सीनेट की 33वी बैठक का कार्यवृत्त

MINUTES OF THE 33RD MEETING OF THE SENATE

16 जून 2010

16TH JUNE 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)

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Minutes of the 33rd meeting of the Senate held on 16.6.2010 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. I.M. Mishra	(Chemical Engineering)
5.	Prof. Surendra Kumar	(Chemical Engineering)
6.	Prof. Bikash Mohanty	(Chemical Engineering)
7.	Prof. Shri Chand	(Chemical Engineering)
8.	Prof. I.D. Mall	(Chemical Engineering)
9.	Prof. Vijay Kumar Agarwal	(Chemical Engineering)
10.	Prof. G. Bhattacharjee	(Chemistry)
11.	Prof. Kamaluddin	(Chemistry)
12.	Prof. Anil Kumar	(Chemistry)
13.	Prof. A.K. Singh	(Chemistry)
14.	Prof. U.P. Singh	(Chemistry)
15.	Prof. V.K. Gupta	(Civil Engineering)
16.	Prof. S.S. Jain	(Civil Engineering)
17.	Prof. Satish Chandra	(Civil Engineering)
18.	Prof. Manoj K. Arora	(Civil Engineering)
19.	Prof. Praveen Kumar	(Civil Engineering)
20.	Prof. N.K. Samadhiya	(Civil Engineering)
21.	Prof. Ashwini Kumar	(Earthquake Engineering)
22.	Prof. M.L. Sharma	(Earthquake Engineering)
23.	Prof. P.K. Gupta	(Earth Sciences)
24.	Prof. A.K. Saraf	(Earth Sciences)
25.	Prof. J.D. Sharma	(Electrical Engineering)
26.	Prof. H.O. Gupta	(Electrical Engineering)
27.	Prof. Vinod Kumar	(Electrical Engineering)
28.	Prof. Pramod Agarwal	(Electrical Engineering)
29.	Prof. Sajjan Pal Singh	(Electrical Engineering)
30.	Prof. R.P. Maheshwari	(Electrical Engineering)
31.	Prof. S.P. Srivastava	(Electrical Engineering)
32.	Prof. R.S. Anand	(Electrical Engineering)
33.	Prof. D.K.Mehra	(Electronics & Computer Engg.)
34.	Prof. (Mrs) Kumkum Garg	(Electronics & Computer Engg.)
35.	Prof. D.K. Srivastava	(Hydrology)
36.	Prof. J.S. Upadhyay	(Paper Technology)
37.	Prof. Satish Kumar	(Paper Technology)
38.	Prof. V.K. Nangia	(Management Studies)
39.	Prof. G.S. Srivastava	(Mathematics)
40.	Prof. S.P. Sharma	(Mathematics)
41.	Prof. Pradeep Kumar	(Mechanical & Industrial Engg.)
42.	Prof. Satish C. Sharma	(Mechanical & Industrial Engg.)

43. Prof. P.K. Jain (Mechanical & Industrial Engg.)
44. Prof. Dinesh Kumar (Mechanical & Industrial Engg.)
45. Prof. P.K. Ghosh (Metallurgical & Materials Engg.)
46. Dr. Arun Kumar, Head, Alternate Hydro Energy Centre
47. Mr. Yogender Singh, Librarian, Central Library
48. Dr. Sunil Singhal, Chief Warden, Cautley Bhawan & Scientist AHEC.
49. Dr. Yogendra Singh, Associate Professor, Earthquake Engineering
50. Lt. Col. A.K. Srivastava, Registrar - Secretary

The Chairman (Director) welcomed the members to the 33rd Meeting of the Senate.

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

1. Prof. P.K. Kalra, I IT Kanpur
2. Prof. Devadutta Dass, WRD&M
3. Prof. A.K. Jain, Department of Physics
4. Prof. Ravi Bhushan, Department of Chemistry
5. Prof. H. Sinvhal, Department of Earth Sciences
6. Prof. B.D. Indu, Dep artment of Physics
7. Prof. Rama Bhargava, Department of Mathematics
8. Prof. Ashok Kumar, Department of Earthquake Engine ering
9. Prof. (Mrs.) Rama Bhargava, Department of Mathematics

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

1. Prof. G. R amasamy, Department of Civil Engineering
2. Prof. Kuldeep Singh, Department of E. & C. Engg.
3. Prof. Ranvir Singh, Department of Hydrology

The Agenda was then taken up:

Item No. 33.1: To consider the mercy appeal of Mr. Vivek Kumar Kumpawat student of IDD-ECW, 3rd year Electronics & Computer Engineering Department for extension of one year (2-semesters) beyond maximum period of seven years.

The Senate decided that the mercy appeal of Mr. Vivek Kumar Kumpawat, student of IDD-ECW, 3rd year, Department of Electronics & Computer Engineering for extension beyond 7 years i.e. by May 2013 be not accepted.

Item No.33.2: **To rename the title of the M.Tech Programme in Conservation of Rivers and lakes.**

As considered and recommended by the Board of Studies, the Senate decided that the M.Tech. Programme in Conservation of Rivers and Lakes be renamed as **"Environmental Management of Rivers and Lakes".** This will be effective from the session 2011-12.

Item No.33.3: **To revise the eligibility criteria for admission to M.Tech programme (Environmental Management of Rivers and Lakes).**

As considered and recommended by the Board of Studies, the Senate decided that the eligibility criteria for admission to M.Tech. programme **Environmental Management of Rivers and Lakes** be approved as under:

A recognized degree in Civil/Electrical/ Mechanical/Industrial/Chemical/Agricultural/ Environmental Engineering/ Architecture/ Planning/ Biotechnology or equivalent with at least 60% marks or a CGPA of 6.00 on a 10 point scale at the Bachelor's level including AMIE examinations of the Institute of Engineers.

OR

Master degree in Science with Mathematics at graduation level (limited to 30% of total seats) with at least 60% marks or a CGPA of 6.00 on a 10 point scale at Master's level.

Item No.33.4: **To consider the proposal of Prof & Head, Civil Engineering Department to split course CE-101: Engineering Graphics into two Courses.**

The Senate decided that the issue be referred back to the Board of Studies for consideration keeping in view the suggestion given on the floor by the Senators.

Item No.33.5: **To consider the request (through Head, Electrical Engineering) of two students of B.Tech. IV year (Electrical Engineering) to amend regulation regarding award of grades in self study course.**

The Senate decided that the status quo be maintained.

Item No.33.6: **To consider New/Revised Teaching Schemes of the PG Programmes as approved by the BOS.**

As considered and recommended by the Board of Studies, the Senate decided that the New/Revised Teaching Schemes of the PG Programmes of the following departments be approved.

(a) Department of Management Studies **(Appendix 'A')**
(b) Centre for Nano Technology **(Appendix 'B')**

The new/revised Teaching Scheme of the PG Programmes of the Department of Architecture & Planning will be taken up alongwith the syllabi of courses of the Department in the forthcoming Senate.

Item No.33.7: **To consider the BOS approved proposal of Department of Management Studies to float two Institute Electives, namely, IBM-01: Knowledge Management and IBM-02: Banking and Bank Finance, as Institute Electives under HSSMEC category for B.Tech./ IDD/ Integrataed M.Sc./ Integrated M.Tech. Programme.**

As considered and recommended by the Board of Studies, the Senate decided that the proposal of the Department of Management Studies to float two Institute Electives, namely **IBM-01:** Knowledge Management and **IBM-02:** Banking and Bank Finance, as Institute Electives under HSSMEC category for B.Tech./ IDD/ Integrated M.Sc./ Integrated M.Tech. Programme as given at **Appendix 'C'** be approved.

Item No.33.8: **To revise the teaching scheme for M.Tech in Conservation of Rivers & Lakes (CRL) in AHEC.**

As considered and recommended by the Board of Studies, the Senate decided that the revised teaching scheme for M.Tech. in Conservation of Rivers and Lakes (CRL) as given at **Appendix 'D'** be approved.

Item No.33.9: **To consider letter from Head, Department of Earth Sciences, regarding anomalies in the status of students admitted after JAM examination laterally into the III year of the 5-year Integrated M.Tech. programme in Geological/ Geophysical Technology.**

As considered and recommended by the Board of Studies, the Senate decided as under:

(i) The fee structure for the two groups of students (i.e. JEE group and JAM group) will be the same.

(ii) The students admitted through JAM, although, are admitted directly in III year of 5-year Integrated Programme in Geological/ Geophysical Technology, will be awarded M.Tech in Geological/ Geophysical Technology degree, as per Senate resolution item No. 27.3.3 dated 24.10.2008. Therefore, these students be considered as I year students of the M.Tech. (Geological/ Geophysical Technology) Programme.

The advertisement be corrected accordingly.

Item No.33.10: **To consider the issue related to offering of the departmental core courses in summer term.**

The Senate decided that the proposal be not accepted. During the discussions, the issue of clearing the pre-requisites also emerged. The Senate resolved the following:

If a student has registered and attended the classes of the pre-requisite subject and has not obtained 'F' grade due to attendance shortage, such

student will be assumed to have met the pre-requisite requirements.

Item No.33.11: **To consider the syllabi of PG courses under new PG programme from the Chemical Engineering and Alternate Hydro Energy Centre (AHEC).**

As considered and recommended by the Board of Studies, the Senate decided that the syllabi of PG courses under new PG programme in the Chemical Engineering and Alternate Hydro Energy Centre as given at **Appendices 'E' & 'F'** be approved.

Item No.33.12: **To consider the Elective Courses of Earth Sciences Department.**

As considered and recommended by the Board of Studies, the Senate decided that the syllabi of the elective courses of Integrated M.Tech. Programmes in Geological and Geophysical Technology of the Department of Earth Sciences as given at **Appendix 'G'** be approved.

Item No.33.13: **To report that the Director and Chairman, Senate, has approved that the change in status of Institute Elective IPH 02, Nano Materials to run in both the semesters (i.e., Autumn and Spring) from the earlier approved to run in Autumn Semester.**

Noted that the Director and Chairman, Senate, has approved the request of Professor & Head, Department of Physics to run Institute Elective **IPH 02:** Nano Materials in both the semesters (i.e. Autumn and Spring).

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

Department of Management Studies
Master of Business Administration (MBA)

Subject Code	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	--

Appendix 'B'
Item No. Senate:33.6

Centre of Nanotechnology

Teaching Scheme for M. Tech. (Nanotechnology)

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		**1st Semester (Autumn)**												
1.	MA-501B	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	50		-	50	-
5.		Open Elective I	OEC	3/4										
6.	HS-501	Technical Communication (Optional)	-	2	1	0	2	-	-	15	15	30	40	-
		Sub Total		**19-22**										
1st Year		**2nd Semester (Spring)**												
1.		Program Elective – I	PEC	4										
2.		Program Elective – II	PEC	4										
3.		Program Elective – III	PEC	3/4										
4.		Program Elective – IV	PEC	3/4										
5.	NT-562	Laboratory Methods (Multidisciplinary Experiments)	PEC	2	0	0	4	-	4	-	50	-	-	50
6.		Open Elective - II	OEC	3/4										
7.	HS-501	Technical Communication (Optional)	-	2	1	0	2	-	-	15	15	30	40	-
		Sub Total		**19-24**										
2nd Year		**III Semester (Autumn)**												
1.	NT-601	Seminar	SEM	2										
2.	NT-602	Project	RP	4										
3.	NT-603	Dissertation	DIS	-										
		Sub total		**6**										
2nd Year		**IV Semester (Spring)**												
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 Nano and Amorphous Materials	PEC	4	3	1	0	3	-	25	-	25	50	
6.	NT-532	Supramolecular Chemistry of Nanomaterials	PEC	4	3	1	0	3	-	25	-	25	50	
7.	NT-542	Nanobiotechnology	PEC	4	3	1	0	3	-	25	-	25	50	
8.	PH-702	Nanomaterials & Technology	PEC	3	3	0	0	3	-	15	-	35	50	
9.	PH-706	Functional Materials and Devices	PEC	3	3	0	0	3	-	15	-	35	50	
10.	NT-552	Physics of Nanomaterials	PEC	3	3	1	0	3	-	25	-	25	50	
11.	MT-506	Metallurgical Thermodynamics & Kinetics	PEC	3	3	0	0	3	-	15	-	35	50	
12.	EC-632N	RF and Microwave MEMS	PEC	3	3	0	0	3	-	15	-	35	50	
13.	EC-642N	Nanoscale Devices and Circuit Design	PEC	3	3	0	0	3	-	15	-	35	50	

Appendix-C
Item No.SENATE: 33.7

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : DEPARTMENT OF MANAGEMENT STUDIES

1. **Subject Code** : **IBM-01** **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:** HSSMEC

9. **Objective of Course:** To acquaint students with various aspects relating to framework, infrastructure, technologies and applications 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: Cases of 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 organisation	4
Total		**42**

11. Suggested Books:

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 : IBM-02** **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:** HSSMEC

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

10. **Details of Course:**

Sl. 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, Cash Reserve Ratio, Statutory Liquidity Ratio 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 electronic clearing services.	5
8.	Scams, frauds, global financial crisis and their effect.	4
	Total	42

11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication / Reprint
1.	Sethi J., Bhatia N., "Elements of Banking and Insurance", PHI	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", PHI	2009
5.	Khan M. Y., "Financial Services", 5th Edition, Tata McGraw Hill	2007

Appendix – D
Item No.SENATE:33.8

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
M. TECH. IN "CONSERVATION OF RIVERS AND LAKES"

I Semester (Autumn)

Teaching Scheme					Teaching Load Hrs/Week			Exam. Duration (Hrs.)		Relative Weightage (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	MA-501F	Numerical Analysis, Probability and Statistics	ICC	4	3	1	0	3	-	25	-	25	50	-
2.	AH-517A	Modeling, Simulation and Computer Application	PCC	4	3	1	2/2	3	-	15	15	30	40	-
3.	AH-523	Integrated Management of Water Bodies	PCC	5	3	1	2/2	3	-	15	15	30	40	-
4.	AH-525	Aquatic Ecology	PCC	4	3	1	2/2	3	-	15	15	30	40	-
5.		Open Elective-I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (Optional)	IEC	2	1	0	2	2	-	15	15	30	40	-
		Subtotal		**20/23**										

II Semester (Spring)

Teaching Scheme					Teaching Load Hrs/Week			Exam. Duration (Hrs.)		Relative Weightage (%)				
S. NO.	SUBJECT CODE	COURSE TITLE	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	-	Programme Elective -I	PEC	4	-	-	-	-	-	-	-	-	-	-
2.	-	Programme Elective-II	PEC	4	-	-	-	-	-	-	-	-	-	-
3.	-	Programme Elective-III	PEC	4	-	-	-	-	-	-	-	-	-	-
4.	-	Programme Elective-IV	PEC	4	-	-	-	-	-	-	-	-	-	-
5.	-	Open Elective-II	OEC	3/4	3	1	0	3	-	-	-	-	-	-
6.	AH-527	Laboratory Course	PCC	2	-	-	3	-	3	-	50	-	-	50
6.	HS-501	Technical Communication (Optional)	IEC	2	1	0	2	2	-	15	15	30	40	-
		Subtotal		**21/22**										

III Semester (Autumn)

Teaching Scheme					Teaching Load Hrs/Week			Exam. Duration (Hrs.)		Relative Weightage (%)				
S. NO.	SUBJECT CODE	COURSE TITLE	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	AH-601	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	AH-602	Project and Site Visits	RP	4	-	-	-	-	-	-	-	-	100	-
3.	AH-603	Dissertation*	DIS	0	-	-	-	-	-	-	-	-	25	-
		Subtotal		**6**										

* To be continued and grades to be awarded in the next Semester

IV Semester (Spring)

Teaching Scheme					Teaching Load Hrs/Week			Exam. Duration (Hrs.)		Relative Weightage (%)				
S. NO.	SUBJECT CODE	COURSE TITLE	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	AH-603	Dissertation	DIS	20	-	-	-	-	-	-	-	-	75	-
		Subtotal		20										
		Total		67/70										

Electives Courses

Teaching Scheme					Teaching Load Hrs/ Week			Exam. Duration (Hrs.)		Relative Weightage (%)				
S. NO.	SUBJECT CODE	COURSE TITLE	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	AH-522	Waste Water Collection, Treatment and Disposal	PEC	4	3	1	-	3	-	25	-	25	50	-
2.	AH-526	Environmental Laws, Public Participation and Institutional Development	PEC	4	3	1	-	3	-	25	-	25	50	-
3.	AH-544	Project Formulation and Implementation	PEC	4	3	1	-	3	-	25	-	25	50	-
4.	AH-548	Coastal Pollution Monitoring and Impact Assessment	PEC	4	3	1	-	3	-	25	-	25	50	-
5.	AH-550	Application of RS and GIS in Environment Management	PEC	4	3	1	-	3	-	25	-	25	50	-
6.	AH-552	Hydrology and Modeling of water bodies	PEC	4	3	1	-	3	-	25	-	25	50	-
7.	AH-576	Planning and Management of Environmental Facility	PEC	4	3	1	-	3	-	25	-	25	50	-
8.	AH-580	Climate Change and Water Resources	PEC	4	3	1	-	3	-	25	-	25	50	-
9.	HY-527	Ground Water Hydrology	PEC	4	3	1	-	3	-	25	-	25	50	-
10.	HY-531	Water Shed Behavior & Conservation Practices	PEC	4	3	1	-	3	-	25	-	25	50	-
11.	HY-542	Urban Hydrology	PEC	4	3	1	-	3	-	25	-	25	50	-
12.	CE-601B	Environment Impact Assessment of Civil Engineering Projects	PEC	4	3	1	-	3	-	25	-	25	50	-
13.	CE-626	Hazardous Waste and Risk Management	PEC	4	3	1	-	3	-	25	-	25	50	-

M.Tech. (Chemical Engineering)

with specialization in

Computer Aided Process Plant Design (CAPPD)

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-501** Course Title: **Modeling and Simulation of Chemical Engineering Systems**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide basic concepts of modeling and simulation of chemical engineering systems.

10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Introduction:** Introduction to process modeling and simulation.	3
2.	**Models:** Models, need of models and their classification, models based on transport phenomena principles, scaling, alternate classifications of models, population balance, stochastic, and empirical models. Unit models of simple chemical engineering systems and their block diagrams	10
3.	**Modeling of Chemical Engineering Systems:** Reactors - fixed bed, fluidized bed and bioreactors (aerobic and anaerobic); Evaporators, cyclone separators, electrostatic precipitators; Stack dispersion modeling; Modeling of safety systems.	16
4.	**Process Simulation:** Techniques of digital simulation. Lumped parameter systems, stability, model analysis, discretization, and discrete to continuous systems. Newton's and globally convergent methods for set of nonlinear equations; Use of Runge-Kutta and Gear's methods for solution of staged separation problems, finite difference approximation of partial differential equations and their solutions.	13
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Denn M.M., "Process Modeling", Longman.	1986
2.	Luyben W.L., "Process Modeling, Simulation and Control for Chemical Engineers", 2nd Ed., McGraw Hill.	1990
3.	Najim K., "Process Modeling and Control in Chemical Engineering", CRC Press.	1990
4.	Aris R., "Mathematical Modeling, Vol. 1: A Chemical Engineering Perspective (Process System Engineering)", Academic Press.	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-503** Course Title: **Advanced Transport Phenomena**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide advanced concepts of momentum, mass and heat transfer operations.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Review of basic principles and equations of change in transport of momentum, heat and mass; Viscosity, thermal conductivity and diffusivity; Shell balance for simple situations to obtain shear stress, velocity, heat flux, temperature, mass flux and concentration distributions.	8
2.	**Equations of Change**: Equations of continuity, motion, mechanical energy, angular momentum, energy, and equation of continuity for multicomponent mixture. Use of the equations of change in solving problems of momentum, heat and mass transport, dimensional analysis of the equation of change.	8
3.	**Distributions with More than One Independent Variable**: Unsteady state flow, heat and mass transfer problems, creeping flow around a sphere, flow through a rectangular channel, unsteady heat conduction in slabs with and without changing heat flux, heat conduction in laminar in compressible flow, potential flow of heat in solids, unsteady state diffusive mass transport, steady state transport of mass in binary boundary layers.	8
4.	**Transport of Mass, Momentum and Heat under Turbulent Flow Conditions**: Velocity, temperature and concentration distributions in smooth cylindrical tubes for incompressible fluids, empirical equations for various transport fluxes and momentum.	6
5.	**Interphase Transport in Isothermal and Non-Isothermal Mixtures**: Definitions of friction factor and heat and mass transfer coefficients; Heat and mass transfer in fluids flowing through closed conduits and packed beds; Mass transfer accompanied with chemical reaction in packed beds; Combined heat and mass transfer by free and forced convection; Transfer coefficients at high net mass transfer rate.	6
6.	**Macroscopic Balances**: Momentum, heat and mass balances and their	6

	application, use of macroscopic balances in steady and unsteady state problems; Cooling and heating of a liquid in stirred tank, start-up of a chemical reactor.	
Total		**42**

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Bird R.B., Stewart W.E. and Lightfoot E.N., "Transport Phenomena", 2nd Ed., Wiley.	1994
2.	Leal L.G., "Advanced Transport Phenomena: Fluid Mechanics and Convective Transport Processes", Cambridge University Press.	2007
3.	Dean W.M., "Analysis of Transport Phenomena", Oxford University Press.	1998
4.	Brodkey R.S. and Hershey H.C., "Transport Phenomena – A Unified Approach", Brodkey.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-505** Course Title: **Chemical Reactor 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: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To provide advanced knowledge of reaction kinetics and chemical reactors.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review of design of ideal isothermal homogeneous reactors for single and multiple reactions.	6
2.	Residence time distribution (RTD) of ideal reactors, interpretation of RTD data, flow models for non-ideal reactors – axial dispersion, N tanks in series, and multiparameter models, diagnosing the ills of reactors, influence of RTD and micromixing on conversion.	9
3.	Adiabatic and non-adiabatic operations in batch and flow reactors, optimal temperature progression, hot spot in tubular reactor, autothermal operation and steady state multiplicity in continuously stirred tank reactor (CSTR) and tubular reactors, introduction to bifurcation theory.	11
4.	Introduction to multiphase catalytic reactors, effectiveness factor, selectivity, catalyst deactivation, use of pseudo-homogeneous models for design of heterogeneous catalytic reactors (fixed and fluidized beds).	8
5.	Gas-liquid-solid reactors, hydrodynamics and design of bubble column, slurry and trickle-bed reactors.	6
6.	Introduction to laboratory reactors.	2
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Fogler H.S., "Elements of Chemical Reaction Engineering", 4th Ed., Prentice-Hall.	2006
2.	Levenspiel O., "Chemical Reaction Engineering", 3rd Ed., Wiley.	1999
3.	Froment G.F. and Bischoff K.B., "Chemical Reactor Analysis and Design", 2nd Ed., Wiley.	1990
4.	Doraiswamy L.K. and Sharma M.M., "Heterogeneous Reactions Analysis. Vol. 1: Gas-Solid and Solid-Solid Reactions", Wiley.	1984
5.	Doraiswamy L.K. and Sharma M.M., "Heterogeneous Reactions Analysis. Vol. 2: Gas-Solid and Solid-Solid Reactions", Wiley.	1984

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-507** Course Title: **Computer Programming and Software Tools**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To train in computer programming and use of software tools for solving chemical engineering problems.

10. Details of Course:

S. No.	Contents	Contact Hours
	Part - A: Development of Computer Programs	
1.	Simple problems	14 x 4
2.	Mathematical series (Taylor series), random number generation	
3.	Solution of equation of states for non-ideal gas mixtures (van der Waals, Virial and RKS equations)	
4.	Solution of thermodynamic equilibrium (UNIQUAC, UNIFAQ, NRTL) models	
5.	Solution of conductive heat transfer through composite walls	
6.	Solution of diffusive mass transfer through a stagnant gas film	
	Part – B: Use of Softwares	
7.	Determination of Laplace transform	
8.	Solution of algebraic equations	
9.	Solution of ordinary differential equations (ODE)	
10.	Numerical integration	
11.	Regression analysis	
12.	Design of CSTR and PFR	
13.	Design of double pipe heat exchanger	
14.	Design of binary distillation column	
	Total	**56**

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Finlayson B.A., "Introduction to Chemical Engineering Computing", Wiley.	2006
2.	Chapra S.C. and Canale R.P., "Numerical Methods for Engineers", 5th Ed., Tata McGraw-Hill.	2006
3.	Elnashaie S. and Uhlig F., "Numerical techniques for Chemical and Biological Engineers using MATLAB – A Simple Bifurcation Approach", Springer.	2007
4.	Attaway S., "MATLAB: A Practical Introduction to Programming and Problem Solving", Elsevier.	2009
5.	White R.E., "Computational Mathematics – Models, Methods and Analysis with MATLAB and MPI", CRC Press.	2004
6.	Beers K.J., "Numerical Methods for Chemical Engineering – Application in MATLAB" Cambridge University Press.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-502** Course Title: **Process Simulators**

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** 0 **PRE** 50

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

8. Pre-requisite: **Nil**

9. Objective: To train on process simulators and CFD software for solving complex engineering problems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to process simulators and CFD software- ASPEN PLUS, HYSYS and FLUENT	14 x 4
2.	Simulation of a batch reactor	
3.	Simulation of a chemostat	
4.	Simulation of a shell and tube heat exchanger	
5.	Simulation of a condenser	
6.	Simulation of a pump/compressor	
7.	Simulation of a fixed bed absorber	
8.	Simulation of a staged distillation column	
9.	Simulation of flow in channels and pipes	
10.	Simulation of flow in sudden expansion/contraction systems	
11.	Simulation of flow in a square cavity	
12.	Process simulation study (flow sheeting)- Production of hydrogen by stream reforming	
13.	Process simulation study (flow sheeting)- Production of vinyl chloride monomer flowsheet	
14.	Process simulation study (flow sheeting)- Production of nitric acid from anhydrous ammonia	
	Total	**56**

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Lewin D.R., "Using Process Simulators in Chemical Engineering – A Multimedia Guide for Core Curriculum", 2nd Ed., Wiley.	2003
2.	Finlayson B.A., "Introduction to Chemical Engineering Computing", Wiley.	2006
3.	Jana A.K., "Process Simulation and Control using ASPEN" Prentice Hall.	2009
4.	Froment G.F. and Bischoff K.B., "Chemical Reactor Analysis and Design", 2nd Ed., Wiley.	1990
5.	Jana A.K., "Chemical Process Modelling and Computer Simulation" Prentice Hall.	2008
6.	Aris R., "Mathematical Modeling, Vol. 1: A Chemical Engineering Perspective (Process System Engineering)", Academic Press.	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-504** Course Title: **Chemical Engineering Laboratory**

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** 0 **PRE** 50

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

8. Pre-requisite: **Nil**

9. Objective: To give an exposure on the latest analytical methods using sophisticated instruments and interpretation of data.

10. Details of Course:

S. No.	Contents	Contact Hours
	Spectroscopic methods	14 x 4
1.	To estimate concentration of a component in liquid solution by UV-spectrometer	
2.	To identify functional groups on a solid sample by Fourier transform infrared spectroscopy (FTIR)	
	Chromatographic methods	
3.	To estimate concentration of a component in liquid solution by gas chromatography (GC)	
4.	To estimate concentration of a component in liquid solution by high performance liquid chromatography (HPLC)	
5.	To estimate concentration of a component in liquid solution by ion chromatograph	
	Electrochemical methods	
6.	To perform a titration reaction in an auto-titrator	
7.	To estimate trace metals concentration in a liquid sample by galvanostat-potentiostat	
8.	To perform plasmid separation and identification by electrophoresis	
	Miscellaneous	
9.	To determine particle size distribution by particle size analyzer	
10.	To estimate COD in a liquid sample by COD analyzer	
11.	To estimate elemental composition of a solid sample by CHNS analyzer	
12.	To estimate absorbable organic halide (AOX) concentration in a liquid sample by AOX analyzer	
13.	To estimate surface area, pore size and pore volume distribution of a porous material	

14.	To estimate TOC in a liquid sample by TOC analyzer	
	Total	**56**

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Skoog A.A., Holler J.F. and Crouch S.R., "Principles of Instrumental Analysis", 6th Ed., Brooks Cole.	2006
2.	Rouessac F. and Rouessac A., "Chemical Analysis: Modern Instrumentation Methods and Techniques", 2nd Ed., Wiley.	2007
3.	Willard H.H., Merritt J.L., Dean J.A. and Settle F.A., "Instrumental Methods of Analysis", 7th Ed., CBS Publisher.	2009
4.	Cleceri L.S., Greenberg A.E. and Eaton A.D., "Standard Methods for the Examination of Water and Wastewater", 20th Ed., American Public Health Association.	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-506** Course Title: **CAD of Heat Transfer Equipment**

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 about design principles and computer aided design of various heat transfer equipment.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Basic design procedure of heat transfer equipment, overall heat transfer coefficient and dirt factors, shell and tube heat exchangers – construction details, selection algorithm, design codes, mean temperature difference.	4
2.	**Heat Exchangers:** General design considerations of shell and tubes of heat exchangers, thermo -physical properties, design of double pipe heat exchangers, tube-side heat transfer coefficient and pressure drop, shell-side heat transfer coefficient and pressure drop by using Kern, Bell and Heat Transfer Research Incorporation (HTRI) methods, CAD of shell and tube heat exchangers; Mechanical and fabricational aspects.	13
3.	**Condensers:** CAD of condensers for single vapours, desuperheater-cum-condenser and condenser-cum-sub-cooler, condensers for multicomponent vapours with and without non-condensables.	6
4.	**Reboilers, Vaporizers and Evaporators:** Pool boiling, convective boiling, selection and CAD of reboilers, vaporizers and evaporators.	6
5.	**Compact Heat Exchangers:** CAD of special heat transfer equipment like plate heat exchangers, finned tube heat exchangers, bayonet heat exchangers, spiral heat exchangers, suction heater, coiled and jacketed heating vessels.	9
6.	**Fired Heaters and Furnaces:** CAD of fired heaters and furnaces.	4
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Sinnott R.K. and Towler G., "Chemical Engineering Design", 5th Ed., Butterworth-Heinemann.	2009
2.	Serth R.W., "Process Heat Transfer Principles and Applications", Elsevier.	2007
3.	Hewitt G.F., Shires G.L. and Bott T.R., "Process Heat Transfer", Begell House.	1994
4.	I.S.: 4503-1967, "Indian Standard Specification for Shell and Tube Type Heat Exchangers".	1967

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-508** Course Title: **CAD of Mass Transfer Equipment**

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 about design principles and CAD of various mass transfer equipment.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Basic Design Principles and Methods:** I deal-liquid-solution models, non-ideal thermodynamic property models, and activity-coefficient models for liquid phase. Design variables and their influence on multi-component separation processes, short cut design methods for absorption, stripping, extraction and distillation column.	12
2.	**Multicomponent Separation Processes and CAD of Staged-Columns:** Separation of multicomponent mixtures by use of a single equilibrium stage, flash calculation under isothermal and adiabatic conditions, tridiagonal formulation of component material balances and equilibrium relationships for distillation, absorption and extraction of multicomponent systems. Design of absorbers, distillation columns, strippers and extractors.	16
3.	**Tray Hydraulics:** Tray hydraulics and design considerations for various trays.	6
4.	**Packed Columns:** CAD of packed absorber, extractor and distillation column using different packings. CAD of pressure-swing adsorption system.	8
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Sinnott R.K. and Towler G., "Chemical Engineering Design", 5th Ed., Butterworth-Heinemann.	2009
2.	Seader J.D. and Henley E.J., "Separation Process Principles", 2nd Ed., Wiley.	2006
3.	Holland C.D., "Fundamentals and Modeling of Separation Processes", Prentice Hall.	1975
4.	Stichlmair J.G. and Fair J.R., "Distillation Principles and Practices", Wiley.	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-510** Course Title: **CAD of Multiphase Reactors and Contactors**

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 on industrial equipment using multi-phase systems and their modeling and design.

10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Introduction**: Review of single phase flow including multi-component mixtures and turbulent flow.	4
2.	**Multiphase Flow**: Modeling concept, multi-fluid models, averaging procedures, two fluid granular flow model, constitutive equations for interfacial momentum closure and interfacial heat and mass transfer closure.	10
3.	**Agitation and Fluid Mixing Technology**: Impeller design, turbulent mixing, heat transfer in stirred tank reactors, mixing of multiphase systems- governing equations and impeller modelling.	5
4.	**Bubble Column Reactor**: Hydrodynamics of simple bubble columns and its types, modelling of bubble column reactors including Trondheim bubble column.	6
5.	**Fluidized Bed Reactors**: Population balance models, fluidization regimes, reactor design and flow characterization for dense phase, lean-phase and other fluidized beds and their modeling.	7
6.	**Packed Bed Reactors**: Modeling using fixed bed dispersion models and packed bed reactor design, moving bed catalytic reactors, trickle bed reactor, slurry reactor.	6
7.	**Miscellaneous Systems**: Ejectors, spray columns, falling film reactors.	4
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Jakobsen H.A., "Chemical Reactor Modeling-Multiphase Reactive Flows", Springer.	2008
2.	Trambouze P. and Euzen J., "Chemical Reactors-From Design to Operations", Technip.	2002
3.	Russell T.W.F., Robinson A.S. and Wagner N.J., "Mass and Heat Transfer-Analysis of Mass Contactors and Heat Exchangers", Cambridge University Press.	2008
4.	Lee H.H., "Heterogeneous Reactor Design", Butterworth.	1985
5.	Ramachandran P.A. and Chaudhari R.V., "Three Phase Catalytic Reactors", Gordon and Breach.	1983
6.	Shah Y.T., "Gas-Liquid-Solid Reactor Design", McGraw Hill.	1979

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-512** Course Title: **Computational Fluid 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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide an understanding of physical models to study hydrodynamics in engineering systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Basic Concepts of Fluid Flow:** Philosophy of computational fluid dynamics (CFD), review of equations of change for transfer processes, simplified flow models such as incompressible, inviscid, potential and creeping flow, flow classification.	5
2.	**Grid Generation:** Structured and unstructured grids, choice of suitable grid, grid transformation of equations, some modern developments in grid generation for solving engineering problems.	3
3.	**Finite Difference Method (FDM):** Discretization of ODE and PDE, approximation for first, second and mixed derivatives, implementation of boundary conditions, discretization errors, applications to engineering problems.	9
4.	**Finite Volume Method (FVM):** Discretization methods, approximations of surface integrals and volume integrals, interpolation and differential practices, implementation of boundary conditions, application to engineering problems.	11
5.	**Special Topics:** Case studies using FDM and FVM, flow and heat transfer in pipes and channels, square cavity flows, reactive flow, multiphase flow, rotary kiln reactors, packed and fluidized bed reactors, furnaces and fire systems. Overview of finite element method (FEM).	14
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Fletcher C.A.J., "Computational Techniques for Fluid Dynamics, Vol. 1: Fundamental and General Techniques", Springer-Verlag.	1998
2.	Fletcher C.A.J., "Computational Techniques for Fluid Dynamics, Vol. 2: Specific Techniques for Different Flow Categories", Springer-Verlag.	1998
3.	Anderson J.D., "Computational Fluid Dynamics", McGraw Hill.	1995
4.	Ghoshdastidar P.S., "Computer Simulation of Flow and Heat Transfer", Tata McGraw Hill.	1998
5.	Ferziger J.H. and Peric M., "Computational Methods for Fluid Dynamics", 3rd Ed., Springer.	2002
6.	Patankar S.V., "Numerical Heat Transfer and Fluid Flow", Taylor and Francis.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-514** Course Title: **Process Integration**

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 introduce concept of process integration in chemical and allied industries.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Process integration (PI) and its building blocks, available techniques for implementation of PI, application of PI.	6
2.	**Pinch Technology:** Basic concepts, role of thermodynamics. Data extraction, targeting, designing, optimization-supertargteing. Grid diagram, composite curve, problem table algorithm, grand composite curve.	12
3.	**Targeting of Heat Exchanger Network (HEN):** Energy targeting, area targeting, number of units targeting, shell targeting, cost targeting.	5
4.	**Design of HEN:** Pinch design methods, heuristic rules, stream splitting, design for maximum energy recovery (MER), multiple utilities and pinches, threshold problem, loops and paths.	6
5.	**Heat and Mass Integration in Process Systems:** Heat engine, heat pump, distillation column, reactor, evaporator, drier, refrigeration system, water recycle and reuse systems.	10
6.	**Heat and Power Integration:** Co-generation, steam turbine, gas turbine.	3
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Kemp I.C., "Pinch Analysis and Process Integration: A User Guide on Process Integration for the Efficient Use of Energy", 2nd Ed., Butterworth-Heinemann.	2007
2.	Smith R., "Chemical Process Design and Integration", 2nd Ed., Wiley.	2005
3.	Shenoy U.V., "Heat Exchanger Network Synthesis", Gulf Publishing.	1995
4.	El-Halwagi M.M., "Process Integration", 7th Ed., Academic Press.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-516** Course Title: **Design of Industrial Piping**

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 provide knowledge of design and engineering problems of piping in process industries.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Pipes and Fittings:** Standards, codes and practices; Wall thickness, tolerances, design of flanges and fittings.	2
2.	**Flow of Fluids:** Frictional loss in pipe and ducts, equivalent resistance of fittings, valves and bends, carrying capacity of pipes and piping networks; Pressure drop and diameter calculations of pipe carrying steam, water, oil and gases; Optimum pipe diameter and optimum pipe network design.	9
3.	**Gas Liquid Piping:** Flow regimes and piping design for two-phase flow; design of piping for reboiler and condenser systems.	4
4.	**Transport of Solids:** Design of homogenous and heterogeneous slurry transport systems; Correlations for various flow regimes. Conveying systems, solid gas flow pattern in vertical, horizontal and inclined pipe lines; Concept of saltation and choking velocities, pressure drop calculations in different pipe lines carrying gas solid mixture; Design of pneumatic systems.	12
5.	**Strength and Failure of Materials:** Stable and unstable deformation, plasticity, plastic instability, design assumptions, stress evaluation and design limits, codes and standards; Local components of pipe bends, branch connections and bolted flange connections.	8
6.	**Simplified Methods for Flexibility Analysis:** Thermal expansion loops, approximate solutions and flexibility analysis by model tests; Expansion joints and approaches for reducing expansion effects.	7
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Smith P., "The Fundamentals of Piping Design: Drafting and Design Methods for Process Applications", Gulf Publishing.	2007
2.	Marcus R.D., Leung L.S., Klinzing G. E. and Rizk F., "Pneumatic Conveying of Solids", Chapman and Hall.	1990
3.	Nayyar M.L., "Piping Handbook", 7th Ed., McGraw Hill.	2000
4.	Boterman R. and Smith P., "Advanced Piping Design", Gulf Publishing.	2008
5.	Deutsch D.J., "Process Piping Systems", McGraw Hill.	1980

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-518** Course Title: **Process Dynamics and Control**

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 about the dynamics and control strategies for linear and non-linear process systems in continuous and discrete domains.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Review of Dynamic Process Models:** Linear and non-linear, lumped and distributed parameter systems.	6
2.	**Control of Linear Systems**: Laplace transform, review of single-loop feedback control systems, stability and controller tuning, Smith compensator for systems with large dead-time and inverse response, multi-loop control-cascade, selective and split-range control, feed-forward control, ratio-control, adaptive control, inferential control, internal model control, model predictive control.	16
3.	**Multiloop and Multivariable Control**: Process interactions and control loop interaction, pairing of controlled and manipulated variables, tuning of multiloop control systems, decoupling and multivariable control strategies, strategies for reducing control loop interactions.	8
4.	**Digital Control**: Z transform, sampling and reconstruction, continuous and discrete-time systems, signal processing and data filtering, tuning of digital PID controllers, direct synthesis for design of digital controllers, stability of discrete-time systems, distributed digital control systems.	8
5.	**Case Studies:** Control of a distillation column and a heat exchanger.	4
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Stephanopoulos G., "Chemical Process Control", Prentice Hall.	1984
2.	Coughanowr D.R. and LeBlanc S., "Process Systems Analysis and Control", 3rd Ed., McGraw Hill.	2008
3.	Seborg D.E., Edgar T.F. and Mellichamp D.A., "Process Dynamics and Control", 3rd Ed., Wiley.	2010
4.	Bequette B.W., "Process Control – Modeling, Design and Simulation", Prentice Hall.	2003
5.	Roffel B. and Betlem B., "Process Dynamics and Control-Modeling for Control and Prediction", Wiley.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-520** Course Title: **Optimization of Chemical Processes**

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 introduce various techniques of optimization and their application to chemical processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Optimization and calculus based classical optimization techniques.	5
2.	**One Dimensional Minimization Methods:** Elimination methods- equally spaced points method, Fibonacci method and golden section method; Interpolation methods- quadratic interpolation and cubic interpolation, Newton and quasi-Newton methods.	6
3.	**Linear Programming:** Graphical representation, simplex and revised simplex methods, duality and transportation problems.	7
4.	**Multivariable Non-Linear Programming**: Unconstrained- univariate method, Powell's method, simplex method, rotating coordinate method, steepest descent method, Fletcher Reeves method, Newton's method, Marquardt's method and variable metric (DFP and BFGS) methods; Constrained- complex method, feasible directions method, GRG method, penalty function methods and augmented Lagrange multiplier method.	9
5.	**Dynamic Programming:** Multistage processes- acyclic and cyclic, sub-optimization, principle of optimality and applications.	4
6.	**Geometric Programming (GP)**: Differential calculus and Arithmetic-Geometric inequality approach to unconstrained GP; Constrained GP minimization; GP with mixed inequality constraints and Complementary GP.	6
7.	**Emerging Optimization Techniques**: Genetic algorithm, simulated annealing, particle swarm and ant colony optimization.	5
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Edgar T.F., Himmelblau D.M. and Lasdon L.S., "Optimization of Chemical Processes", 2nd Ed., McGraw Hill.	2001
2.	Beveridge G.S.G. and Schechter R.S., "Optimization: Theory and Practice", McGraw Hill.	1970
3.	Rao S.S., "Engineering Optimization Theory and Practice", 4th Ed., Wiley.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-522** Course Title: **Design of Experiments and Parameter Estimation**

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 about various techniques of model parameter estimation, analysis and statistical design of experiments.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Strategy of experimentation, basic principles, guidelines for designing experiments;	2
2.	**Simple Comparative Experiments**: Basic statistical concepts, sampling and sampling distribution, inferences about the differences in means, randomized and paired comparison design.	4
3.	**Experiments with Single Factor**: Analysis of variance, analysis of fixed effects model, model adequacy checking, nonparametric methods in analysis of variance.	3
4.	**Design of Experiments:** Randomized blocks, latin squares and related design, factorial design, two-factor factorial design, blocking in a factorial design, the 2^2 and 2^3 factorial design, the general 2^k factorial design, blocking and compounding in the 2^k factorial design, two-level, three level and mixed level factorial and fractional factorial designs.	8
5.	**Parameter Estimation:** Linear regression models, estimation of the parameters in linear regression models, hypothesis testing in multiple regression, confidence intervals in multiple regression, prediction of new response observations, regression model diagnostics, testing for lack of fit.	8
6.	**Response Surface Methods and Other Approaches:** Response surface methodology, method of steepest ascent, analysis of a second-order response surface, experimental designs for fitting response surfaces, mixture experiments, evolutionary operation, robust design; Taguchi's method for optimization of experiments.	8
7.	**Experiments with Random Factors**: Random effect model, two factor factorial with random factors, two-factor mixed model, sample size	5

	determination with random effects, approximate F tests.	
8.	**Design and Analysis:** Nested and split-plot design, non-normal responses and transformations, unbalanced data in a factorial design.	**4**
	Total	**42**

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Lazic Z.R., "Design of Experiments in Chemical Engineering: A Practical Guide", Wiley.	2005
2.	Antony J., "Design of Experiments for Engineers and Scientists", Butterworth-Heinemann.	2004
3.	Montgomery D.C., "Design and Analysis of Experiments", 5th Ed., Wiley.	2004
4.	Roy R.K., "A Primer on the Taguchi method", Society of Manufacturing Engineers.	1990
5.	Roy R.K., "Design of Experiments using the Taguchi Approach: 16 Steps to Product and Process Improvement", Wiley.	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-524** Course Title: **Novel Separation 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: To impart knowledge about various novel separation techniques.

10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Introduction:** Separation processes in chemical and biochemical industries, categorization of separation processes, equilibrium and rate governed processes.	4
2.	**Bubble and Foam Fractionation:** Nature of bubbles and foams, stability of foams, foam fractionation techniques, batch, continuous, single stage and multistage columns.	4
3.	**Membrane Separation:** Characteristics of organic and inorganic membranes, basis of membrane selection, osmotic pressure, partition coefficient and permeability, concentration polarization, electrolyte diffusion and facilitated transport, macro-filtration, ultra-filtration, reverse osmosis, electro-dialysis. Industrial applications.	16
4.	**Special Processes:** Liquid membrane separation, super-critical extraction, adsorptive separation-pressure, vacuum and thermal swing, pervaporation and permeation, nano-separation.	12
5.	**Chromatographic Methods of Separation:** Gel, solvent, ion and high performance liquid chromatography.	6
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	King C.J., "Separation Processes", Tata McGraw Hill.	1982
2.	Seader J.D. and Henley E.J., "Separation Process Principles", 2nd Ed., Wiley.	2006
3.	Basmadjian D., "Mass Transfer and Separation Processes: Principles and Applications", 2nd Ed., CRC Press.	2007
4.	Khoury F.M., "Multistage Separation Processes", 3rd Ed., CRC Press.	2004
5.	Wankat P.C., "Separation Process Engineering", 2nd Ed., Prentice Hall.	2006

M.Tech. (Chemical Engineering)

with specialization in

Industrial Pollution Abatement (IPA)

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-509** Course Title: **Air Pollution Control Engineering**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide comprehensive knowledge of air pollution problems, pollution control strategies and design of equipment.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Basic criteria and strategies for the selection and design of air pollution control equipment, various efficiency equations; Particle size distribution and analysis.	2
2.	**Design of Settling Chambers:** Design with respect to laminar and turbulent flow; overall efficiencies and economic sizing of settling chambers.	4
3.	**Design of Cyclones:** Pressure drop calculation in a cyclonic flow; Design of cyclones and multi-clones for laminar, turbulent and modified flow for various sizes particle distributions; Design of standard centrifugal and reverse flow cyclone collectors; Estimation of pressure drop, power requirement and cost of single and multi-clone separators.	6
4.	**Design of Fabric Filters:** Design of single layer and multilayer fabric systems; Design of cylindrical fabric system; Calculation of overall collection efficiencies and pressure drop for single and multilayer filters; Design of bag filters and bag houses.	4
5.	**Design of Electrostatic Precipitators:** Basic principles of operation; Design of single and multi stage Electrostatic Precipitators for parallel plate electrodes and cylindrical electrodes; Particle charging and diffusion charging; Design for low dust system and high dust system.	5
6.	**Design of Particulate Scrubbers:** Interception, inertial impaction and diffusion to a spherical drop and overall efficiencies for multiple drops; Design of spray chambers: single and multiple stages; Design of jet and venture scrubber.	7

7.	**Design of Absorption System;** Absorption of gases by moving drops; Henry's law and diffusion inside the drop; Gas scrubbers; Absorption towers.	4
8.	**Design of Adsorption System:** Principles of adsorption; Fixed-bed adsorbers; Moving-bed adsorbers.	4
9.	**Design of Combustion System:** Chemistry and thermodynamics of combustion; Combustion chamber design; Design of flammable mixtures and flares; Catalytic afterburners.	3
10.	**Design of Condensation System:** Thermodynamic Properties of pollutants; Direct-contact condensers; Surface heat exchangers; Condensation of steam-pollutant mixtures on surface condensers; Condensation of air-pollutant mixtures on surface condensers.	3
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Cheremisinoff N.P., "Handbook of Air Pollution Prevention and Control", Butterworth-Heinemann.	2002
2.	Wang L.K. and Pereira N.C., "Advanced Air and Noise Pollution Control", Humana Press.	2005
3.	Stern A.C., "Air Pollution", Vol. I, II, and III, Academic Press.	1968
4.	Brauer H. and Varma Y.B.G., "Air Pollution Control Equipment", Springer – Verlag.	1981
5.	Chermisihoff N.P. and Young R.A., "Air Pollution Control and Design Handbook", Part I and II, Marcel Deckker.	1977

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-511** Course Title: **Water Pollution Control Engineering**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide comprehensive knowledge of industrial wastewater problems, control strategies and design of treatment units.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Characterisation and monitoring of industrial and municipal waste water, recycling and reuse of wastewater. Basic philosophy and selection of water pollution treatment plants; Design criteria: hydraulic loading rate, organic loading rate, residence time, dilution rate.	5
2.	**Physico-Chemical Treatment Methods**: Sedimentation, coagulation, flocculation, thickening, floatation.	4
3.	**Biological Treatment Fundamentals**: Microbial metabolism, bacterial growth kinetics; Biological nitrification, denitrification and phosphorus removal; Anerobic fermentation and aerobic treatment.	6
4.	**Aerobic Suspended and Attached Growth Biological Treatment Processes**: Aerated lagoon, activated sludge systems, trickling filter, sequential batch reactor, fluidized bed bioreactors.	7
5.	**Anaerobic Suspended and Attached Growth Biological Treatment Processes**: UASB and hybrid UASB reactors, bio-towers.	4
6.	**Advanced Treatment Processes**: Membrane processes- reverse osmosis, ultrafiltration, nanofiltration and electrodialysis; Wet air oxidation, adsorption and ion-exchange; Wet-land and root-zone treatment of industrial and municipal wastes; Design of sludge drying beds, thermal and biological processes for sludge and land fillings.	10
7.	**Case Studies**: Waste water treatment and disposal strategies in petroleum, petrochemical, fertilizer, distillery, pulp and paper industries.	6
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Tchobanoglous G., Burton F.L., Stensel H.D., "Metcalf and Eddy Inc.- Waste Water Engineering Treatment and Reuse", Tata McGraw-Hill.	2003
2.	Henze M., van-Loosdrecht M.C.M., Ekama G.A. and Brdjanovic D., "Biological Wastewater Treatment: Principles, Modelling and Design", IWA publishing.	2008
3.	Arceivala S.J. and Asolekar S.R., "Wastewater Treatment for Pollution Control and Reuse", 3rd Ed., Tata McGraw Hill.	2007
4.	Sincero A.P. and Sincero G.A., "Environmental Engineering – A Design Approach", Prentice-Hall.	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-526** Course Title: **Environmental Impact Assessment**

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 provide comprehensive knowledge of environmental impact assessment due to industrial and other developmental activities.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Historical perspective and evolution of guidelines for environmental impact assessment (EIA); Developmental and economic activities and their impact on environmental quality; Carrying capacity and sustainable development.	4
2.	**Environmental Impact Policy**: Guidelines for EIA for various developmental activities, environmental indices and indicators; Operational framework, rapid and comprehensive EIA. Environmental review and screening of projects, public hearing, scoping and baseline studies; Projects requiring EIA.	6
3.	**Monitoring and Analysis of Environmental Quality**: Monitoring and analysis of wastewater, surface water, ground water, ambient air and emissions; Micro-meteorology, atmospheric dispersion; Noise level monitoring and modeling;	8
4.	**Environmental Impacts**: Impact of developmental activities on environmental components and their analysis, quality of air, water and land and their impact on biodiversity, socioeconomic and cultural/ethical aspects and their interconnectivity.	8
5.	**Environmental Impact Assessment Methodologies**: Modeling and prediction, impact valuation and composite impact analysis and assessment.	6
6.	**Environmental Management Plan**: Protective and preventive planning, cost-benefit analysis, environmental management plan (EMP) and disaster management plan (DMP), on-site and off-site management plan, forest management plan and green-belt design. Post project monitoring.	5
7.	**Case Studies**: EIA of fertilizer, petroleum and petrochemical units, power plants and hydro-projects.	5
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Canter L.W., "Environmental Impact Assessment", McGraw Hill.	1996
2.	Rau J.G. and David C., "Environmental Impact Analysis Handbook", McGraw Hill.	1980
3.	"Guidelines for EIA of Industrial and other Projects" Ministry of Environment and Forests, Government of India.	2009
4.	Cheremisinoff P.N. and Morresi A.C., "Environmental Assessment and Impact Statement Handbook", Ann Arbor.	1977
5.	Pollution Control Law Series: Pollution Control Acts, Rules and Notification Issued There under, Central Pollution Control Board, Ministry of Environment and Forest, Government of India.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-528** Course Title: **Biochemical Engineering**

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 provide comprehensive knowledge of biochemical engineering principles and their application.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Biochemical engineering fundamentals, role of biochemical engineering in the biochemical product synthesis, bioprocess economics.	2
2.	**Microbiology:** Cell theory, structure of microbial cells, classification of microorganisms, RDNA technology, genetically engineered microbes (GEMS).	5
3.	**Biochemistry:** Chemical composition of microbial cells; properties, classification and metabolism of lipids, proteins, carbohydrates and enzymes, metabolic stoichiometry and energetics.	5
4.	**Kinetics of Enzyme Catalysed Reactions:** Simple enzyme kinetics with mono and multi substrates, determination of elementary step rate constant; Modulation and regulation of enzyme activity, factors influencing enzyme activity, immobilization of enzymes.	5
5.	**Microbial Fermentation Kinetics:** Bacterial growth cycle, mathematical modeling of batch and continuous fermentations with and without recycles, bioreactors in series, product synthesis kinetics, over all kinetics, thermal death kinetics of spores and cells, transient growth kinetics, deviation from Monod model, comparison between batch and continuous fermentation	8
6.	**Sterilization:** Sterilization and pasteurization, batch and continuous sterilization of media, plate and direct injection sterilization; Thermal death kinetics of spores, cells and viruses.	4
7.	**Aeration and Agitation**: Gas-liquid mass transfer, oxygenation of fermentation broth; bubble and mechanical aeration and agitation, design	3

	and power requirement of gassed and un-gassed systems for various impellers, hold-up.	
8.	**Scale-up of Bioreactors:** Dimensionless numbers for scale-up, design estimation of various scale-up parameters, power estimation for gassed and ungassed systems.	**4**
9.	**Aerobic and Anaerobic Fermentations**: Design and analysis of typical aerobic and anaerobic fermentation processes, manufacture of antibiotics, alcohol and other fermentation products.	**3**
10.	**Downstream Processing:** Use of filtration, centrifugation, adsorption, membrane separation processes, electrophoresis chromatography.	**3**
	Total	**42**

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Bailey J.E. and Olis D.F., "Biochemical Engineering Fundamentals", 2nd Ed., McGraw-Hill.	1987
2.	Doble M. and Gummadi S.N., "Biochemical Engineering", Prentice Hall.	2007
3.	Schuler M.L. and Kargi F., "Bioprocess Engineering", 2nd Ed., Prentice Hall.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-530** Course Title: **Solid Waste Treatment and Management**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide comprehensive knowledge of treatment, utilization and management of industrial and municipal solid wastes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Characterization:** Characterization of industrial and municipal solid wastes - hazardous and non-hazardous wastes; Solid waste disposal and management – standards, laws and guidelines.	6
2.	**Solid Waste Collection, Handling and Transportation:** Generation, collection, handling, separation, storage, transfer and processing of solid waste, recycling of solid waste; Segregation of hazardous and non-hazardous wastes.	10
3.	**Solid Wastes Processing:** Physico-chemical method, biological methods, thermal methods; Recycling and reprocessing, handling and processing of sludge; Utilization of municipal solid wastes for landfill, biogasification and manure production; Recent technological advances in composting and thermal gasification.	12
4.	**Landfill**: Site selection and design criteria; Closure, restoration and rehabilitation of landfills.	6
5.	**Case Studies:** Solid waste management in sugar, distillery, pulp and paper, fertilizer, petroleum and petrochemical industries; Management of spent catalysts.	8
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Tchobanglais G., Theisen H. and Vigil S.A., "Integrated Solid Waste Management: Engineering Principles and Management Issues", McGraw Hill.	1993
2.	Tedder D.W. and Pohland F.G. (editors), "Emerging Technologies in Hazardous Waste Management", American Chemical Society.	1990
3.	Pichtel J., "Waste Management Practices: Municipal, Hazardous and Industrial", CRC Press.	2005
4.	Conway R.A. and Ross R.D., "Handbook of Industrial Waste Disposal", Van-Nostrand Reinhold.	1980

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-532** Course Title: **Hazardous 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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide comprehensive knowledge of treatment, utilization and management of hazardous wastes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Overview of hazardous waste, battery waste, electronic waste - global and Indian scenario, hazardous waste regulations, biomedical waste rules, battery management rules, national and international codes; Authorisation procedure and generator requirement.	8
2.	**Identification and Characterisation:** Identification and characterisation of various kinds of hazardous wastes, introduction to toxicology, evaluation of health risks associated with exposure to hazardous wastes, handling, transportation and storage of hazardous wastes.	8
3.	**Treatment of Hazardous Wastes**: Physico-chemical, biological and thermal methods; Recycling and reprocessing of wastes; Processing of and value-winning from electronic wastes, battery wastes, ferrous and non-ferrous wastes, heavy metal containing spent catalysts, spent caustic and tannery wastes.	12
4.	**Disposal of Wastes**: Site selection and design criteria; Remediation of hazardous waste landfill; Common treatment facility concept for hazardous wastes.	6
5.	**Case Studies:** Hazardous waste management in pulp and paper, petroleum and petrochemical industry. Mercury emission and control in thermal power plants and cement plants.	8
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Tedder D.W. and Pohland F.G. (Editors), "Emerging Technologies in Hazardous Waste Management", American Chemical Society.	1990
2.	Conway R.A. and Ross R.D., "Handbook of Industrial Waste Disposal", van-Nostrand Reinhold.	1980
3.	Shah K.L., "Basics of Solid and Hazardous Waste Management Techniques", Prentice Hall.	1999
4.	Side G.W., "Hazardous Materials and Hazardous Waste Management", Wiley.	1993
5.	Pichtel J., "Waste Management Practices: Municipal, Hazardous and Industrial", CRC Press.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-534** Course Title: **Regulatory Practices for Environmental Protection**

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 provide comprehensive knowledge of environmental and pollution control acts and rules.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: India's environmental and forestry policies and programmes- planning, promotion, co-ordination, regulatory and control system; International treaties and protocols for environment protection like Vienna convention, Montreal protocol, UN framework convention on climate change and Kyoto protocol, Bassel convention.	8
2.	**Pollution Boards and Authority**: Constitution of state and central pollution control boards (SPCBs and CPCB), powers and functions of boards.	2
3.	**Water Pollution and Prevention Act and Rules**: Water (prevention and control of pollution) act, 1978; Cess act, 1977 and Cess rules, 1978 and notifications there under; Constitution of appellate authority.	4
4.	**Air Pollution and Prevention Act and Rules**: Air (prevention and control of pollution) act, 1981 and rules, 1982; Constitution of appellate authority.	4
5.	**Environment (Protection) Act and Rules**: Environment (Protection) (EP) Act, 1986; Rules for EP act, emission and effluent standards for pollutants, noise standards, environmental impact assessment of developmental projects; Hazardous waste management rules, biomedical (management and handling) rules, municipal solid waste rules, ozone depleting substances (regulation) rules, plastic manufacturing, sale and usage rules, batteries management and handling rules; Powers of environment and forests under EP act.	15
6.	**Other Acts and Rules**: National Environment Tribunal Act, 1995; Wild Life (Protection) Act, 1972; Forest Conservation Act, 1980; Biological Diversity Act, 2002; Public Liability Insurance Act, 1991; Central Motor	9

	Vehicle rules; Factory act, OHSA rules. Mines and Minerals (Development and Regulation) Act.	
	Total	**42**

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Pollution Control Law Series, "Pollution Control Acts, Rules and Notification Issued Thereunder", Central Pollution Control Board, Ministry of Environment and Forest, Government of India.	2006
2.	Holder J. and McGillivray D., "T aking Stock of Environmental Assessment: Law, Policy and Practice", Oxon: Routledge-Cavendish.	2007
3.	IPCC 2001: Climate Change 2001, Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-536** Course Title: **Clean 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 expose to newer eco-friendly and clean technologies for chemical processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Chemical technology and environmental concerns, environmental impact of chemicals, half-life and fate of chemicals, life-cycle assessment of chemicals, concept of clean technology.	5
2.	**Evaluation of Technology:** Evaluation of existing process technologies of ammonia, sulphuric acid, caustic soda, rayon, pulp and paper, leather, plastics, polymers and organic chemicals. Analysis of raw materials, intermediates, final products, bye-products and waste generation; Emissions and effluents from the process plants and their ultimate fate.	12
3.	**Technology Modification**: Modification in processes, use of new catalysts, waste to wealth approach, recycling and reuse technologies in chemical process industries (petroleum, petrochemical, pulp and paper, chlor-alkali, sugar and distillery).	6
4.	**Alternative Technology:** Alternative raw materials; Low temperature, low pressure and energy-efficient routes for the manufacture of caustic soda, leather, plastics, pulp and paper and rayon; Use of CO_2 for valuable chemicals.	11
5.	**Advanced Technology:** Development of biodegradable end-products of polymers and plastics, eco-friendly technologies for oil extraction and chemical manufacturing.	8
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Schaltegger S., Bennett M., Burritt R.L. and Jasch C.M., "Environmental management Accounting for Cleaner Production", Springer.	2008
2.	Freeman H.M., Puskas Z. and Olbina R., "Cleaner Technologies and Cleaner Products for Sustainable Development", Springer.	1995
3.	Mukhopadhyay P.K. and Roy T.K., "Ecofriendly and Clean Technologies" Indian National Academy of Engineering.	1997
4.	Johansson A., "Clean Technology", CRC Press.	1992
5.	Kafarov V.V., "Wasteless Chemical Processes", Mir.	1985
6.	Guisnet M. and Gilson J.P., "Zeolites for Cleaner Production", World Scientific.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-538** Course Title: **Design of Pollution 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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide comprehensive knowledge of design of pollution control systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Preventive and end-of-pipe (EOP) design, design for value addition from pollution and prevention control systems, concepts of reduce, recycle and reuse (3R) for economic design.	4
2.	**Wastewater Treatment Plant Design**: Design of systems for the removal of organic and inorganic pollutants using the best available technology (BAT); Design, operation, maintenance and control of aerobic and anaerobic systems for the treatment of domestic and municipal sewage, and industrial wastes.	12
3.	**Membrane Systems**: Membranes for pollution treatment, filtration and removal – macro, micro and ultrafiltration, reverse osmosis; Use of different types of membranes and their configurations; Membrane bioreactors, hollow fibres and fouling, design of membrane filters and membrane bioreactors.	9
4.	**Landfill Design**: Site selection, leachate and gas generation, containment landfills, design of landfill elements, landfill operation and monitoring.	5
5.	**Air Pollution Control System Design**: Design of air pollution abatement systems, hoods, ducts and fans; Design of stacks with single and multiple entries and drought balance; Effect of moisture, vapour, particulates and gaseous pollutants on the integrity of stacks; Design for maximum effects for dispersion; Design of multiple equipment in series and their cost optimization; Design for particulate and gaseous pollutants abatement systems.	12
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Henze M., van-Loosdrecht M.C.M., Ekama G.A. and Brdjanovic D., "Biological Wastewater Treatment. Principles, Modelling and Design", IWA publishing.	2008
2.	Bagchi A., "Design, Construction, and Monitoring of Sanitary Landfill", Wiley.	1990
3.	Theodore L. And Buonicore A.J., "Industrial Air Pollution Control Equipment for Particulates", CRC Press.	1976

M.Tech. (Chemical Engineering)

with specialization in

Industrial Safety and Hazards Management (ISHM)

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-513** Course Title: **Reliability Engineering**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objectives: To demonstrate quantitative evaluation of reliability, maintainability, availability, and safety of components, equipment, and systems, to support decision making.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Re view of probability t heories and boolean alzebra, frequency distribution functions- exponential, binomial, multinomial and Poisson's distributions.	4
2.	**Failure Mechanism and Models**: Reliability function and hazard rate; Failure distribution and bathtub curve; Failure data for estimation of mean time to failure (MTTF), mean time between failure (MTBF), mean time to repair (MTTR), mean time to restore.	8
3.	**Reliability of Standby Systems**: Application of failure distributions to series, parallel, r-out-of-n parallel and standby systems; Reliability of complex systems; Reliability and availability formulation.	8
4.	**State Dependent Systems**: Markov analysis; Load sharing systems; Standby systems and three-state devices; Reparability of single equipment system; Reliability and availability formulation.	6
5.	**Monte Carlo Simulation**: Basics of Monte Carlo simulation and its application to reliability of simple flow sheets such as olefin plant, distillation unit, etc.	4
6.	**Failure Analysis and Confidence Limit**: Data source and data bank; Confidence limit on failure frequency; Fitting of failure distribution – graphical and parametric estimation; Event and failure data, fault tree and event tree analysis; Scenario development and consequence modeling, risk criteria.	8
7.	**Reliability as a Design Tool**: Reliability prediction and optimization; Reliability in design and lifecycle costing; Maintenance activity and policy making.	4
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Mannan S. and O'Connor M. K. (Eds.), "Reliability Engineering in Lees' Loss Prevention in the Process Industries", Vol. I, 3rd Ed., Butterwoth-Heinemann.	2005
2.	Ebeling C.E., "An Introduction to Reliability and Maintainability Engineering", Tata McGraw-Hill.	2008
3.	O'Connor P.D.T., "Practical Reliability Engineering", 4th Ed., Wiley.	2009
4.	Nikolaidis E., Ghiocel D.M. and Singhal S., "Engineering Design Reliability Handbook", CRC Press.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-515** Course Title: **Industrial Safety and Hazards Management**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide comprehensive knowledge of safety and hazards aspects in industries and the management of hazards.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Industrial processes and hazards potential, mechanical electrical, thermal and process hazards. Safety and hazards regulations, Industrial hygiene. Factories Act, 1948 and Environment (Protection) Act, 1986 and rules thereof.	9
2.	**Fire and Explosion:** Shock wave propagation, vapour cloud and boiling liquid expanding vapours explosion (VCE and BLEVE), mechanical and chemical explosion, multiphase reactions, transport effects and global rates.	7
3.	**Relief Systems:** Preventive and protective management from fires and explosion-inerting, static electricity passivation, ventilation, and sprinkling, proofing, relief systems – relief valves, flares, scrubbers.	7
4.	**Toxicology:** Hazards identification-toxicity, fire, static electricity, noise and dust concentration; Material safety data sheet, hazards indices- Dow and Mond indices, hazard operability (HAZOP) and hazard analysis (HAZAN).	6
5.	**Leaks and Leakages:** Spill and leakage of liquids, vapors, gases and their mixture from storage tanks and equipment; Estimation of leakage/spill rate through hole, pipes and vessel burst; Isothermal and adiabatic flows of gases, spillage and leakage of flashing liquids, pool evaporation and boiling; Release of toxics and dispersion. Naturally buoyant and dense gas dispersion models; Effects of momentum and buoyancy; Mitigation measures for leaks and releases.	9
6.	**Case Studies:** Flixborough, Bhopal, Texas, ONGC offshore, HPCL Vizag and Jaipur IOC oil-storage depot incident; Oil, natural gas, chlorine and ammonia storage and transportation hazards.	4

		Total	**42**

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Crowl D.A. and Louvar J.F., "Chemical Process Safety: Fundamentals with Applications", 2nd Ed., Prentice Hall.	2001
2.	Mannan S., "Lee's Loss Prevention in the Process Industries", Vol. I, 3rd Ed., Butterworth-Heinemann.	2004
3.	Mannan S., "Lee's Loss Prevention in the Process Industries", Vol. II, 3rd Ed., Butterworth-Heinemann.	2005
4.	Mannan S., "Lee's Loss Prevention in the Process Industries", Vol. III, 3rd Ed., Butterworth-Heinemann.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-540** Course Title: **Fire Science and Engineering**

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 provide comprehensive knowledge of fire and its characteristics and engineering involved in control of fires.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Fuels and combustion process, properties of solid and liquid and gaseous fuels; Physical chemistry of combustion in fuels; adiabatic flame temperature.	6
2.	Flammability limits, characterization of lower and upper flammability limits, dependence on temperature and pressure, flammability diagrams.	5
3.	Ignition of solid and liquid fuels, ignition point, flash point, pool fires, burning of synthetic polymers, metal polymers and paints; Fire in buildings, spread of fires.	5
4.	Diffusion flames and fire plumes, flame length, buoyant flames and characteristics; Radiation from flames, point source model; Fire in liquid/gaseous fuel storage tanks and tank farms.	10
5.	Fire safety systems, design of sprinklers' system, venting systems; Fire extinguishing, extinguishing chemicals/vapours; Fire protection in laboratories and buildings, tank farms and solid/liquid storage yards. Hydrant systems and their design.	10
6.	Compartment fires, growth of fire, temperature of fire, mass flux, heat transfer through boundaries	6
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Zalosh R.G., "Industrial fire protection engineering", Wiley.	2003
2.	Drysdale D., "Intoduction to fire dynamics", Wiley.	1987
3.	Shields T.J. and Silcock G.W.H., "Building and Fire", Longmann.	1987
4.	Butcher E.G. and Parnell A.C., "Designing for Fire Safety", Wiley.	1983
5.	Davletshina T.A. and Cheremisinoff N.P., "Fire and Explosion Hazards Handbook of Industrial Chemicals", Jaico Publication.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-542** Course Title: **Design of Safety 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: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge on the operational principles of safety systems and their design.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Importance of safety systems in industry, relief concepts, definitions, emergency relief system (ERS) design, user groups and ERS design basis.	5
2.	Concept of risk, selection of design bases for safety systems, guidelines for risk tolerability, potential process safety systems and design solutions.	4
3.	Impact of two phase flow, vapour-liquid disengagement and vent flow dynamics and modes, prediction and estimation of two-phase flow.	7
4.	Design of relief systems, overpressure protection, pressure relief devices, valves, bursting discs, vent systems, blowdown and depressuring systems.	7
5.	Control of safety systems, safety system characteristic and design; Safety system computer control; Control of trip, interlock and emergency shut-down systems; Programmable logic and electronic system; Layered control systems for safety.	6
6.	Deflagration venting for dust and vapour explosions, venting system design for fire external to process vessels and relief's for thermal systems.	6
7.	Design of flares, scrubbers and condensers for toxic release from chemical process industries; Design of tank farms for liquid/gaseous fuel storage.	7
	Total	**42**

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Crowl D.A. and Louvar J.F., "Chemical Process Safety: Fundamentals with Applications", 2nd Ed., Prentice Hall.	2001
2.	Mannan S., "Lee's Loss Prevention in the Process Industries", Vol. I, 3rd Ed., Butterworth-Heinemann.	2004
3.	Mannan S., "Lee's Loss Prevention in the Process Industries", Vol. II, 3rd Ed., Butterworth-Heinemann.	2005
4.	Mannan S., "Lee's Loss Prevention in the Process Industries", Vol. III, 3rd Ed., Butterworth-Heinemann.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-544** Course Title: **Safety in Design of Process Equipment**

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 provide comprehensive knowledge of safety aspect / considerations in the design of process equipment to eliminate equipment failures.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** The design process, stages of design, standard and codes, design changes, overdesign, design error propagation, conceptual design and detailed design. Corrosion, electrical hazards, fire protection, explosion protection, pressure relief.	5
2.	**Selection of Materials:** Design considerations, fabrication and installation, corrosion monitoring and control techniques.	3
3.	**Design Assessments:** Critical examination, value engineering assessment, energy efficiency assessment, reliability and availability assessment, hazard identification and assessment, occupational health assessment and environmental assessment.	5
4.	**Inherently Safer Design:** Limitation of inventory, process intensification, substitution, attenuation, selection process, hazards of compromise, design of reactors, semi-batch and high intensity reactors, long-pipe reactors, plate heat exchangers, substitution, application, selection of heat transfer media, design of storage systems for hazards and toxic chemicals, design of overpressure and containment.	8
5.	**Safety in Design of Reactors:** Reactors, reaction hazard evaluation in batch and semi-batch reactors, strategy for control of hazards of chemical reactions, safe operation criteria for batch and continuous reactors.	5
6.	**Safety in Design of Vessels:** Past incidents and present scenario on failure of the process vessels, pressure vessels, reactors, dryers. Potential design solutions, special considerations.	8
7.	**Safety in Design of Special Equipment:** Past incidents and present scenario on failure of the special equipment like fluid machinery,	8

	pipelines for transport of coal and oil-gas slurry, liquid products, heat and mass transfer equipment, solid handling and processing equipment and incorporation of safety aspects into design of equipment.	
	Total	**42**

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	"Guidelines for Design Solutions for Process Equipment Failures", ISBN: 978-0-8169-0684-0, Centre for Chemical Process Safety (CCPS).	1998
2.	Cheremisinoff N.P., "Pressure Safety Design Practices for Refinery and Chemical Operations" Noyes Publications.	1998
3.	Jones, J.C., "Hydrocarbon Process Safety", Penn Well Books.	2003
4.	Sanders R.E., "Chemical process safety: learning from case histories" Elsevier.	2005
5.	Mannan S., "Lee's Loss Prevention in the Process Industries", Vol. I, 3rd Ed., Butterworth-Heinemann.	2005
6.	Henley E.J., Kumamoto H., "Designing for Reliability and Safety Control" Englewood Cliffs.	1985

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-548** Course Title: **Case Studies in Safety and Hazards Management**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To discuss case studies in safety and hazards management in various process and allied industries.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Incident sources, databases; Incidents diagrams, plans and maps.	4
2.	**Hazards Associated with Hydrocarbon and Other Chemical Products**: Crude oil, natural gas, LPG, CNG, LNG, oxygenated hydrocarbons, chlorine, ammonia, hydrogen fluoride.	10
3.	**Safety Management Practices**: Separation, segregation and isolation, safe storage methods, house-keeping and hazard control, ventilation, personal protection, contingency plans.	4
4.	**Hazardous Waste Transportation**: Transporter requirements, enforcement of regulations.	4
5.	**Safety Management Plan**: Disaster management plan, remote sensing for disaster mitigation.	5
6.	**Case Studies of Important Accidents**: Flixborough, Seveso, Mexico city, Pasadena, Rijnmond, Chernobyl, Bhopal, Jaipur incidents.	7
7.	**Case Studies of Safety Related Accidents in Industries:** Accidents in petrochemical, petroleum, fertilizer, pulp and paper, cement, sugar, distillery. Events prior to and after incidents, investigation and lessons.	8
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Sanders R.E., "Chemical Process Safety: Learning from Case Histories", Elsevier.	2005
2.	Davletshina T.A. and Cheremisinoff N.P., "Fire and Explosion Hazards Handbook of Industrial Chemicals" Jaico Publication.	2003
3.	Cheremisinoff N.P. and Graffia M.L., "Environmental Health And Safety Management. A Guide to Compliance", Pressure safety design practices for refinery and chemical operations", Jaico Publication.	2003
4.	Mannan S., "Lee's Loss Prevention in the Process Industries", Vol. III, 3rd Ed., Butterworth-Heinemann.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CH-550** Course Title: **Regulatory Practices for Industrial Safety**

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 provide comprehensive knowledge about regulatory practices for safety of personnel, property and environment in process and allied industries.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Industrial Law; Standards and codes of practice; Indian legislations; Regulatory regime; Health and safety; International treaties and protocols for safety, Bessels convention.	6
2.	Safety, health and management (SHE) concept, policy; SHE management in industries.	2
3.	Factories act 1948; Boiler act and rules. IS 18001: 2000 Occupational health and safety (OH and S) management system.	6
4.	Environmental (protection) act, 1986; Hazardous waste management rules, Biomedical (Management and Handling) rules, Batteries Management and handling rules. Hazardous Chemicals and Hazardous Rules, 1989; Public Liability Insurance Act 1991.	15
5.	Static and mobile pressure vessels (unfired) rules, 1981; Explosive act, 1884; Gas cylinder rules, 1981 and 2004; Building, construction and electricity legislation; Personal safety legislation; Transport legislation: Tankers (under SMPV (U) rules, 1981; Enforcement practice; Petroleum act, 1934, Petroleum rules, 2002.	13
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Mannan S., "Lees' Loss Prevention in the Process Industries: Hazard Identification, Assessment and Control", Butterworth-Heinemann.	2005
2.	Hammer W. and Price D, "Occupational Safety Management and Engineering", 5th Ed., Prentice Hall.	2000
3.	Poltev M.K. and Kolykhmatov V., "Occupational Health and Safety in Manufacturing Industries", MIR publisher.	1985
4.	Pollution Control Law Series, "Pollution Control Acts, Rules and Notification Issued Thereunder", Central Pollution Control Board, Ministry of Environment and Forest, Government of India.	2006

ALTERNATE HYDRO ENERGY CENTRE M. TECH. IN "ALTERNATE HYDRO ENERGY SYSTEMS"

I Semester (Autumn)

Teaching Scheme					Teaching Load Hrs/Week			Exam. Duration (Hrs.)		Relative Weightage (%)				
SL. NO.	SUBJECT CODE	COURSE TITLE	SUBJECT AREA	CREDITS	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	MA-501F	Numerical Analysis, Probability and statistics	ICC	4	3	1	-	3	-	25	-	25	50	-
2.	*AH-511*	Small Hydro Power Planning and Management	PCC	4	3	1	-	3	-	25	-	25	50	-
3.	AH-513	Renewable Energy Resources Development Technology	PCC	4	3	1	2/2	3	-	15	15	30	40	-
4.	*AH-517*	Modeling, Simulation & Computer Applications	PCC	4	3	1	2/2	3	-	15	15	30	40	-
5.		Open Elective-I	OEC	3/4	-	-	-	-	-	-	-	-	-	-
Subtotal				19/20										

II Semester (Spring)

Teaching Scheme					Teaching Load Hrs/Week			Exam. Duration (Hrs.)		Relative Weightage (%)				
SL. NO.	SUBJECT CODE	COURSE TITLE	SUBJECT AREA	CREDITS	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.		Programme Elective-I	PEC	4	-	-	-	-	-	-	-	-	-	-
2.		Programme Elective-II	PEC	4	-	-	-	-	-	-	-	-	-	-
3.		Programme Elective-III	PEC	4	-	-	-	-	-	-	-	-	-	-
4.		Programme Elective-IV	PEC	4	-	-	-	-	-	-	-	-	-	-
5.		Open Elective-II	OEC	3/4	-	-	-	-	-	-	-	-	-	-
6.	HS-501	Technical Communication (Optional)	IEC	2	1	0	2	2	-	15	15	30	40	-
Subtotal				19/22										

III Semester (Autumn)

Teaching Scheme					Teaching Load Hrs/Week			Exam. Duration (Hrs.)		Relative Weightage (%)				
SL. NO.	SUBJECT CODE	COURSE TITLE	SUBJECT AREA	CREDITS	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	AH-601	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
2.	AH-602	Project and Site Visits	RP	4	-	-	-	-	-	-	-	-	100	-
3.	AH-603	Dissertation*	DIS	0	-	-	-	-	-	-	-	-	25	-
Subtotal			6											

* To be continued and grades to be awarded in the next Semester

IV Semester (Spring)

Teaching Scheme					Teaching Load Hrs/Week			Exam. Duration (Hrs.)		Relative Weightage (%)				
SL. NO.	SUBJECT CODE	COURSE TITLE	SUBJECT AREA	CREDITS	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	AH-603	Dissertation	DIS	20	-	-	-	-	-	-	-	-	75	-
Subtotal			20											
Total			**64/68**											

Programme Electives

Teaching Scheme					Teaching Load Hrs/Week			Exam. Duration (Hrs.)		Relative Weightage (%)				
SL. NO.	SUBJECT CODE	COURSE TITLE	SUBJECT AREA	CREDITS	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	AH-512	Design of SHP Structures	PEC	4	3	1	-	3	-	25	-	25	50	-
2.	AH-514	Hydro Electric Equipment	PEC	4	3	1	2/2	3	-	15	15	30	40	-
3.	AH-516	Hydro mechanical Equipment	PEC	4	3	1	2/2	3	-	15	15	30	40	-
4.	AH-518	Environmental Planning and Management	PEC	4	3	1	-	3	-	25	-	25	50	-

5.	AH-522	Wind Energy Application Technology	PEC	4	3	1	-	3	-	25	-	25	50	-
6	AH-526	Instrumentation for Small Hydro Power Station	PEC	4	3	1	2/2	3	-	15	15	30	40	-
7.	AH-528	Rural Electrical Energy System Planning and Design	PEC	4	3	1	-	3	-	25	-	25	50	-
8.	AH-530	Remote Sensing and GIS for SHP Planning	PEC	4	3	-	2	3	-	15	15	30	40	-
9	AH-534	Construction Planning and Management	PEC	4	3	1	-	3	-	25	-	25	50	-
10.	AH-536	Biomass Production and Utilisation	PEC	4	3	1	-	3	-	25	-	25	50	-
11.	AH-538	Operation and Maintenance of Small Hydro Plants	PEC	4	3	1	-	3	-	25	-	25	50	-
12.	AH-540	Solar Photo-Voltaic Design and Application	PEC	4	3	1	-	3	-	25	-	25	50	-
13.	AH-542	Energy Conservation and Management	PEC	4	3	1	-	3	-	25	-	25	50	-
14.	AH-548	Simulation of Small Hydropower Plants	PEC	4	3	1	2/2	3	-	15	15	30	40	-

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-511** Course Title: **SMALL HYDROPOWER PLANNING AND MANAGEMENT**

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

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

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

5. Credits: [**4**] 6. Semester: **Autumn**

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

9. Objective: To give an overview of planning, process of development and management of small hydropower (shp) projects.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Forms, development and purposes of water resources, types of hydro projects, shp development and its relevance, Electricity act, constitutional provisions, development process, allotment of sites, opportunities	8
2.	Small hydropower planning on existing structures and new sites	4
3.	Different methods for stream gauging, rainfall, runoff and its estimation by different methods, peak flood estimation, demonstration of discharge measuring instruments	6
4.	Flow duration studies, assessment of power potential and determination of installed capacity	6
5.	Topographical, geological and power evacuation surveys and investigations, demonstration of surveying instruments, site selection for shp projects	5
6.	Different types of project reports and their relevance	4
7.	Different methods of project implementation	4
8.	Financing of projects, cost estimation for different components, financial and economic analysis, clean development mechanism, management of shp plants	5
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Harvey, A., Brown, A. and Hettiarachi, P., "Micro Hydro Design Manual", Intermediate Technology,	1993
2.	Fritz, J.J., "Small and Mini Hydro Power Systems: Resource Assessment and Project Feasibility", McGraw Hills.	1984
3.	Gulliver, J.S. and Arndt, E.A., "Handbook of Hydro Electric Engineering", McGraw Hills.	1993
4.	Kausal, M.L. and Chauhan, G., "Planning and Design of Small Hydroelectric Projects", (Publication No. 305), Central Board of Irrigation and Power.	2006
5.	"Civil Engineering Guidelines for Hydroelectric Projects", (Vol. 4-Small Hydro), ASCE.	1989
6.	Nigam, P.S., "Handbook of Hydroelectric Engineering", Nem Chand and Bros.	2006
7.	"Guidelines to Develop Small Hydropower Plants", ESHA.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-513** Course Title: **RENEWABLE ENERGY RESOURCES DEVELOPMENT TECHNOLOGY**

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

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

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

5. Credits: **4** 6. Semester: **Autumn**

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

9. Objective: To provide knowledge about various renewable energy technologies, their potential and applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to energy sources, reserves and estimates, global energy scenario, renewable energy vis-à-vis environment implications, global warming and climate change.	4
2.	Solar energy and its application, availability of solar radiation energy, collection and solar thermal storage, photovoltaic and thermal power generation.	8
3.	Wind energy and its application, types of wind mills and their characteristics, elementary design principles.	8
4.	Biomass and its sources, energy plantation, production of fuel wood.	8
5.	Bio-conversion processes, bio-gas, bio-diesel and ethanol production and utilization.	4
6.	Thermo-chemical processes, biomass gasification, process, types of reactors, utilization of producer gas for thermal and electricity generation.	4
7.	New energy technology, ocean and geothermal energy, hydrogen energy, alternate fuels for surface transportation.	6
	TOTAL	**42**

List of Practicals:
i. To determine the heating value of solid and liquid fuels
ii. To determine the heating value of gaseous fuels
iii. To determine the viscosity of liquid fuels and lubricants
iv. To determine the flash point of liquid fuels
v. To evaluate the performance of solar hot water system
vi. To determine the efficiency of SPV water pumping system

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Duffie, J.A. and Beckman, W.A., "Solar Engineering of Thermal Process", 3rd Edition, John Wiley,.	2006
2.	Charles, Y. W.-B. and Essel, B. H., "Biomass Conversion and Technology", John Wiley.	1996
3.	Lysen, E.H.A., "Introduction to Wind Energy", Franklin Institute Press.	1988

4.	Clare, R., "Tidal Power: Trends and Development", Thomas Telford.	1992
5.	"World Energy Outlook 2009", International Energy Agency Publication.	2008
6.	Ledjeff, K. et al., "Hydrogen: A Clean Permanent Source of Future Energy", Pergamon Press.	1981
7.	Kemp, W.H., "The Renewable Energy Handbook: A Guide to Rural Energy Independence, Off-Grid and Sustainable Energy", Aztext Press.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-517** Course Title: **MODELLING, SIMULATION AND COMPUTER APPLICATION**

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

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

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

5. Credits: **4** 6. Semester: **Autumn**

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

9. Objective: To provide basic knowledge about modeling and simulation techniques and their application to civil, electrical and mechanical components of small hydropower plants.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review of C++	8
2.	Principles of modeling, physical, mathematical, static and dynamic models	5
3.	Model development, parameter estimation, validation of model	3
4.	Nature of simulation, techniques of simulation, discrete and continuous system simulation, parallel and distributed simulation, simulation of queuing and inventory system.	5
5.	Methods of random number generation, Monto-Carlo simulation, spread sheet simulation, numerical computation techniques for continuous and discrete models.	5
6.	Modeling of intake, channel, desilting tank, forebay tank, penstock	6
7.	Modeling of electro mechanical equipment	6
8.	Introduction of simulation language and package	4
	TOTAL	**42**

List of Practicals: Software development for planning and designing of small hydropower plant based on C++ programming, development of model with empirical data, software development for simulation technique.

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Kundur, P., "Power System Stability and Control", McGraw-Hill Inc.	2008
2.	Laffore, R., "Turbo C++", Galgotia Publication.	1996
3.	Hubbard, J.R., "Programming with C++", Tata McGraw-Hill Publishing Company.	2000
4.	Deo, N., "System Simulation with Digital Computer", Prentice Hall	1998
5.	Severance, F.L., "System Modelling and Simulation-An introduction", John Wiley and Sons.	2001
6.	Law, A.M., "Simulation Modelling and Analysis", Tata McGraw-Hill Publishing Company.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-512** Course Title: **DESIGN OF SHP 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 provide knowledge of design concepts of various civil structures of small hydro power schemes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Hydraulics and structural designs of civil works, national and international standards and codes of practice, diversion works and intake structures, site selection, innovative designs.	8
2.	Power house layouts , channel (lined and unlined), under drainage works, tunnels and tail race channel	8
3.	Sediment properties and transport, desilting devices, silt disposal	6
4.	Cross drainage works	4
5.	Balancing reservoir, spillway and forebay tank	5
6.	Penstock, anchor block and saddle, surge tank	5
7.	Power house buildings, material handling, machine foundation	6
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Mosonyi, E., "Water Power Development", Vol. I and II, Nem Chand and Brothers.	2009
2.	Brown, G., "Hydro-electric Engineering Practice", Vol. I, II & III, CBS Publication.	2009
3.	"Civil Engineering Guidelines for Hydroelectric Projects", Vol. II and IV, American Society of Civil Engineers (ASCE).	1989
4.	Nigam, P.S., "Hand book of Hydroelectric Engineering", Nem Chand and Brothers.	2001
5.	Varshney, R.S., "Hydropower Structures", Nem Chand and Brothers.	2001
6.	National and International Standards.	-

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-514** Course Title: **HYDRO ELECTRIC EQUIPMENT**
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 provide knowledge about electrical power generation, protection and control of small hydropower stations.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Types, characteristics and testing of ac generators	5
2.	Sizing and specification of single and three phase generators	5
3.	Power factor and its correction methodologies, excitation systems	6
4.	Electro-mechanical and digital governor, electronic load controller	4
5.	Types of relays, contactors and control schemes for shp stations	5
6.	Supervisory control and data acquisition (SCADA), integrated computer control system for shp station	5
7.	Switchyard equipments, power and instrument transformers, circuit breakers, bus-bar	6
8.	Protection schemes for generator, transformer and bus-bar, design of circuit diagram for auxiliary and grounding systems	6
	TOTAL	**42**

List of Practicals:
i. To determine the characteristics of induction generator
ii. To determine the characteristics of synchronous generator
iii. To detect the cable fault
iv. To operate generators in parallel
v. To measure the soil resistivity

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Reimert, D., "Protective Relaying for Power Generation Systems", Taylor and Francis.	2006
2.	Clemen, D.M., "Hydro Plant Electrical Systems", HCI Publication.	1999
3.	Kundur, P., "Power System Stability and Control", McGraw Hill Inc.	2008
4.	Harker, K., "Power System Commissioning and Maintenance Practice", The Institution of Electrical Engineers.	1998
5.	"Manual on Layout of Substations", Central Board of Irrigation and Power.	1989
6.	"Manual on Sub-station, Design of Earthing-Mat for High-Voltage Substation", Central Board of Irrigation and Power.	1992

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-516** Course Title: **HYDRO MECHANICAL EQUIPMENT**
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 provide knowledge about hydro mechanical equipments for small hydropower plants.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Classification and working principles of hydro turbines, different components of impulse and reaction turbines	5
2.	Design concepts of hydro turbines, pump-as-turbine and other non conventional hydro turbines	4
3.	Characteristics of hydro turbines, geometric similarity, main characteristic and operating characteristic curves, hill curves	5
4.	Governing of hydro turbines, mechanical and electro-mechanical governors, electronic load controller, mechanical drives, gear box, pulleys	4
5.	Selection of hydro turbines based on specific speed and their optimal selection	5
6.	Classification, components and selection of gates and valves	4
7.	Model testing of hydro turbines, performance testing of turbines at site	5
8.	Causes and impact of cavitation, silt erosion and their combined effect on operation of hydro turbines	6
9.	Erection, commissioning, operation and maintenance of turbines	4
	TOTAL	**42**

List of Practicals:
i. To measure the flow by different techniques
ii. To measure the efficiency of Pelton, Francis and axial (Kaplan) turbines

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Mosonyi, E., "Water Power Development", Vol. I and II, Nem Chand and Brothers.	2009
2.	Nigam, P.S., "Handbook of Hydroelectric Engineering", Nem Chand and Brothers.	2001
3.	Lal, J., "Hydraulic Mechines", 3rd edition (reprint), Metropolitan Book Co. Private Limited.	2002
4.	National and International Standards.	-
5.	Brown, G., "Hydro-electric Engineering Practice", Vol. II, CBS Publication	1984

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-518** Course Title: **ENVIRONMENTAL 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: **Spring**
7. Subject Area: **PEC** 8. Pre-requisite: **Nil**
9. Objective: To impart knowledge about basic ecological principles and environmental impact assessment of renewable energy projects.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Basic ecological principles, concept and components of ecosystem, energy flow, nutrient cycling, cybernetics, ecological regulating, ecological diversity	10
2.	Interaction of various components of environment, ecological disorders	6
3.	Environmental impact assessment (EIA) of water resources projects with emphasis on renewable energy projects e.g. shp, biomass, solar energy	6
4.	Conservation of resources, environmental policies, laws and acts	8
5.	Significance of EIA of renewable energy projects, case studies of large and small hydro projects	8
6.	Environmental compatible growth.	4
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Naidu, B.S.K., "Planning and Management of Hydropower Resources in India", CBIP.	1992
2.	Sengupta, B. and Guha, H., "Construction Management and Planning", Tata McGraw-Hill Publishing Company Ltd.	1995
3.	Chaturvedi, M.C., Jain, S.K. and Singh, V.P., "Water Resource System Planning and Management", Tata Mcgraw Hill.	2001
4.	Saxena, K.D., "Environmental Planning, Policies and Programmes in India", Sipra Publications.	1993
5.	Jain, S.K., "Water Resource System Planning and Management", Elsevier publication.	2003
6.	Khan, M.A., "Environment Biodiversity and Conservation", APH publication.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-522** Course Title: **WIND ENERGY APPLICATION 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 about wind energy resources and application technologies.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Wind energy scenario in India, properties of wind, wind velocity and wind rose diagram, estimation of power in wind.	7
2.	Types of wind turbines, characteristics, construction of wind mills.	7
3.	Aerodynamic considerations of wind mill design, wind stream profile, rotor blade profile and cross section.	7
4.	Drive system-gears, wind electric generators, regulating and control systems for wind mills.	7
5.	Performance evaluation and recent technologies of wind energy conversion system	7
6.	Wind energy potential estimation and site selection; wind farms, cost estimation of the energy from wind energy conversion system.	7
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Pillai, G.M., "Wind Power Development in India", Part-II, Shailesh Art Print.	2006
2.	Sorensen, B., "Renewable Energy", Academic Press.	2004
3.	Burton, T. et al, "Wind Energy Handbook", John Wiley and Sons Ltd.	2001
4.	Lysen, E.H.A., "Introduction to Wind Energy", Franklin Institute Press.	1988
5.	Boyle, G., "Renewable Energy Power for a Sustainable Future", Oxford University Press.	1996
6.	Bansal, N.K., Kleemann, M. and Heliss, M., "Renewable Energy Sources and Conversion Technology", Tata McGraw-Hill Publishing Company.	1990

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-526** Course Title: **INSTRUMENTATION FOR SMALL POWER STATION**
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 provide knowledge about instrumentation for the measurement of electrical and mechanical parameters in small hydro and other renewable energy projects.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Industrial instrumentation, transducers and their applications.	6
2.	Instrumentation for power system, analog and digital instruments, principles of measurement of voltage, current and power.	7
3.	Electronic voltmeters for non-sinusoidal voltages, dc voltmeter, mechanical and electrical tachometer, altimeter.	5
4.	Current transformers and potential transformers.	5
5.	Digital instrumentation, technology of regulators, sensors and actuators, recorders, signal processing circuits, data acquisition system.	6
6.	Types of a.c. bridges, equation for bridge balance, measurement of self inductance, capacitance, mutual inductance and frequency.	8
7.	Case study of the instrumentation scheme used in small hydro power development.	5
	TOTAL	**42**

List of Practicals: To measure the voltage, current, power, resistance, inductance, capacitance and speed.

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Doebelin, E. O., "Measurement Systems Application and Design", 5th edition, Tata McGraw-Hill Publishing Company.	2003
2.	Patranabis, D., "Principles of Industrial Instrumentation", 2nd edition, Tata McGraw-Hill Publishing Company.	2004
3.	Oliver, B., "Electronic Measurements and Instrumentation", 1st edition, Tata McGraw-Hill Publishing Company.	2001
4.	Bouwens A., "Digital Instrumentation", 1st edition, Tata McGraw-Hill Publishing Company.	2001
5.	Beckwith, T.G., Marangoni, R.D. and Lienhard, J.H., "Mechanical Measurements", 6th edition, Prentice Hall Publishers.	2006
6.	Sawhney, A.K., "A course in Electrical and Electronic Measurement and Instrumentation", 11th edition, Dhanpat Rai and Sons Publishers.	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-528** Course Title: **RURAL ELECTRICAL ENERGY SYSTEM PLANNING 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: **PEC** 8. Pre-requisite: **Nil**

9. Objective: To impart knowledge about planning and design aspects of electrification of rural areas.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Electrical load survey and forecasting, rural load management.	5
2.	Route survey and profiling of transmission and distribution lines.	4
3.	Mechanical design of low-tension distribution lines, selection of poles/supports.	5
4.	Electrical design of low-tension distribution lines: selection of conductors and insulators.	5
5.	Planning, selection and design of substations for rural electrical system.	5
6.	Load flow methods for transmission and distribution system; fault analysis: different types of faults and their calculation procedures	6
7.	Co-ordination between power and tele-communication lines	3
8.	Maintenance of transmission and distribution lines	5
9.	Case study of a typical system	4
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Kamaraju, V., "Electric Power Distribution System", Tata McGraw Hill Education Private Limited.	2009
2.	Grainger, J.J. and Stevenson, W.D., "Power System Analysis", Tata McGraw Hill Publishing Company Limited.	2003
3.	Jangwala, N.K., "Modern Trends and Practices in Power Subtransmission and Distribution Systems", Vol.-I and II, CBIP Publication.	1996
4.	Widmer, P. and Arter, A., "Village Electrification", MHPG, SKAT Publication.	1993
5.	Pabla A.S., "Electric Power Distribution", 5th edition, Tata McGraw Hill Publishing Company.	2004
6.	Harker, K., "Power System Commissioning and Maintenance Practice", The Institution of Electrical Engineers.	1998
7.	Raina, K.B. and Bhattacharya, S.K., "Electrical Design Estimating and Costing", New Age International Publisher Limited.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-530** Course Title: **REMOTE SENSING AND GIS FOR SHP 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 provide knowledge for Remote Sensing and Geographical Information System for planning of small hydro projects.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Remote sensing: Introduction, Satellite platforms and sensors, data acquisition, Indian satellite system.	4
2.	Satellite image: format, resolution, multispectral images, Image processing software, Geo-referencing, pre-processing and enhancement. Information extraction: supervised and unsupervised classification	6
3.	Geographical Information System: introduction, components, Coordinate system, Projection system.	3
4.	Data sources and data collection for small hydro projects: Field survey, topographic maps, satellite images, GPS, Digitization and layers creation.	4
5.	Data types – Spatial, non-spatial, Vector and Raster data, Topological relationship.	3
6.	Data base development for SHP: Database structure, editing, data retrieval and query. Managing data errors: Rubber sheeting, Edge matching, Removal of sliver polygon.	6
7.	Digital elevation model: characteristics, DEM generation, parameters extraction from DEM.	4
8.	SHP data analyses–Catchments delineation - Overlay analyses, Buffering, Neighborhood operation, and distance and area measurement. Network based analysis.	5
9.	Runoff modeling, suitable site selection for small hydro.	3
10.	GIS based Case study for development of small hydro power projects.	4
	TOTAL	**42**

List of Practicals:
i. Geo referencing of toposheet and satellite image
ii. Image enhancement and classification – supervised and unsupervised
iii. Digitization of catchment boundary, contours and other features
iv. Digital elevation model preparation and parameter extraction
v. Data collection from GPS
vi. Development of SHP database on GIS package
vii. Queries and analysis from GIS database

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Lillesand, T.M. and Kiefer, R.W., "Remote Sensing and Image Interpretation", 5th edition, John Willey and Sons Pte. Ltd.	2009

2.	Panda, B.C., "Remote Sensing Principles and Applications", Viva Books Private Limited.	2006
3.	Lo, C.P. and Yeung, A. K.W., "Concepts and Techniques of Geographic Information Systems", Prentice Hall Inc.	2009
4.	Chang, K.T., "Introduction to Geographic Information Systems", Tata Mc Graw-Hill.	2007
5.	Burrough, P.A., "Principles of GIS for Land Resources Assessment", Oxford University Press.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-534** Course Title: **CONSTRUCTION PLANNING AND MANAGEMENT**
2. Contact Hours: L **3** T **1** P **0**
3. Examination Duration (Hrs.): Theory **3** Practical **0**
4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits: **4** 6. Semester: **Spring**
7. Subject Area: **PEC** 8. Pre-requisite: **Nil**
9. Objective: To provide knowledge of construction techniques, equipments, planning, monitoring and overall management of project.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Planning for construction of projects, advantages, stages and limitations of planning	6
2.	Project objectives and activities, tender documents, types of tenders and procedures, cost estimates	6
3.	Construction schedules, network techniques, interrelationship of activities, advantages of network diagrams	8
4.	Construction methods, direct and indirect costs, construction plants and machinery, resource mobilisation	8
5.	Importance of safety, safety measures and benefits	4
6.	Quality control and management, coordination between different organizations and monitoring	6
7.	Construction planning for river diversion, foundation construction and treatment	4
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Peurifoy, R. L., Ledbetter, W. B. and Schexnayder, C. J., "Construction Planning, Equipment and Methods", McGraw-Hill Book Company.	1996
2.	Sengupta, B. and Guha, H., "Construction Management and Planning", Tata McGraw-Hill Publishing Company Ltd.	1995
3.	Seetharaman, S., "Construction Engineering and Management", 4th edition (Reprint), Umesh Publications.	2007
4.	Hutchings, J. F., "Project Scheduling Handbook", Marcel Dekker Inc.	2004
5.	Kaushik, S. K., Asawa, G. L. and Ahuja, A. K., "Civil Engineering Practices", Vol. I-III, New Age International (P) Ltd.	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-536** Course Title: **BIOMASS PRODUCTION AND UTILISATION**
2. Contact Hours: L **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 biomass resources, production and conversion technologies.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Energy crisis, rural and urban energy loads, biomass as a source of energy, energy plantation, forest and agro residues, aquatic biomass, animal waste.	8
2.	Classification, shape, size, ash content and volatile matter in biomass.	4
3.	Biomass characteristics, procedures, proximate and ultimate analysis, ash deformation and fusion characteristics, calorific value, bulk density, devolatilisation	6
4.	Biomass production through energy plantation, agroforestry, short rotation intensive culture, biomass harvesting, handling and pre-conversion processes.	6
5.	Physical, biological and thermo-chemical conversion processes, combustion, pyrolysis, gasification, bio-diesel, biogas production, biogas plants, briquetting/size reduction.	8
6.	Synthetic fuel production, bagasse based co-generation for power, utilization of biomass for the generation of solid, liquid/gaseous fuels for meeting heat and power needs	5
7.	Environmental aspects of biomass production and utilisation and waste minimization system.	5
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Richard, B.D.O., "Fats and Oils Formulating and Processing for Application", 3rd edition, CRC Press.	2004
2.	Donald, K., "Biomass for Renewable Energy, Fuels and Chemicals", Academic press.	1998
3.	Venkat, R.P. and Srinivas, S.N., "Biomass Energy Systems", Proceeding of International Conference, Feb. 26-27, 1996, TERI Press.	1997
4.	Maheshwari, R.C., "Bioenergy for Rural Energisation", Concept publication company	1997
5.	Nair, Ramchandra P.K., "An Introduction to Agroforestry", Springer (India) Pvt. Ltd.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-538** Course Title: **OPERATION AND MAINTENANCE OF SMALL HYDRO 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 provide knowledge about operation, maintenance, safety and financial aspects of various components of small hydropower plants.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Intake weir, desilting tank, forebay, power channel, spillways and power house building	6
2.	Gates, valves, trash rack and penstock	4
3.	Turbines, governors and auxiliaries	6
4.	Hydro-generator and excitation system	6
5.	Control panels, relays, circuit breakers, transformers, batteries and charging equipments	6
6.	Earthing system, switchyard and interconnecting transmission lines	5
7.	Safety aspects and disaster management in small hydropower plants	5
8.	Financial management for operation and maintenance of small hydropower plants	4
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	"Maintenance and Repair Manual for Private Micro Hydropower: Plants", developed by DCS Technology Development, ICIMOD publication.	1999
2.	"Installation and Commissioning Manual for Micro Hydro Plants", developed by DCS Technology Development, ICIMOD publication.	1999
3.	Facilities, Instructions, Standards and Techniques (FIST) Manuals, Vol. I-VI, USBR.	2009
4.	Fischer, G. et al, "Governor product information", SKAT.	1990
5.	Gulliver, J.S. and Arndt, E.A., "Handbook of Hydro Electric Engineering", McGraw Hills.	1993
6.	Harker, K., "Power System Commissioning and Maintenance Practice", The Institution of Electrical Engineers.	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-540** Course Title: **SOLAR PHOTO-VOLTAIC DESIGN AND APPLICATION**

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

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

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

5. Credits: [**4**] 6. Semester: **Spring**

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

9. Objective: To provide knowledge about solar photo-voltaic technology, design and application.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Solar energy data, estimation of solar energy on different planes.	6
2.	Principle, characteristics and types of solar photo-voltaic (PV) cell	6
3.	Manufacturing and performance testing of solar PV modules	5
4.	PV modules, array, batteries, battery chargers, block diodes, inverters, load distribution unit, monitoring equipment, circuit breakers	7
5.	Load estimation, sizing of array and battery	5
6.	Types of PV system, isolated and grid connected PV power plants	6
7.	Installation and maintenance, grid interfacing, field monitoring; economic analysis, cost effective hybrid designs	7
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Boyle, G., "Renewable Energy Power for a Sustainable Future", Oxford University Press.	1996
2.	Sukhatme, S.P., "Solar Energy Principles of Thermal Collection and Storage", 2nd edition", Tata McGraw Hill.	1996
3.	Tiwari, G.N., "Solar Energy: Fundamentals, Design, Modeling and Applications", Narosa Publishing House.	2002
4.	Goswami, D.Y., Kreith, F. and Kreider, J.F., "Principles of Solar Engineering", 2nd edition, Taylor and Francis.	1999
5.	Hsieh, J.S., "Solar Energy Engineering", Prentice-hall Inc.	1986
6.	Bansal, N.K., Kleemann, M. and Heliss, M., "Renewable Energy Sources and Conversion Technology", Tata McGraw-Hill Publishing Company.	1990

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-542** Course Title: **ENERGY CONSERVATION AND MANAGEMENT**
2. Contact Hours: L **3** T **1** P **0**
3. Examination Duration (Hrs.): Theory **3** Practical **0**
4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits: **4** 6. Semester: **Spring**
7. Subject Area: **PEC** 8. Pre-requisite: **Nil**
9. Objective: To provide the knowledge about energy conservation and management.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Definition, organization of an energy conservation programme, definition of energy conservation, energy management, energy conservation opportunities, general principles, types, procedures and instruments for energy auditing.	5
2.	Assessments of technical merits of energy conservation methods and techniques in specific applications, energy saving methods, energy strategy, industrial energy applications.	5
3.	Methods of cost estimation for potential savings of fuel and electricity.	4
4.	Supply and demand side management of energy in residential, commercial, transport and industrial sectors, electricity utilities.	5
5.	Energy conservation in steam boilers, engines; principles, types and applications of different heat recovery systems.	5
6.	Energy conservation in electrical motors, transformers and conductors.	5
7.	Energy conservation in illumination in building shells.	4
8.	Material conservation and recycling, buildings heat losses, effect of fabrics, solar gains, ventilation, cooling, thermal storage and heat pumps.	5
9.	Topping and bottoming cogeneration cycles, total energy systems.	4
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Paul, O'Callaghan, "Energy Management", McGraw-Hill Book Company	1993
2.	Charles, M. G., "Industrial Energy Conservation", John Wiley and Sons.	1996
3.	Bhatia, R., "Energy Demand Analysis, Management and Conservation", Wiley Eastern Publication.	1990
4.	Paul, K.A., "Wetland Ecology Principles and Conservation", Cambridge University Press.	2002
5.	"Energy Conservation Act", Ministry of Power.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-548** Course Title: **SIMULATION OF SMALL HYDROPOWER PLANTS**
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: **AH: 517 A or equivalent**
9. Objective: To provide knowledge about modelling and simulation of electrical, mechanical and civil components of SHP Plant.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review of system modelling and simulation, system states, lumped and distributed parameters, experimental and mathematical simulation, overview of numerical methods for simulation	8
2.	Modelling of water conductor system for low and medium/high head plants	8
3.	Modelling of turbines and governing system	8
4.	Modelling of generators, excitation and power evacuation system	8
5.	Dynamic simulation of shp plants, different response of shp plant	6
6.	Case-studies, introduction to real-time digital simulator for SHP plant	4
	TOTAL	**42**

List of Practicals: Starting, synchronizing, loading, shutting down and malfunctioning of shp plants.

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Law, A. M., "Simulation, Modeling and Analysis", 4th edition, McGraw-Hill.	2008
2.	Zeigler, B. P., Praehofer, H. and Kim, T. G., "Theory of Modeling and Simulation", 2nd edition, Academic Press.	2000
3.	Deo, N., "System Simulation with Digital Computer", Prentice Hall of India Pvt Ltd.	2006
4.	Som, S. and Biswas, G., "Introduction to Fluid Mechanics and Fluid Machines", 1st edition, McGraw-Hill.	2007
5.	Kundur, P., "Power System Stability and Control", McGraw-Hill Inc.	2008
6.	French, R.H., "Open Channel Hydraulics", McGraw-Hill Book Company.	1985

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-517A** Course Title: **MODELING, SIMULATION AND COMPUTER APPLICATION**
2. Contact Hours: L **3** T **1** P **2/2**
3. Examination Duration (Hrs.): Theory **3** Practical **0**
4. Relative Weightage: CWS **15** PRS **15** MTE **30** ETE **40** PRE **0**
5. Credits: **4** 6. Semester: **Autumn**
7. Subject Area: **PCC** 8. Pre-requisite: **Nil**
9. Objective: To give knowledge of modelling and simulation techniques and their application to hydrological and environmental process in the catchment of water bodies.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review of C++	8
2.	Principles of modeling, physical, mathematical, static and dynamic models, transport phenomena based model	6
3.	Modeling of empirical data, estimation of model parameter, goodness of fit, confidence level	3
4.	Experimental and mathematical simulation; numerical methods used for simulation and exposure to available computer softwares; parameter estimation for models and sensitivity analysis/ANN based model development.	7
5.	Design of experiment and optimization.	4
6.	Uniform and non uniform continuous distribution random numbers, computer generation of random numbers, Monte-Carlo simulation, spread sheet simulation, numerical computation techniques for continuous and discrete models	5
7.	Water quality modelling, assimilation capacity, dispersion of pollutants in water bodies	4
8.	Case studies; modelling of waste treatment and other pollution mitigation system; Monte-Carlo simulation for risk analysis of conservation of rivers and lakes, lake water balance and simulation, modelling for dependable yields from a lake	5
	TOTAL	**42**

List of Practicals: Software development for planning and designing of sewage and effluent treatment plant based C++ programming, development of model with empirical data, software development for simulation technique.

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Law, A.M., "Simulation, Modelling and Analysis", Tata McGraw-Hill Publishing Company.	2008
2.	Laffore, Robert, "Turbo C++", Galgotia Publication.	1996
3.	Gordon, G., "System Simulation-The Art and the Science", Prentice Hall	1979
4.	Deo, N., "System Simulation with Digital Computer", Prentice Hall	1998
5.	Ramaswami, A., Milford, J.B. and Small, M.J., "Integrated Environmental Modelling: Pollutant Transport, Fate and Risk in the Environment", John Wiley and Sons Inc.	2005
6.	Wainwright, J. and Mulligan, M., "Environment Modelling: Finding Simplicity in Complexity", John Wiley and Sons Inc.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-523** Course Title: **INTEGRATED MANAGEMENT OF WATER BODIES**
2. Contact Hours: L **3** T **1** P **2**
3. Examination Duration (Hrs.): Theory **3** Practical **0**
4. Relative Weightage: CWS **15** PRS **15** MTE **30** ETE **40** PRE **0**
5. Credits: **4** 6. Semester: **Autumn**
7. Subject Area: **PCC** 8. Pre-requisite: **Nil**
9. Objective: To impart knowledge about the hydrology, causes and impact of water pollution on water bodies.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Hydrology, types, hydrological processes and water balance of water bodies, estimation of present and projected demands, human impacts, inventory of human activities in a basin, land use and impact of anthropogenic activities on water quality, domestic water demand, wastewater generation, collection and treatment and disposal, urban storm water, industrial waste generaion, open defication, municipal solid wastes collection, transport and disposal, impacts of dumping in drains or sewer lines	7
2.	Point and non point sources, types of water pollution, water quality criteria and standards, designated best uses of water; equilibrium, acid base, oxidation – reduction, precipitation and complex reactions	8
3.	Physical methods (turbidimetry, nephlometry, optical methods of measurement, potentiometry, chromatography, spectroscopy); measurement of sulphates, Na, DO, BOD, TOC, all forms of N, fluorides exposure to analytical techniques of IIC like ICP, AAS, GC, biological components (periphyton, phytoplankton, zoobenthos, nekton, biodiversity indices, trophic status, P/R ratio microbiological MPN, coliform and streptococcus, bioindicators, biomonitoring of water bodies), sampling, schedule and water quality monitoring program of national rivers and lakes; sampling protocol of NRCD, standards, water quality indices, strategy for water quality management, case histories of ongoing projects.	10
4.	Principles of environmental management, EIA, water and sustainable development, involvement of stakeholders, water governance, environmental education, public participation; Legal, constitutional provisions, national policies, legal and institutional arrangement for the management of water quality and quantity.	7
5.	Application of remote sensing and GIS for water management, modeling (forecasting and growth modeling), eco–mapping, inter river basin transfer, cost –benefit analysis, environmental taxes, economics of natural resources;	10
	TOTAL	**42**

List of Practicals:

i. Measurement of the total dissolved solids (TDS), total suspended solids (TSS) and total solids (TS) in water sample
ii. Determination of total hardness, calcium, sodium, potassium, magnesium hardness of the water sample
iii. Determination of bi-carbonate carbonate, chloride, sulphate and acidity of water sample
iv. Determination of total phosphorus
v. Bacteriological examination for total coliform, faecal coliform of sewage and water
vi. Estimation of oil and grease, fluorides, volatile acids
vii. Exercise:
   a. To prepare a water budget for a watershed/sub-watershed either from a provided

case study or one where the student can obtain information of on their own
b. To carry out a water demand analysis and future projection.
c. To perform case study on IWRM for a basin

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Lenton, R. and Muller, M. and Carriger, S., "Integrated Water Resources Management in Practice", Earthscan Publishers.	2009
2.	Mollinga, P.P., Dixit, A. and Athukorala, K., "Integrated Water Resources Management Global Theory Emerging Practice and Local Needs", SAGE publication.	2006
3.	Timmerman, J. G., Pahl-Wostl, C. and Moltgen, J., "The Adaptiveness of IWRM, Analysing European IWRM Research", IWA Publisher.	2008
4.	Liu, D. H. and Liptak, B.G., "Environmental Engineers Handbook", 2nd edition CRC Press.	1999
5.	"Standard Methods for the Examination of Water and Waste Water", 21st edition, American Public Health Association.	2005
6.	Clair, S., McCarty, P.L. and Parkin, G.F., "Chemistry for Environmental Engineering", McGraw Hill Publication.	1994
7.	Kulkarni, V. and Ramachandra, T.V., "Environment Management", TERI Press.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-525** Course Title: **AQUATIC ECOLOGY**
2. Contact Hours: L **3** T **1** P **2/2**
3. Examination Duration (Hrs.): Theory **3** Practical **0**
4. Relative Weightage: CWS **15** PRS **15** MTE **30** ETE **40** PRE **0**
5. Credits: **4** 6. Semester: **Autumn**
7. Subject Area: **PCC** 8. Pre-requisite: **Nil**
9. Objective: To impart knowledge about of ecological principles applicable to aquatic resources.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Definition, relevance, principles and scope of ecology, sub-divisions, Structure and functions, biotic and abiotic components and productivity of ecosystem and energy flow, materials cycling, energetics, limiting factors, development and evolution; Trophic levels, food chain and food webs, ecological pyramids, competition, population ecology.	6
2.	Lakes, wetlands and rivers, reservoirs and springs, structure and functions, usefulness, natural and manmade ecosystems; concept, importance and conservation of aquatic biodiversity role of invasive species and its importance	9
3.	System analysis, ecosystem models, Stressed ecosystems, homeostasis, ecological succession, ecosystem resilience	5
4.	Pollution of lakes and rivers, causes, impacts and control of eutrophication; principles and application of restoration methods, ecotechnologies	6
5.	National/international perspectives, policies, Ramsar convention, NLCP, NRCD, case studies of Dal lake, Nainital lake, Chilka, Loktak and Asan wetlands, Tehri dam reservoir, river Ganges and Yamuna.	5
6.	Elementary biochemistry, salient features of biomolecules, enzymes and other tools of biotechnology, discovery and diversity, prokaryotic cell, microbial energetics, biosynthesis and nutrition, autotrophic way of life, growth, macromolecular synthesis.	5
7.	Microorganism in environment, microbiology of water, bacteria and viruses, bacteriophages, animal and plant viruses, structure, replication and quantification, structure and diversity of algae, protozoa and rotifers.	6
	TOTAL	**42**

List of Practicals:

i. To determine the pH, electrical conductivity and turbidity.
ii. To determine the Phosphorous (Total P and Orthophosphate), Nitrogen (Total N, nitrate, ammonia), Fe and Total Iron.
iii. To determine dissolved oxygen, BOD and COD.
iv. To identify Plankton, common phytoplankton, common zooplankton, common periphyton and macroinvertebrates.
v. To estimate chlorophyll.
vi. To identify common aquatic macrophytes.

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Odum, E.P., Barrick, M., and Barrett, G.W., "Fundamentals of Ecology", 3rd edition, W.D. Saunders.	2005

2.	Wetzel, R.G., "Limnology: Lakes and Rivers Ecosystems", 3rd edition, W.D. Saunders.	2005
3.	Christer, B. and Lars, A.H., "The Biology of Lakes and Ponds", Oxford University Press.	2005
4.	Cooke, G.D. et al, "Restoration and Management of Lakes and Reservoirs", 3rd edition, Taylor and Francis publication.	2005
5.	Roberts, M.B.V. and Ingram N.R., "Biology", Nelson Science Publishers.	1995
6.	Smith, J.E., "Biotechnology", 5th edition, South Asian Press.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-522** Course Title: **WASTE WATER COLLECTION, TREATMENT AND DISPOSAL**

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

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

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

5. Credits: [**4**] 6. Semester: **Spring**

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

9. Objective: To provide knowledge about collection, treatment and disposal of waste water.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Overview, sources-domestic and industrial, waste water, its quality, effluent standards, waste water load and its evaluation, flow rates, water supply data, actual measurement and analysis of flow data	4
2.	Waste water collection, sewerage systems and sewage pumping, natural drainage system and waste water disposal	6
3.	Typical sewage quality, its composition and health hazards of handling and disposal	5
4.	Software for sewer design and estimation of waste water, objectives, methods and implementation strategy of treatment processes, physical operations like screening, grit removal, flow equalisation, sedimentation; aerobic, anaerobic, attached and suspended growth processes; pond system, combination and/or alternatives, design of treatment units, life cycle cost	12
5.	Operation and maintenance of waste water treatment plants, polishing of treated waste water, disinfection, nutrient removal, natural treatment systems	5
6.	Treatment of sludge, disposal of treated effluent and sludge	5
7.	Resource generation by way of biogas generation, sale of treated water and sludge, tertiary treatment, reuse of treated water in agriculture/horticulture/construction work, CDM of conservation facilities like STPs, toilets, crematoria to generate additional revenues	5
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Tchobanoglous, G., Burton, F. L. and Stensel, H. D., "Waste Water Engineering: Treatment and Reuse", 4th edition, Tata McGraw Hill Publishing Company.	2003
2.	Davis, M.L., David, A. and Cornwell, W.C.B., "Introduction to Environmental Engineering", 3rd edition, McGraw Hill.	1998
3.	Bajwa, G.S., "Practical Handbook on Public Health Engineering", Deep Publisher.	2003
4.	"Manual of Sewerage and Sewage Treatment", CPHEEO.	1993
5.	Letterman, R.D., "Water Quality and Treatment- A Handbook of Community Water Supplies", 5th edition, American Water Works Association – Mc Graw-Hill Inc.	1988

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-526** Course Title: **ENVIRONMENTAL LAWS, PUBLIC PARTICIPATION AND INSTITUTIONAL 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 acquaint with legal aspects of environmental protection, public awareness, participation of civil society and institutions in the conservation of natural resources.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Genesis of environmental acts and main national laws, water (prevention and control of pollution) act rules, constitution of central and state boards	5
2.	Environment (protection) act rules, prevention, control and abatement of environmental pollution, hazardous wastes management and handling rules, pollution abatement policy, municipal and solid waste (management and handling rules), biomedical waste rules and chemical accidents rules	6
3.	National environmental policy, water policy, EIA guidelines of MoEF and successive amendments, biodiversity act, latest laws and amendments, industrial and MSW rules, health, safety and environment management system, water resources management through community participation	10
4.	Notification of MoEF for construction projects, National environmental tribunal act and appellate authority	5
5.	Environment audit, international protocol, treaties and conventions, Latest International global environmental concepts like global warming and its impact on water resources, Stock-holm and Basal convention, Copenhagen conference, Rio-Earth summit, maintenance of biodiversity, awareness	6
6.	Modes of awareness generation, information, education, communication, costing of awareness generation, Sustainability and impact assessment, role of civil society in awareness generation, stages and forms of public participation, forms of public participation	10
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	"Manual on Environmental Law", Commercial Law Publishers.	2001
2.	Upadhyay, S. and Upadhyay, V., "Handbook on Environmental Laws (Vol. II)-Water Laws, Air Laws and the Environment", 1st edition, Reed Elsevier India Private Limited.	2002
3.	Trivedi, P.R., "International Environmental Laws", APH Publishing Corporation.	1996
4.	Magdolna, T.N., et al, "Manual on Public Participation in Environmental Decision Making, Current Practice and Future Possibilities in Central and Eastern Europe". Budapest	1994
5.	"Pollution Control Acts, Rules and Notifications", Vol.-I, Central Pollution Control Board	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-527** Course Title: **LABORATORY COURSE**
2. Contact Hours: L **0** T **0** P **3**
3. Examination Duration (Hrs.): Theory **0** Practical **0**
4. Relative Weightage: CWS **0** PRS **50** MTE **0** ETE **0** PRE **50**
5. Credits: **2** 6. Semester: **Spring**
7. Subject Area: **PCC** 8. Pre-requisite: **Nil**
9. Objective: To provide practical knowledge about various methods of analysis related to environmental degradation.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Solid waste characterization, soil characteristics: permeability, porosity, LL, PL, grain size distribution, soil classification and resistivity.	3
2.	Performance evaluation: sewage and effluent treatment plants, disposal of treated solid waste and treated water, possibilities of resource generation on account of biogas and manure production.	2
3.	Performance evaluation of toilets, crematoria and river fronts.	1
4.	Flow measurement techniques: 'V' notch and area-velocity method.	1
5.	Sediment analysis	1
6.	Trace element analysis	4
7.	Performance evaluation of various waste water treatment systems: lagoons, oxidation pond, ASP, UASB and other treatment plants	2
8.	Students to work at least for two weeks time at any STP set-up under GAP/NRCD to carry out the comprehensive evaluation of STPs or ETPs	Throughout the semester
9.	Demonstration of latest equipment of Institute Instrumentation Centre.	
	TOTAL	**14 x 3 = 42**

Continuous evaluation will be carried out for each experiment.

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	"Standard Methods of Analysis", 20th edition, Joint publication of APHA, AWWA and WEF.	2003
2.	Indian and International Standards.	-
3.	"Standard Method for the Examination of Water and Sewage", American Public Health Association.	2008
4.	Ramesh, R., and Anbu, M., "Chemical Methods for Environment Analysis: Water and Sediment", Macmillan Publishers India,	1996
5.	Carter, M.R. and Gregorich, E.G., "Soil Sampling and Methods of Analysis", 2nd edition, John Wiley and Sons Inc.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-544** Course Title: **PROJECT FORMULATION AND IMPLEMENTATION**
2. Contact Hours: L **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 project management, related activities and monitoring.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Project objectives and formulation, preparation of pre-feasibility and detailed project reports,	5
2.	Project implementation methods and management, project management agencies, public hearing process	4
3.	Project planning, background of network charts, network elements, drawing the network, PERT and CPM comparison and application, monitoring and control, management concepts.	10
4.	Tendering procedures, tender documents of central and different state governments, standard tender documents from international bodies like world bank, ADB and other funding agencies, on-line tendering procedure, procurement	6
5.	Cost estimates, economic and financial analysis, internal rate of return, cost benefit analysis	5
6.	Financial management, resource mobilization and sustainability of the project, use of application softwares in project management, equipment development of lab, identification of appropriate equipment	8
7.	Specific regulations/statuary acts of other countries not practiced in India, problems of project implementation,	4
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	"The Engineering and Constructive Contract", The Institutions of Civil Engineers.	1995
2.	"Quality in the Constructed Project- A Guide for Owners, Designers and Constructors", Vol.-I, Manual No. 73, American Society of Civil Engineers.	1990
3.	Tambari, L.P. and Jha, C.N., "Commentary on MP Works Department Manual", Suvidha Law House.	2002
4.	Hutchings, J.F., "Project Scheduling Handbook", Marcel Dekker Inc.	2004
5.	Sengupta, B. and Guha, H., "Construction Management and Planning", Tata McGraw-Hill Publishing Company.	1995

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-548** Course Title: **COASTAL POLLUTION MONITORING AND IMPACT 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 impart knowledge of coastal pollution and its impact assessment and monitoring on ocean water quality.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Brief history, importance, fields of application and fundamental concepts of coastal pollution, collection, processing, analysis and quality control of data.	7
2.	Fundamentals of acoustic wave propagation in ocean waters, sound velocity computation, attenuation, refraction and reflection, frequency band width, multibeam echosounders, sea floor classification.	5
3.	Water levels and flow measurements, principles of tides and water levels, astronomical tide producing forces, tidal characteristics, non-tidal water level variations, tide and water level datum, harmonic analysis and tide prediction, principles of tidal currents, measurements and prediction.	7
4.	Biological/chemical indicators of coastal pollution, methods for the assessment of coastal and marine pollution, biological productivity and pollution monitoring, physical/chemical/biological water quality, sampling techniques and problems, nutrients, anoxia, impacts of heavy metals, pathways of radioactivity, data storage and processing, water quality standards.	7
5.	Coastal pollution, types, causes and impact, concept and guidelines of sewage or sludge disposal into the sea.	7
6.	Notification of coastal regulation zone (CRZ) and environment clearance with practical case studies, desalination units for drinking water.	4
7.	Case studies of EIA of developmental projects on coastal areas.	5
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Ingham, A.E., "Sea Surveying", John Wiley and Sons Inc.	1975
2.	Andersen, A.T., "A Manual of Chemical and Biological Methods for Seawater Analysis", Oxford Pergamon Press.	1984
3.	Hocking, M.B., "Handbook of Chemical Technology and Pollution Control", 3rd edition, Academic Press.	2006
4.	Spellman, F.R., "The Science of Environmental Pollution", 2nd edition, CRC Press.	2009
5.	Bhatia, S.C., "Textbook of Air Pollution and its Control", Atlantic Publishing Company.	2007
6.	Pepper, I.L., Gerba C.P. and Brusseau, M.L. "Environmental and Pollution Science", 2nd edition, Academic Press.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-550** Course Title: **APPLICATION OF RS AND GIS IN ENVIRONMENT 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 familiarize with application of Remote Sensing and GIS Techniques for Environmental Management and Conservation.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Definition of remote sensing, ideal remote sensing system, sensors and their characteristics.	4
2.	Image processing software, image registration, image enhancement, image classification.	5
3.	Definition and components of GIS, sources of data, coordinates and projection system, global Positioning System.	5
4.	Spatial and non spatial data, raster and vector data, data errors and editing creation of data base, special data operations and analysis.	5
5.	Applications of RS and GIS in optimal routing of solid wastes collection system of an urban area, environmental siting of industries, zoning atlas development and impact of land use and land cover change on environment.	6
6.	Re-modelling of water distribution and sewer network systems using GIS.	5
7.	GIS for sustainable land use urban development planning, rivers, lakes and coastal areas.	6
8.	Groundwater vulnerability modelling using GIS, environmental degradation and soil erosion of catchment, reservoir capacity and sedimentation.	6
	TOTAL	**42**

List of Practicals:
i. Geo referencing of toposheet and satellite image
ii. Image enhancement and classification – supervised and unsupervised
iii. Digitization of lake boundary, river network and other features
iv. Data collection from GPS
v. Development of environment database on GIS package
vi. Queries and analysis from GIS database

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Clarke, K.C., Parks, B.O. and Crane, M.P., "Geographic Information Systems and Environmental Modeling", Prentice Hall of India Pvt Limited.	2006
2.	Lillesand, T.M. and Kiefer, R.W., "Remote Sensing and Image Interpretation", 5th edition, John Willey and Sons Pte. Ltd.	2009
3.	Panda, B.C., "Remote Sensing Principles and Applications", Viva Books Private Limited.	2006
4.	Lo, C.P. and Yeung, A. K.W., "Concepts and Techniques of Geographic Information Systems", Prentice Hall	2009
5.	Burrough, P.A., "Principles of GIS for Land Resources Assessment", Oxford University Press.	2007

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-552** Course Title: **HYDROLOGY AND MODELLING OF WATER BODIES**
2. Contact Hours: L **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 hydrology and modeling of water bodies.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Definition, importance, practical applications of hydrology; global water availability, India's water availability, hydrologic cycles; definition, forms and types of precipitation, measurement of rain fall using rain gauges, selection of rain gauge stations, consistency of rainfall data, computation of mean rainfall, estimation of missing rainfall data, presentation of precipitation data.	5
2.	Losses from evaporation, definition, process, factors and measurement, estimation using empirical formulae; infiltration, factors affecting infiltration capacity, measurement, Harton's infiltration equation, infiltration indices, runoffs, concept of catchments, water budget, components, factors affecting runoff, rainfall-runoff relationship using simple regression analysis, agricultural practices to minimize impacts of runoffs carrying chemicals and pesticides on river ecology.	6
3.	Hydrographs, definition, components and its derivation from simple storm hydrographs, base flow separation, S-curve and its uses, stream flow and its stages, discharge measurement by area-velocity and slope area methods, simple stage discharge relation.	6
4.	Sediment yield and its determination in reservoir/lake, reservoir sediment control, water wealth, river basins and their potential, importance of water resources projects in India, need of minimum ecological flow in rivers, its regulations in India and other countries, small scale and small tank harvesting, urban rainwater harvesting, methods of ground water recharge.	7
5.	Types of pollutants, modeling approach, molecular diffusion in a stagnant fluid, molecular diffusion equation and its classical solutions advection-diffusion equation, its classical solutions and its depth and cross-section averaging, shear flow dispersion, Taylor's analysis of turbulent shear flow.	5
6.	Mechanisms of vertical mixing from steady transverse line, steady and unsteady point sources, statistical analysis of water quality, mechanisms of transverse mixing, constant-coefficient and two-dimensional numerical mixing models, cumulative discharge method for transverse dispersion, transverse mixing from a diffuser of finite length.	5
7.	Mechanism of longitudinal dispersion, Fickian and alternative models, estimation of mixing length, analytical and numerical solutions of longitudinal dispersion equation, estimation of longitudinal dispersion coefficients, non-Fickian behavior of dispersion process, field measurements of mixing in river and lakes	8
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/Reprint
1.	Subramanya, K., "Engineering Hydrology", 3rd edition, Tata McGraw Hill.	1994

2.	Raghunath, H.M., "Hydrology", Wiley Eastern Publication.	2006
3.	Sharma, R.K. et al, "Hydrology and Water Resources Engineering", Oxford and IBM.	2009
4.	Rutherford, J.C., "River Mixing", 1st edition, John Wiley and Sons.	1994
5.	Fischer, H.B., et al, "Mixing in Inland and Coastal Waters", Academic Press.	1979
6.	Martin, L.M. and McCurchen, S.C., "Hydrodynamics and Transport for Water Quality Modelling", Levis Publishers.	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-576** Course Title: **PLANNING AND MANAGEMENT OF ENVIRONMENTAL FACILITY**

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

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

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

5. Credits: **4** 6. Semester: **Spring**

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

9. Objective: To provide knowledge about conservation and management of environment facitity.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Estimation of earthwork volume by cross-section, spot levels and contour, construction of mass diagram, calculation of haul, over haul and economic haul lead and lift.	4
2.	Procedure for working out quantities and rates for lime and cement mortars, lime and cement concrete, brick and stone masonry, flooring, plastering, RCC works, centering and works for different RCC items, doors, windows and ventilators.	5
3.	Drawing up specifications for construction materials such as coarse aggregate lime, cement, mortars, plain and reinforce concrete, brick masonry, stone masonry, flooring, roofing, plastering, wood work, earthwork and surfing, water supply distribution lines, surface and sub-surface drainage line (including stone-ware pipes).	7
4.	Methods for estimating the quantities, preparation of detailed and abstract estimates for the environmental engineering works like septic tank, manhole, pump house, store room, calculation for procuring steel for reinforcement for the basic components such as small slabs, chejja and lintels.	8
5.	Financial aspects, cost price and its different forms, gross and net income, outgoings and its types, obsolescence, annuity, year's purchase.	5
6.	Capital cost, operating cost, capitalized value, time value of money, sinking fund, depreciation and methods of its calculation, cost fixation on the produced commodity.	5
7.	Fiscal incentives for environmental protection: exemption from it, investment and depreciation allowance, exemption from tax to capital gains, rebate in cess levied on consumption of water.	4
8.	Measures for sustainability, operation and maintenance of the assets and facilities	4
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Dutta, B.N., "Estimating and Costing", S. Dutta and Company.	1996
2.	Mahajan, D.C., "Estimating and Costing in Civil Engineering", 5th edition, Rainbow Book Company.	2010
3.	Amin, R.K., "Economics for Engineers", Charotar Book Stall.	1963
4.	Chand, T., "Engineering Economics", Nem Chand and Brothers.	2000
5.	"Manuals on Water Supply and Wastewater Treatment", CPHEEO.	1993
6.	Current Schedule of Rates (SR) of PWD, KUWS and DB.	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of the Department/Centre: **ALTERNATE HYDRO ENERGY CENTRE**

1. Subject Code: **AH-580** 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 about impact of climate change on water resources.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Natural eco-systems, autotrophs, heterotrophs, energy flows, pre-industrial humanity; efficiency of photosynthesis and ecosystems like forests, crops, respiration, combustion and other oxidation processes, biomethanation.	8
2.	History of climate change, greenhouse gas effect, anthropogenic climate change, role of different gases, global climatic problems, integrated assessment model, impacts and adaptation, uncertainties precautionary principle.	8
3.	Biological and physico-chemical methods for carbon sequestration, CO_2 capture from large point sources, pre-, post- and oxy-combustion technology, transport, storage and monitoring, feasibility, economics and public perceptions.	8
4.	Water resources and green house gas emissions, mitigation measures and adaptation to climate change.	8
5.	Kyoto protocol, UNFCCC, IPCC, geopolitics of GHG control, CDM and other emission trading mechanisms, non-CO_2 GHGs, relevance for India, procedure for registration for CDM projects and its benefit.	6
6.	Case studies.	4
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1.	Metz, B. et al, "Climate Change 2007: Mitigation of Climate Change", Working group III of IPCC, Cambridge University Press.	2007
2.	Pachauri, R.K., "Dealing with Climate Change", TERI Press.	2009
3.	Orford, M. et al, "Climate Change and the Kyoto Protocal's Clean Development Mechanism" 1st edition, ITDG publication.	2004
4.	Graedel, T.E. and Crutzen, P.J., "Atmosphere, Climate and Change", W. H. Freeman Publishers.	1997
5.	Stevens, W.K., "The Change in the Weather: People, Weather and the Science of Climate", Delacorte Press.	1999

Appendix – G
Item No.SENATE:33.12

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code: **ES-421** Course Title: **ROCK AND SOIL MECHANICS**

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

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

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

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

7. Pre-requisite: **NIL**

9 Objective: To impart knowledge on the response of rocks and soils to civil engineering activities

10. Details of Course:

S. No	Contents	Contact Hours
1.	Definitions and importance of rock and soil mechanics	2
2.	State of stress, Mohr's circle relations, intact rock and rock mass; Mohr–Coulomb failure criteria, deformability property of rocks and soils	6
3.	In-situ measurement of strength of rocks and soils, strength of joints	6
4.	Rock mass classification systems, MR and Q- system, application of classifications for underground support and assessment of strength properties of rock mass	10
5.	Weight – volume relationship of soil, index properties of soils, permeability and consolidation of soils	8
6.	Determination of shear strength parameters of soils	4
7.	Soil exploration techniques, baring capacity of soils, foundation of engineering structures	6
	Total	42

10. Suggested Books:

S. No	Name of Authors / Books /Publisher	Year of Publication/ Reprint
1	Coduto, D.P., William, A.K., Young, M.C.R. `"Geotechnical Engineering: Principles and Practices", Prentice Hall	2010
2	Potts, D.M., Jardine, R.J. and Higgins, K.G. "Advances in Geotechnical Engineering", Thomas Telford Services Ltd.	2004
3	Ranjan, G.and Rao, A.S.R., "Basic and Applied Soil Mechanics", New Age International (P) Ltd	2000
4.	Singh, B.and Goel, R.K, "Rock Mass classification: A Practical Approach in Civil Engineering", Elsevier	1999
5	Hudson, J,A. and Harrison, J.P. "Engineering Rock Mechanics: An Introduction to the Principles' Elsevier	2005
6.	Zimmerman,R., Cook, J.C.,Jaeger, N.G and Cook, N.G.W, . "Fundamentals of Rock Mechanics' John Wiley Sons .	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code: **ES- 422** Course Title: **INDIAN MINERAL DEPOSITS**
2. Contact Hours : **L: 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: **DEC**
8. Pre-requisite: **ES-301**
9. Objective: To provide concepts on occurrence, geology, geochemistry and genesis of important economic mineral deposits of India.

19. Details of Course:

Sl. No.	Contents	Contact Hours
1.	Introduction and distribution of various mineral deposits in India with special reference to crustal evolution and metallogeny	**6**
2.	Mineralogy, classification, mode of occurrence, geochemistry and genesis of bauxite, iron and manganese deposits	**9**
3.	Types, characteristics and geological setting of copper, lead zinc, chromite, tin and tungsten deposits.	**8**
4.	Geology, pattern of mineralization, genetic models of gold, silver and platinum deposits, current exploration scenario in India	**5**
5.	Nature and distribution of mica, magnesite, bentonite, baryte limestone and phosphate deposits of India	**9**
6.	Geological controls, occurrence and reserves of coal and petroleum in India	**5**
	Total	**42**

11 Suggested Books

S. No	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1	Banerjee, D.K. "Mineral Resources of India", The World Press	**1992**
2	Prasad, U. "Economic Geology", CBS publishers	**1996**
3	Talapatra, M., "Modeling and Exploration of Mineral Deposits", Capital Publishing	**2006**
4	Indian Minerals Yearbook, Part I and II, IBM Publications	**2007**
5	Ramakrishnan, M and Vaidyanadhan, R. "Geology of India". Special Publication of Geological Society of India	**2008**

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code: **ES-423** Course Title: **COAL GEOLOGY**
2. Contact Hours: **L: 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: **DEC**
8. Pre-requisite: **ES- 301**
9. Objective: To impart knowledge on various aspects of coal formation and basics of coal petrography.
10. Details of Course:

S. No	Contents	Contact Hours
1	Introduction, types of coal, physical properties of coal, different constituents of coal	8
2	Microscopic study of coal, macerals and microlithotypes,	8
3	Coal petrography, microscopic constituents of coal, vitrain, clairen, urain and fusain; sapropylic coal and its economic significance.	8
4	Origin of coal, allochthonous and autochthonous theories; Gondwana and Tertiary coal deposits; comparison of origin of Gondwana and European coal formation	6
5	Global distribution of coal deposits, Distribution and Geology of Coal deposits of India, Geology of Jharia and Raniganj coalfields	8
6	Coal mining and Industrial use of coal	4
	Total	42

1. Suggested Books:

S. No	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1	Thomas L., "Coal Geology", John Wiley and Sons Inc	2002
2	Harder, V. M., R. P., Alexander, C. H., James, C. P., Douglas, "Atlas of Coal Geology: Coal Geology and Coal Petrology", American Association of Petroleum Geologists (AAPG)	1998
3	Douglas, C. P., "Geology in Coal Resource Utilization", American Association of Petroleum Geologists	1991
4	Ward, C. R., "Coal Geology and Coal Technology", Blackwell Scientific Publications	1985
5	Ross, C. A. and Ross, June R. P., "Geology of Coal", Hutchinson Ross Pub. Co.	1984
6	Tatsch, J.H., "Coal Deposits ", Tatsch Associates	1980

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code: **ES-424** Course Title: **HIMALAYAN GEOLOGY**
2. Contact Hours : **L: 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: **DEC**
8. Pre-requisite: **ES- 203 or its equivalent**
9. Objective: To provide basic knowledge of geology, structure and tectonics of Himalaya
10. Details of course:

S. No.	Contents	Contact Hours
1.	Introduction, importance and significance of Himalayas, their morphology, classification of Himalayas, regional, physical and geological.	4
2.	Formation of Himalayas, Indian plate margin, plate movement and rise of Himalayas, Himalayan fore deep, Indo Gangetic plain and its relation with peninsular India.	8
3.	Geology of outer Himalayas, Siwalik foothills, Himalayan frontal fault and upper Ganga region.	5
4.	Geology of lesser Himalayas, geological history and structures, sedimentary basins and igneous and metamorphic belts.	6
5.	Geology of higher Himalayas, its geological history and metamorphism.	6
6.	Tethys Himalayas, its geology and structure, and relationship with higher Himalayas and trans-Himalayan geology.	5
7.	Himalayan seismicity, its characteristics, major earthquakes, gravity and magnetotelluric characteristics and structure of Himalayas, mineral deposits and metallogeny of Himalayas.	8
	Total	**42**

11.: Sugegsted Books :

S. No.	Name of Author/Books / Publishers	Year of Publication/ Reprint
1	Gansser A., "Geology of Himalayas", Wiley and Sons	1964
2.	G. Kumar, "Geology of Uttar Pradesh and Uttaranchal", Geological Society of India	2005
3.	K. S. Valdiya, "Geology of Kumaon Himalayas", Wadia IInstitute of Hinalayan Geology	2004
4.	Srikantia S.B. and Bhargava, O.N. , "Geology of Himachal Pradesh", Geological Society of India	2005
5.	Brown G.G., Hawkesworth C.J. and Wilson, R.C.L., "Understanding the Earth- A New Synthesis", Cambridge Univ. Press	1992

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code :**ES-425** Course Title: **ADVANCED CONCEPTS IN STRATIGRAPHY**
2. Contact Hours : **L: 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: **DEC**
8. Pre-requisite: **ES- 302**
9. Objective: To impart advanced knowledge of current stratigraphic methods

10.Details of Course:

S. No	Contents	Contact Hours
1.	Introduction to stratigraphic classification and correlation.	5
2.	Magnetostratigraphy; concept and applications.	6
3.	Isotope stratigraphy; oxygen, carbon, strontium, sulphur.	8
4.	Sequence stratigraphy; eustatic and relative sea level changes, sequences, systems tracts, parasequences and sequence stratigraphic surfaces.	10
5.	Seismic stratigraphy: concept and application.	5
6.	Boundary problems in stratigraphy: Precambrian-Cambrian, Permo-Triassic, Cretaceous-Tertiary, Neogene-Quaternary.	8
	Total	42

11. Suggested Books:

S. No	Name of Books/ Authors/Publisher	Year of Publication/ Reprint
1.	Lemon, R. R., "Principles of Stratigraphy", Merill Publishing Co.	1990
2.	Brookfield, M.E., "Principles of Stratigraphy", Blackwell Publishing Ltd.	2004
3.	Boggs, S. Jr., "Principles of Stratigraphy", Merill Publishing Co..	1987
4.	Emery, D. and Myers, K (Eds.), "Sequence Stratigraphy", Blackwell Science Ltd.	1996
5.	Catuneanu, O., "Principles of Sequence Stratigraphy", Elsevier.	2006
6.	Vaidyanathan, R. and Ramakrishnan, M., "Geology of India", vol. 1 and 2, Geological Society of India,	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code : **ES-426** Course Title : **ADVANCED PALEONTOLOGY**
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: **Autumn:** 8. Subject Area: **DEC**
6. Pre-requisite: **ES-209 or its equivalent**
9. Objective : To impart knowledge of advanced theoretical concepts and laboratory techniques in paleontology
10. Details of Course

S. No	Contents	Contact Hours
1.	Fossil record, evolutionary patterns and processes; micro-and macroevolution, adaptation, co-evolution, rates of evolution, cladistics, taxonomy, phylogeny, biostratigraphy.	10
2.	Paleoecology, nature, paleocommunities, evolutionary paleoecology, form and function, biomechanics, paleoenvironmental and paleoclimatic reconstruction including geochemical proxies.	8
3.	Paleobiogeography, vicariance, dispersal.	4
4.	Taphonomy, introduction, factors responsible for taphonomic bias.	4
5.	Trace fossils, introduction and various ichnofacies.	5
6.	Major mass extinction events and their causes with special reference to Permo-Triassic, Cretaceous –Tertiary and Neogene – Quaternary boundary extinctions.	8
7.	Laboratory techniques in paleontology; extraction of microfossils, preparation of macrofossils, electron microscopy.	3
	Total	42

11. Suggested Books:

S. No	Name of Authors/Books/Publishers	Year of Publication/ Reprint
1.	Foote, M. and Miller, A. I., "Principles of Paleontology" W.H. Freeman and Company	2007
2.	Briggs, D.E.and Crowther, P.R. (Eds.), "Paleobiology: A Synthesis", Blackwell Scientific Publications	1990
3.	Hammer, O. and Harper, D., "Paleontological Data Analysis", Blackwell Publishing	2006
4.	Benton, M.J. and Harper, D.A.T., "Introduction to Paleobiology and the Fossil Record', Wiley-Blackwell	2009
5.	Green, O.R., "A Manual of Practical Laboratory and Field Techniques in Paleobiology', Kluwer Academic Publishers	2001
6.	Martin, R.E. (Ed.), "Environmental Micropaleontology", Kluwer Academic/Plenum Publishers	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code : **ES-431** Course Title **GEOHAZARD 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: **DEC**
8. Pre-requisite: **NIL**

9. Objective To impart basic concepts of geological hazards and management

10. Details of Course

S. No	Contents	Contact Hours
1	Introduction to geohazards, disasters, natural and manmade, environmental concepts.	4
2	Definition of hazard, vulnerability and risk assessment.	4
3	Terrain units, mapping and landslide assessment, droughts, desertification, soil erosion, mitigation and management.	8
4	Geology of earthquakes, seismic zone mapping and microzonation, a0ctive faults, their characteristics, recognition of surface ruptures, mitigation and management, volcanic hazards.	8
5	Introduction to flood, flood hazard mapping, river behavior in different tectonic setups, mitigation and management.	7
6	Coastal hazards, tsunamis and sea level changes.	5
7	Preparedness and management, how to cope with disasters, pre and post disaster preparedness, education and training of managers, and what to do when disaster strikes.	6
	Total	42

11. Suggested Books:

S. No	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1	Hoek E. and Bray J.W., "Rock Slope Engineering", Spoon Press, 3rd edition.	1980
2	Thornbury W.D., "Applied Geomorphology", John Wiley and Sons	1980
3	Keller E.A., "Environmental Geosciences", Prentice Hall.	1976
4	Petak W.J. and Aitkinson A.D., "Natural Hazard risk Assessment and Public Policy", Springer-Verlag.	1982
5	Roy .P.S., Van Western C.J. and Jha V.J., "Natural Disasters and Mitigation", IIRS.	2000
6	Haque C. E., "Mitigation of Natural Hazards and Disasters", International perspectives", Springer.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code: **ES-432** Course Title: **ADVANCED ENGINEERING GEOLOGY**

2. Contact Hours : **L: 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: **DEC**

7. Pre-requisite: **ES - 405**

9. Objective: To impart knowledge about surface and subsurface investigations for river valley projects and evaluation of landslides

10. Details of Course:

S. No	Contents	Contact Hours
1.	Limitations of engineering geological investigations for engineering projects	2
2.	Systematic investigations for dams, reconnaissance, detailed, preconstruction and construction stage investigations	6
3.	Water pressure test at dam site, selection of sites, arrangements for test, test procedures, collection and interpretation of data	6
4.	Foundation treatments for dams, environmental impacts of dams and reservoirs	8
5.	Different ground conditions for tunnel excavation, tunneling problems, identification of tunneling problems and support measures	6
6.	Geophysical investigations for river valley projects	4
7.	Systematic investigations for route locations in hills; bridge investigations	4
8.	Investigations for landslides, mapping, types, causative factors, analysis and remedial measures	6
	Total	42

11. Suggested Books:

S. No	Name of Authors/Books/Publisher	Year of Publication/ Reprint
1	Watham, T. "Foundations of Engineering Geology", Spon Press	2009
2	Defreitas, M. and Defreitas, M.H., "Engineering Geology: Principles and Practices" Springer Verlag	2008
3	Bell, F.G., "Engineering Geology" Butterworth and Heinemann	2007
4	Wyllie, D.C., "Foundations on Rock" Routledge	1999
5	Singh, B.and Goel, R.K ."Rock Mass Classification: A Practical Approach in Civil Engineering"; Elsevier	1999
6	Wyllie, D.C. and Mah, C.W. "Rock Slope Engineering: Civil and Mining"; Taylor and Francis	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code: **ES-433** Course: **ADVANCED 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: **DEC**

8. Pre-requisite: **ES - 401** 8

9 Objective of Course: To provide advanced knowledge of remote sensing techniques of data acquisition, processing and interpretation with suitable examples from geosciences

10. Details of Course:

S. No	Content	Contact Hours
1.	Blackbody radiation principle and atmospheric interaction, ground interaction including selective reflection, absorption and emission of radiation	4
2.	Spectra of mineral groups and igneous, sedimentary and metamorphic rocks in optical and thermal-IR parts of the spectrum	4
3.	Orbits and satellites, field data/ground truth	2
4.	Digital scanner systems and cameras, factors affecting sensor performance, types of sensor resolutions, status of space-borne sensors	5
5.	Geometric distortions in image data, factors affecting radiometric quality of image data	4
6.	Principle of image interpretation in the solar reflection region	2
7.	Thermal infra-red sensing and interpretation; apparent thermal inertia mapping, temperature estimation; spectral emmissvity mapping	4
8.	Advanced techniques of image data correction, enhancement and classification; multi-image data integration	5
9.	Hyperspectral sensing, microwave sensors, SAR image data interpretation, SAR interferometry	6
10.	Geological applications in geomorphology, structure, lithology and resources exploration	6
	Total	42

List of Practicals:

S. No	Contents
1.	Familiarization with various types of image and photo products, Image Processing software – ERDAS, ENVI, ILWIS.
2.	Collection of spectra of igneous, sedimentary and metamorphic rocks and various natural objects in the field using spectro-radiometer.
3.	Visual image interpretation, image interpretation elements and image interpretation key.
4.	Image enhancement, feature reduction and digital image classification.
5.	Structural, lithological and geomorphological mapping using satellite images; application approaches in exploration.

11. Suggested Books:

S. No	Name of Authors/ Books / Publishers	Year of Publication/ Reprint
1.	Gupta, R. P., "Remote Sensing Geology, Springer-Verlag	2003
2.	Henderson, F. M., and Lewis, A. J., (Eds). "Principles and Applications of Imaging Radar. Manual of Remote Sensing, vol.2, John Wiley and Sons.	1998
3.	Rencz, A. N., (Ed). "Manual of Remote Sensing", vol.3. "Remote Sensing for Earth Sciences", John Wiley and Sons.	1999
4.	Richards, J.A., and Jia, X., "Remote Sensing Digital Image Analysis: An Introduction" Springer Verlag .	2005
5.	Jensen, J. R., "Introductory Digital Image Processing", Prentice Hall.	2007
6.	Lillesand T. M, Keifer, R. W., and Chipman, J.W., "Remote Sensing and Image Interpretation, 8th Edition", John Wiley & Sons.	2007
7.	Sabins, F.F. Jr., "Remote Sensing-Principles and Interpretation", Freeman and Co, .	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code: **ES-434** Course: **ADVANCED GEOGRAPHIC INFORMATION SYSTEMS**

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: **DEC**

8. Pre-requisite: **ES – 403**

9. Objective of Course: To impart advanced knowledge of GIS technology and its integration with remote sensing and GPS and applications to earth sciences

10. Details of Course:

S. No	Content	Contact Hours
1.	Different co-ordinate systems, various data models in GIS, concept of 'no data'.	6
2.	Spaghetti, Polygon, DIME vector data models, construction of topology; its requirements and limitations.	5
3.	Various types of digital elevation models (DEM), its derivatives, DEM based Surface hydrologic modelling and applications, DEM applications in quantitative geomorphology.	8
4.	Advanced GIS analysis: network, neighbourhood, weighted overlay, different types of buffering techniques, change detection.	8
5.	Classification methods in GIS, modelling in GIS.	4
6.	Precision and accuracy, errors in GIS, their detection and optimization.	3
7.	Concept of global positioning system (GPS), differential GPS, GPS applications in Earth Sciences, GPS integration with GIS and remote sensing.	8
	Total	**42**

11. List of Practical:

S. No	Content
1.	Familiarization with various GIS software
2.	Georeferencing of scanned maps, satellite images, fly-through projection etc. image to map, map to map and image to image rectifications
3.	Vector data generation / digitization and topology construction
4.	Deriving various standard DEM derivatives and surface hydrologic modeling for watershed characteristic and stream networks
5.	Performing various GIS analysis functions / operations, classification of continuous data by various methods and their comparisons
6.	Utilization of various standard models e.g. USLE, SWAT, MODFLOW etc. in GIS
7.	Field utilization of GPS & differential GPS and integration / applications of GPS data into remote sensing and GIS

12. Suggested Books:

S. No	Name of Authors / Publishers	Year of Publication/ Reprint
1.	Tomlinson, R., "Thinking About GIS: Geographic Information System Planning for Managers" 3rd Ed., ESRI Press	2008
2	Michael, D. N., "GIS Modeling in Raster", John Wiley & Sons Inc.	2001
3.	Maguire, D., Michael, B. and Michael, G., "GIS, Spatial Analysis, and Modeling", ESRI Press	2005
4.	El-Rabbany, A., "Introduction to GPS: The Global Positing System", 2nd Ed., Artech House	2006
5.	Steede-Terry, K., "Integrating GIS and the Global Positioning System", ESRI Press	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT **DEPARTMENT OF EARTH SCIENCES**

1 Subject Code: **ES-435** Course Title: **PETROLEUM PROSPECT EVALUATION**

2 Contact Hours: **L -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: **DEC**

8. Prerequisite: **ES-409**

9 Objective: To evaluate petroleum prospects of sedimentary basins using advanced methodologies

10 Details of course:

S.No.	Contents	Contact Hrs.
1.	Introduction to the geology of petroleum, and petroleum exploration, petroleum occurrence, origin, migration, traps, above – surface, surface, subsurface exploration	**6**
2.	Source rocks and their classification; source rock evaluation in terms of quantity, quality of organic matter and its maturation	**5**
3.	Burial history and maturation, models of organic matter; identification of petroleum kitchen, time of petroleum generation and primary migration	**5**
4.	Petroleum reservoir , reservoir rocks and their classification, evaluation of reservoir rocks - pore space, pore-fluid saturation, pore fluids movements, compressibility of reservoir rock system	**6**
5.	Drilling, coring, logging, drill stem testing, casing and cementation, perforation, production testing	**8**
6.	Mechanism of oil/gas production, water, gas and gravity drives well stimulation methods and enhanced recovery of hydrocarbons	**6**
7.	Petroleum resources, reserves and their categories, estimation of reserves – volumetric methods, pressure decline methods and material balance approach	**6**
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors/ Books//Publishers	Years of Publication/ Reprint
1.	Cliff, R.M. and Barrows, M.H.; " Hydrocarbon generation and source rock evaluation- origin of Petroleum" ,AAPG Publication.	1982
2.	Dake, L.P., "Fundamentals of Reservoir Engineering (Developments in petroleum Sciences)," Elsevier Science	2001
3.	Dandekar, Y. A. " Petroleum Reservoir Rock and Fluid Properties"; CRC – Taylor and Francis	2006
4.	Ellis, D.V. and Singer, J.M., "Well logging for Earth Scientists , Second Edition" , Springer	2008
5.	Nind, R.C., " Principles of Oil well Production", McGraw Hill.	1991
6.	Selley, R.C.' "Applied Sedimentology, second edition"; Elsevier Science	2000
7.	Waples, D.W., "Geochemistry in Petroleum Exploration", D. Reidel Publ. Company	1985

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code : **ES - 436** Course Title : **ENVIRONMENTAL GEOCHEMISTRY**

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

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

4. Relative weightge: **CWS** [25] **PRS** [0] **MTE** [25] **ETE** [50] **PRE** [0]

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

8.Pre-requisite: **ES- 202 or equivalent**

9. Objective To introduce various Earth environmental processes and associated geochemical changes

10. Details of Course:

S. No	Contents	Contact Hours
1	Residence time, earth reservoirs, mass transfer concepts	4
2	Equilibrium thermodynamics, kinetics, acid-base equilibria, oxidation-reduction reactions, reaction rate mechanisms	6
3	Rivers, river-water components, suspended matter in rivers, river runoff, factors controlling global sediment loads in rivers, nutrients in river water, physico-chemical and biological processes in lakes, pollutive changes in lakes, biogeochemical cycle of phosphorus	8
4	Marginal marine environments, conservative and non-conservative elements, nutrient removal and heavy metals in estuaries, Oceans, modeling sea-water composition, major processes of seawater modifications, biogeochemical cycle of nitrogen	8
5	Atmospheric divisions and compositions, biogeochemical cycle of carbon and sulfur, acid rain, green house gases and effects, ozone hole	8
6	Rock-water interactions, acid mine drainage, heavy metals and metalloids, trace elements and organic compounds in natural waters, sediment organic matter and tracking paleo-environment	8
	Total	42

11. Suggested Books:

S. No	Name of Authors/Books/ Publisher	Year of Publication/ Reprint
1	Drever, J.I., "The Geochemistry of Natural Waters", Prentice-Hall Publ., 3rd Ed.	1997
2	Ruddiman, W.F., "Earth's Climate", W.H.Freeman & Co. NY	2001
3	Killops,S. & Killops, V., "Introduction to Organic Geochemistry", Blackwell Publ.	2005
4	Berner, E.K.,and Berner, R.A., "The Global water Cycle- Geochemistry and Environment", Prentice-Hall Publ.	1987
5	Ahrens, C.D. "Essentials of Meteorology", Thomson Learning Publ.	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code: **ES- 437** Course Title: **FLUID INCLUSIONS**
2. Contact Hours : **L: 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. 6 Semester: **Autumn** 7. Subject Area: **DEC**
8. Pre-requisite: **ES-202 or equivalent**
9. Objective: To provide concepts and impart knowledge on fluid inclusions in minerals and importance in understanding geological processes.

19 Details of Course

Sl. No.	Contents	Contact Hours
1.	Introduction, nature and occurrence of fluid inclusions	5
2.	Sample selection and preparation; fluid inclusion petrography	5
3.	Basic principles of thermometric analysis involving pressure-temperature diagrams	5
4.	Practical aspects of heating- freezing techniques	7
5.	Presentation and interpretation of fluid inclusion data	7
6.	Decrepitation technique, laser Raman spectroscopy and crush- leach methods	6
7.	Application of fluid inclusions in mineral exploration,, tectonics, sedimentary environments and hydrocarbon exploration	7
	Total	42

S. No	Name of Books/ Authors. Publishers	Year of Publication/ Reprint
1	Roedder, E. "Fluid Inclusions", Reviews in Mineralogy, Volume 12, Mineralogical Society of America	1984
2	Shepherd, T., Rankin, A.H. and Alderton, D.H.M., "Fluid Inclusion Studies", Blackie	1985
3	Nesbitt ,V., "Short course on fluids in tectonically active regimes of the continental crust", Mineralogical Association of Canada.	1990
4	Benedetto, D.V. and Freezzoti, M., "Fluid Inclusions in Minerals. Methods and Applications", International Mineralogical Association Special Publication	1997
5	Samson, I., Anderson, A and Marshall, D. Fluid Inclusions, "Analysis and Interpretation, Mineralogical Association of Canada", Short Course Series, Vol. 32	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code : **ES-438** Course Title **PHOTOGEOLOGY**

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

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

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

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

8. Pre-requisite: Nil

9. Objective: To impart basic concepts of photo interpretation for geological processes, exploration and environment.

10. Details of Course:

S. No	Contents	Contact Hours
1	Introduction to aerial photographs, their characteristics, aerial photography using balloon and unmanned aerial platforms.	4
2	Stereoscopy, types of stereoscopes, twin stereoscope, principle.	2
3	Digital photography using low level aerial platforms, intelligence operations including targets of terrorist.	5
4	Elements of photo interpretation, drainage, subsurface and surface features of earth materials and their tone, texture used in interpretation.	8
5	Landforms and geomorphology, glacial, fluvial, desert, coastal.	8
6	Exploration for ground water and minerals, environment, case studies.	8
7	Interpretation of geology, stratigraphy, structure interpretation.	7
	Total	42

List of Practicals:

1- Study of characteristics of aerial photograph, flight paths, mosaics.
2- Stereoscopy, elementary photogrammetry, sidelap, overlap, types of stereoscope, stereoscopic vi and exaggeration.
3- Stereometer, scale calculation and measurements.
   a) Study of landforms and geomorphology for photo interpretation.
   b) Study of tone texture and colour.
   c) Study of aerial photograph for startigraphy and structure.
   d) Study of aerial photograph for ground water, natural disasters, environment and exploration.
   e) Aerial surveillance for intelligence operations, including targets of terrorist.
4- Some examples of digital aerial photography.

12. Suggested Books:

S. No	Name of Authors/Books/Publishers	Year of Publication/ Reprint
1	Mekel J.F.M., "Textbook of photo interpretation", ITC.	1970
2	Gupta R.P., "Remote Sensing Geology", Springer Verlag.	2003
3	Miller V.C. and Miller C.F., "Photogeology", Mc Graw Hill Co.	1961
4	Allen W., "Photogeology and regional mapping", Franklin Book Co.	1966
5	Sabins F.F. Jr., "Remote Sensing-Principles and Interpretation", 5th Edition, Freeman and Co.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code : **ES-439** Course Title **MINERAL 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 **TE** 25 **ETE** 50 **PRE** 0

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

8. Pre-requisite: **ES - 301**

9. Objective: To provide knowledge of mineral industry and its role in socio-economic development

10. Details of Course:

S. No	Content	Contact Hours
1	Mineral economics and its concept and its inherent specialties, concept of Mineral resources and reserves estimation	8
2	Mineral legislation	4
3	Economics of Mineral Exploration and Problems related to Infrastructure, Production, Processing; Effect of coproducts and byproducts	7
4	Marketing and trade, Demand Analysis, Market Survey, Consumption and Substitution	8
5	Mineral taxation and incentives, Pricing of minerals, Conservation and substitution; Strategic, critical and essential minerals	8
6	Mineral industry and its impact on environment, National Mineral Policy	7
	Total	42

11. Suggested Books:

S. No	Name of Authors/Books/Publisher	Year of Publication/ Reprint
1	Wellmer, F. W., Manfred, D., Markus, W., Economic Evaluations in Exploration , Springer Verlag	2008
2	Chatterjee.K.K., An Introduction to Mineral Economics , New Age International	2004
3	Wellmer, F. W., Statistical Evaluations in Exploration for Mineral Deposits, Springer Verlag	1998
4	Sinha, R.K., and Sharma, N.L., Mineral Economics, Oxford & IBH Pub. Co.	1988
5	Govett, G.J.E., and Govett, M.H., World Mineral Supplies, Elsevier Scientific Pub. Co	1976

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code : ES-440 Course Title GLOBAL BIOGEOCHEMICAL CYCLES

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: **ES -202 or equivalent**

9. Objective: To impart a knowledge of the assessment of biogeochemical cycling of elements in the context of global climate

10. Details of Course:

S. No	Contents	Contact Hours
1	Earth's atmosphere, geosphere, hydrosphere, biosphere and their composition, atmospheric circulations, global climate and climate change	6
2	Atmospheric and oceanic circulation patterns, global climate-past and present	4
3	Ecosystems, energy flow and matter cycling, evolution and biodiversity, origins, niches, adaptations, geological processes, plate tectonics and climate, aquatic systems	8
4	Biogeochemical cycle of carbon and sulfur, atmospheric fluxes, CO_2 and long term climate, acid rain, remediation	8
5	Biogeochemical cycle of phosphorus and nitrogen in lakes, oceans, rivers and other water bodies, eutrophication, simple box-models	8
6	Selected trace elements cycles, quantitative modeling of natural chemical cycles	8
	Total	**42**

11. Suggested Books:

S. No	Name of Authors/ Books / Publishers	Year of Publication/ Reprint
1	Ruddiman, W.F., " Earth's Climate-Past and Future", W.H.Freeman and , New York	2001
2	Ahrens, C.D.,."Essentials of Meteorology", Thomson Learning Publ.	2001
3	Miller, G.T.Jr., "Environmental Science", Thomson Learning Publ.	2003
4	Botkin, D.B.and Keller, E.A., "Environmental Science", John Wiley and Sons Publ.	2003
5	Jensen, J.N., "A problem solving approach to Aquatic Chemistry", John Wiley and Sons Publ.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code : **ES-521** Course Title **ADVANCED 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: **Autumn** 7. Subject Area: **DEC**

6. Pre-requisite: **ES-207 or equivalent**

9. Objective: To impart advanced concepts and applications in geomorphology

10. Details of Course:

S. No	Contents	Contact Hours
1	Review of basic geomorphology.	4
2	Concept of time and space in earth processes for landform analyses.	4
3	Plate tectonics and geomorphology.	5
4	Remote sensing and aerial photo interpretation in the study of geomorphology of various landforms, sequences in geomorphology.	7
5	Regolith and soil mapping, micromorphology, weathering profiles in different climate zones and weathering products, landforms, their relationship, economic aspects of geomorphology.	8
6	Techniques in geomorphology, sediment analyses, mapping techniques.	4
7	Terrain evaluation, terrain mapping and classification of landforms, study of various 3D fluvial, aeolian, glacial geomorphological models.	10
	Total	42

11. Suggested Books:

S. No	Name of Authors/Books/Publishers	Year of Publication/ Reprint
1	Thornbury W.D., "Principles of Applied Geomorphology", New Age International (P) Ltd.	2004
2	Sabin F. F. Jr., "Remote Sensing-Principles and Interpretation", Freeman and Company.	2007
3	Daniels, R.B. and . Hammer, R.D., "Soil Geomorphology", John Wiley.	2000
4	Birkeland, W. P, "Soils and Geomorphology", Oxford University Press.	1999
5.	Stoops, G, "Interpretation of Micromorphological Features of Soils and Regoliths", Elsevier	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: DEPARTMENT OF EARTH SCIENCES

1. Subject Code : **ES -522** Course Title **ISOTOPE GEOLOGY**

2. Contact Hours : **L: 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: **DEC**

8. Pre-requisite: **ES- 202 or equivalent**

9. Objective: To impart various aspects of Isotope Geology and geochronology and their application in the study of evolution of earth and terrestrial planets.

10. Details of Course:

S. No	Contents	Contact Hours
1	Basics of geochronology/isotope geology	4
2	Principles of mass-spectrometry, types of mass-spectrometer for geochronology/isotope geology and their uses,	6
3	Sample preparation and ion chromatography, Isotopic dilution mass spectrometry	8
4	Rb-Sr Systematics for geochronology and its importance in igneous petrogenesis,	4
5	Sm-Nd system, isochron dating, modal ages and their uses in crustal processes	4
6	U-Pb system for mineral dating technique	4
7	Lu-Hf and other lithophile isotope system	2
8	Geochemistry of radiogenic isotopes for evolution of earth	4
9	Concept of closure temperature and Exhumation of terrains	2
10	Cosmogenic nuclides, new frontiers in isotope geology	4
	Total	42

11. Suggested Books:

S. No	Name of Books/ Authors/Publisher	Year of Publication/ Reprint
1.	Dickin, A.P. "Radiogenic Isotope Geology" Cambridge University Press,	2005
2.	Faure, G. and Mensing, T. M., "Isotopes: Principles and Applications" John Wiley, New York	2004
3.	Rollinson, H., "Using geochemical data: evolution, presentation, interpretation" Pearson Education Limited	1993
4.	Faure, G., "Principles of Isotope Geology", John Wiley	1986
5.	Claude, A. C.,and Allegre, C. "Sutcliffe "Isotope Geology", Cambridge University Press	2009

INDIAN INSTITUTE OF TECHNOLOGY

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code: **ES -523** Course Title: **ENVIRONMENTAL GEOTECHNOLOGY**

2. Contact Hours : **L: 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: **DEC**

8. Pre-requisite: **ES-205 or equivalent**

9. Objective : To impart basic knowledge of application of geology in sustainable development

10. Details of course:

S.No.	Contents	Contact Hours
1.	Introduction; Role of geology in society; philosophy and fundamental concepts.	5
2.	Geology and soil development and land use planning and landscape aesthetics;	5
3.	Resources and pollution: Water resources, water pollution; Geophysical method for ground water and geotechnology; Mineral resources; energy and resources; Waste disposal, solid waste, landfill site selection , radioactive waste management and site selection	10
4.	Natural Hazards management and mitigation, Landslides, floods, earthquakes, droughts, volcanic eruptions	5.
5.	Environmental Impact Assessment and Environmental law	5
6.	Indian scenario and Indian Environmental laws for cities, mines and other activities; case histories; air pollution and geological mitigation.	7
7	Geology of underground spaces, futuristic trends in technology and preparedness	5
	Total	42

11.: Suggested Books :

Sr.No.	Name of Author/ Books/ Publishers	Year pf Publication/ Reprint
1	Alexander, D. "Natural Disasters"., UCL Press, Univ.College, London	1993
2.	Coates, D., "Environmental Geomorphology", State University of New York	1973
3.	Keller, E: "Introduction to Environmental Geology.", Prentice Hall	2004
4.	Nath, S.K., Patra, H.P. and Shahid,S. "Geophysical prospecting for ground water", Oxforf & IBH Pub.Company	2000
5	Miller, G.T.Jr., "Environmental Science", Thomson Learning Publications	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code: **ES-524** Course Title: **MICROPALEONTOLOGY**

2. Contact Hours : **L- 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: **DEC**

8. Pre-requisite: **ES-209 or equivalent**

9 Objective To impart knowledge of microfossils and their applications in stratigraphy, paleoecology, paleoclimatology and petroleum exploration

10. Details of Course:

S. No	Contentz	Contact Hours
1.	Introduction, scope and overview of applications.	6
2.	Techniques of recovery of important microfossil groups.	4
3.	Overview of morphology, systematics, ecology and biostratigraphy of foraminifers and ostracods	7
4.	Overview of morphology, systematics, ecology and biostratigraphy of radiolarians, dinoflagellates, diatoms and others.	7
5.	Palynology; introduction, morphology of the main groups, applications	8
6.	Microvertebrates; introduction and applications	5
7.	Indian case histories	5
	Total	42

11. Suggested Books:

S. No	Name of Books/ Authors/Publisher	Year of Publication/ **Reprint**
1.	Haq, B.U. and Boersma, A. (eds.), "Introduction to Marine Micropaleontology", Elsevier Science Ltd.	**1998**
2.	Armstrong, H. and Brasier, M.D., "Microfossils", Blackwell Pub.	**2005**
3.	Bignot, G., "Elements of Micropaleontology", Kluwer Academic Pub.	**2002**
4.	Kennett, J. P., "Marine Geology", Prentice Hall	**1982**
5.	McGowran, B., "Biostratigraphy, Microfossils and Geologic Time", Cambridge University Press	**2005**
6.	Jones, R.W., "Micropaleontology in Petroleum Exploration", Oxford University Press	**1996**

NDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code: **ES-525** Course Title: **MINERAL 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: **Autumn** 7. Subject Area: **DEC**

7. Pre-requisite: **ES 306 or equivalent**

9. Objective: To impart basic knowledge on ore beneficiation techniques based on physical properties of ore and gangue minerals and their influence on metallurgy

10. Details of Course:

S. No	Contents	Contact Hours
1	Introduction to the principles of ore dressing and application to various deposits	4
2	Crushing and crushers, concept of liberation of grains sizing and grinding, different types of mills, screening and classification application of microscopy	10
3	Heavy-liquid separation, jigging and tabling	6
4	Flocculation and dispersion, floatation process: different aspects – physical, chemical, mineralogical parameters; floatation circuits, flotation of polymetallic ores	8
5	Magnetic separation and other concentration processes	4
6	Separation of solid from fluid and auxiliary operations	4
7	Selected case studies of ore beneficiation in India: copper, lead-zinc, iron, manganese ores, and others	6
	Total	42

11. Suggested Books:

S. No	Name of Authors / Books/ Publishers	Year of Publication/ Reprint
1	NPCS Board of Consultants and Engineers, "The Complete Technology Book on Minerals and Mineral Processing", Asia Pacific Business Press Inc.	2008
2	Wills, B., "Mineral Processing Technology: An Introduction to the Practical Aspects of Ore Treatment and Mineral Recovery", Butterworth-Heinemann	2006
3	Gupta, A. and Yan D., "Mineral Processing Design and Operation: An Introduction", Elsevier Science and Technology	2006
4	Fuerstenau, M. C., Kenneth, N. H., "Principles of Mineral Processing", Society for Mining Metallurgy and Exploration	2003
5	Somasundaran, P., Moudgil, B. M. "Reagents in Mineral Technology", M. Dekker	1987
6	Gaudin, A.M., "Principles of Mineral Dressing", McGraw-Hill Education	1939

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code : **ES-526** Course Title: **MINING GEOLOGY**

2. Contact Hours : **L: 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: **DEC**

7. Pre-requisite: **ES- 312 or equivalent**

9. Objective: To provide basic concepts of mining of various types of economic mineral deposits

10 Details of Course:

S. No	Contents	Contact Hours
1	Principles of mining geology	2
2	Surface/opencast mining, various methods, calculation of stripping ratio, blast hole patterns, drilling, blasting, transport of ore and waste	6
3	Sub-surface methods of mining: without artificial support, room and pillar, shrinkage stopping and other methods.	6
4	Sub-surface methods of mining: with artificial support, cut-and-fill method, caving methods and other methods.	6
5	Geological operations, drilling, sampling, bench mapping, underground mine mapping, preparation of geological plans and sections, ore reserve estimation	10
6	Elements of mineral dressing	4
7	Role of a geologist in a working mine, production planning, quality control in production, mineral beneficiation	8
	Total	42

11. Suggested Books:

S. No	Name of Authors/ Books /Publishers	Year of Publication/ Reprint
1	Park J., "A Text-Book Of Mining Geology For The Use Of Mining Students and Miners", BiblioLife	2009
2	Rajaram, R., Dutta, S., Parameswaran, K., "Sustainable Mining Practices: A Global Perspective", Taylor and Francis	2005
3	Arogyaswamy, R.N.P., "Courses in Mining Geology", India Book House Limited	1996
4	Peters, W.C., "Exploration and Mining Geology", 2nd Edition, Wiley	1987
5	Harris, D. P., Mineral Resources Appraisal: Mineral Endowment, Resources and Potential Supply: Concepts, Methods, Cases" (Oxford Monographs on Geology and Geophysics), Oxford University Press	1984
6	Mckinstry, H.E., Tyler, S.A. and Richard, K.E., "Mining Geology with Sections", Prentice-Hall	1962

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT : **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code : **ES-471** Course Title: **SEISMIC MIGRATION**

2. Contact Hours : **L : 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: **DEC**

8. Pre-requisite: **ES- 354**

9. Objective: To provide basic knowledge of the theory and methods of seismic migration.

10. Details of Course:

S. No	Contents	Contact Hours
1	Introduction. Migration and Inversion	2
2	Basic principles of seismic migration Exploding Reflector Model. Downward continuation of Seismic wave fields	5
3	Manual and graphical procedures. Analytic methods. Kirchoff Migration. Wave equation migration	5
4	Seismic migration- Rayleigh integrals and their use in inversion of seismic reflection data, and applications in seismic migration..	8
5	Migration algorithms in spatiaL:spatial, spatiaL:spectral and spectraL:wavenumber domains, numerical experiments and results	10
6	2D-Seismic and 3-D migration algorithms, time and depth migration, physical principles and methodology for different geological situations.	8
7	Case Histories	4
	Total	42

11. **Suggested Books**

S. No	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1	Bleistein N. Cohen J.K, and Stockwell, J.W. "Mathematics of Multidimensional Seismic Imaging, Migration, and Inversion", Springer	2000
2	Berkhout, A.J.. "Seismic Migration : Imaging of Acoustic Energy by Wave Field Extrapolation", Elsevier Science Ltd	1984
3	.Berkhout, A.J, "Seismic Migration, A. Theoretical aspects", Elsevier Science Ltd	1980
4	Berkhout, A.J, "Seismic Migration:, B. Practical Aspects", Elsevier Science Ltd	1980
5	Zhdanov, M.S.,."Integral Transforms in Geophysics", Springer	1988

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code: **ES-472** Course: **GEOMAGNETISM**

2. Contact Hours: **L : 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: **DEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce morphology and the source mechanism of spatial and temporal variations of earth's natural magnetic field and their implication in exploration geophysics.

10.Details of the Course:

S. No	Contents	Contact Hours
1	Introduction. geomagnetic elements and their distribution on a global scale, classification – polar zone, auroral zone, auroral oval, mid latitude and equatorial regions, geomagnetic variations and geomagnetic time scale, current model for interaction of solar wind with the geomagnetic field envelope, ionosphere and its importance	5
2	Magnetospheric contributions to terrestrial magnetic field, marine magnetic anomalies and geomagnetic polarity time scale, spherical, cap spherical and ellipsoidal harmonic analysis, harmonic analysis as inverse problem, schmidt normalization, interpolation of harmonic coefficients in terms of multipoles, decomposition of geomagnetic field into internal and external parts.	10
3	Solar and lunar daily variation, morphology, quiet days and disturbed days, geomagnetic indices, source mechanisms, equivalent current systems – toroidal and poloidal, equivalent current stream function linkage with harmonic coefficients.	5
4	Geomagnetic disturbances, sudden storm commencement (ssc),	5

	magnetic storms and substorms (bays), sources of storms and substorms, typical magnetic storms from indian geomagnetic observatories (for the last 5 years at least), polar magnetic storms, polar electrojet, equatorial electrojet and importance of annamalainagar geomagnetic observatory.	
5	Pulsations, atmospherics, whistlers, VLF and electromagnetic wave emissions, spherics, solar cycle variations, international scientific organization devoted geomagnetic studies (IAGA), geomagnetic equipment, network of Indian geomagnetic observatories.	**6**
6	Inverse problems of geomagnetism, inversion of daily and secular variation data in terms of conductivity structure of crust, mantle and core, GDS studies, linkage with magnetic storm activity.	**5**
7	Elements of magnetohydrodynamics and earth's internal dynamics, Elsasser's geomagnetic dynamo model, magnetic field environments of other members of solar system and knowledge gained by their studies.	**6**
	Total	**42**

11. **Suggested Books**

S. No	**Name of Authors/ Books / Publishers**	**Year of Publication/ Reprint**
1.	Parkinson., W.D.," Introduction to Geomagnetism", Scottish Academic Press.	**1983**
2	Jacobs, J.A., "Geomagnetism", Academic Press.	**1988**
3.	Chapman, S. and Bartels, J., "Geomagnetism", Oxford University Press.	**1962**
4.	Backus, G., Parker, R., Constable, C., "Foundations of Geomagnetism", Cambridge University Press.	**1996**
5.	Kono, M., "Geomagnetism", Elsevier.	**2009**
6.	Campbell, W.H., " Introduction to geomagnetic fields", Second Edition, Cambridge University Press.	**2003**

INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code : **ES-473** Course Title: **PHYSICAL OCEANOGRAPHY**
2. Contact Hours : **L : 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: **DEC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge of the physics of oceanic phenomena
10. Details of Course:

S. No	Contents	Contact Hours
1	Introduction, oceans and their physical setting, atmospheric influences	3
2	Physical and chemical properties of sea water, heat budget, oceanographic measurement techniques.	8
3	Geophysical fluid dynamics, Navier Stokes' equations, Coriolis force, eddy viscosity, Reynolds stresses.	4
4	Response of upper oceans to winds, inertial motion Ekman layer and Ekman mass transport., Langmuir circulation.	5
5	Geostrophic currents,. wind driven ocean circulation, Sverdrup's theory. Munk's solution, vorticity in oceans, deep circulation in oceans, El Nino and La Nina, numerical models in oceanography	10
6	Linear theory of oceanic surface waves . ocean wave spectra, tsunamis, storm surges, theory of ocean tides, tidal prediction.	5
7	Marine geology and marine geophysics, exploitation of ocean resources, marine pollution.	7
	Total	42

11. **Suggested Books**

S. No	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1	Apel ,J.R. "Principles of Ocean Physics" , Academic Press	**1987**
2	Garrison ,T."Essentials of Oceanography", Thomson Learning	**2002**
3	Knauss,J.A. "Introduction to Physical Oceanography", Waveland Pr Inc	**2005**
4	Open University ,"Ocean Circulation", Butterworth Heinemann	**2002**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code : **ES - 474** Course Title: **ADVANCED SEISMIC PROSPECTING**

2. Contact Hours: **L : 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: **DEC**

8. Pre-requisite: **ES-357, ES-354**

9. Objective: To impart understanding of different techniques used for migration of seismic data to improve lateral resolution of seismic sections and 3-D seismic exploration techniques.

10. Details of Course:

S. No	Contents	Contact Hours
1	Migration – Exploding reflector model, migration principles, Kirchoff migration, finite difference migration, frequency – migration, frequency-wave number migration.	10
2	DiP:moveout (DMO) correction and pre-stack migration- DMO and stacking velocities, principles DMO correction, pre-stack time migration, migration velocity analysis.	9
3	3-D Seismic exploration- 3-D survey design and processing of 3-D seismic data, 3-D pre-stack migration.	9
4	Earth Imaging in depth- PosT:stack and pre-stack depth migration of 2-D and 3-D data, effect on interpretation.	9
5	Structural and stratigraphic interpretation of seismic data.	5
	Total	42

11. **Suggested Books:**

S. No	Name of Authors / Books / Publishers	Year of Publication Reprint
1	Yilmaz ,O., "Seismic Data Analysis vol 1 & 2", Society of. Exploration Geophysicists.	2001
2	Robinson,E.A., Durani,T.S and Peardon,L.G., "Geophysical Signal Processing", Prentice Hall International.	1985
3	Berkhout ,A.J.,"Seismic Migration- Imaging of Acoustic Energy by Wavefield Extrapolation", Elsevier.	1984
4	Sheriff,R.E. and. Geldart, L.P., "Exploration Seismology", Cambridge University press.	1980
5.	Cordsen, A., Galbraith, M. and Peirce, J., "Planning land 3-D Seismic Surveys", Soc. Exploration Geophysics.	2000
6.	Gadallah, M.R. and Fisher, R.L., "Applied Seismology, A Comprehensive Guide to Seismic Theory and Application", PennWell.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1 Subject Code: **ES-475** Course Title: **PETROLEUM GEOSCIENCE**

2 Contact Hours: **L : 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: **DEC**

8. Prerequisite: **ES-359**

9 Objective : To impart basic understanding of origin, occurrence, migration and accumulation of hydrocarbon resources, reservoir engineering and evaluation of petroleum provinces

10 Details of course:

S. No.	Contents	Contact Hrs.
1.	Petroleum as natural resource, properties of petroleum, its uses; mode of occurrence of petroleum in rocks, distribution of petroleum in space and time on earth.	5
2.	Genesis of commercial quantities of petroleum, source rocks, reservoir rocks, evaluation, petroleum kitchens, assessment of quantity of petroleum generated and expelled, migration mechanism.	10
3.	Entrapment mechanism and accumulation of petroleum, petroleum reservoirs, reservoir rocks and their classification, reservoir pore space, reservoir fluids, traps, cap rock, seat seal, undersaturated and saturated and oversaturated reservoir.	7
4.	Petroleum prospection and exploration – geological, geophysical and geochemical methods of exploration; principles of drilling; drilling mud and its functions	6
5.	Principles of drill stem testing and production testing; mechanism of petroleum drives; well stimulation techniques and enhanced recovery methods	7
6	Petroleum resources and reserves; estimation of petroleum reserves, overview of important petroleum provinces with special emphasis on India basins	7
	Total	42

11. Suggested Books:

S. No.	Name of Authors/ Books / Publishers	Year of Publication/ Reprint
1	Cubit, J.M., England, WA and Larter, S.R., " Understanding Petroleum Reservoirs towards Integrated Reservoir and Geochemical Approach", Geological Society (London)	2004
2	Ellis, D.V. and Singer, G.H. , "Well logging for Earth Scientists", Second edition, Springer	2008
3	Nind, R.C., " Principles of Oil Well Production" McGraw Hill	1991
4	Peter, L.K., " Basic Petroleum Geology", OGCI Publishers	2001
5	Singh, Lakshman, "Oil and Gas Fields of India", Indian Petroleum Publication/s	2009
6	Tissot, B.P. and D.H. Welle, " Petroleum Formation and Occurrence", Springer	1993

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code : **ES - 476** Course Title: **ADVANCED SEISMOLOGY**
2. Contact Hours: **L : 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: **DEC**
6. Pre-requisite: **ES -357**
9. Objective: To impart advanced theory of seismic sources, methods and analysis of seismological data and the practical utility in seismic hazard and risk mitigation studies

10. Details of Course:

S. No	Contents	Contact Hours
1	Local earthquake P: and S-wave attenuation, coda normalization methods, single scattering and multiple scattering methods of estimation, various methods of estimation of intrinsic attenuation and scattering attenuation coefficients, Lg wave attenuation and attenuation modeling of mantle and core.	12
2.	Determination of earth structure, Herglotz-Wiechert inversion, parameterized model inversion, seismic tomography	5
3.	Earth structure, crustal structure, upper-mantle structure, lower mantle structure, core structure	5
4.	Representation of seismic sources, faulting sources, equivalent body forces, elastostatics	5
5.	Elastodynamics, seismic moment tensors, source spectrum, stress drop, particle velocity, rupture velocity, seismic energy and magnitude.	5
6.	Waveform modeling, body waveform modeling, surface waveform modeling, source-time function and fault slip	5
7.	Seismic Hazard AssessmenT: Seismic Hazard, Seismic waves, Probabilistic seismic hazard assessment, deterministic (level I,II and III) hazard assessment, seismic hazard maps	5
	Total	42

11. **Suggested Books:**

S. No	Name of Authors / Books / Publishers	Year of Publication Reprint
1	Aki, K. and Richards, P.G; "Quantitative Seismology", W.H. Freeman & Co.	**2002**
2	Stein, S. and Wyssession, M., "An Introduction to Seismology, Earthquakes and Structure", Blackwell Publishing.	**2003**
3	Lay, T. and Wallace, T.C., "Modern Global Seismology", Academic Press.	**1995**
4	Udias, A., "Principles of Seismology", Cambridge Publisher.	**1999**
5.	Lee, W.H.K., Kanamori, H., Jennings, P.C. and Kisslinger, C., "International Handbook of Earthquake and Engineering Seismology", vol 1 & 2, Academic Press.	**2003**
6.	Sato, H. and Fehler, M.C., "Seismic Wave Propagation and Scattering in the Heterogeneous Earth", AIP Press, Springer.	**1998**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code: **ES-477** Course Title: **GEOTECHNICAL INVESTIGATIONS**

2. Contact Hours : **L : 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: **DEC**

7. Pre-requisite: **ES-359**

9. Objective: Systematic investigations adopted for evaluating river valley projects, landslides and application of Geophysical knowledge in the above investigations.

10. Details of Course:

S. No	Contents	Contact Hours
1.	Introduction to geotechnical investigations for river valley projects	2
2.	Planning for river valley projects, types of river valley projects and criteria for selection	8
3.	Investigations for evaluation of dam foundations – mapping, surface and subsurface exploration and data collection; Tunnel classification ; Importance of geophysical knowledge during investigations	10
4.	Use of geophysical methods for explorations related to river valley projects	6
5.	Engineering properties of rocks, laboratory & field tests and Investigations for evaluation of construction materials	8
6.	Importance of landslide studies in planning of hill projects and investigation techniques	4
7.	Investigations for planning roads in hills	4
	Total	42

10. Suggested Books:

S. No	Name of Authors/Books/Publisher	Year of Publication// Reprint
1	Bell, F.G., `Engineering Geology' Butterworth and Heinemann	**2007**
2	West, T.R., `Geology applied to Engineering'; Waveland Pr. Inc.	**2010**
3	D.P. Krynine and W. R. Judd, "Principles of Engineering Geology and Geotechnics" CBS Publishers	**2001**
4	Singh, B.& Goel, R.K ., "Rock Mass Classification: A Practical Approach in Civil Engineering", Elsevier	**1999**
5	Waltham, T. "Foundations of Engineering Geology", Spon Press	**2002**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code: **ES- 478** Course Title: **STRONG MOTION SEISMOLOGY**

2. Contact Hours : **L : 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: **DEC**

8. Pre requisite: **ES -357**

9 Objective: To provide basic understanding of strong motion seismology and its uses in earthquake engineering

10. Details of Course:

S. No	Contents	Contact Hours
1	Introduction, basic concepts, characterization, some Indian strong motion earthquakes, Characterization of strong and weak ground motion, instruments used parameters of strong ground motion	8
2	Method of recording, linear correction, instrumental correction, band pass filtering, methods of selection of low corner of band pass Earthquake source spectra, Brune's model, Atkinson model, Barrier model, Huddon model,	8
3.	Vibration of single degree of freedom system, free vibration, forced vibration of a damped system, Duhamel integral, Attenuation relations, method of computation , parameters used in defining attenuation relations,	8
4	Seismic hazard and risk, deterministic and probabilistic approach for seismic hazard zonation, Cornell's approach of probabilistic hazard, GSHAP and its relevance	8
5	Simulation of strong ground motion, parameters required for simulations, stochastic simulation technique, empirical Green's function technique, self similarity laws of source and spectral parameters, semi empirical approach, advantages and disadvantages of different techniques.	10
6	Case study of strong ground motion simulations of some well known earthquakes	
	Total	42

11. **Suggested Books:**

S. No	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1	Bullen, K. and Bolt, B.A., "An Introduction to the Theory of Seismology", Cambridge University Press.	**1985**
2	Aki, K. and Richards, P.G., "Quantitative Seismology", University Science Books	**2002**
3	Bolt, B.A., "Earthquakes", W.H. Freeman	**2003**
4	Erdik M.O. and Toksöz, M.N. "Strong Ground Motion Seismology", Springer	**1987**
5.	Bolt, B.A., "Strong Motion Synthetics"(Computational techniques, Academic press	**1987**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
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NAME OF THE DEPARTMENT: DEPARTMENT OF EARTH SCIENCES

1. Subject Code: **ES-481** Course Title: **ENGINEERING GEOPHYSICS**
2. Contact Hours: **L : 3** **T : 1** **P : 0**
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:** DEC
8. Pre-requisite: **ES – 352, ES – 354 and ES - 451**

9. Objective : To impart knowledge of geophysical techniques for solving site investigation and environmental problems of near surface of earth

10. Details of Course:

S. No	Contents	Contact Hours
1	Introduction, role of geophysics in solving major site investigation and environmental problems pertaining to soil and groundwater	2
2	Microgravity data acquisition, processing and interpretation, applications illustrated by case studies– underground cave detection, mapping of fractures, shear zones, site selection for underground disposal of nuclear and hazardous material, prediction of rock bursts in underground mine shafts	5
3	High-resolution magnetic surveys in mapping underground pipes, intrusives, mapping basement, identifying unexploded mines, buried drums and tanks and archeological site mappings illustrated by case studies	5
4	Geoelectrical imaging (2-D, 3-D and 4-D), basic theory including inversion algorithms, case studies highlighting several civil engineering site characterization problems, dam site suitability and leak detection and underground contaminant leachate tracking	9
5	Georadar (2-D and 3-D), physical principles, theory, data processing and interpretation, applications with case studies – underground utility mapping in urban environment, unexploded mine detection and ordinance mapping, groundwater table mapping, prediction of lithological sections at project sites	8

6	High resolution seismics in near surface applications, marine seismics for location of basement below sea bottom for offshore civil engineering constructions and harbour needs, cross-hole seismic tomography in tunnel site investigations.	**5**
7	Multi-channel analysis of surface waves (MASW) – theory, processing and interpretation. Dispersion curve. shear wave velocity depth section and estimation of stiffness depth profile, case studies highlighting rippability studies, voids or cave detection, shallow basement mapping, soil classification and aiding geotechnical site characterization	**8**
	Total	**42**

List of Practicals:

1. Data acquisition through resistivity and IP imaging equipment
2. Resistivity and IP imaging data processing
3. Resistivity and IP imaging data interpretation
4. Georadar data acquisition procedures
5. Georadar data processing
6. Georadar data interpretation
7. Data acquisition through Seismic refraction unit
8. Data acquisition through high-resolution reflection seismic unit
9. Seismic data acquisition, processing and interpretation

11. Suggested Books:

S. No	Name of Authors/Books/ Authors	Year of Publication/ Reprint
1	Burger H.R., Sheehan A.F., Jones C.H., " Introduction to applied geophysics: Exploring the shallow subsurface", W.W. Norton	**2006**
2	Sharma P.V., " Environmental and engineering geophysics", Cambridge University Press	**1997**
3	Kearey P., Brooks M., Hill I., "An introduction to geophysical exploration", Wiley-Blackwell	**2002**
4	Milson J., "Field geophysics (Geological field guide)", John Wiley& Sons	**2003**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code: **ES - 482** Course Title: **GEOPHYSICAL FLUID DYNAMICS**
2. Contact Hours : **L : 3 T : 1 P : 0**
3. Examination Duration (Hrs): Theory: 3 Practical: 0
4. Relative Weightge: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0
5. Credits 4 6. Semester: **Spring** 7. Subject Area: **DEC**
8. Pre-requisite: **ES - 353**
9. Objective: To introduce Fluid dynamics principles and their use in geophysical processes
10. Details of Course:

S. No	Contents	Contact Hours
1	Introduction, importance of geophysical fluid dynamics, distinguishing attributes of flow of geophysical fluids, importance of rotation/stratification; distinction between atmospheric and oceanic flows.	4
2	Coriolis Force, Lagrangian and Eulerian description; rotating framework of reference.	4
3	Equations governing flow of geophysical fluids, mass budget; momentum budget; equation of state; energy budget; salt and moisture budget, Boussinesq approximation	6
4	Diffusive and advective Processes: isotropic, homogeneous turbulence; turbulent diffusion	6
5	Rotation effects, geostrophic flows, vorticity dynamics, Ekman Layer, barotropic waves and instability	6
6	Stratification effects, stratification, layered models, internal waves	6
7	Dynamics of stratified rotating flows, fronts, jets and vortices etc., atmospheric and oceanic general circulation	10
	Total	42

11. **Suggested Books:**

S. No	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1	Cushman-Roisin, B, and Beckers, J.M., "Introduction to Geophysical Fluid Dynamics: Physical and Numerical Aspects", Academic Press	2005
2	Kundu, P.K., and Cohen I.M., "Fluid Mechanics", Academic Press	2004
3	McWilliams, J.C.," Fundamentals of Geophysical Fluid Dynamics", Cambridge	2006
4	Pedlosky J., "Geophysical Fluid Dynamics", Springer	1987
5	Pedlosky J., " Waves in the Ocean and Atmosphere: Introduction to Wave Dynamics", Springer	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. **Subject Code : ES - 483 Course Title: RESERVOIR GEOPHYSICS**
2. **Contact Hours: L : 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: DEC**
6. **Pre-requisite: ES-354**
9. **Objective :** To impart knowkedge of application of Geophysical Technology to oil and gas fields development and exploitation.
10. **Details of Course:**

S.No.	Contents	Contact hours
1	Reservoir management, reservoir description, role of geophysics in reservoir management, predevelopment phase, initial development phase, operating phase, enhanced oil recovery phase.	5
2	Synergism, synergism and organization, management philosophy, reservoir system, reservoir simulation, forecasting, decision and decision making.	6
3	Reservoir management using 3D seismic data, types of 3D data, timing of data acquisition, data acquisition, data processing and data interpretation, geometric framework, rock properties, hydrocarbon indicators	4
4	Interpretation of 3D data, amplitude, phase and color, interactive interpretation, seismic inversion and shear properties, borehole studies, time lapse measurements	6
5	A.V.O., elastic waves and rock properties, AVO equations, processing sequence for AVO analysis, derivation of AVO attributes by pre-stack amplitude inversion, interpretation of AVO attributes, 3D AVO analysis	8
6	Acoustic impedance estimation, synthetic sonic logs, processing sequence for acoustic impedance estimation, derivation of acoustic impedance attributes, 3D acoustic impedance estimation, instantaneous attributes, VSP, seismic anisotropy.	8
7	Mathematical foundation of elastic wave propagation, wave propagation phenomena, the Zoeppritz equation, pre-stack amplitude inversion.	5
	Total	42

11. **Suggested Books:**

S. No	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1	Sheriff, R.R. (ed) "Reservoir Geophysics" Society of Exploration Geophysicists	1999
2	Castagna, J.P. and Backus, M.M. (eds) "Offset Dependent Reflectivity- Theory and Practice of AVO Analysis", Society of Exploration Geophysicists	1992
4	S. Edward, (Ed.) "Mathematics in Oil Production ", Oxford University Press	1988
5	G.D. Hobson (Ed.) "Modern Petroleum Technology", John Wiley and Sons	1987
6	J.H. Schon, "Physical Properties of Rocks", Elsevier	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code : **ES-484** Course Title: **SEISMIC STRATIGRAPHY**
2. Contact Hours : **L : 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: **DEC**
8. Pre-requisite: **ES - 354**
9. Objective: To provide knowledge of interpreting seismic sections with stratigraphic traps and depositional history of sedimentary basins.
10. Details of Course:

S. No	Contents	Contact Hours
1.	Introduction, basic concepts, attributes of seismic reflections	5
2.	Seismic sections, various forms of visualization, processing and interpretation	5
3.	Pitfalls in interpretation of seismic sections, stratigraphic traps and their expression on seismic sections	5
4.	Reflection patterns, identification, various forms and their interpretation on seismic sections	9
5.	Depositional history, its reconstruction, relation with seismic patterns, extracting geological information of rock layers from seismic sections	10
6.	Use of shear waves in seismic prospecting, direct detection of hydrocarbons	8
	Total	42

11. **Suggested Books:**

S. No	Name of Authors/ Books/ Publishers	Year of Publication Reprint
1.	McQuillin, R., Bacon, M. and Barclay, W, "An Introduction to Seismic Interpretation, : Reflection Seismics in Petroleum Exploration"; Kluwer Academic Pub	1985
2.	Sheriff,R. E., "Seismic Stratigraphy", Springer	1980
3.	Tucker, P. M. and Yorston, H. J., "Pitfalls in Seismic Interpretation" , SEG Pub	1973
4.	Catuneanu,O., " Principles of Sequence Stratigraphy", Elsevier	2006
5.	Miall, A. "The Geology of Stratigraphic Sequences", Springer	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code: **ES-485** Course Title: **ADVANCED ELECTROMAGNETIC PROSPECTING**

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: **DEC**

8. Pre-requisite: **ES - 453**

9. Objective: To impart the knowledge of advances in electromagnetic prospecting for shallow, intermediate and deep exploration.

10. Details of Course:

S. No	Particulars	Contact Hours
1	Boundary value problems in cylindrical and spherical co-ordinates	5
2	1D, 2D and 3D model and source, analytical and numerical solutions and examples	5
3	Frequency domain differential equation methods, finite difference, finite element and integral equation methods.	5
4	Numerical solution of 1D electromagnetic problem for natural and artificial source field, modes separation in conductor and insulators, partial wave decomposition, spectral impedance and thin sheet approximation, numerical solution of 2D electromagnetic induction problem, description of surface, side and bottom boundary conditions.	7
5	Low frequency electromagnetic fields; natural source electromagnetic (Magnetotelluric) methods, origin of natural source and its frequency spectrum, theory of Magnetotelluric (MT) methods and field procedure, On-line (real time) and off-line processing of MT time series.	7

6	Transfer function estimation, dimensionality and directionality of impedance tensor and impedance polar diagram, TE and TM modes apparent resistivity and phase characterization for 1D, 2D and 3D earth models, static shift and impedance decomposition.	8
7	Recent development and new research direction; sea bottom MT, case studies	5
	Total	**42**

11. Suggested Books:

S. No	Name of Authors / Books / Publishers	Year of Publication Reprint
1	Nabighian, M (ed.s), "Electromagnetic methods in Applied Geophysics ", Society of Exploration Geophysicists	**1987**
2	Oristaglio, M. J. and Spies, B.R.:, "Three Dimensional Electromagnetics", Society of Exploration Geophysicists	**1999**
3	Kaufman, A. A. and Keller, G. V., "The Magnetotelluric sounding method", Elsevier	**1981**
4	J. T. Weaver, "Mathematical Methods for Geo-Electromagnetic Induction " , John Wiley and Sons	**1994**
5	Michael S Zhdanov, "Geophysical Electromagnetic Theory and Methods" ; Elsevier.	**2009**
6	Mark Berdichevsky and Vladimir I. Dmitriev; "Models And Methods of Magnetotellurics", Springer	**2008**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code : **ES - 486** Course Title: **ADVANCED WELL LOGGING**
2. Contact Hours : **L: 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: **DEC**
7. Pre-requisite: **ES- 455**
9. Objective: To provide advanced knowledge in well logging.
10. Details of Course:

S.No.	Contents	Contact Hours
1	Overview of well logging methods, formation parameters	6
2	Quick look log interpretation, basic quality control, identifying the reservoir, fluid type and contacts, calculating porosity, hydrocarbon saturation and pressure, sampling, permeability determination	6
3	Full interpretation, net sand definition, porosity calculation, Archie saturation, permeability; advanced log interpretation techniques:	6
4	Advanced log interpretation techniques, shaly sand analysis, carbonates, multi-mineral / statistical models, NMR logging, thin beds, thermal decay Neutron interpretation, borehole corrections, error analyses	8
5	Well logs and their detailed interpretation in terms of structure, lithology, depositional environments, source rock and reservoir rock analysis, basin analysis using latest tools of well logging	5
6	Production geology and reservoir engineering issues, behaviour of gases, behaviour of oil/ wet gas reservoirs, material balance, Darcy's law and well testing, synthetic well logs, their generation and application	5
7.	Horizontal wells, well deviation and geo-steering, logging while drilling in hydrocarbon prospect evaluation	6
	Total	42

11. **Suggested Books:**

S. No	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Brock, J.R, "Applied Open Hole Analysis", Wellesley–Cambridge	1986
2.	Serra, O., "Fundamentals of Well log Interpretation", Vol. 2, Elsevier	1986
3.	Darling, T., "Well logging and Formation Evaluation", Elsevier	2005
4.	Dake, L.P., "Fundamentals of Reservoir Engineering", Elsevier	1978

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code: **ES- 487** Course Title: **SYNTHETIC SEISMOGRAMS**

2. Contact Hours : **L: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: **DEC**

8. Pre requisite: **ES-357, ES -354**

9. Objective: To introduce modeling of seismic wave field in varied geological conditions.

10. Details of Course:

S. No	Contents	Contact Hours
1	Introduction, an overview of application of synthetic seismograms in oil prospecting and seismology, elastic parameters,	4
2	Parameters required, generalized Hook's law, constitutive equation and its role in modeling various subsurface earth structures, vertically transversely, isotropic media, Understanding the anisotropy, velocity anisotropy terminology for geophysicist, weak elastic anisotropy, Thomsen parameters	8
3	Characteristics of reflection process, normal incidence seismogram for layered earth media, role of constitutive equation and boundary condition to generate synthetic seismogram, Synthetic seismogram from well log data, staggered algorithm, leap frog algorithm for generating synthetic seismogram	8
4	Generation of synthetic seismogram for marine data, synthetic seismogram under different seismic source and receiver conditions, derivation of expression for Christofell equation, generation of synthetic seismogram for earthquake source,	8
5	Seismic ray tracing for minimum time path, ray equation and wave equation, derivation from Fermat's principle, unified approach for finding solution of ray equation, synthetic seismogram using ray tracing	8

6	Application of synthetic seismogram in seismic prospecting and in seismic hazard prediction, case studies for land seismic and marine seismic survey, case studies of synthetic seismogram of some well known earthquakes	6
	Total	**42**

11. **Suggested Books**

S. No	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1	Waters, K.H., "Reflection Seismology: A Tool for Energy Resource Exploration", Krieger Publishing	1992
2	Aki, K. and Richards, P.G. "Quantitative Seismology", University Science Books	2002
3	Sheriff, R. E., "Seismic Stratigraphy", Springer	1980
4	Roberson E. A., "Seismic Inversion and Deconvolution", Elsevier Science	1999
5.	Yilmaz, O., "Seismic Data Processing", Society of Exploration Geophysicists.	1987

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1.Subject Code : **ES-488** Course Title: **FRACTALS AND THEIR 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: **DEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the concepts of fractal geometry and its applications in Earth Sciences.

10. Details of Course:

S. No	Contents	Contact Hours
1.	Mathematical background, self similarity, Sierpinski triangles, Koch curves, cantor sets	**4**
2.	Box-counting dimensions, Kolmogrov capacity, 1D and 2-D box counting	**6**
3.	Hausdorff measures and dimension, deterministic and random fractals, natural fractals, iterated Function Systems, stochastic dynamical systems, compression of images	**7**
4.	Dynamical systems, interval self-mappings, complex iteration, perturbation theory, geometrical theory, small divisors, deterministic chaos to deterministic division	**10**
5.	Fractals in earth science, various applications in fragmentation, tectonics, geomorphology, seismology	**10**
6.	Applications to other Fields, image compression, finance, soil mechanics	**5**
	Total	**42**

11. Suggested Books

S. No	Name of Authors/ Books/ Publishers	Year of Publication Reprint
1.	Falconer, K., "Fractal Geometry: Mathematical Foundations and Application" , Wiley .	2003
2.	Turcotte, D.E., "Fractals and Chaos in Geology and Geophysics", Cambridge Univ Press	1997
3.	Peitgen, H., Jurgens, H., Saupe, D., Maletsky, E. M., Perciante, T. and Yunker, L. E, "Fractals for the Classroom", Springer Verlag	1992
4.	Sprott, J. C., "Chaos and Time Series Analysis", Oxford Univ. Press	2003
5.	Schroeder, M., "Fractals, Chaos, Power Laws: Minutes from an infinite paradise", Dover	2009
6.	Ott, E., "Chaos in Dynamical Systems", Cambridge Univ. Press, 2nd ed.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code: **ES-571** Course Title: **DIGITAL 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: **Autumn** 7. Subject Area: **DEC**
8. Pre-requisite: **ES – 355**
9. Objective: To impart knowledge of Digital Image Processing (DIP) with emphasis on geophysical applications.
10. Details of Course:

S. No	Contents	Contact Hours
1	Introduction, origin of digital image processing, examples of disciplines using DIP and its geophysical applications.	2
2	Digital image fundamentals, visual perception; image sensing and acquisition; image sampling and quantization.	6
3	Image enhancement techniques, enhancement in spatial domain – basic gray level transformations, histogram processing, spatial filtering; enhancement in frequency domain – introduction to 2D-Fourier transform, smoothing filters, sharpening filters, homomorphic filtering.	8
4	Image restoration techniques, image degradation/restoration process; restoration in presence of noise; periodic noise reduction; inverse filtering, geophysical applications.	6
5	Colour image processing, color models; color transformations; smoothing and sharpening, color segmentation	4
6	Wavelets and multiresolution processing: multiresolution expansion, wavelet transforms; fast wavelet transform; DIP using wavelets, geophysical applications.	6
7	Image compression algorithms, image compression models; information theory; error-free compression; lossy compression, morphological image processing, brief introduction, image segmentation and object recognition	10
	Total	42

11. **Suggested Books**

S. No	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1	Gonzalez, R.C. and Woods, R.E., "Digital Image Processing", Pearson Education Asia	2002
2	Jahne, B,"Digital Image Processing", Springer	2005
3	Pitas, I, "Digital Image Processing Algorithms and Applications", Wiley	2000
4	Richards, J.A., "Remote Sensing Digital Image Analysis", Springer Verlag	1986
5	Ritter G.X. and Wilson J.N., "Handbook of Computer Vision Algorithms in Image Algebra", CRC Press	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code: **ES-572** Course: **GEOTOMOGRAPHY**

2. Contact Hours: **L : 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: **DEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce tomographic techniques used in geophysical exploration.

10. Details of the Course:

S. No	Contents	Contact Hours
1	Introduction: tomography genesis & necessary definitions, elements of functional analysis: mathematical spaces, mappings, tomographic problems as mappings between mathematical spaces, Frechet's derivative and its computation, contraction mapping theorem and its application, ilL:posed inverse problems and Tikhonov's method of regularization	7
2	Medical tomography and numerical solvers like algebraic reconstruction technique (ART), simultaneous iterative reconstruction technique (SIRT), adoption to geotomographic problems, conjugate gradient methods, numerical solvers for non-linear equations, sparse matrix solvers.	8
3	Reconstruction from projections Radon transform;	5
4	Seismic tomography, basics of seismic travel time tomography, seismic refraction and reflection time and waveform tomography	5
5	Seismic topographic methods, cross-hole tomography, seismic forward and inversion algorithms. 4D seismics and seismic time lapse measurements in enhanced oil recovery (EOR) operations.	6

6	Electrical resistivity tomography, electrical charge accumulation concepts, efficient approximate forward modelling algorithms, application of resistivity tomography in environmental impact assessment (EIA), multi-electrode experiments including mobile ones.	5
7	SP tomography and imaging of mineral deposits, micromagnetic surveys and tomography in EIA investigations.	6
	Total	**42**

11. Suggested Books:

S. No	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1	Tarantola,A., "Inverse Problem Theory", Elsevier.	1987
2	Nolet,G., "Seismic Tomography", D.Reidel	1987
3	Scales,J.A., "Theory of Seismic Imaging", Springer-Verlag	1995
4.	Golub,G.H. and Van Loan,C.F., "Matrix Computations", John Hopkins University Press.	1989
5.	Herman, G.T., "Image Reconstruction from Projection: The Fundamentals of Computerized Tomography", Academic Press	1980
6.	Anderson, D.L., "New Theory of Earth", Cambridge University Press.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code : **ES - 573** Course Title: **MARINE GEOPHYSICS**

2. Contact Hours : **L : 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: DEC**

7. Pre-requisite: **ES-352 , ES-354**

9. Objective: To introduce geophysical methods for marine exploration .with emphasis on techniques of data acquisition and position location.

10. Details of Course:

S. No	Contents	Contact Hours
1	Introduction to marine geophysics, basic concepts	2
2	Marine resources including hydrocarbons, manganese nodules, other minerals	5
3	Marine gravity and magnetics, data acquisition, processing, interpretation methods specific to marine environment	5
4	Radio and satellite positioning, basic concepts, methods of data collection and processing	4
5	Acquisition of seismic data at sea, special data acquisition techniques, marine specific processing methodology,	7
6	Marine seismic signal processing and interpretations, specific issues related to marine environment, their similarities and differences with land seismic data processing techniques	7
7	Marine MT, data acquisition, instruments, methodology of data processing specific to marine environment	7
8	Geological Applications, mineral and petroleum exploration	5
	Total	42

11. **Suggested Books**

S. No	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Parkes,G.E and Hattoi,L., "The Marine Seismic Source", Springer	2001
2.	Jones, E J W., " Marine Geophysics", John Wiley and Sons	1999
3.	Verma, R.K.., "Offshore Seismic Exploration", Gulf Pub Co	1986
4.	Emery, W. and Thomsen, R., "Data Analysis methods in Physical Oceanography", Elsevier	2004
5.	Hwang, C., Schum, C. and Li, J., "Satellite altimetry for geodesy, geophysics and oceanography", Springer-Verlag	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code : **ES-574** Course Title: **SEISMIC SIGNAL 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: **Autumn** 7. Subject Area: **DEC**
8. Pre-requisite: **ES-354, ES-355**
9. Objective: To introduce the signal processing techniques specific to seismic data interpretation
10. Details of Course:

S. No	Contents	Contact Hours
1.	Introduction, basic concepts	2
2.	Seismic data corrections, static and dynamic corrections, wavelet denoising,	7
3.	Deconvolution techniques, predictive deconvolution, homomorphic deconvolution, application in petroleum exploration	8
4.	Seismic data migration, pre-stack and post-stack migration, Kirchoff's migration, phase shift migration	9
5.	Time series analysis techniques applied to seismic data, advanced filtering, tapering, windowing methods	8
6.	Synthetic seismogram techniques for data interpretation, Haskell's method, Cagniard's method, ray tracing method	8
	Total	42

11. **Suggested Books:**

S. No	Name of Authors/ Books/ Publishers	Year of Publication Reprint
1.	Aki, K. and Richards, Paul G., "Quantitative Seismology- Theory and Practice", W.H. Freeman and Co.	**2002**
2.	Berkhout, A. J., , "Seismic Migration – Imaging of Acoustic Energy by Wavefield Extrapolation", Elsevier Scientific Pub.	**1984**
3.	Robinson, E. A., Durrani, T. S. and Peardon, L. G., "Geophysical Signal Processing", Prentice Hall	**1986**
4.	Yilmaz, O. and Doherty, S. M., "Seismic Data Analysis: Processing, Inversion and Interpretation of Seismic Data", Society of Exploration Geophysicists	**2001**
5.	Waters, K. H, "Reflection Seismology – A Tool for Energy Resource Exploration", Wiley.	**1978**
6.	Khan, A. , "Digital Signal Processing Fundamentals", Da Vinci Engineering Press.	**2006**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **DEPARTMENT OF EARTH SCIENCES**

1. Subject Code : **ES-575** Course Title: **VERTICAL SEISMIC PROFILING**
2. Contact Hours : **L : 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: **DEC**
8. Pre-requisite: **ES-354**
9. Objective: To impart knowledge of vertical seismic profiling (VSP) method of seismic exploration.
10. Details of Course:

S. No	Contents	Contact Hours
1	Introduction, types of vertical seismic profiling (VSP), zero offset VSP, offset VSP.	2
2	Synthetic seismograms, need for and methodology of their generation,VSP corridor stack.	4
3	Data acquisition, downhole receivers and energy sources; VSP data processing, editing, three-components' rotation and polarization filters, event pick.	6
4	Decomposition of the recorded wave field into upward and downward going waves, need for, methodology of decomposition, and advantages, stacking and migration.	6
5	VSP imaging and analysis, reasons for imaging, VSP imaging methods and their geological applications, inversion of P:SV waves and their application in VSP interpretation.	8
6	VSP migration, basic principles, methodology and application in different geological situations, reverse time migration, its need, basic principles and methodology ,. VSP interpretation case studies in different oil fields..	8
7	3D- VSP, data acquisition, instrumentation and field procedure, 3d- mapping and pre-stack migration, VSP modeling for determining velocity structure and attenuation characteristics, reverse VSP, seismic while drilling(swd) technique	8
	Total	42

11. **Suggested Books:**

S. No	Name of Authors Books / Publishers	Year of Publication/ Reprint
1	Hardage, B.A. "Vertical Seismic Profiling Principles", Pergamon	2000
2	Tang, X.M. "Quantitative Borehole Acoustic Methods", Pergamon	2004
3	Paillet, F.L. and Chen C.H.. "Acoustic Waves in Boreholes", CRC Press	1991
4	Galperin, E.I. "Vertical Seismic Profiling and its Exploration Potential" Springer	1985
5	Balch,A.H. and Lee, M.W. "Vertical seismic profiling : techniques, applications, and case histories, International Human Resources Development Corporation ,	1984