosivity, toxicity of powder	8
4	**Powder compaction:** Slip casting, slurry casting, Die compaction, isostatic pressing, single level and multi level part compaction, repressing, plane strain compression, powder forging, powder roll compaction, powder extrusion	8
5	**Sintering:** Theory of sintering, sintering practice, furnaces and atmosphere control, activated sintering techniques, after sintering treatments; industrial sintering practice for various and non-ferrous products	6
6	**Application of powder metallurgy:** Self-lubricating bearing, magnetic materials, tungsten carbide tool bits, bearing materials, dispersion strengthen materials for high temperature applications and manufacture of diamond based cutting tools	5

7	**Development of friction material through P/M route**: Clutch plate, and break pads for airplanes	4
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Books/Authors/Publisher	Year of Publication/ Reprint
1	Masuda H., Powder Technology Handbook, Taylor & Francis	2006
2	German R.M., A to Z of Powder Metallurgy, Elsevier	2005
3	Sands R.L. and Shakespeare C.R., Powder Metallurgy Practice and Applications, Newness Publication	1970
4	Powder Metal Technologies and Applications, Metals Handbook, Vol. 7, 9^{th} edition, ASM	1989
5	Hirschhorn J.S., Introduction to Powder Metallurgy, APMI	1975
6	Upadhyaya G.S., Powder Metallurgy Technology, Cambridge Press	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT- 516 **Course Title**: Principles of Materials Selection

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

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

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

5. Credits: 0 4 **6. Semesters:** Spring

7. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective:

To introduce the salient materials selection criteria for various engineering applications

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction :** Selection criteria, service requirement, design fabricability, functionability, structure-property relationship reappraisal of the role of microstructure; Crystal structure and defect structure vis-à-vis properties; Materials and their applications, compositions, codes and properties	6
2	**Ferrous materials:** Applications of important ferrous materials like stainless steels, maraging steels, tool and die steels, high speed steels, and alloyed cast irons: their composition, heat treatment and properties	8
3	**Non-ferrous materials:** Applications of important non ferrous metals like Cu base, Al base, Ti base and Mg base alloys- their compositions, heat treatment, and properties	5
4	**Composites:** Some important composites like metal-matrix and composite, ceramic matrix composites- their composition, preparation, properties and their applications, some important structural ceramics	6
5	**Polymers:** Thermoplastic, thermo-setting polymers and elastomers, structures, properties and specific applications	6
6	**Wear and corrosion resistant materials:** Important wear resistant alloys for hydro and thermal power stations, low and high temperature materials	7
7	**Case studies:** Case studies highlighting selection of materials for specific applications	4
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Books/Authors/Publisher	Year of Publication/ Reprint
1	Raghavan V., Physical Metallurgy: Principles and Practice, 2nd edition, Prentice-Hall of India	2007
2	Callister W.D. Jr., Material Science and Engineering –An Introduction, 5th edition, John Wiley and Sons	2000
3	Askland R., The Science and Engineering of Materials, 2nd Edition, PWS-KENT Publishing	1989
4	Raghavan V., Materials Science and Engineering: A First Course, 5th edition, Prentice-Hall of India	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-518 **Course Title:** Theory of Metal Forming

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical:** 0 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. Pre-requisite: MT-501 **8. Subject Area:** PEC

9. Objective

To inculcate the ability to calculate load for forming and stress-strain values for a particular metal forming processes

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	**Stress tensor and yield criteria:** Single crystal versus polycrystal, state of stress, representing stress as tensor, principal stresses, stress deviator, yield criteria, comparison of yield criteria, octahedral shear stress and shear strain	8
2	**Fundamentals of metal forming:** Classification of forming processes, mechanics of metal working, flow stress determination, effect of temperature, strain rate and metallurgical structure on metal working, friction and lubrication; Deformation zone geometry, workability, residual stresses, strain rate sensitivity, superplasticity	10
3	**Forging and rolling:** Classification, calculation of forging loads, forging defects- causes and remedies, residual stresses in forging; Rolling- Classification of rolling processes, forces and geometrical relationship in rolling, analysis of rolling load, torque and power, rolling defects	8
4	**Extrusion and drawing:** Direct and indirect extrusion, variables affecting extrusion, deformation pattern, simple analysis of extrusion	8
5	**Sheet metal forming and other processes:** Forming methods - shearing, blanking, bending, stretch forming, deep drawing defects in formed part, sheet metal formability, formability limit diagram	8
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Dieter G.E., Mechanical Metallurgy, McGraw-Hill	1995
2	Avitzur A., Metal Forming - Processes and Analysis, Tata McGraw-Hill	1977
3	Juneja B.L., Fundamentals of Metal Forming Processes, New Age International	2010
4	Taylor A., Soo-Oh I.K. and Gegel H.L., Metal Forming: Fundamentals and Applications, ASM	1983
5	Rowe G.W., Sturgess C.E., Hartley P. and Pillinger I., Finite-Element Plasticity and Metal Forming Analysis, Cambridge University Press	1991

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-520 **Course Title:** Inspection and Quality Control

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical:** 0 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. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective

To introduce the importance of quality control and quality assurance, and role of non-destructive testing

10. Details of Course:

S. No	Contents	Contact Hours
1	**Introduction:** Non-destructive testing and its comparison with destructive testing; Role of NDT in quality control and quality assurance	3
2	**Liquid penetrant inspection:** Principles, types of penetrant system, developers and types of dust for emulsifiers advantages, limitations and applications	6
3	**Magnetic particle inspection:** Principles, method of magnetization magnetic particles, fluids and applications	6
4	**Ultrasonic inspection:** Principles, advantages and limitation, A-, B- and C-scan system, probes, applications	6
5	**Eddy current inspection:** Principle, advantage and limitations, probes, eddy current system	6
6	**Radiography:** Principles, instruments, image formation, X-ray tube, scattering, types of films, recording media, penetrameters and identification markers applications	6
7	**Quality control:** Organizing for quality, fitness for use concept Statistical quality control, control chart for attribute, acceptance sampling	5
8	**Quality assurance and ISO 9000:2000:** Principle of quality assured ISO, TQM, difference between ISO 9000 and ISO 9100:2000, processing ISO for obtaining ISO certification	4
	Total	**42**

11. Suggested Books:

Sl No	Name of Author/ Book/ Publisher	Year of Publication/ Reprint
1	Non-destructive Evaluation and Quality Control, Metals Hand Book, 9th edition, Volume 17, ASM International	1989
2	Srivastava K.C., Handbook of magnetic particle testing American Book Centre, Delhi	1998
3	Srivastava K.C., Handbook of liquid penetrant testing, American Book Centre, Delhi	1997
4	Srivastava K.C., Handbook of Ultrasonic Testing, International Inspection Services, Delhi	2001
5	Larenwork E., Grant L. and Richard S., Statistical quality control Tata McGraw-Hill	2000
6	Montgomery D.C., Introduction to Statistical Quality Control, 6th edition, Wiley	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-522 **Course Title:** Composite Materials

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical:** 0 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. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective

To provide an in-depth knowledge on the constituents that make-up a composite materials and its various applications

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction:** Definition, classification, distribution and topology of constituents and interfacial bonding of matrix and reinforcing components	4
2	**Composite materials:** Metal matrix composites, polymer matrix composites and ceramic matrix composites	5
3	**Performance analysis of composites:** Combination effects-summation, complementation and interaction; Quantitative analysis-black box approach and analytical approach - thermoelasticity, plasticity and creep; Composites models- Law of mixtures, shear lag model, laminated plate model and Eshelby's model, others models	6
4	**Strengthening of composites:** Strengthening of matrix, role of matrix in continuous fibre composite, stress distribution in fibre and matrix, critical length of fibre for full strengthening, analysis of uniaxial tensile stress-strain curve of unidirectional continuous and short fibre composite, estimation of minimum and critical amount of fibre to gain a composite strength, analysis of strength during angular loading fibre composite, particle strengthening of matrix	6
5	**Fabrication:** Selection of components, wetting of components, chemical reactivity of components, incorporation of reinforcing components in matrix; Metal matrix, polymer matrix and ceramic matrix composites, in-situ composites and inorganic nano filler polymer composites	8
6	**Fracture and safety of composites:** Griffith theory of brittle fracture and modification for structural materials, basic fracture mechanics of composite- fracture toughness, COD and J-integral	6

	approaches, fatigue crack growth rate; Fracture mechanics of brittle matrix fibre composite, fracture mechanics of metal matrix fibre composite, experimental evaluation- fibre composite; Elementary reliability analysis	
7	**Joining of composites:** Welding, brazing, adhesive joining, weld bonding and mechanical fastening	4
8	**Application of Composite Materials:** Civil constructions of structures/pannels, aerospace industries, automobile and other surface transport industries, packaging industries, house hold and sports components	3
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Chawla K.K., Composite Materials, 2nd editions, Springer-Verlag	1987
2	Chawla K.K., Ceramic Matrix Composites, 1st edition, Chapman & Hall	1993
3	Piatti G., Advances in Composite Materials, Applied Science Publishers	1978
4	Shojiro O., Mechanical Properties of Metallic Composites, Marcel Dekker	2002
5	Hull D. and Clyne T.W., An Introduction to Composite Materials, 2nd edition, Cambridge Solid State Science Series	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-524 **Course Title:** Polymeric Materials

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical:** 0 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. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective:

To impart knowledge on the structure-property relationship of polymeric materials along with a broad range of applications of polymers in industry

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction:** The genesis of polymers, types of polymers	3
2	**Synthesis:** Free radical polymerization, ionic and coordination polymerization, kinetics of polymerization	4
3	**Glass transition and polymer crystallinity:** Morphological changes in polymers, glass transition temperature, influence of crystallinity on physical properties	6
4	**Mechanical properties:** Viscoelasticity– introduction, creep, stress-relaxation, Boltzmann superposition principle; mechanical models; experimental methods for studying viscoelastic behaviour– transient measurements, dynamic measurements; elastomers and their deformation behaviour	9
5	**Polymer characterizations:** Measurement of molecular weight and size, X-ray diffraction analysis, thermal analysis, spectroscopy method	6
6	**Polymer blends and processing:** Miscibility between the polymers, compatibilisation, polymer matrix composites, various processing techniques and industrial practices	7
7	**Polymer degradation:** Types of degradation – thermal degradation, mechanical degradation, degradation by ultrasonic waves, photo degradation, degradation by high energy radiation, oxidative degradation	3
8	**Exotic polymer materials:** Conductive polymers, liquid crystals, fullerene	4
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Rudin A., The Elements of Polymer Science and Engineering, Second edition, Academic Press	1999
2	Young R.L. and Lovell P.A., Introduction to Polymers, Second edition, Viva Books	1991
3	Allcock H.R., Lampe F.W. and Mark J. E., Contemporary Polymer Chemistry, Third edition, Pearson Prentice Hall	2003
4	Bower D.I., An Introduction to Polymer Physics, Cambridge University Press	2002
5.	Billmeyer F.W. Jr., Textbook of Polymer Science, 3rd edition, Wiley	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-526 **Course Title:** Failure Analysis

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical:** 0 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. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective

To impart knowledge on the analysis of the probability of failure under various service conditions and methods to ensure safety

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Sources of failure:** Material problems including chemical composition, microstructure, faulty selection, faulty heat treatment, corrosion susceptibility and defects; Mechanical irregularities including faulty design, mismatch and notch effects; Wrong welding fabrication and abnormal service conditions	4
2	**Failure analysis**: First hand documentation, planning of steps of analysis, collection of back ground data and samples, selection, cleaning and preservation of fracture surface	4
3	**Failure analysis methodology:** Use of advanced instruments, macroscopic and microscopic examinations of fracture surface, selective application of non-destructive testing, mechanical testing and stress analysis, metallographic examination and analysis; Bulk and micro chemical analysis	12
4	**Fracture:** Mechanisms and models of fracture, ductile flat-face and shear-face tensile fractures, brittle inter-granular and trans-granular fractures, embrittlement failure- Strain-age, quench-age, temper, hydrogen, sigma-phase and neutron embrittlement and blue brittleness; Factors influencing different types of fracture	6
5	**Fracture mechanics (FM):** Applications of FM under static and dynamic loading, application of NDT for defect assessment and monitoring, analysis of failure mechanism, safety and residual life estimation	6
6	**Failure mechanism:** Fatigue, corrosion, stress corrosion cracking and elevated or cryogenic temperature failure- Metallurgical and	6

	mechanical factors affecting these failures, loading condition and stages of fracture, macroscopic and microscopic salient features of failure	
7	**Result analysis and reporting**: Correlations of observations and evidences, documentation, logical conclusions and remedial measures	4
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Shipley R.J. and Becker W.T., Failure Analysis and Prevention, ASM handbook, Vol. 11, ASM International	2002
2	Colangelo V.J. and Heiser F.A., Analysis of Metallurgical Failure, 2nd edition, Wiley-Interscience	1987
3	Powell G.W. and Mahmoud S.E., Failure Analysis and Prevention, Metals Handbook, Vol. 11, 9th edition, ASM International	1986
4	Cooper T.D., Prevention of structural failure-the role of quantitative nondestructive evaluation, ASM International	1975
5	Sachs N.W., Practical Plant Failure Analysis: A guide to understanding machinery deterioration and improving equipment reliability, Dekker Mechanical Engineering, CRC press	2006
6	Gulati R. and Smith R., Maintenance and Reliability Best Practices, Industrial Press	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT- 528 **Course Title**: Tribology of Engineering Materials

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 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. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective:

The impart knowledge on friction and methods to minimize wear of engineering components

10. Details of Course:

S. No	Contents	Contact Hours
1	**Surface properties and surfaces in contact:** Nature of metallic surface, surface geometry, measurement of surface topography, quantifying surface roughness, contact between surfaces; Friction, the laws of friction, measurement of friction, origin of friction, theories of friction adhesion- theory, extension of the adhesion theory	8
2	**Wear:** Types of wear, adhesive wear, Archard's law, abrasive wear, erosion wear, factors affecting corrosive wear, wear map, various wear testing methods- pin on disc, pin on drum, slurry wear, air jet and water jet erosion as per ASTM standards	12
3	**Tribological properties of solid materials:** Hardness, strength, ductility and work hardening rate, effect of crystal structure, effect of microstructure, mutual solubility of rubbing pairs and effect of temperature	11
4	**Surface treatments to reduce wear:** Surface treatments with or without change of composition, surface coating- welding, flame, spraying, plasma spraying, electroplating and electroless coating, chemical vapour deposition (CVD) and physical vapour deposition (PVD), super hard coatings	11
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Hutchings I.M., Tribology – Friction and wear of engineering Materials, Edward Arnold	1992
2	Arnold R.D., Davies P.B., Halling J. and Whomes T.L., Tribology – Principles and Design Applications, Springer Verlag	1991
3	Bhusan B., Introduction to Tribology, John Wiley	2002
4	Bhusan B., Principles and Applications of Tribology, John Wiley	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-530 **Course Title**: Nanomaterials and Applications

2. Contact Hours: L: 3 T: 1 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: 04 **6. Semester:** Spring

7. Pre-requisite: MT-501 **8. Subject Area:** PEC

9. Objective

To impart knowledge on the synthesis and properties of nanostructured materials and their importance as advanced materials

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Nanomaterials:** Introduction, Classification: 0D, 1D, 2D, 3D nanomaterials and nano-composites, their mechanical, electrical, optical, magnetic properties; Nanomaterials versus bulk materials	5
2	**Thermodynamics and kinetics of nanostructured materials:** Size and interface/interphase effects, interfacial thermodynamics, phase diagrams, diffusivity, grain growth, and thermal stability of nanomaterials	8
3	**Processing:** Bottom-up and top-down approaches for the synthesis of nanomaterials, mechanical alloying, chemical routes, severe plastic deformation, and electrical wire explosion technique	8
4	**Structural characteristics**: Principles of emerging nanoscale X-ray techniques such as small angle X-ray scattering and X-ray absorption fine structure (XAFS), electron and neutron diffraction techniques and their application to nanomaterials; Grain size, phase formation, texture, stress analysis	8
5	**Deformation Behavior:** Elastic and plastic deformation, mechanisms of plastic deformation- lattice dislocation motion, evolution of grain boundary defect structures, comparison between deformation mechanisms and effect of grain size distribution, grain boundary sliding and triple junction migration, triple junction diffusion, abnormal Hall-Petch effect dependence, localization of plastic flow and rotational plastic deformation in nanostructured materials. Nanoindentation techniques- principles and measurement of elastic and plastic properties of nanomaterials	9
6	**Case studies:** Design issues and applications of nanomaterials in various industries	4
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Poole C.P, and Owens F.J., Introduction to Nanotechnology, John Wiley	2003
2	Nalwa H.S., Encyclopedia of Nanoscience and Nanotechnology, American Scientific Publishers	2004
3	Koch C.C., Nanostructured Materials: Processing, Properties and Applications, William Andrew	2006
4	Zehetbauer M.J. and Zhu Y.T., Bulk Nanostructured Materials, Wiley	2008
5	Wang Z.L., Characterization of Nanophase Materials, Wiley	2000
6	Gutkin Y., Ovid'ko I.A. and Gutkin M., Plastic Deformation in Nanocrystalline Materials, Springer	2004
7	Fischer A.C., Nanoindentation, Springer	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-532 **Course Title**: Corrosion Protection Methods

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 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. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective:

To impart knowledge on the principles related to protection of materials against corrosion

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	**Introduction:** Importance and economics of corrosion, principles of corrosion	4
2	**Forms of corrosion:** Classification of different forms of corrosion- general corrosion, selective corrosion including pitting corrosion, crevice corrosion, intergranular corrosion, filiform corrosion, stress corrosion cracking, corrosion fatigue, fretting corrosion, cavitation corrosion, dezincification, dealuminization, graphitization, erosion-corrosion	8
3	**Principle behind protection of materials against corrosion:** Protection against corrosion by modifying physical, chemical and/or mechanical aspects of materials- coating, alloying, heat treatment	8
4	**Protection by modifying the environmental parameters:** Concentration, pH, temperature, velocity, oxidizing agents, suspended particles, use of inhibitors	9
5	**Protection against corrosion by modification of external circuit:** By anodic and cathodic protection, problems encountered, study of mechanisms involved, some case studies	9
6	**Systematic approach for protection:** protection with respect to various corrosive environments under different parametric conditions	4
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Fantana M.G., Corrosion Engineering, 3rd Ed., McGraw Hill	2005
2	Plendek R.V., Design and Corrosion Control, The Macmillan Press	1977
3	Annual book of ASTM standards, ASTM	1978
4	Roberge P.R., Handbook of Corrosion Engineering, McGraw Hill	2000
5	Revie W.R. and Uhlig H.H., Corrosion and Corrosion Control, 4th Ed., Willey	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-534 **Course Title**: Special Steels and Superalloys

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical:** 0 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. Pre-requisite: MT-501 **8. Subject Area:** PEC

9. Objective:

To impart knowledge on the variety of steels and superalloys for structural applications

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	**Structural aspects of steels:** Correlation of mechanical properties with structure of steels, behaviour of alloying elements in steels, strengthening mechanisms applicable to steels	5
2	**Low carbon steels:** Formability aspects of low carbon steels, metallurgical controls to improve formability; Yield point phenomena, strain ageing, forming and packaging steels, dual phase steels	6
3	**High strength low alloy steels:** Historial aspects, classification, designing, correlations in ferrite/pearlite, ferrite/bainite, ferrite martensite steels and their processing, application aspects in various structures	8
4	**Ultra high strength steels:** Role of carbon and other alloying elements in designing steels, mechanical properties and processing, tempering, ausforming, maraging, controlled transformation and TRIP processes as applicable to these steels, applications of these steels	6
5	**Stainless steels:** Classification, role of carbon, chromium, nickel and other alloying elements in SS, weld decay, stabilization, carburization aqueous corrosion aspects, 13/4 stainless steel, surgical steels, cutting and shearing steels	7
6	**Superalloys:** Classification, high temperature deformation behaviour, design criteria, strengthening concepts and mechanisms, processing aspects such as casting, directional solidification, wrought alloys and P/M alloys, oxide dispersion strengthened alloys, applications of super alloys under different environmental conditions	10
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Pickering F.B., Physical Metallurgy and Design of steels, Applied Science	1978
2	Rothenberg G.B., Speciality Steels – Recent Developments, Noyes Data Corporation	2001
3	Eisenhutteneute V.D., A handbook for Materials Research and Engineering., Vol. 2 – Applications, Springer Verlag	2002
4	Fletcher, E.E., High Strength Low Alloy Steels – Status, Selection and Physical Metallurgy, Battelle Press	1979
5	Bradley E.F., Superalloys a technical guide, ASM International	1988
6	Metals Handbook, vol. 2, 10^{th} Edition, ASM International	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-536 **Course Title:** Corrosion Testing

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical:** 0 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. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective

To impart knowledge on the principles related to corrosion testing of materials and test procedures as per ASTM standard

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction:** Basic principles, forms of corrosion, its classification, mechanisms involved and remedial measures, corrosion rate expressions	8
2	**Materials and specimens: P**reparation, measurements, weighing and other detailings, environmental parameters- concentration, exposure time and volume as per NACE standards	6
3	**Evaluation of different corrosion tests:** General corrosion, selective corrosion including pitting corrosion, crevice corrosion, intergranular corrosion, filiform corrosion, stress corrosion cracking, corrosion fatigue, fretting corrosion, cavitation corrosion, dezincification, dealuminization, graphitization, erosion-corrosion, physio–chemical tests	6
4	**Laboratory tests, field tests and In-service tests:** Their classification test methods as per ASTM standards, corrosion inspection and monitoring, monitoring equipments	6
5	**Electrochemical tests:** Its principles, classification and testing as per ASTM standards, theoretical background, electro-chemical measurements, typical electro-chemical accelerated tests, factors involving reproducibility, advantages and defects in corrosion test methods	8
6	**Some Special property Tests:** Stress corrosion cracking (SCC) tests, corrosion fatigue, intergranular tests	8
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Robert B., Corrosion test and Standards - Application and Interpration, ASTM Manual Series 20	2005
2	Fantana M.G., Corrosion Engineering, 3rd Ed., McGraw Hills	2005
3	Plendek R.V., Design and corrosion control, Macmillan Press	1977
4	Annual book of ASTM standards, ASTM	1978
5	Roberge P.R., Handbook of Corrosion Engineering, McGraw Hill	2000
6	Revie W.R. and Uhlig H.H., Corrosion and Corrosion Control, 4th Ed., Willey	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-538 **Course Title**: High Temperature Corrosion

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical:** 0 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. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective

To impart knowledge on the principles of high temperature corrosion of metallic materials and their remedial measures

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction:** metallic materials used in high temperature applications and corrosion issues, selection of materials to combat high temperature corrosion	5
2	**Thermodynamics and kinetics:** Gas/metal reactions, stability of oxides/sulphides, Ellingham diagrams; Oxidation kinetics-rate laws, Wagner's theory of oxidation, electrochemical dependence, morphological and kinetic dependence, Pilling-Bedworth ratio	8
3	**Mechanisms of oxidation:** Adsorption, oxide nucleation, and growth, oxide defect structure, effect of alloying, defects in oxides, Wagner Hauffe rules, Kröger-Vink notations, oxidation versus sulphidation, electron-optical techniques for assessing oxidation damage of materials	8
4	**Oxidation of alloys**: Laws governing high temperature oxidation, role of alloying elements and rare/reactive elements in increasing resistance to oxidation, selective oxidation, internal oxidation, breakaway and catastrophic oxidation	7
5	**Hot corrosion:** Chemistry of hot corrosion, low temperature hot corrosion, high temperature hot corrosion	5
6	**Protective coatings**: Classification, metallic and inorganic coatings, conversion coatings, smart coatings, protection mechanisms, selection of coatings for different corrosive environments	6
7	**Case studies:** Corrosion issues in thermal power plants, aerospace, automobile, petrochemical industries	3
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Fontana M.G., Corrosion Engineering, McGraw-Hill	2004
2	Evans U.R., Corrosion and Oxidation of Metals, Arnold Publication	1981
3	Birks N. and Meier G.H., Introduction to Oxidation of Metals, Edward-Arnold	1983
4	Khanna A.S., Introduction to High Temperature Oxidation and Corrosion, ASM International	2002
5	Kofstad P., High Temperature Corrosion, Elsevier Applied Science	1988
6	Munger C.G., Corrosion Prevention by Protective Coatings, NACE	1984

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-540 **Course Title**: Corrosion of Metal Joints

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 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. Pre-requisite: Nil

8. Subject Area: PEC

9. Objective:

To impart knowledge on the environmental degradation of weld joints and ways to protect them

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction:** Theories and mechanisms of corrosions, wet and dry corrosion, fretting, crevice and pitting corrosion, intergranular corrosion and stress corrosion	5
2	**Characterization of metals and alloy:** Equilibrium phase diagrams of steels, cast iron and non ferrous alloys, isothermal and non-isothermal heat treatment, and effect on microstructure	5
3	**Joining methods:** Arc welding, electric resistance welding, weld-bonding, solid state welding, brazing and soldering, adhesive joining and mechanical joining	6
4	**Thermal and mechanical effects of joining**: Effect of thermal cycle on microstructure and chemistry of weld and heat affected zone - dilution and diffusion, development of stresses in various types of metal joints	4
5	**Weld corrosion of different metals:** Effects of chemical composition, microstructure and stresses of weld and HAZ in structural steels, high strength low alloy steels, stainless steels, aluminium alloys and dissimilar welds	8
6	**Corrosion of non-welded metal joints:** Joints of brazing and soldering, mechanical joints, adhesive joints	4
7	**Corrosion testing:** Standards for testing, pitting corrosion, intergranular corrosion, stress corrosion	4
8	**Measures to reduce corrosion susceptibility:** Control of joint design, reduction of stresses, microstructure and chemical heterogeneity, production of clean and defect free joint, Cathodic and anodic protection, environmental control	6
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Davis J.R., Corrosion of Weldments, ASM International	2006
2	Fontana M.G., Corrosion Engineering, 3rd Ed. McGraw Hill International	1987
3	Roberge P., Corrosion Engineering: Principles and Practice, 2nd edition, Wiley-Interscience	2005
4	Roberge P., Handbook of Corrosion Engineering, 2nd Ed., Wiley-Interscience	2005
5	Winston R.R., Corrosion and Corrosion Control, 4th Ed., Wiley-Interscience	2008
6	Jones D.A., Principles and Prevention of Corrosion, 2nd Ed., Prentice Hall	1995

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-542 **Course Title:** Biomaterials

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical:** 0 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. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective

To impart knowledge on structure-property relationship in biomaterials and their applications as implants

10. Details of Course:

S. No	Contents	Contact Hours
1	**Introduction:** Historical background, construction materials, impact of biomaterials, strength of biological tissues, performance of implants, tissue response to implants, interfacial phenomena, safety and efficacy testing	4
2	**Metallic and Ceramic materials:** Stainless steels, Co-Cr alloys, Ti-based alloys, Nitinol, biological tolerance of implant metals, ceramic implant materials, alumina, yittria stabilized zirconia, hydroxyapatite glass ceramics carbons, restorable ceramics, composites	6
3	**Polymeric implant materials:** Polymers in biomedical use, polyethylene, polypropylene, acrylic polymer, hydrogels, polyurethans, polyamides, biogradable synthetic polymers, silicon rubber, micro-organisms in polymeric implants, polymer sterilization	6
4	**Dental Materials:** Tooth composition and mechanical properties, impression materials, bones, liners, and varnishes for cavities, filling and restorative materials, oral implants, use of collagen in dentistry	4
5	**Cardiovascular and Orthopedic implants:** Artificial heart, aorta and valves, geometry of circulation, vascular implants, cardiac pace makers, bone composition and properties, fracture healing, joint replacement, knee joint repair, bone regeneration with restorable materials	6
6	**Tissue Engineering Materials and Regeneration**: Substrate scaffolds materials, cellular aspects, viability, stem cells, bladder regeneration, cartilage regeneration, skin regeneration, regeneration in cardiovascular system	6
7	**Tissue response to implants:** Normal wound healing process, body response to implants, blood compatibility, carcinogenicity	3
8	**Degradation of Materials in the biological environment:** Chemical and biochemical degradation of polymers, degradation effects on metals and ceramics, pathological classification of biomaterials	4
9	**Case studies:** Selection and design of biomaterials, implant and device failures	3
	Total	**42**

10. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication/ Reprint
1	Park J.B. and Bronzino J.D., Biomaterials: Principals and Applications, CRC Press	2003
2	Park J.B., Biomaterials Science and Engineering, Springer Press	1984
3	Rattner B.D., Hoffman A.S, Schoen F.J., Lemons J.E., Biomaterials Science: An Introduction to Materials in Medicine, Academic Press	2004
4	Park J.B. and Lakes R.S., Biomaterials: An Introduction, 3rd edition, Springer press	2007
5	Bhat, S.V., Biomaterials, 2nd edition, Narosa Publishing	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-544 **Course Title**: Physical Metallurgy of Light Metals and Alloys

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 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. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective

To provide the fundamentals of processing-structure-property relationships among commonly used light metals and their alloys

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction**: Definition of light metals, cast and wrought alloys, characteristics of light metals and alloys, trends in applications	2
2	**Physical metallurgy of aluminum alloys:** Work hardening and annealing, forming limit curves, textures, principles of age hardening, microalloying effects, hardening mechanisms, aging processes, mechanical behavior, corrosion behavior	8
3	**Wrought aluminum alloys:** Designation and tempers, heat treatable and non-heat treatable alloys, Li containing alloys, joining, special products-aircraft alloys, automotive alloys, packaging alloys, electrical conductor alloys	7
4	**Cast aluminum alloys:** Designations, tempers and characteristics, alloys based on Al-Si, Al-Cu, Al-Mg, Al-Zn-Mg systems, modification in Al-Si alloys, joining	7
5	**Magnesium alloys:** Introduction to alloying behavior, alloy designations, Zr-free and Zr-containing alloys, wrought magnesium alloys, extrusion alloys, forging alloys, trends in applications of Mg alloys, electrochemical aspects	8
6	**Titanium alloys:** Introduction and classification, basic principles of heat treatment, alpha alloys, α/β alloys, beta alloys, wrought and cast commercial titanium alloys, texture effects, surface treatments, engineering performance-tensile, creep, and fatigue behaviour, applications- general applications, aerospace, power generation, automotive, marine, biomaterials	7
7	**Novel Materials:** Light metal matrix composites, metallic foams, nanophase alloys	3
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Polmear I.J., Light Alloys, 4th Ed., Elsevier	2004
2	Brandes E.A. and Brook G.B., Smithells Light Metals Handbook, Elsevier	1998
3	Totten G.E. and Mackenzie D.S., Handbook of Aluminum Vol. 1: Physical Metallurgy and Processes, CRC Press	2003
4	Friedrich H.E., Mordike B.L. and Friedrich H., Magnesium Technology, 1st Ed., Springer	2004
5	Ber L.B., Kolobnev N. and Kablov E.N., Heat Treatment of Aluminum Alloys: Advances in Metallic Alloys, CRC Press	2010
6	Lütjering G., Williams J.C., Titanium, 2nd edition, Springer	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-546 **Course Title**: Metallurgy of Joining

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical:** 0 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. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective

To impart knowledge on the metallurgy of welding and other joining methods, and their suitability for various applications

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction:** Arc welding, electric resistance welding, solid state welding, brazing and soldering, and adhesive joining	5
2	**Thermal effect of welding**: Weld isotherm and thermal cycle, continuous cooling transformation diagram, non-conventional phase transformation	4
3	**Mechanical effect of welding:** Differential expansion and contraction in fusion welding, distortion, residual stress development	4
4	**Basic considerations:** Flux characteristics, slag-metal and gas-metal reactions in weld, solidification of weld metal and microstructure of weld and heat affected zone (HAZ)	6
5	**Weldability:** Plain carbon steels, low and high alloy steels, stainless steels, cast irons, aluminium and its alloys, copper and its alloys, magnesium base alloys and titanium alloys	6
6	**Joint defects:** Porosity, mismatch, metallurgical notch in HAZ, hot and cold cracking and remedial measures	5
7	**Joint testing:** All weld and axial tensile test, hardness, impact toughness test, lap shear test, fatigue test, standards of test methods and their applications	8
8	**Physical aspects of adhesive joining:** Role of surface preparation of substrate, wetting, bonding	4
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Jenney C.L. and O'Brien A., Welding Handbook, Vol. 1, 9th edition, AWS Publications	2001
2	Robert W. and Messler J.R., Principles of Welding, John Willey	1999
3	Lancaster J.F., Metallurgy of Welding, 6th Ed., Abington Publishing	1999
4	DeGarmo P.E., Black J.T. and Kohser R.A., Materials and Processes in Manufacturing, 8th edition, Prentice-Hall of India	2000
5	Parmer R.S., Welding Engineering and Technology, Khanna Publishers	1997
6	Mittal K.L. and Pizzi A., Adhesion Promotion Techniques, Marcel Decker	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-548 **Course Title:** Diffusion in Solids

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical:** 0 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. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective

To introduce the concepts of diffusion in solids in relation to various metallurgical processes

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction:** Phase Diagrams, iron–carbon phase diagrams, annealing, normalizing and hardening	3
2	**Diffusion equations:** Chemical potential, Fick's 1st and 2nd laws, solutions to Fick's law, kinetics and precipitation, stress assisted diffusion, solutions to diffusion coefficient, diffusion in non-cubic lattices	5
3	**Atomic theory of diffusion:** Random movement, mechanism of diffusion, random walk problem, Zener theory, empirical rules for calculating ΔH, effect of hydrostatic pressure on diffusion	8
4	**Diffusion in dilute alloys:** An elasticity due to diffusion, impurity diffusion in pure metals, correlation effects, diffusion in dilute binary alloys	6
5	**Diffusion in concentration gradient:** Kirkendal effect, Darken's analysis, ternary alloys	6
6	**Diffusion in non-metals:** Defects in ionic solids, diffusion in semiconductors, diffusion in ordered alloys and intermetallic compounds	8
7	**High diffusivity paths:** Grain boundary diffusion, dislocation effects, effect of temperature, dependence of rate of diffusion on temperature	6
	Total	**42**

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications
1	Shewmon P.G., Diffusion in solids, McGraw-Hill	1963
2	Crank J., Mathematics of Diffusion, Oxford University Press	1956
3	Carslaw H.S. and Taeger, J.C., Conduction of heat in solids, Oxford University Press	1959
4	Kellog O.D., Foundations of Potential Theory, Dover Publications	1953

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-550 **Course Title**: Engineering Applications of Dislocation

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 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. Pre-requisite: Nil **8. Subject Area:** DEC

9. Objective

To impart knowledge on the applications to the theory of dislocation motion at low and high temperatures

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction:** Defects in crystalline materials; Observation of dislocations; Concept of slip, cross-slip, climb; Plastic strain; Elements of dislocation theory, self-energy of a dislocation line; Forces on a dislocation, Peach-Koehler equation, forces between dislocations	10
2	**Dislocations in crystals:** FCC system - perfect dislocation; Shockley partial, Frank partial; Thompson's tetrahedral, Lomer-Cottrell dessile; Dislocations in HCP, BCC, ionic crystals	8
3	**Dislocation interactions:** Movement of dislocations containing jogs, jogs and prismatic loops, attractive and repulsive junctions; Nucleation of dislocations; Multiplication of dislocations by Frank-Read source, multiple cross-glide, climb, grain-boundary sources	8
4	**Dislocation arrays and boundaries:** Plastic deformation, recovery and recrystallization; Low angle boundaries; Stress field of Dislocation arrays; Strain energy of dislocation arrays; Movement of boundaries; Dislocation pile-ups	8
5	**Strength of crystalline Solids:** Temperature and strain-rate dependence of flow stress; Peierls stress and lattice resistance; Interaction between point defects and dislocations; Solute atmospheres and yield phenomena; Strength of alloys, work hardening; Deformation of polycrystals; Dislocations and fracture.	8
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Hull D. and Bacon D.J., Introduction to Dislocations, 4th edition, Butterworth-Heinemann	2001
2	Hirth J.P. and Lothe J., Theory of Dislocations, 2nd edition, Krieger Publishing	1991
3	Weertman J. and Weertman J.R., Elementary Dislocation Theory, Oxford University Press	1992
4	Nabarro F.R.N., Theory of Crystal Dislocation, Dover Publications	1987

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-552 **Course Title:** Stress Assisted Corrosion

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical:** 0 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. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective

To impart knowledge on stress related corrosion aspects of metallurgical materials

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction of corrosion principles:** Electrode reactions, type of corrosion cells, potential-pH diagram, Evans diagram, pH and advanced methods of its measurements, hydrogen embrittlement mechanism	4
2	**Brittle fracture in metallic materials:** Concept of fracture mechanics, different modes of failures, role of stresses in failures, application to corrosion testing	8
3	**Stress corrosion cracking (SCC):** Characterization, testing methods, use of fracture mechanics, mechanism, intergranular stress corrosion cracking, transgranular stress corrosion cracking, various factors affecting SCC, seasonal cracking, caustic embrittlement	8
4	**Corrosion fatigue:** Characteristics, testing methods, mechanisms, factors affecting corrosion fatigue, remedial measures	8
5	**Hydrogen assisted cracking (HAC):** Characteristics, testing methods, mechanisms, hydrogen embrittlement in steels under environmental conditions, HAC problems in electroplating, remedial measures	8
6	**Fretting corrosion, corrosion–erosion, cavitation:** Characteristics, testing methods, mechanisms, factors affecting fretting corrosion, remedial measures	6
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Fantana M.G., Corrosion Engineering 3rd Ed., McGraw Hill	2005
2	Plendek R.V., Design and Corrosion Control, The Macmillan Press	1977
3	Annual book of ASTM standards, ASTM	1978
4	Roberge P.R., Handbook of Corrosion Engineering, McGraw Hill	2000
5	Revie W.R. and Uhlig H.H., Corrosion and Corrosion Control, 4th Ed., Willey	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-554 **Course Title:** Crystallographic Texture

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

3. Examination Duration (Hrs): **Theory:** 0 | 3 **Practical:** 0 | 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. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective

To impart knowledge on crystallographic texture and the evolution of texture during different material processing techniques

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction**: Crystallographic texture- preferred orientation of crystals in a polycrystalline material, effect on different properties of material	4
2	**Representation of texture:** Introduction to stereographic projection pole figure, inverse pole figure, Euler angles, {hkl}<uvw>, orientation distribution function (ODF), grain boundary characteristics	10
3	**Measurement of texture:** X-ray diffraction technique, electron backscattered diffraction (EBSD)	4
4	**Origin and evolution of texture:** During processing of material by solidification, deformation, annealing, phase transformation, coating processes, thin film deposition	10
5	**Effect of texture:** Mechanical, electrical and magnetic properties	6
6	**Case studies:** Sheet metal forming of Al, electrical steels, superplastic forming, crack propagation study, recent publications	8
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Randle V., Engler O., Texture Analysis: Macrotexture, Microtexture and Orientation Mapping, Gordon & Breach	2000
2	Bunge H.-J., Texture Analysis in Materials Science, London-Butterworths	1982
3	Cullity B.D., Stock S.R., Elements of X-Ray Diffraction, 3rd Ed., Prentice Hall	2001
4	Kocks U.F., Tomé C., Wenk H.-R., Texture and Anisotropy, Cambridge University Press	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-556 **Course Title**: Surface Engineering and Coating Technology

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 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. Pre-requisite: Nil

8. Subject Area: PEC

9. Objective:

To impart knowledge on surface engineering and coating technology that can protect surfaces in adverse environments

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction.** Surface Engineering – background, state of the art and future developments, thermal treatment, coating method, gaseous state processes, ion implantation, nano-layered super-hard coatings	8
2	**Electroless nickel coatings:** History of electroless deposition, electroless Ni-P bath chemistry, kinetic of Ni-P deposition, mechanism of Ni deposition, choice of electroless bath conditions: some practical considerations, structure of alloys, physical properties of Ni-P coatings, applications of electroless Ni-P coatings: case studies, other specialist applications, charaterisation of Ni-P coatings, nanocomposite coatings, stealth coating with radar avoiding materials (RAM)	16
3	**Thermal spraying:** Introduction, charateristics, materials and processes, spray coatings, coating quality and reproducibility, quality assurance, applications	8
4	**Surface degradation of turbine engines:** Introductions, gas turbine design, materials, compressor, combustor, turbine coatings, future engine developments	6
5	**Fretting and fretting fatigue**: Incidence and alleviation, press fits, riveted joints, clamped and flanged assemblies, sealing faces, wine ropes and cables	4
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Burnell-Gray J.S. and Datta P.K., Surface Enginering Casebook: Solution to corrosion and wear related failure, Woodhead	1996
2	Nylen P., Sunderland E., Modern Surface Coatings, Interscience, John Wiley and Sons	1965
3	Bayliss, D.A. and Deacon, D.H., Steel work corrosion control, 2nd Edition, Taylor and Francis	2002
4	Agarwala R.C., Agarwala V. and Sharma R., Electroless Ni-P Based Nanocoatings Technology-A review, Metal-Organic, and Nano-Metal Chemistry (SRINMC), American Chemical Society	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT- 558 **Course Title**: Energy Storage Materials

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 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. Pre-requisite: Nil

8. Subject Area: PEC

9. Objective

To impart knowledge on different types of energy storage materials, their functions and applications

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction**: Basics of solid state chemistry, defect structure of solids, surface and interface analysis	6
2	**Materials for energy storage:** Fuel cells, different types, materials used, mechanism of operation, applications; Solar cells – introduction on photovoltaics, materials used, principle of operation, applications; Storage batteries – battery technology, assembly, electrochemical tests; Supercapacitors – theory, high power super capacitor from carbon nanotubes; Hydrogen storage materials – mechanism of hydrogen storage	12
3	**Material Analysis:** Thermal, structural and morphological analysis of the energy storage materials, different experimental techniques used	6
4	**Rechargable lithium ion battery:** Intercalation compounds, anodes and composite anodes, cathode materials, polymeric electrolyte, currents trends of lithium ion batteries for consumer applications	8
5	**Nanoscale materials:** Nano crystalline materials, nanocomposites, nanotubes, energy storage capacity of the nanostructured materials	6
6.	**Magnetocaloric materials**: Different types of materials, application of the magnetocaloric effect	4
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Nazri G.A., Pistoia G., Lithium Batteries: Science and Technology, Kluwer Academic Publishers	2004
2	Kumta P.K., Supercapacitors: Fundamentals, Systems, Applications, Emerging trends, Wiley-VCH Verlag	2009
3	Markvart T. and Castaner L., Solar cells: Materials, Manufacture and Application, Elsevier	2003
4	Walker G., Solid State Hydrogen Storage: Materials and Chemistry, Woodhead Publishing	2008
5.	Tishin A.M. and Spichkin, Y.I., The Magnetocaloric Effect and its Applications, IOP publishing	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-560 **Course Title**: Fracture, Fatigue and Creep Deformation

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

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 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. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective

A impart knowledge on material damage through fatigue and creep phenomena

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Fracture:** Conventional failure criteria, characteristic brittle failures, Griffith's work, linear elastic stress field - crack deformation modes and basic concepts, Westergaard method, singular stress and displacement fields, stress intensity factor, three-dimensional cracks	4
2	**Fracture mechanics:** Elastic-plastic stress field, determination of crack-tip plastic zone, Irwin's model, Dugdale's model; Crack growth based on energy balance - Griffith theory, graphical representation, equivalence between strain energy release rate and stress intensity factor, compliance, crack stability; Critical stress intensity factor - fracture criterion, Variation of *Kc* with thickness, experimental determination of *KIc,* crack growth resistance curve (*R*-curve); *J*-Integral and crack opening displacement (COD) - path-independent integrals, *J*–integral, relationship between the *J*-integral and potential energy, *J*-integral fracture criterion, experimental determination of the *J*–integral, stable crack growth studied by the *J* –integral	8
3	**Fracture criterion:** COD- fracture criterion; Growth - volume strain energy density, 2D linear elastic crack problems; Special consideration for weldments, constraint effects and microscopic aspects of fracture, cleavage fracture, ductile fracture, ductile-brittle transition	3
4	**Fatigue:** Cyclic loading, S-N curves, low cycle fatigue, cyclic stress-strain behaviour, crack tip cyclic plasticity, damage, crack closure, ΔJ integral, test methods for characterizing FCGR under large–plasticity condition, behaviour of small cracks	7
5	**Fatigue failure prediction:** High cycle and low cycle fatigue under multi-axial loading, fatigue in welded structures, defects, notches	6

	and crack growth, creep-fatigue interactions, polymeric fatigue, fractography, fatigue life predictions, adapting data to real conditions, total life and damage tolerant approaches to component life prediction	
6	**Creep:** Phenomenology of creep, creep mechanisms, stages of creep, dislocation creep, diffusion creep, grain boundary sliding, deformation mechanism maps	7
7	**Creep Mechanism:** Creep fracture, test methods for characterizing creep crack growth, microscopic aspects of creep crack growth, creep crack growth in weldments, early approaches for characterizing creep-fatigue crack growth behaviour, experimental methods for characterizing creep-fatigue crack growth, creep-fatigue crack growth correlations	7
	Total	**42**

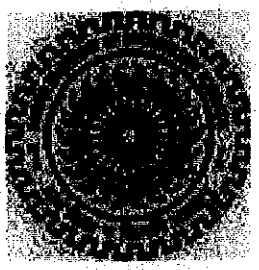
11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Gdoutos E.E., Fracture Mechanics – An Introduction, Springer	2005
2	Saxena A., Non-linear Fracture Mechanics for Engineers, CRC Press	1997
3	Courtney T.H., Mechanical Behavior of Materials, 2nd Ed., McGraw Hill	1990
4	Nabarro F.R.N. and de Villiers H.L., The Physics of Creep, Taylor and Francis	1995
5	Kassner M.E., Fundamentals of creep in metals and alloys, 2nd Ed., Elsevier	2009
6	Suresh S., Fatigue of Materials, 2nd Ed., Cambridge University Press	2003

Appendix-J
Item No.SENATE/36.2.2

M.Tech. Syllabus

(Spring Semester)



Department of Pulp & Paper Technology
Indian Institute of Technology Roorkee
Roorkee – 247 667

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 and 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 and Design	PCC	4	3	1	0	3	-	25	-	25	50	-
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										
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
† Same loading as in other M.Tech programee
** To be continued in IV semester but evaluated for 25% weightage in III[rd] 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	2/2	3	-	15	15	30	40	-
2	PP-531	Advances in Papermaking	PEC	4	3	1	2/2	3	-	15	15	30	40	-
3	PP-532	Advances in Chemical Recovery	PEC	4	3	1	2/2	3	-	15	15	30	40	-
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 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	2/2	3	-	15	15	30	40	-
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-522** Course Title: **Chemical Reactor 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: **Spring** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of chemical reactor analysis and design.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Review of design of ideal isothermal homogeneous reactors for reversible and irreversible single and multiple reactions	6
2	Residence time distribution (RTD) of ideal reactors, interpretation of RTD data, flow models for nonideal reactors-axial dispersions and tanks in series and multi-parameter models, diagnosing the ills of reactor, influence of RTD and micro mixing on conversions	9
3	Adiabatic and nonadiabatic operations in batch and flow reactors, flow reactors, optimal temperature progression, hot spot in tubular reactor, auto-thermal operation and steady state multiplicity in continuously stirred tank reactor (CSTR) and tubular reactor, introduction to bifurcation theory	11
4	Introduction to multiphase catalytic reactor, effectiveness factor, selectivity, deactivation of catalyst, use of pseudo-homogenous models for design of heterogeneous fixed and fluidized beds catalytic reactor	8
5	Gas-liquid-solid phase reactors, hydrodynamics and design of bubble column, slurry and trickle bed reactors	5
6	Introduction to bio chemical reactor design, enzyme and microbial fermentation	3
	Total	**42**

11. Suggested books:

S. No.	Name of Authors/Book /Publisher	Year of Publication/ Reprint
1	Belfiore, L. A., "Transport phenomena for Chemical Reactor Design", John Wiley	2003
2	Fogler, H. S., "Elements of Chemical Reaction Engineering", 4th Ed., Prentice Hall of India	2008
3	Levenspiel, O., "Chemical Reaction Engineering", 3rd Ed., John Wiley	2008
4	Froment, G. F. and Bischoff, K. B., "Chemical Reactor Analysis and Design", 2nd Ed., Wiley	1990

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PP- 530** Course Title: **Advances in Pulping and Bleaching**

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: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of advances in pulping and bleaching technology.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Chemical Pulping Processes:** Pulping with additives, oxygen delignification, alkaline peroxide pulping, alkaline sulphite and alkaline sulphite anthraquinone pulping; Extended delignification, cold blow techniques, rapid displacement heating, modified continuous cooking, superbatch process	9
2	**Unconventional Pulping:** Organosolv pulping, explosion pulping process, bio-pulping process	3
3	**High Yield Pulping:** Pressurized ground wood pulping, chemi-mechanical pulping, Chemithermo-mechanical pulping	4
4	**Pulp Washing and Screening:** Radial washer, pressurized diffuser, hi-heat washing system, double-wire pulp washers, screw press, and wash press; Screening and cleaning system, cascading of screens and cleaners	5
5	**Bleaching Processes:** Impact of bleaching on environment, elemental chlorine free (ECF) bleaching, total chlorine free (TCF) bleaching; Bleachability; Bleaching of mechanical, deinked and nonwood pulps; Principles of displacement bleaching; Water reuse and recycle in bleaching; Effect of process variables and properties of bleached pulp	10
6	**Bleaching Chemistry**: Bleaching chemicals, chlorine dioxide, oxygen, peroxide, ozone, peracids, enzymes; Bleaching reactions, reaction kinetics and operating variables for different bleaching agents like Cl_2, ClO_2, O_2, O_3, hypochlorite	6
7	**Bleaching Equipment**: Selection of process equipment, towers, mixers, washers, pumps	5
	Total	**42**

List of Experiment

i. Proximate analysis of raw material : Solubility in hot water, 1% NaOH, and alcohol-benzene, ash, moisture
ii. Determination of lignin, cellulose, and pentosans in raw material
iii. Pulping in a laboratory batch digester- Analysis of cooking liquor, determination of pulp yield and kappa number
iv. Laboratory bleaching of pulp-determination of brightness and viscosity

11. Suggested books:

S. No.	Name of Authors/Book /Publisher	Year of Publication/ Reprint
1	Dence, C. W. and Reeve, D. W., "Pulp Bleaching: Principles and Practices", TAPPI Press	1996
2	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 7: Recycled Fiber and Deinking (ed. Göttsching, L. and Pakarinen, H.)", Finnish Paper Engineers' Association and TAPPI	1999
3	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 6: Chemical Pulping (ed. Gullichsen, J and Fogelholm, C-J.)", Finnish Paper Engineers' Association and TAPPI	1999
4	Kocurek, M. J., "Pulp and Paper Manufacture, Volume 5: Alkaline Pulping (ed. Grace, T. M. and Melcolm, E. W.)", TAPPI Press	1989
5	Kulas, K. A., "Elemental Chlorine Free Bleaching: A Tappi Press Anthology of Published Papers (Pulp/Wood Products)", TAPPI Press	2005
6	Raymond, A. Y. and Akhtar, M., "Environmentally Friendly Technologies for the Pulp and Paper Industry", John Wiley	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PP-531** Course Title: **Advances in Papermaking**

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: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of the advances in the design and operation of papermaking processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Approach Flow System:** Consistency control, design of piping; Screening and cleaning; Deaeration of stock, pulse attenuation, flow distributers; Headboxes, head control, control of jet velocity and jet angle	7
2	**Stock and Whitewater Systems:** Design principles of short circulation and long circulation, closing the whitewater system, saveall; Broke system design, handling of brokes of different grades such as coated, colored, wet strength papers	4
3	**Sheet Formers:** Developments in sheet formers, gap formers, formers for multi-layered paper and boards; Formation, quantitative measurement of formation	6
4	**Pressing and Drying:** Development in press parts, emended nip presses, development in paper drying, steam and condensate handling, hoods and hood exhaust, IR drying; Surface sizing	5
5	**Finishing and Calendering:** Developments in calendering, soft calendering, moisture and temperature calendering; Rewinder and sheet cutters	2
6	**CD Variability and its Control:** Benefits of improved CD uniformity, online measurement, CD control of grammage, moisture, caliper, and smoothness	4
7	**Paper Machine Clothing**: Design of forming, press and dryer fabrics; Material of construction; Manufacturing techniques; Cleaning and conditioning of forming, press, and dryer fabrics	4
8	**Auxiliary Systems of Paper Machine:** Paper machine showers and doctors; Paper machine drives; Paper machine vacuum systems	6
9	**Paper Machine Safety:** Vibration measurement and control; Corrosion measurement and control; Safety from steam, moving parts and chemicals	4
	Total	**42**

List of Experiment

i. To determine strength properties of paper: Tensile index, stretch, burst index, folding endurance, and tear index
ii. Evaluation of optical properties of paper
iii. Laboratory coating with different coating color compositions and super calendering- evaluation of gloss, smoothness, porosity, and bending stiffness
iv. Determination of surface strength and oil absorbency of paper
v. Demonstration of printability testing with an IGT printability tester

11. Suggested books:

S. No.	Name of Authors/Book /Publisher	Year of Publication/ Reprint
1	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
2	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
3	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 10: Papermaking Part 3, Finishing (ed. Jokio, M.)", Finnish Paper Engineers' Association and TAPPI	1999
4	Kocurek, M. J., "Pulp and Paper Manufacture, Volume 7: Paper Machine Operations (ed. Thorp, B.)", TAPPI Press	1991

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PP-532** Course Title: **Advances in Chemical Recovery**

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: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of recovery technology for chemicals, energy and byproducts from black liquor.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Kraft and Soda recovery cycles, various terms associated with chemical Process; Impact of pulping and washing on chemical recovery process	3
2	**Black Liquor Properties:** Chemical, physico-chemical, thermal and polymeric properties	5
3	**Black Liquor Treatment:** Importance and methods of black liquor oxidation and desilication	3
4	**Concentration of Black Liquor:** Multiple effect evaporators (MEE), process design calculations- feeding sequence, heat transfer area optimum cycle time; Scale formation and its remedies; Instrumentation and control of MEE; Condensers- indirect and direct types, process design calculations; Steam jet ejectors- operating principle, entrainment ratio, motive steam requirement, performance factors, load calculation	10
5	**Incineration of Black Liquor:** Process chemistry, incineration process, recovery boilers and accessories, boiler safety, NO_X generation, material and energy balance calculations, parameters affecting thermal performance; Recovery of fume particles, ESP, calculation of corona voltage, ionic density, corona current, particle charging, migration velocity, variables affecting emission of particulate from ESP; Cogeneration with recovery boiler	9
6	**Causticizing of Green Liquor:** Green liquor treatment and clarification, slaking and causticizing reactions, causticization equilibrium, causticizing efficiency; White liquor clarification, mud washing and filtration equipment, soda loss in lime sludge, process design calculations for clarifiers, slakers, causticizers and mud filters; Soda, sulphur and water balance across the causticization plant	6
7	**Lime Mud Reburning**: Process description, lime kiln, variables affecting lime mud reburning, material and energy balance calculations, instrumentation and control	3

8	**Non Conventional Recovery Systems:** Process description of various unconventional recovery processes, application in medium and small scale paper mills, production of lignin derivatives from black liquor	3
	Total	**42**

List of Experiment

i. Determination of chemical properties of black liquor
ii. Determination of physico-chemical properties of black liquor
iii. Determination of thermal properties of black liquor
iv. Analysis of green liquor
v. Desilication of black liquor

11. Suggested books:

S. No.	Name of Authors/Book /Publisher	Year of Publication / Reprint
1	Hough, G., "Chemical Recovery in Alkaline Pulping Processes" TAPPI Press	1985
2	Kocurek, M. J., "Pulp and Paper Manufacture, Volume 5: Alkaline Pulping (ed. Grace, T. M. and Melcolm, E. W.)", TAPPI Press	1989
3	Adams, T. N., Frederick, W. J., Grace, T. M., Hupa, M., Iisa, K., Jones, A. K. and Tran, H. N., "Kraft Recovery Boiler" TAPPI Press	1997
4	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 6B: Chemical Pulping (ed. Gullichsen, J and Fogelholm, C-J.)", Finnish Paper Engineers' Association and TAPPI	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PP-533** Course Title: **Pulp Mill Calculations**

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 process calculations for pulping, screening, cleaning, washing and bleaching systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Raw Material Preparation Section:** Material and energy balance calculations for raw material preparation section; Physical properties of raw materials, bulk density; Energy calculations for conveyers, chippers, and chip screens	4
2	**Pulping Section:** Analysis of white, green and black liquors, process calculations for batch and continuous digesters, bath ratio; Calculations for Superbatch, RDH, MCC, and EMCC processes; Steam and power calculations; Modeling of soda and kraft pulping, calculation of H- and modified H-factors, use of empirical models for prediction of various parameters; Calculation for blow-heat recovery, digester and liquor heater	10
3	**Screening and Cleaning Systems:** Performance of screening and cleaning systems and their process design aspects, mass balance and efficiency for single and multiple stage systems, screening and cleaning equipment sizing, power consumption calculations	4
4	**Washing Systems:** Material and energy balance calculations for different types of washing systems, washing losses and washing efficiency, calculation of washing efficiency for varying dilution factor, displacement ratio and number of stages; Norden efficiency	5
5	**Bleaching Systems:** Calculations involving bleach liquor analysis; Material and energy balance for single and multiple stage bleaching sequences; Process design of tower, mixer and reactors; Calculations for bleaching efficiency, target brightness, shrinkage and environmental impact	5
6	**Recovery Section:** Material and energy balance calculations for multiple effect evaporators, area requirement and efficiency; Process design calculations for condensers and steam-jet ejectors; Process design calculations for slakers, causticizers, clarifiers, mud washers, filters, lime mud reburning system; Energy efficiency and performance calculations	10
7	**Stock Pumps and Piping:** Sizing of piping and pumps for stock flow in different sections of a pulp mill, power requirement for pumping	4
	Total	**42**

11. Suggested books:

S. No.	Name of Authors/Book /Publisher	Year of Publication/ Reprint
1	Dence, C. W. and Reeve, D. W., "Pulp Bleaching: Principles & Practice", TAPPI Press	1996
2	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 6: Chemical Pulping (ed. Gullichsen, J and Fogelholm, C-J.)", Finnish Paper Engineers' Association and TAPPI	1999
3	Kocurek, M. J., "Pulp and Paper Manufacture, Volume 5: Alkaline Pulping (ed. Grace, T. M. and Melcolm, E. W.)", TAPPI Press	1989
4	Abrams, T. L., "Process Engineering Design Criteria Hand Book: Pulp and Paper Normal Design Criteria," TAPPI Press	1996
5	Adams, T. N., Frederick, W. J., Grace, T. M., Hupa, M., Iisa, K., Jones, A. K. and Tran, H. N., "Kraft Recovery Boiler" TAPPI Press	1997
6	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 6B: Chemical Pulping (ed. Gullichsen, J and Fogelholm, C-J.)", Finnish Paper Engineers' Association and TAPPI	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PP-534** Course Title: **Paper Mill Calculations**

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 process design calculation of papermaking processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Approach Flow System:** Basic Mass balance calculations in approach flow system, sizing of chests and piping, design parameters of screens, cleaners, and fan pumps, deaerator, flow distributors; Estimation of electrical power consumption	6
2	**Headbox:** Calculations for the required head, pressure and thrust in the headbox, selection of perforated rolls, no-wake distance for the nozzle, calculations for the pressurized and hydraulic headbox, characterization of turbulence; Calculations for jet angle, slice opening, volumetric flow rate from the head box	4
3	**Formers:** Drainage rate calculations, wire tension, selection of forming fabrics, dimensions of wire, sizing of different rolls, drainage elements and suction boxes on wire table; Calculation of vacuum, drag load, and other parameters for wire part; Design of cylinder mold machines; Calculation of drive load.	7
4	**Overall Water and Fiber Balance:** Mass balance for white water and fiber systems, broke handling, first pass retention, savealls, water requirement for showers and other cleaning devices, Concepts of system closure	4
5	**Vacuum Systems:** Vacuum producing devices; Sizing of vacuum pumps, piping, foils and separators; Calculation of energy requirements	3
6	**Press Part:** Water removal rate calculations; Dimensioning of press rolls and water drainage elements; Selection of press fabrics; Calculation of press parameters; Calculation of drive load	4
7	**Dryer Part:** Material and energy balance for multi-cylinder and Yankee dryers; Calculations of drying rate, surface area of dryers, air and steam requirement; Steam and condensate handling systems, sizing of steam piping; Calculation of drying rate for surface sized and pigment coated papers, calculations for IR and air impingement dryers, calculation for dryer hoods; Calculation of drive load	10

8	**Stock Pumps and Piping:** Sizing of piping and pumps for stock flow in different sections of a paper mill, power requirement for pumping	4
	Total	**42**

11. Suggested books:

S. No.	Name of Authors/Book /Publisher	Year of Publication/ Reprint
1	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
2	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
3	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 10: Papermaking Part 3, Finishing (ed. Jokio, M.)", Finnish Paper Engineers' Association and TAPPI	1999
4	Kocurek, M. J., "Pulp and Paper Manufacture", Vol. 7, TAPPI Press	1994
5	TAPPI Technical Information Papers, TAPPI Press	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PP- 535** Course Title: **System Closure and Sustainable 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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of methodology for conserving water, energy and fiber resources.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Concepts, issues and challenges of sustainability, section wise inputs and outputs in paper manufacturing, open, partially closed, and closed systems	4
2	**Legislative and Sustainable Approaches:** Discharge standards for liquid, solid and gaseous emissions, the Earth summit and other protocols, environmental impact assessment (EIA), eco-labeling, green rating, green house gas emissions, life cycle analysis (LCA), paper use and disposal; Energy usages, clean development mechanism	6
3	**Raw Materials for Paper Industry:** Sustainable fiber supply- woods, nonwoods, agro residues and recycled fibre; Integrating fibre supply and mill operations; Social forestry; Environmental, social and economic issues,	8
4	**Water Needs of Pulp and Paper Industry:** Water sourcing; Closed system operations in fiber preparation, pulping, bleaching, papermaking and chemical recovery; Condensate recovery, management of non process elements; Process integration in closed water cycle; Rain water Harvesting	8
5	**Waste Management:** Liquid effluent discharges, tertiary treatment methods; Issues of TDS, Color, and AOX; Solid waste management, incineration and land fill; Air emission control for SO_x, NO_x, HCI, NCGs, TRS, and VOC	9
6	**Energy Management in Pulp and Paper Mills:** Renewable and non-renewable energy sources, increasing use of bio-mass, cogeneration, development of energy efficient processes, process integration	7
	Total	**42**

11. Suggested books:

S. No.	Name of Authors/Book /Publisher	Year of Publication/ Reprint
1	Brune, D., Chapman, D. V., Gwynne, M. D. and Pacyna, J. M., "The Global Environment: Science, Technology and Management", Marcel Dekker	1996
2	Environmental Issues and Technology in Pulp and Paper Industry – TAPPI Press Anthology of Published Papers, 1991-94	1995
3	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 19: Environmental Control (ed. Hynninen, P.)", Finnish Paper Engineers' Association and TAPPI	1998
4	Nebel, B. J., Adams, C. E. and Wright, N., "Environmental Science – The Way World Works", 4th Ed., Prentice Hall	1999
5	Boyce, M. P., "Handbook of Cogeneration and Combined Cycle Power", ASME Press	2002
6	Tappi Kraft Recovery Short Notes, TAPPI Press	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PP-536** Course Title: **Secondary Fiber Processing**

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 processes of papermaking from secondary fibers.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction**: Utilization, collection, recovery rate, legislation for use of recycled fibers, import of wastepaper; Ecological labeling	4
2	**Recyclability and Economics:** Handling, storage, and sorting of wastepaper, quality control of recovered paper, recyclability of paper products, economics of secondary fiber utilization	5
3	**Pulping:** Batch and continuous pulpers, slushing, deflaking, fractionation, dispersion and kneading, dewatering, refining, screening and cleaning; Effect of variables like temperature, pressure, agitation, consistency, and chemicals on pulp properties; Process water reuse	9
4	**Stickies in Recycled Fiber Pulp:** Type and size of stickies, origin and behavior of stickies, characterization of stickies	3
5	**Deinking:** Deinking operations, washing and flotation, comparison of washing and froth-flotation deinking systems, advances in deinking techniques, enzymatic deinking, disposal of deinking sludge	8
6	**Screening, Cleaning and Bleaching:** Forward cleaner operating parameters, reverse cleaner, pressure screen, reject screen, screening and cleaning system design parameters; Bleaching of high yield mechanical stock, bleaching of chemical grade secondary stock	9
7	**Processes for Different Recycled Papers Grades:** Newsprint, white paper grades, packaging paper and board grades, high wet strength papers	4
	Total	**42**

11. Suggested books:

S. No.	Name of Authors/Book /Publisher	Year of Publication/ Reprint
1	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 7: Recycled Fiber and Deinking (ed. Göttsching, L. and Pakarinen, H.)", Finnish Paper Engineers' Association and TAPPI	2000
2	Kocurek, M. J., "Pulp and Paper Manufacture, Volume 3: Secondary Fibers and Non-wood Pulping (ed. Hamilton, F. and Leopold, B.)", TAPPI Press	1987
3	McKinney, R. W. J., "Technology of Paper Recycling", Blackie and Academic Professional	1995
4	Spangenberg, R. J., "Secondary Fiber Recycling", TAPPI Press	1993

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PP-537** Course Title: **Paper Converting**

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 principal features of web converting operations and converted products.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Finishing Operations:** Winding, winding equipment, control of roll structure, winding variables, theory of slitting, slitters, sheeting, rotary cutters, sorting, inspecting and packaging, sampling techniques, sorting machines, packaging of finished paper	8
2	**Calendering and Super Calendering:** Fundamentals, objectives of calendering, types of calenders, mechanics of action of calender and supercalender, soft calendering, calendering defects and their remedies	5
3	**Extrusion Coating:** Equipment, laminator, polymers- polyethylene, polypropylene, polyesters, ethylene copolymer; Coextrusion, adhesive coatings	6
4	**Hot-melt Coating:** Preparation of hot-melts, ingredients of hot-melts, paraffin waxes, microcrystalline waxes, low molecular weight polyethylenes, copolymers, resins, antioxidants, application equipment - curtain coaters, roll coaters, slot-die coating	4
5	**Paper Laminates:** Process of making laminates, types of paper used in lamination, function of the resins, decorative laminates, industrial laminates	6
6	**Aqueous and Solvent Coating:** Solution and emulsion properties of polymers, preparation of polymer solutions, formation and properties of coating films, functional properties of coated papers; Coating methods, polymers used in functional coatings	4
7	**Metalizing and Lamination:** Characteristics of metalized products and process of metalizing; Types of laminated paper products, characteristics of papers, films, and foils used in laminating, laminating process, pressure sensitive adhesive label laminates	3
8	**Corrugated Board Manufacturing:** Corrugated board qualities, production of corrugated board, adhesives for corrugating, factors	3

	affecting gluing behavior, requirements of the linerboard and fluting medium, testing of corrugated board	
9	**Carton-board Package Manufacturing:** Packaged products and requirements for cartons, carton manufacturing and requirement for board	3
	Total	**42**

11. Suggested books:

S. No.	Name of Authors/Book /Publisher	Year of Publication/ Reprint
1	Kocurek, M. J., "Pulp and Paper Manufacture, Volume 8: Coating, Converting, and Specialty Papers (ed. Kouris, M.)", TAPPI Press	1990
2	Casey, J. P., "Pulp and Paper: Chemistry and Chemical Technology", Vol. 4, 3rd Ed., John Wiley	1981
3	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 11: Pigment Coating and Surface Sizing of Paper (ed. Lehtinen, E.)", Finnish Paper Engineers' Association and TAPPI	2000
4	Gullichsen J. and Paulapuro, H., "Papermaking Science and Technology, Book 12: Paper And Paperboard Converting (ed. Savolainen, A.)", Finnish Paper Engineers' Association and TAPPI	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PP-538** Course Title: **Advances in Stock Preparation**

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: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of advances in chemistry aspects in stock preparation and papermaking.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Surface and colloid chemistry interactions, fiber water systems, thermodynamics of cellulose water system; Electrokinetic behavior of stock, charge determination, zeta potential, cationic demand	6
2	**Refining:** Mechanism of refining, variables affecting refining, controlling parameters, types of refiners, selection of refiners for different grades of papers, effect of refining on pulp properties, specific edge load concept in refiner design, C-factor for a refiner, optimization of energy and refining action	9
3	**Sizing:** Basic surface science considerations in sizing, measurement of sizing, types of sizing agents, rosin, AKD, ASA, trouble-shooting of sizing problems	6
4	**Strength Additives:** Dry and wet strength additives, mechanisms of strength development, factors affecting wet and dry strength properties	4
5	**Fillers and Dyes:** Types and properties of fillers, effect of fillers on optical and mechanical properties of paper, dyes and pigments, dying of paper	4
6	**Control Chemicals at Wet End**: Retention aids, drainage aids, defoamers, deflocculants, pitch controlling agents, interfering materials, deposit control in papermaking	6
7	**Design of Equipment:** Stock chests and agitators, screening and cleaning system, fan pump; Control of consistency, stock flow and head	7
	Total	**42**

List of Experiment

i. Bauer McNett classification of pulps
ii. Beating of a given pulp and preparation of handsheets at different °SR
iii. Preparation of hand sheets from a given pulp at different dosing of sizing agents and determination of Cobb value
iv. Preparation and evaluation of hand sheets at different dosing of retention aids and fillers
v. Addition of dye and measurement of color

11. Suggested books:

S. No.	Name of Authors/Book /Publisher	Year of Publication/ Reprint
1	Kocurek, M. J., "Pulp and Paper Manufacture, Volume 6: Stock Preparation (Ed. Hagemeyer, R. W. and Manson, D. W.)", TAPPI Press	1992
2	Casey J. P., "Pulp and Paper: Chemistry and Chemical Technology", Vol. 2, 3rd Ed., John Wiley	1981
3	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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PP-539** Course Title: **Electrokinetics in Papermaking**

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 electrokinetics in papermaking processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Colloidal State:** Classification of colloidal systems, the motion of particles in liquid media	2
2	**Surface and Total charge:** Charge on fibre, filler and other particles in papermaking furnish, charged groups and their ionization	4
3	**Factors Affecting Fibre Charge:** Effect of chemical environment - pH, electrolyte concentration, valency of counter ion; Anionic trash in papermaking	5
4	**Electrokinetic Phenomena:** Electric double layer, effects of stock additives and process operations such as pulping, bleaching, and refining on electrokinetic properties of papermaking furnish	6
5	**Charge Measurement:** Zeta potential, microelectrophoresis, streaming potential, AC streaming current, titration techniques such as potentiometric, conductometric and polyelectrolyte, colloid titration ratio, absolute charge and charge demand	6
6	**Sorption and Swelling:** Sorption and swelling of cellulosic materials in water and other media, physical- and chemi-adsorption, surface area of cellulose and cellulosic materials	5
7	**Coagulation and Flocculation in papermaking:** Coagulation with electrolytes, flocculation and dispersion of colloidal materials, effects of additives on fiber flocculation	5
8	**Retention Mechanisms:** Charge neutralization, patch model, bridging, complex flocculation, dissolved and colloidal substances; Influence of shear	4
9	**Foam and Slime Control:** Nature of foam, foam formation and stabilization, effect of additives on foam stability, antifoam action; Micro-organisms and slime formation, chemical slime control	5
	Total	**42**

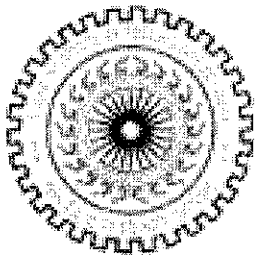
11. Suggested books:

S. No.	Name of Authors/Book /Publisher	Year of Publication /Reprint
1	Eklund, D. and Lindstrom, T. D., "Paper Chemistry: An Introduction", TAPPI Press	1991
2	Gess, J. M., "Retention of Fines and Fillers During Papermaking", TAPPI Press	1998
3	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 4: Papermaking Chemistry (ed. Neimo, L.)", Finnish Paper Engineers' Association and TAPPI	1999
4	Kocurek, M. J., "Pulp and Paper Manufacture, Volume 6: Stock Preparation (ed. Hagemeyer, R. W. and Manson, D. W.)", TAPPI Press	1992
5	Swanson, J., "Colloid Chemistry of Papermaking Materials", TAPPI Press	2002

Appendix-K
Item No.SENATE/36.2.2

M.Tech. Syllabus

(Spring Semester)



Department of Electrical Engineering
Indian Institute of Technology Roorkee
Roorkee – 247 667

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-502** Course Title: **Modeling, Simulation and Evolutionary Techniques**

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: **Spring** 7. Subject Area: **PCC**

8. Pre-requisite: **NIL**

9. Objective: To impart the knowledge of modeling and simulation of engineering systems and evolutionary techniques for modeling systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Modelling and Simulation:** Model Classification, mathematical, physical and analog models, population models, world models, transfer function approach and state variable approach of modeling linear systems, modeling of nonlinear systems, linearization, introductory ideas of chaos and fractals, comparison of simulation and analytical models, steps involved in simulation, validation and verification of simulation models, computer simulation of continuous and discrete systems.	10
2.	**Neural Networks:** Different network configurations, perceptron, perceptron training rule, multi-layer perceptron, backpropagation algorithm, radial basis function networks, Hopfield networks, Support Vector Machines, Unsupervised neural networks, neural network application in control, identification, pattern recognition and modeling.	12

3.	**Fuzzy logic:** Basic notions and Fuzzy sets, Fuzzy set operations, fuzzy arithmetic, concept of linguistic variables, fuzzy relations, fuzzy logic, inference methods, Mamdani method, Sugeno-Takagi method, fuzzy logic controllers and other applications, fuzzy modeling, type2 fuzzy logic.	**10**
4.	**Evolutionary techniques and hybrid approaches:** Genetic algorithm, schemata theorem, evolutionary computing. Particle swarm optimization, Neuro-fuzzy techniques, Genetic algorithm and particle swarm optimization in neural networks and fuzzy controllers, other hybrid approaches.	**10**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Gordon Geoffrey, System Simulation , Prentice Hall of India	**1984**
2.	Law Averill M Simulation Modeling and Analysis, TMH	**2001**
3.	Haykin Simon, Neural Networks: A Comprehensive Foundation, Second Edition, Prentice Hall	**1999**
4.	Bishop Christopher M, Neural networks for pattern recognition, Oxford University Press	**1995**
5.	Driankov Dimiter 'An Introduction to Fuzzy Control' 2nd edition, Springer-Verlag	**2001**
6.	Goldberg, David E Genetic Algorithms in Search, Optimization and Machine Learning, Kluwer Academic Publishers,	**1989**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **Department of Electrical Engineering**

1. Subject Code: **EE-522** Course Title: **Biomedical 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 introduce instrumentation systems being used in clinical laboratory, medical imaging, biotelemetry, prosthetics, orthotics and assisting and therapeutic devices.
10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Human Body Subsystems:** Brief description of neuronal, muscular, cardiovascular and respiratory systems, their electrical, mechanical and chemical activities.	4
2.	**Transducers and Electrodes:** Principles and classification of transducers for biomedical applications; Electrode theory, different types of electrodes.	4
3.	**Cardiovascular System:** Measurement of blood pressure, blood flow, cardiac output, cardiac rate, heart sounds; Electrocardiograph; Phonocardiograph; Plethysmograph; Echocardiograph.	4
4.	**Respiratory System:** Measurement of gas volume, flow rate, carbon-dioxide and oxygen concentration in exhaled air.	4
5.	**Clinical Laboratory:** Measurement of pH value of blood, ESR measurement, Haemoglobin measurement, O_2 and CO_2 concentration in blood, GSR measurement, Polarographic measurements.	4
6.	**Electrical Activity in Neuromuscular System and Brain:** Neuron potential, muscle potential, electromyograph, brain potentials, electroencephalograph.	4
7.	**Medical Imaging:** Diagnostic X-rays, CAT, MRI, Thermography, Ultrasonography; Medical use of Isotopes; Endoscopy.	4
8.	Patient Care, Monitoring and Safety Measures	2

9	**Computer Applications and Bio-Telemetry:** Real time computer applications, Data acquisition and processing.	**3**
10	**Prosthetics and Orthotics:** Introduction to artificial kidney, artificial heart, heart lung machine, limb prosthetics and orthotics; Elements of audio and visual aids.	**4**
11	**Assisting and Therapeutic Devices:** Introduction to cardiac pacemakers, defibrillators, ventilators, muscle stimulators, diathermy.	**3**
12	**Lasers:** Application of lasers to biomedical sciences.	**2**
	Total	**42**

11. Suggested Books :

S. No.	Name of Books/Authors	Year of Publication /Reprint
1.	Geddes L. A. and Baker L. E., "Principles of Applied Biomedical Instrumentation", John Wiley and Sons.	**1989**
2.	Khandpur R. S., "Handbook on Biomedical Instrumentation", 2nd Ed., Tata McGraw-Hill	**2008**
3.	Cromwell L., Weibell F. J. and Pfeifer E. A., "Biomedical Instrumentation and Measurements", Prentice Hall of India	**2003**
4.	Aston R., "Principles of Biomedical Instrumentation and Measurements", Macmillian.	**1991**
5.	Antoui H., Chilbert M. A., and Sweeny J. D., "Applied Bioelectricity", Springer-Verlag.	**1998**
6	Hill D. W. and Dolan A. M., "Intensive Care Instrumentation", Academic Press.	**1982**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **Department of Electrical Engineering**

1. Subject Code: **EE-523** Course Title: **Process Instrumentation 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: **PEC**
8. Pre- requisite : **NIL**
9. Objective: To impart knowledge of transducers, design of analog and digital controllers, programmable logic controllers and computer control of processes.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Review of Concepts of System Response:** First order systems, Transient response to different forcing functions, Non-interacting and interacting systems.	2
2.	**Sensors and Transducers:** Basic concepts and working principles of sensors and transducers for measuring process variables like pressure, temperature, level and flow; Electromechanical, capacitive, inductive, resistive and photoelectric type proximity sensors.	10
3.	**Controller Principles:** Process characteristics; Control system parameters; Discontinuous and continuous controller modes, composite control modes.	4
4.	**Analog Controllers:** General features; Electronic controllers; Pneumatic controllers; Design considerations.	4
5.	**Digital Controllers:** Digital simulation of control systems, simulation software, computer software for process control, microprocessor based controller.	6
6.	**Control Loop Characteristics:** Control system configuration, multivariable control system, control system quality and stability, process loop tuning.	4
7.	**Control Equipment and Final Control Elements:** Details of controllers including measurement unit, comparator, actuator and final control elements; Pneumatic, hydraulic and electric actuators; Control valve characteristics; Pneumatic to electric and electric to pneumatic converters, hydraulic and pneumatic power supply system.	5

8.	**Programmable Logic Controllers:** Relay controllers and ladder diagrams, relay sequences; PLC operation and programming.	**3**
9	**Distributed and Supervisory Controls:** Introduction and relevance of distributed control; Hardware components of distributed control; Introduction and necessity of supervisory control; Master control station and remote terminal units.	**4**
	Total	**42**

11. Suggested Books :

S. No.	Name of Authors /Book/ Publisher	Year of Publication/ Reprint
1.	Coughanowr D. R., "Process Systems Analysis and Control", 2nd Ed., McGraw-Hill.	**2008**
2.	Johnson C. D., "Process Control Instrumentation Technology", 8th Ed., Prentice Hall of India	**2008**
3.	Harriott Peter, "Process Control", Tata McGraw-Hill	**2008**
4.	Chemsmond C. J., "Basic Control System Technology", Viva Books	**2004**
5.	Chemsmond C. J., Wilson and Lepla, "Advanced Control System Technology", Viva Books	**2004**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **Department of Electrical Engineering**

1. Subject Code: **EE-524** Course Title: **Telemetry and SCADA**
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 signal transmission techniques, telemetry, remote control and SCADA.
10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Introduction:** Meaning and importance of telemetry, remote control, remote signaling and SCADA; Messages and signals; Signal formation; Conversion and transmission.	3
2.	**Analog Transmission Techniques:** Analog modulation; Amplitude modulation; AM transmitter and receiver; Frequency modulation; FM transmitter and receiver; Phase modulation; Pulse modulation techniques.	8
3.	**Digital Transmission Techniques:** Digital modulation, pulse analog modulation, pulse width modulation; Pulse code modulation; Frequency and phase shift keying; transmission techniques; Error detecting and correcting codes.	7
4.	**Signal Transmission Media:** Wires and cables; Power-line carrier communication, terrestrial and satellite radio links, optical fiber communication; Multiplexing – TDM, FDM and WDM.	5
5.	**Telemetry:** Telemetry error; dc, pulse, and digital telemetry methods and systems; Multichannel telemetry schemes.	6
6.	**Remote Control and Remote Signaling:** Principle of independent messages and combinatorial principle; Multi-wire FDM and TDM schemes.	5
7.	**Supervisory Control and Data Acquisition:** Layout, functions and operation of SCADA system, remote terminal unit details, Control centre details, communication among control centres and between control centre and remote terminal units.	8
	Total	**42**

11. Suggested Books :

S. No.	Name of Authors /Book/ Publisher	Year of Publication
1.	Karp H. R. (Editor), "Basics of Data Communication", McGraw- Hill.	1976
2.	Tomasi W., "Electronic Communication Systems: Fundamentals", 5th Ed., Pearson Education.	**2008**
3.	Gruenberg E. L., "Handbook of Telemetry and Remote Control", McGraw-Hill.	**1967**
4.	Ginzburg S. A., Lekhtman I. Ya. and Malov V. S., "Fundamentals of Automation and Remote Control", Mir Publishers	**1967**
5.	Cegrell T., "Power System Control Technology", Prentice Hall.	**1986**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-525** Course Title: **Measurement Errors and Statistical 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 impart knowledge of different types of errors in a measurement system and statistical analysis.
10. Details of course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Concept of generalized measurement system; Static sensitivity, drifts, linearity, hysteresis, threshold, resolution, generalized static stiffness, input/output impedances, impedance loading and matching.	5
2.	**Mathematical Model:** Mathematical model of measurement system; Transfer function; Frequency response of zero, first and second order measurement systems; Dynamic response of various inputs.	5
3.	**Instrument Characteristics:** Static calibration; True value; Static error; Static correction; Scale range and scale span; Error calibration curve; Reproducibility; Repeatability; Noise to signal ratio; Sources and types of noise.	5
4.	**Errors in Measurement:** Limiting error; Relative limiting error; Combination of quantities with limiting error; Types of errors; gross error, systematic errors, instrumental error, environmental errors, observational errors.	4
5.	**Random Error:** Control value; Statistical treatment of data; Histogram; Arithmetic mean; Measure of dispersion from the mean; Variance	5
6.	**Statistical Analysis:** Normal or Gaussian curve of errors; Precision index; Probable Error; Average deviation for curve; Probable error of a finite number of readings; Standard deviation; Probability tables.	5
7.	**Measurement Data:** Specifying measurement data; Confidence interval; Confidence level; Rejection of data-Chauvernet's criterion; Rejection of data based upon confidence interval; Variance, standard deviations and probable error of combination of components.	3
8.	**Normal Probability Distribution Functions:** Probability density function; Integral Gaussian probability control; Limit theorem; Significance test; Criteria for goodness of fit; Contingency tables.	3

9.	**Graphical Representation and Curve Fitting:** Equations of approximating curves; Graphical representation of functional relationships; Determination of parameters in linear relationships; Graphical method; Method of sequential differences; Methods of extended differences; Method of least squares; Linear least square curve fitting; Determination of uncertainties in the slope and intercept values for linear regression.	**5**
10.	**Auto-Correlation Functions:** Auto-correlation functions of a random signal; Statistical properties of a pair of random signals.	**2**
	Total	**42**

11. Books suggested:

S.No.	Name of Authors /Book/ Publisher	Year of Publication/ Reprint
1.	Nakra B. C. and Chaudhry K.K., "Instrumentation, Measurement and Analysis", Tata Mc Graw Hill	**2004**
2.	Sawhney A.K. "Electrical and Electronic Measurements and Instrumentation", Dhanpat Rai.	**2007**
3.	Helfrick A. D. and Cooper W.D., "Modern Electronic Instrumentation and Measurement Techniques", Prentice Hall.	**2000**
4.	Murty D. V. S., "Transducers and Instrumentation", Prentice Hall.	**2003**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-526** Course Title : **Bioelectric Signals and Processing**
2. Contact Hours: L: **3** T: **1** P: **0**
3. Examination Duration (Hrs.) : **Theory** 3 **Practical** 0
4. Relative Weight age: **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 bioelectrical signals under normal and disease conditions and their processing and analysis.
10. Details of course:

S. No.	Contents	Contact Hours
1.	**Basic Neurology:** Nervous System, neuron; Resting potential; Nernst equation; Electrical equivalents.	4
2	**Noise and Interference:** Sources of noise in bioelectrical signal recordings; Grounding and shielding.	3
3	**Filtering:** Filtering techniques-active and passive filters; Digital filtering; Design of digital filters.	6
4	**Electrical Activity of Heart:** Introduction to ECG Lead system and recording; ECG wave component detection and analysis; Vector cardiography; Inverse cardiography; Signal conditioning and processing.	8
5.	**Electrical Activity of Neuromuscular System:** Muscular system; Electrical signals of motor unit and gross muscle; Human motor coordination system; Electrodes; Correlation of force and work; EMG integrators; Signal conditioning and processing.	4
6.	**Electrical Activity of Brian:** Sources of brain potentials; Generation of signals, component waves; EEG recording electrodes, 10-20 electrode system; EEG under normal, Grand mal and Petit mal seizures; Signal conditioning and processing.	4
7.	**Electrical Signals from Visual System:** Sources of electrical signals in eye; Generation of signals; Electroretinogram; Electroocculogram; Analysis of signals	4
8.	**Electrical Signals from Auditory System:** Generation of cochlear potentials and nature; Evoked responses; Auditory nerves; Signal conditioning and processing.	3

9	**Frequency Analysis**: z-Transform; Fourier transform; Fast Fourier transform; Frequency analysis; Filtering of signals in frequency domain.	**6**
	Total	**42**

11. Books suggested:

S.No.	Name of Authors /Book/ Publisher	Year of Publication/ Reprint
1.	Rangayyan R. M., "Biomedical Signal Analysis", John Wiley & Sons	**2002**
2.	Bruce E. N., "Biomedical Signal Processing and Signal Modeling", John Wiley & Sons	**2006**
3.	John L. Semmlow, "Biosignal and Biomedical Image Processing : MATLAB-Based Applications", CRC press.	**2008**
4.	Amine N. A., "Advanced Biosignal Processing", Springer	**2009**
5.	Tompkins W. J., "Biomedical Digital Signal Processing: C Language Examples and Laboratory Experiments for the IBM PC", Prentice Hall	**2006**
6.	Sawhney G.S., "Fundamentals of Biomedical Engineering", New Age International.	**2007**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-527** Course Title : **Computer Applications in Medicine**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.) : **Theory** 3 **Practical** 0
4. Relative Weight age: **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 use of computers in hospitals for better healthcare delivery.
10. Details of course:

S. No.	Contents	Contact Hours
1.	**Computer in Data Collection:** Introduction; Basic building blocks of data acquisition systems; Use of computers in physiological data acquisition; Off-line data collection; Data collection techniques; Patient database; Computerized medical records.	5
2.	**Hospital Data Management:** Hospital information system; Functional capabilities of computerized hospital information system; Efficiency; security and cost effectiveness of computer records; Patient data management.	4
3.	**Automated Clinical Laboratory System:** Database approach to laboratory computerization; Automated clinical laboratories; Automated methods in haematology, Chromosome analyzers; Computerized cytology and histology.	5
4.	**Bio-signal Analysis:** Computerized electrocardiography; Holter electrocardiography; Electromyography; Electroencephalography and echocardiography; Computer analysis of non-electrical bio-signals; Computer aided medical decision making.	6
5.	**Medical Imaging:** Introduction to medical imaging; Computes in medical imaging, Nuclear medicine, Digital subtraction radiography, Computerized ultrasonography, X-rays, Computerized tomography, Computerized emission tomography, Nuclear magnetic resonance.	8
6.	**Computer-Assisted Therapy:** Computer based cardiac assist devices; Computers for care of renal disorders; Computer based cancer chemotherapy; disorders; Protocol advisors; Radiotherapy; Diabetes management; Automated drug delivery; Lithotripsy.	5
7.	**Aids for Handicapped:** Computer aids for visually handicapped and deaf.	3
8.	**Medical Research:** Computer in simulation, modeling and analysis of bio-systems; On-line interactive systems with patients for analysis and research; Introduction to expert systems	6
	Total	42

11. Books suggested:

S.No.	Name of Authors /Book/ Publisher	Year of Publication/ Reprint
1.	Joseph D. Bronzino, "Biomedical Engineering Handbook", Second Edition Volume II , CRC Press	**2000**
2.	Atam P. Dhawan, "Medical Image Analysis", John Wiley & Sons, Inc.,	**2003**
3.	John G. Webster, "Encyclopedia of Medical Devices and Instrumentation", (Volume 1-4), John Wiley & Sons, Inc.	**1988**
4.	Suetens P., " Fundamentals of Medical Imaging", 2nd Edition, Cambridge University Press	**2009**
5.	Bichindaritz I., Vaidya S., Jain A., and Jain L .C., "Computational Intelligence in Healthcare: Advanced Methodologies", Springer-Verlag	**2010**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-528** Course Title : **Virtual Instrumentation**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.) : **Theory** 3 **Practical** 0
4. Relative Weight age: **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 virtual instrumentation concept and use of graphical language to develop virtual instrumentation systems.
10. Details of course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Historical perspective and traditional bench-top instruments; Virtual instruments and their advantages, applications and test cases.	4
2.	**Structure of Virtual Instruments:** Acquire, analyze and present; Low (Register) level programming; Interface buses – serial (RS-232, RS 485, GPIB, USB, etc.) PCI; HLL programming – Basic, C, C++.	4
3.	**LabVIEW:** Introduction, arrays, clusters, graphs, charts, programming techniques, string operation, data logging, front panel design; VI server; Web publishing; Remote operation.	12
4.	**Basics of Data Acquisition:** Transducers: input voltage and current levels, amplifiers; Signal conditioners: filters, integrators, differentiators, thresholding; DAQ h/w and s/w: sampling rate, aliasing, number of channels, input levels of each channel, data storage.	12
5.	**Analyses in LabVIEW:** Mathematical tools and signal processing tools.	6
6.	**Advanced Concepts in LabVIEW:** Data Socket; TCP/IP VI's; Synchronization DLL of LV; Compilation and execution in LV; Memory management; Bus extensions – PXI and PCMCIA; Concepts of real–time systems; Image acquisition; Motion control.	4
	Total	42

11. Books suggested:

S.No.	Name of Authors /Book/ Publisher	Year of Publication/ Reprint
1.	Paton B. E., "Sensors, Transducers & Lab VIEW", Prentice Hall International	**1999**
2.	Clark C. L., "Lab VIEW Digital Signal Processing", Tata McGraw – Hill Publishing Company Ltd.	**2005**
3.	Johnson G., "Lab VIEW Graphical Programming", 2nd Edition, McGraw Hill	**1997**
4.	Wells L. K. and Travis J., "Lab VIEW for Everyone", Prentice Hall,	**1997**
5.	Sokoloff, "Basic Concepts of Lab VIEW 4", Prentice Hall,	**1998**
6.	Technical Manuals for DAS Module: Advantech and National Instruments	

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **Department of Electrical Engineering**

1. Subject Code: **EE-529** Course Title: **Medical Imaging**
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 introduce standard medical imaging systems and their applications.
10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Introduction:** General overview of medical imaging system, spectrum of their applications in medical diagnosis and therapy	3
2.	**Ionizing Radiation:** Introduction, interaction with matter, radiation dosimetry, clinical use, biological effects and safety	5
3.	**Radiography:** X-Rays, detectors, dual energy imaging, equipment, film-screen and digital; mammography & fluoroscopy	4
4.	**Ultrasound Imaging:** Introduction, generation and detection of ultrasound, Doppler imaging, image quality, equipment, clinical use, biological effects & safety.	6
5.	**Image Analysis:** Image types, removal of artifacts, frequency domain analysis, detection of region of interests, shape and texture analysis	8
6.	**Computer Tomography(CT):** X-Ray detectors in CT, cardiac CT, dual-energy CT equipment	4
7.	**Magnetic Resonance Imaging (MRI):** Principles of MR imaging, interaction with tissues, signal detection, imaging, FMRI, clinical application	6
8.	**Nuclear Medicine Imaging:** Radio nuclides, interaction of γ photons and particles with matter, single photon emission computed tomography (SPECT), positron emission tomography(PET)	3
9.	**Imaging applications in Therapy:** Radiation therapy treatment planning; Conformal therapy / Brachyytherapy	3
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Book/ Publisher	Year of Publication/ Reprint
1.	Bushberg J. T., Seibert J. A., Leidholdt E. M., Boone J. M, "The Essential Physics of Medical Imaging", 2nd Edition, Lippincott Williams & Wilkins Pub. (Kluwer)	**2002**
2.	Webb S., "The Physics of Medical Imaging", Institute of Physics Publishing	**1988**
3.	Brown B. H., Smallwood R H, Barber D C and Hose D R, " Medical Physics and Biomedical Engineering" , Institute of Physics Publishing Ltd.	**1999**
4.	Dyk J. V., "The Modern Technology of Radiation Oncology", Medical Physics Publishing	**1999**
5.	Guy C. and Ffytche D., "An Introduction to the Principles of Medical Imaging", World Scientific	**2005**
6.	Suetens P., " Fundamentals of Medical Imaging", 2nd Edition, Cambridge University Press	**2009**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **Department of Electrical Engineering**

1. Subject Code: **EE-530** Course Title: **Power System 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 : **Spring** 7.Subject Area: **PEC**
8. Pre- requisite : **NIL**
9. Objective: To provide knowledge of instrumentation of power system network and relays.
10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Measurement of Electrical Quantities:** Measurement of voltage, current, phase angle, frequency, active power and reactive power in power plants; Energy meters and multipart tariff meters	7
2.	**Voltage and Current Transformers:** Voltage transformers for measurement and protection, errors, transient performance; Capacitive voltage transformers and their transient behavior; Current transformers for measurement and protection, composite errors, transient response.	8
3.	**Hydroelectric Power-Plant Instrumentation:** Measurement of flow, level, pressure, temperature, hydraulic head and mechanical vibrations; Temperature scanners; Alarm annunciators.	8
4.	**Thermal Power-Plant Instrumentation:** Measurement of gas flow; Gas and feed-water analysis; Flame monitoring; Steam turbine instrumentation.	7
5.	**Nuclear Power-Plant Instrumentation:** Reactor safety, Neutron flux measurement; Reactor power level and coolant measurements.	7
6.	**Protective Relays:** Organization of protective relay; Single input, two-input, multi-input, electromagnetic, electronic and digital relays.	5
	Total	42

11. Suggested Books :

S. No.	Name of Authors /Book/ Publisher	Year of Publication/ Reprint
1.	"Modern Power Station Practice, Volume F: Control and Instrumentation", British Electricity International, Pergmon Press.	**1990**
2.	Elliott T. C., "Standard Hand Book of Power Plant Engineering", McGraw-Hill.	**1989**
3.	Van A. R. and Warrington C., "Protective Relays- Their Theory and Practice", Vol. 1, Chapman and Hall.	**1968**
4.	Rao T. S. M., "Power System Protection – Static Relays with Microprocessor Applications", 2nd Ed., Tata McGraw-Hill.	**2008**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **Department of Electrical Engineering**

1. Subject Code: **EE-531** Course Title: **Ultrasonic and Laser 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 : **Spring** 7.Subject Area: **PEC**

8. Pre- requisite : **NIL**
9. Objective: The impart knowledge of ultrasonics, lasers and their applications.
10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Ultrasonic Wave Motion :** Non-planer waves, Interference of waves: Plane sound waves at boundaries: Wave physics of sound field	5
2.	**Ultrasonic Wave Generation and Reception:** Piezoeletcric method: Mechanical effects: Thermal effects and laser techniques: Electrostatic methods: Electrodynamoc methods(EMATs): Magnetostrictive methods: Optical methods: Transducer structure and design	5
3.	**Ultrasonic Scanning and Testing Methods:** Echo from and shadow of an obstacle in the sound field: Pulse echo method: Design and Performance of a pulse-echo detector	6
4.	**Ultrasonics in Industrial Testing and Measurement:** Various scanning methods used in industry: Transit-time method: Imaging and methods of reconstruction: Various industrial applications	5
5.	**Ultrasonics in Medial Diagnosis:** Scanning methods used in medical field: Doppler method: Various applications	4
6.	**Lasers:** Definition, properties generation of laser: Mathematical foundations.	6
7.	**High Intensity Applications of Lasers in Industry:** Surface hardening, welding, cutting, laser assisted machining, laser marking, hole piercing, alloying and cladding	5
8.	**Low Intensity Applications of Lasers in Industry:** Scanning, shadow projection, alignment, triangulation,	3
9.	**Application of Laser in Medical field:** Lasers used in medical field and their properties; Laser surgery	3
	Total	42

11. Suggested Books :

S. No.	Name of Authors /Book/ Publisher	Year of Publication
1.	Krautkramer J. and Krautkramer H., "Ultrasonic Testing of Materials, Springer Verlag	**1990**
2.	Kundu T. " Ultrasonic Nondesrtructive Evaluation : Engineering and Biological Material Characterization". CRC Press	**2000**
3.	Shull P. J., "Nondestructive Evaluation : Theory, Techniques and Applications", Marcel Dekker	**2002**
4.	Luxon J. T. and Parker D. E, "Industrial Lasers and their Applications", Prentice Hall.	**1985**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-533** Course Title: **Advances in Signal and Image Processing**
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 students about the advance topics in signal and image processing.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** General overview of first course on digital signal and image processing; Introduction to advanced topics.	4
2.	**Multi-rate Signal Processing:** Decimation and interpolation, filters for decimation and interpolation, multistage decimators and interpolators; Filter banks; Two-channel QMF banks.	5
3.	**Adaptive Signal Processing:** Wiener filter, gradient search, steepest descent, LMS and block LMS; Frequency domain adaptive filtering.	6
4.	**Least Squares Adaptive Algorithms:** The RLS, EDS and fast EDS, ADPCM; 2-D adaptive algorithms; Image restoration.	4
5.	**Linear Prediction:** Forward and backward predictions; Levisson-Durbin Algorithm; Predictive error filter; Adaptive lattice z-filter; Speech coding	5
6.	**Random Variables, Vectors and Sequences:** Random variables and vectors; Discrete-time stochastic processes; Principles of estimation theory; Higher order statistics	3
7.	**Nonparametric Power Spectrum Estimation:** Spectral analysis of deterministic signals; Estimation of the autocorrelation of stationary random signals; Estimation of the power spectrum of stationary random signals; Joint	5

	signal analysis; Multitaper power spectrum estimation; Blind deconvolution; Unsupervised adaptive filters- blind equalizers	
8.	**Wavelets and Multiresolution Processing:** Background; Multiresolution expansions, wavelet transform in one dimension, fast wavelet transform, wavelet transforms in two dimensions, wavelet packets	**4**
9.	**Color Image Processing:** Color fundamentals; Color models; Psedocolor image processing; Basics of full-color image processing; Color transformations; Smoothing and Sharpening; Color segmentation; Noise in color images, Color image compression	**6**
	Total	**42**

11. Suggested Books :

S. No.	Name of Authors /Book/ Publisher	Year of Publication/ Reprint
1.	Gonzalez R.C. and Woods R.E., " Digital Image Processing", Perason-Prentice Hall,	**2005**
2.	Bose T., " Digital Signal and Image Processing", John Wiley and Sons	**2004**
3.	Manolkis D.G., Ingle V. K. and Kogon S. .M., " Statistical and Adaptive Signal Processing: Specrtal Estimation, Signal Modelling, Adaptive Filtering and Array Processing", Artech House	**2005**
4.	Marshall S. and Sicuranza G. L." Advances in Nonlinear Signal and Image Processing", Hindawi.	**2006**
5.	Barner K.E. and Arce G.R., "Nonlinear Signal and Image Processing: Theory, Methods, and Applications", CRC Press	**2004**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-543** Course Title: **Advanced 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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **EE-541 or equivalent**

9. Objective:

To provide state of art speed control techniques used in modern ac drives fed from LCI/VSI/CSI.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Review**: Power electronic converters for ac drive control, voltage source and current source inverters.	3
2.	**LCI-IM Drive:** Drive configuration, commutation at different speeds, mathematical modeling, control structure, resonance problem and performance.	5
3.	**FOC-IM Drive:** Drive configuration, mathematical modeling, direct and indirect FOC, influence of parameters, VSI and CSI fed schemes, adaptive drive control.	7
4.	**Brushless DC Drive:** Self control, CSI with load commutation, low speed commutation, inverter control strategies and performance.	5
5.	**Permanent Magnet SM Drive:** Principle of operation, converter configuration, synchronization, trapezoidal and sinusoidal drive control structures and performance.	6
6.	**Switched Reluctance Motor Drive:** Principle of operation, converter circuits, sensors, speed control and performance.	5
7.	**Resonant-Link Converter fed Drive:** Principle of soft switching in inverters and converters utilizing resonant circuits, modulation strategies and application in IM drives.	5

S.No.	Contents	Contact Hours
8.	**Advanced Control Techniques:** Application of modern and evolutionary techniques in drives such as fuzzy and ANN control.	6
	Total	**42**

List of Practicals:

1. Simulation of Load commutated Induction Motor drive
2. Simulation of Field Oriented Controlled Induction Motor drive
3. Simulation of Brushless DC Motor drive
4. Simulation of Permanent Magnet Synchronous Motor drive
5. Simulation of Switched Reluctance Motor drive
6. Simulation of Resonant Link Converter fed Induction Motor drive
7. Performance evaluation of Induction motor drive

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Dubey G. K., "Power Semiconductor Controlled Drives", Prentice-Hall International Editions.	1989
2.	Murphy J. M. D. and Turnbull F. G., "Power Electronics Control of AC Motors", Peragmon Press.	1990
3.	Bose B. K., "Power Electronics and Variable Frequency Drives", IEEE Press, Standard Publisher Distributors.	2001
4.	Krishnan R., "Electric Motor Drives – Modeling, Analysis and Control", Prentice Hall of India Private Limited.	2007
5.	Bose B. K., "Modern Power Electronics and AC Drives", Pearson Education.	2008
6.	Leonard W., "Control of Electric Drives", Springer Press.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-544** Course Title: **Microprocessor Controlled Electric Drives**

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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **EE-206, EE-304 and EE-307 or equivalent**

9. Objective:

To provide knowledge of microprocessor-based control system for electrical drives with an emphasis on generation of firing signals for power electronic converters, processing of speed and current error in closed loop control of drives.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Review of 8-bit microprocessor, programmable peripheral interface Intel 8255A, programmable Interval timer Intel 8253, programmable interrupt controller Intel 8259A; Review of phase angle controlled converters, chopper, quasi- square and PWM Inverters; Overview of microcomputer control of power electronic systems.	7
2.	**Microprocessor Controlled Converters:** Firing pulse generation of single-phase and three-phase converters, control techniques.	5
3.	**Microprocessor Controlled Choppers:** Firing pulse generation of single-quadrant and multi-quadrant choppers, control techniques.	3
4.	**Microprocessor Controlled Inverters:** Firing pulse generation of voltage source PWM inverters, three-timer and four-timer methods, foreground and back ground calculation, current source inverters.	5
5.	**Feed Back Signal Processing**: Measurement of electrical and mechanical variables- current, speed and position of motor, signal conditioning.	4

S. No.	Contents	Contact Hours
6.	**Closed Loop Drive:** Control philosophy, closed loop dc drive fed from dual converter and chopper, VSI, CSI and PWM inverter fed drives.	6
7.	**Modeling:** Mathematical modeling, simulation of drives, design of current and speed controllers in continuous and discrete data system, stability studies.	6
8.	**Modern Control Theory Applications to Drives:** Fuzzy control of dc drive, ANN control of dc drive,	6
	Total	42

List of Practicals:

1. Microprocessor based firing pulse generation for Single-phase Converter
2. Microprocessor based firing pulse generation for Three-phase Converter
3. Microprocessor based firing pulse generation for Chopper
4. Microprocessor based firing pulse generation for Voltage Source Inverter
5. Microprocessor based measurement of motor speed
6. Microprocessor based measurement and filtering of motor current

11. Suggested Books:

S.No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Dubey G. K., "Power Semiconductor Controlled Drives", Prentice-Hall International Editions.	2001
2.	Bose B. K., "Power Electronics and Variable Frequency Drives", IEEE Press, Standard Publisher Distributors.	2001
3.	Bose B. K., "Microcomputer Control of Power Electronics and Drives", IEEE Press.	1999
4.	Toliyat H. A. and Campbell S., "DSP Based Electromechanical Motion Control", CRC Press.	2004
5.	Kenjo T., "Power Electronics for the Microprocessor Age", Oxford University Press.	1994

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-545** Course Title: **Embedded Controllers and Applications**

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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **EE-307 or equivalent**

9. Objective:

To provide knowledge of Intel 8051 family microcontrollers and applications, their architectures, operation, instruction set, programming and interfacing and, basics of PIC controllers.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Review of 8-bit Microprocessor:** State transition diagram, interrupt structure, input/output techniques.	3
2.	**Review of Peripheral Devices:** Intel 8255 PPI, Intel 8253 PIT, Intel 8259 PIC, ADC and DAC chips and their interfacing.	4
3.	**Serial Communication Interface:** Intel 8251 USART, pin configuration, functional description, synchronous and asynchronous serial transmission of data, interfacing serial device, programming, RS-232C signals, modem control, communication standards.	4
4.	**Intel 8051/8052 Microcontroller:** Architecture, functional diagram, pin description, CMOS and HMOS microcontrollers and their difference, oscillator, CPU Timing, Intel 8031 and 8751.	3
5.	**Memory Organization:** Accessing external program and data memory, internal data memory, special function registers, hardware interfacing, I/O expansion.	4
6.	**I/O Ports:** Internal structure of ports P0, P1, P2 and P3, alternative functions of port P3.	2

S. No.	Contents	Contact Hours
7.	**Timer/Counter:** Timer and counter operation, TM0, TM1 and TM2, modes of operation.	3
8.	**Serial Port**: Modes of operation, programming, multi-processor control.	3
9.	**Interrupts**: Types, interrupt priority and interrupt enable registers, processing of interrupt, single-step operation.	2
10.	**Programming:** Addressing modes; Instruction set: Data transfer group, arithmetic group, logical group, control group and Boolean processing capability; Programming and erasing EPROM.	6
11.	**Applications of Micro-controller:** Generation of firing pulses for phase controlled converter, chopper and inverter.	2
12.	**PIC Controllers:** Intel 16 series microcontroller, configuration, pin description, instruction set and programming.	6
	Total	42

List of Practicals:

1. Study of Intel 8255A PPI
2. Study of Intel 8253 PIT
3. Study of Intel 8259A PIC
4. Study of Intel 8251A USART
5. Programming of Intel 8051 microcontroller
6. Study of Timer and interrupts of Intel 8051 microcontroller

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Intel Manual on 8-bit Microcontroller	--
2.	Ayala K. J.," The 8051 Microcontroller- Architecture, Programming and Applications", 3rd Ed, Cengage Learning.	2008
3.	Hall D.V., "Microprocessor and Interfacing –Programming and Hardware", 2nd Ed., Tata McGraw-Hill Publishing Company Limited.	2008
4.	Mazidi M.A. and Mazidi J.G., "The 8051 Microcontroller and Embedded Systems", 2nd Ed., Pearson Education.	2008
5.	Deshmukh A.V., "Microcontroller: Theory and Applications", Tata McGraw-Hill Publishing Company Limited.	2008
6.	Peatman J.B., "Design with PIC Microcontrollers", Pearson Education.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-546** Course Title: **Design of Electric Drives**

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: **Spring** 7. Subject Area: **DEC**

8. Pre-requisite: **EE-304 or equivalent**

9. Objective:

To provide knowledge of interdependence of various elements of the elective drive system.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Review of Electric Drive System:** Elements of drive system, power converters and their influence on supply systems, mechanical system transmitting system, nature of load; Drive characteristics, range of speed control, constant torque and constant power drive.	6
2.	**Design of Converters and Drives**: Selection of power semiconductor devices, their protection and cooling; Design of power converters-chopper, phase controlled converters, inverters and cyclo-converters.	10
3.	**Design Modifications:** Input transformers and converter fed machines.	4
4.	**Design of Closed Loop Drive Systems**: Drive structure, multiple loop and multi-quadrant operation, controllers, synthesis of ac and dc drives.	8
5.	**Energy Conservation in Drives:** Optimisation of operational efficiency of drive including controller design modifications for converters, on-line optimization of efficiency for dc and ac drives.	10
6.	**Case Studies:** Industrial drives in traction and transportation system, steel, cement, paper and textile industries.	4
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication / Reprint
1.	Pillai S. K., "A First Course in Electric Drives", 2nd Ed., New Age International Private Limited Publishers.	2008
2.	Derek A. P., "Power Electronic Converter Harmonics-Multipulse Methods for Clean Power", IEEE Press.	1995
3.	Dubey G. K., "Power Semiconductor Controlled Drives", Prentice-Hall International Edition.	2001
4.	Murphy J. M. D. and Turnbull F. G., "Power Electronics Control of AC Motors", Pregamon Press.	1988
5.	Bose B. K., "Power Electronics and Variable Frequency Drives", IEEE Press, Standard Publisher Distribution	2001
6.	Mohan N., Undeland T.M. and Robbins W.P., "Power Electronics-Converters, Applications and Design", 3rd Ed., Wiley India.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-547** Course Title: **Instrumentation in Electric Drives**

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: **Spring** 7. Subject Area: **DEC**

8. Pre-requisite: **EE-304 or equivalent**

9. Objective:

To impart knowledge of instrumentation related to electric drive parameters and their signal conditioning circuits.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Transducers and sensors, definitions, classification of errors.	3
2.	Review of characteristics and parameters of transducers: tachometers, shaft-encoders, torque sensors, Hall-effect sensors and magnetic pick-ups.	5
3.	Devices for instrumentation, design characteristics and typical applications of instrumentation, operational trans-conductance, isolation amplifiers, analog multipliers and dividers, function generators, timers, analog multiplexers.	8
4.	Sample and hold circuits; Optical and magnetic isolators; Frequency to voltage converters; Temperature to current converters.	4
5.	Review of A/D and D/A converters, specifications, multiplexed ADC, multiplying ADC; Data acquisition system.	4
6.	Instrumentation and signal processing.	3
7.	Basic concept of PLL system, definitions of lock-in-range, capture-range, loop gain, design aspects of phase detector, loop filter, PLL based motor speed control.	6

S. No.	Contents	Contact Hours
8.	Drive related signals and their instrumentation and conditioning.	3
9.	Data acquisition system, basic structure, data acquisition of voltage, currents, speed, temperature, torque and flux.	6
	Total	42

11. Suggested Books:

S.No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Cerni, R. H. and Foster L. E., "Instrumentation for Engineering Measurement", John Wiley and Sons.	1966
2.	Coughlin R. F. and Driscoll F. F., "Operational Amplifier and Linear Integrated Circuits", Prentice Hall of India Private Limited.	2008
3.	Norton N., "Handbook of Transducers", Prentice Hall International Edition.	2004
4.	Hamilton T. D. S., "Handbook of Linear Integrated Electronics", McGraw-Hill International Book Company.	1977

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-548** Course Title: **Drive System in Electric Traction**

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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Electric Machines, Power Electronics**

9. Objective:

To impart knowledge of applications of modern ac and dc drives in Electric Trains, Trams, Electric Buses.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	General features of electric traction, mainline and suburban trains, nature of load and motor for traction	6
2.	Mechanism of train movement, duty cycle, torque sharing between motors, driving axle code	5
3.	Calculation of tractive effort, drive rating and energy consumption, specific emery consumption	5
4.	Electrical motors for traction, starting and speed control of sc motors and ac motors	5
5.	Power electronic converters in modern traction practice, phase controlled converters, choppers, VSI for ac motor, PWM control	12
6.	Diesel electric traction, characteristics of diesel engine	5
7.	AC drives in Electric Traction , comparative advantages over dc drives	4
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Dubey G.K., "Fundamental of Electrical Drives" Narosa Publishing House, New Delhi.	2005
2.	Shepherd W., Halley L.N., Liang D.T.W., "Power Electronics and Motor Control", Cambridge Printing Press, UK.	1990
3.	Andrews H.I., "Railway Traction-The Principles of Mechanical and Electrical Railway Traction", Elsevier, Prentice Hall.	2004
4.	Bose B.K., "Power Electronics & Variable Frequency Drives – Technology & Applications", IEEE Press, Standard Publisher Distributors, Delhi.	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-549** Course Title: **Control Techniques in Power Electronics for AC Drives**

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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Power Electronics, Electric Drives**

9. Objective:

The aim of the course is to discuss in depth the various control techniques such as Field Oriented Control, Direct torque control and Energy efficient control used in AC drives.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Review of Pulse Width Modulation Techniques for Voltage Source Inverters; Carrier based PWM; Space Vector Modulation (SVM); Current controlled PWM; Advanced Current Controllers	4
2.	Matrix Converter, bidirectional switch commutation techniques, modulation techniques, input filter, clamp circuit, power-up circuit	4
3.	Control and Modeling of PWM Inverter-Fed Induction Motors, Vector Control, Direct and Indirect Field Oriented Control; Flux vector estimation	6
4.	Control Techniques for PMSM Drives, Flux Weakening Control, Constant Power Loss Controller; Comparison of torque control strategies	6
5.	Control and Modeling of Synchronous Reluctance Machines; Control techniques; Sensorless control	5
6.	Direct Torque and Flux Control of AC Drives; Flux, torque and speed estimation; Torque and flux controller; Flux, Torque and Speed Estimator	5
7.	Neural Network and Fuzzy Logic Control in Power Electronics; Open loop SVM; Closed loop PWM current control; Motor speed estimation	6
8.	Control and Modeling of Three-phase PWM Rectifiers; Direct power control; Voltage and virtual flux oriented control; Sensorless operation	6
	Total	42

List of Practicals:

1. Simulation study of Current Controlled Voltage Source Inverter
2. Simulation study of Space Vector Modulated Voltage Source Inverter
3. Simulation study of Matrix Converter
4. Simulation study of Direct Torque Controlled Induction Motor drive
5. Simulation study of Indirect Torque Controlled Induction Motor drive
6. Simulation study of PMSM drive
7. Simulation study of Synchronous Reluctance Motor drive
8. Simulation study of Three-phase PWM Rectifier

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Dubey G.K., "Power Semiconductor Controlled Drives" Prentice Hall, New Jersey.	1989
2.	Mohan N., Underland T.M., Robbins W.P., "Power Electronics – Converters, Applications and Design", John Wiley & Sons Inc., New York.	2004
3.	Kazmierkpwski Marian P., Krishnan R., Blaabjerg F., "Control in Power Electronics – Selected Problems", Academic Press, New York.	2002
4.	Krishnan R., "Electric Motor Drives – Modeling, Analysis & Control", Prentice Hall of India, New Delhi.	2001
5.	Bose B.K., "Power Electronics & Variable Frequency Drives – Technology & Applications", IEEE Press, Standard Publisher Distributors, Delhi.	2001
6.	Vas Peter, "Electrical Machines & Drives – A Space Vector Theory Approach", Oxford Science Publications.	1992

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **Electrical Engineering Department**

1. Subject Code: **EE-550** Course Title: **Pulse Width Modulation for Power Converters**

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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Power Electronics, Electric Drives**

9. Objective:

The objective of the course is to discuss in depth the various advanced PWM control techniques including Space Vector Modulation for 1-phase and 3-phase voltage source inverters, current source inverters and multi-level inverters.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Review of Voltage Source Inverters, Voltage Control (V/f, phase shift modulation); Multi-level Inverters	3
2.	Harmonic Distortion: Voltage and Current Distortion Factors, Weighted THD	2
3.	Modulation Techniques for One-Inverter Phase Leg, Frequency ratios, Effect of Minimum Pulse Width, PWM Dead-Time Compensation	5
4.	Modulation Techniques of Single-Phase and Three-Phase VSI; Three-Level modulation, Harmonic losses; Sideband modulation	6
5.	Space Vector Modulation (SVM); Naturally sampled SVM; Harmonic losses; Placement of Zero Space Vector	4
6.	Overmodulation of an Inverter, naturally sampled overmodulation, Regular sampled overmodulation	3
7.	Programmed Modulation Strategies- optimized SVM, harmonic elimination PWM, optimum PWM, minimum loss PWM	5

S.No.	Contents	Contact Hours
8.	Modulation of Multi-Level Converters, switching angles for equal and unequal voltage levels, equalization of voltage and current stresses, minimum loss PWM	4
9.	Carrier Based and Space Vector PWM of MLI,; Three-level naturally sampled PD/APOD/POD PWM; Overmodulation of MLI, Third harmonic injection for MLI	6
10.	Implementation Techniques for a Modulation Controller, PWM converter system, hardware and software implementation of the PWM	4
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Mohan N., Underland T.M., Robbins W.P., "Power Electronics – Converters, Applications and Design", John Wiley & Sons Inc.	2004
2.	Kazmierkpwski Marian P., Krishnan R., Blaabjerg F., "Control in Power Electronics – Selected – Selected Problems", Academic Press.	2002
3.	Bose B.K., "Power Electronics & AC Drives", Prentice Hall.	2002
4.	Murphy J.M.D., Turnbull F.G., "Power Electronic Control of AC Motors", Pergaman Press.	1988
5.	Holmes D.G., Lipo T.A., "Pulse Width Modulator For Power Converters – Principles and Practice", IEEE Press, John Wiley & Sons, Inc.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE- 551** Course Title: **Enhanced Power Quality AC/DC Converters**

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: **Spring** 7. Subject Area: **DEC**

8. Pre-requisite: **EE-206 or equivalent**

9. Objective:

To provide knowledge of the harmonics generated by different phase controlled converters and the methods of improving the input performance of various converters.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review of 2-pulse and 6-pulse converters and their performance with inductive and capacitive loads.	3
2.	Harmonic analysis of phase controlled converters, IEEE standards.	3
3.	Conventional methods of power factor improvement techniques, controlled free-wheeling operation, asymmetrical triggering, sequence control of phase controlled converters, extinction angle control; PWM converters: Single-pulse and multiple pulse modulation techniques.	5
4.	Multi-pulse converters using delta, zigzag, Fork, Polygon transformers, analysis and harmonic calculations..	4
5.	Configurations of passive filters, single tuned and high pass filters, filter design criteria.	3
6.	Shunt, series and hybrid active power filters, Single-phase and three-phase APF topologies, control strategies;	6
7.	High quality single-phase and three-phase converters, control techniques - Buck, Boost control, Power flow control, hysteresis and carrier wave control, space vector control.	10

S. No.	Contents	Contact Hours
8.	Multi-level converters, topologies and control techniques; Harmonic elimination techniques; Space Vector PWM	6
9.	Snubber circuits and their design.	2
	Total	**42**

List of Practicals:

1. Simulation study of phase controlled converters
2. Simulation study of power factor controlled converters
3. Simulation study of multi-pulse converters
4. Simulation study of active power filters
5. Simulation study of multi-level converters

11. Suggested Books:

S.No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Rashid M. H., "Power Electronics Circuits Devices and Applications", 3rd Ed., Pearson Education.	2008
2.	Dubey G.K., Doradla S.R., Joshi A. and Sinha R.M.K., "Thyristorised Power Controllers", New Age International Private Limited.	2008
3.	Lander Cyril W., "Power Electronics", Prentice Hall of India Private Limited.	2004
4.	Mohan N., Undeland T.M. and Robbins W.P., "Power Electronics-Converters, Applications and Design", 3rd Ed., Wiley India.	2008
5.	Paice D. A., "Power Electronic Converter Harmonics – Multipulse Methods for Clean Power", IEEE press.	1995
6.	Kazmierkpwski M. P., Krishnan R. and Blaabjerg F., "Control in Power Electronics – Selected Problems", Academic Press.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-552** Course Title: **Switch Mode Power Supply**

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: **Spring** 7. Subject Area: **DEC**

8. Pre-requisite: **EE-206 or equivalent**

9. Objective:

To input knowledge of control techniques, protection and design of different configurations of SMPS.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Linear voltage regulators, shunt and series regulators.	2
2.	**Switching Concepts**: Ideal switch, practical switch, switching functions.	4
3.	**Switching Circuits:** Int roduction, harmonic concepts, and power computations.	3
4.	**Non-Isolated Switch-Mode DC-DC Converters:** Buck, Boost, Buck-Boost converters, operation and control, design of converters, continuous and discontinuous conduction modes.	6
5.	**Isolated Switch-Mode DC-DC Converters:** Introduction, Buck and Boost derived isolated converters, half-bridge and full bridge converters, operation and control; Isolated Cuk converter; Multi-output converters	8
6.	**Soft Switched DC-DC Converters**: Series and Parallel resonant circuits, ZCS and ZVS switching topologies; Resonant converters, generalized analysis for ZCS, zero-voltage and zero current transition converters.	10
7.	**Simulation Techniques:** Simulation of non-isolated and isolated dc-dc converters.	4

S. No.	Contents	Contact Hours
8.	**Switching Converter Design**: Choke and transformer design; driver circuits, snubber circuits; EMI suppression, Input rectifiers with unity input power factor; Case Studies.	5
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Rashid M. H., "Power Electronics Circuits Devices and Applications", 3rd Ed., Pearson Education.	2008
2.	Mohan N., Undeland T.M. and Robbins W.P., "Power Electronics-Converters, Applications and Design", 3rd Ed., Wiley India.	2008
3.	Whittington H.W., Aflynn B.W. and Macpherson D.E., "Switch Mode Power Supplies – Design and Construction", John Wiley and Songs.	1997
4.	Hart Daniel W., "Introduction to Power Electronics", Prentice Hall International Edition.	1996
5.	Ang Simon S., "Power Switching Converter", Marcel Dekker Inc.	1995
6.	Luo Fang Lin and Ye Hong, "Advanced DC/DC Converters", CRC Press.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE- 553** Course Title: **Power Quality Improvement Techniques**

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: **Spring** 7. Subject Area: **DEC**

8. Pre-requisite: **EE-206 and EE-301 or equivalent**

9. Objective:

To introduce power quality parameters, reasons and effect of load generated harmonics and techniques for their suppression.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Concept of Power Quality**: Frequency variations, voltage variations- sag and swell, waveform distortion –dc offset, harmonics, inter-harmonics, notching and noise.	2
2.	**Fundamentals of Harmonics:** Representation of harmonics, waveform, harmonic power, measures of harmonic distortion; Current and voltage limits of harmonic distortions: IEEE, IEC, EN, NORSOK	3
3.	**Causes of Harmonics**: 2-pulse, 6-pulse and 12-pulse converter configurations, input current waveforms and their harmonic spectrum; Input supply harmonics of AC regulator, integral cycle control, cycloconverter, transformer, rotating machines, ARC furnace, TV and battery charger.	7
4.	**Effect of Harmonics:** Parallel and series resonance, effect of harmonics on static power plant, harmonic interference with power system protection, communication systems and power measurement.	3
5.	**Elimination/ Suppression of Harmonics:** High power factor converter, multi-pulse converters using transformer connections (delta, polygon)	4

S. No.	Contents	Contact Hours
6.	**Passive Filters:** Types of passive filters, single tuned and high pass filters, filter design criteria, double tuned filters, damped filters and their design.	4
7.	**Active Power Filters:** Compensation principle, classification of active filters by objective, system configuration, power circuit and control strategy.	2
8.	**PWM Inverter**: Voltage sourced active filter, current sourced active filter, constant frequency control, constant tolerance band control, variable tolerance band control.	2
9.	**Shunt Active Filter:** Single-phase active filter, principle of operation, expression for compensating current, concept of constant capacitor voltage control; Three-phase active filter: Operation, analysis and modelling; Instantaneous reactive power theory..	8
10.	**Three-phase Series Active Filter:** Principle of operation, analysis and modelling.	3
11.	**Power Conditioning:** Unified power quality conditioner, voltage source and current source configurations, principle of operation for sag, swell and flicker control.	4
	Total	42

List of Practicals:

1. Measurement of Harmonics of Industrial Load.
2. Simulation study of Phase Controlled Converters and their Harmonics
3. Simulation study of Multi-pulse Converters and their Harmonics
4. Design and Simulation study of Passive Filters
5. Design and Simulation study of Single-phase Active Power Filters
6. Design and Simulation study of Three-phase Active Power Filters

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Derek A. P., "Power Electronic Converter Harmonics", IEEE Press.	1989
2.	Arrillaga J., Smith B. C., Watson N. R. and Wood A. R., "Power System Harmonic Analysis", 2nd Ed., Wiley India.	2008
3.	Arthur R. B., "Power System Analysis", 2nd Ed., Pearson Education.	2008
4.	Arrillaga J., Braedlley D. A. and Bodger P. S ., "Power System Harmonics", John Wiley and Sons.	1985
5.	Dugan R. C., McGranaghan M. F. and Beaty H. W., Electrical Power System Quality", McGraw-Hill International Book Company.	1996
6.	Sankaran C., "Power Quality", CRC Press.	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-554** Course Title: **FACTS Devices**

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: **Spring** 7. Subject Area: **MSC**

8. Pre-requisite: **EE-206 and EE-301 or equivalent**

9. Objective:
To impart knowledge of FACTS devices, their control techniques and applications.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**FACTS**: Concept, power flow and stability, basic theory of line compensation	4
2.	**Power Electronic Controllers:** Review of PWM voltage source inverters used in FACTS, classifications of FACTS controllers.	4
3.	**Static Shunt Compensators:** SVC and STATCOM - TCR, TSC, their operation and control, system stability, comparison between SVC and STATCOM	6
4.	**Static Series Compensators:** GCSC, TSSC, TCSC and SSSC, their operation and control techniques, voltage stability.	6
5.	**Static Voltage and Phase Angle Regulators**: Power flow control, TCVR and TCPAR; Switching converter bases voltage and phase angle regulators.	4
6.	**Unified Power Flow Controller (UPFC)**: Concept of power flow control, operation and control of UPFC, Interline Power Flow Controller.	4
7.	**Stability Analysis:** Modeling of FACTS devices, optimization of FACTS, transient and dynamic stability enhancement	8

S.No.	Contents	Contact Hours
8.	**Applications:** Co-ordination of FACTS devices with HVDC links.	3
9.	Advanced FACTS devices; Case studies and other applications of FACTS controllers.	3
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Miller T. J. E., "Reactive Power Control in Electric Systems," Wiley-Interscience.	1982
2.	Song Y. H. and Johns A. T., "Flexible AC Transmission Systems (FACTS)", IEEE Press.	2000
3.	Hingorani N. G. and Gyugyi L., "Understanding FACTS", IEEE Press, Standard Publishers Distributors.	2001
4.	Ghosh A. and Ledwich G., "Power Quality Enhancement Using Custom Power Devices," Kluwer Academic Publishers.	2002
5.	Mathur R. M. and Varma R. K., "Thyristor – Based FACTS Controllers for Electrical Transmission Systems," John Wiley and Sons.	2002
6.	Padiyar K. R., "FACTS Controller in Power Transmission and Distribution", New Age International Private Limited.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE- 555** Course Title: **CAD of Power Apparatus**

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: **Spring** 7. Subject Area: **DEC**

8. Pre-requisite: **EE-202 and EE-303 or equivalent**

9. Objective:

To introduce design procedure and performance evaluation of rotating machines and transformers with sinusoidal and non-sinusoidal supply system.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review of design of transformers and rotating machines.	5
2.	Calculation of reactance parameters, losses, temperature rise and performance.	3
3.	Application of Finite Element Method (FEM) in thermal and field analysis of electrical machines.	5
4.	Design consideration for rotating machines fed from non-sinusoidal supply.	5
5.	Computer aided design, philosophy and economics, selection of input data and design variables, flow chart for design of transformer and rotating machine.	12
6.	Review of optimization techniques, objectives and constraint functions, constrained and unconstrained minimization.	4
7.	Flow chart development for design optimization of power apparatus, converter fed drives and energy efficient machines.	8
	Total	42

11. Suggested Books:

S.No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Say M. G., "The Performance and Design of AC Machines", CBS Publishers and Distributors.	2002
2.	Veinott C. G., "Computer Aided Design of Electrical Machinery", MIT Press.	1987
3.	Sen S. K., "Principle of Electrical Machine Design with Computer Programs", Oxford and IBH Company Pvt. Ltd.	2001
4.	Ramamoorthy M., "Computer Aided Design of Electrical Equipment", East West Press.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE- 556** Course Title: **Selected Topics in Machines & Transformers**

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: **Spring** 7. Subject Area: **DEC**

8. Pre-requisite: **Electrical Machines**

9. Objective:

The objective of the course is to discuss behavior of induction machine under abnormal conditions, effect of space and time harmonics on the performance of machine, operation of multi-winding transformers and non conventional machines.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Multi winding transformers**: Equivalent circuit, regulation, efficiency and parallel operation; Sequence impedances of two-winding and three-winding transformers; Single-phase loading of three-phase transformer,	6
2.	**Inrush current phenomenon in transformers**: Causes, problems and methods of prevention	2
3.	**Parallel Operation:** Parallel operation of transformers with optimum losses	2
4.	**Harmonics in Induction Machines**: Effect of space harmonics, crawling, cogging, voltage ripples and magnetic noise.	4
5.	**Induction Motor**: Abnormal operation of induction machine on non-sinusoidal supply; High starting torque motors, Energy efficient motors; Two- phase induction motor, Servomotor, Tachogenerator.	12
6.	**Linear induction motors**: Principle of operation, construction and applications.	5
7.	**Non-Conventional Motors**: Angled field motors; Motors using phase shift control; Log motor; Axial field motors; Tubular and arc motors	7

S.No.	Contents	Contact Hours
8.	Permanent magnet motors, Stepper motors	4
	Total	**42**

List of Practicals:

1. Measurement of parameters of Equivalent Circuit of Three winding Transformer.
2. Measurement of inrush current of Single Phase Transformer.
3. Performance Evaluation of Three Phase Induction motor on Single Phasing.
4. Performance Evaluation of Permanent Magnet Synchronous Motor.

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Vickers, "The Induction Motors: The Theory, Design and Application of Alternating Current Machines including Fractional HP Motors", Pitman.	1989
2.	Alger P.L., "Induction Machines – Their Behavior and Use", Routledge.	1995
3.	M.I.T. Staff, "Magnetic Circuit & Transformer"	1961
4.	Laithwate E.R., "Induction Machine for Special Purpose"	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **Department of Electrical Engineering**

1. Subject Code: **EE-557** Course Title: **Synchronous Machines and System Stability**

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: **Spring** 7. Subject Area: **DEC**

8 Pre-requisite: **Electrical Machines**

9. Objective:

To analyze the power system behavior under small and large disturbances and to study the effect of excitation and governing on power system control.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Mathematical modeling of synchronous machine & load, Operational impedances, machine impedances, time constants, torque expression	4
2.	Steady state and transient performance, Phasor diagrams, Power angle characteristics for one and multi machine systems	3
3.	Short circuit analysis, Symmetrical and asymmetrical short circuits, measurement of reactances and time constants	5
4.	Concept and types of stability, Transient stability, Direct and indirect method, critical fault clearing and circuit breaker reclosing times.	5
5.	Effect of exciter and governor, state modeling	3
6.	Steady state and dynamic stability, Perturbation equation, Parameter synthesis, Long distance power transmission, compensations, Sub-synchronous and Self excited oscillations	10
7.	DC systems terminal equipment, control characteristics, stabilization	6
8.	Application of modern techniques for power system control.	6
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Concordia, Charles, "Synchronous Machines – Theory and Performance", Wiley.	1989
2.	Kimbark E.W., "Power System Stability: Synchronous Machines", Vol.3, Dover Publication.	1976
3.	Adkins B., Harley R.G., "The Generalized Theory of Alternating Current Machines"	1979
4.	Machowski J., Bialak J.W., Bumby J.R., "Power System Dynamics & Stability", John Wiley & Sons.	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **Department of Electrical Engineering**

1. Subject Code: **EE-558** Course Title: **Special 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: **Spring** 7. Subject Area: **DEC**

8 Pre-requisite: **Electrical Machines, Power Electronics**

9. Objective:

The objective of the course is to discuss the advancement in drives such as permanent magnet brushless motor drive, switched reluctance motor, linear induction motors and stepper motors.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Review of adjustable speed drives, motor requirement for drives, induction motor and synchronous motor drives; Vector control and Field Oriented Control methods	5
2.	Permanent- magnet materials, characteristics, energy density and equivalent circuits, losses and efficiency of PM motors.	3
3.	Principle and construction of permanent magnet brushless dc motor drives (PMBDCM); Operation with sinusoidal, square and trapezoidal waves; Vector control of PM synchronous motor; Control strategies; Flux weakening operation; Modeling of drive; Converter topologies for PMBDCM drive.	10
4.	Sensor-less control of AC drives, parameter identification in PM BDCM and induction motor drive, speed and position estimation, parameter sensitivity; Robust motion control.	6
5.	Principle and construction of synchronous reluctance based drive, operating condition and power factor of synchronous reluctance motors, constant power operation, PM reluctance motors.	5

S.No.	Contents	Contact Hours
6.	Principle, construction and operation of switched reluctance motors, torque developed, losses and efficiency; Design and application considerations	5
7.	Principle, construction and operation of linear induction motors, Goodness factor, short stator and short rotor effect; High speed and low speed applications.	4
8.	Principle, construction and operation of stepper motors, variable reluctance and permanent magnet stepping motors, hybrid stepping motors, drive circuits.	3
9.	Energy efficient motors	6
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Murphy J.M.D., Turnbull F.G., "Power Electronics Control of AC Motors", Pergamon Press, New York.	1988
2.	Miller T.J.E., "Brushless Permanent Magnet and Reluctance Motor Drives", Oxford Clarender Press.	1982
3.	Bose B.K., "Power Electronics & Variable Frequency Drives – Technology & Applications", IEEE Press, Standard Publisher Distribution.	2001
4.	Nasar S.A., "Linear Induction Machine"	2002
5.	Andreas J.C., "Energy Efficient Electric Motors", Springer.	1982

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-563** Course Title: **Flexible AC Transmission System**

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: **Spring** 7. Subject Area: **DEC**

8. Pre-requisite: - **NIL**

9. Objective:

To familiarize the students with the system issues when FACTS devices are incorporated in a power system.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Overview of FACTS devices:** SVC, TCSC, STATCOM, SSSC, UPFC, IPFC, GUPFC	4
2.	**Balanced load flow of power system with FACTS devices:** Balanced load flow formulation for SVC, TCSC, STATCOM, SSSC, UPFC, IPFC and GUPFC	14
3.	**3-phase load flow of power system with FACTS devices:** Three phase unbalanced load flow formulation of SVC, TCSC, STATCOM, SSSC, UPFC, IPFC and GUPFC	10
4.	**Optimal power flow with FACTS devices:** Basic concept of optimal power flow with series and shunt connected FACTS devices, representation of voltage source inverter based FACTS devices (STATCOM, SSSC, UPFC, IPFC and GUPFC) in optimal power flow problem.	6
5.	**Elementary concept of stability improvement with FACTS devices:** Revision of equal area criterion of stability, illustration of improvement of stability margin with SVC, TCSC, STATCOM, SSSC, UPFC, IPFC and GUPFC through equal area criterion	4
6.	**Protection issues with FACTS devices:** Revision of basic distance protection schemes, basic concepts of problems of distance protection and remedial strategies with the above FACTS devices	4
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Acha E., Fuerta-Esquivel C. R., Ambriz-Perez H. and Angeles-Camacho C., "FACTS modeling and simulation in power networks", John Wiley & Sons Ltd., England.	2004
2.	Hingorani N. G. and Gyugi L., "Understanding FACTS: concepts and technology of Flexible AC Transmission systems", Wiley IEEE Press.	1999
3.	Song Y. H. and Johns A. T, "Flexible AC Transmission Systems", IEE Power Series, IET.	2000
4.	Mathur R. M. and Verma R. K., "Thyristor based FACTS controllers for electrical transmission systems", IEEE press series on power engineering, Wiley IEEE press.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT . /CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-565** Course Title: **Power System Planning**

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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **NIL**

9. Objective:

To inpart knowledge of different aspects of power system planning, mainly in the Indian context.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Basic Elements of Power System Planning:** Various issues relating to power system planning: overview of the generation, transmission and distribution aspects of planning, Long term and short term planning; growth and development of the Electrical Power Industry global and Indian scenario, five year plans. Indian power industry and current developments, Role of key organizations in power system planning in Indian context.	8
2.	**Generation Planning:** Load forecasting, importance and various methodologies, power system reliability , indices, Markov two- state model for generating systems availability, upgradation of old power stations, technical and economic issues	8
3.	**Transmission Line Planning:** Selection of voltage levels and type of system EHVAC, HVDC, Corona losses and Radio interference , Right - of-Way requirements, environmental issues relating to electromagnetic and electrostatic field radiations, Routing of transmission lines , Applications of FACTS and system reactive power control, Line congestion in deregulated systems and their minimization Grid issues and regulations. Transmission line reliability evaluation	8
4.	**Distribution Planning :** Distribution systems ; ring and radial systems, loss minimization by reconfiguration; substation location and planning, automation, Loss minimization in feeders by reactive power	10

	compensation: series and shunt compensation, Improved billing strategies, System measurements using SCADA	
5.	**Planning issues :** Deregulation of power systems, energy conservation and audits, Security and contingency analysis	**8**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Pabla. A.S. " Electrical Power Distribution Systems ", Tata-McGraw Hill, New Delhi.	**1992**
2.	National Power Plan (1985 -2000AD) Central Electricity Authority, Ministry of Power , Govt. of India,, New Delhi	**1987**
3.	Sullivan W. and Wayne, W, "Fundamentals of Forecasting" , Reston Publishing Company. Virizinia	**1977**
4.	Billington, Roy and Allen , R. N. " Reliability Evaluation of Power Systems", Pitman, London (U.K.)	**1984**
5.	Weedy, B.M. " Electrical Power Systems" John Wiley and Sons, Singapore	**1988**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-566** Course Title: **Power System Harmonics**

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

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

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

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

8. Pre-requisite: **- NIL**

9. Objective:

To introduce the harmonic analysis of power systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Harmonics Theory: harmonic wave form, harmonic distortion and its calculations	2
2.	Harmonic sources: types and their modeling both in time domain and frequency domain	5
3.	Effects of harmonic distortion on power systems: thermal losses, effects on transformers and rotating machines, limits of harmonic distortions, modeling of system components	7
4.	Frequency domain and time domain analysis methods for calculation of harmonic propagation and distortion, harmonic load flow, harmonic filters	10
5.	Harmonic state estimation, determination of location of harmonic source, harmonic monitoring	8
6.	Power quality problems, detection and elimination of power quality problems	10
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Arrillaga, Jos: Smith, Bruce C.; Watson, Neville R.; Wood, Alan R., "Power System Harmonic Analysis", John Wiley & Sons	1997
2.	Tutorial on Harmonics Modeling and Simulation", IEEE Power Engineering Society	1998
3.	Wakileh G.J. , "Power Systems Harmonics: Fundamentals, Analysis and Filter Design, Springer Berlin Heidelberg.	2001
4.	F. C. De La Rosa, " Harmonics and Power Systems", CRC/Taylor & Francis, 2006	

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-568** Course Title: **Power System Reliability**

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: **Spring** 7. Subject Area: **DEC**

8. Pre-requisite: **NIL**

9. Objective:

To introduce the reliability modeling of generation, transmission and distribution systems and their applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Revision of Probability Theory:** Probability concepts, rules for combining probability, probability distributions, random variables, density and distribution functions, mathematical expectations, variance and standard deviation.	3
2.	**Basic Reliability Evaluation:** General reliability functions, probability distributions in reliability evaluation, network modeling and evaluation of series, parallel, series –parallel and complex systems, cut-set method, tie-set method, discrete Markov chains, continuous Markov process, frequency and duration technique concepts, application to multi-state problems, approximate system reliability evaluation methods.	6
3.	**Generation System Reliability:** Generation system models, capacity outage table, recursive algorithm, loss of load indices, inclusion of scheduled outages, load forecast uncertainty, loss of energy indices, expected energy generation, energy limited systems, Gram-Charlier series and its application to generation system reliability evaluation, generating capacity –frequency and duration method.	10

S. No.	Contents	Contact Hours
4.	**Interconnected System:** Probability array method in two inter-connected systems, effect of tie capacity, tie reliability and number of tie lines, equivalent assistance unit method for reliability evaluation of inter-connected system, elementary concepts for reliability evaluation of multi-connected systems.	7
5.	**Composite Generation and Transmission System Reliability:** Radial configurations, conditional probability approach, network configuration, state selection, system and load point indices.	6
6.	**Distribution System Reliability:** Basic technique and application to radial systems, customer–oriented indices, load and energy indices, effect of lateral distributor protection, effect of disconnects, effect of protection failures, effect of load transfer, meshed and parallel networks, approximate methods, failure modes and effects analysis, inclusion of scheduled maintenance, temporary and transient failures, inclusion of weather effects.	10
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Billinton R. and Ronald N. A., "Reliability Evaluation of Power Systems", Pitman Advanced Publishing Program.	1984
2.	Billinton R. and Ronald N. A., "Reliability Evaluation of Engineering Systems Concepts and Techniques", Pitman Advanced Publishing Program.	1983
3.	Endrenyi J., "Reliability Modeling in Electric Power Systems", John Wiley and Sons.	1978

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-570** Course Title: **Distribution System Automation**

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

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

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

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

8. Pre-requisite: **NIL**

9. Objective:

To introduce the fundamentals of distribution system automation

10. Details of Course:

S. No.	Contents	Contact Hours
1.	System Automation: Basic theory. Cost justification. Risks/benefits-direct and indirect	3
2.	Central control and outage management, decision support applications, hardware for distribution systems	5
3.	Protection and Control, building blocks, interfaces within building blocks, control logic	6
4.	Data Communication systems for control and automation, Open Systems Interconnection model (OSI) model, wired and wireless communication	8
5.	communication network protocols: fieldbus, profibus, Eithernet, modbus	5
6.	Automation architecture: SCADA system: hardware, software, data acquisition, control and features, RTU, PLC, IED, types of architecture, equipment monitoring for reliability and safety, Utility integration of communication and Control, and Protection-examples, wide-area measurement system, synchronised phasor measurements, adaptive protection concept., IEC standards	10
7.	Internet, internet communication, security problems	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Stauss C., "Practical Electrical Network Automation & Communication Systems" Elsevier Eastern, Limited, New Delhi.	2003
2.	Brand K., Lohmann V., Wimmer W., "Substation Automation Handbook", Utility Automation Consulting Lohman, Germany	2003
3.	Electric Power Substations Engineering Edited By John D. McDonald, CRC Press	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-571** Course Title: **Wind Energy**

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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **- NIL**

9. Objective:

To impart knowledge of various aspects related to wind energy systems and technology

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Wind Energy Engineering Fundamentals:** Origin and nature of winds, major applications, measurement of wind speed and parameters, wind energy dynamics, power extracted, axial thrust on turbines, torque, maximum power and Betz coefficient, wind turbine operational characteristics.	10
2.	**Construction of Wind Turbines** : Horizontal and vertical axis wind turbines, constructions, basic 8 rotor differences, relative merits and operational difficulties, lift and drag turbines, upwind and down wind machines, wind energy input controlling mechanisms and strategies.	10
3.	**Wind Energy Conversion Systems (WECS):** Basic components, fixed and variable speeds systems. Type of generators used-D.C., induction and synchronous machines; self and line excited windmills, grid, standalone, and hybrid schemes. Power electronics based controllers used with WECS.	8
4.	**Wind Farms:** Typical layouts, site selection of wind farms, power evacuation, and operational problems with grid interface. Offshore and onshore wind farms, merits and challenges.	6

5.	**Environmental Aspects of Wind Power Projects:** main environmental problems - noise, flicker, ecological impact on wildlife, birds, marine life (offshore wind farms), aesthetics, Public opinions and solutions.	4
6.	**Wind Energy Program in India and the World:** Overview of growth, development, progress and challenges facing the wind industry : perspectives from developed and developing nations	4
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Golding E. W., "The Generation of Electricity by Wind farms", E & F.N. Spon Ltd, London.(U.K)	1976
2.	Justus, C.G, "Winds and Systems Performance", Franklin Institute Press, Philadelphia(USA)	1978
3.	Johnson, Gary, L., "Wind Energy System", Prentice Hall Inc. Englewood Cliffs. N.J. (USA)	1985
4.	Freris, L.L., " Wind Energy Conversion System" Prentice Hall, (U.K.)	1990
5.	Gipe, Paul, " Wind Power" Chelsea Green Publishing Company, Vermount, (USA)	1995
6.	Heier, S,, "G rid Integration of Wind Energy Conversion Systems", Wiley, New York (USA)	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-572** Course Title: **Digital Protection of Power System**

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: **Spring** 7. Subject Area: **DEC**

8. Pre-requisite: **NIL**

9. Objective:

To familiarize the students with the fundamental of digital protection systems of power networks and elements.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review of microprocessors and interfacing concepts, block diagram of microprocessor based relays:	5
2.	Digital signal processing and fundamentals of Fourier, Walsh and Harr Transforms:	6
3.	Digital communication and Fiber optics:	5
4.	Sinusoidal waveform, Least square and differential equation based techniques	6
5.	Digital protection of generators	4
6.	Digital protection of transformers	4
7.	Digital protection of transmission lines (differential, travelling wave based and DFT based)	8
8.	Fundamental of frequency estimation techniques	4
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Singh R. P. "Digital power system protection", PHI Ltd., New Delhi.	2007
2.	Johns A. T. and Salman S. K., "Digital protection of power system", IEE power engineering series, IEE Press, London, UK.	1997
3.	Power System protection, Vol.-4: Digital protection and signaling, edited by the Electricity Training Association, IEE press, London, UK.	1997
4.	Various journal papers (most of the current techniques are available in various journal papers). The relevant papers would be suggested during the lectures.	

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-573** Course Title: **Power System Dynamics**

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

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: **Spring** 7. Subject Area: **DEC**

8. Pre-requisite: **NIL**

9. Objective:

To familiarize the students with the dynamic analysis of power systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Review of synchronous machine modeling and transmission system modeling:** one axis model of synchronous machine, two axis model of synchronous machine, d-q transformation, model of transmission grid	8
2.	**Basic concepts of different types of stability:** Basic concepts of transient stability, dynamic stability and voltage stability	4
3.	**Small signal stability analysis (SSSA) of a generalized multi-machine power system (MMPS) with and without slow and fast exciter and Power system stabilizer (PSS):** SSSA of MMPS with slow exciter only, SSSA of MMPS with fast exciter only, SSSA of MMPS with slow exciter and PSS, SSSA of MMPS with fast exciter and PSS.	10
4.	**Time domain simulation (TDS) of a generalized MMPS using partition explicit (PE) and simultaneous implicit (SI) methods:** Basic formulation of the PE and SI methods, TDS of MMPS using PE with i) fast exciter only and ii) with fast exciter and PSS, TDS of MMPS using SI with i) fast exciter only and ii) with fast exciter and PSS.	12

5.	**Direct estimation of transient stability using energy function approach:** Revision of Lyapunov statbility criterion, concept of energy function of a MMPS, stability evaluation of MMPS using the energy function	**4**
6.	**Voltage stability of power system:** Basic concept of voltage stability, P-Vcurve, voltage stability analysis of MMPS	**4**
	Total	**42**

Practicals:

Use of software for performing stability analysis of sample systems

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Sauer P. W. and Pai M. A., "Power system dynamics and stability", prentice-Hall.	**1998**
2.	Kundur P., Power System Stability and Control, Mc Graw Hill.	**1994**
3.	Anderson P. M. and Fouad A. A., "Power system control and stability", IEEE Press.	**1994**
4.	Padiyar K. R., "Power system dynamics: stability and control", BS publications, Hyderabad.	**2002**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-574** Course Title: **Distribution System Analysis and Operation**

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

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

4. Relative Weight: **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 distribution system operation and analysis.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Overhead and underground distribution systems,	3
2.	Distribution system modeling: modeling of feeders, cables, transformers, capacitors, sectionalizes.	6
3.	Distribution system load flow for balanced and unbalanced systems, radial and weakly meshed systems (with and without PV buses), voltage regulation, regulators, line drop compensation, calculation of losses	7
4.	Short circuit analysis: General fault characteristics, fault calculations, high impedance faults, short circuit protection	3
5.	State estimation of distribution systems	4
6.	Distribution system reliability: customer based and load based indices, methods for improving reliability	4
7.	Control of distribution systems, distribution system management, real time control, communication system for control and automation	9
8.	Distribution system protection, single phase protective devices	3
9.	Distributed generation integration: modeling of distributed generation, islanding issues, quality impact	3
	Total	42

List of Practicals:

1. Determination of voltage profile of a radial single-phase distribution system
2. Determination of voltage profile of a radial three-phase distribution system
3. GIS based distribution system analysis
4. Capacitor allocation in distribution system

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	T.A. Short, "Electric Power Distribution Handbook", CRC Press	2003
2.	J. Northcote-Green and R. G. Wilson, "Control and Automation of Electric Power Distribution Systems", Taylor & Francis	2007
3.	R.E. Brown, "Electric Power Distribution Reliability", CRC Press	2009
4.	W. H. Kersting, "Distribution system modeling and analysis", CRC Press	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-583** Course Title: **Stochastic Systems**

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/Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **NIL**

9. Objective: To impart the knowledge of stochastic signals, the response of feedback processes and their design.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Concepts of probability, random variables and stochastic signals. First & second order statistics of stochastic process. Ergodic hypothesis & correlation functions. Poisson distribution of event points.	10
2.	Random variables and their characteristics. CDF & PDF and their properties. Existence theorem. Gaussian RV, Poisson RV, Bernoulli distributed RV and uniformly distributed RV	6
3.	Response of a linear system to stochastic signal inputs; power density spectra and basic relationships.	6
4.	Analytical design of linear feed-back controls. Parseval's theorem and its generalization. M.S.E. estimation for different cases. Wiener-Hopf integral equation and methods of solution.	10
5.	Gauss – Markov sequence and process models, optimal prediction, filtering and smoothing for continuous and discrete linear systems	10
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Deuschel Jean-Dominique et al, Interacting Stochastic Systems, Springer, New York	2005
2.	Kulkarni V. G., Modeling and Analysis of Stochastic Systems, Chapman and Hall	1995
3.	Medhi J., Stochastic Processes, Wiley Eastern Limited	1982/1984
4.	Meditch J.S., Stochastic Optimal Linear Estimation and Control, McGraw-Hill, Inc	1969
5.	Papoulis A, Probability, Random variables, and Stochastic Processes, Third edition, McGraw-Hill,	1991
6.	Pugachev V.S, Stochastic Systems: Theory and Applications, RiverEdge,NJ World Scientific	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-584** Course Title: **Optimal Systems**

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/Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **NIL**

9. Objective: To familiarize with the concept of optimal control of continuous and discrete time systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Definitions of Optimal Control, plant, Performance Index, constraints, formulation of optimal control problem, selection of a performance index	4
2.	**Calculus of Variations and Optimal Control:** Basic Concept, Optimum of a Function and a Functional, The Basic Variational Problem, Fixed-End Time and Fixed-End State System, Euler-Lagrange Equation, Different Cases for Euler-Lagrange Equation, The Second Variation, Extrema of Functions with Conditions, Variational Approach to Optimal Control Systems, Terminal Cost Problem	8
3.	**Linear Quadratic Optimal Control Systems:** Problem Formulation, Finite-Time Linear Quadratic Regulator, LQR System for General Performance Index, Analytical Solution to the Matrix Differential Riccati Equation, Infinite-Time LQR System, Stability Issues of Time-Invariant Regulator, Linear Quadratic Tracking System: Finite-Time Case, LQT System: Infinite-Time Case, LQR with a Specified Degree of Stability	10
4.	**Discrete-Time Optimal Control Systems:** Variational Calculus for Discrete-Time, Discrete-Time Optimal Control Systems, Discrete-Time Linear State Regulator, Closed-Loop Optimal Control: Matrix Difference Riccati Equation	4
5.	**Pontryagin Minimum Principle:** Pontryagin Minimum Principle, Dynamic Programming, Principle of Optimality, Optimal Control Using Dynamic Programming, Optimal Control of Discrete-Time Systems, Continuous-Time Systems, The Hamilton-Jacobi-Bellman Equation, LQR System Using H-J-B Equation	8

6.	**Time-Optimal Control of LTI System:** Problem Formulation and Statement, Solution of the TOC System, Structure of Time-Optimal Control System, TOC of a Double Integral System, Fuel and Energy-Optimal Control Systems	**8**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Book/ Publisher	Year of Publication/ Reprint
1.	Kirk Donald E., Optimal Control Theory An Introduction", Dover Publication Inc, Mineola, New York.	**2004**
2.	Naidu Desineni Subbaram, OPTIMAL CONTROL SYSTEMS, CRC PRESS, Boca Raton London New York Washington, D.C.	**2002**
3.	Sage A. P. and White C. C, Optimum Systems Control, Prantice-Hall, Englewood Cliffs, N.J.	**1977**
4.	M. Gopal, Modern Control Engineering, TMH	**2005**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-585** Course Title: **ADVANCED COMPUTER CONTROLLED SYSTEMS**

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/Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **NIL**

9. Objective: To impart knowledge of designing and control of Computer Controlled Systems for controlling multivariable processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Overview of the execution environment of Pentium processor in PC, Floating Point Unit and assembly level programming under protected mode operation.	8
2.	Review of Z-transforms, frequency spectrum and reconstruction theorem	4
3.	Pulse transfer functions, Data hold, state transition signal flow diagrams of pulse transfer functions, decomposition and Stability consideration, Routh-Hurwitz criterion and Jury's test	6
4.	Modified Z-transforms, applications and computer simulation of computer controlled processes with transportation lag	4
5.	Direct digital control algorithms: digital controller design from analog controllers, PDI control action, method of differentials, bilinear transformation and mapping of poles and zeros.	6
6.	Digital controller design using plant models: Identification of plant model through reaction curve, dead-beat algorithm, Dahlin's method, Kalman's approach and Smith predictor design	8
7.	Digital controller structures and PC implementation	6
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Astrom K.J. et al., Computer Controlled System: Theory and Design, Prentice-Hall	1997
2.	Irvine Kip R., Assembly Language for Intel-Based Computer, Fourth Edition, Pearson Education (LPE)	2004
3.	Ogata K., Discrete Time Control Systems, Prentice-Hall	1987
4.	Philips C.L. et al., Digital Control System, Analysis and Design, Second Edition, Prentice-Hall	1990
5.	Rosenwasser Efim et al., Multivariable Computer-Controlled Systems: A Transfer Function Approach, London:Springer	2006
6.	Smith Cecil L., Digital Computer Process Control, Intext Education: London	1972

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **Department of Electrical Engineering**

1. Subject Code: **EE- 586** Course Title: **Database Management**

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: **Both** 7. Subject Area: **PEC**

8. Pre-requisite: **NIL**

9. Objective of course:

To develop skills in accession, modeling, analyzing, designing, using and implementing database systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Collection, growth and management of data, classification of data, database approach, level of abstraction, integrity, consistency, security and recovery issues, data independence, mappings, transition management, structure of a database management, relational network and hierarchical data models, design methodology.	5
2.	**Conceptual Design:** Selection of perspective, ordering and consolidation of local views, conflict resolution, selection of entities, identification of data relationships, information structure in graphical form and verification of information structure.	3
3.	**Entity-Relationship Approach:** Database design and ER diagram, identifying entities, attributes and relationships; Key constants, participation constraints, weak entities, class hierarchies, aggregation, conceptual design of large enterprises, case studies.	4
4.	**Relational Data Models:** Domain, relation, relation variables, relational algebra, creating and modifying relations using SQL, integrity constraints over relations, logical database diagram: ER to relational model, views and queries in SQL, case studies.	4

S.No.	Contents	Contact Hours
5.	**Schema Refinement and Normal Forms (NF):** Problems caused by redundancy, functional dependencies (FD), closure of a set of FDs, attribute closure, 1NF, 2NF, 3NF and Boycee-Codd normal form (BCNF); Properties of decompositions, schema refinement in database design, multivalued dependency and 4NF, join dependency and 5NF, case studies.	8
6.	**Physical Storage Media, Blocking and Buffering:** Classification of storage, secondary storage devices, types of records, design of record formats, overall running time, blocking and buffering.	2
7.	**File Organization:** Heap, sorted and index files, comparison of file organizations, tree-structured, and hashed based indexing; External sorting.	4
8.	**System Implementation Techniques:** System catalog, query processing and optimization concepts, transaction processing concepts, concurrency control, serializability, lock management, dead lock, data security and integrity, crash recovery techniques, distributed databases, case studies, advance data models and emerging trends, use of DBMS like DB2/ ORACLE/ACCESS.	12
	Total	42

Practical:

The students will practice with the DBMS packages such as ORICAL, ACCESS, and FOXPRO. Different quarry statements and programs will be written and tested for practical data base systems.

11. Suggested Books:

S. No.	Name of Authors /Book / Publisher	Year of Publication/ Reprint
1.	Silberschatz A., Korth H.F. and Sudarshan S., "Database System Concepts", McGraw-Hill International Book Company.	2008
2.	Ramez E. and Shamkant B. M., "Fundamentals of Database Systems", 2nd Ed., Pearson Education.	2008
3.	Date C. J. and Kannan, "An Introduction to Database Systems", 8th Ed., Pearson Education.	2008
4.	Ullman J. D., 'Principle of Database and Knowledge Base Systems – Vol.1: Classical Database Systems", Computer Science Press	1995
5.	Ramakrishnan R. and Gehrke J., Database Management Systems, McGraw-Hill	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./ CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-588** Course Title: **Large Scale Systems**

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

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

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

5. Credits: **04** 6. Semester: **Both** 7. Subject Area: **PEC**

8. Pre-requisite: **NIL**

9. Objective: To impart the knowledge of Large scale systems, modeling methodologies, system simplification and various analysis techniques.

10. Details of Course :

S. No.	Contents	Contact Hours
1.	Introduction to large scale systems, modeling, Hierarchical structures, Decentralized Control, Aggregation method.	6
2.	Eigen value assignment, Pole placement Design, formula, State and Parameter estimation, .	6
3.	Order reduction methods, Transfer function, Frequency domain, Model simplification, Continued fraction expansion method, Time moment matching, Pade approximation.	8
4.	Stability based reduction methods, Stability equation method, Routh approximation, Routh Hurwitz array method, Dominant Pole retention, and Differentiation and Truncation methods.	8
5.	Error Minimization Methods, Factor Division method, Order reduction of discrete time systems.	6
6.	Minimal realization, Time scale analysis, Decoupling methods, Fast and slow sub system, State feedback design, Singular perturbation, Controller reduction.	8
	Total	42

11. Suggested Books:

Sr. No.	Name of Books/Authors/Publishers	Year of Publication
1.	Chen, C.T., Linear System Theory and Design, Oxford University Press	**1999**
2.	Dragoslav D. Siljak ,Large scale dynamic systems: stability and structure, Norht Holland, New York	**1983**
3.	Jamshidi M., ,Large Scale Systems Modeling and Control „ Series Volume- 9, North Holland NY	**1983**
4.	Mahmoud M. S., Singh M. G., , Large Scale Systems Modelling,, Volume -3, Pergamon Press	**1981**
5.	Sinha N. K., Kuszta B., ,Modeling and Identification of Dynamic Systems, Van Nostrand Reinhold Company	**1983**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE- 589** Course Title: **Advanced Microprocessor and Applications**

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

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

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

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

8. Pre-requisite: NIL

9. Objective: To introduce knowledge of the architecture, instruction set and assembly language programming of typical 16-bit and higher order microprocessors.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Review:** 8-bit ,16-bit microprocessors, & Intel IA32 processors.	2
2.	**Software Architecture of a 16-bit and 32 bit Microprocessor**: concept of pipelining and memory segmentation, logical address, offset address and physical address; Bus Interface Unit (BIU); Execution Unit (EU), segment registers. Memory reference using descriptors in protected mode.	5
3.	**16-bit Microprocessor:** Pin configuration of Intel 8086/8088; Minimum and maximum modes of operation; Address bus, data bus and control bus; Clock generator Intel 8284; Memory organization, memory address space; comparision with 32 bit processor.	5
4.	**Interfacing:** Interfacing concepts, interfacing memory; Input-output techniques, interfacing of I/O devices to the processor.	2
5.	**Generalised instruction set of IA-32 microprocessor;** 8086/8088instruction set as subset of IA-32, Addressing Modes Data related addressing modes- register, immediate, direct, register indirect, based relative, indexed relative and based indexed, branch related addressing modes- intrasegment direct and indirect, intersegment direct and indirect. Machine cycles, data transfer, arithmetic, bit manipulation, string, program execution transfer and processor control instructions.	10

6.	**Assembler Directives:** ASSUME, DB, DD, DQ, DT, DW, DUP, END, EQU, EVEN, ORG, OFFSET, PROC, ENDP, LABEL and PTR. Real variable directives, Assembly Language Programming Macro-assembler, segment definition and models. MODEL approach	5
7.	**Interrupt Structure:** Interrupt pointer, type numbers, processing of interrupt, internal and external interrupts, interrupt priorities, BIOS routines.	4
8.	**Programmable Support Chips**: Interfacing of programmable parallel interface Intel 8255, programmable interval timer Intel 8253, programmable interrupt controller Intel 8259 with 16-bit processor.	5
9.	Coprocessors and Multiprocessing, Floating Point Unit of Pentium	4
	Total	42

Practical:
The verification of various algorithms written in ALP/MLP on the micro-processor kits/ Assemblers.

11. Suggested Books:

S. No.	Name of Authors /Book / Publisher	Year of Publication/ Reprint
1.	Brey B. B., "Intel 8086, 8088, 80186, 80187, 80286, 80386, 80486, Pentium and Pentium Pro Processors, Architecture, Design and Application", Prentice Hall of India.	2006
2.	Hall D. V., "Microprocessor and Interfacing –Programming and Hardware", Tata McGraw-Hill.	2006
3.	James L Antonakos,"The Pentium Microprocessors, Pearson Education Asia.	2002
4.	Liu Yu-Cheng and Gibson G. A., "Microcomputer Systems; The 808618088 Family", 2nd Ed., Prentice Hall of India	2007
5.	Mazidi M. A. and Mazidi J. G., "The 80x86 IBM PC and Compatible Computers (Vol. I and II), Assembly Language, Design and Interfacing", Prentice Hall International Edition.	2003
6.	Triebel W. A. and Singh A., "The 8088 and 8086 Microprocessors, Programming Interfacing, Software, Hardware and Applications", 4th Ed., Prentice Hall of India	2007

:

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-590** Course Title: **Modelling of Industrial Processes**

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

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

4. Relative Weight: **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 fundamentals of Mathematical Modelling of Processes and study the Dynamics of industrial processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Development of a Mathematical Model**: Linear State Space Models. Introduction to Laplace Transforms. Transfer Functions. Need of a mathematical model, State variables and State equations for a Chemical process.	8
2.	**Process Dynamics of Fluid Flow and Heat transfer systems:** Fundamentals of fluid flow. Conservation laws for mass, momentum and mechanical energy. Flow of fluids in conduits. Flow past immersed bodies. Fundamentals of heat transfer	8
3.	**Mathematical Model of Different processes and Distillation column Dynamics:** Continuous Stirred Tank Reactor, Mixing Process, T abular Heat Exchanger, Distillation column Dynamics, Mathematical model and controller for Two-tank System	8
4.	**Introduction to Process controllers:** Need of process controller, different types of process controllers: Electric, Pneumatic and Hydraulic controller.	8
5.	**Computer Aided process Control:** Different control actions: on-off or two-position control, Proportional control, Integral control, Derivative control. Analogue Control Systems, Direct Digital Control, Supervisory Computer Control, Distributed Control System.	10
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1	Coughnowr,D.R.,and Koppel,I.B.,"Process Systems Analysis and Control",2nd Ed.,Mcgraw-Hill,New York	**1991**
2	Johnson, Curtis D.," Process control instrumentation technology", Prentice- Hall of India Pvt. Ltd.	**2006**
3	Luyben W. L. "Process Modeling ,Simulation and Control for Chemical Engineers", McGraw-Hill Book Company,New York	**2006**
4	Seborg,D.E.,Edgar,T.F. and Mellichamp,D.A.,"Process Dynamics and Control",2nd Ed.,John Wiley and Sons	**2004**
5	Singh, S.K," Computer-aided process control", Prentice-Hall of India	**2003**
6	Stephanopoulos.G.,"Chemical process control: An Introduction to theory and practice", Prantice-Hall,Englewood Cliffs, N.J.	**1984**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-591** Course Title: **System Reliability**

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

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

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

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

8. Pre-requisite: NIL

9. Objective:

To introduce the concepts of reliability modeling of systems and their applications in assessing the system.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Review of Probability Theory:** Probability concepts, rules for combining probability, probability distributions, random variables, density and distribution functions, mathematical expectations, variance and standard deviation.	3
2.	**Catastrophic failure models:** Component reliability from test data, MTTF, time dependent hazard models, stress dependent hazard models, treatment of field data	5
3.	**Reliability Evaluation:** General reliability functions, probability distributions in reliability evaluation, and evaluation of series, parallel, series –parallel, and complex systems, event space method, cut-set method, tie-set method, and other methods, discrete Markov chains, continuous Markov process, frequency and duration technique concepts, standby and k-out of n: G systems, application to multi-state problems, approximate system reliability evaluation, fault tree technique	12
4.	**Reliability enhancement:** Component improvement, proper design and simplicity, creative design, conservative design and de-rating, redundancy and redundancy allocation	10

S. No.	Contents	Contact Hours
5.	**Drift failures:** Concept of drift failures, failure mechanism, change in device and unit performance with time and loading/stresses, accelerated stress testing, creative design for drift failures.	5
6.	**System with repair:** Availability, maintainability, MTBF, MTTR, UTR, k-out of n: G system with repair and installation, preventive maintenance.	7
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book / Publisher	Year of Publication/ Reprint
1.	Shooman M.L., Probabilistic Reliability- An Engineering Approach, McGraw Hill	**2005**
2.	Sinha S.K., Reliability and Life Testing, Wiley Eastern Limited	**1986**
3.	Gupta A.K., Reliability, Maintenance and Safety Engineering, University Science Press	**2009**
4.	Fuqua N.B., Reliability Engineering for Electronic Design, Marcel Dekker Inc.	**1986**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./ CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-592** Course Title: **Reliability Testing and Prediction**

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

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

4. Related 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 failure mechanism, estimation theory, life testing, reliability test standards test plan and prediction.

10. Details of Course :

S. No.	Contents	Contact Hours
1.	Elements of Estimation theory, discrete stochastic dynamic and stochastic observation models, conditional mean & mode estimation, discrete Kalman filter	6
2.	Failure modes and Mechanism, reliability models for failure mechanisms, failure mechanisms related to electrical components.	7
3.	Reliability testing, Accelerated testing, Software Testing, Testing Automation, Component Stress Testing, Reliability testing methods, Reliability and Fatigue testing of Micro-electro-mechanical-structures(MEMS)	10
4.	Reliability test Standards, Test Items and Conditions, Evaluation Standards,	5
5.	Reliability test Plans, Accelerated Reliability test Plans and procedures, test plan structure, Environmental needs	7
6.	Reliability Prediction, Methodology, Redundancy Allocation, MTTF Allocation, Catastrophic Failure Analysis, Out-of-Tolerance/ Wear out failure, Analysis Common Cause of Failure.	7
	Total	42

11. Suggested Books:

Sr. No.	Name of Books/Author/Publisher	Year of Publication
1.	Sinha S.K., "Reliability and Life Testing", Wiley Eastern Limited	**1986**
2.	Shooman M. L., "Probabilistic Reliability- An Engineering Approach", McGraw Hill Book Company	**1968**
3.	Siegmund H., "The Assurance Sciences", Prentice Hall Inc	**1978**
4.	Gupta A.K., "Reliability, Maintenance and Safety Engineering", University Science Press.	**2009**
5.	Levy B. C., "Principles of Signal Detection and Parameter Estimation", Springer	**2008**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./ CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-593** Course Title: **Graph Theory and Applications**

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

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

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

5. Credits: **04** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: NIL

9. Objective: To familiarize with the concepts of graph theory and its applications in the analysis of circuits, switching theory and operation research.

10. Details of Course :

S. No.	Contents	Contact Hours
1.	Definition of graph, types of graphs, sub graph, Graphs and Examples, Connected graph, Undirected and Directed graph, Disjoint graphs, Planar Graphs, Dual Graphs, Complete graph, Isomorphic Graph, Incidence of a branch, Adjacency and Incidence Matrices, Walks, Trails, Paths, Cycles, Bipartite, Degree, Regular, Distance, Eulerian Graphs, Hamiltonian Graphs	12
2.	Fundamental circuits, trees, counting trees, twigs, links, cut-sets and tie-sets	8
3.	Electrical network analysis by graph theory, state space analysis using graph theory	8
4.	Network flows, Cut and its capacity, enumeration of graphs, Graphs in switching and Coding theory	6
5.	Graph theory in operations research, Traveling Salesmen problem, Shortest path problem, Minimal cost network problem, Network analysis including PERT and CPM	8
	Total	42

11. Suggested Books:

Sr. No.	Name of Books/Author/Publisher	Year of Publication
1.	Balakrishnan V., ,Theory and Problems of Graph Theory, Schaum's Outline Series, McGraw-Hill	**2004**
2	Bazaraa M. S., Jarvis J. J., Sherali H. D., Linear Programming and Network Flows,, 2nd Edition, Willey India Edition	**2008**
3.	Douglas B. West, Introduction to Graph Theory, Prentice Hall	**2000**
4.	Narsingh Deo, ,Graph Theory with applications in the engineering and computer science.	**1974**
5.	Taha H. A., ,Operation Research: An Introduction, Pearson Education	**2008**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-587** Course Title: **Data Structures**

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/Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **NIL**

9. Objective:

To familiarize with the concept of abstract data type, hardware and software implementations of data structures, various existing data structures and their related operations.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Need of data structures, hardware and software implementations of data structures, various existing data structures and their related operations, compile time memory allocation and dynamic (run time) memory allocation, garbage collection.	3
2.	**Linked List:** linked array and pointer representations their advantages and disadvantages, creation traversal, insertion and deletion, sorting, concatenation, merging, searching, header node, link list with grounded header node, circular link list, Josephus doubly linked (two way) link, its advantages and disadvantages.	7
3.	**Stack:** Array Representation, overflow and underflow, push and pop operations, recursion its advantages, converting a recursive procedure to a non-recursive procedure. Tower of Hanoi problem, Infix, prefix and postfix notations, evaluation a postfix expression using stack, implementing quick sort algorithm using stack,	4
4.	**Queue:** Simple queue, addition to a queue, removal from a queue, de-queue, input restricted and output restricted de-queue, addition and removal with respect to de-queue.	3

S. No.	Contents	Contact Hours
5.	**Tree:** Basic definitions, representation in computer memory, creating a binary tree, traversal algorithms threading in a binary tree, heap tree, creation of heap tree, inserting a node in a heap tree, deleting the root of heap tree, heap sort algorithm, link list representation using binary tree, multi-way search tree, representation in computer memory and its advantages.	**10**
6.	**Graph:** Basic definitions, representation in computer memory, creation of a graph, traversal in a graph, depth first traversal and breadth first traversal, sorting, inserting an arc in a graph, deleting an arc from a graph, searching a node and an arc in a graph.	**7**
7.	**Searching Algorithms:** Sequential search, binary search, efficiency of searching algorithms, improving the efficiency of sequential search by move to front , move forward, indexed sequential search.	**2**
8.	**Table Data Structure:** Hash function and hashing, selection of hash function, collision and collision resolving methodologies, linear probing, quadratic probing, buckets, chaining, storing (inserting) data in table, searching a data record in a table, deleting a data record from a table, efficiency of search.	**4**
9.	**Sorting Algorithms:** Bubble sort, quick sort, heap sort, insertion sort, selection sort, merge sort, efficiency of sorting algorithms.	**2**
	Total	**42**

Practical:
The algorithms related to various data structures discussed in the class shall be implemented on C/C++ in the lab.

11. Suggested Books:

S. No.	Name of Authors /Book / Publisher	Year of Publication/ Reprint
1.	Lipschutz S., "Data Structures Schaum's Outline Series", Tata McGraw-Hill Publishing Company Limited.	**2008**
2.	Preiss B. R., "Data Structures and Algorithms with Object Oriented Design Patterns in C++", Wiley India.	**2008**
3.	Rowe G. W., "Introduction to Data Structures and Algorithms With C++", Prentice Hall of India Private Limited.	**2004**
4.	Sahni S., "Data Structures, Algorithms and Application in C++", 2nd Ed., University Press.	**2007**
5.	Tenenbaum A. M., Langsam Y., and Augenstein M. J., "Data structures using C and C++", 2nd Ed., Prentice Hall of India Private Limited.	**2008**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-564** Course Title: **High Voltage Techniques**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective:

To impart knowledge about the breakdown processes in gases, liquid and solids, generation of high voltage and testing of equipments.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Breakdown in Gases:** Ionization processes, breakdown in uniform field; Townsend's mechanisms, breakdown in electronegative gases, Streamer Theory of Gaseous breakdown, Paschen's law, breakdown in electronegative gases, breakdown of gases in non-uniform field; effect of space charge, corona for positive and negative polarities; breakdown phenomena under AC voltage and impulse voltage.	11
2.	**Lightning phenomenon:** Charge formation in clouds; Wilson's theory, Simpson's theory; Mechanism of lightning: stepped leader, return stroke, multiple strokes.	3
3.	**Breakdown in liquid:** Classification of liquids, breakdown in pure liquids, breakdown in commercial liquids.	2
4.	**Breakdown in solids:** Intrinsic breakdown, Electromechanical breakdown, Thermal breakdown, Treeing and tracking, breakdown in Composite Insulators.	2
5.	**Breakdown in Vacuum:** Vacuum arc, formation, vacuum interrupter	2

6.	**Generation of High Voltages:** Generation of High Direct Voltages: Rectifier circuits, Voltage doubler and multiplier circuits, cascade circuits. Generation of High Alternating Voltages: Cascaded transformers, Series resonant circuits. Generation of Impulse Voltages: Characteristics of Impulse and switching surge voltage, analysis of single stage impulse generator circuit, multi-stage impulse generators, constructional features of multi-stage impulse generators. Generation of Switching surges.	**10**
7.	**High Voltage testing of Power System Equipments:** Testing of insulators, bushings, circuit breakers, cables, transformers, surge arrestors.	**6**
8.	**Overvoltages in power systems and insulation co-ordination :** External Overvoltages, Internal Overvoltages, Principles of insulation coordination	**6**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	Kuffel J., Kuffel E., and Zaengl W.S., "High Voltage Engineering fundamentals", 2nd edition, Newness(Oxford, Boston)	**2000**
2.	Naidu, M.S. and Kamaraju, V.," High Voltage Engineering ",4th, edition, Tata McGraw-Hill, New Delhi	**2008**
3.	Abdel-salam M., Anis H. and , Abdel-salamani," High-Voltage Engineering: Theory and Practice", 2nd edition, CRC Press.	**2001**
4.	Kind D. and Freser K.," High Voltage Test Techniques",2nd edition, Newnes (Oxford, Boston)	**2001**
5.	Ray S.," An introduction to High Voltage Engineering", Prentice Hall India, New Delhi	**2004**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EE-569** Course Title: **Relaying and Switchgear**

2. Contact Hours: **L: 3** **T: 1** **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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **NIL**

9. Objective:

To introduce the electronic, digital and computer techniques in power system relaying and switchgear

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review of relay characteristics and operating equations with respect to static comparators. CTs, PTs and mixing transformers, effect of CT saturation on relay operation.	4
2.	Basic construction of static relays, input output devices, d.c. supplies and associated elements; time delay circuits.	3
3.	Static comparators: Different types of amplitude and phase comparators; theory and operation, effect of offset and its remedy. Introduction of multi input comparators and characteristics	8
4.	Transient over voltages and their suppression; Different type of relays: static, digital and computer aided relaying	6
5.	Bus bar arrangements; High current bus bars and design consideration	3
6.	**Switchgear:** review of arc formation, properties and characteristics; interruption of current in circuit breakers; high resistance and low resistance theories of interruption; Effect on circuit breaker performance under different conditions in power system operation; Circuit breaker ratings.	9
7.	Study and operation of air blast, SF_6, vacuum and d.c. circuit breakers. Selection and design considerations.	6
8.	Circuit breaker testing methods as per standard	3
	Total	42

Practical:
Testing of different type of relays
Study of optical communication techniques for electrical quantities

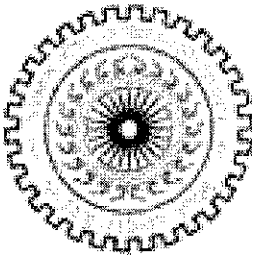
11. Suggested Books:

S. No.	Name of Authors / Book / Publisher	Year of Publication/ Reprint
1.	A. R. van C. Warrington, "Protective Relays Their Theories and Practice". Volume II, Third Edition, John Wiley & Sons, Inc, New Yark	1977
2.	B. Ravindranath and M. Chander,"Power System Protection and Switchgear", First Edition, New Age International (P) Limited.	Reprint 2005
3.	B. Ram And D. N. Vishwakarma, "Power System Protection And Switchgear", Ninth Reprint, Tata McGraw-Hill Publishing Company	2002
4.	R. T. Lythall, "The J&P Switchgear Book". Seventh Edition, Newnes-Butterworth	1976
5.	Stan Stewart, "Distribution Switchgear", The Institution of Electrical Engineers, London	2002

Appendix-L
Item No.SENATE/36.2.2

M.Tech. Syllabus

(Spring Semester)



Department of Architecture & Planning
Indian Institute of Technology Roorkee
Roorkee – 247 667

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **AR-202** Course Title: **Architectural Design-III**

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

3. Examination Duration (Hrs) **Theory** 0 **Practical** 7

4. Relative Weightage: **CWS** 10 **PRS** 50 **MTE** 20 **ETE** 0 **PRE** 20

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

8. Pre-requisite: **AR-201**

9. Objective:

To develop design ability to evolve site responsive design solutions for multifunctional buildings on intermediate scale.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Relationship between site and sustainability	2
2.	Passive design strategies for climatically responsive buildings, open spaces and built form relationships	3
3.	Design of multifunctional spaces and buildings, space standards, norms and case studies	6
4.	Design issues concerning educational buildings	3
	Total	14

Design Exercises

1. Site analysis and site planning
2. Multifunctional community buildings and spaces for congregation
3. Educational buildings – schools, lecture theatre complex
4. Library, gymnasium

- Rendering
- Architectural Study Tour

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year
1.	Russ, T.H., "Site Planning and Design Handbook", McGraw-Hill	2002
2.	Agkathidis, A., Hubert, M. and Schillig, G., "Form Defining Strategies: Experimental Architectural Design", Wasmuth	2007
3.	Parliament Library Building: A Documentation, Central Public Works Department	2003
4.	Neufert, P., "Architects' Data", 3rd Ed., Blackwell Science	2000
5.	Watson, D. (Ed.), "Time-saver Standards for Architectural Design: Technical Data for Professional Practice", 8th Ed., McGraw-Hill.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **AR-204** Course Title: **Building Construction - III**
2. Contact Hours: **L: 1** **T: 0** **P: 4**
3. Examination Duration (Hrs): **Theory** [0] **Practical** [4]
4. Relative Weightage: **CWS** [0] **PRS** [50] **MTE** [20] **ETE** [0] **PRE** [30]
5. Credits [3] 6. Semester: **Spring** 7. Subject Area: **PCC**
8. Pre-requisite: **AR-203**
9. Objective:

To impart knowledge on advanced construction materials and techniques, and industrialized building components.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Advanced construction materials**: Steel, aluminium, glass; Properties and applications	2
2.	**Walls**: curtain walls, partition walls, dry wall, composite wall; Gypsum wall and plaster	2
3.	**Suspended ceiling systems**: Construction details	2
4.	**MS frame structure**: Metal frame structural components, connections and joinery; Steel tubular space frame with joints	2
5.	**Trusses**: Types, materials; Timber and steel truss construction with connection detailing; Cover and drainage details; North light glazing	2
6.	**Industrialized windows and doors**: Types- sliding, revolving, collapsible, rolling shutters; Steel, aluminium and composite sections; System details and specifications	2
7.	**Staircase**: Principles of staircase construction and its elements; Details of staircases in wood, stone and steel	2
	Total	14

Exercises:

- Construction details of
  - Dry wall and partition wall
  - Industrialized door and window system details
  - Steel frame structure
  - Steel truss using MS flats and tube sections
  - Joints of column to beam, beam to beam, column base, column splice
  - Joinery like welding, bolt, rivet and soldering

- Site visits to project site, modern buildings
- Market survey of building materials and
- Visit to building materials' industries

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Mehta, M., Scarborough, W. and Armpriest, Diane, "Building Construction: Principles, Materials and Systems", Pearson Prentice Hall	2008
2.	National Building Code-2005, BIS	2005
3.	Rangwala, S.C., "Building Construction", 19th Ed., Charotar Publishing House	2001
4.	Mckay, W.B., "Building Construction- Vols. II & III", Longman	2005
5.	Kumar, S.K., "Building Construction", 19th Ed., Standard Publishers Distributors	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **AR-206** Course Title: **History of Architecture-I**

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: **Spring** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective:

To impart knowledge about the evolution of architecture through early historical periods.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Evolution of architecture in early historical periods	2
2.	**Primitive Architecture**: Development of forms of shelters and megalithic structures	2
3.	**Architecture of Ancient Civilizations**: Egyptian – mastabas, royal pyramids and great temples; West Asiatic (Mesopotamia and Persia) – ziggurats and palaces	6
4.	**Classical Architecture**: Greek – columnar and trabeated architecture, Doric, Ionic and Corinthian orders, acropolis, temple at Parthenon, cultural and sports buildings; Roman – arcuated architecture, monumental scale, Tuscan and Composite orders, Pantheon, Forum, basilicas and thermae	6
5.	**Medieval Architecture**: Early Christian – evolution of church architecture; Byzantine – Hagia Sophia; Romanesque – Pisa cathedral complex; Gothic – pointed arch architecture, Notre Dame	6
6.	**Renaissance Architecture**: Early and High Renaissance – cathedral of St. Peter and St. Paul; Baroque and Rococo – Piazza of St. Peter Neo-classical	6
	Total	28

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Watkin, D., "A History of Western Architecture", Thames and Hudson	1986
2.	Fletcher, B., "A History of Architecture", 20th Ed., Butterworth Heinemann	1996
3.	Moffet, M., Fazio, M. and Wodehouse, L., "A World History of Architecture", McGraw-Hill	2008
4.	Borngasser, Barbara, "History of Architecture – From Classic to Contemporary", Parragon	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CE-292** Course Title: **Theory of Structures-I**

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**

7. Pre-requisite: **Nil**

9. Objective:

To impart knowledge on mechanical properties of common engineering materials, simple types of structural elements and determination of forces and stresses in the elements.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Types of engineering materials, their mechanical properties and tests for determination	4
2.	Introduction to structural elements	4
3.	Stresses and Strains; Elastic constants and their mutual relationships; Working stresses and factors of safety; Partial safety factors for load and stresses at limit state of collapse	8
4.	Simple redundant problems of stresses and strains; Temperature stresses in composite sections	4
5.	Analysis of trusses - method of joints and methods of sections	6
6.	Bending moment and shear force diagrams for determinate beams under simple types of loads; Methods of super position	8
7.	Theory of simple bending; Bending and shear stresses in symmetrical sections; Combined direct and bending stresses	8
	Total	42

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication
1.	Kumar, A., "Stability Theory of Structures", Tata McGraw Hill	1985
2.	Prakash Rao, D.S., "Structural Analysis", University Press	2007
3.	Jain, A.K., "Strength of Materials and Structural Analysis", 2nd Ed., Nem Chand & Bros	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **AR-308** Course Title: **Fire Protection and Security Systems**

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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective:

To impart understanding of fire protection and security systems in buildings.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Basic understanding about fire, fire triangle, growth decay curve, fire properties	3
2.	**Reaction to Fire:** Basic fire properties of materials - ignitability, combustibility, surface-spread of flame, fire propagation, toxicity	6
3.	**Fire Retardance:** General behaviour of materials, imparting fire retardance, combination of fire retardance material and non combusitible materials	3
4.	**Active Fire Protection:** Understanding of active fire protection, manual alarm system; Detectors - basic understanding, heat detectors, smoke detectors, flame detectors; Fire fighting equipments - sprinkler systems, hydrant systems, water requirements; Special protected areas like basements, high rise buildings; Life safety considerations	7
5.	**Passive Fire Protection:** Fire properties of construction materials, fire resistance of building elements, compartmentation, fire protection of structural elements	6
6.	**Security Systems:** CCTV cameras, fire alarm systems, PA systems, detectors	3
	Total	28

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	National Building Code-2005, Part IV, BIS	2005
2.	Latalie, J., "Fire Protection Engineering in Building Design", Butterworth-Heinemann	2002
3.	Capel, V., "Security Systems and Intruder Alarms", Butterworth-Heinemann	1999
4.	Dudley, R., "Fire Protection and Alarm Systems", IHS BRE Press	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **AR-312** Course Title: **History of Modern 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: **Spring** 7. Subject Area: **PEC**

7. Pre-requisite: **Nil**

9. Objective:

To impart knowledge of evolution and trends of modern architecture from the 18th to 20th century.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Beginning of modern architecture through Neoclassicism in the 18th century; Industrial revolution and related socio-economic developments; Eclecticism and the architectural predicament in the 19th century	4
2.	Art Nouveau- reaction against Eclecticism, morphed forms, plastic treatment of plans; Chicago School- evolution of the highrise office building	4
3.	F.L. Wright and Organic Architecture; Le Corbusier- the Domino System and points of a new architecture; Expressionism; Mies Van der Rohe- Minimalism, long span and tall buildings in steel and glass	6
4.	Walter Gropius and Bauhaus; Adolf Loos and Internationalism; G.T. Reitveld and De Stil Architecture; Alvar Aalto and Scandinavian Regionalism; Works of the early 20th century architects like Richard Neutra, Eero Saarinen, Bruce Goff, P.L. Nervi, Philip Johnson and other architects	6
5.	Beginning of Late and Post Modernism through the works of Richard Meier, Arata Isozaki, Kisho Kurokawa, Peter Eisenmann, Michael Graves, Robert Venturi, Norman Foster, Richard Rogers, Renzo Piano and other architects	4
6.	Beginning of modern architecture in India; Contributions of Le Corbusier and Louis Kahn; Early works of Charles Correa, A.P. Kanvinde, U.C. Jain, B.V. Doshi, J.A. Stein, Laurie Baker and other architects	4
	Total	**28**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication
1.	Gossel. P., "Architecture in the 20th Century", Vol.1, Taschen	2005
2.	Gossel. P., "Architecture in the 20th Century", Vol.2, Taschen	2005
3.	Borngasser, Barbara, "History of Architecture – From Classic to Contemporary", Parragon	2008
4.	Tietz, J., "The Story of Modern Architecture", H.F. Ullmann	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **AR-316** Course Title: **Acoustics and Lighting**

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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective:

To impart knowledge of acoustics and lighting in buildings.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	General principles of transmission and passage of sound, reverberation absorption, reflection; Types of absorbents and reflectors; Study of acoustical design for various enclosures for speech, music and conference	7
2.	Noise and its control; Special problems related to structure borne noise; Basics of noise insulation; Insulation of A.C. ducts and plants from acoustical point of view	7
3.	Lighting in buildings, light and its sources, lighting criteria, the visual field, daylight prediction methods	4
4.	Artificial lighting, lighting levels for various activities, calculation for lighting levels, practical examples/case studies	10
	Total	28

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Cavanaugh, W.J., Gregory, C.T. and Wilkes, J.A. (Editors), "Architectural Acoustics: Principles and Practice", 2nd Ed., John Wiley	2010
2.	Vigran, T.E., "Building Acoustics", Taylor and Francis	2008
3.	Steffy, G., "Architectural Lighting Design, 2nd Ed., Wiley	2001
4.	Philips, D., "Lighting Modern Buildings", Butterworth-Heinemann	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **AR-414** Course Title: **Futuristic 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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective:

To impart knowledge of futuristic architectural concepts, building materials and building technologies

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Future concepts envisioned by earlier theorists and architects like Antonio Saint Elia and F.L. Wright	2
2.	Emerging architectural paradigms such as programme generated architecture, dynamic architectural systems, virtuality, transarchitecture, data driven structures and 'glocal' approach through the study of relevant projects	8
3.	Evolution of contemporary architectural concepts - historical revival, biomimcry, adaptive reuse and low cost buildings; Futuristic building materials: Building tectonics and systems	8
4.	Study of specific building types - houses, office spaces, public buildings, skyscrapers and transportation hubs through various projects	6
5.	Sustainable buildings including energy efficiency, Zero Energy and Energy Plus buildings and resource conservation	4
	Total	28

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/ Reprint
1.	Bell, J., "21st Century House", Laurence King Publishing	**2006**
2.	Bell, Victoria Ballard, "Materials for Architectural Design", Laurence King Publishing	**2006**
3.	Jodidio, P., "Building a New Milleneum", Vol.1, Taschen	**2003**
4.	Jodidio, P., "Architecture Now", Vol. 2, Taschen	**2004**