सीनेट की छियासीवीं बैठक का कार्यवृत्त

MINUTES OF THE 86th MEETING OF THE SENATE

9 फरवरी 2021
9th FEBRUARY 2021

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

भारतीय प्रौद्योगिकी संस्थान रूड़की

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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ROORKEE – 247 667

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MEETING SECTION

Minutes of the 86th Meeting of the Senate held on 09.02.2021 at 04.00 P.M. over WebEx.

The list of participants who attended the meeting is appended at **Annexure-I.**

At the outset, the Chairman welcomed the members to the 86th meeting of the Senate.

The Chairman thanked and placed on record the valuable contributions of outgoing member Prof. D.C. Srivastava, Department of Earth Sciences.

The Chairman also welcomed the following new member of the Senate and wished for his active participation in the proceedings of the Senate:

Prof. Sanjeev Kumar, Head, Institute Computer Centre

Prof. Rajat Rastogi, Department of Civil Engineering conveyed his inability to join the meeting.

Prof. Sparsh Mittal Department of Electronics & Communication Engineering attended the meeting on invitation.

The agenda was then taken up.

Item No. 86.1: **To confirm the minutes of the 81st,82nd, 83rd, 84th and 85th Senate meetings held on 08.01.2020, 09.07.2020, 22.10.2020, 24.11.2020 & 18.12.2020, respectively.**

The Senate confirmed the minutes as circulated on 04.02.2020, 13.07.2020,10.11.2020, 04.12.2020 and 23.12.2020.

Item No.86.2: **To report on the actions taken to implement the decisions of the Senate taken in its 81st , 82nd , 83rd, 84th and 85th Senate meetings held on 08.01.2020, 09.07.2020, 22.10.2020, 24.11.2020 & 18.12.2020, respectively.**

The Senate noted the actions taken on the minutes.

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Item No. 86.3: **To consider the proposal of Department of Electronics and Communication Engineering to start an online M.Tech. (Microelectronics and VLSI) for working industry professionals.**

The Senate considered and recommended the proposal to the Board of Governors for approval.

Further, the Senate decided that the progress and status of the programme be placed before the Senate after the next year admissions are over.

Item No. 86.4: **To consider the proposal of renaming the Department of Biotechnology as Department of Biosciences and Bioengineering.**

The Senate considered and recommended the proposal to the Board of Governors for approval.

Item No. 86.5: **To consider the proposal of Department of Biotechnology regarding B.Tech. (Biotechnology):**

1. **To change the programme name of B.Tech. (Biotechnology) to B.Tech. (Biosciences and Bioengineering)**

2. **Revised structure and syllabi of B.Tech. of Department of Biotechnology.**

The Senate considered and approved the proposal as given in **Appendix-A** and decided to implement the changes with immediate effect i.e. from 2020-21 batch since the first semester of the old and new programmes are same.

Item No. 86.6: **To consider the proposal of Department of Architecture & Planning to include Minor Specialization and Departmental Honours Courses (MSC/DHC) in the existing B. Arch curriculum.**

The Senate considered and approved the proposal.

Item No. 86.7: **To consider the proposal to introduce M. Tech in Dam Safety and Rehabilitation programme.**

The Senate considered and approved the proposal as given in **Appendix-B** with a total intake of 30 students alongwith a minimum of 05 seats for GATE qualified candidates.

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Item No. 86.8: To consider the revision of eligibility criteria under 'Extensive Professional Experience Scheme' for Ph.D. Admission.

The Senate considered and approved the modified eligibility criteria for Ph.D. admission under 'Extensive Professional Experience Scheme' (EPE). Further, it was approved that the candidates can choose their department on the basis of their interest or area of expertise. Proposals for further changes can be placed before the IRC.

Item No. 86.9: To consider the report on the plagiarism complaint against Mr. Pramod Sharma's published papers and Ph.D. thesis.

The Senate considered the report and decided the following in respect of Mr. Pramod Sharma:

1. His academic programme be terminated and he will not be awarded a Ph.D. degree.

2. He will not be allowed re-admission in IIT Roorkee.

Item No. 86.10: To consider the report on the plagiarism complaint against Mr. Vivek Kumar Mishra, M.Tech. (PP) and Mr. Elyas Khairandish, M.Tech. (WR).

The Senate considered the report and decided the following:

Case-1 Mr. Vivek Kumar Mishra, M.Tech. (PP) student.

1. His academic programme be terminated and he will not be awarded an M.Tech. degree.

2. He will not be allowed re-admission in IIT Roorkee.

Case-2: Mr. Elyas Khairandish, M.Tech. (WR) student.

1. His academic programme be terminated and he will not be awarded an M.Tech. degree.

2. He will not be allowed re-admission in IIT Roorkee.

3. The sponsoring agency/Ministry be informed about this decision of the Senate.

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Item No. 86.11: To report the approvals accorded by Chairman, Senate:

(a) Recommendations of 79th, 80th, 81st (emergency), 83rd, 84th (emergency), 85th (emergency), 86th, 87th (emergency), 88th, 89th (emergency), 90th (emergency), 91st, 92nd (emergency), 93rd (emergency), 94th, 95th, 96th, 97th and 98th meetings of IAPC.

(b) On the recommendations of 37th, 38th, 39th, 40th, 41st and 42nd meeting of IRC.

(c) Recommendations of SCSP:

The Senate noted the item.

Item No. 86.12: To consider the proposal to start following M.Tech. programs by the Centre for Artificial Intelligence and Data Science (CAIDS).

1. **M.Tech. (Artificial Intelligence)**
2. **M.Tech. (Data Science)**

The Senate considered the proposal for the creation of a **Centre for Artificial Intelligence and Data Science (CAIDS)** and recommended it to the Board of Governors for approval. The Centre will start as a Virtual Centre. Two new Academic Programmes: (1) M.Tech in Artificial Intelligence and (2) M.Tech in Data Science will be offered by this Centre w.e.f Academic Session 2021-22.

Further, the Senate decided that an open house be conducted to finalize their course structure, curriculum, admission criteria etc. After the open house, the revised proposal be considered by the IAPC.

Item No. 86.13: To consider the proposal to start the following Master Programmes:

1. **M. Des. (Industrial Design)**
2. **MIM (Masters in Innovation Management)**

The Senate considered the proposal for the establishment of a Department of Design (DoD) for these programmes and recommended it to the Board of Governors for approval. Two new Academic Programmes: (1) M.Des. (Industrial Design) and (2) MIM (Masters in Innovation Management) will be offered by this Department w.e.f. academic session 2021-22.

Further, the Senate approved the structure of the programmes as given in **Appendix-C.**

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Item No. 86.14: To consider the proposal of Department of Humanities and Social Sciences to introduce a New Integrated M.Sc. Economics (Five Year Integrated) programme.

The Senate considered the proposal and recommended it to the Board of Governors for approval. It will have the provision for exit after four years with a BS degree.

Further, the Senate approved the structure of the programme as given in **Appendix-D.**

Item No. 86.15: To consider the proposal of Department of Management Studies to introduce Executive MBA (EMBA) programme.

The Senate considered the proposal and recommended it to the Board of Governors for approval. Further, the Senate approved the structure of the programme and admission eligibility criteria as given in **Appendix-E.**

Item No. 86.16: To consider the proposal for the provision of S grade for Autumn Semester 2020-21 End Term Examination for all students.

The Senate considered and decided that 'S' grade be allowed on request in a maximum of two courses (excluding UG first year courses) of Autumn Semester 2020-21.

Item No. 86.17: To consider the revised report of the committee constituted to review the current thesis evaluation process for M.Tech./IMT/IDD.

The item was deferred.

Item No. 86.18: To consider the acceptance of Second Class Degree of B.E./B.Tech with 55% and above score with respect to the officers of Indian Army for M.Tech./M.Arch./ MURP admission.

The item was deferred.

Item No. 86.19: To consider Senate Nominees for the selection committees for faculty positions.

The Senate considered and decided that: Academics/Scientists with at least five years of experience of the level of Professor or equivalent from the following academic/research Institutes be considered as Senate nominees:

IITs, IISc, IISERs, IIMs, SPAs, AIIMSs, BHU, JNU, Delhi University, University of Hyderabad and DST/NID/DBT/

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ISI/ICSSR/TISS/DAE/DoS/DRDO/CSIR/ICAR/ICMR labs/ institutes.

Further, more names can also be sent by the departments for the consideration of the Senate.

Item No.86.20: To ratify the award of provisional Ph.D. Degree certificates to the students who have completed the requirements for the award of Ph.D. Degree in various disciplines w.e.f. 30.11.2020 to date.

The Senate ratified the item as given in **Appendix-F.**

Item No. 86.21: To report the extension of panel of Senate's Nominees on the Selection Committees for Group 'A' Academic positions.

The Senate noted the item.

UNDER ANY OTHTE ITEMS:

Item No. 86.22 To consider the admission of foreign nationals in MBA programme (2021-22).

The item was deferred.

Item No. 86.23: To consider the request of some of the students to allow them to appear in the second examination of ETE Autumn Semester 2020-21.

The Senate considered the requests of students who suffered with the issues of poor internet connectivity/shutdown in some of the areas during ETE (excluding UG 1st year) of Autumn Semester 2020-21. The Senate allowed the provision of second examination of ETE Autumn Semester 2020-21 for such students.

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

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Annexure-I

Following were present:

1.	Prof. Ajit K. Chaturvedi	Director & Chairman
2.	Prof. M. Parida	Deputy Director
3.	Prof. Milli Pant	Applied Science & Engineering
4.	Prof. P. Chani	Architecture & Planning
5.	Prof. V. Devadas	Architecture & Planning
6.	Prof. Mahua Mukherjee	Architecture & Planning
7.	Prof. Gaurav Raheja	Architecture & Planning
8.	Prof. Sanjoy Ghosh	Biotechnology
9.	Prof. Pravindra Kumar	Biotechnology
10.	Prof. Naveen Kumar Nawani	Biotechnology
11.	Prof. Ranjana Pathania	Biotechnology
12.	Prof. Ramasare Prasad	Biotechnology
13.	Prof. Partha Roy	Biotechnology
14.	Prof. R.P. Singh	Biotechnology
15.	Prof. Ashwani Kumar Sharma	Biotechnology
16.	Prof. Shailly Tomar	Biotechnology
17.	Prof. Prakash Biswas	Chemical Engineering
18.	Prof. Amit Kumar Dhiman	Chemical Engineering
19.	Prof. P.P. Kundu	Chemical Engineering
20.	Prof. C.B. Majumdar	Chemical Engineering
21.	Prof. Prasenjit Mondal	Chemical Engineering
22.	Prof. Basheshwer Prasad	Chemical Engineering
23.	Prof. Shishir Sinha	Chemical Engineering
24.	Prof. Vimal Chandra Srivastava	Chemical Engineering
25.	Prof. Naseem Ahmad	Chemistry
26.	Prof. R.K. Dutta	Chemistry
27.	Prof. Kaushik Ghosh	Chemistry
28.	Prof. P. Jeevanandam	Chemistry
29.	Prof. M.R. Maurya	Chemistry
30.	Prof. R.K. Peddinti	Chemistry
31.	Prof. Muniappan Sankar	Chemistry
32.	Prof. U.P. Singh	Chemistry
33.	Prof. Z. Ahmad	Civil Engineering
34.	Prof. Anupam Chakrabarti	Civil Engineering
35.	Prof. P.K. Garg	Civil Engineering
36.	Prof. Rahul Dev Garg	Civil Engineering
37.	Prof. J.K. Ghosh	Civil Engineering
38.	Prof. S.K. Ghosh	Civil Engineering
39.	Prof. Pramod Kumar Gupta	Civil Engineering
40.	Prof. B.R. Gurjar	Civil Engineering
41.	Prof. M.A. Iqbal	Civil Engineering

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42.	Prof. Absar Ahmad Kazmi	Civil Engineering
43.	Prof. Priti Maheshwari	Civil Engineering
44.	Prof. Satyendra Mittal	Civil Engineering
45.	Prof. C.P.S. Ojha	Civil Engineering
46.	Prof. Vipul Prakash	Civil Engineering
47.	Prof. K. Hari Prasad	Civil Engineering
48.	Prof. G.D. Ransinchung R.N.	Civil Engineering
49.	Prof. N.K. Samadhiya	Civil Engineering
50.	Prof. Vishwas Sawant	Civil Engineering
51.	Prof. Umesh Kumar Sharma	Civil Engineering
52.	Prof. Mahendra Singh	Civil Engineering
53.	Prof. Akhil Upadhyay	Civil Engineering
54.	Prof. R. Balasubramanian	Computer Science & Engineering
55.	Prof. Manoj Mishra	Computer Science & Engineering
56.	Prof. Rajdeep Niyogi	Computer Science & Engineering
57.	Prof. Durga Toshniwal	Computer Science & Engineering
58.	Prof. Pankaj Agarwal	Earthquake Engineering
59.	Prof. B.K. Maheshwari	Earthquake Engineering
60.	Prof. M.L. Sharma	Earthquake Engineering
61.	Prof. Manish Shrikhande	Earthquake Engineering
62.	Prof. Yogendra Singh	Earthquake Engineering
63.	Prof. Sunil Bajpai	Earth Sciences
64.	Prof. Kamal	Earth Sciences
65.	Prof. Sagarika Mukhopadhyay	Earth Sciences
66.	Prof. R.S. Anand	Electrical Engineering
67.	Prof. N.P. Padhy	Electrical Engineering
68.	Prof. M.K. Pathak	Electrical Engineering
69.	Prof. G.N. Pillai	Electrical Engineering
70.	Prof. S.P. Singh	Electrical Engineering
71.	Prof. P. Sumathi	Electrical Engineering
72.	Prof. Anand Bulusu	Electronics & Comm. Engineering
73.	Prof. Sudeb Dasgupta	Electronics & Comm. Engineering
74.	Prof. Brajesh Kaushik	Electronics & Comm. Engineering
75.	Prof. N.P. Pathak	Electronics & Comm. Engineering
76.	Prof. Amalendu Patnaik	Electronics & Comm. Engineering
77.	Prof. Dharmendra Singh	Electronics & Comm. Engineering
78.	Prof. Rashmi Gaur	Humanities & Social Sciences
79.	Prof. Smita Jha	Humanities & Social Sciences
80.	Prof. Nagendra Kumar	Humanities & Social Sciences
81.	Prof. Anindya Jayanta Mishra	Humanities & Social Sciences
82.	Prof. Sanjit Kumar Mishra	Humanities & Social Sciences
83.	Prof. Binod Mishra	Humanities & Social Sciences
84.	Prof. S.P. Singh	Humanities & Social Sciences
85.	Prof. D.S. Arya	Hydrology
86.	Prof. N.K. Goel	Hydrology
87.	Prof. M.K. Jain	Hydrology

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88.	Prof. Himanshu Joshi	Hydrology
89.	Prof. Arun Kumar	Hydro & Renewable Energy
90.	Prof. R.P. Saini	Hydro & Renewable Energy
91.	Prof. Sunil Kumar Singhal	Hydro & Renewable Energy
92.	Prof. Ramesh Chandra	Institute Instrumentation Centre
93.	Prof. Rajat Agarwal	Management Studies
94.	Prof. M.K. Barua	Management Studies
95.	Prof. Usha Lenka	Management Studies
96.	Prof. Anil Kumar Sharma	Management Studies
97.	Prof. Vinay Sharma	Management Studies
98.	Prof. Kusum Deep	Mathematics
99.	Prof. Tanuja Srivastava	Mathematics
100.	Prof. Shiv Prasad Yadav	Mathematics
101.	Prof. Navneet Arora	Mechanical & Industrial Engg.
102.	Prof. Sushanta Dutta	Mechanical & Industrial Engg.
103.	Prof. Akshay Dvivedi	Mechanical & Industrial Engg.
104.	Prof. Dheerendra Kumar Dwivedi	Mechanical & Industrial Engg.
105.	Prof. B.K. Gandhi	Mechanical & Industrial Engg.
106.	Prof. S.P. Harsha	Mechanical & Industrial Engg.
107.	Prof. Dinesh Kumar	Mechanical & Industrial Engg.
108.	Prof. Ravi Kumar	Mechanical & Industrial Engg.
109.	Prof. B.K. Mishra	Mechanical & Industrial Engg.
110.	Prof. Manish Mishra	Mechanical & Industrial Engg.
111.	Prof. K. Murugesan	Mechanical & Industrial Engg.
112.	Prof. Kaushik Pal	Mechanical & Industrial Engg.
113.	Prof. Pushparaj Mani Pathak	Mechanical & Industrial Engg.
114.	Prof. V.H. Saran	Mechanical & Industrial Engg.
115.	Prof. Apurbba Sharma	Mechanical & Industrial Engg.
116.	Prof. Inderdeep Singh	Mechanical & Industrial Engg.
117.	Prof. Indra Vir Singh	Mechanical & Industrial Engg
118.	Prof. A. Tariq	Mechanical & Industrial Engg.
119.	Prof. S.H. Upadhyay	Mechanical & Industrial Engg.
120.	Prof. G.P. Chaudhuri	Metallurgical & Materials Engg.
121.	Prof. B.S.S. Daniel	Metallurgical & Materials Engg.
122.	Prof. Vivek Pancholi	Metallurgical & Materials Engg.
123.	Prof. Anjan Sil	Metallurgical & Materials Engg.
124.	Prof. S.C. Sharma	Paper Technology
125.	Prof. Sujay Chattopadhyay	Polymer & Process Engineering
126.	Prof. Y.S. Negi	Polymer & Process Engineering
127.	Prof. P. Arumugam	Physics
128.	Prof. Rajdeep Chatterjee	Physics
129.	Prof. Anil Kumar Gaurishetty	Physics
130.	Prof. Tulika Maitra	Physics
131.	Prof. Aalok Misra	Physics
132.	Prof. Tashi Nautiyal	Physics
133.	Prof. Vipul Rastogi	Physics

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134. Prof. G.D. Varma — Physics
135. Prof. Ajay Wasan — Physics

136. Prof. Davinder Kaur Walia — Physics
137. Prof. Kanhaiya Lal Yadav — Physics
138. Prof. M.L. Kansal — WRD&M
139. Prof. Deepak Khare — WRD&M
140. Prof. S.K. Mishra — WRD&M
141. Prof. Ashish Pandey — WRD&M
142. Prof. Kiran Ambatipudi, Associate Dean of Students' Welfare (Student Wellness)
143. Prof. Bhavesh Kumar Bhalja, Associate Dean of Academic Affairs (Evaluation)
144. Prof. Rama Chandran C.N., Associate Dean of Academic Affairs (Curriculum)
145. Prof. Ganesh Kumbhar, Associate Dean, Infrastructure (Electrical & A/C)
146. Prof. Sanjeev Kumar, Head, Institute Computer Center
147. Dr. C. Jayakumar, Librarian

Students' representatives:

148. Mr. Shivam Chopra, General Secretary, Hostel Affairs
149. Mr. Dheeraj Etta, General Secretary, (UG)

150. Mr. Prashant Garg, Registrar & Secretary, Senate

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Program Code : 111 - B.Tech. (Biotechnology)
Department : Department of Biotechnology
Year : I

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credit	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
FIRST YEAR (Autumn)														
1.	MAN-001	Mathematics-I	BSC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
2.	PHN-007	Modern Physics	BSC	4	3	0	2	3	0	10-25	25	15-25	30-40	
3.	CEN-105	Introduction to Environmental Studies	GSC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
4.	HSN-001A	Communication Skills (Basic)	HSSC	2	1	0	2	2	0	25	-	25	50	-
	HSN-001B	Communication Skills (Advance)	HSSC	2	1	0	2	2	0	25	-	25	50	-
5.	HSN-002	Introduction of Psychology	HSSC	2	1	1	0	2	0	20-30	-	20-30	40-50	-
6.	BT-101	Introduction to Biotechnology	PCC	2	2	0	0	2	0	-	-	-	100	-
7.	BT-103	Computer Programming	ESC	4	3	0	2	3	0	10-25	25	15-25	30-40	-
		Total		**21**										
FIRST YEAR (Spring)														
1.	MAN-006	Probability and Statistics	BSC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
2.	BT-102	Biochemistry	PCC	4	3	-	2	3	0	10-25	25	15-25	30-40	-
3.	BT-104	Cell Biology	PCC	4	3	-	2	3	0	10-25	25	15-25	30-40	-
4.	BT-106	Microbiology	PCC	4	3	-	2	3	0	10-25	25	15-25	30-40	-
5.	CYN- 002	Organic and Inorganic Chemistry	BSC	4	3	1	2/2	3	0	15-30	20	15-25	30-40	-
6.	CEN-108	Fluid Mechanics	ESC	4	3	1	2/2	3	0	15-30	20	15-25	30-40	-
		Total		**24**										

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Program Code: 111 - B.Tech. (Biotechnology)
Department : Department of Biotechnology
Year : II

S. No.	Subject Code	Course Title	Subject Area	Credit	Contact Hours/Week			Exam Duration		Relative Weight (%)				
					L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
SECOND YEAR (Autumn)														
1.	MIN-106	Engineering Thermodynamics	ESC	4	3	1	2/2	3	0	15-30	20	15-25	30-40	-
2.	BT-201	Genetics and Developmental Biology	PCC	4	3	-	2	3	0	10-25	25	15-25	30-40	-
3.	BT-203	Immunology	PCC	4	3	-	2	3	0	10-25	25	15-25	30-40	-
4.	BT-205	Bioinformatics	PCC	4	3	-	2	3	0	10-25	25	15-25	30-40	-
5.	BT-207	Process Calculations	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
6.	HSN-ELE	HSS Elective Course	HSSMEC	3	2	1	0	3	0	20-35	-	20-30	40-50	-
		Total		**23**										
SECOND YEAR (Spring)														
1.	BT-202	Structural Biology	PCC	4	3	-	2	3	0	10-25	25	15-25	30-40	-
2.	BT-204	Physiology of Animals and Plants	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
3.	BT-206	Transport phenomenon in Biological System	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
4.	BT-208	Biomaterials and Devices	PCC	4	3	1	2/2	3	0	15-30	20	15-25	30-40	-
5.	BT-210	Molecular Biology and Genetic Engineering	PCC	4	3	-	2	3	0	10-25	25	15-25	30-40	-
6.	ECN-102	Fundamentals of Electronics	ESC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
		Total		**24**										

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Program Code : 111 - B.Tech. (Biotechnology)
Department : Department of Biotechnology
Year : III

S. No.	Subject Code	Course Title	Subject Area	Credit	Contact Hours/Week			Exam Duration		Relative Weight (%)				
					L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
THIRD YEAR (Autumn)														
1.	BT-301	Bioprocess Engineering	PCC	4	3	1	2/2	3	0	15-30	20	15-25	30-40	-
2.	BT-303	Animal and Plant Tissue Culture	PCC	4	3	-	2	3	0	10-25	25	15-25	30-40	-
3.	BT-305	Computational Biology	PCC	4	3	-	2	3	0	10-25	25	15-25	30-40	-
4.	BT-ELE1	Department Elective Course - I	PEC	4	3	1	-	3	0	20-35	-	20-30	40-50	-
5.	OEC/BM-ELE	Management Studies/ Open Elective Course*	HSSMEC/ OEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
6.	BT-391	Technical Communication	PCC	2	0	2	0	0	0	-	-	-	100	-
			Total	**21**										
THIRD YEAR (Spring)														
1.	BT-300	Case Study	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
2.	BT-302	Genomics, Proteomics and Metabolomics	PCC	4	3	1	2/2	3	0	15-30	20	15-25	30-40	-
3.	BT-304	Molecular Diagnostics	PCC	4	3	1	2/2	3	0	15-30	20	15-25	30-40	-
4.	BT-ELE2	Department Elective Course - II	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
5.	MSC1/ DHC1	Minor Specialization Course-I / Departmental Honours Course-I	MSC/DHC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
6.	OEC/BM-ELE	Management Studies/ Open Elective Course*	HSSMEC/ OEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
7.	BT-399	Educational Tour	PCC	0	0	0	0	0	0	-	-	-	-	-
			Total	**19-23**										

* One course each from the OEC and the HSSMEC categories is to be opted either in the Autumn or in the Spring semester in the third year. The HSSMEC course should be selected from the list (basket) of Management Studies Elective Course.

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Program Code : 111 - B.Tech. (Biotechnology)
Department : Department of Biotechnology
Year : IV

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credit	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
FOURTH YEAR (Autumn)														
1.	BT-400A	B.Tech. Project	PCC	4	0	0	8	0	0	-	-	-	-	-
2.	BT- ELE3	Department Elective Course -III	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
3.	BT- ELE4	Department Elective Course -IV	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
4.	MSC2/ DHC2	Minor Specialization Course-II Departmental Honours Course-II	MSC/DHC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
5.	MSC3/ DHC3	Minor Specialization Course-III Departmental Honours Course-III	MSC/DHC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
6.	BT-499	Training Seminar	PCC	2	0	2	0	0	0	100	-	-	-	-
		Total		**14-22**										
FOURTH YEAR (Spring)														
1.	BT-400B	B.Tech. Project	PCC	8	0	0	16	0	0	-	100	-	-	-
2.	BT-ELE5	Department Elective Course –V	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
3.	BT-ELE6	Department Elective Course -VI	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
4.	MSC4/ DHC4	Minor Specialization Course-IV / Departmental Honours Course-IV	MSC/DHC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
5.	MSC5/ DHC5	Minor Specialization Course-V / Departmental Honours Course-V	MSC/DHC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
		Total		**16-24**										

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DEPARTMENT OF BIOTECHNOLOGY
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
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List of Department Minor Specialization Courses:

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credit	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1.	BT-490	Fundamentals of Biotechnology	MSC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
2.	BT-491	Biophotonics	MSC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
3.	BT-492	Introduction to Computational Biology	MSC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
4.	BT-493	Recombinant DNA Technology	MSC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
5.	BT-494	Environmental Biotechnology	MSC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
6.	BT-495	Fermentation Technology	MSC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
7.	BT-496	Fundamentals of Food Biotechnology	MSC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
8.	BT-497	NMR Techniques	MSC	4	3	1	0	3	0	20-35	-	20-30	40-50	-

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
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List of Department Honours Specialization Courses:

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credit	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1.	BT-471	Drug Discovery and Development	DHC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
2.	BT-472	Stem Cell Technology	DHC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
3.	BT-473	Phytomedicine	DHC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
4.	BT-474	Advanced Virology	DHC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
5.	BT-475	Enzyme Technology	DHC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
6.	BT-476	Protein Crystallography	DHC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
7.	BT-477	Biomedical Optics and Biophotonics	DHC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
8.	BT-478	Protein NMR	DHC	4	3	1	0	3	0	20-35	-	20-30	40-50	-

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DEPARTMENT OF BIOTECHNOLOGY
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
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List of Department Elective Course

Category-I

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credit	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
Basket-1 (Cell and Molecular Biology)														
1.	BT-341	Gene Regulation	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
2.	BT-342	Food Biotechnology	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
3.	BT-343	Virology	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
4.	BT-344	Nano- Bioengineering	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
5.	BT- 345	Separation and Analysis of Biomolecules	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
6.	BT-346	Drug Discovery	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
Basket-2 (Biological Engineering)														
7.	BT-347	Bioprocess Control	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
8.	BT-348	Bioprocess Modelling and Simulation	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
9.	BT-349	Biomechanics	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
Basket-3 (Structural and Computational Biology)														
10.	BT-350	Machine Learning and Deep Learning	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
11.	BT-351	Protein Engineering	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
12.	BT-352	Biophotonics	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-

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Category- II

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credit	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
Basket-1 (Cell and Molecular Biology)														
1.	BT-441	Principles of Synthetic Biology	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
2.	BT-442	Environmental Biotechnology	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
3.	BT-443	Stem Cell Engineering	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
4.	BT-444	Industrial Bioprocessing	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
5.	BT-445	High Throughput Sequencing	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
6.	BT-446	Chemical Genetics	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
7.	BT-447	Genetically Modified Organisms	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
8.	BT-448	Vaccine Biotechnology	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
9.	BT-449	Cell and Tissue Engineering	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
Basket-2 (Biological Engineering)														
10.	BT-450	Bioreactor Design and Analysis	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
11.	BT-451	Bioprocess Optimization	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
12.	BT-452	Bioseparation Engineering	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
13.	BT-453	Bioelectronic Medical Devices	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-

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Basket-3 (Structural and Computational Biology)														
14.	BT-454	Big Data Analytics	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
15.	BT-455	Biomolecular NMR	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
16.	BT-456	Biomolecular Modelling	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
17.	BT-457	Systems Biology	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
18.	BT-458	Molecular Biophysics	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
19.	BT-459	Biomolecular Interactions	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
20.	BT-460	Design and Analysis of Algorithms	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **BT-101** Course Title: **Introduction to Biotechnology**

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

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

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

5. Credits: **2**

6. Semester: **Autumn** 7. Subject Area: **PCC** 8. Pre-requisites: **Nil**

9. Objective: To impart the basic knowledge of various concepts in different areas of biotechnology

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction : Basic unit of life; macromolecules; prokaryotes; eukaryotes; cell components- sub-cellular organelles.	4
2	Microbial life and fermentation process: Bacteria, fungi and viruses; basic concept of microbial growth, bioprocess technology and enzymes.	5
3	Molecular biology concepts: Central dogma of molecular biology-replication, transcription and translation; recombinant DNA technology; basic concept of immune system, vaccines, GMOs.	6
4	Plant and Animal Biotechnology: Cell and tissue culture, transgenic plant and animals.	3
5	Medical Biotechnology: Introduction to biopharmaceuticals, herbal medicines, gene therapy, nanobiotechnology, bioinformatics and drug design, biosafety and bioethics.	5
6	Molecular techniques in Biotechnology: Introduction to microscopy, spectroscopy, electrophoresis, chromatography, centrifugation, , radioisotope technique, PCR, northern blotting, southern blotting, western blotting	5
	Total	**28**

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	Walker, J.M. and Gingold, E.B., "Molecular Biology and Biotechnology", The Royal Society of Chemistry UK	1999
2	Wilson, K. and Walker, J., "Principles and Techniques of Practical Biochemistry", 5th edition, Cambridge University Press.	2000
3	Nelson, D.L. and Cox, M.M., "Lehninger's Principles of Biochemistry", 5th edition, W.H. Freeman.	2009
4	Smith, J.E., "Biotechnology", Cambridge University Press, 5th edition.	2009
5	Bernard R. G., Jack J. P., "Molecular Biotechnology : Principles and Applications of Recombinant DNA", ASM Press 4th Edition.	2009
6	Murray, Moo-Young., "Comprehensive Biotechnology", 2nd edition ,University of Waterloo, Canada (Volumes 1, 4 and 5) Elsevier Press	2011

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT-102** Course Title: **Biochemistry**

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

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

4. Relative Weightage: **CWS: 10-25** **PRS: 25** **MTE: 15-25** **ETE: 30-40** **PRE: 0**

5. Credits: **4**

6. Semester: **Spring** 7. Subject Area: **PCC** 8. Pre-requisites: **Nil**

9. Objective: To impart knowledge of basic biochemistry concepts for understanding many important problems of biology.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Chemical basis of life; Water-properties of water, acid and base, pH, buffers, physiological buffers; Non-covalent interactions; Macromolecular assemblies	5
2	Proteins-classification, structure, function, dynamics, specificity, and basics of protein purification and analysis; Functional and structural proteins-Hemoglobin, myoglobin, collagen	9
3	Enzymes-introduction, classification, kinetics and catalysis; Enzyme inhibitors; Enzyme mechanisms and regulation	8
4	Nucleic acids-structure and properties of DNA and RNA, DNA double helical structure, A, B & Z DNA; Carbohydrates-Mono, di and polysaccharides, glycoproteins and glycolipids; Lipids-Classification, structure, function, lipid bilayer	5
5	Metabolism- basic concepts and design; Metabolism of carbohydrates-glycolysis & gluconeogenesis, citric acid cycle, electron transport chain and oxidative phosphorylation; Metabolism of lipid, amino acid and nucleotides	11
6	Integration of metabolism, coordinated control and regulation	4
	Total	42

S. No.	Practical course contents
1	Preparation of stock solutions and buffers.
2	Titration of a weak acid and a weak base.
3	Quantitative analysis of amino acid, sugars, fats
4	Protein estimation by spectroscopic, Biuret and Lowry's and Bradford methods.
5	Estimation of nucleic acids by absorbance at 260 nm
6	Purification of proteins using column chromatography and SDS-PAGE
7	Determination of Enzyme kinetic parameters

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11. Suggested Books:

S. No.	Authors/ Name of Books/Publisher	Year of Publication /Reprint
1	Stryer, L., "Biochemistry" 7th edition, W. H. Freeman.	2010
2	Horton, H.R., Moran, L.A., Ochs R.A., Rawn, J. D. and Scrimgeor, R.S., "Principles of Biochemistry" 3rd edition Prentice Hall,.	2001
3	Voet, D. and Voet, J. G., "Biochemistry" 3rd edition, John Wiley and Sons.	2004
4	Nelson, D.L. and Cox, M.M.,"Lehninger Principles of Biochemistry", 5th edition, W.H. Freeman.	2009
5	Wilson, K. and Walker, J., "Principles and Techniques of Practical Biochemistry" 5th edition, Cambridge University Press.	2000

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1 .Subject Code: **BT-103** Course Title: **Computer Programming**

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

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

4. Relative Weightage: **CWS: 10-25** **PRS: 25** **MTE: 15-25** **ETE: 30-40** **PRE:0**

5. Credits: **4**

6. Semester: **Autumn** 7. Subject Area: **PCC** 8. Pre-requisites: **Nil**

9. Objective: To impart the basic knowledge of Computer System and Develop Basic skills in programming.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Basic Computer Fundamentals:** Introduction to computer systems; number system, integer, signed integer, fixed and floating point representations; IEEE standards, integer and floating point arithmetic; CPC organization, ALU, registers, memory, the idea of program execution at micro level.	7
2	**Basic Programming in C++:** Input/output; Constants, variables, expressions and operators; Naming conventions and styles; Conditions and selection statements; Looping and control structures (while, for, do-while, break and continue); File I/O, header files, string processing; Pre-processor directives such as #include#, #define, #ifdef, #ifndef; Compiling and linking.	8
3	**Programming through functional decomposition:** Functions (void and value returning), parameters, scope and lifetime of variables, passing by value, passing by reference, passing arguments by constant reference; Design of functions and their interfaces (concept of functional decomposition), recursive functions; Function overloading and default arguments; Library functions; Matters of style, naming conventions, comments.	8
4	**Aggregate data-types:** Arrays and pointers; Structure; Dynamic data and pointers, dynamic arrays; Introduction to data structure, use of pointers in linked structures.	7
5	**Object Oriented Programming Concepts:** Data hiding, abstract data types, classes, access control; Class implementation-default constructor, constructors, copy constructor, destructor, operator overloading, friend functions; Object oriented design (an alternative to functional decomposition) inheritance and composition; Dynamic binding and virtual functions; Polymorphism; Dynamic data in classes.	12
	Total	**42**

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11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	Heller, Steve., 'Who's Afraid of C++', Academic Press.	1996
2	Koren, I., 'Computer Arithmetic Algorithms', A.K. Peters Ltd, 2nd edition.	2001
3	Eckel, B., 'Thinking in C++ Volume 1 & 2', Prentice Hall, 2nd edition.	2003
4	Oualline, S., 'Practical C++ Programming', O'Reilly Media, 2nd edition.	2003
5	Prata, S., 'C++ Primer Plus', Sams, 5th edition.	2004
6	Lippman, C.B., Lajoie J. & Moo. B.E., 'The C++ Primer. Addison', Wesley Professional, 4th edition.	2005
7	Stallings, W., 'Computer Organisation and Architecture: Designing for Performance', Prentice-Hall, 7th edition.	2005
8	Deitel, H.M. & Deitel, P.J., 'C++ How to Program', Prentice Hall, 8th edition.	2011
9	Stroustrup, B., 'The C++ Programing Language', Addison-Wesley, 4th edition.	2013

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: Department of Biotechnology

1. Subject Code: **BT-104** Course Title: **Cell Biology**

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

3. Examination Duration (Hrs.): **Theory: 03** **Practical:0**

4. Relative Weightage: **CWS: 10-25** **PRS:25** **MTE: 15-25** **ETE:30-40** **PRE:0**

5. Credits: **4**

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

9. Objective:To give an overview of fundamental and advance knowledge on cell biology and its practical application to various regulatory processes.

10. Details of course:

S. No.	Contents	Contact Hours
1	**Cell structure and function**: Road map of the course,introduction to cell biology, cell theory, cell size and their ccomponents, microscopy,cell nutrition, eukaryotic and prokaryotic cell, difference between bacterial, plant, animal and fungal cells, structure and function of cellular organelles, origin of life and cell, cytoskeleton, transport across cell membrane,	14
2	**Cell division**: Mitosis and the phases of cell division, meiosis, cell cycle regulation and its checkpoints.	4
3	**Cell death**: significance of cell cycle regulation in in connection to cell death by apoptosis and their regulation, intracellular trafficking,	4
4	**Cell Signaling**: Cell-cell interactions; important cell signaling mechanisms, cell receptors, ligands and trans-membrane signaling;	5
5	**Cancer**: Cell signaling pathways related to cancer, proto-oncogenes, oncogenes and tumour suppressor genes,	5
6	**Stem cells**: Cellular differentiation including early embryonal development, conditions of stem cells; application of stem cells; induced pluripotency	6
7	**Basics of in vitro cell culture:** Isolation of cells; various types of cell/ organs/ tissue cultures; stem cell cultures	3
8	**Basics of Tissue engineering**: Stem cells in tissue engincer; types of materials for tissue engineering	2
	Total	42

S. No.	Practical course contents
1	Display of cell organelles and micro structures
2	Overview of light microscopy methods
3	Observation of distinguishing features of different eukaryotic cells.
4	Study of divisional stages in Mitosis.
5	Study of divisional stages in Meiosis
6	Introducing in vitro cell cultures for cell biology
7	Observation of growth and differentiation in single cells.
8	Isolation and estimation of chloroplasts and DNA.

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11.Suggested Books:

S No.	Author(s)/ Title/ Publisher	Year of Publication/ Reprint
1	Vunjak Novakovic, G., Freshney, I.A., "Culture of Cells for Tissue Engineering", John Wiley & Sons, Inc. ISBN:9780471741817	2006
2	Cell Biology: A Short Course, 3rd Edition Stephen R. Bolsover, Elizabeth A. Shephard, Hugh A. White, Jeremy S. Hyams. ISBN: 978-0-470-52699-6	2011
3	Bruce Alberts, et al. Molecular biology of the cell. Garland Science, 2015. 6th edition.	2015
4	Slack, J.M.W., "The Science of Stem Cells" John Wiley & Sons, Inc. ISBN: 9781119235293	2018
5	Karp's Cell Biology, 8th Edition, Global Edition by Gerald Karp, Janet Iwasa, Wallace Marshall. ISBN: 978-1-119-45629-2	2018

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT: **Department of Biotechnology**

1. Subject Code: **BT-106** Course Title: **Microbiology**

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

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

4. Relative Weightage: **CWS: 10-25** **PRS: 25** **MTE: 15-25** **ETE: 30-40** **PRE: 0**

5. Credits: **4**

6. Semester: **Spring** 7. Subject Area: **PCC** 8. Pre-requisites: **Nil**

9. Objective: To impart the knowledge of the mechanistic features of the microbes to use them as a tool for various applications related to human health, industrial applications and environment.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Discovery of Microorganisms, Eukaryotic and Prokaryotic cells, Classification and nomenclature of microorganisms. Microscopy, Principles and applications- dark field, bright field, electron microscopy, TEM and SEM, Staining techniques. Control of Microorganisms-Sterilization, disinfection, antisepsis, Physical and chemical methods.	9
2	Morphological and structural organization of microbes- Bacteria, fungi, viruses.Cellular growth- Isolation, identification and cultivation of bacteria, fungi, viruses (lysis and lysogeny)and growth curve.	8
3	Microbial nutrition and metabolism- aerobic and anaerobic respiration, fermentation, bacterial photosynthesis. Food Microbiology-Preservation of food, Microbiological fermentation of food-products-cheese, yogurt, breadand other fermented foods.	12
4	Industrial Microbiology- Outline of production of ethanol,organic acids,vitamins, antibiotics, leaching of ores by microorganisms. Bacterial genome, recombination, mutations, diseases caused by bacteria, fungi, viruses; antibiotic resistance.	13
	Total	42

S. No.	Practical course contents
1	Preparation and sterilization of culture media.
2	Preparation of culture media plates by pouring
3	Growth of model microorganisms (E.coli) by streaking, pour plating and spread plating.
4	Isolation of bacteria from different sources (soil, water, air).
5	Characterization of the isolated bacteria obtained from different source samples.
6	Identification of isolated bacterial calories using microscopic & staining techniques.
7	To plot a growth curve of isolated bacterial strain.
8	Determination of Minimum inhibitory concentration of a known antibiotic against reference bacterial strains-micro-broth dilution and disk diffusion assays.

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11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	William, M., O'Leary, "Practical handbook of microbiology", CRCPress.	1989
2	Talaron, K., Talaron, A., Pelczar, C. and Reid, A., "Foundations In Microbiology", W.C.Brown Publishers	2005
3	Pelczar, M.J., Chan, E.C.S. and Krein, N.R., "Microbiology", Tata McGraw Publication	2007
4	Goldman E., Lorrence, H. "Greenpractical handbook ofmicrobiology", CRC Press.	2008
5	Prescott, L.M., Harley, J.P. and Klein, D.A., "Microbiology", W. C. Brown Publications	2012
6	Frazier and Westnoff., "Food Microbiology", Tata Mcgrawhill	2012

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code : **BT-201** Course Title: **Genetics and Developmental Biology**

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

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

4. Relative Weightage: **CWS: 10-25** **PRS: 25** **MTE: 15-25** **ETE: 30-40** **PRE: 0**

5. Credits: **4**

6. Semester: **Autumn** 7. Subject Area: **PCC** 8. Pre-requisites: **Nil**

9. Objective: To impart fundamental knowledge of genetics and developmental biology in understanding the basis of inheritance, and structure and molecular mechanism of gene function and mechanism of development in animals and plants.

10. Details of Course:

S. No.	Content	Contact Hours
1	Introduction and history of genetics, Reproduction as the basis of heredity; Mendelian principles of genetics, Exceptions of Mendelian principles	5
2	Genetic recombination and prokaryotes and eukaryotes, Chromosomal basis of inheritance and linkage; genetic complementation, Construction of genetic and physical maps; genetic mapping in prokaryotes and eukaryotes	6
3	Mechanism of sex determination, Chromosomal aberration and gene mutations, types of mutations, cause and consequences of mutations	5
4	Cytoplasmic inheritance, Genetic disorders and genetic counseling: Applications of genetics in agriculture and medicine, eugenics	5
5	Fundamentals of development; Potency, Commitment, Specification, Competence, Cell fate and cell lineages, stem cells, homeotic transformation, Developmental mutants, Approaches to study development	4
6	Gametogenesis and fertilization in animals and plants, Embryogenesis in animals; Cleavage, Blastula formation, Gastrulation, Embryogenesis in plants; embryo sac development, establishment of shoot and root meristem	5
7	Morphogenesis and organogenesis in animals; Axes and pattern formation in Drosophila, vulva formation in *Caenorhabditis elegans,* Differentiation of neurons, Regeneration in vertebrates.	6
8	Morphogenesis and organogenesis in plants; organization of shoot and root apical meristem, transition to flowering, Floral organ development and determinacy, Lateral root development	6
	Total	**42**

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S. No.	Practical
1	Analyzing Mendelian genetic segregation of mutant phenotypes in plants
2	Observing tissue-specific expression pattern of developmental regulators in plants
3	Analyzing developmental defects in mutant plants
4	Observation of Sea urchin embryology by microscopic slides
5	Observation of Amphibian embryology by microscopic slides
6	Observation of Chicken embryology by microscopic slides
7	Isolation of Chicken embryo from fertilized and incubated egg

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	Snustad, S., "Principles of Genetics", John Wiley & Sons Inc. Hoboken.	2003
2	Leyser, O., Day S., Mechanisms in Plant Development, 1st edition, Blackwell Science Ltd	2003
3	Klug, W.S. and Cummings, M.R., "Concepts of Genetics", Pearson Education Inc.	2004
4	Wolpert, L., Tickle, C., "Principles of Development", 4th Edition, OUP Oxford Press	2011
5	Gilbert, S. F., Developmental Biology, Tenth Edition, Sinauer Associates, Inc.	2013
6	Taiz, L., Zeiger, E., Møller, I.M., Murphy, A., Plant Physiology and Development. Sixth edition, Sinauer Associates	2017

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **BT-202** Course Title: **Structural Biology**

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

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

4. Relative Weightage: **CWS: 10-25** **PRS: 25** **MTE: 15-25** **ETE: 30-40** **PRE: 0**

5. Credits: **4**

6. Semester: **Spring** 7. Subject Area: **PCC** 8. Pre-requisites: **Nil**

9. Objective: To impart an overview of basic concepts and principles of structural biology.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Overview of structural biology; Primary, secondary, tertiary and quaternary structure of protein; Motifs and domains of protein structures; Structure of RNA and DNA; Conformational analysis	4
2	Enzymes structure-function relationship and the basis of structure-based drug design	4
3	Folding and flexibility; Techniques for studying macromolecular structure	5
4	UV Visible Spectroscopy; Fluorescence Spectroscopy; Circular Dichroism Spectroscopy	8
5	Symmetry, Space group crystal lattices, Brag's law in real & reciprocal space; Structure determination of macromolecules by Crystallography technique	10
6	Nuclear Magnetic Resonance, dynamics, engineering, and design of protein structures	8
7	Other methods such as cryo-electron microscopy, tomography and small angle X-ray scattering, Structure of some molecular machines and virus assembly	3
	Total	**42**

11. Suggested Books:

S. No.	Authors/ Name of Books/Publisher	Year of Publication/ Reprint
1	Wüthrich K "NMR of Proteins and Nucleic Acids" 2nd edition, (Baker Lecture Series)/ John-Wiley.	1986
2	Horton, H.R., Moran, L.A., Ochs R.A., Rawn, J. D. and Scrimgeor, R.S., "Principles of Biochemistry" 3rd edition Prentice Hall,.	2001
3	Cavanagh, J., Fairbrother, W.J., Palmer III, A.J., Skelton, N.J., and Rance M. "Protein NMR Spectroscopy: Principles and Practice" 2nd edition, Academic Press	2005
4	Gale Rhodes, Crystallography Made Crystal Clear - 3rd edition, Academic Press	2006
5	Cantor, C. R. and Schimmel, P. " Biophysical Chemistry" Vol. I, II and III, W.H. Freeman and Company, New York, USA.	2010
6	Keeler J. "Understanding NMR Spectroscopy" 2nd edition, Academic Press	2010
7	B.V Venkataram Prasad and Steve Ludtke, Advances in Protein Chemistry and Structural Biology – 1st edition, Academic Press	2011

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **BTN-203** Course Title: **Immunology**

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

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

4. Relative Weightage: **CWS: 10-25** PRS: **25** MTE: **15-25** ETE: **30-40** PRE: **0**

5. Credits: **4**

6. Semester: **Autumn** 7.Subject Area: **PCC** 8. Pre-requisites: **Nil**

9. Objective: To give an overview of the basic concepts of immune system and immunobiology, and a complete understanding of the principles and applications of immunotechniques.

10. Details of course:

S. No.	Contents	Contact Hours
1	Introduction and overview of immune system, Types of immunity - innate and adaptive, Cells and organs of the immune system,Inflammation, Antigens – epitopes, antigenicity, factors influencing antigenicity	8
2	Immunoglubulins: Structure and types of Immunoglobulins, Biological activities. Polyclonal and monoclonal antibodies,Monoclonal antibodies- productions and applications,Complement System, Antibody-dependent protection mechanisms	6
3	Antigen receptors,BCR and TCR genes, Genetic mechanisms and molecular basis for generation of antibody diversity,Hypersensitivity,	6
4	Major Histocompatibility Complex (MHC) and its role. Antigen processing and Presentation. Cellular responses. B lymphocyte and T lymphocyte development,T-cell activation and Cytokines. Immune response to various classes of pathogens	8
5	Transplantation immunology,Allograft rejection,.Tumor immunology, categories of tumor antigen,. Autoimmunity, criteria and causes of autoimmune diseases,Immunotherapeutics, .Vaccines,Engineering of immune cells	8
6	Applied immunology, generation and purification of antibodies, antigen and antibody interactions, affinity and avidity, agglutination and immunoprecipitation, immunoassays, Immunodiagnostics: principles and applications. RID Assays, ELISA, Western blotting, Immunofluorescence, Fluorescence activated cell sorting.	6
	Total	**42**

Sl. No	Practical course contents
1	Affinity chromatography for Antibody purification
2	Immunodiffusion and/or Immunoprecipitation Assays
3	Giemsa staining of the peripheral blood smear
4	Immune cell isolation, counting with trypan blue staining and culture
5	Enzyme Linked Immunosorbent Assay (ELISA)
6	Western Blotting
7	Flow cytometry

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11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/ Reprint
1	A.K. Chakravarty., "Immunology and Immunotechnology", Oxford University Press	2006
2	Peter J. Delves., Seamus J. Martin., Dennis R. Burton. and Ivan M. Roitt., "Immunology", John Wiley & Sons	2011
3	Kenneth Murphy.,"Janeway'sImmunobiology",Garland Science	2011
4	Kindt., Goldsby., Osborne. and Kuby.,"Kuby Immunology", W.H. Freeman& Co.	2013

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: Department of Biotechnology

1. Subject Code: **BT-204** Course Title: **Physiology of Animals and Plants**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Spring** 7. Subject Area: **PCC** 8. Pre-requisites: **Nil**

9. Objective: The course emphasizes on the fundamentals of physiological systems in animals and plants understanding the mechanisms by which coordination and control system works.

10. Details of course:

S. No.	Contents	Contact Hours
1.	Introduction to animal physiology; Concept of metabolism in animals; Various physiological organ-systems and their importance to the integrative functions of the human body; Body fluid compartments; Intracellular and extracellular communication systems	6
2.	Motility, secretion, digestion, absorption in the gastrointestinal system; Structure and functions of the respiratory system; Gas transport in blood; Structure and functions of smooth muscle, including excitation-contraction coupling in smooth muscle	5
3.	Principles of hormone action;Structure and, mechanism of release from endocrine cell; Mode of transport in blood; Mechanism of action in target cells; Systemic effects of important hormones	5
4.	Organization structural and functional organization of the nervous system; Resting membrane and action potential and propagation along the axon; Chemical messenger molecules of the nervous system	5
5.	The organization of plants and plant cells; plant-water relations, uptake, transport and translocation of water and solutes, transpiration, mechanism of phloem loading and unloading. Engineering of plant physiological process.	5
6.	Photosynthesis; light and pigments, light reaction, dark reactions, carbon assimilation and allocation, C3, C4 and CAM cycles, photorespiration, Respiration; glycolysis, Krebs cycle, electron transport and ATP synthesis	6
7.	Growth and Development; cellular basis of growth and development, Seed dormancy and germination, primary and secondary growth, leaf development and phyllotaxy, light control of plant growth and development	5
8.	Plant growth regulators and phytohormones; biosynthesis, storage, breakdown, transport, signalling and their physiological effects, stress physiology	5
	Total	**42**

11.SuggestedBooks:

S No.	Author(s)/ Title/ Publisher	Year of Publication/ Reprint
1.	Salisbury and Ross, Plant Physiology, third edition, Wadsworth Publishing	2010

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	Company, 1985	
2.	Hill, R.W., Wyse, G.A., Andrson, M., "Animal Physiology, Third Edition 3rd Edition, Sinauer Associates, Inc.	2012
3.	Moves, C.D., Schulte, P.M., "Principles of Animal Physiology" 3rd Edition, Pearson Press.	2015
4.	Taiz, L., Zeiger, E., Møller, I.M., Murphy, A., Plant Physiology and Development. Sixth edition,Sinauer Associates	2017
5.	Fundamentals of Plant Physiology 1st Edition by Lincoln Taiz et al. Publisher: Sinauer Associates is an imprint of Oxford University Press; 1 edition (June 5, 2018), ISBN-13: 978-1605357904	2018
6.	Rastogi, S.C., "Essentials of Animal Physiology", Fourth edition; New Age International.	2019

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **BT-205** Course Title: **Bioinformatics**

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

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

4. Relative Weightage: **CWS: 10-25** **PRS: 25** **MTE: 15-25** **ETE: 30-40** **PRE: 0**

5. Credits: **4**

6. Semester: **Autumn** 7. Subject Area: **PCC** 8. Pre-requisites: **Nil**

9. Objective: To understand the functions of each gene and protein that is essential for creating knowledge database and its annotation.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction, database model, raw database and processed database, data mining, data storage and retrieval, querying in database and tools for querying-BLAST, FASTA.	7
2	Gene finding, Hidden Markov Models (HMM), annotation of protein sequences, prediction of co-regulated genes from sequences and sequence alignment-pairwise, substitution matrices, local, global, multiple sequence alignment, clustering, prediction.	8
3	Protein-ligand interaction, Protein-protein interaction, searching in databases, binding site prediction, phylogenetic tree analysis, structural database – protein structure database, homology modeling, comparison and superposition of structures.	7
4	Molecular visualization, structure comparison and alignment, searching for patterns and motifs. Evolution of protein structure and sequences by comparing different organisms.	12
5	Docking methods, ligand design and validating data sets in structural genomics era and molecular dynamics	8
	Total	**42**

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	Gusfield, D., "Algorithm on Strings, Trees and Sequences: Computer Science and Computational Biology", Cambridge University Press.	1997
2	Attwood, T. and Pary-Smith, D., "Introduction to Bioinformatics", Prentice Hall.	1999
3	Mount, D.W., "Bioinformatics: Sequence and Genome analysis", Cold Spring Harbor Laboratory Press.	2001
4	Baxevanis, A.D. and Ouellette, B.F.F., "Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins", Wiley-Interscience.	2001
5	Sensen, C.W., "Essentials of Genomics and Bioinformatics", John Wiley and Sons.	2002

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **BT-206** Course Title: **Transport Phenomenon in Biological System**

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

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

4. Relative Weightage: **CWS: 20-35 PRS: 0 MTE: 20-30 ETE: 40-50 PRE:0**

5. Credits: **4**

6. Semester: **Spring** 7. Subject Area: **PCC** 8. Pre-requisites: **Nil**

9. Objective: To provide the knowledge of advanced processes of energy and mass transfer in relation to food preservation, drying, bioreactor modeling and bioprocess modeling.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Equation of change and its application in non conventional systems, turbulence and boundary layer theory. Unsteady state heat transfer, chilling and freezing of food and biological material. Boundary layer flow and turbulence in heat transfer.	7
2	Mass transfer in suspension, diffusion and convection in chemical and biochemical reactions, numerical analysis. Heat transfer in various geometries in forced convection, heat exchangers, boiling and condensation.	12
3	Radiation heat transfer, in non Newtonian fluids, numerical analysis. Heat and mass transfer in evaporation, evaporators and condensers, evaporation of biological materials.	10
4	Drying equipments, drying curves, combined convection, radiation and conduction heat transfer, freeze drying for biological materials.	7
5	Membrane separation processes, gas permeation membranes derivation of equation for counter and co-current flow for gas separation, multicomponent mixtures, cross flow models.	6
	Total	**42**

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	Sissom, L. S. and Pitts, D. R., "Elements of Transport phenomena", McGraw Hill	1983
2	Broodkey, R.S. and Hershey, H. C., " Transport Phenomena', McGraw Hill international	1988
3	Geankoplis, C. J., "Transport Processes and Separation Process Principles", 4th Ed., Prentice-Hall of India Pvt. Ltd.	2003
4	Bird, R. B., Stewart, W. E. and Lightfood, E. W, "Transport Phenomena", John Wiley	2006
5	Wilty, J. R., Wilson, R. W. and Wicks, C.W., "Fundamentals of Momentum Heat and Mass Transfer", 5th Ed, John Wiley	2010

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **BT-207** Course Title: **Process Calculations**

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

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

4. Relative Weightage: **CWS: 20-35 PRS: 0 MTE: 20-30 ETE: 40-50 PRE:0**

5. Credits: **4**

6. Semester: **Autumn** 7. Subject Area: **PCC** 8. Pre-requisites: **Nil**

9. Objectives: To introduce the concepts of material and energy balance and its importance in analyzing biochemical process systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Units and Dimensions in chemical process engineering, stoichiometric relations, degree of freedom and their dependence.	4
2	**Material Balance:** Selection of Basis, conservation of mass with and without chemical reactions, material balances involving gases, vapors, liquids and solids. Analysis of systems with recycles, bypass and purge with and without chemical reaction. Analysis of system with condensation and vaporization. Concept of humidity, due point and saturation	14
3	**Energy Balance:** Conservation of energy with and without chemical reactions, Analysis of systems involving reversible processes. Heat of change of phase, heat of reaction, heat of combustion, heat of solution, heat of mixing, Temperature determination for adiabatic and non adiabatic processes.	12
4	**Simultaneous Mass and Energy Balance:** Degree of freedom, analysis of multicomponent systems, Steady state material and energy balance.	4
5	**Unsteady State Material and Energy Balance:** Transient material and energy balance with and without chemical reactions.	4
6	Degree of reductance, metabolic heat calculation, yield concepts for biochemical reactions	4
	Total	42

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	Bhatt B I and Vora S M: "Stoichiometry", 4th Ed, Tata McGraw-Hill	2004
2	Felder R M and Rousseau R W: "Elementary Principles of Chemical Processes", 3rd Ed, John Wiley	2005
3	Himmelblau, D.M. "Basic Principles and Calculations in Chemical Engineering", 7th Ed Prentice Hall of India, New Delhi, India	2006
4	Lakshmi Kutty B and Narayan K V: "Stoichiometry and Process calculations", Printice Hall of India.	2010

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT: **Department of Biotechnology**

Subject Code: **BT-208** Course Title: **Biomaterials and Devices**

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

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

4. Relative Weightage: **CWS: 15-30** **PRS: 20** **MTE: 15-25** **ETE: 30-40** **PRE:0**

5. Credits: **4**

6. Semester: **Spring** 7. Subject Area: **PCC** 8. Pre-requisites: **Nil**

9. Objective: To provide fundamental aspects of material properties as well as state-of the art techniques for fabrication, processing and application of materials in biomedical engineering.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction to Biomaterials: Structure & Properties - Materials commonly used for biomedical application, such as their properties from a biocompatibility or medical device perspective. In addition, materials interactions with biological systems are examined from the molecular (e.g., protein), cellular, tissue and systemic (whole body) perspective.	9
2	Introduction to organic materials - Uses, structure, processing and properties of organic materials, including polymers, biomacromolecules and small molecule organic materials.	6
3	Clinic and Biomaterial interphase – Understanding the needs and unmet needs of the clinical problems and to critically evaluate potential solutions for clinical problems.	8
4	Biomedical Materials - Engineering biomaterials for biological environment, principles underlying use and design of medical implants and matrices/scaffolds. Biodegradable materials and their uses in prosthetics etc.	6
5	Biomaterials for Drug Delivery – basic principles of engineering controlled release systems, polymer chemistry and biomaterials.	7
6	Applications of Biomaterials – Tissue engineering, antibacterial material development, Biomimic designs.	6
	Total	**42**

S. No.	Practical course contents
1	Characterization of Biomaterials
2	Interaction studies of Biological fluids and macromolecules with implantable devices (ASTM E2799-12)
3	Testing of disinfection efficacy against biofilm producing pathogens
4	Biomaterials for antibacterial activities: Generation and Testing

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11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	Joon B. Park, Joseph D. Bronzino, "Biomaterials – Principles and Application", CRC Press	2002
2	Frederick H. Silver, David L. Christiansen, "Biomaterials Science and Biocompatibility", Springer Verlag New York	2018
3	Hasirci, Vasif, Hasirci, Nesrin, "Fundamentals of Biomaterials", Springer	2019

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code : **BT-210** Course Title: **Molecular Biology and Genetic Engineering**

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

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

4. Relative Weightage: **CWS: 10-25** **PRS: 25** **MTE: 15-25** **ETE: 30-40** **PRE: 0**

5. Credits: **4**

6. Semester: **Spring** 7.Subject Area: **PCC** 8. Pre-requisites: **Nil**

9. Objective: To impart fundamental knowledge on genetics and molecular biology and genetic engineering.

10. Details of Course:

S. No.	Content	Contact Hours
1	Introduction and general background on molecular biology. Central dogma, DNA replication in prokaryote and eukaryotes, enzymes and accessory proteins, telomere replication. DNA repair, mutagenesis	8
2	Basic translation mechanism in prokaryote and eukaryotes and its control.Gene expression in prokaryote & eukaryote, operon model, genes silencing, transcription factors, antisense and ribozymes	6
3	Basic of genetic engineering. Molecular biology techniques used for gene manipulation: DNA cloning, restriction enzyme and its application, PCR, RT-PCR	4
4	Cloning vectors: plasmids, phages cosmids, phagemid, YAC, eukaryotic vectors. Gene targeting vector for plant and animal	4
5	Gene transfer in plant and animal cells, genetic manipulation in animal, generation of transgenic mice and its application	4
6	Transgenosis in plants: Agrobacterium tumefaciens, Ti-plasmid a T-DNA, Direct DNA transfer to plants.	8
7	Genetically modified (transgenic): Resistance to herbicides, Resistance to insect pests, Value added Transgenic crops, Tolerance to abiotic stresses.	8
	Total	42

S. No.	Practical course contents
1.	Preparation of competent cells and determination of transformation efficiency using plasmid DNA (pUC19)
2.	Plasmid DNA isolation
3.	Restriction Enzyme digestion of plasmid DNA
4.	Vector and Insert Ligation
5.	Polymerase Chain Reaction and analysis by agarose gel electrophoresis
6.	Confirmation of the insert by Colony PCR and Restriction mapping

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11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	Watson J, "Molecular Biology of the Gene", Seventh Edition, Pearson.	2013
2	Primrose SB, "Principles of Gene Manipulation and Genomics, Seventh edition, Wiley Blackwell	2014
3	Alberts B, "Molecular Biology of the Cell", Sixth Edition, Garland Science.	2015
4	Gupta, P.K., "Biotechnology and Genomics", Rastogi Publications.	2017
5	Rup Lal., "Genetic Engineering of Plants for Crop Improvement"	2017

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **BT-301** Course Title: **Bioprocess Engineering**

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

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

4. Relative Weightage: **CWS: 15-30** PRS: **20** MTE: **15-25** ETE: **30-40** PRE: **0**

5. Credits: **4**

6. Semester: **Autumn** 7.Subject Area: **PCC** 8. Pre-requisites: **Nil**

9. Objectives: To impart the knowledge of kinetics of microbial growth, product formation and its role in various modes of bioreactor operation.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Microbial kinetics, Monod's equation, substrate inhibition, double substrate equations	5
2	Structured and unstructured models, substrate & product inhibition models , cybernetic models, segregated models, maintenance coefficient	8
3	Media and air sterilization, sterilization kinetics, batch and continuous sterilization	4
4	Agitation and aeration in bioreactor, different types of impellors, power requirements, k_La determination, mixing, multiphase reaction	8
5	Types of bioreactor operation, batch, fed-batch, continuous, cell recycle and cascade mode, calculation of productivity, yield and reactor sizing	8
6	Extractive fermentation, high cell density culture, Scale-up and scale down of bioreactor	4
7.	Heterogenous enzyme kinetics, first order, zero order, Thiele modulus, Effectiveness factor	5
	Total	42

S. No.	Practical course contents
1	Study of batch sterilization kinetics and parameters estimation
2	Operation of fermentor and sterilization
3	Batch growth kinetics and estimation of growth parameters
4	Immobilization of enzyme and parameter estimation
5	Determination of volumetric oxygen mass transfer coefficient by dynamic method
6	Analytical methods for estimation of metabolites using HPLC and yield calculation

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11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	Bailey, J.E. and Ollis, D.F., "Biochemical Engineering Fundamentals", McGarw Hill	1986
2	James, M. Lee, "Biochemical Engineering", Prentice Hall	1991
3	Shuler, M.L. and Kargi, F., "Bioprocess Engineering", Prentice Hall	2002
4	Nielsen, J., Villadsen, J. and Gunnar Liden, "Bioreaction Engineering Principles", 3rd edition Springer	2011
5	Doran, P.M., "Bioprocess Engineering Principles", 2nd Edition Academic Press	2013

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **BT-302** Course Title: **Genomics, Proteomics and Metabolomics**

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

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

4. Relative Weightage: **CWS: 15-30** PRS: **20** MTE: **15-25** ETE: **30-40** PRE: **0**

5. Credits: **4**

6. Semester: **Spring** 7.Subject Area: **PCC** 8. Pre-requisites: **Nil**

9. Objective:The focus of the subject is to introduce novel analytical methodologies (genomics, proteomics and metabolomics) with application in pre-clinical, clinical trials, cell models and plant experiments.

10. Details of course:

S. No.	Contents	Contact Hours
1	**Genomics:** Genome evolution and organization in prokary and eukaryotes, Genome sequencing, basics, strategies and methodology, databases and sequence comparisons, Comparative genomics, functional genomics, expression sequence tags (ESTs), serial analysis of gene expression (SAGE) and targeting induced local lesions in genome (TILLING), Microarrays technology: Principles and applications, transcriptome analysis and SNPs determination, RNA seq expression analysis: methods and applications	14
2	**Proteomics**: Isolation of proteins from different sources (e.g., plants, animals and humans) and biofluids (e.g., saliva, blood, urine and milk). Extraction proteins by different precipitation methods (e.g., TCA and acetone precipitation). Estimation of protein concentration by different assays (BCA and Bradford). Separation of proteins by gel electrophoresis (1D and 2D PAGE). Pros and cons of different stains (e.g., Coomassie, Silver stain, Sypro Ruby stain). Quantification of protein expression (e.g. 2-DIGE). Sample preparation for mass spectrometry (e.g., in-solution and in-gel methods). Qualitative analysis by MS (e.g. MALDI and LC-ESI MS). Quantitative analysis by MS – Label free quantitation by AUC and spectral counts ; Labeled quantitation by iTRAQ and TMT. Database and search engines.	14
3	**Metabolomics**: Introduction to metabolomics, statistical aspects both before and after design and implementation of experiments. Sample preparation for metabolomics study, analytical methods in metabolomics (with special focus on mass spectrometry), identification tools for metabolites, raw data analysis to study the metabolome using mass spectroscopy, data processing using univariate and multivariate statistical analysis, annotation, VIP score, pathway analyses. Structural elucidation of new compounds using mass spectrometry, inclusion of metabolites into biosynthetic pathways, examples of metabolomics studies using plant models. Access tool for important public metabolomics database and search engine for mass-spectrum based identification of metabolites and network analysis of metabolite-metabolite interactions ("interactomics").	14
	Total	42

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S. No.	Practical course contents
1	Identification of an unknown nucleotide sequence by database search and BLAST (BLASTN, BLASTP etc.)
2	Analysis of ESTs from different organisms.
3	Comparative genomics for identification of related genes from different organisms.
4	Phylogenetic analysis
5	Gel electrophoresis, Protein staining, in-solution and in-gel trypsin digestion.
6	Generation of peptide mass fingerprint, MSMS and data analysis
7	GC-MS metabolomics of sugar, amino acid, fatty acids and secondary metabolites
8	Identification of an unknown metabolites using mass spectrometry
9	Multivariate analyses of practical metabolomics data and normalization process

11.Suggested Books:

S No.	Author(s)/ Title/ Publisher	Year of Publication/ Reprint
1	PLANT metabolomics : methods and protocols / edited by Nigel W. Hardy, Robert D. Hall. – New York : Humana Press : Springer, cop. 2012. – XIII, 340 str. ISBN 978-1-61779-593-0	2012
2	Mass Spectrometry Data Analysis in Proteomics by Rune Matthiesen. 2nd Edition	2013
3	METABOLOMICS in practice: successful strategies to generate and analyze metabolic data / edited by Michael Lämmerhofer and Wolfram Weckwerth. – Weinheim : Wiley-VCH, ISBN 978-3-527-65589-2	2013
4	Genomes 4 by T. A. Brown, Garlent Science publication, 4thedi.	2017
5	PROTEOMCS: Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology. 8th Edition	2018

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: Department of Biotechnology

1. Subject Code: **BT-303** Course Title: **Animal and Plant Tissue Culture**

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

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

4. Relative Weightage: **CWS: 10-25** PRS: **25** MTE: **15-25** ETE: **30-40** PRE: **0**

5. Credits: **4**

6. Semester: **Autumn** 7.Subject Area: **PCC** 8. Pre-requisites: **Nil**

9. Objective: To impart the knowledge of the most recent techniques used in animal cell and tissue culture practices and its link to animal biotechnology and their applications to animal husbandry and biomedical field.

10. Details of course:

S. No.	Contents	Contact Hours
1	Introduction to animal tissue culture; applications; culture environment; cell adhesion; cell proliferation; differentiation; Animal cell culture facility	5
2	Animal cell culture media; Isolation of tissue; Steps involved in primary cell culture; Immortalization of cell lines; Routine maintenance; Cryopreservation and cell banks	6
3	Characterization of cell lines; Chromosome analysis; DNA content; Cytotoxicity and viability assays, Cell separation techniques, Flow cytometry and fluorescence associated cell sorting	5
4	In situ hybridization; Hybridoma technology; Industrial products of animal cell culture; Role of enzymes / isozymes in culture	5
5	Introduction to Plant Tissue culture, Terms and definitions, Historical background, laboratory organization, methods of sterilization. laboratory contaminants- it's control and measures. Role of micro and macro nutrients, explants selection, sterilization and inoculation; various media preparations; MS, B5, LS.	5
6	Induction and growth parameters; culture initiation, callus culture, cell suspension culture, micropropagation, protoplast fusion, somaclonal variation, hairy root culture.	6
7	Plant cell culture as production platform for value added products. Engineering of plant cell and cell cultures (precursor feeding, biotransformation, elicitor treatment, cell encapsulation, *trans*-genic and *cis*-genic cell lines) for targeted production of values added products. Isolation and commercial production strategies for value added products using plant cell culture (phytomedicine and food supplements). Technologies to generate transgenic plants	10
	Total	42

S. No.	Practical course contents
1	Introduction to laboratory manuals for animal and plant tissue culture
2	Sterilization techniques for animal and plant tissue culture
3	Media preparation for animal cell culture
4	Practical introduction to animal cell cultures
5	Media and growth regulator preparations for plant tissue culture
6	Development of plant callus culture and cell culture
7	Isolation of value added natural products from plant cell culture
8	Development of plant hairy root cultures

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11. Suggested Books:

S. No.	Name of Books/Authors/publisher	Year of Publication
1	S. M. Bhatt, Animal Cell Culture - Concept and Application, Narosa Publishing House.	2009
2	J. P. Matcher., P. E. Roberts., Introduction to Cell and Tissue Culture. Plenum Press, New York and London.	2010
3	I. A. Freshney, Culture of Animal Cells, Academic Press	2010
4	S. B., Primerose, Molecular Biotechnology. Blackwell Scientific Publication	1993
5	Plant Cell and Tissue Culture – A Tool in Biotechnology Basics and Application. Authors: Neumann, Karl-Hermann, Kumar, Ashwani, Imani, Jafargholi. ISBN 978-3-030-49096-6	2020
6	Razdan, M. K. (2003). *Introduction to Plant Tissue Culture*. Enfield, NH: Science.	2003
7	Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). *Biochemistry & Molecular Biology of Plants*. Chichester, West Sussex: John Wiley & Sons.	2015
8	Plant Biotechnology by B D Singh. ISBN-13: 978-9327211801, Kalyani publication.	2014
9	Introduction To Plant Biotechnology 3Ed by CHAWLA H S; OXFORD & IBH PUBLISHING; 3rd Revised edition (2020); ISBN-13: 978-8120417328	2020

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT :**Department of Biotechnology**

1. Subject Code: **BT-304** Course Title: **Molecular Diagnostics**

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

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

4. Relative Weightage: **CWS: 15-30** **PRS: 20** **MTE: 15-25** **ETE: 30-40** **PRE: 0**

5. Credits: **4**

6. Semester: **Spring** 7.Subject Area: **PCC** 8. Pre-requisites: **Nil**

9. Objective: To impart the knowledge of the basics and advanced concepts of diagnostic methods and their application to environment, food and healthcare sector.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction to Molecular Diagnostics: History of diagnostics, Age of molecular diagnostics, Significance, Scope, Rise of diagnostic industry in Indian and global scenario.	3
2	Infectious diseases and diagnosis: Microbial pathogenesis, diagnostic pathology, immune pathology, and immunohistopathology. Detection & differentiation of pathogens – bacterial, viral, fungal, zoonotic, protozoan, Drug susceptibility testing, drug resistance testing.	8
3	Clinical Biochemistry in Diagnostics: Laboratory diagnostics – routine blood & urine analysis, enzyme assays - liver function tests, cell free biopsies, non-invasive testing. Point of care testing, Cellular and functional genomics in diagnostics.	7
4	Nucleic acids: Principle and methods, Genomic DNA isolation, Plasmid isolation, Restriction digestion, DNA ligation, and agarose gel electrophoresis, quantification, RNA isolation and purification methods	5
5	Nucleic acid analysis technologies: PCR Principle, procedure, types and applications. cDNA synthesis and cloning, DNA primers, linkers, adapters, DNA finger printing, PCR-RFLP, RAPD, Micro satellites, SCAR (Sequence characterized amplified region). Role of NGS in diagnostics.	5
6	Diagnostics meets Nano – Role of nanoparticles in nanodiagnostics, Molecular recognition elements, Conjugation of MREs to Nanoparticles for diagnostics.	6
7	Molecular Diagnostics and the future – Diagnostic market analysis – major players, their platforms, role of AI and ML in diagnostics, Futuristic ideas in diagnostic field.	3
	Total	42

S. No.	Practical course contents
1	Single Nucleotide Polymorphism Diagnostics using Allele Specific – PCR methods
2	Real time PCR for pathogen detection
3	Clinical Biochemistry – Widal test, lateral flow tests for antigen screening (Pathology Lab)
4	GFP – based diagnostic methods for rare diaseases, pollutants and xenobiotics

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11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	David bruns, Edward Ashwood, carl Burtis, "Fundamentals of Molecular Diagnostics", Saunders Press	2007
2	Bruce Alberts, "Molecular Biology of the Cell", Taylor & Francis Group	2012
3	Nader Rifai, A. Rita Horvath, Carl T. Wittwer, Jason Park, "Principles and Applications of Molecular Diagnostics",Elsevier Science	2018
4	Anthony Warford, NadegePresneau, "Molecular Diagnostics: Fundamentals of Biomedical Science", Oxford University Press	2019

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT-305** Course Title: **Computational Biology**

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

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

4. Relative Weightage: **CWS: 10-25** PRS: **25** MTE: **15-25** ETE: **30-40** PRE: **0**

5. Credits: **4**

6. Semester: **Autumn** 7.Subject Area: **PCC** 8. Pre-requisites: **Nil**

9. Objective: The course provides exposure to the vast field of computational biology, methodologies and techniques used in the field. The course discusses about various topics in depth around published research.

10. Details of course:

S. No.	Contents	Contact Hours
1.	Introduction to computational biology, basic introduction to cell, genome, rna, protein, cell biology and big picture of research problems in computational biology	4
2.	Genomic analysis and whole sequence assembly, exact string matching and approximate string-matching algorithms, sequence alignment, genome structure, constraint-based optimization	10
3.	RNA folding, RNA-sequence analysis, various algorithms used in the field.	6
4.	Protein: protein folding, protein sequence matching, proteomics, integrative structural modeling, drug designing	10
5.	Metabolomic pathway analysis, metabolomics, microbiome analysis, metagenomics	7
6.	Whole-cell modeling, various whole cell modeling methods developed, introduction to big consortiums (4D Nucleosome Project, Pancreatic Beta Cell Consortium, Human Atlas, Allen Institute, Cancer Systems Biology Consortium, etc.)	5
	Total	**42**

S. No.	Practical course contents
1.	BLAST search and FASTA search; its different types; observing the effect of change in various parameters in the search; comparison of the result between BLAST and FASTA
2.	Whole genome sequence alignment
3.	Comparison of distance matrices, searching for patterns and motifs.
4.	Prediction of protein structure -homology based, protein threading/fold recognition, ab-initio modelling, template recognition, model generation, loop modelling, model validation
5.	Phylogenetic analysis
6.	Designing a small molecule; binding-site prediction in protein; protein-small molecule docking

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11.Recommended Books:

S No.	Author(s)/ Title/ Publisher	Year of Publication/ Reprint
1.	"Algorithms on Strings, Trees and Sequences" by Dan Gusfield	1997
2.	Pierre Baldi and Soren Brunak, "Bioinformatics: The Machine Learning Approach" 2nd Edition (The MIT Press)	2001

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **BT-490** Course Title: **Fundamentals of Biotechnology**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **MSC** 8. Pre-requisite: **Nil**

9. Objective: To provide understanding of the basics of biotechnology

10. Detail of Course:

S.No.	Content	Contact Hours
1	**Introduction to Biotechnology:** Basic unit of life; Biomolecules, Prokaryotes, Eukaryotes, Cell components, Sub-cellular organelles	5
2	**Microbial life and fermentation process:** Bacteria, fungi and viruses, Basic concept of microbial growth and bioprocess technology	5
3	**Molecular biology concepts:** Central Dogma of molecular biology, Replication, Transcription, Translation, Gene mutations, Recombinant DNA Technology, Cell fusion technology-hybridoma technology, basic concept of immune system	8
4	**Vectors used in biotechnology**: Restriction and modifying enzymes, cloning vectors: Plasmids, phage cosmids, phasmid, YAC, eukaryoticvectors	2
5	**Plant and Animal Biotechnology:** Transgenic Plants and Animals	2
6	**Medical Biotechnology:** Introduction to - Biopharmaceuticals, Gene therapy, Vaccines, Nanobiotechnology, Bioinformatics and Drug design	7
7	**Environmental technology:** Pollution and human health, waste treatment, bioremediation, Biofuels	4
8	**Analytical techniques in Biotechnology:** Introduction to microscopy, radioisotope technique, electrophoresis, chromatography, centrifugation, spectroscopy, PCR, Northern blotting, Southern blotting, Western blotting, Sequencing techniques. Biosafety and Bioethics	9
	Total	42

11. Suggested Books:

S. No	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Stryer, L., "Biochemistry", 4th Ed., WH Freeman & Co. 2000	2000
2.	Old, R. W. and Primrose, S. B., "Principles Of Gene Manipulation: An Introduction To Genetic Engineering", Blackwell Science. Publications.	2001
3.	Brown, T.A., "Gene Cloning and DNA Analysis", Blackwell Science Ltd.	2001
4.	Watson, J.D., "Molecular Biology of The Cell", Taylor & Francis	2002
5.	Sambrook, J. and Russel, D.W., "Molecular Cloning: A laboratory Manual", Cold Spring Harbor Laboratory Press.	2011

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT - 491** Course Title: **Biophotonics**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **MSC** 8. Pre-requisite: **Nil**

9. Objective: To impart knowledge about the emerging field of biophotonics and the application of optical based technologies in the field of biosensing, imaging etc.

10. Detail of Course:

S. No.	Contents	Contact Hours
1	Light and matter: - Fundamental nature of light, Basics of structure and function of living materials, Process of light interaction with matter, Types of light sources, Basic optics for light transmission.	5
2	Interaction of light with cells and tissues- Components that interact with light, light absorption in cells, light induced cellular processes, Interaction of light with tissues- absorption, scattering, tissue optical properties, light induced processes in tissue, radiative transport theory	7
3	Optical Spectroscopy: Fluorescence spectroscopy, Raman spectroscopy, CARS, fluorescence detection and quantification of nucleic acids, proteins and cells, Optical activity and circular dichroism.	6
4	Basic principles of lasers, Lasers relevant to biophotonics, Time resolved studies.	5
5	Optical imaging- Background and need for optical imaging, Different optical imaging techniques, Microscopy –Simple, compound, , Fluorescence microscopy, confocal microscopy, Optical coherence tomography, Spectral and time resolved imaging- fluorescence resonance energy transfer (FRET), fluorescence life time imaging (FLIM).	8
6.	Applications of Bioimaging- endogenous and exogenous fluorophores, tissue imaging, in vivo imaging. Optical biosensing- principle, fiber optic biosensors, surface Plasmon resonance biosensors	4
7	Microarray technology for analysing bio samples, flow cytometry-optical diagnostic technique, Light for therapy and treatment, optical tweezer, laser scissor.	5
8	Bio nanophotonics - major areas of nanophotonics, semiconductor quantum dots for bioimaging.	2
	Total	42

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	T. Vo-Dinh ed., "Biomedical Photonics Handbook", CRC Press Optics, E. Hecht, Addison-Wesley	2002

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2	Paras N. Prasad, "Introduction to Biophotonics", Wiley & Sons	2003
3	Joseph R Lakowicz , "Principles of fluorescence spectroscopy", Springer	2006
4	Splinter R, and Hooper BA, "An Introduction to Biomedical Optics", CRC Press, Taylor and Francis Group, Boca Raton	2007
5	Bahaa Saleh and Malvin Teich, "Fundamentals of Photonics", Wiley & Sons	2007

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT - 492** Course Title: **Introduction to Computational Biology**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **MSC** 8. Pre-requisite: **Nil**

9. Objective: To understand the structure and function of macromolecules by computational approach.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Process of Molecular Visualization, Molecular Models, Visualization Programs	5
2	Protein Structure Evolution, Structure Comparison and Alignment.	5
3	CATH domain structure, Similarity and Evolutionary relationship in CATH, Classifying close homologues, Structure based methods for identifying structural homologues and related folds, Population of super-families and families	6
4	Algorithms for identifying structural domains in proteins: Insight into history and methodology, in-depth analysis, evaluating automatic methods, Domain prediction based on sequence information, SCOP Database	6
5	Protein function from Structure: Inferring function from structure, Structural Genomics (High –throughput function prediction).	6
6	Structural annotation of genome, Methodologies for identifying Structural protein domains in genomes, Structural genomics	5
7	Evolutionary Studies using Protein structure: structures as evolutionary units, phylogeny by protein domain content, Evolutionary history of Protein Domain	4
8	Homology Modeling, Ligand Designing and Docking Methods	5
	Total	42

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/ Reprint
1	Attwood, T. and Pary-Smith, D., "Introduction to Bioinformatics", Prentice Hall.	1999
2	Carl Branden, John Tooze,"Introduction to Protein Structures", Routledge publishers,2nd Edition	1999
3	Mount, D.W., "Bioinformatics: Sequence and Genome analysis", Cold Spring Harbor Laboratory Press.	2001
4	Sensen, C.W., "Essentials of Genomics and Bioinformatics", John Wiley and Sons.	2002
5	Jenny Gu, Philip E. Bourne,"Structural Bioinformatics" John Wiley & Sons.	2009

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code : **BT-493** Course Title: **Recombinant DNA Technology**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **MSC** 8. Pre-requisite: **Nil**

9. Objective: The course intends to offer students the opportunity to gain a theoretical knowledge and understanding of basic techniques of recombinant DNA technologies, and their applications.

10. Details of course

S.No.	Contents	Contact Hours
1	Introduction to Recombinant DNA Technology:- Establishment, development and history	2
2	Introduction to vectors as cloning vehicles:- Plasmids, Cosmids, Viral vectors, Ti and Ri plasmids, BAC, YAC expression vectors, Shuttle vectors,Transposons; Vector preparation; Genomic DNA preparation; DNAquantification; DNA labeling and detection; Electrophoresis; Blottingtechniques and applications; Southern Blotting and Northern Blotting; Insitu hybridization.	6
3	Enzymes technology:- Exonucleases, Endonucleases, Restriction Endonucleases, Ligases, Topoisomerase, DNA polymerases, RNApolymerases, Reverse transcriptase, DNA and RNA Modifying enzymes:-Methylase, Alkaline phosphatase, Terminal deoxynucleoside acyltransferase,T4 polynucleotide kinase etc	8
4	Primer designing, Polymerase chain reaction (PCR), Site directed mutagenesis, Gene Cloning:- Ligation independent cloning; Selection of cloned genes –Antibiotics, Gene expression analysis, Reporter genes; Replicons; Recombinant protein production; Bacterial expression system, Eukaryotic expression system, Cell free expression system.	10
5	Gene transfer techniques - Gun shooting methods, Transformation, Transduction and Conjugation; Transformation:- Competence preparation, Heat shock method; Transfection methods, Electroporation, Viral methods, Chemical based transfection.	5
6	Genomic library; Genomic library construction; cDNA library construction; Genome mapping; DNA finger printing; Restriction fragment length polymorphism (RFLP); Random amplified polymorphic DNA (RAPD); DNA foot printing.	5
7	Transgenic plants:- Herbicide tolerance, Fruit ripening - resistance to viruses, Pests, Fungi and bacteria; Transgenic animals, Applications in agriculture, medicine and industry.	6
	Total	**42**

11. Suggested books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/

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		Reprint
1	James D. Watson, Watson and Michael Gilman., "Recombinant DNA", Publisher W.H. Freeman & Company	1992
2	Bernard R. Glick , Jack J. Pasternak and Cheryl L. Patten., "Molecular Biotechnology: Principles and Applications of Recombinant DNA", ASM press	2009
3	Sandy B. Primrose and Richard Twyman., "Principles of Gene Manipulation and Genomics", John Wiley & Sons	2013
4	TA brown., "Gene cloning and DNA analysis: An Introduction", Wiley- Blackwell	2010

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NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT - 494** Course Title: **Environmental Biotechnology**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **MSC** 8. Pre-requisite: **Nil**

9. Objective of Course: To impart the knowledge of biotechnological applications in waste treatment and biodegradation of various xenobiotic compounds using microorganisms.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction, pollution monitoring, biotechnological treatment of waste, Microorganisms and nutrient cycle in aquatic environments, Waterborne infectious agents, detection and control of pathogenic microbes in water, sewage & sludge	8
2	Wastewater treatment-activated sludge processes, wastewater treatment efficiency assessment, Microorganisms in the soil environment, Phyllosphere, Rhizosphere and Rhizoplane microorganisms	12
3	Sampling and analysis of Airborne microorganisms- fungi and mycotoxins, Airborne viruses, Biotransformation and biodegradation of pollutants, methods for determining biodegradability	10
4	Biodegradation of lignocelluloses, PAH, agricultural chemicals, Microbial Leaching, Molecular biological techniques in the characterization of environmental populations of microorganisms, Emerging Technologies - bioreporters, biosensors and microprobes	12
	Total	42

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/ Reprint
1	Pickup R.W and Saunders J.R., "Molecular approaches to environmental microbiology", Ellis Horwood Limited, First Edition, UK.	1996
2	Scragg, A," Environmental Biotechnology", First Edition, Pearson Education Limited, UK.	1999
3	Hurst, C.J., Crawford, R.L., Knudsen, G.R., MacInerney, M.J., Stetzenbach, L.D., "Manual of Environmental Microbiology", ASM press, Washington, DC, Second edition.	2002
4	Evans, G.M., Furlong, J C.," Environmental Biotechnology - Theory and application", John Wiley & Sons, Ltd, USA.	2003
5	Metcalf & Eddy, INC, "Wastewater Engineering- Treatment, Disposal and Reuse, 5th Edition, Tata MacGraw-Hill publishing company Limited, New Delhi.	2005

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NAME OF DEPTT. /CENTRE: Department of Biotechnology

1. Subject Code: **BT - 495** Course Title: **Fermentation Technology**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **MSC** 8. Pre-requisite: **Nil**

9. Objective: This course is designed with objective of introducing the basic concepts of bioprocess engineering to non-biologist.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Introduction to microbial growth,Basics of growth kinetics, growth of animal cell, enzyme kinetics	6
2.	Microbial nutrient, media design, mass balance, air and media sterilization techniques	7
3.	Modes of fermentation: batch, continuous and fed-batch fermentation	5
4.	Types of bioreactors: Stirred tank reactor, packed bed reactor, solid state bioreactor, membrane bioreactor, photo-bioreactor	6
5.	Animal and plant cell culture techniques	3
6.	Mass and heat transfers in bioreactor, scale-up of bioreactor	6
7.	Purification of bio-products: chromatography, membrane separation, purity requirements, examples of primary and secondary metabolites production, recombinant product	9
	Total	42

11. Suggested Books:

S.No.	Author(s)/ Title/Publisher	Year of Publication/ Reprint
1	Shuler, M.L., and Kargi, F. Bioprocess engineering:Basic concepts 2nd Edition, Prentice Hall	2001
2	Stanbury, P.F., Hall, S. and Whitaker A.,"Principles of Fermentation Technology" Second Edition Macmillian	2009
3	Bailey, J. and Ollis, D., "Biochemical Engineering Fundamentals", McGraw-Hill	2010
4	Doran, P.M., "Bioprocess engineering Principles" 2nd Edition Academic press	2012

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT - 496** Course Title: **Fundamentals of Food Biotechnology**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **MSC** 8. Pre-requisite: **Nil**

9. Objective: This course will introduce the students to the concept of biotechnological processes in food industry, natural microflora of fermented foods, bio-preservation, contaminants in food and their detection, potential use of microorganisms and nanotechnologies in food & food products.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction to biotechnology and microbiology, factors affecting the growth & survival of microorganisms. Methods of gene engineering of microbes for food industry	8
2	Microbial spoilage of food- milk, meat, plant products, food borne diseases. Bacterial agents of food borne illness- Clostridium, Listeria, Salmonella, Shigella,Staphylococcus, Vibrio Yersini.	13
3	Non-bacterial agents of food borne illness- helminthes and protozoa, toxigenic algae, toxigenic fungi, food borne viruses. Fermented and microbial foods- fermented milk, cheese, sauerkraut, fermented meat, beer, vinegar, mould fermentation	9
4	Microbiological examination of foods- direct examination, culture techniques, MPN count, and dye reduction assay; Immunological methods, advance techniques	5
5	Microbiology of food preservation- biological based preservation systems – acid and antibacterial peptides. Future applications- Nanobiotechnology for food industry – preservation, smart packaging and functional foods	7
	Total	42

11. Suggested Books:

S. No.	Authors/ Title/ Publisher	Year of Publication/ Reprint
1	Adams, M.R. and Moss-Food, M.O., "Microbiology", Royal Society of Chemistry.	2000
2	James, M. J., "Modern Food Microbiology", Aspen Publications.	2000
3	Michael,P. D., Larry, R.B. and Thomas, J., "Montville.Food Microbiology-Fundamentals and Frontiers", ASM press.	2001
4	Perry Johnson-Green, "Introduction to Food Biotechnology". Publisher; CRC Press.	2002

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5	Richard, K. R., Carl, A. B., "Encyclopedia of Food Microbiology",ASM Press.	2014
6	Frazier, W.C. and Westhoff, D.C. Food Microbiology. 5th Edition. Tata McGraw- Hill	2017

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: Department of Biotechnology

1. Subject Code: **BT - 497** Course Title: **NMR Techniques**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **MSC** 8. Pre-requisite: **Nil**

9. Objective: To impart the concepts of nuclear magnetic resonance and its applications in biology.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction to NMR – Angular momentum and nuclear magnetism, Precession, resonance frequencies, classical and quantum mechanical principles	4
2	Continuous and pulsed NMR, Fourier transformation, rotating frame of reference, Bloch equation, free induction decay, one dimensional NMR, measurement of parameters-chemical shift, intensity	6
3	Spin-spin coupling, multiplet pattern, karplus relation, spin systems, Relaxation times T_1 and T_2 measurement of relaxation times, structure based on chemicals shift and coupling constant, dipolar coupling, nuclear overhauser effect	8
4	Instrumentation, nmr probes, sensitivity, resolution, solvent effects, effect of pulses, Population and coherence, polarization transfer, INEPT, DEPT, chemical exchange, kinetics, rotational motion, multinuclear NMR	12
5	Two dimensional NMR-principle and techniques, homonuclear and heteronuclear techniques, applications	4
6	Determination of three dimensional structure, distance geometry and restrained molecular dynamics, of NMR derived Structure – Energy calculation and minimization, Restrained molecular dynamics, solid state NMR, magic angle spinning cross polarization, application. Magnetic resonance imaging, principle, applications	8
	Total	42

11. Suggested Books:

S. No.	Authors/ Title/ Publisher	Year of Publication/ Reprint
1.	P.J.Hore, "Nuclear Magnetic Resonance", Oxford Chemistry Primers.	1995
2	Evans, J.N.S., "Biomolecular NMR spectroscopy", Oxford University Press.	1995
3	Gunther H., NMR Spectroscopy: Basic principles, Concepts and Applications in Chemistry, Wiley.	1995
4.	Pavia, D.L., Lampman G.M., Kriz G.S., Vyvyan J.A., "Introduction to Spectroscopy", Brookes Cole.	2008

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5.	K.V.R. Chary and Grijesh Govil, "NMR of biological Systems", Springer.	**2008**
6.	James Keeler, "Understanding NMR spectroscopy", 2nd Edition, Wiley.	**2010**

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT - 471** Course Title: **Drug Discovery and Development**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE:0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **DHC** 8. Pre-requisites: **Nil**

9. Objective: To provide understanding of the discovery and development of therapeutics and why they fail in the market

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction to Drugs, Classification of drug targets – Nucliec acids, post-translational processing enzymes, metabolic enzymes involved in nucleic acid synthesis, G-protein coupled receptors, small molecule receptors, transporters.	8
2	Physiochemical properties of drugs- Molecular properties, geometries, Stereochemistry, Medicinal chemistry,	5
3	Synthetic small molecules and natural products High throughput screening, Target discovery and validation strategies, Combinatorial chemistry.	5
4	Molecular mechanism of Drug action- characterization, drugability, drug targets, drug receptor theories, and enzyme targets.	4
5	Structure activity relationships-SAR, efficacy and toxicity, pharmacokinetics and pharmacodyanamic parameters of drugs, pre-clinical and clinical trials	8
6	Patent issues in drug development, Technology transfer, Commercialization	5
7	Setbacks in global drug market- development of drug resistance, efflux mechanisms, enzymatic modifications, multiple drug resistance in pathogens, strategies to overcome drug resistance.	7
	Total	**42**

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	Christopher Walsh, "Antibiotics: Actions, Origins, Resistance"	2003
2	Silverman, R.B., " The organic chemistry of drug design and action", Elsevier, New York	2004
3	Brahmankar, D.M. and Jaiswal, S.B.,"Biopharmaceutics and Pharmacokinetics", Second Edition	2009
4	Benjamin E. Blass, "Basic Principles of Drug Discovery and Development"	2015
5	Bayya Subba Rao, P. V. Appaji, "Intellectual Property Rights in Pharmaceutical Industry: Theory and Practice", Second Edition	2018

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT - 472** Course Title: **Stem Cell Technology**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **DHC** 8. Pre-requisites: **Nil**

9. Objective: To impart the knowledge of the most recent techniques used in understanding the basics of stem cells and their applications in cure and management of various human diseases.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Developmental Biology: principles and applications of developmental biology, earlyembryonic development, types of cleavage and mechanisms, gastrulation; cell fate determination.	6
2	Concepts of stem cells: basic concepts and properties; totipotency; Pluripotency; embryonic stem (ES) cells; germinal stem cells; adult stem cells; tumor stem cells; stem cell plasticity; general methods of characterization of stem cells.	6
3	ES cells: isolation of ES cells; salient features and application of ES cells; human and mouse ES cells; differentiation of ES cell; maintenance of ES in undifferentiated state.	6
4	Stem cells and cloning: therapeutic and reproductive cloning; nuclear transfer methods; applications of nuclear transfer in ES cells; safety of nuclear transfer in ES cells.	6
5	Hematopoietic, mesenchymal and neural Stem Cell (HSC) (MSC) and (NSC): identification and characterization of HSCs, MSCs and NSC; sources of HSC; mouse assay of HSC; HSC in leukemia and lymphoma; Clinical use of HSC; embryonic origin of MSC's, harvesting; isolation and characterization; Differentiation; NSC and Neural crest stem cell.	6
6	Stem cell therapy and future of stem cell research: potential of stem cell therapy for various diseases like AIDS/HIV; alzhemier's disease; anaemia; multiple sclerosis; Parkinson disease; rheumatoid arthritis; injuries; cancer	6
7	Tissue Engineering: introduction; structural and organization of various tissues like epithelial and connective; vascularity and angiogenesis; basic wound healing; cell migration; use in therapeutic and in-vitro testing, scaffold and transplant -Engineering biomaterials; degradable materials; porosity; mechanical strength; 3-D architecture and cell incorporation; engineered tissues for replacing bone, cartilage,tendons, ligaments, skin, liver, pancreas.	6
	Total	42

11. Suggested Books:

S. No.	Authors/ Title/ Publisher	Year of Publication/ Reprint

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1	Lanza, R.P., Langer, R. and Vacanti, J., "Principles of Tissue Engineering", Academic Press.	**2007**
2	Lanza R., "Essentials of Stem Cell Biology", 2nd Edition. Academic Press	**2009**
3	I. A. Freshney., "Culture of Animal Cells", Academic Press	**2010**
4	Atala, A., Lanza R., Thomson J. A., "Principles of Regenerative Medicine", Elsevier Inc.	**2010**

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT - 473** Course Title: **Phytomedicine**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE:0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **DHC** 8. Pre-requisites: **Nil**

9. Objective: To impart knowledge of plant based medicine, emerging technologies and case studies on the subject of phytomedicine.

10. Details of Course:

S. No.	Contents	Contact Hours
1	History of phytomedicine. Taxonomy, Morphology and Ecology of Medicinal plants: a botanical perspective. Economic value of phytomedicne.	5
2	Bioactive compounds in phytomedicine. Role of plant-derived compounds in drug development. Different classes of plant Secondary metabolites as a source of phytomedicine.	7
3	Selecting medicinal plants for development of phytomedicine and use in primary health care; bioactive phytocompounds and products traditionally used in India and Asia. Recent developments in drug discovery from plants. Examples of plant-derived compounds currently involved in clinical trials Phytomedicine: India's contribution.	5
4	Medicinal plant: molecular biology and Biotechnology approaches. Breeding and cultivation of medicinal plants, quality issues of current herbal medicines.	5
5	Development of phytomedicine; extraction, sample preparation, application of all available modern, high-tech methods to standardize phytomedicines before going for systematic pharmacological investigations and clinical studies. Quality control, screening, toxicity, and regulation of herbal drugs.	8
6	Application of phytomedicine in modern drug development. Molecular modes of action of some successful molecules used in phytomedicine, phyto-complexes versus single-entity drug, bioavailability issue. Drug delivery system for herbal-based therapeutics	5
7	Methods for testing the anti-microbial, anti-cancer, anti-HIV, anti-diabetic, and neuroprotective activities of plant extracts. Reverse pharmacology approach for Phytomedicine development.	7
	Total	42

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11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/ Reprint
1	Iqbal Ahmad, Farrukh Aqil, Mohammad Owais: Modern Phytomedicine: Turning Medicinal Plants into Drugs. (Wiley)	2006
2	Leland J. Cseke; Ara Kirakosyan, Peter B. Kaufman, Sara Warber; James A. Duke; Harry L. Brielmann: Natural Products from Plants, 2nd edition; (CRC Press)	2006
3	Naturally Occurring Bioactive Compounds, 1st Edition (Advances in Phytomedicine vol 3). Edited by Rai & Carpinella. Publisher: Elsevier Science; 1 edition (December 2, 2006)	2006
4	Stephen Neidle, Antony D Buss, Mark S Butler: Natural Product Chemistry for Drug Discovery; 1st Edition; (Royal Society of Chemistry).	2009
5	Chemistry and Pharmacology of Naturally Occurring Bioactive Compounds. Editor, Goutam Brahmachari. Publisher: CRC Press; 1 edition (February 20, 2013)	2013

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT - 474** Course Title: **Advanced Virology**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE:0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **DHC** 8. Pre-requisites: **Nil**

9. Objective: To impart knowledge of the principles and applications of virology, their role in disease pathogenesis, antivirals, vaccines and applications of viruses.

10. Details of course:

S. No.	Contents	Contact Hours
1	**Introduction:** History and origin of viruses. General characteristics and structural components of virus: viral proteins, nucleic acids, lipids, carbohydrates and genome	3
2	**Viral Taxonomy:** Classification and nomenclature of different groups of viruses infecting microbes, plants and animals	3
3	**Animal viruses**: DNA virus transcription and replication, Positive-strand RNA virus replication, Negative-strand RNA virus replication, dsRNA viruses, Regulation of retrovirus replication	6
4	**Bacteriophages:** Replication and regulation, classification, lytic and lysogenic phages (lambda and P1 phage), regulation of transcription in lambda phage and applications of bacteriophages. Plant viruses. Insect viruses: Baculoviruses	5
5	**Oncogenic viruses:** DNA and RNA tumor viruses. Oncogenes, protoncogenes and tumor suppressor genes. Molecular mechanisms of activation of proto-oncogenes	3
6	**Viral multiplication and replication strategies:** Attachment, penetration, uncoating, replication, assembly, maturation and release of virions. Replication strategies of viruses	6
7	**Viral diseases:** Prevention and control, antiviral compounds, interferons, structure based drug designing and screening for antivirals, mechanisms of action, replicons, vaccines, pseudoviruses, chimericviruses, antiviral libraries, antiretrovirals—mechanism of action, drug resistance.	7
8	**Applications of Virology:** Uses of viral vectors: recombinant DNA technology, gene therapy and development of vaccines, viral nanoparticles, drug delivery, biological warfare.	9
	Total	42

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11. Books suggested:

S No.	Author(s)/ Title/ Publisher	Year of Publication/ Reprint
1	Fundamental Virology: Fields and Knipe, ed. Raven Press	1991
2	Flint, S.J., Enquest, L.W., Krug, R. M., Racaniello, V. R., and Skalka, A. M., "Principles of Virology: Molecular Biology, Pathogenesis and Control", ASM Press.	2000
3	Strauss, E. G. and Strauss, J. H., "Viruses and Human Disease", Academic Press	2002
4	Vaccines. Stanley A. Plotkin, Walter A. Orenstein. Elsevier Health Sciences.	2003
5	Paul F. Torrence., (Editor), "Antiviral Drug Discovery for Emerging Diseases and Bioterrorism Threats", Wiley, John & Sons, Incorporated	2005
6	Matthews., "Plant Virology", Academic Press	2013

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT - 475** Course Title: **Enzyme Technology**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE:0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **DHC** 8. Pre-requisites: **Nil**

9. Objectives: This course is designed for familiarising students with basic idea of enzyme kinetics, immobilization kinetics, immobilized reactor and varied applications of enzymes

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Introduction to enzyme catalysis, nomenclature, class, specificity, Single substrate enzyme kinetics, effects of environmental parameters, inhibition	9
2.	Bi-substrate enzyme kinetics, enzyme co-operativity, allosteric inhibition, various co-operativity models	9
3.	Interfacial enzyme kinetics, Metabolic regulation and control analysis	10
4.	Immobilization techniques and kinetics, Immobilized reactors	8
5.	Applications of enzymes in process industry, enzymes in organic solvents, extremozymes	6
	Total	42

11. Suggested Books :

S.No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	Palmer, T., "Understanding Enzymes" 4th Edition Prentice Hall	1995
2	Shuler, M.L., and Kargi, F. Bioprocess engineering: Basic concepts 2nd Edition, Prentice Hall	2001
3	Marangoni, A., J., "Enzyme kinetics : A Modern Approach" Wiley & Sons	2003
4	Doran, P.M., "Bioprocess engineering Principles" 2nd Edition Academic press	2012

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT– 476** Course Title: **Protein Crystallography**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **DHC** 8. Pre-requisites: **Nil**

9. Objective: To impart the knowledge of macromolecules crystallization, X-ray crystallography and tools for solving the three dimensional structures of macromolecules by X-ray crystallography.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Overview of macromolecular crystallography, principles of macromolecules crystallization	4
2.	Crystallization techniques and crystal preparation	3
3.	X-ray sources and detectors, X-ray diffraction by a crystal, scattering, reciprocal lattice and Ewald construction	7
4.	Crystal symmetry, point groups, crystal system and Bravais lattices, space group determination	6
5.	Crystal mounting and data collection, crystal orientation matrix, indexing and data reduction	6
6.	Data processing: AutoMar, HKL2000 and MOSFLM software packages	4
7.	Fourier transforms, phase problem and structure determination	6
8.	CCP4, MOLREP, PHASER, PHENIX, PYMOL and COOT software packages	6
	TOTAL	**42**

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1.	McPherson, A., "Crystallization of Biological Macromolecules, first edition", Cold Spring Harbor Laboratory Press.	1999
2.	Ducruixand, A., Gieg'e,R., "Crystallization of Nucleic Acids and Proteins: A Practical Approach", 2nd edition,Oxford University Press, USA.	2000
3.	Drenth, J., "Principles of Protein X-ray Crystallography", II edition, Springer.	2000
4.	Rhodes, G., "Crystallography made crystal clear". IInd edition, Academic	2000

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	Press, Inc. USA.	
5.	McPherson, A., "Introduction to Macromolecular Crystallography", Wiley-Liss,	2002

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT - 477** Course Title: **Biomedical Optics and Biophotonics**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **DHC** 8. Pre-requisites: **Nil**

9. Objective: To impart knowledge about the emerging field of biophotonics and the application of optical based technologies in the field of biosensing, imaging etc.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Light – matter interaction, fundamental nature of light, Basics of structure and function of living materials, Process of light interaction with matter, Types of light sources	5
2	Interaction of light with cells and tissues- Components that interact with light, light absorption in cells, light induced cellular processes, Interaction of light with tissues- absorption, scattering, tissue optical properties, light induced processes in tissue, radiative transport theory	7
3	Optical Spectroscopy: Fluorescence spectroscopy, Raman spectroscopy, CARS, fluorescence detection and quantification of nucleic acids, proteins and cells, Optical activity and circular dichroism	6
4	Basic principles of lasers, Lasers relevant to biophotonics, Time resolved studies	5
5	Optical imaging- Background and need for optical imaging, Different optical imaging techniques, Microscopy –Simple, compound, Fluorescence microscopy, confocal microscopy, Optical tomography, Spectral and time resolved imaging-fluorescence resonance energy transfer (FRET), fluorescence life time imaging (FLIM)	8
6	Optical biosensing- principle, fiber optic biosensors, , surface Plasmon resonance biosensors, Applications of Bioimaging- endogenous and exogenous fluorophores, tissue imaging, in vivo imaging. Microarray technology for analysing bio samples, flow cytometry-optical diagnostic technique, Light for therapy and treatment, optical tweezer, laser scissor	9
7	Bio nanophotonics - major areas of nanophotonics, semiconductor quantum dots for bioimaging	2
	Total	**42**

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11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/ Reprint
1	T. Vo-Dinh ed., "Biomedical Photonics Handbook", CRC Press Optics	2002
2	E. Hecht, "Optics" , Addison-Wesley	2002
3	Paras N. Prasad, "Introduction to Biophotonics", Wiley & Sons.	2003
4	Joseph R Lakowicz , "Principles of fluorescence spectroscopy", Springer	2006
5	Bahaa Saleh and Malvin Teich, "Fundamentals of Photonics", Wiley & Sons	2007
6	Splinter R, and Hooper BA, "An Introduction to Biomedical Optics", CRC Press,Taylor and Francis	2007

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT - 478** Course Title: **Protein NMR**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **DHC** 8. Pre-requisites: **Nil**

9. Objective: To impart in depth knowledge of NMR methodologies that are essential to unravel protein structure-dynamics-folding-function paradigms.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Basic concepts of solution NMR spectroscopy and NMR spectrometer, Principles of 1D and 2D homonuclear and heteronuclear protein NMR and insights into basic structural characteristics of proteins	9
2	Labeling strategies for producing isotopically enriched proteins using bacterial cell cultures.	4
3	Theory and applications of solution state NMR Triple resonance (3-Dimensional/4-Dimensional) experiments for protein backbone, side chain assignment and structure determination of proteins and their complexes	9
4	Principles of NMR relaxation measurements, understanding protein dynamics and allostery using solution state NMR	6
5	NMR analysis of protein folding energy landscapes, stability, kinetics and thermodynamics of protein-ligand interactions.	6
6	TROSY based NMR methodologies for studying structure and dynamics of large proteins/macromolecular complexes. In-vivo protein NMR and solid state protein NMR	8
	Total	**42**

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11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/ Reprint
1	Wüthrich K "NMR of Proteins and Nucleic Acids" 2nd edition, (Baker Lecture Series)/ John-Wiley.	1986
2	James, T.L., Dotsch, V., and Schmitz, V. Nuclear Magnetic Resonance of Biological Macromolecules, Part B, Volume 339: Methods in Enzymology. Elsevier	2001
3	Cavanagh, J., Fairbrother, W.J., Palmer III, A.J., Skelton, N.J., and Rance M. "Protein NMR Spectroscopy: Principles and Practice" 2nd edition, Academic Press	2005
4	James, T.L. "Nuclear Magnetic Resonance of Biological Macromolecules" Part C, Volume 394: Methods in Enzymology. Elsevier/Academic Press	2005
5	Rama Krishna, N., and Berliner, L.J., "Protein NMR for the Millennium (Biological Magnetic Resonance)", Springer, 2003 edition	2007
6	Keeler J. "Understanding NMR Spectroscopy" 2nd edition, Academic Press	2010

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE :Department of Biotechnology

1. Subject Code: **BT- 341** Course Title: **Gene Regulation**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: Toprovide information about the various mechanisms of gene regulation in bacteriphages prokaryotes and eukaryotes.

10. Details of Course:

S. No.	Particulars	Contact Hours
1	Introduction to gene, genome and different concepts and aspects of gene regulation process, brief introduction about gene expression in prokaryotes and eukaryotes, cis- and trans-regulatory elements and regulatory factors	5
2	To understand the difference between prokaryotic and eukaryotic genetic material, types of genes and other organelle genomes, Tissue specific expression of messenger RNAs and proteins	5
3	Transcriptional regulation in Bacteria; Operon concept, Riboswitches, Translational and post-translational regulation in bacteria	6
4	Viral gene regulation with special emphasize on bacteriophage life cycle	4
5	Gene regulation at transcription in eukaryotes; chromatin structure, DNA sequence elements, transcriptional factors, riboswitches	6
6	Post-transcriptional regulation in eukaryotes, alternative splicing, miRNAs, siRNAs	6
7	Gene regulation at translation; regulation at 5' Cap, Cap-independent translation and gene regulation, post-translational protein modifications and proteolysis	5
8	Current research activities and methods in the study of gene regulation, Application and future prospects of gene regulation studies	5
	Total	**42**

11. Suggested Books:

S. No.	Authors/ Name of Books/Publisher	Year of Publication / Reprint
1	Latchman, D. S., "Gene Regulation: An Eukaryotic Perspective", 4th, Ed., Chapman and Hall.	2003
2	Jun, M.A., "Gene Expression and Regulation", Springer Verlag.	2005
3	Jeffery, W., "Post Transcriptional Gene Regulation", Humana Press.	2008
4	Lewin's GENES XII by Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick	2017

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT - 342** Course Title: **Food Biotechnology**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To provide comprehensive picture of applications and basics of biotechnology in food sector.

10. DETAILS OF COURSE:

S. No.	Contents	Contact Hours
1.	Introduction, general background (History and evolution of food biotechnology) Compositional, nutritional and technological aspects of plant, animal foods	3
2.	Background, status of nutraceuticals and functional food market, definitions, difference between nutraceuticals and functional foods, types of nutraceutical compounds and their health benefits, current scenario Nutraceuticals. Types of nutraceutical compounds – Phytochemicals, peptides and proteins, carbohydrates, prebiotics, probiotics and synbiotics, their sources and role in promoting human health.	8
3.	Fermented foods – Food Fermentations, Fermentation – definition and types, Microorganisms used in food fermentations, Dairy Fermentations Probiotic properties, their health benefits and role in conditions like cardiovascular diseases, hypertension, diabetes etc. Future prospects of functional foods and nutraceuticals and their potential for use in improving health, Food spoilage: (a) By pathogens (b) By oxidation. Food as a substrate for microorganism, factors affecting growth of microbes. Types of foodborne infections, foodborne toxins.	8
4.	Types of food processing: Refining and Milling, Canning, Concentration, Freezing, Drying, Pasteurization and sterilization, Fermentation, Irradiation, Packaging, Ethnic Fermented Foods – types, examples, Classical and Modern methods to study ethnic fermented food microbiology. Food preservatives	7
5.	Food packaging: Objectives of packaging, flexible packaging, properties of the packaging materials, Smart packaging. Antimicrobial food packaging. Role of nanotechnology in food packaging.	6
6.	Food Biotechnology market, innovation and upcoming trends in food industry. Major global and country players in food sector. Food safety, food laws and Standards – FSSAI and FDA regulations.	6
7.	Recent concerns - New and Emerging Pathogens, Genetically modified foods \ Transgenics, Organic foods, Newer approaches to food safety	4
	Total	42

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11. Suggested Books:

S.No.	Book Title	Year of Publication / Reprint
1	B. Srilakshmi, Food science, New Age Publishers,2002	2002
2	Frazier WC and Westhoff DC, Food Microbiology, TMH Publication, New Delhi, 2004	2004
3	Ramaswamy H and Marcott M,Food Processing Principles and Applications CRC Press,2006	2006
4	Forsythe,S.J.The Microbiology of Safe Food , second edition, Willey-Blackwell,U.K.,2010	2010
5	Roday,S. Food Science, Oxford publication, 2011.	2011
6	Nanotechnology Applications in Food -1st Edition, Flavor, Stability, Nutrition and Safety- Editors: Alexandru Grumezescu Alexandra Oprea. Academic Press	2017
7	Food Microbiology and Biotechnology – Ed-uadalupe Virginia Nevárez-Moorillón, Arely Prado-Barragan, et al.CRC Press.	2020

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **BT - 343** Course Title: **Virology**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To emphasize understanding of the basic concepts of virology, a rapidly developing and important subject from biomedical technology perspectives. The course gives comprehensive introduction to the fundamentals of virology.

10. Details of course:

S. No.	Contents	Contact Hours
1	Introduction to basic virology, Brief history and recent outbreaks of viral pandemics and epidemics; Basic strategies to prevent, control and combat viral diseases;	3
2	DNA viruses: ds DNA and ss DNA; Their replication strategies eg	6
3	RNA viruses: ds RNA viruses, +ss RNA viruses, -ss RNA viruses; +SS RNA via DNA viruses: replication strategies of each eg	12
4	Viral pathogenesis and transmission: Virus-host interactions, Host range and tissue tropism; Acellular antiviral response, immune response, host signaling and molecular-interaction networks, and the role of host genetics in determining disease outcome.	5
5	Virological methods: Cultivation of viruses in cell culture and animals; Quantification of viruses, virus purification strategies. Virus like particles, Chimeric viruses, Pseudo viruses, Mini viral genomes, Purification of viral replication complexes and viral proteins.	6
6	Viral disease diagnostics: virus neutralization assays, western blot, RIPA, flowcytometry and immunohistochemistry, viral genome based diagnosis; Electron microscopy; Biosafety levels for viruses, risk groups for viruses, handling and transport of clinical samples containing infectious viruses and handling of viruses etc	4
7	Antiviral targets and antivirals; immunotherapies and viral vaccines Structural biology and computational biology: development of antiviral therapeutics	4
	Total	42

11. Books suggested:

S. No.	Author(s)/ Title/ Publisher	Year of Publication / Reprint
1	Concepts in Viral Pathogenesis; Editors A. L. Notkins; M. B. A. Oldstone; Copyright 1984; Publisher Springer-Verlag New York	1984
2	Fundamental Virology: Fields and Knipe, ed. Raven Press	1986
3	Basic Virology, 3rd Edition; Edward K. Wagner, Martinez J. Hewlett, David C. Bloom, David Camerini ISBN: 978-1-405-14715-6; Wiley-Blackwell	2007
4	Principles of Virology Authors: S. J. Flint, L. W. Enquist, V. R. Racaniello, A. M. Skalka, Edition: Third Edition Publisher: ASM Press ISBN-13: 978-1555814434	2009

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE:Department of Biotechnology

1. Subject Code: **BT- 344** Course Title: **Nano-Bioengineering**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To impart the knowledgeabout nanoscale physical and biological systems and their applications in biology and medicine.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction to nanotechnology and nanobiotechnology	3
2	Introduction to Nanostructures: Carbon Nanotubes (CNT), Fullerenes (C60, C300)., Quantum Dots and Semiconductor Nanoparticles, Metal-based Nanostructures (Iron Oxide Nanoparticles), Nanowires, Polymer-based Nanostructures (Dendrimers), Biogenic Nanoparticles	8
3	Introduction to Nanostructures: Gold and Silver Nanostructures:(Nanorods, Nanocages, Nanoshells), Protein-based Nanostructures:Nanomotors: Bacterial (E.coli)	7
4	Nanobiosensors: Science of Self-assembly -From Natural to Artificial Structures	5
5	Nanoparticles in Biological Labeling and Cellular Imaging: Science of Nanoparticles Functionalization	5
6	Nanotechnology Meets Detection: Rapid diagnostics with nanoparticles, molecular beacons	6
7	Medical and food Applications: Nanoparticles' Cytotoxicity	3
8	Applications of Nanostructures in Drug: Discovery, Delivery, and Controlled Release, Nanostructures in Cancer Research: examples of Nanostructures in Research and Therapy.	5
	Total	**42**

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	Christof M. Niemeyer, Chad A. Mirkin, "Nanobiotechnology: Concepts, Applications and Perspectives", VCH Verlag GmbH & Co.	2004
2	Chad A. Mirkin, Christof M. Niemeyer, "Nanobiotechnology II: More Concepts and Applications",VCHVerlag GmbH & Co.	2007
3	Nanobiotechnology : NPTEL Course (IIT Roorkee) http//nptel.ac.in/corses/118/107/118107015 Co-ordinators: Dr. N K Navani and Dr. R P Singh	2013
4	Nanobiotechnology : NPTEL Course (IIT Madras) http//nptel.ac.in/courses/118/106/118106019 Co-ordinators: Dr. K. Uma Maheshwari	2013
5	Clive Jarvis, "Nanobiotechnology: An Introduction", Larsen and Keller Education Publishers	2018

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **BTN-345** Course Title: **Separation and Analysis of Biomolecules**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To emphasize and give knowledge of techniques used for isolation and purification and characterization of nucleic acid and proteins.

10. Details of course:

S.No	Contents	Contact Hours
1	Brief introduction to Biomolecules, Chemical properties of biomolecules, native conformation of proteins, application of purified molecules	3
2	Sedimentation, centrifugation, preparative centrifugation, density gradient separation: discontinuous, continuous; analytical ultracentrifugation, suspension and disruption methods	7
4	Precipitation methods: precipitation with salts, organic solvents, Non-ionic hydrophilic polymers, polyelectrolytes, isoelectric point precipitation, immuno-precipitation,	5
5	Electrophoresis methods: gel electrophoresis, agarose, PAGE, vertical electrophoresis, horizontal Electrophoresis,2D gel electrophoresis, denaturing, non-denaturing and reducing gels, immuno-electrophoresis, pulse field electrophoresis, isoelectric focusing, isotachophoresis affinity electrophoresis, capillary electrophoresis, electroblotting, methods for staining and visualization of molecules, Silver staining of biomolecules.	10
6	Principles and applications of chromatography: gelfiltration chromatography, ion-exchange chromatography, hydrophobic interaction chromatography, affinity chromatography, immuno affinity chromatography, affinity tags and applications, IMAC chromatography, HPLC, gas chromatography, paper and thin layer chromatography.	10
7	High throughput purification and application in structural genomics	4
8	Filtration, membrane filtration, ultrafiltration, dialysis, evaporation, crystallization, Methods of protein, DNA, RNA concentration.	3
	Total	**42**

11.Books suggested:

S No.	Author(s)/ Title /Publisher	Year of Publication/ Reprint
1	Willard H.H., Merritt L.L., Dean J.A. and Settle F. A., "Instrumental Methods of Analysis", Wadsworth Publishing Co USA	1986
2	Dechow F., "Separation and Purification Techniques in Biotechnology", Elsevier	1989
3	Schweitzer P. A., "Handbook of Separation Techniques for Chemical Engineers", McGraw-Hill Professional	1996
4	Wilson K. and Walker J., "Practical biochemistry: Principles and Techniques", Publisher Cambridge University Press	2000
5	Scopes R. K., "Protein purification: Principles and practice", Springer	2005

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **BT-346** Course Title: **Drug Discovery**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To provide basic understanding of the principles of design and discovery of drugs using various disciplines of biotechnology

10. Details of Course:

S. No.	Contents	Contact Hours
1	Drug target classification – DNA, RNA, post- translational processing enzymes, metabolic enzymes involved in nucleic acid synthesis, G-protein coupled receptors, small molecule receptors, transporters.	8
2	Molecular basis of Drug discovery- Molecular properties, geometries, Stereochemistry, Medicinal chemistry, natural products, small molecules and High throughput screening, Target discovery and validation strategies, Combinatorial chemistry.	9
3	Molecular basis of Drug action- Drugability, drug targets, receptor targets, drug receptor theories, and enzyme targets.	8
4	Structure activity relationship, toxicity, efficacy, pharmacokinetics and pharmacodyanamic parameters of drugs, pre-clinical trials, clinical trials	9
5	Drug discovery in global market- development of drug resistance, efflux mechanisms, enzymatic modifications, multiple drug resistance in pathogens, strategies to overcome drug resistance.	8
	Total	**42**

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	Christopher Walsh, "Antibiotics: Actions, Origins, Resistance"	2003
2	Silverman, R.B., " The organic chemistry of drug design and action", Elsevier, New York	2004
3	Brahmankar, D.M. and Jaiswal, S.B. (2009) Biopharmaceutics and Pharmacokinetics. 2nd Edition	2009

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT - 347** Course Title: **Bioprocess Control**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objectives: To impart the knowledge of the control aspects of the process engineering and integrating various process schemes and control loop interactions.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Laplace transformation, transformation of standard function, open loop systems, first order systems, transient response, input functions, linearization, first and second order system and dynamics, transfer functions of bioreactor and dynamics.	8
2.	Closed loop control system, block diagram, servo and regulator problem, Transfer functions for controllers. Transient response, lag, closed loop control	8
3	State space model: Introduction, state variables, matrix algebra, transfer function matrix, multivariable control	6
4	Controller mechanism, proportional controller, PI, PD and PID controller. Introduction to advanced control system, feed forward control, introduction to microprocessor and computer control of bioprocesses, application in bioprocess control.	8
5	Stability: Concept, definition of stability, stability criterion, Routh test for stability	4
6	Frequency response closed loop systems, design by frequency, Bode diagram, stability criterion, Nyquist diagram. Tuning.	8
	Total	42

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/ Reprint
1.	Luyben, W.L., "Process Modeling, Simulation and Control for Chemical Engineers", 2nd Ed, Mc.Graw-Hill International	1990
2.	George Stephanopolous, "Chemical Process Control", Prentice-Hall of India Pvt. Ltd	1990
3.	Eckman, D.P., "Industrial Instrumentation", Wiley Publications	2004
4.	Coughanowr D.R., "Process System Analysis and Control", 3rd Ed., McGraw Hill.	2017

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE:Department of Biotechnology

1. Subject Code: **BT- 348** Course Title: **Bioprocess Modeling and Simulation**

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

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

4. Relative Weightage : **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To impart the concepts of mathematical modeling of bioprocesses and thereby parameter estimation, testing and model validation.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction, dimensionless models. General form of linear systems of equations, nonlinear function	3
2	State space models for linear and nonlinear models, solution of general state-space form, solving homogeneous, linear ODEs with distinct and repeated Eigenvalues, solving non-homogeneous equation with time varying parameter, Routh	8
3	Transfer function, lead-lag models, transfer function analysis of higher order systems, pole location, pade approximation for dead time, converting transfer function model to state space form	7
4	Block diagrams , system in series, pole-zero cancellation, block in parallel, feedback system, Routh stability criterion transfer functions, discrete time models and parameter estimation, phase plane analysis, nonlinear system, nonlinear dynamics, cobweb diagram, bifurcation and orbit diagram, stability cascade of period doubling	12
5	Case studies, stirred tank heaters, developing the dynamic model, steady state condition, state space model, dynamic model, steady state analysis, isothermal continuous stirred tank chemical reactors, biochemical rectors: model equation, Steady-state function, dynamic behavior, linearization, phase analysis, multiple steady state, bifurcation behavior	12
	Total	**42**

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	Luyben, W. L., "Process Modeling, Simulation and Control for Chemical Engineers", 2nd ed., McGraw-Hill international	1990

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2	Wayne Bequette, B., "process Dynamics, Modeling, Analysis and Simulation", Prentice Hall	1998
3	Schugerl, K. and Bellgardt, K.H., "bioreaction Engineering, Modeling and Control", Springer-Verlag	2000
4	Nielsen, J. and Villadsen, J., "Bioreaction Engineering Principles', 2nd Ed., Kluwer Acadmic/ Plennum publisher	2003

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NAME OF DEPTT. /CENTRE: Department of Biotechnology

1. Subject Code: **BT- 349** Course Title: **Biomechanics**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objectives of Course : To impart knowledge of basic concepts and broad overview of biomechanics with applications in areas of musculoskeletal, cardiovascular, sports, injury, and cellular biomechanics, biomedical engineering.

10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Introduction to Biomechanical Analysis:** Mathematical overview, Forces and moments, Statics, Kinematics and kinetics, Levers and fulcrum	03
2	**Fundamentals of Solid Mechanics:**Stress and strain,Material properties, loading of axial bars, Tension, Compression, Shear, Material testing and fracture, Effect of bending and torsion, Buckling of column, Measurement of Kinematics and Kinetics of motion, Experimental techniques to characterize motion of biological tissues	06
3	**Biomechanics of Joints**: Classification and structure of human joints, Joint motion mechanics, Factors influencing joint motion.	04
4	**Biomechanics of Hard Tissues - Bone**: Introduction to bone biology and structure, Mechanical properties of bone, Change in mechanical properties with age and activity, Constitutive relations - elastic, plastic.	05
5	**Biomechanics of Soft Tissues - Skeletal Muscle, Cartilage, Tendons and Ligaments:**Structure of Muscle, Cartilage, Tendons and Ligaments, Functionality of soft tissues in movements, Mechanical properties of soft tissues, Constitutive relations for soft tissues (Hyperelastic and viscoelastic), Effect on body movements.	05
6.	**Cell Biomechanics**: Cell mechanics and its role in human disease diagnosis, adhesion, mechanotransduction, and mechanobiology, cellular contractility and extracellular vesicles, cell motility, interaction with microenvironment, computational and experimental methods in cellular mechanics	06
7	**FEM: Tool for Biomechanics Analysis:**Introduction to Finite Element Analysis, Basic mathematical formulation,Application of FEA, Introduction of commercial software for FEA.	06
8	**Case Study:** Musculoskeletal, cardiovascular, Sports, Injury, Cellular Biomechanics, Tissue Engineering, Biomechanics in nature (e.g., flight mechanics in birds, plant biomechanics), Biomimetics	06
9	**Biomechanical analysis using computational or experimentalmechanics:** Short projects assigned to small group of students. Presentation to be attended by the whole class.	-
	Total	42

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11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication
1	Y.C. Fung, Biomechanics: Mechanical Properties of Living Tissues, Springer	1993
2	D J Schneck, J D Bronzino: Biomechanics – Principles and Applications, CRC Press	2003
3	C A Oatis, Kinesiology:The Mechanics and Pathomechanics of Human Movement,Lippincott Williams & Wilkins	2004
4	J N Reddy, An Introduction to the Finite Element Method, Tata McGraw Hill publishing Company Limited	2005
5	F P Beer, E R Johnston, J T DeWolf and D F Mazurek, Mechanics of Materials, Tata McGraw Hill publishing Company Limited	2014

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE:Department of Biotechnology

1. Subject Code: **BT- 350** Course Title: **Machine Learning and Deep Learning**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **3**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To impart knowledge of Machine Learning and Deep learning algorithms, hands-on experience with using Python and exposure to applications in computational biology and bioinformatics by discussion around published research.

10. Details of course:

S. No.	Contents	Contact Hours
1.	Introductio to Machine Learning. Python Foundation: Python Basics, handling data using numpy, pandas. Introduction to package sklearn, Data visualization in Python	3
2.	Supervised Machine Learning: Classification (kNN), Handling data for building models, train/validation/test data split, model evaluation, Cost Function, Model Evaluation	4
3.	Supervised learning techniques: Linear Regression, Decision trees, Random Forest, Support Vector Machines, Applications in computational biology and bioinformatics	6
4.	Neural Networks: Basic Intuition, representation, learning (back propagation), Some basic neural networks and their use in Biology	6
5.	Introduction to Fully Connected Networks, Convolutional Neural Networks	6
6.	Practical Aspects of Deep Learning, Optimization algorithms and Hyperparameter tuning, Using Python package (keras) to develop basic networks to have hand on experience with neural networks, Real world deep learning examples, Recurrent Neural Networks	6
7.	Unsupervised Machine Leaning: Clustering Methods (k-means, Hierarchical, DBSCAN)	4
8.	Dimension Reduction: PCA, t-SNE, Autoencoders and Decoders	4
9.	Relevant algorithms: GANs, Hidden Markov Models. Paper examples using various algorithms discussed in the course.	3
	Total	**42**

11. Recommended Books:

S No.	Author(s)/ Title/ Publisher	Year of Publication/ Reprint
1.	Tom M. Mitchell, "Machine Learning" (McGraw-Hill)	1997
2.	Pierre Baldi and Soren Brunak, "Bioinformatics: The Machine Learning Approach" 2nd Edition (The MIT Press)	2001

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3.	Christopher M. Bishop "Pattern Recognition and Machine Learning" Springer	2006
4.	Kevin Murphy, "Machine Learning: A Probabilistic Approach" 1st Edition (The MIT Press)	2012
5.	Ian Goodfellow, YoshuaBengio and Aaron Courville, deeplearningbook.org (MIT Press)	Online book

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT- 351** Course Title: **Protein Engineering**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objectives: To impart the knowledge of recent advantage in protein folding and function, chemical synthesis of peptides and proteins, site- directed mutagenesis, de novo protein design and protein engineering.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Protein synthesis, protein structure, protein function and structure-function relationships.	4
2.	Identification of putative enzymes in sequence databases, bioinformatic analysis.	4
3.	Isolation of genes from host organisms, cloning, preparation of recombinant proteins, host organisms, protein expression and protein purification.	6
4.	Structural characterization of proteins, an overview of spectroscopic techniques for the analysis of protein secondary and tertiary structure; an overview of techniques for analysis of protein quaternary structure.	8
5.	Enzymes, enzyme catalysis, factors influencing the speed of enzymatic reaction, Enzyme applications, targets of protein engineering, protein engineering approaches, advantages and limitations.	8
6.	Rational design, prediction of the structure of enzyme variant, evaluation of the effect of mutations on enzyme structure and function, Directed evolution, screening of mutants	6
7.	Examples of application of protein engineering to improve- enzyme catalytic efficiency, enzyme stability, enzyme enantioselectivity.	6

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	Moody, P.C.E, and Wilkison, A.J., "Protein Engineering", IRL, Press	1990
2	Braden, C. and Trooze, J., "Introduction to protein structure", Galland Publishing.	1999
3	Voet, D. and Voet, G., "Biochemistry", John Wiley Sons.	2001
4	Park S. J. and Cochran J.R., "Protein Engineering and Design" CRC Press, 1st Edition	2009

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT – 352** Course Title: **Biophotonics**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To impart knowledge about the emerging field of biophotonics and the application of optical based technologies in the field of biosensing, imaging etc.

10. Detail of Course:

S. No.	Contents	Contact Hours
1	Light and matter: - Fundamental nature of light, Basics of structure and function of living materials, Process of light interaction with matter, Types of light sources, Basic optics for light transmission.	5
2	Interaction of light with cells and tissues- Components that interact with light, light absorption in cells, light induced cellular processes, Interaction of light with tissues- absorption, scattering, tissue optical properties, light induced processes in tissue, radiative transport theory	7
3	Optical Spectroscopy: Fluorescence spectroscopy, Raman spectroscopy, CARS, fluorescence detection and quantification of nucleic acids, proteins and cells, Optical activity and circular dichroism.	6
4	Basic principles of lasers, Lasers relevant to biophotonics, Time resolved studies.	5
5	Optical imaging- Background and need for optical imaging, Different optical imaging techniques, Microscopy –Simple, compound, , Fluorescence microscopy, confocal microscopy, Optical coherence tomography, Spectral and time resolved imaging- fluorescence resonance energy transfer (FRET), fluorescence life time imaging (FLIM).	8
6.	Applications of Bioimaging- endogenous and exogenous fluorophores, tissue imaging, in vivo imaging. Optical biosensing- principle, fiber optic biosensors, , surface Plasmon resonance biosensors	4
7.	Microarray technology for analysing bio samples, flow cytometry-optical diagnostic technique, Light for therapy and treatment, optical tweezer, laser scissor. Bio nanophotonics - major areas of nanophotonics, semiconductor quantum dots for bioimaging.	7
	Total	42

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	T. Vo-Dinh ed., "Biomedical Photonics Handbook", CRC Press Optics, E. Hecht, Addison-Wesley	2002

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2	Paras N. Prasad, "Introduction to Biophotonics", Wiley & Sons	2003
3	Joseph R Lakowicz , "Principles of fluorescence spectroscopy", Springer	2006
4	Bahaa Saleh and Malvin Teich, "Fundamentals of Photonics", Wiley & Sons	2007
5	Splinter R, and Hooper BA, "An Introduction to Biomedical Optics", CRC Press, Taylor and Francis Group, Boca Raton	2007

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE:Department of Biotechnology

1. Subject Code: **BT- 441** Course Title: **Principles of Synthetic Biology**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To impart the knowledge of the key technologies and their applications in the field of synthetic biotechnology.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to Biotechnology and Synthetic Biology – Structure of Nucleic acids, basic functions of nucleic acids, Synthesis of nucleic acids in-vitro. Introduction to iGEM community.	6
2.	Basics of Recombinant DNA technology and Genomics – rDNA technology and its application overview. Introduction to genetic circuits in natural systems; engineering principles in biology; BioBricks and standardization of biological components.	8
3.	Protein design/expression in prokaryotic cells – Basics of protein design, expressing foreign proteins in cells, overview of various expression systems. Use of synthetic biology in evolving proteins with customized functions.	8
4.	Synthetic biology: Biological components and circuits, novel organisms.	6
5.	Synthetic biology in microbial biotechnology – Synthetic regulatory elements, riboswitches, Design and selection of artificial gene switches.	6
6.	Application of synthetic DNA switches, toggles in therapeutics, environmental diagnostics, etc.	8
	Total	42

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1.	R. W. Old, S. B. Primrose, "Principles of Gene Manipulation: An introduction to Genetic Engineering", Blackwell Scientific Publication	1980
2.	J. Craig Venter, "Life at the Speed of Light: From the Double Helix to the Dawn of Digital Life", Penguin Books, New York	2014
3.	George M. Church, Ed Regis, "Regenesis: How Synthetic Biology will Reinvent Naure and Ourselves", Basic Books	2014
4.	Jamie A. Davies, "Synthetic Biology: A very Short Introduction",Oxford Press	2018

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT - 442** Course Title: **Environmental Biotechnology**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To impart the knowledge of the biotechnological applications in waste treatment and biodegradation of various xenobiotic compounds using microorganisms.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction, pollution monitoring, biotechnological treatment of waste, microorganisms and nutrient cycle in aquatic environments, waterborne infectious agents, detection and control of pathogenic microbes in water, sewage & sludge	8
2.	Wastewater treatment-activated sludge processes, wastewater treatment efficiency assessment	6
3.	Microorganisms in the soil environment, Phyllosphere, Rhizosphere and Rhizoplane microorganisms	6
4.	Sampling and analysis of Airborne microorganisms- fungi and mycotoxins, Airborne viruses	4
5.	Biotransformation and biodegradation of pollutants, methods for determining biodegradability	6
6.	Biodegradation of lignocelluloses, PAH, agricultural chemicals, Microbial Leaching	6
7.	Molecular biological techniques in the characterization of environmental populations of microorganisms, Emerging Technologies - bioreporters, biosensors and microprobes	6
	Total	42

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/ Reprint
1	Metcalf & Eddy, INC, "Wastewater Engineering- Treatment, Disposal and Reuse, 3rd Edition, Tata MacGraw-Hill publishing company Limited, New Delhi.	1995
2	Pickup R.W and Saunders J.R., "Molecular approaches to environmental microbiology", Ellis Horwood Limited, First Edition, UK.	1996
3	Scragg, A," Environmental Biotechnology", First Edition, Pearson Education Limited,UK.	1999
4	Hurst, C.J., Crawford, R.L., Knudsen, G.R., MacInerney, M.J., Stetzenbach, L.D., "Manual of Environmental Microbiology", ASM press, Washington, DC, Second edition.	2002
5	Evans, G.M., Furlong, J C.," Environmental Biotechnology- Theory and application", John Wiley & Sons, Ltd, USA.	2003

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT - 443** Course Title: **Stem Cell Engineering**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To impart the knowledge of the most recent techniques used in understanding the basics of stem cells and their applications in cure and management of various human diseases.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Developmental Biology: principles and applications of developmental biology, early embryonic development, types of cleavage and mechanisms, gastrulation; cell fate determination.	6
2.	Concepts of stem cells: basic concepts and properties; totipotency; Pluripotency; embryonic stem (ES) cells; germinal stem cells; adult stem cells; tumor stem cells; stem cell plasticity; general methods of characterization of stem cells.	6
3.	ES cells: isolation of ES cells; salient features and application of ES cells; human and mouse ES cells; differentiation of ES cell; maintenance of ES in undifferentiated state.	6
4.	Stem cells and cloning: therapeutic and reproductive cloning; nuclear transfer methods; applications of nuclear transfer in ES cells; safety of nuclear transfer in ES cells.	6
5.	Hematopoietic, mesenchymal and neural Stem Cell (HSC) (MSC) and (NSC): identification and characterization of HSCs, MSCs and NSC; sources of HSC; mouse assay of HSC; HSC in leukemia and lymphoma; Clinical use of HSC; embryonic origin of MSC's, harvesting; isolation and characterization; Differentiation; NSC and Neural crest stem cell.	6
6.	Stem cell therapy and future of stem cell research: potential of stem cell therapy for various diseases like AIDS/HIV; alzhemier's disease; anaemia; multiple sclerosis; Parkinson disease; rheumatoid arthritis; injuries; cancer	6
7.	Tissue Engineering: introduction; structural and organization of various tissues like epithelial and connective; vascularity and angiogenesis; basic wound healing; cell migration; use in therapeutic and in-vitro testing, scaffold and transplant - Engineering biomaterials; degradable materials; porosity; mechanical strength; 3-D architecture and cell incorporation; engineered tissues for replacing bone, cartilage, tendons, ligaments, skin, liver, pancreas.	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Books/Authors/publisher	Year of Publication/ Reprint
1.	Lanza, R.P., Langer, R. and Vacanti, J., "Principles of Tissue Engineering", Academic Press.	2007
2.	Lanza R., "Essentials of Stem Cell Biology" 2nd Edition. Academic Press	2009
3.	I. A. Freshney, Culture of Animal Cells, Academic Press	2010
4.	Atala, A., Lanza R., Thomson J. A., "Principles of Regenerative Medicine" Elsevier Inc.	2010

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT-444** Course Title: **Industrial Bioprocessing**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To provide the knowledge of scientific and industrial principles for the bioconversion of raw materials into value added products using microorganisms.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Selection of microorganism, screening for metabolites, strain improvement, industrial microorganisms	5
2.	Fermentation, raw materials for fermentation, submerged, surface and solid-state systems, bioreactor	6
3.	Production of organic acids and amino acids	6
4.	Production of antibiotics, polysaccharides, biosurfactants and applications	7
5.	Biofuels-butanol, ethanol, biodiesel and hydrogen; production process and factors regulating production.	6
6.	Production of enzymes from microbial sources, immobalized enzymes, industrial enzymes and applications	5
7.	Metabolic engineering, molecular approaches for improved and economical production of metabolites, downstream processing, economics, legislative and safety aspects	7
	Total	**42**

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication / Reprint
1.	Rehm, H. J. and Reed, G., " Biotechnology", VCH Publ.	1996
2.	Lee, S.Y. and Papoutsakis, E.T., "Metabolic Engineering", CRC press	1999
3.	Crueger, W. and Crueger, A., "Biotechnology: A Textbook of Industrial Microbiology", R. Oldenbourg Publ.	2000
4.	Ratledge, C. and Kristiansen, B., " Basic Biotechnology", Cambridge Univ Press	2003
5.	Okajor, N., "Modern Industrial Microbiology and Biotechnology" Science pull	2007
6.	Rhodes, A. and Fletcher, D.L., "Principals of Industrial Microbiology", Pergamon Press	2008

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: Department of Biotechnology

1. Subject Code: **BT - 445** Course Title: **High Throughput Sequencing**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objectives: This course will provide details on next generation sequencing technology and its application in human health and disease.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Genome sequencing technology:** Introduction to high throughput biology, concept on next generation sequencing, brief overview to select and prepare samples for next generation sequencing.	4
2	**Platform used for high throughput sequencing:** Library constructions for Illumina, HiSeq and MiSeq next generation sequencing platform, single read, paired-end read, mate-pair, targeted resequencing technology.	6
3	**Genome sequencing project**: Overview on Human, Mouse, Drosophila and Arabidopsis genome sequence.	6
4	**RNA sequencing**: Preparation of mRNA library for sequencing. Removal of rRNA from samples. Isolation of small RNA (miRNA and piRNA) from animal cells, small RNA sequencing and exome sequencing.	6
5	**Gene expression studies:** Multiplexed gene expression, miRNA expression, and copy number variation analysis. Genome wide association study, single nucleotide polymorphism. ChIP-seq, third generation sequencing.	8
6	**Protein sequencing:** Isolation and preparation of protein samples for sequencing. Comparative proteomics. Stable isotope labeling by amino acids in cell culture (SILAC) and isobaric tags for relative and absolute quantification (iTRAQ) method in proteomic research.	8
7	**Metagenomics**: Bacterial genome sequencing, Microbiome 16S rRNA sequencing, and barcode multiplexing.	4
	Total	42

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	Campbell M., Heyer L. J., Discovering Genomics, Proteomics and Bioinformatics (2nd Edition)", Benjamin/Cummings.	2006

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2	Brown S.M., "Essential of Medical Genomics (2nd edition)", Wiley-Blackwell.	**2009**
3	Brown S.M., "Next-Generation DNA Sequencing Informatics", Cold Spring Harbor Laboratory Press.	**2013**
4	Gorodkin J., Ruzzo W.L., "RNA Sequence-Structure and Function: Computational And Bioinformatic Methods", Springer.	**2014**

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT - 446** Course Title: **Chemical Genetics**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To impart knowledge in the upcoming area of chemical genetics and synthetic biology.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to genetics, Forward genetics, Reverse genetics, Phenotypes, Target identification, biochemical methods. Introduction to Chemical genetics, Forward chemical genetics, Reverse chemical genetics	7
2.	Forward chemical genetics -Chemical libraries: target-oriented synthesis and diversity oriented synthesis. High throughput screening, Phenotype based screens. Target identification, biochemical approaches; 3-hybrid screens. Chemical approaches, labelling of small molecules, pull-down and cross-linking.	10
3.	Reverse chemical genetics- Relationship to "classical" drug discovery. Lead discovery; fragment based approaches. Diversity oriented synthesis. High throughput screening, high content screening , Small molecules, Small molecules as probes of cellular physiology	8
4.	Synthetic biology- Structure of operons, gene regulation in prokaryotes, promoters, Natural and synthetic promoters; attenuation and termination. Codon usage, RBS, small RNA, Principles of genome engineering.	9
5.	Functional nucleic acids - ribozymes, DNAzymes, aptamers, riboswitches and applications, small RNA and ribolocks, Assembly of synthetic genomes.	8
	Total	**42**

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/ Reprint
1.	Kubinyi, et al., ed., " Chemogenomics in drug discovery: A medicinal chemistry perspective". John Wiley and sons	2004
2.	Hisashi, K., "Reverse chemical genetics – methods and protocols", Springer protocols, Humana Press., ISBN 978-1-60761-231-5	2009
3.	Marechal, E., Roy, S., Lafanechere, L., " Chemogenomics and Chemical Genetics", Springer-Verlag Berlin and Heidelberg GmbH & Co. KG., ISBN: 9783642196140	2011
4.	George Church and Ed Regis "Regenesis: How Synthetic Biology Will Reinvent Nature and Ourselves" Basic Books; 1st edition, ISBN-10: 0465021751	2012
5.	Paul S. Freemont (Editor), Richard I. Kitney (Editor), "Synthetic Biology - A Primer", World Scientific Publishing; 1 edition , ISBN-10: 1848168632	2012

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT - 447** Course Title: **Genetically Modified Organism**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To impart in-depth knowledge about various genetically modified organismsengineered for improvement of resistance against biotic and abiotic stresses, nutritional quality and shelf life, production of pharmaceutical and industrial products.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	History of recombinant DNA and guidelines for research. Methods of Gene cloning and cloned genes, selectable markers and reporter genes.	9
2.	Promoters and transformation cassettes, transformation methods.	6
3.	Characterization of GMOs, toxicological and allergenicity assessment. Regulatory agencies and commercialization.	8
4.	GMOs for resistance against abiotic stresses, resistance against biotic stresses, improved nutritional quality and shelf life, engineered enzymes, proteins and pathways, pharmaceutical proteins.	12
5.	Gene therapy for congenital and other diseases. Risk assessment, IPRs and ethical issues.	7
	Total	42

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	Old, R.W. and primrose, S.B., "Principles of Gene Manipulation: An Introduction To Genetic Engineering", Blackwell Science Publications	1993
2	Sambrook, J. and Russel, D.W., "Molecular Cloning : A laboratory Manual", Cold Spring Harbor Laboratory Press	2001
3	Brown, T.A., "Gene cloning and DNA Analysis", Blackwell Science Ltd.	2001
4	Curiel, D.T. and Douglas,J.T., "Adenoviral Vectors for Gene Theraphy", Academic Press	2002

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT-448** Course Title: **Vaccine Biotechnology**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To impart the knowledge of various aspects of pathogens and the approaches used for the development of vaccines.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction - Basic concepts of antigen and antibody, Lymphoid organs, humoral and cell-mediated immunity, primary and secondary immune response, immunological memory	7
2	Vaccine – concepts and features of an ideal vaccine, conventional vaccines-live attenuated and non-living vaccines, modern vaccine technologies-recombinant live vaccines, subunit vaccines, peptide and nucleic acid vaccines.	8
3	Vaccine for Viral pathogens I - Hepatitis B virus, Influenza and swine flu virus and Polio virus: structure, mechanism of pathogenesis, treatment, approaches for designing of the vaccines	8
4	Vaccine for Viral pathogens II - HIV, Herpes simplex virus: structure of the pathogen, genome organization, pathogenesis, approaches for designing of vaccines	7
5	Pertussis toxin – structural and molecular features, chemical toxoids, recombinant DNA toxoids; Cholera toxin –molecular structure, pathogenesis and designing of the vaccine; Streptococcal and Rickettsial infections	6
6	Pharmaceutical aspects – production, formulation, characterization and storage of vaccines; regulatory and clinical aspects – phase I, II and III trials; safety and economics of vaccine production	6
	Total	42

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	Bittle, J.A. and Murphy, F.L., "Vaccine Biotechnology", Academic Press	1989
2	Manuel, J.T.C., Griffiths, B. and Jose, L.P.M., "Animal cell Technology: From Vaccines to Genetic Medicine", Springer	1996
3	Ellis R.W., "Combination Vaccines: Development, Clinical Research and Approval", Humana Press	1999
4	Bloom, B., Bloom, B. R., Lambert, P.H., (2002) The Vaccine Book, Academic Press	2002

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	Strategies", Caister Academic Press	
6	Plotkin S.A., Orenstein W.A., Offit P.A., "Vaccines", Saunders-publ.	2012

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT- 449** Course Title: **Cell and Tissue Engineering**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To impart the knowledge of tissue engineering with special emphasis on the molecular basis of cellular function and interactions.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction to tissue engineering, biomaterials for tissue engineering, biological study of different cell types, tissue structures, tissue modifications	10
2	Principles and practice gene therapy, musculoskeletal tissue engineering, scaffolds, their various physicochemical properties	8
3	Modification of tissues ring, tissue structure, tissues as scaffolds, classification of scaffolds, manufacture and processing of scaffolds	10
4	Receptor ligand interaction, receptor structures, types of receptors, biological functions of receptors	6
5	Development of artificial tissues, transplantation biology, immuno-rejection ,tissue grafting, tissue typing	8
	Total	42

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	Morgan, J.R. and Yarmush,M.L., "Tissue Enginering Methods and Protocols", Humana Press	2000
2	Atala, A.,and Lanza, R., "Methods of Tissue Engineering", Academic Press	2001
3	Lanza, R.P.,Langer,R. and Vacanti,J., "Principles of Tissue Engineering", Academic Press	2007
4	Palsson, B.O. and Bhatia, S.N., "Tissue Engineering", Pearson Press.	2009

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE:Department of Biotechnology

1. Subject Code: **BT-450** Course Title: **Bioreactor Design and Analysis**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To impart the concept of various types of bioreactors, analysis, non-ideality and uses in microbial bioprocesses

10. Details of Course:

S. No.	Contents	Contact Hours
1	Bioreactor models, CSTR, plug flow, physical processes in the reactors, ideal CSTR, bubble column and air-lift tower loop reactor, description and physical processes.	5
2	Gas-liquid flow in stirred tank reactor, single phase flow, Transport equations, simulation with experimental observations, multiple impellors, interfacial forces, turbulence model; Non-ideal behavior of bioreactor and its analysis with RTD analysis, basic models for non-ideal reactors.	9
3	Bioprocess control, disturbances, stability and its analysis, dynamic models, feedback, proportional action, integral action, linear and non-linear control Heat transfer effects in bioreactors, reactor dynamics, CFD approach for simulation.	8
4	Bubble column bioreactors, basic equation of motion, fundamental laws of fluid motion ,two fluid model, dynamics of the dispersed gas phase, mass transfer and chemical reaction ,mixing due to bubble ,fluidized bed; trickle bed bioreactor, photobioreactor.	9
5	Models for kla, interfacial area and bubble behavior, mass transfer correlations gas-liquid oxygen and other mass transfer, design and operation of aseptic and aerobic fermentation process.	6
6	Scale-up, of bioreactor, basic requirement and reactor type, CSTR, mixing, power consumption heat transfer, scale-up related effect on mass transfer, rheology of fermentation broth.	5
	Total	**42**

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1	James, E.Bailey and David,F. ollis, "Biochemical Engineering Fundamentals", McGraw Hill	1986
2	Doran, P.M., "Bioprocess Engineering principles", Academic Press	1995

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3	Schugerl, K. and Bellgart, K.H.(editors), "Bioreaction Engineering : Modeling and Control" Springer-Verlag	**2000**
4	Shuler ,M.L. and Kargi, F., "Bioprocess Engineering", Prentice Hall	**2002**
5	Nielsen, J., Villadsen, J. and Liden, G., "Bioreaction Engineering Principles", 2nd ED. Kluwer Academics/Plenum Publisher	**2003**

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: Department of Biotechnology

1. Subject Code: **BT-451** Course Title: **Bioprocess Optimization**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To introduce various techniques of optimization and their application to bioprocesses.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Basic concepts, essential features of optimization, few examples and obstacles of optimization. Various mathematical tools and methods for optimization.	5
2	**Fitting of Models:** Classification of Models, fitting function to empirical data, various methods of fitting data. Development of objective function. Numerical methods, one-dimensional and multidimensional search methods.	6
3	**Multivariable Optimization:** Direct methods e.g.Random search. Grid search, simplex method, conjugate search. Indirect methods e.g. Gradient method, Newton's method, movement in search direction. Secant methods.	7
4	**Linear and Non-Linear Programming:** Basic concepts in linear programming, simplex methods, standard LP form, revised simplex methods.Unconstraine –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 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.	Name of Books/Authors/Publisher	Year of Publication/ Reprint
1	Beveridge G.S.G. and Schechter R.S., "Optimization: Theory and Practice", McGraw Hill.	1970
2	Edgar T.F., Himmelblau D.M. and Ladson L.S., "Optimization of Chemical Processes", 2nd Ed., McGraw Hall.	2001
3	Rao S.S., "Engineering Optimization	2009

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE:Department of Biotechnology

1. Subject Code: **BT-452** Course Title: **Bioseparation Engineering**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objectives: To provide the knowledge of various separation techniques used in the purification of biological materials from the fermentation broth and complex mixture.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Characteristics of fermentation broth and bioproducts, sedimentation and centrifugation, different type of centrifuges and their theory	6
2	Theory of filtration, Darcy's law, derivation, filtration of biological fluids and fermentation broth. Relationship between filtration rate and pressure difference, membrane filtration theory, cross flow system, filtration rate	8
3	Cell disruption, mechanical, chemical and biological methods, precipitation of protein by solvent and ammonium salt, thermodynamic principles, solvent extraction, super critical fluid extraction and aqueous two phase extraction and adsorption	8
4	Principles of various liquid chromatography: Gel Chromatography, Ion-Exchange, Affinity chromatography, Hydrophobic interaction chromatography, Adsorption, Isotherms of adsorption, scale-up of liquid chromatography	8
5	Membrane based separation techniques: micro and ultrafiltration, tangential filtration	6
6	Crystallization, drying, mass and heat transfer, rate of drying	6
	Total	42

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication / Reprint
1.	Belter, P.A., Cussler, E.L. and Wei-Shou Hu., "Bioseparation: Downstream Processing for Biotechnology", Wiely Interscience	1988
2.	Asenjo, J.A. and Merchuk, J.C., "Bioreactor System Design", Marcel Dekker Inc.	1995
3.	Garcia, A.A., "Bioseparation Science", Blackwell Science.	1999
4.	Ghosh. R.,"Principles of Bioseparations engineering" World scientific publishing co ltd.	2006

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

DEPTT./CENTR: **Department of Biotechnology**

1. Subject Code: **BT-453** Course Title: **Bioelectronic Medical Devices**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To introduce fundamentals of algorithms, their analysis and complexity issues.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Basic Bio-electronics Concepts and Methods: Hydrophobic and Hydration Forces, Electrochemical Gradients and Ion Distributions Across Membranes, Osmotic Properties of Cells, Electrical Properties of Cells. Membrane Equilibrium Potentials, Nernst Potential and Nernst Equation, Membrane Action Potential, Channel Conductance, The Voltage Clamp, Electrokinetic Effects.	9
2	Electrochemical Principles and Electrode Reactions: The Beer-Lambert Law, Impedance Spectroscopy, Electrochemical Cells and Electrode Reactions, Electrical Control of Electron Transfer Reactions, Reference Electrodes, Electrochemical Impedance Spectroscopy (EIS)	9
3	Bioelectronic Instrumentation and Electrochemical Sensor Interfaces: Transducer Basics, Signal Amplification, The Operational Amplifier, Basics of Electrochemical , Impedance and FET Based applications in bioelectronics. Transducer Technology for Neuroscience and Medicine.	12
4	Neural sensors and actuators: Microelectrode arrays, neural implants, Implantable medical devices: Biofouling, materials and regulation, Wireless sensor interfaces: Sensor networks and wireless power	12
	Total	42

11. Suggested References/Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1	Introductory Bioelectronics, Ronald R. Pethig, Stewart Smith, Wiley,	2012
2	Biomedical Instruments - Theory and Design"; W. Welkowitz, S. Deutsch, M. Akay; Academic Press Inc.	2012
3	Introduction to Biosensors, Yoon, Jeong-Yeol, Springer,	2015

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: Department of Biotechnology

1. Subject Code: **BT-454** Course Title: **Big Data Analytics**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: The course provides exposure to the vast field of computational biology, methodologies and techniques used in the field. Discusses various topics in depth by discussion around published research.

10. Details of course:

S. No.	Contents	Contact Hours
1.	Introduction to Big Data And Hadoop Types of Digital Data, Introduction to Big Data, Big Data Analytics, History of Hadoop, Apache Hadoop, Analysing Data with Unix tools, Analysing Data with Hadoop, Hadoop Streaming, Hadoop Echo System, IBM Big Data Strategy, Introduction to Infosphere BigInsights and Big Sheets.	8
2.	HDFS(Hadoop Distributed File System) The Design of HDFS, HDFS Concepts, Command Line Interface, Hadoop file system interfaces, Data flow, Data Ingest with Flume and Scoop and Hadoop archives, Hadoop I/O: Compression, Serialization, Avro and File-Based Data structures.	12
3.	Map Reduce Anatomy of a Map Reduce Job Run, Failures, Job Scheduling, Shuffle and Sort, Task Execution, Map Reduce Types and Formats, Map Reduce Features.	6
4.	Hadoop Eco System Pig : Introduction to PIG, Execution Modes of Pig, Comparison of Pig with Databases, Grunt, Pig Latin, User Defined Functions, Data Processing operators. Hive : Hive Shell, Hive Services, Hive Metastore, Comparison with Traditional Databases, HiveQL, Tables, Querying Data and User Defined Functions. Hbase : HBasics, Concepts, Clients, Example, Hbase Versus RDBMS. Big SQL : Introduction	8
5.	Data Analytics with R Machine Learning : Introduction, Supervised Learning, Unsupervised Learning, Collaborative Filtering. Big Data Analytics with BigR.	8
	Total	42

11.RecommendedBooks:

S No.	Author(s)/ Title/ Publisher	Year of Publication/ Reprint
1.	Alain F. Zuur, Elena N. Ieno, Erik H.W.G. Meesters- A Beginner's Guide to R, Springer.	2009
2.	Paul Zikopoulos, Dirk deRoos, Krishnan Parasuraman, Thomas Deutsch , James Giles, David Corrigan- Harness the Power of Big Data The IBM Big Data Platform , Tata McGraw Hill Publications	2012
3.	Shui Qing Ye- Big Data Analysis for Bioinformatics and Biomedical Discoveries, CRC Press	2015
4.	Ka-Chun Wong- Big Data Analytics in Genomics, Springer	2016

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT - 455** Course Title: **Biomolecular NMR**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To impart the knowledge of modern concepts of bio-molecular nuclear magnetic resonance

10. DETAILS OF THE COURSE:

S. No.	Contents	Contact Hours
1.	Magnetic moments, Principles of Nuclear Magnetic Resonance (NMR)- classical and quantum mechanical, Understanding NMR spectrometer, Fourier transformation, Resolution, sensitivity, NMR Probes, NMR Pulses, Gradients, etc	8
2.	Theory of Chemical Shifts, Spin- spin coupling, dipolar coupling, longitudinal, transverse and cross relaxation parameters, polarization transfer, homonuclear and heteronuclear two-dimensional NMR, Product operator formalism.	12
3.	Basic structural characteristics of proteins, Isotopic labeling strategies, Theory and applications of solution state NMR Triple resonance (3-Dimensional) experiments for protein backbone, side chain assignment. NMR analysis of protein dynamics and stabilities	8
4.	Nucleic acid structural analysis, strategies and assignment, sugar conformation, Experimental restraints, Restrained Molecular Dynamics (rMD) based structure. NMR of protein-DNA/carbohydrate/membrane interactions, Characterizing binding surfaces and affinities	8
5.	Solid state NMR: Magic Angle Spinning (MAS), Cross Polarization (CP), CP-MAS, and biomolecular applications. Advanced NMR concepts: In-vivo NMR and Magnetic Resonance Imaging	6
	Total	42

11. Suggested books:

S. No.	Author(s)/Title/Publisher	Year of Publication
1.	Wuthrich, K., "NMR of protein acid", John Wiley & Sons.	1986
2.	Derome, A.E., "Modern NMR Techniques for Chemistry Research", Pergamon Press	1987
3.	Evan, J.N.S., "Biomolecular NMR spectroscopy", Oxford University Press	1995
4.	Evan, J.N.S., "Biomolecular NMR spectroscopy", Oxford University Press	1995
5.	Cavanagh, J., Fairbrother, W.J., Palmer III, A.J., Skelton, N.J., and Rance M. "Protein NMR Spectroscopy: Principles and Practice" 2nd edition, Academic Press	2005
6.	Keeler J. "Understanding NMR Spectroscopy" 2nd edition, Academic Press	2010
7.	P.J. Hore, "Nuclear Magnetic Resonance" Oxford University Press	2015

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT-456** Course Title: **Biomolecular Modeling**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To impart the knowledge of molecular modeling, computer-based technology to identify and design molecules for new medications for the discovery phase of drug development.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Quantum mechanics & concepts in molecular modeling : Introduction – coordinate systems – potential energy surfaces – introduction to quantum mechanics – postulates – Schrodinger wave equation – hydrogen molecule – Born-Oppenheimer approximation.	6
2.	Molecular mechanics and energy minimization: Empirical force field models – Bond stretching – angle bending – torsional term – nonbonding interactions – thermodynamics properties using a forcefield – derived and non derived energy minimization method – simplex – sequential univariate method – steepest descent method – conjugate gradient method- Newton-Rapson method.	6
3.	Molecular Dynamics and Monte Carlo simulation :) Introduction – Using single Model – time steps – Multiple steps – Setting up MD – energy conservation in MD Simulation Examples – Monte Carlo – Random number generation – Difference in MD & MC.	8
4.	Homology modeling: Comparative modeling of proteins – comparison of 3D structure – Homology – steps in homology modeling – tools – databases – side chain modeling – loop modeling.	6
5.	Drug design: General approach to discovery of new drugs - lead discovery – lead modification – physiochemical principles of drug action – drug stereo chemistry – drug action - 3D database search – computer aided drug design	8
6.	Understanding of docking tools- molecular modeling in drug design – pharmacophores - QSAR. Molecular visualization tools	8

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1.	A. R.Leach - Molecular Modeling Principles and Application, 2nd edition, Longman Publications,	1996
2.	Baxivanis and Foulette - Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Wiely Indian Edition.	2001
3.	Valerie Daggett-Protein Simulations, 1stedition,Volume 66 - Academic Press	2003
4.	Philip E. Bourne-Structural Bioinformatics, 2nd edition,	2009

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT- 457** Course Title: **Systems Biology**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective:Systems Biology is an integrated approach to the study of biology through experiment and the use of computer models with both predictive power

10. Details of course:

S. No.	Contents	Contact Hours
1.	Introduction to systems biology and metabolism: Components of Biological systems (DNA, RNA, Protein, Metabolites), their properties and function. Overview of cellular metabolism, enzyme kinetics and metabolic pathways	6
2.	Biological network: Biological networks and their significance – at the level of genome, transcriptome, proteome, and metabolome. Omics - applications and its role in systems biology. Analytical methods for detecting and quantifying metabolites. General work flow and Statistical methods in omics. Pathway and omics databases.	12
3.	Modelling and Analysis of networks (MAN): The module focuses on mathematical and statistical methods used to evaluate and analyse large-scale data sets. Cellular systems include genetic switches and oscillators, network motifs, genetic network evolution, and cellular decision-making.	10
4.	Large biological data analyses: Differential gene expression analysis of transciptome data, 16S rRNA based phylogenetic profiling, phylogenetic tree, introduction to Gene Ontology, KEGG, EcoCyc databases, Automated pathway mapping and annotation of proteins and metabolites, Metabolic network reconstruction, Genome scale model analysis.	12
	Total	**42**

11.SuggestedBooks:

S No.	Author(s)/ Title/ Publisher	Year of Publication/ Reprint
1.	A Practical Approach to Microarray Data Analysis (Hardcover) by Daniel P. Berrar (Editor), Werner Dubitzky (Editor), Martin Granzow (Editor)	2003
2.	System Biology: Computational Systems Biology (Hardcover) by Andres Kriete (Editor), Roland Eils (Editor)	2005
3.	Microarray Data Analysis: Gene Expression Data Analysis. A Beginner's Guide By: Helen Causton (Imperial College), J Quackenbush and AlvisBrazma (The European Bioinformatics Institute)	2009
4.	Stochastic Modelling for Systems Biology. ISBN-10 1-58488-540-8 and ISBN-13 978-158488-540-5	2018

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT- 458** Course Title: **Molecular Biophysics**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objectives: To teach the concepts of energetic for structure-stability-conformational transitions in biological molecules.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Levels of structure of biomacromolecules– random coils, proteins, nucleic acids, polysaccharides, biological membranes, computer aided simulations	7
2.	Polypeptide chain geometry, Ramachandran Map, Estimate of potential Energy – nonbonded and dipolar terms, intrinsic torsional potential, Conformational energy of peptide residues, Hydrogen bonding, Hydrophobic and Electrostatic Interactions, Disulfide bonds, applications to protein structure	6
3.	Conformation of Sugar, Glycosidic bond and Backbone torsional angles, Base Pairing and Stacking Interactions, Thermodynamic parameters, Conformation of A, B, Z DNA, transfer RNA, Triple helix and DNA Quadruplexes	6
4.	Helix to Coil Transitions, Molecular mechanism, Simple and Statistical thermodynamic treatment, Zipper model, Host-guest experiment	5
5.	Reverse Folding of proteins, Equilibrium studies, Kinetics, Experimental observations	4
6.	Ligand-Macromolecule Interactions, phase transitions in biopolymers and aggregates	7
7.	Transport of ions across biological membranes, electron transfer in bioenergetics	7
	Total	**42**

11. Suggested Books:

S. No.	Author(s)/Title/Publisher	Year of Publication/ Reprint
1.	Van Holde, K. E., Johnson, W. C., Ho P. S., 'Principles of Physical Biochemistry, Prentice Hall Intl.	1998
2.	Cantor, C. R., and Schimmel, P.R., 'Biophysical Chemistry, Part-I and Part III", W H Freeman & Co.	2008
3.	Atkins, P., and De Paula J., 'Physical Chemistry for the Life Sciences'. Second Edition	2011
4.	Atkins, P., De Paula, J., and Keeler, J., 'Atkin's Physical Chemistry'. International Edition	2018

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : Department of Biotechnology

1. Subject Code: **BT - 459** Course Title: **Biomolecular Interactions**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To impart in depth knowledge of biomolecular interactions to execute structure based drug design.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Overview of biomolecules; primary, secondary, tertiary/ quaternary structure of proteins, RNA and DNA, carbohydrates, lipids/membranes. structural properties of biological macromolecules. Motifs and domains of protein structures.	4
2.	Structural and energetic principles governing the biomolecular interactions. Role of electrostatics/surface potentials, hydrogen bonding and hydrophobicity. Cooperativity and allostery in mediating the macromolecular recognition	6
3.	Molecular Recognition: Recognition of proteins, Recognition of DNA/RNA, Recognition of foreign molecules by immune system, Thermodynamics of Binding, Binding Energetics, Specificity of macromolecular recognition	6
4.	Biochemical methods for characterization of biomolecular interactions: Size Exclusion Chromatography, Ala-screening, GST-pull down assays, Co-Immunoprecipitation, Biotin-Avidin, Native PAGE, protein-protein interactions in living cells, Gel-shift assays etc	5
5.	Biophysical approaches to elucidate biomolecular interactions and binding kinetics: Nuclear Magnetic Resonance Spectroscopy, X-ray diffraction, Isothermal calorimetry, Surface Plasmon resonance, Fluorescence Spectroscopy, Analytical ultracentrifugation, Dynamic light scattering, Small angle x-ray scattering (SAXS), CD etc	12
6.	Computation biology methods and tools for identification and characterization of biomolecular interactions	4
7.	Biomolecular interactions as drug targets; Ligand binding thermodynamics in drug discovery, Biomolecular interactions and rational drug design, Binding affinity of monoclonal antibodies to molecular engineering of antibodies with improved stability and affinity.	5
	Total	42

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11. Suggested Books:

S. No.	Authors/ Name of Books/Publisher	Year of Publication/ Reprint
1.	Introduction to Protein Structure. 2e, Carl Branden and John Tooze, Garland Science	1999
2.	Serdyuk, I.N., Zaccai, N.R., Zaccai, J., "Methods in Molecular Biophysics-Structure, Dynamics, Function", Cambridge University Press	2007
3	Rice, P.A. and Correll C.C., " Protein-Nucleic Acid Interactions: Structural Biology " 1nd edition, RSC Biomolecular Sciences	2008
4.	Giralt, E., Peczuh, M.W., Salvatella, X., "Protein Surface Recognition-Approaches for Drug Discovery", 1st edition, Wiley.	2010
5.	Cantor, C. R. and Schimmel, P. " Biophysical Chemistry" Vol. I, II and III, W.H. Freeman and Company, New York, USA.	2010
6.	The Molecules of Life: Physical and Chemical Principles, John Kuriyan, Boyana Konforti, David Wemmer, Garland Science (2012)	2012

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE:Department of Biotechnology

1. Subject Code: **BT-460** Course Title: **Design and Analysis of Algorithms**

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

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

4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits: **4**

6. Semester: **Both** 7. Subject Area: **PEC** 8. Pre-requisites: **Nil**

9. Objective: To introduce fundamentals of algorithms, their analysis and complexity issues.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Notion of algorithm, pseudo code conventions, Performance analysis, Time and space complexities, Asymptotic notation, Big oh notation, omega notation, theta notation, Average and worst case analysis, Probabilistic analysis, Amortized analysis.	5
2.	Recurrence relations, Divide and conquer relations, Solving of recurrences by iteration method and substitution method, Master theorem, Binary search algorithm, Merger sort, Quick sort, Strassen's matrix multiplication method	9
3.	Greedy strategy, Huffman coding algorithm, Data structures of disjoint sets, Complexity analysis of Depth first search, Breadth first search, Prim's algorithm, Kruskal's algorithm, Dijkstra's and Bellman-Ford algorithms, Knapsack problem, Warshall's and Floyd's algorithms.	12
4.	Introduction to dynamic programming, Principle of optimality, Optimal binary search trees, Matrix-chain multiplication, Longest common subsequence.	7
5.	String matching, The naive string matching algorithm, The Rabin-Karp algorithm	3
6.	Introduction to computability, Reducibility, Polynomial-time verification, NP-completeness, NP-complete problems.	6
	Total	42

11. Suggested References/Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Aho A. V., Hopcroft J. E. and Ullman J. D., "The Design and Analysis of Computer Algorithms", Pearson Education	2002
2.	Levitin A., "Introduction to the Design and Analysis of Algorithm", (2nd edition) Pearson Education	2003
3.	Cormen T. H., Leiserson C. E., Rivest R. L. and Stein C., "Introduction to Algorithms", Prentice Hall India, (3rd Edition)	2004
4.	Horowitz E., SahniS. and Rajasekaran S., "Fundamentals of Computer Algorithms", Orient Longman	2006
5.	Kleinberg J. and Tardos E., "Algorithm Design", Pearson Education	2008

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M. TECH. IN DAM SAFETY AND REHABILITATION

(After incorporating suggestions of the IAPC meeting held on December 28, 2020, suggestions of associated faculty, suggestions of faculty colleagues across the Institute on Faculty Discuss and IAPC meeting held on January 11, 2021)

BACKGROUND

India has 5334 large dams in operation and about 411 large dams are under construction. In addition to the large dams, there are more than 90,000 small and medium dams in the country. These dams have been built to ensure water safety, which in turn, is essential for the food and energy security of the country. The recorded history of dam construction in the country dates back to the 11^{th} century when Veeranam dam was constructed in Central India and since then the dams are being built for the storage of water. In addition to this, there are numerous dams all over the world. IIT Roorkee is playing a major role in the design and execution of these dams since its inception in 1847.

The safety of these dams is of utmost importance. Many of the existing dams are very old and need rehabilitation. Keeping these concerns in view, Ministry of Water Resources, River Development & Ganga Rejuvenation through Central Water Commission initiated the DRIP project in April 2012 with the assistance of World Bank. IIT Roorkee is the academic partner in this programme and has entered in MoU with Central Water Commission in September 2017. This project is coming to an end in March 2021.

Keeping the importance of the dams in view and to cover more number of dams in the project, phase II and phase III of the DRIP programme have been approved by Ministry of Jal Shakti, Government of India on October 29, 2020.

Dam Safety Bill 2019 was introduced in Lok Sabha on July 29, 2019, and was passed on August 2, 2019. The bill provides for the surveillance, inspection, operation, and maintenance of all specified dams across the country. The bill is likely to be passed by Rajya Sabha soon.

During the concurrence of the Dam Safety Bill, Government India desired that apex institutions in the country should be approached to start a regular course in the dam safety management at the post-graduation level. Accordingly, in pursuance to this, Secretary, DoWR, RD&GR

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requested Secretary, Department of Higher Education, Ministry of HRD for this. The Chairman, CWC also requested to the academic partners of DRIP in June 2019.

IIT Roorkee kept a close eye on these developments and constituted a 4-member committee, consisting of Prof N.K. Goel, Prof. M.L. Sharma, Prof. Zulfequar Ahmad, and Prof. M.L. Kansal, in December 2019 to draft the proposal for the establishment of the International Centre for Dams at IIT Roorkee and start a M. Tech. programme in Dam Safety and Rehabilitation with effect from July 2021.

A meeting through video conferencing was held on May 27, 2020, under the Chairmanship of the Additional Secretary, D/o WR, RD & GR, Ministry of Jal Shakti to discuss about the matters related to the experience of IIT Roorkee with ongoing DRIP, plan for the introduction of Postgraduate programme in Dam Safety Management and establishment of a Centre of Excellence (CoE) in Dam Engineering. This meeting was attended by Director, IIT Roorkee and Prof. N.K. Goel. The intent of IIT Roorkee to establish the Centre for dams and start of the M. Tech. programme on Dam safety and Rehabilitation was reiterated in the meeting.

The committee had a series of meetings and after receiving the inputs from Central Water Commission finalised its proposal for the establishment of the 'International Centre for the dams' at IIT Roorkee and start of M. Tech programme in Dam safety and Rehabilitation and sent it to the Departments of Civil Engineering, Hydrology, Earthquake and WRDM for consideration and inputs for the M. Tech. Programme. The proposal for the Establishment of the Centre was also sent to the CWC and the World Bank for consideration and providing inputs for the finalisation of the proposal in October 2020.

A number of suggestions were received from the Departments of Civil, EQ, Hydrology and WRDM. The present proposal incorporates the suggestions received till date. The requirements, structure and the syllabus of different subjects of the programme are given in the next section.

Who can Attend the Programme

The programme will be meant for the sponsored officers of state implementing agencies of DRIP programme and other agencies within India and abroad with relevant experience of 2 years and fresh GATE qualified candidates having valid GATE score.

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Eligibility for sponsored Candidates

1. Graduation/ Post Graduation degree in Civil/ Mechanical/ Earthquake/ Hydrology/ Water Resources Engineering/ equivalent;
2. Post-graduation degree in Physics/ Mathematics/ Geology/ Geophysics; Environmental Engineering/ equivalent;
3. Any other degree acceptable to the State Implementing agencies for regular appointment in the dam safety wings.

Eligibility for GATE qualified Candidates

1. Graduation engineering degree in Civil/ Mechanical engineering / equivalent;
2. Post-graduation degree in Geology/ Geophysics; equivalent;

Number of seats:

30 with a minimum of 5 seats for GATE qualified candidates.

Faculty

The programme will be jointly delivered by the faculty members of IIT Roorkee and the national and international experts. The national and International experts have been proposed with the delivery of the programme as the number of subjects proposed to be dealt with are new and the faculty members of IIT Roorkee need to develop the expertise of delivering the programme independently over a period of next five years through continuous interaction with international experts and exposure visits.

Financial Support:

The programme shall be supported by Ministry of Jal Shakti under DRIP phase II and III and the World Bank.

Reference Material:

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A number of guidelines have been prepared by CPMU of CWC in consultation with National and International subject matter specialists during the last 6 years. These guidelines document the best National and International practices in the area. The M. Tech. programme will give the participants enough exposure to follow these guidelines and implement the best practices in the field. So far, the following 14 guidelines have been prepared and are available online.

1. Guidelines for developing Emergency action plans for dams, February 2016;
2. Guidelines for safety inspections of dams, January 2018;
3. Guidelines for instrumentation of large dams, January 2018;
4. Guidelines for preparing operation and maintenance manual for dams, January 2018;
5. Guidelines for mapping flood risks associated with dams, January 2018;
6. Manual for rehabilitation of large dams, January 2018;
7. Inspection Manual for Dam Field Engineers After Seismic Events, Ichari Dam, Uttarakhand, January 2018;
8. Technical Specifications of Hydro-meteorological, Geodetic, Geotechnical and Seismic Instruments, January 2018;
9. Guidelines for Assessing and Managing Risks Associated with Dams; February 2019;
10. Handbook for Assessing and Managing Reservoir Sedimentation, February 2019;
11. Inspection Manual for Dam Field Engineers after Seismic Events, Maithon Dam, Damodar Valley Corporation, Jharkhand, February 2019;
12. Guidelines for Classifying the Hazard Potential of Dams, November 2020;
13. Operational Procedures for Assessing and Managing Environmental Impacts in Existing Dam Projects, November 2020;
14. Manual for Assessing Structural Safety of Existing Dams, November 2020.

Apart from the above guidelines, few more guidelines have been prepared by other organisations:

1. Guidelines for community-based ecotourism development, WWF International, 2001;
2. Guidelines for maintaining longitudinal connectivity through dams, 2017;

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3. ICOLD, "Selecting Seismic Parameters for Large Dams, Guidelines", Bulletin 148 Committee on Seismic Aspects of Dam Design, International Commission on Large Dams (ICOLD), Paris, 2014;
4. National Disaster Management Guidelines, 2007;

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COURSE OBJECTIVES, STRUCTURE AND THE SYLLABUS

Course Objectives

The course objective is to train the sponsored officers to deal with the complete life cycle of the dam and take up the challenges of safety and rehabilitation of the older dams and the design of new dams. To develop analytical, operational, and sectoral understanding, M. Tech. students will be exposed to a plethora of courses related to dam safety which would enhance the qualitative and quantitative research methodology, policy aspects, and skills to device appropriate solutions.

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Course structure of M. Tech. (Dam Safety and Rehabilitation)

INTERNATIONAL CENTRE FOR DAMS

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Program Code: XX M. Tech. (Dam Safety and Rehabilitation)

Year: I

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
Semester- I (Autumn)														
1.	DS-501	Assessing and Managing Risks Associated with Dams	PCC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
2.	DS-502	Basics of Disaster Management and its Implementation Concepts	PCC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
3.	DS-503	Hydrologic Safety Evaluation of dams	PCC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
4.		Programme Elective Course -I	PEC	4										
5.		Programme Elective Course -I	PEC	4										
		Total		20	9	3								

Note: * Weightage of the CWS, PRS, MTE, and PREE may vary in accordance with the prevailing rule of the Institute.

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Semester-II (Spring)														
1.	DS-504	Sediment Management in Reservoirs	PCC	4	3	1	-	3	-	20-35	-	20-30	40-50	0
2.	DS-505	Dam Safety Surveillance, Instrumentation and Monitoring	PCC	4	2	1	2/2	3	-	15-30	20	15-25	30-40	0
3.	DS-701	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
4.		Programme Elective Course -I	PEC	4										
5.		Programme Elective Course -II	PEC	4										
6.		Programme Elective Course -III	PEC	4										
		Total		22	5	2	1							

*Credit requirement for PG Diploma/ I[st] year M. Tech is 42 credits.

Note: * Weightage of the CWS, PRS, MTE, and PREE may vary in accordance with the prevailing rule of the Institute.

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INTERNATIONAL CENTRE FOR DAMS

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Program Code: XX M. Tech. (Dam Safety and Rehabilitation)

Year: II

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
Semester- I (Autumn)														
1.	DS-701A	Dissertation Stage–I (to be continued next semester)	DIS	12	-	-	-	-	-	-	-	-	100	-
		Total		12										
Note: Students can take 1 or 2 audit courses as advised by the supervisor if required.														

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Semester-II (Spring)														
1.	DS-701B	Dissertation Stage–II (contd. From III semester)	DIS	18	-	-	-	-	-	-	-	-	100	-
		Total		18										

Summary				
Semester	1	2	3	4
Semester-wise Total Credits	**20**	**22**	**12**	**18**
Total Credits	**72**			

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List of Programme of Electives Courses

Teaching Scheme					Contact Hours/ Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1.	DS-511	Seepage through Dams	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
2.	DS-512	Assessment and Management of Environmental issues in Reservoirs	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
3.	DS-513	Earthquake Geotechnical Engineering	PEC	4	2	1	2/2	3	-	15-30	20	15-25	30-40	-
4.	DS-514	Study tour/ Case studies	PEC	4	2	1	2/2	3	-	15-30	20	15-25	30-40	-
5.	DS-515	Geo-Mechanics	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
6.	DS- 516	Geospatial Technology for Monitoring of Dams	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
7.	DS- 517	Hydraulic and structural design of dams, spillways and energy dissipators	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-

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8.	DS-518	Ground Improvement and Geo-synthetics	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
9.	DS-519	Contract and Financial Management	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
10.	DS-520	Sustainable Tourism around Dams	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
11.	DS-521	Earth Retaining Structures and Dams (Concrete, RCC, CFRD, Arch, Earth, Rockfill dams & Barrages)	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
12.	DS- 522	Seismic Safety of Embankment Dams	PEC	4	2	1	2/2	3	-	15-30	20	15-25	30-40	-
13.	DS-523	Concepts of Planning & Design of Hydro-Mechanical Components in Dams	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
14.	DS-524	Engineering Seismology and Hazard Assessment for dams	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-

Note: * Weightage of the CWS, PRS, MTE, and PRE may vary in accordance with the prevailing rule of the Institute.

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SYLLABI (PROGRAMME COMPULSORY COURSES)

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **INTERNATIONAL CENTRE FOR DAMS**

1. Subject Code: **DS-501** Course Title: **Assessing and Managing Risks Associated with Dams**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs): **Theory: 3** **Practical: 0**
4. Relative Weightage: **CWS: 20-35 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0**
5. Credits: **4** 6. Semester: **Autumn**
7. Subject Area: **PCC** 8. Pre-requisite: **NIL**
9. Objective: To provide necessary background about the various risk associated with dams and the techniques for dam safety assessment and management
10. Details of Course:

S. No.	Contents	Contact Hours
1	**Overview of Dams Risk Assessment and Management**: Smart Governance and risk management, Risk analysis Formal Framework, Risk-informed decision-making and its importance in an integral Dam Safety Management Program, Dam Safety Program Fundamentals in USA, Spain, Argentina, Brazil etc.	4
2	**Basis for a Risk-Informed Dam Safety Management Program for India:** Dam failure risks worldwide, Dam failure risks in India, Lessons learnt from Risk Assessment and Management worldwide.	6
3	**Initial Risk-Based Screening:** Purpose of a risk-based screening tool, elements of the risk-based screening tool, brief reference to the Hazard Classification in India, dam safety inspections reports and DHARMA. Practical workshop or hands-on exercise.	5
4	**Identification of Failure Modes:** PFMA (Potential Failure Mode Analysis), types of failure modes and loading scenarios, the purpose of the failure mode identification, Identification and classification of Failure Modes, Identification of investigation and surveillance needs, Proposal of risk reduction actions. Practical workshop or hands-on exercise.	5
5	**Semi-Quantitative Risk Analysis:** Introduction, scope, and limitations of a semi-quantitative risk analysis (Failure probability categories Vs. Consequences categories), Prioritization of new studies or instrumentation. Practical workshop or	4

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	hands-on exercise.	
6	**Quantitative Risk Assessment**: Introduction, scope and limitations. Incremental Risk Concept, Failure modes structure, Risk model input data, Levels of Detail in Risk Calculation input data, Event tree concept and calculation examples, Common Cause Adjustment, Risk Calculation in dam systems, Risk Representation (FN and FD Graphs). Uncertainty analysis in risk calculations. Practical workshop or hands-on exercise.	6
7	**Risk Evaluation (Quantitative Risk Assessment):** Introduction, scope and limitations on Risk Evaluation process. Tolerability Guidelines Worldwide (ANCOLD, USBR, USACE, other countries/agencies), Proposal and justification of Tolerability Guidelines for India, Definition and prioritization of risk reduction actions, Risk reduction principles, Relation between quantitative risk models and DRIP Guidelines. Practical workshop or hands-on exercise.	5
8	**Portfolio Risk Management:** Introduction, Risk-informed decision-making inputs, risk-informed decision-making process (conditioning aspects). Structure of Reports on Dam Safety Risk Assessment. Practical workshop or hands-on exercise.	3
9	**Risk Governance:** Introduction, Capacity building, Risk Communication, Overall Regulatory Framework, Review and quality assurance, Other Factors Affecting Decision Making- Climate Change, Inter-State Issues etc. **Institutional Framework in Dam Safety**: Perspective of Institutional framework in Switzerland, USA, Australia; Existing Dam Safety Monitoring Mechanism in India-Dam Safety Organization (DSO), National Committee on Dam Safety (NCDS), National Committee on Seismic Design Parameters (NCSDP); Dam Safety Legislation in India-Historical Development, Important Provisions of the Dam Safety Bill 2019.	4
Total		42

11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication
1.	Zhang L., Peng M., Chang D. and Xu Y., "Dam Failure Mechanisms and Risk Assessment", John Wiley & Sons	1976
2.	Hartford D. N. and Baecher G. B., "Risk and Uncertainty in Dam Safety", Thomas Telford, Ltd	2004
3.	Raftery J., Loosemore M. and Reilly C., "Risk Management in Projects", United Kingdom: Tayor & Francis	2006
4.	Rodríguez Valladares M., "Overview of Credit Risk Portfolio Management", (n.p.): FT Press Delivers	2011
5.	"Risk Analysis, Dam Safety, Dam Security and Critical Infrastructure Management". Netherlands: CRC Press	2011

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6.	Solozhentsev E., "Risk Management Technologies: With Logic and Probabilistic Models", Netherlands: Springer Netherlands	2012
7.	"Hydrology of Disasters", Netherlands: Springer Netherlands	2012
8.	Iverson D., "Strategic Risk Management: A Practical Guide to Portfolio Risk Management", Germany: Wiley	2013
9.	Wagner R., "The Handbook of Project Portfolio Management", United Kingdom: Taylor & Francis	2018
10.	"Guidelines Assessing and Managing Risks Associated with Dams", DRIP, DoWR, MoJ, GoI, New Delhi	2019

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NAME OF DEPTT. /CENTRE: **INTERNATIONAL CENTRE FOR DAMS**

1. Subject Code: **DS-502** Course Title: **Basics of Disaster Management and its implementation Concepts**

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

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

4. Relative Weightage: **CWS: 20-35 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0**

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

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

9. Objective: To provide the basics of disaster management and implementation of various concepts to the dam by various modelling and mapping etc.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Overview of Disaster Management and Flood Mapping:** Disaster management cycle, Disaster Management Policies in India. Potential Uses of Flood Mapping in brief, Tiered Flood Modelling and Mapping Approach in India.	4
2	**Flood Risk Associated with Dams:** Types of Dams, Dam Failure concept, Estimation of consequences.	8
3	**Disaster Mitigation:** Warning and evacuation, do's and dont's about disaster, damage survey for designing aid package, detailed survey for reconstruction, repair and retrofitting, post disaster survey, long term measures, codal practices.	5
4	**Remote Sensing and Geographic Information Systems (GIS) applied to Emergency Preparedness and flood Mapping:** Techniques, uses, importance, Planning the Mapping Process, Geographical Information System (GIS), GIS Software, Practical workshop or hands-on exercises	5
5	**Dam Hazard Classification Framework in India:** CWC Guidelines; Assessment of the Area Affected by Dam break; Failure Scenarios, Classification of the Dams in India Based on Hazard Potential; Potential	4

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	Consequences Index Definition and Calculation Process (Additive-weighting scheme), Potential Implications of Hazard Potential Classification; Requirement for Emergency Action Plans (EAP) and their revision. Practical workshop or hands-on exercises.	
6	**Emergency Action Plans Preparation:** Emergency management Organisation (Stakeholders), Relationship of the EAP document and the O&M manual. Establishment of emergency response protocols/procedures, Notification Flowcharts, levels of alerts and associated thresholds, preparedness actions/protocols, local evacuation plan [shelters, evacuation routes, warning time], communications networks, emergency resources and equipment. Practical workshop or hands-on exercises.	8
7	**Emergency Action Plans Implementation:** Stakeholder's Consultation Meeting (discussion-based exercise), mock-drill or table top exercise for EAP testing and improvement. Design of an incident management system, types, and design process of a warning system network in the flood plain. Integration of the Dam EAP with the District/State Disaster Management Plan. Practical workshop or hands-on exercises.	5
8	**Environmental Management:** Introduction; Existing Policies and Legal Framework; Procedure for Environment, Forest and Wildlife Clearances; EIA Procedure; Environmental Management and Control; External Funding Agency's Policy and Requirements on Environmental and Social Safeguards	3
Total		42

11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication
1.	"National Disaster Management Guidelines", Government of India	2007
2.	Baas S., "Disaster Risk Management Systems Analysis: A Guide Book", Italy: Food and Agriculture Organization of the United Nations	2008
3.	"Swaziland Disaster Risk Reduction National Action Plan", 2008 to 2015. Eswatini: Swaziland Government	2008
4.	MacDonald W. and Ritchie L. A., "Enhancing Disaster and Emergency Preparedness, Response, and Recovery Through Evaluation: New Directions for Evaluation", Number 126, United Kingdom: Wiley	2010
5.	Dwivedi O., "India's Environmental Policies, Programmes and Stewardship". United Kingdom: Palgrave Macmillan UK	2016
6.	Huggel C. and Singh R., "Climate Change, Extreme Events and Disaster Risk Reduction: Towards Sustainable Development Goals", Germany: Springer International Publishing	2017
7.	"Environmental Modelling with GIS and Remote Sensing", United Kingdom: Taylor & Francis	2017
8.	Esmail M., and Abdalla R., "WebGIS for Disaster Management and Emergency Response", Germany: Springer International Publishing	2018
9.	"Emergency and Disaster Management: Concepts, Methodologies, Tools, and Applications", United States: IGI Global	2018

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10.	Mondal D. and Basu D., "Disaster Management Concepts and Approaches", CBS Publishers and Distributors	2020

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NAME OF DEPTT. /CENTRE: **INTERNATIONAL CENTRE FOR DAMS**

1. Subject Code: **DS-503** Course Title: **Hydrologic Safety Evaluation of Dams**

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

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

4. Relative Weightage: **CWS: 20-35 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0**

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

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

9. Objective: To provide the knowledge and aspects of Hydrologic Evaluations for dam safety.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Design Flood Analysis**: Design flood estimation by Hydro-meteorological approach: Concept of Unit hydrograph, design storm, depth estimation from PMP Atlas, clock hour correction, areal reduction factor, Storm transposition, Location Adjustment Factor (LAF), Barrier Adjustment Factor (BAF), Transposition Adjustment Factor (TAF), Moisture Maximization Factor (MMF), loss rate, base flow, time distribution coefficient, HEC-HMS model	8
2	**Design flood estimation by flood frequency approach:** Statistical tests on flood data, stationary and non-stationary flood frequency analysis, computation of return period floods, Goodness of fit tests	8
3	**Channel routing**: Hydrological and hydraulic channel routing	4
4	**Reservoir routing**: Modified Pul's and other applicable methods	3
5	**Dam Breach Modelling:** Parameters estimation methodologies, Breach outflow routing (Upstream Flood Routing methodologies, Downstream Flood Routing methodologies, two-dimensional depth averaged models, one-dimensional models and coupled 2D-1D models, Modelling Software available), Practical workshop or hands-on exercises for three different levels of detail in dam breach modelling (Tier I, II and III)	8
6	**Reservoir Rule Curve:** Consistency check of inflow data, computation of percentile and dependable flow, derivation of rule curve, conservation rule	5

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	curve, upper rule curve, testing of rule curve for different dependable flows	
7	**Hydrological safety under changing climate**: Climate change, Changes in precipitation domain and its impact of inflows.	6
Total		42

11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication
1.	"Statistical Distributions for Flood Frequency Analysis", WMO operational hydrology report no. 33.	1989
2.	"Design Flood Estimation Manual", Central Water Commission, New Delhi	2000
3.	Haan C. T., "Statistical Methods in Hydrology", Wiley Publication, 378 pages	2002
4.	Hosking, J.R.M. and Wallice J.R. "Regional Frequency Analysis- An Approach Based on L-Moments", Cambridge University Press.	2005
5.	"Guide to hydrological practices", World Meteorological Organization (WMO)	2008
6.	Boes R. M. and Schleiss A. J., "Dams and Reservoirs Under Changing Challenges", Netherlands: CRC Press	2011
7.	AghaKouchak A., Easterling D., Hsu K., Schubert S. and Sorooshian S. (Eds.), "Extremes in a changing climate: detection, analysis and uncertainty (Vol. 65)", Springer Science & Business Media	2012
8.	Beven, K.J. "Rainfall-Runoff Modelling: The Primer", 2nd Edition, Wiley-Blackwell	2012
9.	Zhang J., Zhang L. and Wang R., "Dam Breach Modelling and Risk Disposal: Proceedings of the First International Conference on Embankment Dams (ICED 2020)", Germany: Springer International Publishing	2020
10.	Xu Y., Zhang L., Chang D. and Peng M., "Dam Failure Mechanisms and Risk Assessment", Singapore: Wiley	2016
11.	"Flood Evaluation and Dam Safety", United States: CRC Press	2018

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NAME OF DEPTT. /CENTRE: **INTERNATIONAL CENTRE FOR DAMS**

1. Subject Code: **DS-504** Course Title: **Sediment Management in Reservoirs**

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

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

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

4. Relative Weightage: **CWS: 20-35 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0**

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

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

9. Objective: To provide the background of sedimentation in reservoirs, its assessment and measurement, various options to manage sedimentation of the reservoir.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Sediment Management; Magnitude of the Problem	2
2	**Erosion and Sedimentation in Drainage Basins:** Weathering and Erosion Processes, sediment properties, modes of sediment transport, mathematical models, Sediment Delivery Ratio, Rates of Erosion and Delivery, Human Impact on Sediment Yield, Impact of Natural Events, Measurement of Sediment Load	8
3	**Reservoir Sedimentation Process:** Hydrological and Hydraulic Processes, Erosion, Transport and Sedimentation, Sources and Processes, Morphological Processes, Sediment Size, Entrainment, Suspension, Suspended Material Load, Bed Material Load, Unit Weight of Deposits, Delta Formation	5
4	**Reservoir sedimentation:** Computation of sediment yield, trap efficiency, distribution of sediment in reservoir, new zero elevation	5
5	**Predictive Methods for Reservoir Sedimentation:** Measurement and Monitoring Techniques, Empirical and Analytical Methods, Physical Modelling, Satellite, UAV and USV, Post-Processing and Analysis Tools for Topo-Bathymetric Data, Computational Modelling	6
6	**Mitigation of Reservoir Siltation:** Erosion and Sedimentation Control, Sediment Routing, Sediment Removal, Structural and Non-Structural Adaptive Measures,	6

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	Watershed Management, Check Dams, Sediment Bypassing, Sediment Flushing, Sediment Sluicing, Density Current venting, Sediment Dredging	
7	**Reservoir Sedimentation in India:** National Records and Regulation of Dams in India, Indian Standard Code, Guidelines and Compendium on Reservoir Sedimentation, Reservoir Sediment Management in India, Sedimentation Data and Observation in Selected Reservoirs, Sediment Management in Indian Reservoirs: Good Practices and Problems, published Indian case studies from journals	6
8	Reservoir sedimentation- International Practices	4
Total		42

11. Suggested Books:

Sl. No.	Name of Authors/Books/Publisher	Year of Publication
1.	Annandale G.W., "Reservoir sedimentation", Elsevier, New York	1987
2.	Morris G. L. and Fan J., "Reservoir sedimentation handbook: design and management of dams, reservoirs, and watersheds for sustainable use", McGraw Hill Professional	1998
3.	Garde R.J. and Raju K., "Mechanics of Sediment Transportation and Alluvial Streams Problems", Taylor & Francis	2006
4.	"Reservoir Sediment Management Hardcover"-Illustrated, CRC Press, 1st edition	2011
5.	Tigrek S. and Aras T., "Reservoir sediment management", CRC Press, Taylor & Francis Group, Boca Raton	2012
6.	Bhattacharyya K. and Singh V. P., "Reservoir Sedimentation: Assessment and Environmental Controls", CRC Press, Taylor & Francis Group, Boca Raton	2019
7.	"Handbook for Assessing and Managing Reservoir Sedimentation", DRIP, DoWR, MoJ, GoI	2019

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NAME OF DEPTT. /CENTRE: **INTERNATIONAL CENTRE FOR DAMS**

1. Subject Code: **DS-505** Course Title: **Dam Safety Surveillance Instrumentation and Monitoring**
2. Contact Hours: **L: 2** **T: 1** **P: 2/2**
3. Examination Duration (Hrs): **Theory: 3** **Practical: 0**
4. Relative Weightage: **CWS: 15-30** **PRS: 20** **MTE:15-25** **ETE: 30-40** **PRE: 0**
5. Credits: **4** 6. Semester: **Spring**
7. Subject Area: **PCC** 8. Pre-requisite: **NIL**
9. Objective: To provide the concepts of dam inspection, monitoring etc. and explore the theory and practical knowledge for the dam safety surveillance instrumentation.
10. Details of Course:

S. No.	Contents	Contact Hours
1	**Dam Safety Inspection Program:** Types, preparing for an Inspection, Inspecting Embankment Dams, Concrete and Masonry Dams, Spillways, Outlets and Mechanical Equipment, Inspecting General Areas, Visual Inspection using remotely Operated Vehicles (ROVs), Use of Remotely Operated Underwater Vehicles (ROVs), Use of Unmanned Aerial Vehicles (UAVs)	4
2	**Documenting an Inspection:** Method, Checklist, Field Sketches, Photographs, Monitoring Data, Global Positioning Sensors (GPS), Inspection Notes, Visual Inspection Documentation, Writing an Inspection Report, Comprehensive Inspection Report.	8
3	**Comprehensive Dam Safety Review:** Procedures, Details to be provided to DSRP before inspection, Composition of DSRP, Reports of Comprehensive Safety Evaluation, Roles and the Responsibilities of Dam Safety Review Panel, Empanelment of Members of DSRP	5
4	**Instrumentation and Monitoring:** Monitoring Frequency, Measurement of Seepage and Leakage, Movement, Types of Movement, Reservoir / Tail water Elevations, Staff Gauge, Precipitation, Local Seismic Activity, Stress and Strain, Types of Pressure (Stress) Measuring Devices, Temperature, Critical Physical Data to be monitored, Data Evaluation. **Instrumentation System Planning: Embankment Dams:** Instrumenting Existing Embankment Dams, Monitoring Seepage and Water Pressure, Monitoring Soil Stresses, Indian Standards Instrumentation System Planning, Instrumentation System Planning: Seismic Monitoring, Instrumentation of	5

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	Existing Dam	
5	**Hydro-Meteorological Instrumentation:** Measurement, Recording, Installation, Data validation, Errors in measurement of rainfall, temperature, relative humidity, wind speed, evaporation, snowfall, water level, suspended load etc.	4
6	**Instrumentation Data Collection and Management:** Introduction, Data Collection, Manual Data Collection, Stand Alone Data loggers, Real time Monitoring Networks, Advantages and Disadvantages, Data Management and Presentation, Database software, Data Processing, Data Maintenance, Data Presentation, Critical Data Analysis.	8
7	**Monitoring Data Organization and Analysis:** Introduction, Design Aspects, Numerical Modelling, Back Analysis for Calibration, Dynamic Loading, Dynamic Analysis, Monitoring Data Analysis, The Purposes of Monitoring Data Analysis, Automatic Data Acquisition, Evaluation of Measurement Data, Data analysis and Evaluation Summary	5
8	**Automation of Instrumentation:** Power for remote equipment, Vandalism, Lightning protection, Notification protocols, Data Acquisition and Management	3
Total		42

11. Suggested Books:

Sl. No.	Name of Authors/Books/Publisher	Year of Publication
1.	Bartholomew C. L. and Murray B. C., "Embankment dam instrumentation manual", US Department of the Interior, Bureau of Reclamation	1987
2.	Dunnicliff J., "Geotechnical instrumentation for monitoring field performance", John Wiley & Sons	1993
3.	Penman A.D.M., Saxena K.R. and Varma V.M., "Instrumentation, Monitoring and Surveillance: Embankment, Dams", Hardcover, Routledge	1999
4.	"Guidelines for instrumentation and measurements for monitoring dam performance", ASCE Task Committee on Instrumentation and Dam Performance	2000
5.	Roth J. J. and Hughes W., "Dam Maintenance and Rehabilitation II". CRC Press	2010
6.	"Guidelines for instrumentation of large dams" GoI, CWC, Central Dam Safety Organization, New Delhi	2018
7.	"Guidelines for preparing operation and maintenance manual for dams", CWC, DoWR, MoJ, GoI, New Delhi	2018

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8.	"Guidelines for safety inspections of dams", CWC, DoWR, MoJ, GoI, New Delhi	2018
9.	Penman A. D., "Instrumentation, monitoring and surveillance: embankment dams", Routledge	2018
10.	"Monitoring Dam Performance: Instrumentation and Measurements", United States: American Society of Civil Engineers	2018
11.	Technical Specifications of Hydro-meteorological, Geodetic, Geotechnical and Seismic Instruments	2018

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SYLLABI (ELECTIVE COURSES)

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **INTERNATIONAL CENTRE FOR DAMS**

1. Subject Code: **DS-511** Course Title: **Seepage through Dams**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs): **Theory: 3** **Practical: 0**
4. Relative Weightage: **CWS: 20-35 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0**
5. Credits: **4** 6. Semester: **Both**
7. Subject Area: **PEC** 8. Pre-requisite: **NIL**
9. Objective: To develop the understanding of basic principles and concepts of Seepage and its control in Dams.
10. Details of Course:

S. No.	Contents	Contact Hours
1	Importance of seepage in dam safely and rehabilitation, Types and causes of seepage through various types of Dams	4
2	Fundamentals of seepage through porous media, Darcy's law, seepage velocity, Dupuits theory, Seepage charts, Phreatic lines, Flow nets, Determination of free surface and seepage discharge through dams for isotropic and anisotropic media. Flow net for earth dam under steady/transient seepage condition, the stability of dams	10
3	Seepage Analysis, Boundary conditions, numerical techniques and modelling tools, Phreatic line with and without filter, stability conditions	5
4	Seepage through main body of various types of dams; Measurement of seepage water in galleries, Various methods of seepage control, Selection of core materials, Drainage of embankments, Design criteria of filters, Use of geo-textiles, Seepage Control through Embankments, Foundations	7
5	Seepage through bottom of reservoir area; various types of geological formations in the bed; identification techniques to know the seepage from the beds, Dam Grouting, Design and installation of grout curtains	6
6	Seepage detection, control and monitoring. Plan and design of various dams and adopt suitable measures for its safety	6
7	Practical examples and site visits	4
Total		42

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11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication
1.	Sherard J. L., "Earth and Earth-rock Dams: Engineering Problems of Design and Construction", United States: John Wiley & Sons	1967
2.	Mahgerefteh K., "Seepage and Stability Analysis of Earth Dams", (n.p.): Virginia Polytechnic Institute and State University	1979
3.	"Seepage Analysis and Control for Dams: Engineering and Design", Department of the Army, Corps of Engineers, Office of the Chief of Engineers	1986
4.	Cedergren H. R., "Seepage, Drainage, and Flow Nets" (Vol. 16). John Wiley & Sons	1997
5.	Bedmar A. P. and Araguas L., "Detection and prevention of leaks from dams", Netherlands: Taylor & Francis	2002
6.	Pezhman T.G., Junaidah A., Amirhoss M., "Seepage Modelling of the Dam" Paperback – Import, 28, Scholars Press; Illustrated edition	2004
7.	"Internal Erosion of Dams and Their Foundations: Selected and Reviewed Papers from the Workshop on Internal Erosion and Piping of Dams and Their Foundations", Aussois, France, Netherlands: Taylor & Francis	2007
8.	Garg S. K., "Irrigation Engineering and Hydraulic Structures" Twenty-fourth Revised Edition.	2011
9.	Jansen R. B., "Advanced dam engineering for design, construction, and rehabilitation", Springer Science & Business Media	2012
10.	Guyer, J.P. "An Introduction to Seepage Mitigation in Embankment Dams", The Clubhouse Press	2020

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NAME OF DEPTT. /CENTRE: **INTERNATIONAL CENTRE FOR DAMS**

1. Subject Code: **DS-512** Course Title: **Assessment and Management of Environmental issues in Reservoirs**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs): **Theory: 3** **Practical: 0**
4. Relative Weightage: **CWS: 20-35 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0**
5. Credits: **4** 6. Semester: **Both**
7. Subject Area: **PEC** 8. Pre-requisite: **NIL**
9. Objective: To provide background of ecosystem, environment, legal issues, guidelines etc. and necessary practices and application on environmental issues in reservoirs.
10. Details of Course:

S. No.	Contents	Contact Hours
1	**Water quality issues:** Impact of reservoir on water flow; Impacts on thermal regime; Water chemistry; Sedimentation; Nutrient enrichment; Water pollution; Emission of greenhouse gases; Climate change; Hydrological and water quality impacts; Soil and landscape changes; Agro-economic issues; Human health impacts.	7
2	**Ecosystem resilience issues:** Concept of an Ecosystem; importance of biological diversity; Destruction in ecosystem; Impacts on organisms and biodiversity; Influence in primary production; Effects on aquatic ecosystems; Value of ecosystem goods and services; Social and cultural impacts	8
3	**Assessment of carbon footprints in dams**	2
4	**Guidelines and Standard Codes:** Introduction; National and international legislative frameworks, codes; Future challenges.	5
5	**EIA methods and Tools:** Introduction; basic principles of EIA for reservoir; Development of scope; Mandate and study design; Base line survey; Methodology for EIA; Economic approaches; Environmental Impact Statement (EIS) preparation; temporal and spatial scales; socio-environmental factors; Planning and reservoir management; case studies.	8
6	**Environmental Clearances:** Introduction; Requirement for environmental clearances; Procedure for environmental clearances; Analysis of alternatives	5
7	**Legal Issues:** Introduction; Policy, legal and regulatory compliance; Statutory	5

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	clearance approval and permissions	
8	**Societal considerations in dams**: Societal considerations, Gender related issues in Dam safety and rehabilitation	2
Total		42

11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication
1.	Govardhan V., "Environmental Impact Assessment of Tehri Dam, India", Ashish Publishing House	1993
2.	Canter L.W., "Environmental Impact Assessment". McGraw Hill International Edition, New York	1995
3.	Petts J., "Handbook of Environmental Impact Assessment", Vol., I and II, Blackwell Science London	1999
4.	Barathwal R. R., "Environmental Impact Assessment", New Age International Publishers, New Delhi	2002
5.	Lawrence D. P., "Environmental Impact Assessment – Practical solutions to recurrent problems", Wiley-Inter Science, New Jersey	2003
6.	Berga L., Buil J. M., Bofill E., De Cea J. C., Perez J. G., Mañueco G., and Yagüe J., "Dams and Reservoirs, Societies and Environment in the 21st Century", Two Volume Set: Proceedings of the International Symposium on Dams in the Societies of the 21st Century, 22nd International Congress on Large Dams (ICOLD), Barcelona, Spain, CRC Press	2006
7.	"Issues in Environmental Law, Policy, and Planning: 2012" Edition United States: Scholarly Editions	2013
8.	"Evolution of Dam Policies: Evidence from the Big Hydropower States", Germany: Springer Berlin Heidelberg	2014
9.	Dević G., "Environmental Impacts of Reservoirs", In: Armon R., Hänninen O. (eds), Environmental Indicators, Springer, Dordrecht. https://doi.org/10.1007/978-94-017-9499-2_33	2015
10.	Annandale G. W., Morris G. L. and Karki P., "Extending the life of reservoirs: sustainable sediment management for dams and run-of-river hydropower. The World Bank. https://doi.org/10.1596/978-1-4648-0838-8	2016
11.	Shah A. and Mareddy A. R., "Environmental Impact Assessment: Theory and Practice", India: Elsevier Science	2017
12.	"Water Conflicts in Northeast India", Taylor & Francis	2017
13.	Khagram S., "Dams and Development: Transnational Struggles for Water and Power", United States: Cornell University Press	2018
14.	Singh A., Saha D. and Tyagi A. C., "Water governance: challenges and prospects", Singapore: Springer	2019

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **INTERNATIONAL CENTRE FOR DAMS**

1. Subject Code: **DS-513** Course Title: **Earthquake Geotechnical Engineering**
2. Contact Hours: **L: 3** **T: 1** **P: 2/2**
3. Examination Duration (Hrs): **Theory: 3** **Practical: 0**
4. Relative Weightage: **CWS: 15-3 PRS: 20 MTE: 15-25 ETE: 30-40 PRE: 0**
5. Credits: **4** 6. Semester: **Both**
7. Subject Area: **PEC** 8. Pre-requisite: **NIL**
9. Objective: The objective is to introduce the potential consequences of strong earthquakes on dam site areas for Design, construct and maintain the safety and evaluation.
10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Earthquakes, characteristics and distribution, tectonic features of the earth, geo-tectonic divisions of the Indian continent, geologic hazards perception. Background and lessons learnt from damages in past earthquakes.	3
2	**Earthquakes in Different Geological Set-Ups:** Geological structures and deformation pattern, inter and intra – continent set up, convergent zones, divergent margins, trenches, thrusts and faults. Earthquake implication of structural discontinuities, the impact of the neo-tectonic activity.	3
3	**Mapping:** Coordinate and coordinate systems; geographical and map projection system, 2D and 3D data transformation, types of maps, scales, map sheet numbering systems and uses, types of maps, introduction to topographical and geological maps, thematical maps, geological sections, data processing, analysis and presentation techniques.	2
4	**Wave Propagation:** Waves in semi-infinite media – one-, two- and three-dimensional wave propagation; Attenuation of stress waves – material and radiation damping; Dispersion, waves in a layered medium.	2
5	**Dynamic Soil Properties:** Stress & strain conditions, the concept of stress path; Measurement of seismic response of soil at low and high strain, using laboratory tests; Cyclic triaxial, cyclic direct simple shear, resonant column, shaking table,	4

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	centrifuge and using field tests - standard penetration test, plate load test, block vibration test, SASW/MASW tests, cross borehole; Evaluation of damping and elastic coefficients; Stress-strain behaviour of cyclically loaded soils; Effect of strain level on the dynamic soil properties; Equivalent linear and cyclic nonlinear models; Static and dynamic characteristics of soils.	
6	**Ground Response Analysis:** Introduction-, one-, two- and three-dimensional analyses; Equivalent and nonlinear finite element approaches; Introduction to soil-structure interaction.	2
7	**Liquefaction:** Introduction, pore pressure, liquefaction related phenomena – flow liquefaction and cyclic mobility: Factors affecting liquefaction, liquefaction of cohesionless soils and sensitive clays, liquefaction susceptibility; State Criteria –CVR line, SSL, FLS; **Evaluation of liquefaction potential:** characterization of earthquake loading and liquefaction resistance, cyclic stress ratio, Seed and Idriss method; Effects of liquefaction.	3
8	**Earth Pressure:** Active and passive earth pressures; Terzaghi's passive wedge theory, numerical methods, earth pressure measurements.; Seismic design of retaining walls: types, modes of failures, static pressure, seismic response (including M-O Method), seismic displacement, design considerations.	2
9	**Seismic Slope Stability:** Types of earthquake-induced landslides; Evaluation of slope stability – stability analysis with dynamic loading, friction circle method, effective and total stress methods of analysis, factor of safety, yield acceleration, damage potential, displacement analysis, effect of saturated and submerged conditions, FEM analysis of slope stability.	3
10	**Remote Sensing in Earthquake Geology:** Basic concepts of satellite imaging of ground, types of satellite data in identifying the tectonic features, recognising characteristics of earthquake deformation features, SAR interferometry for earthquake deformation studies; Application of GPS for mapping;	4
Total		28

List of Experiments: Processing of pre and post-earthquake satellite images, Collection of data using GPS and mapping, Use of SAR interferometry for surface displacement measurement, Liquefaction Resistance of Soil using Vibration Table, Shear Velocity Profile using MASW, N values of cohesionless soils using SPT, c and Φ of soil using direct shear/triaxial tests, Liquefaction resistance of soil using cyclic triaxial test apparatus, Determination of dynamic properties using laboratory tests; Shear velocity profile using cross-bore test; Model Testing on Small Geotechnical Centrifuge.

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11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication
1.	Prakash S., "Soil Dynamics", McGraw Hill Book Company	1981
2.	Mather P.M., "Computer Processing of Remotely Sensed Images", John Wiley	1999
3.	Demers Michael N., "Fundamentals of Geographic Information Systems", John Willey	2000
4.	Gibson P.J. and Power C.H., "Introductory Remote Sensing – Digital Image Processing and applications", Routledge	2000
5.	Kameshwara Rao, N.S.V, "Dynamic Soil Tests & Applications", Wheeler Publications	2000
6.	Ranjan G. and Rao A.S.R., "Basic and Applied Soil Mechanics", New Age Int. Ltd	2000
7.	Day Robert W., "Geotechnical Earthquake Engineering Handbook", McGraw-Hill	2001
8.	Hoffmann-Wellenhoff B., "GPS Theory & Practice", Springer	2001
9.	Kramer S.L., "Geotechnical-Earthquake Engineering", Pearson Education – Indian Low-Price Edition	2004
10.	Chandra A.M. and Ghosh S.K., "Remote Sensing and Geographical Information System", Narosa, Oxford: Alpha Science International	2006
11.	Saran S., "Soil Dynamics & Machine Foundation", Galgotia Publication, New Delhi	2006
12.	Das B. M. and Ramana G.V., "Principles of soil dynamics", Cengage Learning	2011

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **INTERNATIONAL CENTRE FOR DAMS**

1. Subject Code : **DS-514** Course Title: **Study Tour/ Case Studies**
2. Contact Hours: **L: 2** **T: 0** **P: 2**
3. Examination Duration (Hrs): **Theory: 3** **Practical: 0**
4. Relative Weightage: **CWS: 15-30 PRS: 20 MTE:15-25 ETE: 30-40 PRE: 0**
5. Credits: **4** 6. Semester: **Both**
7. Subject Area: **PEC** 8. Pre-requisite: **NIL**
9. Objective: To reinforce the understanding of different physical aspects of dams through the case studies and visits to major national and international dams.
10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Introduction to dams; types of dams; major dams in India and abroad; characteristics of major dams.	2
2	**Case studies:** Case studies on major dams in India and abroad, such as Tehri Dam, Hirakund Dam, Tungabhadra Dam, Bhakra Nangal Dam, Nagarjuna Sagar Dam and Krishnasagar dam	2
3	**Discussions on Detailed Project Report (DPRs) of major dams**: Introduction to DPRs; understanding the different elements of DPRs: survey & investigation, geology, hydrology, structural design, hydro-mechanical design, power generation, cost estimates, etc.; discussions on DPRs	4
4	**Field visits to majors dams**: Visits to some of the dams; visit reports; and discussions. Tehri Dam, Hirakund Dam, Tungabhadra Dam, Bhakra Nangal Dam, Nagarjuna Sagar Dam and Krisnasagar dam	2
5	**Expert lectures:** Lectures by experts from different national and international agencies/institutes on design and operations of dams.	4

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6	Provision of the visit to one or cluster of the international dams following the best practices during semester breaks	-
Total		14

11. Suggested References

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Detailed Project Report (DPRs) of major dams	
2.	"Advanced Dam Engineering for Design, Construction, and Rehabilitation", United States: Springer US	1988
3.	Paranjpye V. "Evaluating the Tehri Dam: An Extended Cost Benefit Appraisal", India: Indian National Trust for Art and Cultural Heritage	1988
4.	Weaver K. D., "Dam Foundation Grouting", United States: American Society of Civil Engineers	1991
5.	Jain S. K., Singh V. P. and Agarwal P. K., "Hydrology and Water Resources of India", Germany: Springer Netherlands	2007
6.	Ramanathan K. and Abeygunawardena P., "Hydropower Development in India: A Sector Assessment", Philippines: Asian Development Bank	2007
7.	Scudder T. T., "The Future of Large Dams: Dealing with Social, Environmental, Institutional and Political Costs", Iran: Taylor & Francis	2012
8.	"Dam and Levee Safety and Community Resilience: A Vision for Future Practice", United States: National Academies Press	2012

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NAME OF DEPTT. /CENTRE: **INTERNATIONAL CENTRE FOR DAMS**

1. Subject Code : **DS-515** Course Title : **Geo Mechanics**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs): **Theory: 3** **Practical: 0**
4. Relative Weightage: **CWS: 20-35 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0**
5. Credits: **4** 6. Semester: **Both**
7. Subject Area: **PEC** 8. Pre-requisite: **NIL**
9. Objective: To provide *mechanical* behaviour of geological materials. The engineering aspects of these studies, or applied *geo-mechanics.*
10. Details of Course:

S. No.	Contents	Contact Hours
1	**Basics of Engineering Geology:** A brief about Earth's Interior and Plate Tectonics; brief about Minerals, Formation of minerals and their Classification; Types of Rock: Igneous, Sedimentary and Metamorphic; Formation of Rocks and Rock Cycle; Classification and Properties of Rocks; Weathering, Erosion and Soil Formation;	4
2	**Structural Geology:** Structural Configuration of Strata: Strike, Dip, Bedding Plane, etc., Types of Fractures: Joints, Faults, Folds, Unconformity; Formation and Classification of Joints, Faults and Folds; Effects of Joints, Faulting, Folding and their Civil Engineering Importance; Shear Zone; Topographic and Geological Maps;	8
3	**Engineering Properties of Rocks:** Engineering Properties of Rocks; Rock Deformation: Hooke's Law, Volumetric Strain, Elastic Moduli; **Types of Rock Stresses:** In-situ Stresses, Induced Stress;	5
4	**Hydrological Studies:** Sources of Ground Water; Aquifer, Aquiclude, Aquitard and Aquifuge; Types of Aquifer: Unconfined and Confined; Permeability of Rock mass and its test; Chemical properties of Ground Water and its effects on Rock Mass; **Geological Exploration:** Bore Holes (Vertical and inclined), Drifts in Abutments; Methods of Drilling;	5
5	**Rock Strength and Rock Mass Strength:** Rock Strength Test and Rock Failure Criteria; Rock Mass Strength and its measurement; Rock Mass Classification: Rock Mass Rating and Norwegian Q System;	4

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6	Geophysical Methods and their Suitability; **Geology of Dam sites and Reservoirs** - Importance of Geology in Dam Construction; Types of Dams and bearing of Geology in their selection; Geological considerations in the selection of a Dam Site; Factors affecting the Feasibility of Reservoir Site; Investigation of Reservoir Sites; Geological Considerations and the Stability of the Sides of Reservoirs; Sedimentation in Reservoir and Leakage from Reservoir;	8
7	**Geological Hazards** - Landslides, Subsidence; Slope Stability; Slope Strengthening and Stabilization Effect of Reservoir and Tunnel Construction;	5
8	Numerical and computer methods in Geomechanics.	3
Total		42

11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication
1.	Desai C. S. and Christian J. T., "Numerical Methods in Geotechnical Engineering" , McGraw-Hill	1977
2.	Goodman R. E., "Introduction to Rock Mechanics", 2nd Edition, Wiley	1988
3.	Hudson J. A. and Harrison J. P., "Engineering rock mechanics: an introduction to the principles", Elsevier	1997
4.	Bell F. G., "Geological Hazards: Their Assessment, Avoidance and Mitigation", United Kingdom: Taylor & Francis	2003
5.	Jager J. C., Cook N. G. W. and Zimmerman R., "Fundamental Rock Mechanics", 4th Edition, Wiley	2007
6.	Peng S. and Zhang J., "Engineering geology for underground rocks", Springer Science & Business Media	2007
7.	Farmer I. W., "Engineering behaviour of rocks", Springer Science & Business Media	2012
8.	Zhang L., "Engineering Properties of Rocks", Germany: Elsevier Science	2016
9.	Wyllie D. and Mah C. W., "Rock Slope Engineering", 5th Edition, CRC Press	2017
10.	Kesavulu N. C., "A Textbook of Engineering Geology", Laxmi Publications	2018
11.	Desai C. S., Prashant A. and Sachan A., "Advances in Computer Methods and Geomechanics: IACMAG Symposium 2019 Volume 1", Germany: Springer Singapore	2020
12.	Pollard D. D. and Martel S. J., "Structural Geology: A Quantitative Introduction", United Kingdom: Cambridge University Press	2020

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NAME OF DEPTT. /CENTRE: **INTERNATIONAL CENTRE FOR DAMS**

1. Subject Code: **DS-516** Course Title: **Geospatial Technologies for Dam Monitoring**

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

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

4. Relative Weightage: **CWS: 20-35 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0**

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

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

9. Objective: This course will impart the knowledge and application of geospatial technologies in monitoring changes in geomorphological characteristics and structural changes of dams and other hydraulic structures.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Overview of Geospatial Technologies	2
2	Introduction to optical remote sensing and its applications to surface water changes; Fundamentals of Digital Image Processing	4
3	Introduction to microwave (SAR) remote sensing; InSAR processing and its application to dam monitoring and associated tools/software; Structural Monitoring of Dam Structures using SAR	6
4	Introduction to UAV sensing; various components of UAV; autonomous UAVs; UAV data collection and processing methods; Indian Regulatory Systems for UAV sensing	6
5	Introduction to LiDAR; LiDAR data collection methods; Application of LiDAR technology to dam monitoring	6
6	Introduction to GPS Systems; GPS data collection techniques; Application of GPS to dam monitoring	6
7	Monitoring of Catchment Characteristics using geospatial technologies: Snow covered areas and rain-fed areas	6
8	Monitoring of landslide zones using geospatial technologies and their representation in GIS	3
9	Application of geospatial technologies for land use/cover change monitoring in flood-prone downstream areas of dams and risk assessment	3

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Total		42

11. Suggested books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	Burrough P.A. and McDonnel R.A., "Principles of Geographic Information System", Oxford University Press	2000
2.	Joseph G., "Fundamentals of Remote Sensing", India: Universities Press	2005
3.	Nayak S. and Zlatanova S., "Remote Sensing and GIS Technologies for Monitoring and Prediction of Disasters", Germany: Springer Berlin Heidelberg	2008
4.	Richards J.A., "Remote Sensing Digital Image Analysis", Springer	2013
5.	Ferretti A., "Satellite InSAR Data – Reservoir Monitoring from Space", Eage Publications	2014
6.	Thenkabail P.S., "Remote Sensed Data Characterization, Classification, and Accuracies", CRC Press	2016
7.	Shaw R., "Land Use Management in Disaster Risk Reduction: Practice and Cases from a Global Perspective", Japan: Springer Japan	2016
8.	Dong P and Chen Q., "LiDAR Remote Sensing Applications", CRC Press	2018
9.	Shimada M., "Imaging from Spaceborne and Airborne SARs, Calibration, and Applications", Taylor and Francis	2018
10.	Garg P.K., "Introduction to Unmanned Aerial Vehicles", New Age International Publishers	2020

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NAME OF DEPTT. /CENTRE: **INTERNATIONAL CENTRE FOR DAMS**

1. Subject Code : **DS-517** Course Title: **Hydraulic and structural design of dams, spillways and energy dissipators**

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

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

4. Relative Weightage: **CWS: 20-35 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0**

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

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

9. Objective: To discuss design methodology for dams, spillways and energy dissipators

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction to hydraulic structures and their necessity.	2
2	**Embankment Dams:** Types, design considerations, seepage analysis and control, stability analysis, construction techniques	7
2	**Gravity Dams:** Forces acting on failure of a gravity dam, stress analysis, elementary profile, design of gravity dam, other functional features of a gravity dam	7
3	**Spillways:** Types and their design, Ogee spillway, Chute and side spillway, Shaft spillway, Labyrinth and Piano Key Weirs, spillway gates, cavitation, aerators, inflatable rubber weirs, stepped spillway, nappe and skimming flow	7
4	**Energy dissipators:** Necessity, Types and their selection, design of hydraulic jump type stilling basins, Bucket and Flip type energy dissipators, Impact and pipe outlet	9
5	Supercritical flow, oblique jump, supercritical transition	3
6	Hydraulic modelling of spillways and energy dissipators, dimensional analysis, modelling of turbulence, friction, air entrainment etc., scale effects,	3
7.	Life time assessment of dam and associated works	4
Total		42

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11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication /Reprint
1.	Creager W. P., Justin J. D. W. and Hinds J., "Engineering for Dams, Vol I & Vol II", John Wiley & Sons	1945
2.	Peterka A. J., "Hydraulic design of stilling basins and energy dissipators", USBR Engineering Monographs No. 25	1984
3.	"Design of Small Dams-Third Edition", A Water Resources Technical, Publication - US Bureau of Reclamation	1987
4.	Hager W.H. and Vischer D.L., "Energy Dissipators: IAHR Hydraulic Structures Design Manuals", CRC Press	1992
5.	Varshney R. S., "Engineering for Embankment Dams", Netherlands: A.A. Balkema Publishers.	1995
6.	Varshney R. S., "Hydro Power Structures", Nem Chand & Bros., Roorkee	2001
7.	Khatsuria R. M., "Hydraulics of spillways and energy dissipators", CRC Press	2004
8.	Singh B. and Varshney R. S., "Embankment Dam and Engineering", Nem Chand & Bros, Roorkee	2004
9.	Novak P. and Nalluri C., "Hydraulic Structures", Edition 4, Taylor & Francis	2007
10.	Chanson H., "Energy Dissipation in Hydraulic Structures" Netherlands: CRC Press	2015
11.	Nalluri C., Narayanan R., Novak P. and Moffat A., "Hydraulic Structures", United States: CRC Press	2017
12.	Guyer J. P., "An Introduction to Construction Control for Embankment Dams", Amazon Digital Services LLC - KDP Print US	2019

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **INTERNATIONAL CENTRE FOR DAMS**

1. Subject Code: **DS-518** Course Title: **Ground Improvement and Geosynthetics**

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

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

4. Relative Weightage: **CWS: 20-35 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0**

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

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

9. Objective: To introduce the ground improvement techniques and geo-synthetics for the dam safety, repair and rehabilitation.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Basics:** Principles of ground improvement, Types/Classification of ground improvement techniques. Mechanical modification, Types of compaction techniques, Properties of compacted soil. Hydraulic modification, dewatering systems, preloading and vertical drains, electro-kinetic dewatering, chemical modification, modification by admixtures, stabilization using industrial wastes, grouting, soil reinforcement principles,	06
2	**Methods of stabilizations:** – Mechanical – Admixture (Cement/Lime) - Bituminous - Chemical. Types of admixture stabilisation- Grouting (permeation grouting, compaction grouting, jet grouting), Deep Soil Mixing, Mass Soil Stabilisation, Cutter Soil Mixing. Grouting: - basic functions- permeation-compaction-hydro fracture, classification of grouts- grout ability ratio- properties of grouts - viscosity, stability, fluidity, rigidity, thixotropy, permanence Grouting applications : - seepage control in soil and rock under dams- seepage control in soil for cut off walls – stabilization grouting for underpinning. Properties of admixture stabilised soils, Design of hydraulic cut-off walls, grout curtains.	10
3	**Geosynthetics:** Properties of geosynthetics and its testing, applications of geosynthetics in bearing capacity improvement, slope stability, retaining walls, embankments on soft soil, and pavements, filtration, drainage and seepage control with geosynthetics, geosynthetics in landfills, soil nailing and other applications of geosynthetics. improvement of ground using geomembranes,	08

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	geocells, geonets, geotubes	
4	**Reinforced earth:** - Mechanism- types of reinforcing elements- reinforcement-soil interaction –applications- reinforced soil structures with vertical faces. Design of reinforced earth retaining walls, reinforced earth embankments structures	06
5	**Advances** in ground improvement technologies- thermal stabilisation, biotechnical stabilization, hydroseeding etc.	02
6	**Case Studies:** Different case studies in India and around the world in the field of Ground Improvement and Geosynthetics.	10
Total		42

11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication
1.	"Reinforced Soil Engineering: Advances in Research and Practice", Switzerland: Taylor & Francis	2003
2.	Indraratna B., Chu J., Hudson H.A., "Ground Improvement- Case Histories", Elsevier	2005
3.	Saran S., "Reinforced Soil and Its Engineering Applications", I.K. International	2005
4.	Shukla S.K. and Yin J. H., "Fundamentals of Geosynthetic Engineering", Taylor & Francis	2006
5.	Rao G.V., "Geosynthetics – An Introduction", Sai Master geo-environmental services	2007
6.	Kitazume M., and Terashi M., "The Deep Mixing Method", CRC Press	2012
7.	Koerner R.M., "Designing with Geosynthetics", Sixth Edition, Xlibris Corporation	2012
8.	Kirsch K. and Bell A., "Ground Improvement", Third Edition, CRC Press	2013
9.	Mittal S., "An Introduction to Ground Improvement Engineering", Medtech	2013
10.	Denies N., and Huybrechts N., "Handbook- Soil mix walls, Design and Execution", First Edition, CRC Press	2018
11	"Ground Improvement Techniques and Geosynthetics: IGC 2016 Vol (2)", Germany: Springer Singapore,	2018
12.	Huat B. B., Anggraini V., Prasad A. and Kazemian S., "Ground Improvement Techniques", Netherlands: CRC Press	2019

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NAME OF DEPTT. /CENTRE: **INTERNATIONAL CENTRE FOR DAMS**

1. Subject Code : **DS-519** Course Title : **Contract and Financial Management**

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

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

4. Relative Weightage: **CWS: 20-35 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0**

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

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

9. Objective: To ensure and aware to the contract and financial management over respective obligations as efficiently and effectively as possible for the dam safety evaluation.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Contract Management:** Formation, Standard bid documents, tender and award of tenders, Online contracts, mistake and auctions, Breach and termination of contract, Impossibility of performance (force majeure clause), Forfeitures, loss and damages, Delays and liquidated damages, Risk, loss and indemnities, Condition, warranty, merchantability and quality of goods, Transportation, delivery, and Incoterms, Letters of credit, bank guarantee, and performance guarantee, Jurisdiction of courts, arbitration and dispute resolution, Confidentiality clauses and exemption/exclusion clauses, Contracts and taxation.	4
2	**Financial Management, Financial Analysis:** Introduction, uses, M&A, Private Equity, Equity Research, Career Opportunities, Skills Required	8
3	**Financial Statement Preparation:** Balance Sheet, Profit and Loss and Cash Flow, Revenues and Expenses, Consolidated Accounts, Tangible Assets, Goodwill, Depreciation	5
4	**MS Excel:** Spreadsheet Vocabulary, Logical & Statistical Functions, Data Validation, Custom List, Goal Seek, Scenarios, Data Manipulation, Pivot Tables and Macros	5
5	**Accounting Basics:** The Accounting Process, Accounting & Book-Keeping, Financial Terminologies, Accounting Concepts, the Accounting Cycle, Hindalco: Walk Through of Financial Statements	4

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6	**Ratio Analysis:** Introduction to Ratio Analysis, Objectives of Ratio Analysis, Dupont Analysis, Types of Ratios, Simple Consolidation, Preparing Consolidated Statements	8
7	**Financial Modelling:** Create a Basic IB Financial Model, Types of Data & Variables, Growth Rates and Proportions, BEDMAS Principle	5
8	Forecasting and Modelling	3
Total		42

11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication
1.	Hughes W. and Champion R, "Construction contracts: law and management", Routledge	2007
2.	Juan D. A., "Fundamentals of Accounting: Basic Accounting Principles Simplified for Accounting Students", United States: Author House	2007
3.	Fletcher S. and Gardner C., "Financial Modelling in Python", Germany: Wiley	2010
4.	Netscher P., "Successful Construction Project Management: The Practical Guide", Createspace Independent Pub	2014
5.	Roy M., "Microsoft Excel 2018: Learn Excel Basics with Quick Examples" United States: Create Space Independent Publishing Platform	2018
6.	Syrstad T. and Jelen B. "Microsoft Excel 2019 VBA and Macros" (n.p.): Pearson Education	2018
7.	Jelen B. and Syrstad T., "Microsoft Excel 2019 VBA and Macros (Business Skills)", Microsoft Corpn	2019
8.	Raina V. K., "Raina's Construction and Contract Management Vol.1", Shroff	2020

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NAME OF DEPTT. /CENTRE: **INTERNATIONAL CENTRE FOR DAMS**

1. Subject Code : **DS-520** Course Title : **Sustainable Tourism around Dams**

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

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

4. Relative Weightage: **CWS: 20-35 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0**

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

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

9. Objective: To explore the opportunities, *sustainable tourism across* the world and awareness for dam safety.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Understanding the concepts of Sustainability, Sustainable Development, Sustainable tourism	4
2	Socio-cultural problems related to dams- Social problems of displaced people, Strategies for integration of local people into mainstream tourism, Skill up-gradation as an essential mechanism for success of sustainable tourism	8
3	Understanding dam Tourism as a tool to enhance socio-economic and environmental aspects, Techno-Economics aspects of Dam sustainability, Tools and methodology for determining economic sustainability of dams	5
4	Understanding feasibility report for Dam tourism, components of feasibility reports	5
5	Concept of Sustainable Tourism around dams, issues and challenges	4
6	Challenges and limitations of sustainable tourism around dams in India	8
7	Current state of tourism around dams in India Best case studies of sustainable tourism around dams in India and world	3
8	Discussion and possible line of action for the dams in the purview of the Implementing Agencies	3
9	Risk Associated with tourism around dams; awareness and management	2
Total		42

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11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication
1.	Stevens J. E., "Hoover Dam: An American Adventure", University of Oklahoma Press.	1990
2.	"Guidelines for community-based ecotourism development", WWF International	2001
3.	Prasad K., "Water resources and Sustainable Development: challenges of 21st century", Shipra Publications	2003
4.	Narasaiah M. L., "Water and sustainable tourism", Discovery Publishing House	2005
5.	Bansal S. P. and Gautam P., "Sustainable Tourism Development: A Himalayan Experience", India: Indus Publishing Company	2007
6.	Schleiss A. J. and Boes R. M. (Eds.), "Dams and reservoirs under changing challenges", CRC press	2011
7.	Bass S. and Dalal-Clayton B., "Sustainable development strategies: a resource book", Routledge	2012
8.	Sharma N. and Flügel W. A., "Applied geoinformatics for sustainable integrated land and water resources management (ILWRM) in the Brahmaputra River basin", Springer India	2015

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **INTERNATIONAL CENTRE FOR DAMS**

1. Subject Code : **DS-521** Course Title: **Earth Retaining Structures and Dams**

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

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

4. Relative Weightage: **CWS: 20-35 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0**

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

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

9. Objective: The objective is to introduce the various earth retaining structures design and its analysis by various software.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Basic Concept/ Design:** Classification of Dam Types, Physical Factors governing Selection of Type, General Arrangement, Area Capacity Curve, Fixation of different hydraulic Levels and Capacities	4
2	**Diversion Arrangement:** Design of Coffer Dams, Design of Diversion Tunnels, Design of Diversion Channels	8
3	**Spillways:** Types of Spillways (Ogee, Sluice, Side Channel, Chute channel, Conduit and Tunnel, Morning Glory etc.), Hydraulics, Profiles and Spillway Capacity, Types of Energy Dissipation Arrangement (EDA) (Stilling Basin, Bucket type etc.), Design of EDAs	5
4	**Foundation Design:** Embankment: Treatment of foundation, Cut off trenches, Toe Drains and Pressure relief wells etc., Concrete Dam: Consolidation Grouting, Curtain Grouting etc., Other suitable foundation measures for other type of dams and barrages	5
5	**Stability Analysis:** Forces/ Loads to be considered, Different load cases, Factors of safety in different conditions, Allowable stress/ deformation conditions	4
6	**Design of other structures:** Free board calculations and conditions for different types of dams, Piers, Spillway bridges, Different Galleries, Stair Case/ Lift, Control Room, Retaining walls, Dam Toe Power House etc	8
7	Construction Methods and suitable treatments for Concrete Dams/ RCC Dams/ CFRD Dams/ Arch Dams, Earth/ Embankment Dams/ Rock fill Dams,	5

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	Barrages, Specific Studies such as Thermal Analysis etc., Physical & Numerical Model Studies	
8	**Software analysis:** Different software and their detailed applications, Analysis of all the above designs using Softwares.	3
Total		42

11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication
1.	"Treatise on Dams", United States: U.S. Department of the Interior, Bureau of Reclamation, [Commissioner's Office]	1950
2.	"Design of gravity dams: design manual for concrete gravity dams", Bureau of Reclamation United States	1976
3.	Hoek E. and Brown E.T., "Underground Excavation in Rocks", The Institution of Mining and Metallurgy, London	1980
4.	Saran S., "Reinforced soil and its engineering applications", IK International Pvt Ltd	2005
5.	Weaver K. D. and Bruce D. A., "Dam Foundation Grouting", revised and expanded edition, American Society of Civil Engineers, ASCE Press, New York, 504	2007
6.	Desai Y. M. and Shah A. H., "Finite Element Method with Applications in Engineering", India: Pearson Education India	2011
7.	Saran S., "Analysis and design of foundations and retaining structures subjected to seismic loads", IK International Publish	2012
8.	Clayton C. R., Woods R. I. and Milititsky J., "Earth pressure and earth-retaining structures". CRC press	2013
9.	Zhang C., "Seismic Safety Evaluation of Concrete Dams: A Nonlinear Behavioral Approach", Netherlands: Elsevier Science & Technology Books	2014
10.	Mohammad A. R., "Nonlinear Finite Element Analysis of Earthen Dam", Germany: Lap Lambert Academic Publishing GmbH KG	2015

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **INTERNATIONAL CENTRE FOR DAMS**

1. Subject Code : **DS-522** Course Title: **Seismic Safety of Embankment Dams**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs): **Theory: 3** **Practical: 0**
4. Relative Weightage: **CWS: 20-35 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0**
5. Credits: **4** 6. Semester: **Both**
7. Subject Area: **PEC** 8. Pre-requisite: **NIL**
9. **Objective:** To cover the issues pertaining to earth and rock-fill dams under seismic loads and their analysis using classical and contemporary approaches.
10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction to Earth and Rock-fill Dams:** Introduction to dams; Characteristics of embankment dams; Differences between embankment dam and other types of dams; Components of embankment dam, functions and suitable materials; Zones of an embankment dam; Types of embankment dams: Homogeneous, Zoned and Diaphragm type dams; Influence of inclined and vertical core; Composite dams; Site selection for an embankment dam: Geology and seismicity of dam site, Reservoir rim and basin, Construction materials, Suitable spillway location, Submergence aspects, and Construction infrastructure;	6
2	**Case Studies Related to Dam Failures:** Performance of embankment dams in past earthquakes; Causes of dam failure: Non-Earthquake conditions, and Earthquake conditions; Different modes of dam failures; Inferences from various case studies: Teton dam, Machchhu dam failure, Hebgen dam, Los Angeles dam, San Fernando dam, and Sheffield Dam.	3
3	**Stability Analysis of Dams:** Effective and total stress methods of analysis; Analysis by Fellinius, Spencer, Bishop, Spencer method, Morgenstern price methods; Seismic slope stability methods: Inertial slope stability methods, Pseudostatic analysis, Displacement analysis; Pseudo-static analysis by Friction-circle, Fellinius and Bishop's methods; Factor of safety, yield accelerations and damage potential under saturated and submerged conditions; Displacement analysis by Newmark and Makdisi-Seed methods; Different loading cases for dam stability analysis: End of the construction, Partial submergence, Sudden drawdown, Steady state seepage, Sustained rainfall, and Earthquake; Slope protection measures	8

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4	**FEM for Dam Analysis:** Application of FEM, Dam-foundation interaction; Identification of zones of hydraulic fractures and cracks; Nonlinear analysis, Tangent stiffness, Secant stiffness methods and No-tension analysis; Inertial and Weakening slope stability analysis; Modelling aspects: Element size, Domain size, Boundary conditions. Computer applications: Software to compute static & dynamic stresses induced, Deformations & displacements resulted, and Zones of liquefaction within the dam; Dynamic analysis of dams with examples;	8
5	**Seismic Performance Criteria for Large Embankment Dams:** Background; Integral dam safety concept; Seismic hazard a multi-hazard; Primary factors to consider in seismic design: Regional factors, Local factors; Selection of earthquakes for analysis; Seismic evaluation requirements; Seismic input parameters for analysis; The conceptual and constructional criteria for seismic-resistant fill dams	3
6	**Design Response Spectra – Generation of Time History:** Introduction, Standard code of practices; Synthesis of uncorrelated accelerograms: Modification of recorded accelerograms in time-domain, Modulated sum of harmon, Superposition of narrow-band time histories, Parametric time series modelling, Modification of recorded time history in frequency domain, Ground motion synthesis in frequency-domain; Spatially correlated accelerograms: Modelling of spatial variation, Method of spectral factorization, Method of principal components.	4
7	**Reservoir Rim and Basin Stability:** Causes and effects of rim stability, methods for assessing rim and basin stability: Earthquake induced landslide activity, Different types of earthquake induced landslides and their assessment methods.	3
8	**Assessment of Seepage Pressures:** Seepage in earth and rockfill dams and their foundations, Different methods of seepage assessment; Standard analytical solutions for seepage problems, Piping and Liquefaction; Estimation of pore pressure by flow net and its construction: Confined flow and Unconfined flow; FEM analysis for the estimation of seepage pressures.	4
9	**Guidelines for the Seismic Design and Construction of Embankment Dams:** Different codal provisions: Core, Shell, Cut-off wall, Cut-off Barrier, Transition Zones and Transition Filters; Internal drainage system; Protective layers for erosion control; Free board; Parapet wall; Riprap;	3
Total		42

List of Experiments:

1. Demonstration of GeoStudio
2. Stability assessment of an existing dam suing SLOPE/W
3. Seismic stability assessment of an existing dam using QUAKE/W
4. Assessment of seepage pressures using SEEP/W.
5. Generation of spectrum compatible time histories.
6. Deconvolution of time histories to obtain base input motions.
7. Dynamic stability assessment of a model dam using shake table experiment.

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11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	"Embankment Stability Analysis, Preliminary Design: Proposed Indian Creek Dam, North Dakota", United States: Soil Exploration Company	1974
2.	"IS 7894, Code of practice for stability analysis of earth dams", Bureau of Indian Standard (BIS), New Delhi, India	1975 (Reaffirmed 2002)
3.	Prakash S., "Soil Dynamics", McGraw Hill Book Company	1981
4.	Zienkiewicz O. C. and Morgan K., "Finite Elements and Approximation", John Wiley & Sons	1983
5.	Kramer S.L., "Geotechnical-Earthquake Engineering", Pearson Education – Indian Low-Price Edition	2004
6.	Singh, B. and Varshney, R.S., "Embankment Dam Engineering", Nem Chand & Brothers.	2004
7.	Akin J.E., "Finite Element Analysis with Error Estimators", Elsevier Publications	2005
8.	Bandyopadhyay J. N., "Design of Concrete Structures", India: PHI Learning	2008
9.	"Earthquake-Induced Landslides: Proceedings of the International Symposium on Earthquake-Induced Landslides, Kiryu, Japan, 2012", Germany: Springer Berlin Heidelberg	2012
10.	"Selecting Seismic Parameters for Large Dams, Guidelines, Bulletin 148 Committee on Seismic Aspects of Dam Design", International Commission on Large Dams (ICOLD), Paris	2014
11.	Al-Labban S. N., "Seepage and Stability Analysis of the Earth Dams Under Drawdown Conditions by Using the Finite Element Method", United States: University of Central Florida	2018

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **INTERNATIONAL CENTRE FOR DAMS**

1. Subject Code: **DS-523** Course Title: **Concepts of Planning and Design of Hydro-Mechanical Components in Dams**

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

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

4. Relative Weightage: **CWS: 20-35 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0**

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

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

9. Objective: To introduce the basic concepts of Planning and Design of hydro-mechanical components of the Dam.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction & Types of Gates:** Brief history of development, Gates components, main applications, types and classification.	4
2	**Selection of Hydraulic Gates:** Selection criteria of Hydraulic gates,	8
3	**Hydraulic Gates Design & Weight Estimation:** Hydrostatic, load cases, allowable stresses, design of skin plate, horizontal beams, embedment, gate weight estimation	5
4	**Hydro-dynamic Forces:** Hydro-dynamic forces (down pull, uplift, cavitation etc.), aeration, modeling, etc.	5
5	**Gate Operating Systems:** Gate operating forces, hoists (Hydraulic & mechanical).	4
6	**Materials, Fabrication, Erection, Testing& Commissioning etc.:** Materials, rubber seals, fabrication, transportation & erection materials, fabrication transportation, erection, testing & commissioning.	8
7	**Hydraulic Gates for Dam Safety:** Operation & maintenance of hydraulic Gates, rehabilitation, inspection, operation & maintenance, automation, etc. Recent trends & developments in Hydraulic gates engineering.	5
8	Practical Examples/ Workshops	3
Total		42

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11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication
1.	Singh B. and Varshney R. S., "Hydropower Structures", Nem Chand & Bros., Roorkee	1977
2.	"Safety of Existing Dams: Evaluation and Improvement", United States: National Academy Press	1983
3.	Nigam P. S., "Handbook on Hydro Electric Engg", Nem Chand & Bros., Roorkee	1985
4.	"Small Hydro Stations" (Publication No. 175), Central Board of Irrigation and Power, New Delhi	2008
5.	"Dam and Levee Safety and Community Resilience: A Vision for Future Practice", United States: National Academies Press	2012
6.	"Standards/Manual/Guidelines for small Hydro Development", IIT Roorkee	2013
7.	Erbisti P. C., "Design of Hydraulic Gates, 2nd Edition", Netherlands: Taylor & Francis	2014
8.	Chen S., "Hydraulic Structures", Belgium: Springer Berlin Heidelberg	2015
9.	Ascila R. and Hartford D. N. D., "Operational Safety of Dams and Reservoirs: Understanding the Reliability of Flow-control Systems", United Kingdom: ICE Publishing	2016
10.	"Guidelines for Preparing Operation and Maintenance Manual for Dams", DRIP, MoWR, New Delhi	2018
11.	Sur S. K., "A Practical Guide to Construction of Hydropower Facilities", United States: CRC Press	2019

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **INTERNATIONAL CENTRE FOR DAMS**

1. Subject Code: **DS-524** Course Title: **Engineering Seismology and Hazard analysis of Dams**

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

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

4. Relative Weightage: **CWS: 20-35 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0**

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

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

9. Objective: To provide the concepts of engineering seismology, seismological instrumentation, reservoir induced seismicity, seismic hazard assessment.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction**: Scope of seismology; Definitions of important terms; Causes of earthquakes and their classifications; Earthquake effects on ground and structures, Plate tectonics- continental drift, types and characteristics of various plate margins; Earthquake catalogue and seismicity of the earth; Major earthquakes in the world; Important Indian earthquakes	10
2	**Wave Propagation and Instrumentation**: Theory of elasticity; Body and surface waves; Local site effects; Seismic phases; Internal structure of earth; Reference models, Earthquake intensity, Earthquake magnitude, frequency magnitude relations, Earthquake recordings - principles and theory of seismograph; Real time warning system; International monitoring system (IMS); Local seismological networks, strong motion networks and their engineering importance.	8
3	**Seismic Hazard Assessment:** Definitions- seismic hazard, disaster and risk; Probabilistic and deterministic approach; Earthquake occurrence models; Seismotectonic modeling and type of sources; Estimation of maximum magnitude, maximum credible earthquake, design basis earthquake; Frequency magnitude relationship; Poissonian and Non Poissonian models; Ground motion prediction equations; Uncertainties in seismic hazard assessment and their quantification; Return periods and strong motion exceedance rates; Site-specific design earthquake parameters; Case studies.	8
4	**Geophysical Methods**: Seismic methods; Well logging: Steady state Rayleigh method; Spectral analysis of surface waves-SASW and MASW methods;	6

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	Ground penetrating radar, bedrock profiling. Quantification of Site Effects: Experimental methods; Microearthquake- standard spectral ratio method & horizontal to vertical spectral ratio method; Microtremors - absolute spectra, SSR method & H/V ratio; Empirical relations; Analytical method; 1D ground response of layered medium	
5	**Site-specific Ground Motion Estimation:** Empirical Green's function; Numerical methods; Basic concept, recent developments; Domain method, boundary method & hybrid method; Effects of nonlinearity on ground motion	5
6	**Seismic Microzonation:** PSHA and DSHA; Seismic microzonation of mega cities, scales used in seismic microzonation; Recent developments and case studies.	5
Total		42

11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication
1.	Gupta H., "Reservoir Induced Earthquakes", Netherlands: Elsevier Science	1992
2.	Lay T. and Wallace T. C., "Modern Global Seismology", United States: Elsevier Science	1995
3.	Bertero V. V., "Earthquake Engineering: From Engineering Seismology to Performance-Based Engineering", Ukraine: CRC Press	2004
4.	"Earthquake Early Warning Systems", Germany: Springer Berlin Heidelberg	2007
5.	Shearer P. M., "Introduction to Seismology", Cambridge University Press	2009
6.	Mayne P. W. and Coutinho R. Q., "Geotechnical and Geophysical Site Characterization 4", Netherlands: CRC Press	2012
7.	Gupta H. and Rastogi, "Dams and Earthquakes", Netherlands: Elsevier Science	2013
8.	Wysession M. and Stein, S., "An Introduction to Seismology, Earthquakes, and Earth Structure", Germany: Wiley	2013
9.	Shroder J. F., "Earthquake Hazard, Risk and Disasters", United Kingdom: Elsevier Science	2013
10.	Lai C. G., Rix G. J., Strobbia C. and Foti S., "Surface Wave Methods for Near-Surface Site Characterization", United Kingdom: Taylor & Francis	2014
11.	Beer M., "Encyclopaedia of Earthquake Engineering", Germany: Springer Berlin Heidelberg	2015
12.	Murru M., Console R., Falcone G. "Earthquake Occurrence: Short- and Long-term Models and Their Validation", United Kingdom: Wiley	2017
13.	"Monitoring Dam Performance: Instrumentation and Measurements", United States: American Society of Civil Engineers	2018
14.	Chopra A. K., "Earthquake Engineering for Concrete Dams: Analysis, Design, and Evaluation", United Kingdom: Wiley	2020

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A proposal on

Establishment of a

Department of Design and Innovation (DoDI)

at

IIT Roorkee

CONCEPT PAPER

01 MAR 2021

Indian Institute of Technology Roorkee
Roorkee – 247 667
2020

PREAMBLE

Education in Design enables the students to empathize the needs of people and to develop useful products to solve the problems related to human being and the society. In recent time, need of design professionals is on the rise due to the cutthroat competitions among the industries to launch innovative products to enhance the customer base. Various courses/departments/centers were established by different institutes of global repute world-wide to cater skilled professionals to fulfil the industrial needs. In the last few years, awareness about design and innovation has been leapfrogging in India due to various research programs conceptualized and initiated by the Government of India. In the year 2014, Ministry of Human Resource Development launched a scheme called 'National Initiative for Design Innovation' (NIDI) to boost design-centered innovation in the country with a motive to enhance the value chain, making Indian industry globally competitive. In order to realize the initiative, twenty Design Innovation Centres (DICs), one Open Design School (ODS) and a National Design Innovation Network (NDIN) have been established in the country. The prime objective of these centers, schools and the network is to ensure maximum reach of design education and practice in the country through various collaborative education programs (linking a broad spectrum of educational institutions), and free sharing of its courseware through the Internet. Under the scheme, Indian Institute of Technology Roorkee (IIT Roorkee) was awarded a DIC as the Hub Institute in May 2018 which was formally launched on September 17, 2018. The center is actively involved in continuing the saga of knowledge exchange among the well-known experts, young innovators and common man by providing a common platform for effective utilization of the available resources and addressing various issues associated with farmers and common man in the region around the institute, especially in the Himalayan region. The center proposed to run Elective Courses and two Masters Programs to impart design education and to develop manpower in the area of industrial design and innovation management.

IIT Roorkee has participated in such initiatives in the past to contribute in the growth of the nation as well as improving its own resources for quality education and research. The institute has been in the forefront in conceptualizing and executing many national projects for the nation and human being. The institute has the legacy of excellence in the diverse fields of technologies for addressing the issues related to social, environmental, elderly and physically disable people. In the recent years, the institute has established a number of Centers of Excellence and advanced research facilities to foster research among the students and faculty members. Keeping these in view and the existing strength of IIT Roorkee, there is a proposal to create a Department of Design and Innovation (DoDI) to sustain the activities of the DIC, to develop academic research programs in this area, to train manpower in a specific area, and to create a Design and Innovation culture in the society. Therefore, it was recommended at different fora (including an Institute Committee constituted for the purpose) that the faculty members engaged/working in the related areas be brought at one platform to further strengthen and enhance the outputs in a focused manner. In order to realize establishment of an appropriate platform – a Centre for Excellence in Design (CoED), a Core Group of eighteen Faculty Members from different Departments/Centers of the institute was formed. The Group deliberated at length on the relevance and operational aspects of the proposed platform. The Committee on CoED unanimously recognized the operational difficulties associated with an academic Centre and opined towards launching the new academic programs through a potentially more stable platform in the form of a Department; the concept was later strongly echoed by domain experts from IISc, IITs, NID and Industries in the 'Workshop on Academic Curriculum Development' organized by the DIC to develop the curricula of the proposed masters programs. The present Concept Paper has emerged from these deliberations.

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CONTENTS

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1. BACKGROUND

Established in the year 1846, Indian Institute of Technology Roorkee (IIT Roorkee) is an institute of national importance. The Institute has twenty two academic departments covering engineering, architecture & planning, applied sciences, humanities and social sciences, and management programs, two academic centers and two centers of excellence. In the recent years, the institute has realized the need of a common platform which can accelerate the saga of knowledge exchange among the well-known experts, young innovators and common man in the domain of Design and Innovation. Accordingly, in order to promote design-centered innovation, the National Initiative for Design Innovation (NIDI) scheme of the Ministry of Human Resource Development (MHRD) was targeted. Under this initiative of the MHRD, twenty Design Innovation Centers (DICs), one Open Design School and a National Design Innovation Network have been established in India. The establishments under this scheme would raise the standards of design education and innovation in the country through various initiatives including the creation of fabrication labs and digital media zones across educational institutions. IIT Roorkee, being known for its contributions towards the national causes, submitted a proposal to set up a DIC under the NIDI scheme of the MHRD, Government of India. The Institute was awarded the DIC in the month of May, 2018 and the center was launched on September 17, 2018 as a Hub Institute with three other promising Institutions of the region – NIT Uttarakhand, IIM Kashipur and College of Technology, G B Pant University of Agriculture & Technology, Pantnagar as the Spokes. The center is thriving for developing design and innovation as a culture while primarily addressing the relevant problems of the Himalayan region, in particular, and other national priority areas in general. Apart from various outreach and research activities, the DIC has proposed two Masters Programs – M. Des. (Industrial Design) and MIM (Innovation Management) and development of a few elective courses related to design and innovation to the MHRD. The Institute has a pool of experienced as well as talented faculty members and researchers in the proposed area. The Institute has been offering number of UG and PG courses on Design and Innovation through different Departments and Centers. It is, therefore, proposed to provide a common platform to the faculty members working in the related areas to further strengthen and enhance this outputs in a focused manner. Thus, the Institute finds it apt to propose a Department of Design and Innovation (DoDI) to initiate the academic activities committed to the MHRD by the DIC for developing specialized professionals in the areas of design and innovation.

2. VISION AND OBJECTIVES

2.1 Vision

To evolve as a unique entity focusing on design and innovation culture based on human-environment engagement in collaborative partnership with society, industry and other stakeholders.

2.2 Objectives

The basic objectives of establishing a DoDI at IIT Roorkee is to:

- To create a culture of innovation and creative problem solving.
- To impart design based education and to create an ambience of systematic design practice.
- To facilitate interdisciplinary design-focused education, research and entrepreneurial activities with a focus to create commercial opportunities.
- To develop Documentation and Archival Repository of Design Innovation practices at grass-root level.
- To build an environment of handshaking between academia and the industry to address the relevant societal issues through co-creation and their transformation into products.

3. PROPOSED ACTIVITIES

3.1 Research

a. Identified Areas of Research

The DoDI will be involved in multi-disciplinary research activities; a few identified areas with expected participating departments/centres are given in Table. 1. These areas are in line with the innovative product development for societal and human needs.

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Table 1: Potential Areas of Research

S. No.	Areas of Research	Participating Departments
Short Term		
1	Product Design	AP, MIE, MS, PT, PPE, CE, CTRANS
2	Rapid Prototyping	MIE, MME, PHY, PPE
3	Graphic Design	AP, CSE, MS
4	Product Styling and Perception	AP, HSS, CSE, PT, PPE
5	Product Innovation	MIE, MS, MME, ECE, EE, CE
6	Design Strategy and Management	MS, AP, MIE, CE, EQE
7	Human-Computer Interaction	CSE, ECE, MS, MATH, HSS
8	Computer Aided Design	MIE, CSE, CE, EE, AP, ECE
9	Space Design	AP, CE, CTRANS, MS, MIE ECE
10	Systems Design	CSE, ECE, EE, CE, MIE, MATH
11	Visual Cognition	AP
12	Ergonomics	AP, MIE, MS
13	Design for Society	MS, MIE, HSS, AP
14	Mobility Design	CSE, ECE, EE, AP, CTRANS, CE, MIE
15	User Centered Design	AP, MS, MIE
16	Animation	CSE, AP
17	Automotive Design	MIE, AP
18	Product form and Aesthetics	AP, MS
19	Environmental Design	CE, EQE, ES, CHE, ASE, HYDRO, CoEDMM, HRE, WRDM
20	Nature of Materials and Processes	CE, MIE, MME, CHE, CHEM, PHY, PT, CN, PT
21	Material and Manufacturing	CE, MIE, MME, CHE, CHEM, PHY, PT, CN
22	Harnessing Green Energy	HRE, WRDM, MIE, CE, EE
23	Industrial Design	MIE, CE
24	Facility Design	MIE, MS
25	Design for Disabled	MIE, BT, AP, CoEDMM
26	Bio-Inspired Design	AP, BT, MIE, CE, CN
27	Medical Product Design	AP, BT, MIE, CE, CN
28	Energy Storage Devices	MIE, MME, EE, CE
29	Web Programming	CSE, AP
30	Innovation Management	MIE, MS
31	Marketing of Innovation	MS, HSS
32	Human Centric Supply Chain	AP, MIE, MS
33	Data Analytics	CSE, MATH, MS
Long Term		
1	Digital Film-Making	AP, MS, HSS
2	Participatory Innovation	MS, AP, HSS
3	Innovation Knowledge Network	AP, MS, HSS

AP – Architecture and Planning, ASE – Applied Science and Engineering, BT – Biotechnology, CHE – Chemical Engineering, CHEM – Chemistry, CE – Civil Engineering, CSE – Computer Science and Engineering, EQE – Earthquake Engineering, ES – Earth Sciences, EE – Electrical Engineering, ECE – Electronics and Communication Engineering, HSS – Humanities and Social Sciences, HYDRO – Hydrology, MS – Management Studies, MATH –Mathematics, MIE – Mechanical and Industrial Engineering, MME – Metallurgical and Materials Engineering, PT – Paper Technology, PPE – Polymer and Process Engineering, PHY – Physics, WRDM – Water Resources Development and Management, HRE – Hydro & Renewable Energy, CN – Centre of Nanotechnology, CoEDMM – Centre of Excellence in Disaster Mitigation & Management and CTRANS – Centre for Transportation Systems

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b. Ph.D./Post-Doctoral Program

Ph. D. /Post-Doctoral Programs will be undertaken in the identified areas of the research. The bright and dedicated candidates will be admitted in the program as per the admission procedure of the institute. The candidates having research funding/scholarship from the funding sources such as DST, CSIR, UGC etc. will be allowed to take admission as per the norms of the institute.

c. Sponsored Research and Development Programs and Consultancy Activities

The sponsored research and consultancy projects will be undertaken in the related areas of the DoDI. There is a scope of potential funding from various Ministries/Departments of Government of India, Industries, and Organizations for Research & Development and Consultancy in Product Innovation. Some of the funding sources are below –

- *Government organizations/agencies of India:* Ministry of Human Resource and Development, Department of Science and Technology, Ministry of Urban Development, Airports Authority of India, Ministry of Railways, Ministry of Health, Council of Scientific & Industrial Research, Ministry of Culture, Technology Information Forecasting & Assessment Council, Digital India Corporation, Ministry of Textiles, Indian Space Research Organization, Defense Research and Development Organization, Electronics Corporation of India Limited, Ministry of Electronics and Information Technology, Ministry of Communications & Information Technology, Department of Biotechnology, All India Council for Technical Education etc.

- *Private organizations/agencies:* Dassault Systems, Microsoft Research, Nokia, Samsung Electronics, LG Electronics, Microsoft, Bill and Melinda Gates Foundation, Honeywell Corporation, Yahoo, IBM Research, Reliance, Hindustan Lever Research Centre etc.

3.2 Teaching Programs

Two Masters Programs – M. Des. (Industrial Design) and MIM (Master in Innovation Management) are proposed to run from July 2020. The course structures of the proposed masters programs were debated in an interdisciplinary institute committee comprising faculty members of departments – Department of Architecture and Planning, Department of Electronics and Communication, Department of Management Studies and Department of Mechanical and Industrial Engineering after receiving inputs (Annexure - I) from their respective Departmental Faculty Committees (DFCs). The committee resolved that a workshop including experts in the area of Design should be organized to finalize the program structures/courses/syllabi of the proposed Masters Programs. Accordingly, a workshop on Curriculum Development was organized during December 6-7, 2019. Design experts from industries (including Vice President, Dassault Systems, President, Catalign Innovation Consulting, Senior Design Director and Strategic Design Director, Designit, Co-founder, Zenatix Solutions Pvt. Ltd. and Co-founder, Log9 Materials) and academia (including Chairperson, CPDM, IISc Bangalore, Heads, Department of Design (IIT Hyderabad, IIT Guwahati, IIT Delhi (through Skype)), faculty members from IIT Kanpur, IIT Guwahati, NID Ahmadabad and IIT Roorkee) participated in the workshop. Deliberations were carried out on the structures and courses of M Des and MIM programs in various sessions chaired by Associate Dean of Academic Affairs (Curriculum), Associate Dean of Academic Affairs (Evaluation), Associate Dean of Academic Affairs (Admission), Heads of Dept. of Mechanical and Industrial Engineering and Dept. of Electronics & Communication Engineering, The structures and courses were finalized and presented to the Director, IIT Roorkee during the valedictory session. The following are the outcomes of the workshop –

3.2.1 Admission Procedure

The following eligibility criteria and admission procedures will be adopted for admission (Table 2).

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Table 2: Admission Proposed Master Programs

S. No.	Program	Number of seats	Eligibility Requirements	Eligibility Test
1.	M. Des. (Industrial Design)	20	Four-year Graduate Degree in any discipline with Mathematics as one of the subjects in 10+2.	Valid CEED/GATE score, followed by Aptitude Test (AT) and Personal Interview (PI)
2.	MIM (Master in Innovation Management)	20	Graduate Degree in any discipline with post-degree experience of 5 years	Valid CAT/GMAT/GATE score, followed by Group Discussion (GD) and Personal Interview (PI)

3.2.2 Program Structures

The draft program structures of Masters Programs in M. Des. (Industrial Design) and MIM (Maters in Innovation Management) finalized during the workshop are given in Annexure – II.

3.3 Training Program

It is proposed to organize Training Programs as well as specialist courses to train the manpower in various specialized areas of Design, Innovation, Intellectual Property Rights and related areas. Different academic institutes, research organizations, industry and NGOs will be approached directly/through Placement and Internship Cell, IIT Roorkee for possible training of the Masters Students.

4. STRENGTH OF DoDI

The proposed DoDI will have the following resources/facilities developed/being created by DIC, IIT Roorkee –

a. **Financial Support** – DIC has received financial support rupees ten crores (including one third share of spokes) from the MHRD, Government of India and the end date of the project is March 31, 2020.

b. **Laboratory and Office Space** – A 6400 Sq. feet space in ground floor and mezzanine of Hafiz Mohd. Ibrahim Building, IIT Roorkee has been allotted for DIC. Laboratories, offices and other relevant infrastructure which may be developed in tune with the requirements of the DoDI.

c. **Organizational structure** – A well-defined organizational structure including the Coordinators, Co-coordinators, and Project Monitoring Committee is functional under the mentorship of Dean SRIC, IIT Roorkee. One Coordinator & PI, DIC, two Co-coordinators and two Co-PIs are already looking after the activities of the DIC.

d. **Manpower** – Three Project Officers, one Office Attendant and three JRFs are working presently, the JRFs are registered in different departments under DIC Ph. D. Fellowship.

e. **Equipment** – Some laboratory equipment have been proposed in the DIC to improve research facilities in the institute. Purchasing of a Coordinate Measuring Machine (CMM) and two workstations has been initiated by the DIC as per institute rules through Material Management Department. Necessary office set-up including desktops, printer, stationary etc. has been created. Budgeted money is also available to create a fabrication laboratory; which is under process.

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f. **Proposals for collaboration** – Some organizations such as Dassault System, BOSCH and Lucerne School of Engineering and Architecture are willing to collaborate with DIC for Masters Programs and future research work.

5. REQUIREMENT OF FACULTY MEMBERS AND STAFF

For smooth functioning of DoDI activities, the following manpower will be required –

5.1 Faculty Members

The DoDI will be needing eight dedicated faculty members having Ph. D. in the areas – Design, Engineering, Architecture, Management and Humanities/Social Sciences for conducting the teaching and research activities apart from joint/associated faculty members from other Departments/Centers. Requirements of the DoDI will be assessed from time to time and Professors, Associate Professors, Assistant Professor need to be appointed as per the institute rules on regular/ contract/deputation/visiting terms. Faculty Members in different departments who have interest in the research activities of the department may be transferred and/or appointed as Joint Faculty as per the institute norms.

5.2 Technical/Office Staff

In the proposed DoDI, the staff requirement will be as follows on the basis of minimum need –

a. Technical Staff (04)
b. Office superintendent (01)
c. Office attendant (01)

5.3 Research Staff

JRF/SRF/Research Associate/Post-doctoral candidates under CSIR/UGC/DST/Institute schemes will be attracted to join the research programs of the Department. In addition to the above, M. Tech. /Ph. D. Fellowships will also be sought from the different sponsors.

6. EQUIPMENT AND BUILDING SPACE

6.1 Laboratory Requirement

Some of the requirement and specifications of the major equipment have already been identified and steps are underway for their procurement. Other laboratory infrastructure available with the Departments/Centers – Architecture and Planning, Biotechnology, Chemical Engineering, Civil Engineering, Computer Science and Engineering, Electrical Engineering, Electronics and Communication Engineering, Humanities and Social Sciences, Management Studies, Mechanical and Industrial Engineering, Metallurgical and Materials Engineering, Centre of Excellence in Disaster Mitigation & Management (DoEDMM) and Centre for Transportation Systems (CTRANS) will be used as per availability for research and teaching activities. Additionally, facilities available with other central facilities such as Mahatma Gandhi Central Library, Continuing Education Centre (CEC), Institute Computer Centre (ICC), Institute Instrumentation Centre (IIC) and Rethink! The Tinkering Lab shall also be used to maintain synergy among them. Additionally, as discussed in the Academic Curriculum Workshop, the Department will need the following infrastructure to start teaching, research, laboratory and studio activities –

a. Books (approximately, 100)
b. Journals (approximately, 10)
c. Workshop Facilities including –
    - Cutters (thermacol and laser cutters)
    - Workstations: High end Mac Pros (10), Windows based systems (10)
    - Wacom digital Tabs (5)

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- I-pads (5)

d. Digital scanners (2)
e. Digital Printers (Inkjet: 2 and Laser: 2)
f. Basic tools and furniture for workshop
g. Display panels and boards (8)
h. Digital camera (DSLR: 5)
i. LCD Projectors (5)

6.2 Building Space

An area of 6400 Sq. feet (ground and mezzanine floor) is allotted to DIC in Hafiz Mohammad Ibrahim building. Apart from this allotted space, additional need based space for laboratory(s), faculty, research scholars, library, conference/committee/seminar room, class rooms etc. need to be allocated by the institute.

It is proposed that the MIM program will be run at the Greater Noida Extension Center, IIT Roorkee.

7. FINANCIAL REQUIREMENT

The financial requirements, recurring and non-recurring, need to be met by the institute. However, some recurring expenses for laboratory/research/supporting staff as well as research related activities (such as, laboratory field studies and computational facilities etc.) will be met from the sponsored projects.

8. LONG-TERM PLANS

The DoDI will work on the following long-term plans to sustain –

8.1 Development/Growth Projection

The financial support model for the proposed DoDI is divided into two phases : Phase – I (Fig. 1a) will be a formative phase with support from the MHRD (funding for DIC) and Phase – II (Fig. 1b) will be a grown up stage partial/without support of the MHRD (funding for DIC). The DoDI would be receiving support from the MHRD for conducting DIC activities. However, it will need support from IIT Roorkee during its formative phase. It is understood that the Institute shall provide the basic infrastructure including faculty members, land, building and power. However, as the center would grow, it will try to generate revenue through the services provided (although 'as is' basis, i.e., no-profit-no loss), through the licensing/selling of probable IPR, if any, consultancy, funding from other agencies, training and skill development programs etc. Thus, financial dependency of the center on MHRD and the Institute will drop significantly.

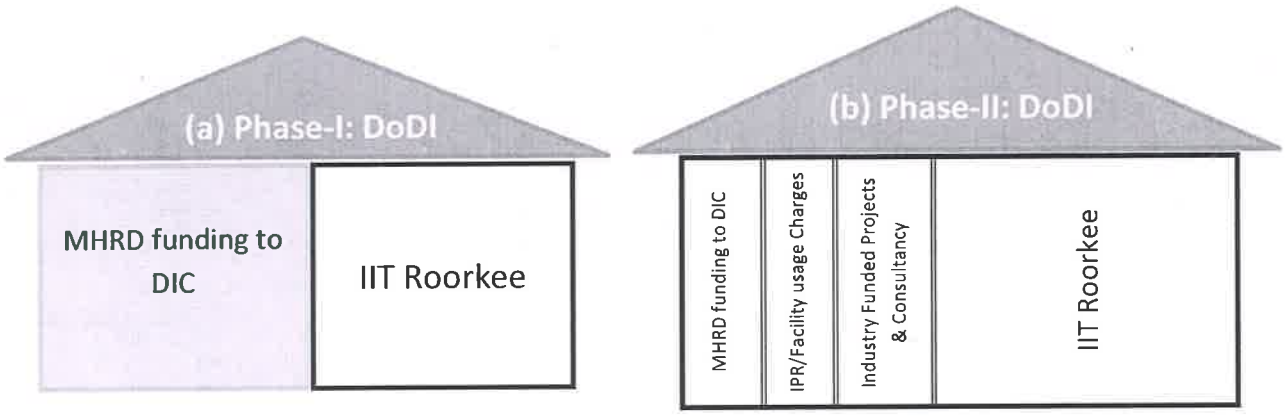

Fig. 1: Financial support to DoDI in (a) Phase – I and (b) Phase – II

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The center will be an integral part of the IIT Roorkee. It is proposed to generate the resources through following ways –

a. **Fellowship for M. Tech. and Ph. D. Program**
   Apart from Institute funding, Funding agencies such as DST, UGC, CSIR etc. shall also be approached for award of fellowships to Master students and Ph. D. research scholars.
b. **DST** will be approached for funding in the **FIST Program.**
c. **Sponsored R&D and Consultancy Projects**
   The concerned ministries (Planning Commission, MHRD, Urban development, DST etc.) will be approached for granting funds for R&D Projects.
d. **Establishment of Professional Chairs**
   The DoDI will approach relevant funding agencies and alumnus of IIT Roorkee for creating Professional Chairs.

Based on the contributions made by DoDI in R&D and Consultancy projects, it is expected that the proposed DoDI would generate funds through R&D and Consultancy Projects for its long term sustainability.

8.2 Future Programs and requirements

The Department will start B. Des. in the next phase of development. In this program, admission of 30 students will be targeted in First year through the national level examination as followed by the other IITs/IISc. The projected strength of students will be 120 (B. Des) and 80 (M. Des and MIM). Accordingly, the space and faculty will be required as per the below details –

8.2.1 Faculty projection

In addition to the available 8 faculty members, approximately, additional 12 faculty members will be required with expertise in the area of Design, Engineering, Architecture, Management and Humanities/Social Sciences.

8.2.2 Space projection

The spaces for the following will be required to run the activities of Bachelor and Masters Programs in the Department. The exact floor area requirement may be calculated by appropriate authorities in consultation with the Department.

- Laboratories/workshops/studios such as Computer Lab, Model and Styling Lab, Digital Lab, Printing and Graphics Lab, Fab Lab, Photography Lab, Animation Lab etc.
- Class Rooms (08)
- Faculty Offices (20)
- Officer for Head of Department (01)
- Department Office (01)
- Committee Room (01)
- Library (01)
- Digital Spaces for Displace of Archival Stuff (01)
- Exhibition Space (01)
- Seminar Room (02)
- Sitting space for Research Scholars (30)

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Annexure – I

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Department of Architecture and Planning

DEPARTMENT OF ARCHITECTURE AND PLANNING
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

No.Arch/ 652 /D-3 Dated: Aug. 16 2019

Dean SRIC

Sub: Establishment of Centre of Excellence in Design (CoED) and launching of Masters Programs in Industrial Design and Innovation Management

We refer to your letter dated June 10, 2019 on the above subject. As desired, the matter was discussed in DFC meeting held on 13 Aug. 2019 and resolved as follows:

1. *The DFC considered the matter of Establishment of Centre of Excellence in Design (CoED) and launching of Masters Programs in Industrial Design and Innovation Management. It was unanimously decided that from the Department of Architecture and Planning, Prof. Saptarshi Kolay, Prof. Sonal Atreya, Prof. Gaurav Raheja, and Prof. Smriti Saraswat will contribute towards the establishment of CoED.*

   The DFC also proposed to extend the facilities of the Fabrication Lab and Art Lab of the Architecture and Planning Department to CoED.

   DFC considered the recommendations w.r.t. points 2, 3 and 4 of the letter under reference and decided that the team of the 4 proposed faculty members should deliberate on the above points.

Head of Deptt.

Encl: minutes of DFC

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DEPRTMENT OF ARCHITECTURE AND PLANNING
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Minutes of the DFC held on 13.08.2019 in the conference room, Department of Arch. & Plng.

The following members were present:
Dr. P.S. Chani, Prof. and Head
Prof. Pushplata
Prof. Gaurav Raheja
Prof. Uttam K. Roy
Prof. Harshit Lakra
Prof. Avlokita Agarwal
Prof. Saptarshi Kolay
Prof. Manavvi Suneja
Prof. Sonal Atreya
Prof. Shubhajit Sadhukhan

1. The DFC considered the matter of Establishment of Centre of Excellence in Design (CoED) and launching of Masters Programs in Industrial Design and Innovation Management, conveyed vide Dean SRIC letter dated June 10, 2019. It was unanimously decided that from the Department of Architecture and Planning, Prof. Saptarshi Kolay, Prof. Sonal Atreya, Prof. Gaurav Raheja, and Prof. Smriti Saraswat will contribute towards the establishment of CoED.

   The DFC also proposed to extend the facilities of the Fabrication Lab and Art Lab of the Architecture and Planning Department to CoED.

   DFC considered the recommendations w.r.t. points 2, 3 and 4 of the letter under reference and decided that the team of the 4 proposed faculty members should deliberate on the above points.

2. The DFC considered the proposal by the M.Arch. Coordinator regarding the procedure to assign the Advisor, and this matter was decided to be taken up at a later date in the presence of MURP Coordinator.

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

(P.S. Chani)
Head of Deptt.

Copy to all faculty members

01 MAR 2021

Department of Electronics and Communication Engineering

-------- Original Message --------
From: **Sudeb Dasgupta** <sudebfec@iitr.ac.in>
Date: Aug 2, 2019 3:08:31 PM
Subject: DFC minutes_DIC/ECE
To: Dean SRIC <dsric@iitr.ac.in>, Apurbba Kumar Sharma <akshafme@iitr.ac.in>

Dean SRIC

The relevant portion of the DFC minutes of ECE is appended for your perusal.

Minutes of the DFC meeting (24th July 2019)

Extensive discussion on the courses as communicated by Dean, SRIC for DIC was done. It was decided that the Department will offer the courses in the modular format, and will be part of ECN course structure. It was also recommended to have joint Master and Ph.D supervision with DIC faculty members. Further the members appreciated the launch of DIC.

Regards

Sudeb Dasgupta

--

Professor and HoD
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Indian Institute of Technology, Roorkee
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India
Alternate Email: sudebdg@gmail.com
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Home-Page: https://www.iitr.ac.in/departments/ECE/pages/People+Faculty+Sudeb_Dasgupta.html

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Department of Mechanical and Industrial Engineering

यांत्रिक एवं औद्योगिक इंजीनियरी विभाग
DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING
भारतीय प्रौद्योगिकी संस्थान रुड़की
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
रुड़की-247667 (भारत)
Roorkee – 247667 (India)

NO.MIED/M-01 Dated: July 26, 2019

MINUTES OF THE MEETING OF THE DEPARTMENTAL FACULTY COMMITTEE (DFC) HELD ON JULY 26, 2019 AT 12.00 NOON IN THE COMMITTEE ROOM (EAST BLOCK), MIED.

Following attended the meeting:

1. Prof. B. K. Gandhi, Head - Chairman
2. Prof. Ankit Bansal
3. Prof. Sushanta Dutta
4. Prof. Akshay Dvivedi
5. Prof. Shailesh Ganpule
6. Prof. P.K. Jha
7. Prof. D.M. Joglekar
8. Prof. M.M. Joglekar
9. Prof. Anil Kumar-II
10. Prof. Dinesh Kumar
11. Prof. Ravi Kumar
12. Prof. B.K. Mishra
13. Prof. K.B. Mishra
14. Prof. Manish Mishra
15. Prof. K. Murugesan
16. Prof. Avinash Parashar
17. Prof. P.M. Pathak
18. Prof. V.H. Saran
19. Prof. Apurbba Kumar Sharma
20. Prof. Satish C. Sharma
21. Prof. Varun Sharma
22. Prof. I.V. Singh
23. Prof. Sneha Singh
24. Prof. S. Subudhi
25. Prof. A.K. Swain
26. Prof. Andallib Tariq

The items on the agenda were considered and the minutes are as under:

For the kind attention of	Agenda Items
Dean, Sponsored Research and Industrial Consultancy	**MIED/DFC-07/19/1: DFC considered the email communication of Dean, SRIC dated June 10, 2019 regarding establishment of Center of Excellence in Design (CoED). DFC considered the recommendations of the Departmental Committee formed under the convenorship of Prof. Akshay Dvivedi to study the different aspects.** Consequent to detailed deliberations, DFC resolved the following: ***Clause 1:*** *"Specify the area(s) in which your department can contribute towards the establishment of the CoED – including availability of faculty members and other resources like laboratory infrastructure."* **DFC Resolution:** In principle, MIED welcomes the formation of Center of Excellence in Design (CoED) in IIT Roorkee and AGREES to extend its full cooperation and support for establishment of the Center and its functioning. DFC also resolves that the departmental infrastructure including laboratories may be available for the use of CoED. Further, the faculty members of the department may help in admission procedure and academic responsibilities including supervision of Masters' Dissertation and PhD programs.

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	Clause 2: *"Suggest the possible course(s) (Lecture/Laboratory/Studio/Industrial training/Dissertation) that should be included in the M. Des. (Indl. Design) and MIM Programs. The course(s) can be modular in nature to be taught by multiple departments/instructors."* **DFC Resolution:** DFC resolved that department will make the relevant courses being run by the department available to the students of the proposed CoED programs. Further, department may contribute to any new course(s) being developed for the proposed M Des (Industrial Design) and MIM programs. ***Clause 3:*** *"Suggest the eligibility requirement and selection procedure for admission to both the programs. It may be mentioned here that the MIM program is proposed for mid-career executives."* **DFC Resolution:** DFC resolved that the eligibility requirement and selection procedure for admission into the programs be - For M Des (Indl. Design): As per the Common Entrance Examination for Design (CEED), which is the benchmark joint entrance exam for post-graduate studies in the field of technological design at other IITs and Indian Institute of Science. For MIM: Five (05) years of experience with a professional degree in Architecture & Planning, Engineering and Management. ***Clause 4:*** *"Suggest on possible specializations of faculty members to be associated with CoED."* **DFC Resolution:** DFC resolved that all the specializations currently available for entry in the MIED be kept open for the *faculty members to be associated with CoED as* the possible specializations.
All the Faculty Members, MIED	**MIED/DFC-07/19/2:** In Any other Item, Chairman, DFC requested all faculty members to a priori inform the students about rescheduling of classes, if any.

The meeting ended with the Vote of Thanks to the Chair.

-sd-
(Apurbba Kumar Sharma)
Professor & Secretary, DFC

Copy to :

1. All faculty members of the Department
2. Dean Academic Affairs
3. Dean Sponsored Research and Industrial Consultancy

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Department of Management Studies

Addendum to minutes of DFC meeting held on July 11, 2019 .

(6) Under any other item with the permission of Chair

(iv) HoD discussed the letter received from Dean SRIC dated June 10, 2019 regarding proposal of establishment of Centre of Excellence in Design, and launching of Masters Program in Innovation in Management.

With respect to various issues on which recommendations of DFC was sought, DFC resolved as follows:

1. Specify the area(s) in which your department can contribute towards the establishment of the CoED – including availability of faculty members and other resources like laboratory infrastructure.

It was resolved that Department of Management Studies can contribute in taking courses as per availability of faculty members in area of entrepreneurship, marketing management, creativity, innovation management, intellectual property management etc.

2. Suggest the possible course(s) (Lecture/Laboratory/Studio/Industrial training/Dissertation) that should be included in the M. Des. (Indl. Design) and MIM Programs. The course(s) can be modular in nature to be taught by multiple departments/instructors.

It was resolved that DoMS faculty members would be interested in taking courses in MIM program. However, depending upon the detailed syllabi, faculty members can take interdisciplinary courses such as Design thinking etc.

3. Suggest the eligibility requirement and selection procedure for admission to the both the programs. It may be mentioned here that the MIM program is proposed for mid-career executives.

It was resolved that a personal interview is sufficient for admitting candidates for MIM program. Personal Interview will be conducted only for short listed candidates on the basis of their experience, marks in UG/ PG and interest expressed in the application form.

4. Suggest on possible specializations of faculty members to be associated with CoED.

It was resolved that almost all the faculty members of DoMS can be associated with CoED, particularly to offer MIM program.

15.7.19

Rajat Agrawal

Secretary, DFC

Copy to:- All members of DFC, DoMS.

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Annexure – II

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PROGRAM STRUCTURES OF THE PROPOSED MASTERS PROGRAMS

(a) M. Des. (Industrial Design)

Teaching Scheme

I Year: Autumn Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage %				
S No.	Course Code	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	IDN-501**	Introduction to Design and Prototyping	PCC	Audit	15	5	10	02	-	35	35	--	30	--
2	IDN-503	Design Thinking	PCC	3	1	0	4	2	0	20-35	20-30	20-30	40-50	-
3	IDN-505	Elements and Principles of Visual Design	PCC	3	2	1	0	2	0	20-35	-	20-30	40-50	-
4	IDN-507	Human Factor Design	PCC	3	1	2	0	2	0	20-35	-	20-30	40-50	-
5	IDN-509	Materials and Manufacturing	PCC	3	1	1	2	2	0	20-35	20-30	20-30	40-50	-
6	IDN-511	Effective Communication	PCC	2	1	1	0	2	0	20-35	-	20-30	40-50	-
7	IDN-513	Ideation Project	PCC	4	1	0	6	-	-	-	100	-	-	-
8		Program Elective I	PEC	3	-	-	-	-	-	-	-	-	-	-
			Sub Total	**21**										

** This is a foundation course which will be running for 7-10 days to give orientation of Design course. It will be held before actual start of the semester teaching.

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I Year: Spring Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage%				
S No.	Course Code	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	IDN-502	Design Methodology	PCC	3	2	0	2	2	0	20-35	20-30	20-30	40-50	-
2	IDN-504	Form Design	PCC	3	1	0	4	0	4	20-35	20-30	-	-	40-50
3	IDN-506	Design for Sustainability	PCC	3	2	1	0	2	0	20-35	-	20-30	40-50	-
4	IDN-508	Creation Project	PCC	5	-	-	10	-	-	-	100	-	-	-
5	IDN-510	Design Seminar	PCC	2	-	-	4	-	-	100	-	-	-	-
6		Program Elective II	PEC	3	-	-	-	-	-	20-35	-	20-30	40-50	-
7		Program Elective III	PEC	3	-	-	-	-	-	20-35	-	20-30	40-50	-
			Sub Total	**22**										

II Year: Autumn Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage%				
S No.	Course Code	Course Title	Subject Area	Credit	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	IDN-702	Internship (Industrial Training/ Project/ Interaction)	SEM	4	-	-	-	-	-	-	-	-	-	100[$$]
2		Program Elective IV	PEC	3	-	-	-	-	-	15-35	-	25-35	40-50	-
3		Program Elective V[*]	PEC	3	-	-	-	-	-	-	-	-	-	-
4	IDN-701A	Design Project (Phase – I)	DIS	5	-	-	-	-	-	-	-	-	-	100
			Sub Total	**15**										

$$ Evaluation scheme: (Industry: 40 + Institute: 60) Internship will be completed during summer break.
[*]May be completed through online mode (for example, NPTEL).

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II Year: Spring Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage %				
S No.	Course Code	Course Title	Subject Area	Credit	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	IDN-701 B	Design Project (Phase – II)	DIS	12	-	-	-	-	-	-	-	-	-	100
			Sub Total	12										
			Total	**70**										

Basket of Elective Courses for M. Des. (Industrial Design)

Basket 1 Engineering Group

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage%				
S No.	Course Code	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
	First Semester													
1	IDN-521	Sensors, Actuators and IOT	PEC	3	2	0	2	2	0	20-35	20-30	20-30	40-50	-
2	IDN-522	Computer Aided Design	PEC	3	2	0	2	2	0	20-35	20-30	20-30	40-50	--
3	IDN-523	Rapid Prototyping	PEC	3	2	0	2	2	0	20-35	20-30	20-30	40-50	--
	Second Semester													
4	IDN-524	Digital Systems Design	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
5	IDN-525	CAE in Product Design	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
6	IDN-526	Reverse Engineering	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
	Third Semester													
7	IDN-527	Artificial Intelligence and Data Science	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-

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Basket 2 Management Group

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage%				
S No.	Course Code	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
	First Semester													
1	IDN-528	Product Planning and Marketing	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
	Second Semester													
2	IDN-529	Valuation	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
3	IDN-530	Business and Service Innovation	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
	Third Semester													
4	IDN-531	Legal Standards/IPR	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
5	IDN-532	Systems Thinking	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-

Basket 3 Design Group

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage%				
S No.	Course Code	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
	First Semester													
1	IDN-533	User Experience Design	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
	Second Semester **													
1	IDN-534	Interaction Design	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
2	IDN-535	Mobility Design	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
3	IDN-536	Service Design	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
1	IDN-537	Research into Design	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
2	IDN-538	Bio Inspired Design	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
	Third Semester													
1	IDN-539	Computer Game Design	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
2	IDN-540	Design for Society	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-

** **Student can take PEC either from first three or last two subjects.**

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Basket 4 Visual Design Group

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage%				
S No.	Course Code	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
	First Semester													
1	IDN-541	Graphic Design	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
	Second Semester													
1	IDN-542	Product Detailing	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
2	IDN-543	Contemporary Visual Design	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
	Third Semester													
1	IDN-544	Representation Techniques for Animation	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
2	IDN-545	Visual Narrative	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-

Basket 5 On-line mode: NPTEL

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A list of approved NPTEL courses by DAPC will be provided to students.

- Course duration: 20hrs

The courses will be PEC without laboratory work

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MIM (Masters in Innovation Management)

Teaching Scheme

I Year: Autumn Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage%				
S No.	Course Code	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	IMN-501	Design Thinking	PCC	3	1	0	4	2	0	20-35	-	20-30	40-50	-
2	IMN-503	Effective Communication	PCC	2	1	1	0	0	2	20-35	20-30	-	-	40-50
3	IMN-505	Business Valuation	PCC	3	2	1	0	3	0	20-35	-	20-30	40-50	-
4	IMN-507	Innovative Entrepreneurship Strategies	PCC	3	2	0	2	2	0	20-35	-	20-30	40-50	20-30
5	IMN-509	Legal Aspects of Business	PCC	2	2	0	0	2	0	20-35	-	20-30	40-50	-
6	IMN-511	Business Decision Making	PCC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
7	IMN-513	Contemporary Management Practices	PCC	2	2	0	0	2	0	20-35	-	20-30	40-50	-
	Sub Total			18										

I Year: Spring Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage%				
S No.	Course Code	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	IMN-502	Technology Management	PCC	2	2	0	0	2	0	20-35	-	20-30	40-50	-
2	IMN-504	Contemporary Strategic Management	PCC	3	2	1	0	2	0	20-35	-	20-30	40-50	-
3	IMN-506	Intellectual Property Management	PCC	3	2	1	0	2	0	20-35	-	20-30	40-50	-
4	IMN-508	Process Innovation Management	PCC	2	2	0	0	2	0	20-35	-	20-30	40-50	-
5	IMN-510	Product Innovation Management	PCC	2	2	0	0	2	0	20-35	-	20-30	40-50	-
6	IMN-512	Innovative Services and Business Models	PCC	3	2	1	0	2	0	20-35	-	20-30	40-50	-
7	IMN-514	Financing and Marketing of Innovation	PCC	3	2	1	0	2	0	20-35	-	20-30	40-50	-
	Sub Total			18										

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II Year: Autumn Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage%				
S No.	Course Code	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	IMN-601	Summer Training	SEM	3	-	-	-	-	-	-	-	-	-	100
2	IMN-602	Project	RP	2	-	-	-	-	-	-	-	-	-	100
3		Elective I	PEC	3	-	-	-	-	-	-	-	-	-	-
4		Elective II	PEC	3	-	-	-	-	-	-	-	-	-	-
5		Elective III	PEC	3	-	-	-	-	-	-	-	-	-	-
6		Elective IV	PEC	3	-	-	-	-	-	-	-	-	-	-
7		Elective V	PEC	3	-	-	-	-	-	-	-	-	-	-
	Sub Total			20										

II Year: Spring Semester

Teaching Scheme					Contact Hrs Per Week			Exam Duration		Relative Weightage%				
S No.	Course Code	Course Title	Subject Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1	IMN-603	Project (Continued from Sem III)	RP	18	-	-	-	-	-	-	-	-	100	-
	Sub Total			18										
	Grand Total			74										

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List of Elective Courses for MIM (Innovation Management):

S. No.	Course Code	Subject Name	Credit	L	T	P	Exam Dur. (Hrs)		Relative Weightage (%)				
							T	P	CWS	PRS	MTE	ETE	PRE
1	IMN-521	IP Portfolio Management	3	2	1	0	2	--	20-35	-	20-30	40-50	-
2	IMN-522	Intellectual Capital and Corporate Value Creation	3	2	1	0	2	--	20-35	-	20-30	40-50	-
3	IMN-523	Licensing and Commercialization of IP	3	2	1	0	2	--	20-35	-	20-30	40-50	-
4	IMN-524	Diffusion of Innovations in Social networks	3	2	1	0	2	--	20-35	-	20-30	40-50	-
5	IMN-525	Design for Extreme Affordability	3	2	1	0	2	--	20-35	-	20-30	40-50	-

All the elective subjects for MBA and M Des Course are also available for the students of MIM as PECs.

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Indian Institute of Technology Roorkee
Department of Humanities and Social Sciences

MSE (BS+MS in Economics)
(Five Year Integrated Programme)

Programme Overview

MSE (MS in Economics) programme will be of particular interest if one envisages a career which calls for advanced analytical skills, draws on advanced knowledge of economics, and shall ensure exposure to contemporary and emerging economic policy issues at the national and international levels. The programme is unique as it would help the students to apply various economic principles, theories and models, and understand the technical foundations behind them. This would enable students to alter, amend, empirically test and adapt them to the changing economic environment.

Programme Features

The MSE (MS in Economics) programme will be an in-depth programme that will equip students with the tools a professional economist needs to work in government or in international organisations, or to carry out economic research. This programme will give students rigorous training in the core areas of economics to make them proficient in the latest analytical and quantitative techniques. Students will also receive a firm grounding in mathematical and econometric techniques, microeconomics and macroeconomics, including their application to new economic problems.

Students want to have an exit degree may get it as BS (Economics) in completion of 4th year of the Programme.

Admission Eligibility/ Mode of Admission

Through IIT JEE Entrance Examination.

No. of Proposed Seats

The total number of seats proposed for the 5yr MSE (MS in Economics)programmeis**33.**
The breakup of the seats for this programme is: **16 (GEN) + 8 (OBC) + 3 (EWS) + 4 (SC) + 2 (ST)**

Programme Duration

The MSE (MS in Economics)programme would be a five-year full-time programme, with each year comprising the autumn and spring semesters with complete programme spread over total of ten semesters. **(Teaching Scheme attached)**

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Note: Students want to have an exit degree may get it as BS (Economics) in completion of 4th year of the Programme.

Students want to have BS degree have to intimate to DAA about their Option before the commencement of the Autumn Sem of 3rd Year during their subject registration and they may exit the Programme at the end of 4th Year

Students want to have BS degree may exit the Programme at the end of 4th Year; Students with BS degree can opt for Project wok as an elective under Department elective III and IV (total 6 credits, 3 credit each)

Programme Structure

	Autumn Semester		Spring Semester	
1ST YEAR	Semester I	Courses taught are of the same Structure like all other Branches (BSC, ESC, HSSMEC, GSC), One PCC (Introduction to the Discipline)	Semester II	Three PCC- Level 1 Microeconomics, Level 1 Macroeconomics, Basic Statistics along with BSC and ESC Courses
2ND YEAR	Semester III	Four PCC Courses along with One ESC course	Semester IV	Three PCC Courses along with One BSC Course and One HSSMEC Course
3RD YEAR	Semester V	PCC and PEC Courses (Programme Elective)	Semester VI	PCC and PEC Courses (Programme Elective)
	• Students will have ProgrammeElectives starting this year(from Autumn Semester). • Students will have Institute Open Elective (in Spring Semester). • Students can start opting for Minor Specialization Course from Other Departments/Courses (from Spring Semester).			
4TH YEAR	Semester VII	PCC and PEC Courses (Programme Elective)	Semester VIII	PCC and PEC Courses (Programme Elective)
	• Students will have Programme Electives (in Autumn and Spring Semester). • Students can opt for Minor Specialization Course from Other Departments/Courses(in Autumn and Spring Semester).			

5TH YEAR	Semester IX	PCC and PEC Courses (Programme Elective)	Semester X	PCC (Dissertation) and PEC Courses (Programme Elective)
	• Students will have Seminar (in Autumn Semester). • Students will have Dissertation (inSpring Semester).			

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	• Students can start opting for Minor Specialization Course from Other Departments/Courses(in Autumn and Spring Semester).

MSE (MS in Economics)Programme structure shall be according to minimum and maximum credit requirements in each semester. In each semester, the student shall require to fulfill maximum of 18-24 credits. Courses may be of credits ranging from 2 to 4.

Programme Evaluation

The programme course(s) evaluation would be based on mid-term, end-term and coursework including seminar presentations, group discussions, term papers and summer internship as per institute evaluation scheme.

Total Credits: as per other MS/MScprogrammes of the Institute)

Career Prospects

Careers open to students who successfully complete the MS Economics degree include economic advisory at government and semi-government departments, financial analysts and advisors to national and international financial institutions, data analysts and researchers as well as consultancy. In addition, the programme may also offer a route into further study at the Ph.D. level at various international academic institutions. The institute placement and training Centre can arrange campus placements by prospective employers from:

Financial Services-Reserve Bank of India, American Express Bank, HSBC Bank, ICICI Bank, Roulac Global Investments, National Institute of Securities Markets (NISM), Fidelity Investments, Indian Credit Rating Association (ICRA), Industrial Development Bank of India (IDBI), Iflex Solutions, National Commodities & Derivatives Exchange Ltd., etc.

Government Departments-Planning Commission (NITI Aayog), Ministry of Finance, Indian Council for Social Science Research (ICSSR), etc.

Research and Consultancy-Crisil Research, Deloitte, Ernst & Young and PwC, Institute for Financial Management and Research, NCAER, etc.

International Agencies- Economic advisor and experts to World Bank, Asian Development Bank, International Monetary Fund, OECD, etc.

Development- Social sector, NGOs, MFIs, NABARD, etc.

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Teaching Scheme

Program Code: **MSE** (MS in Economics)
Department:Department of HSS, Code: ECO (Economics)

Year	Credits in Autumn Semester	Credits in Spring Semester	Credits (year-wise)
1	21	24	**45**
2	20	19	**39**
3	20	18/22	**38/42**
4	17/ 21	17/21	**34/42**
5	18/22	18/22	**36/44**
Total	**96/104**	**96/108**	**192/212**

Curricular Components	Credit Distributions	
	Credits as per Institute Structure	Credits for MS in Economics
Institute Core Courses		
HSSC	4	4
BSC	16	16
ESC	16	16
GSC	3	3
Total	**39**	**39**
Programme Core Courses (PCC)		
Class Contact Core Courses	104	102
Intro to Discipline	2	2
Tech Communication	2	2
Project	12	12
Seminar	2	2
Educational Tour	0	0
Total	**122**	**120**
HSS and Management Electives (HSSMEC)		
HSS	3	3
Management	3	3
Total	**6**	**6**
Open Elective Course Total	**3**	**3**
Programme Elective Courses Total	**24-32**	**24**
Co-curricular Activities		
(i) Discipline (To be awarded after Final Year)	2	2
(ii) NCC/NSO/NSS (First Year)	-	-
Total	2	2
Grand Total	**192-200**	**194**

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Program Code: **MSE** (MS in Economics)

Department: Department of HSS

Year : I

Teaching Scheme					Contact Hours/Week			Exam Duration (Hrs.)		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
Autumn														
1	MAN-001	Mathematics-1	BSC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
2	HSN-101	Introduction to Economics	PCC	2	2	0	0	2	0	20-35	-	20-30	40-50	-
3	HSN-103	Computer Programming for Economists	ESC	4	3	0	2	3	0	10-25	25	15-25	30-40	-
4	PHN-001	Mechanics	BSC	4	3	0	2	3	0	10-25	25	15-25	30-40	-
5	HSN-002	Introduction to Psychology	HSSC	2	1	1	0	2	0	20-30	-	20-30	40-50	-
6	HSN-001A	Communication Skills (Basic)	HSSC	2	1	0	2	2	0	25	-	25	50	-
	HSN-001B	Communication Skills (Advance)	HSSC	2	1	0	2	2	0	25	-	25	50	-
7	CEN-105	Introduction to Environmental Studies	GSC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
			Total	**21**										
Spring														
1	MAN-002	Mathematical Methods	BSC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
2	HSN-102	Introductory Microeconomics	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
3	HSN-104	Introductory Macroeconomics	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
4	HSN-106	Basic Statistics	PCC	4	3	0	2	3	0	10-25	25	15-25	30-40	-
5	MAN-010	Optimization Techniques	BSC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
6	CHN-112	Energy Engineering	ESC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
			Total	**24**										

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Program Code: **MSE** (MS in Economics)
Department: Department of HSS
Year : II

Teaching Scheme					Contact Hours/Week			Exam Duration (Hrs.)		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
Autumn														
1	EEN-112	Electrical Sciences	ESC	4	3	1	2/2	3	0	15-30	20	15-25	30-40	-
2	HSN-201	Advanced Statistics	PCC	4	3	0	2	3	0	10-25	25	15-25	30-40	-
3	HSN-203	Advanced Microeconomics	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
4	HSN-205	Advanced Macroeconomics	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
5	HSN-207	Elementary Development Economics	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
			Total	**20**										
Spring														
1	MIN-102	Basic Manufacturing Process	ESC	4	2	0	4	3	0	15	15	30	40	-
2	HSN-202	Monetary Economics	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
3	HSN-204	Advanced Development Economics	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
4	HSN-206	Introduction to Econometric Theory	PCC	4	3	0	2	3	0	10-25	25	15-25	30-40	-
5	HSN-ELE	HSS Elective Course	HSSMEC	3	2	1	0	2	0					
			Total	**19**										

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Program Code: **MSE (**MS in Economics)
Department: Department of HSS
Year : III

Teaching Scheme					Contact Hours/Week			Exam Duration (Hrs.)		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
Autumn														
1	HSN-301	Public Finance	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
2	HSN-303	Principles of International Economics	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
3	HSN-305	Advanced Topics in Econometric Theory	PCC	4	3	0	2	3	0	10-25	25	15-25	30-40	-
4	HSN-ELE1	Department Elective 1	PEC	3	2	1	0	2	0	20-35	-	20-30	40-50	-
5	BM-ELE1	Management Elective Course	HSSMEC	3	2	1	0	2	0	20-35	-	20-30	40-50	-
6	HSN-307	Technical Communication	PCC	2	1	0	2	2	0	20-35	-	20-30	40-50	-
		Total		**20**										
Spring														
1	HSN-302	Advanced Topics in International Econom cs	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
2	HSN-304	Growth Economics	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
3	HSN-306	Indian Economy	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
4	HSN-ELE2	Department Elective 2	PEC	3	2	1	0	2	0	20-35	-	20-30	40-50	-
5		Open Elective I	OEC	3	2	1	0	2	0	20-35	-	20-30	40-50	-
6	MSC-1	Minor Specialization Course	MSC	4	3	1	0	3	0	-	-	-	-	-
7		Educational Tour	PCC	0	0	0	0	0	0					
		Total		**18/22**										

Department Elective Courses (HSN Elective-I and HSN Elective-II) to be chosen in III Year; Some of the PEC Courses will have Lab component.
Note: Students want to have BS degree have to intimate to DAA about their Option before the commencement of the Autumn Sem of 3rd Year during their subject registration and they may exit the Programme at the end of 4th Year

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Program Code: **MSE** (MS in Economics)
Department: Department of HSS
Year : IV

Teaching Scheme					Contact Hours/Week			Exam Duration (Hrs.)		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
Autumn														
1	HSN-501	Industrial Organisation	PCC	3	2	1	0	2	0	20-35	-	20-30	40-50	-
2	HSN-503	Financial Economics: Theory & Applications	PCC	4	3	0	2	3	0	10-25	25	15-25	30-40	-
3	HSN-505	Environment Economics: Theory & Policy	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
4	HSN-507	Time Series Analysis and Applications	PCC	3	2	0	2	2	0	10-25	25	15-25	30-40	-
5	HSN-ELE3	Department Elective III	PEC	3	2	1	0	2	0	20-35	-	20-30	40-50	-
6	MSC-2	Minor Specialization Course	MSC	4	3	1	0	3	-	-	-	-	-	-
		Total		**17/21**										
Spring														
1	HSN-502	Public Policy	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
2	HSN-504	Econometrics Lab	PCC	4	2	0	4	3	0	10-25	25	15-25	30-40	-
3	HSN-506	Energy Economics	PCC	3	2	1	0	2	0	20-35	-	20-30	40-50	-
4	HSN-508	Institutional Economics	PCC	3	2	1	0	2	0	20-35	-	20-30	40-50	-
5	HSN-ELE4	Department Elective IV	PEC	3	2	1	0	2	0	20-35	-	20-30	40-50	-
6	MSC-3	Minor Specialization Course	MSC	4	3	1	0	3	0	-	-	-	-	-
		Total		**17/21**										

Department Elective Courses (HSN Elective-III and HSN Elective-IV) to be chosen in Fourth Year; Some of the PEC Courses will have Lab component.
Note: Students want to have BS degree may exit the Programme at the end of 4th Year; Students with BS degree can opt for Project wok as an elective under Department elective III and IV (total 6 credits, 3 credit each)

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Program Code: **MSE** (MS in Economics)
Department: Department of HSS
Year : V

Teaching Scheme					Contact Hours/Week			Exam Duration (Hrs.)		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
Autumn														
1	HSN-601	Welfare Economics	PCC	3	2	1	0	2	0	20-35	-	20-30	40-50	-
2	HSN-603	History of Economic Thought	PCC	3	2	1	0	2	0	20-35	-	20-30	40-50	-
3	HSN-605	Advanced Growth Theory	PCC	4	3	1	0	2	0	20-35	-	20-30	40-50	-
4	HSN-607	Seminar	PCC	2	0	0	0	-	-	-	-	30	70	-
5	HSN-600 A	Project (Stage-I)	PCC	3	0	0	0	-	-	-	-	30	70	-
6	HSN-ELE5	Department Elective V	PEC	3	2	1	0	2	0	20-35	-	20-30	40-50	-
7	HSN-ELE6	Department Elective VI	PEC	3	2	1	0	2	0	20-35	-	20-30	40-50	-
8	MSC-4	Minor Specialization Course	MSC	4	3	1	0	3	0	-	-	-	-	-
			Total	**21/25**										
Spring														
1	HSN-600 B	Project (Stage-II)	PCC	9	0	0	0	-	-	-	-	30	70	-
2	HSN-ELE7	Department Elective VII	PEC	3	2	1	0	2	0	20-35	-	20-30	40-50	-
3	HSN-ELE8	Department Elective VIII	PEC	3	2	1	0	2	0	20-35	-	20-30	40-50	-
5	MSC-5	Minor Specialization Course	MSC	4	3	1	0	3	0	-	-	-	-	-
			Total	**15/19**										

Department Elective Courses (HSN Elective-IV, V, VI, VII and VIII) to be chosen in Fifth Year

Note: Subject Codefor 4th year and 5th yearsubjects are of 5 and 6 serieskeeping in view that since it is a master's programme students from other masters programme/PhD can take these courses as elective/pre-PhD courses.

Some of the PEC Courses will have Lab component.

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Humanities and Social Sciences

1. **Subject Code:** HSN-101 **Course Title:** Introduction to Economics
2. **Contact Hours:** **L:** 2 **T:** 0 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 2 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 2 **6. Semester:** Autumn
7. **Pre-requisite:** Nil **8. Subject Area:** PCC
9. **Objective:** To provide basic understanding of economic principles/analysis.
10. **Details of the Course**

S.No.	Contents	Contact hours
1.	**The Central Concepts of Economics:** The Concepts of Scarcity, Choice, Opportunity Costs and Efficiency; The Modern Mixed Economy-Market and Government	5
2.	**Microeconomic Concepts:** Demand, Supply and Markets; Equilibrium and Surplus; Quotas, and Price Ceilings; Compare and Contrast Monopoly, Perfect Competition and Other Market Structures.	7
3.	**Macroeconomic Concepts:** Circular Flow, Measuring Economic Activity-Gross Domestic Product; Macroeconomic Challenges: Unemployment, Inflation and Macroeconomic Performance-Business Cycles	8
4.	**Growth and Development:** Sources of Economic Growth: Human Resources, Natural Resources, Capital, Technological Change and Innovation, The Challenge of Economic Development	4
5.	**Global Economy:** International Trade: The Nature of International Trade, The Principle of Comparative Advantage; Protectionism: Supply-and-Demand Analysis of Trade and Tariffs	4
	Total	**28**

11. **Suggested Books:**

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Economics, Paul A. Samuelson, William D. Nordhaus, McGraw-Hill; 19th Edition	2010
2.	Principles of Economics, N. Gregory Mankiw, Cengage Learning, 7th Edition	2015
3.	Economics-A Very Short Introduction, Partha Dasgupta, Oxford University Press, 1st Edition	2007
4.	Principles of Economics, Carl Menger, Ludwig von Mises Institute, 1st Edition Reprint	2007
5.	Economics: Principles and Policy, William J. Baumol, Alan S. Blinder, Cengage Learning, 11th Edition	2010

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Humanities and Social Sciences

1. **Subject Code:** HSN-102 **Course Title:** Introductory Microeconomics
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Spring
7. **Pre-requisite:** Nil **8. Subject Area:** PCC
9. **Objective:** To provide an understanding of consumer and producer behavior, markets and competition, and tools of comparative statics and their application to price theory.

10. **Details of the Course**

S.No.	Contents	Contact hours
1.	**Introduction:** Key concepts in Microeconomics; Concepts of Scarcity and Wants; Models and Methodology; Positive and Normative Analysis	2
2.	**Consumer Behaviour**: Theories of consumer behavior - Total and Marginal Utility; Cardinal and Ordinal Utility; Preference orderings and Indifference Curves; Marginal Rate of Substitution; Budget Constraint; Utility Maximisation; Derivation of demand; Concepts of Elasticity; Changes in prices and income and individual demand curve; Substitution and Income effects; Revealed preference approach; Aggregate demand	8
3.	**Producer Behaviour**: Short-run vs Long-run analysis; Technology and production sets; Production with single variable; Production with two or more variables; Production functions (for competitive firm) and Isoquants; Returns to Scale; Technological progress; Cost Concepts; Expansion path and long-run cost curves; Output and Profit maximization; Cost minimization; Duality theory in production; Multiproduct firms and cost dynamics	8
4.	**Competitive Market**: Prefect Competition-Assumptions; Demand and supply curves; Market equilibrium, stability and comparative static properties; Impact of taxes and subsidies on market equilibrium; Consumer and producers surplus; Firm equilibrium and supply curve in the short-run; Firm and industry equilibrium in the long-run; Constant, Increasing and decreasing cost industries; General equilibrium and Pareto optimality - fundamental theorems of welfare economics; Externalities and market failures	8
5.	**Imperfect Markets**: Imperfect competition and market structure; Pure monopoly; Short-run and long-run equilibrium; Profit maximization; Price discrimination; Bilateral monopoly; Single product monopoly; Durable goods monopolist; Multi-plant monopolist; Barrier to entry and natural monopoly; Welfare loss from monopoly; Dumping, tying and bundling; Monopsony	8
6.	**Monopolistic Competition and Oligopoly**: Characteristics of monopolistic and oligopolistic competition; Advertising and monopolistic competition; Output, price, and profit of a monopolistic competitor; Long-Run equilibrium in a monopolistically competitive industry; Models of oligopoly behavior –	8

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	Cartel model, contestable markets; Oligopoly model with homogeneous products; Oligopoly model with differentiated products	
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Intermediate Microeconomics with Calculus, H. R. Varian, W. W. Norton & Company, International Student Edition	2014
2.	Microeconomics, D. Acemoglu, D. Laibson and J. List, Pearson Education, 1st Edition	2019
3.	Microeconomics, P. Jeffrey, Pearson Education, 7th Edition	2019
4.	Microeconomic Theory: Basic Principles and Extensions, W. Nicholson and C. Snyder, Cengage India	2017
5.	Microeconomics, R. Pindyck and D. Rubinfeld, Pearson Education, 8th Edition	2017
6.	Microeconomics, E. Mansfield and G. Yohe, Viva-Norton, 11th Edition	2010
7.	Microeconomics, H. Gravelle and R. Rees, Pearson India, 3rd Edition	2007
8.	Microeconomics: Theory and Applications, A. Sen, Oxford University Press, 2nd Edition	2006

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Humanities and Social Sciences

1. **Subject Code:** HSN-103 **Course Title:** Computer Programming for Economists
2. **Contact Hours:** **L:** 3 **T:** 0 **P:** 2
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 10-25 **PRS:** 25 **MTE:** 15-25 **ETE:** 30-40 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Autumn
7. **Pre-requisite:** Nil **8. Subject Area:** ESC
9. **Objective:** To provide an understanding of different programming techniques and integrating it with Economics.

10. **Details of the Course**

S.No.	Contents	Contact hours
1.	**Introduction**: Programming concepts and paradigm; Development of programming languages; Structures of programming languages: Lexical structure, Syntactic structure, Contextual structure, Semantic structure; Understanding programming: Data types, Data structures, Automation basics ; Programming as social science.	8
2.	**Introduction to C/C++**: Getting started with C/C++; Control structures: Operators, Basic selection structures, Iteration structures; Complex types: Arrays and string, Pointer, Constants; Compound data types: Union, Array of structures using static memory allocation; Input and output: Standard input and output, Variable-length argument lists, File access; Recursive structures and applications.	10
3.	**Programming using Python**: Basic elements of Python; Conditional logic, Loops; Debugging Python code; Reading and writing to files: Working with database files, Text and CSV files; Obtaining data from the web: Using python to read from HTML files, JSON, API queries; Statistical calculations; Data visualization; Machine learning and text mining.	10
4.	**Programming using R:** Fundamentals of R; R and Rstudio: Working directory, Script, Vectors, Matrices, Data frames; Getting data into R; R for data science: Exploratory data analysis, Statistical simulation; R for machine learning: Lazy learning, Probabilistic learning, Forecasting numeric data.	7
5.	**MATLAB Programming:** Basic Matlab and introductory examples; Writing scripts and functions: Functions, Plotting curves, Root finding, Interpolation and extrapolation; Solving differential equations and Simulations; Data Input/Output: Importing from excel, text, and native Matlab files; User written functions: Function m-files, Anonymous functions.	7
Total		**42**

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11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Brooker, Phillip. Programming with Python for Social Scientists, Sage.	2020
2.	Guttag, John. Introduction to Computation and Programming Using Python: With Application to Understanding Data, Second Edition, MIT Press.	2016
3.	Kaefer, F. & Kaefer, P. Introduction to Python Programming for Business and Social Science Applications, Sage.	2020
4.	Chen, Y. Introduction to Programming Languages, Sixth Edition, Kendall Hunt Publication Company.	2019
5.	Mueller, J., & Massaron, L. Machine Learning for Dummies, John Wiley & Sons.	2016
6.	Vries A., & Meys, J. R for Dummies, Second Edition, John Wiley and Sons.	2015
7.	Dayal, V. An Introduction to R for Quantitative Economics, Springer, India.	2015
8.	Kendrick, D., Mercado, R., Amman, H. Computational Economics, Princeton University Press.	2006

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Humanities and Social Sciences

1. **Subject Code:** HSN-104 **Course Title:** Introductory Macroeconomics
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Spring
7. **Pre-requisite:** Nil **8. Subject Area:** PCC
9. **Objective:** To provide students a basic understanding of the principles of macroeconomics as they relate to how a country's economy works including the outputs, unemployment, inflation, fiscal policy, monetary policy and international trade of the economy.

10. **Details of the Course**

S.No.	Contents	Contact hours
1.	**National Income Accounting**: Structure, Key concepts, Measurements, and Circular flow of Income- for Closed and Open Economy; Money, Fiscal and Foreign Sector Variables- Concepts, Measurements	6
2.	**Behavioural and Technological Functions**: Consumption Functions-Absolute Income Hypothesis, Lifecycle and Permanent Income Hypothesis; Investment Functions-Keynesian; Money Demand and Supply Functions; Production Function	9
3.	**Business Cycles and Economic Models**: Business Cycles-Facts and Features; The Classical Model of the Business Cycle; The Keynesian Model of the Business Cycle- Simple Keynesian Cross Model of Income and Employment determination and the multiplier (in closed economy);	10
4.	**Business Cycles and Economic Models**: IS-LM Model -Hicks' IS-LM Synthesis; Fiscal and Monetary Policy: Role of Fiscal Policy and Monetary Policy in taming Business Cycles	9
5.	**Inflation and Unemployment**: Inflation-Theories, Philips Curve; Monetary Policy; Government Debt and Ricardian Equivalence; Measurement, Causes, and Effects; Unemployment-Types, Measurement, Causes, and Effects	8
	Total	**42**

11. **Suggested Books:**

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Macroeconomics, N. Gregory Mankiw, 10th Ed, Macmillan	2019
2.	Macroeconomics, Rudiger Dornbusch and Stanley Fischer and Richard Startz, 13th Ed., McGraw-Hill	2018
3.	Macroeconomics, Robert J. Gordon, 12th Ed., Pearson	2012
4.	Macroeconomics: Theories and Policies, Richard T. Froyen, 10th Ed., Pearson	2013
5.	Macroeconomics: Theory and Applications, G.S. Gupta, 4th Ed., McGraw Hill Education	2017

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NAME OF DEPARTMENT/CENTRE: Department of Humanities and Social Sciences

1. **Subject Code:** HSN-106 **Course Title:** Basic Statistics
2. **Contact Hours:** **L:** 3 **T:** 0 **P:** 2
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 10-25 **PRS:** 25 **MTE:** 15-25 **ETE:** 30-40 **PRE:** 0
5. **Credits:** 4 6. **Semester:** Spring
7. **Pre-requisite:** Nil 8. **Subject Area:** PCC
9. **Objective:** To provide an understanding of interpretation of elementary statistics and analyze statistical data.

10. **Details of the Course**

S.No.	Contents	Contact hours
1.	**Introduction:** Samples versus Populations; Descriptive Statistics: Measures of Central Tendency, Measures of Dispersion, Measures of Position and Outliers; Graphical Summaries of Data and Some Related Issues: Relative Frequencies, Histograms, Boxplots; Distributions, Percentiles, and Percentile Ranks	6
2.	**Probability and Sampling Distribution:** The Meaning of Probability; Expected Values; Conditional Probability and Independence; The Binomial Probability Function; Discrete Probability Distributions; The Normal Probability Distribution: Properties of the Normal Distribution, The Standard Normal Distribution, Applications of the Normal Distribution; Sampling Distributions: Sampling Distribution of a Binomial Random Variable, Sampling Distribution of the Mean Under Normality, Non-Normality and the Sampling Distribution of the Sample Mean, Sampling Distribution of the Median	10
3.	**Estimation and Hypothesis Testing:** Hypotheses about Single Means (z and t); Estimation: Confidence Interval for the Mean: Known Variance, Confidence Intervals for the Mean: σ Not Known, Confidence Intervals for the Population Median; Hypothesis Testing: Testing Hypotheses about the Mean of a Normal Distribution, σ Known, Testing Hypotheses about the Mean of a Normal Distribution, σ Not Known	8
4.	**Correlation and Regression:** Simple Linear Regression: Ordinary Least Squares Regression, Inferences about the Slope and Intercept, The Coefficient of Determination, Testing the Significance of the Least-Squares Regression Model; Correlation	10
5.	**Inferences on Two or More than Two Samples:** Comparing the Means of Two Independent Groups, Comparing Two Dependent Groups, The ANOVA F Test for Independent Groups, Two-Way ANOVA; Chi-Square Goodness of Fit Test: Chi-Square Test for Independence and Homogeneity of Proportions	8
	Total	**42**

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11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Basic Statistics, Rand R. Wilcox, Oxford University Press, 1st Edition	2009
2.	The Basic Practice of Statistics, David S. Moore, W. H. Freeman and Company New York, 1st Edition	2010
3.	Introduction to Mathematical Statistics, Robert V. Hogg, Joseph W. McKean, Allen T. Craig. Pearson Education, 7th Edition	2013
4.	A Modern Introduction to Probability and Statistics: Understanding Why and How, F.M. Dekking, C. Kraaikamp H.P. Lopuhaa¨ L.E. Meester, Springer- London, 1st Edition	2005
5.	Statistics-A Very Short Introduction, David J. Hand, Oxford University Press, 1st Edition	2008

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Department of Management Studies

Indian Institute of Technology Roorkee, Roorkee

Proposal to Start Executive MBA at IIT Roorkee

Introduction:

It is a matter of pride that DoMS, IIT Roorkee is one of the top ten B-School of the country as per NIRF 2017, 2018 and 2019. Department is offering only two programmes, MBA and PhD. It is a very appropriate time for the department to leverage its ranking, particularly by starting a new programme. Over last 20 years of its existence, department has acquired sufficient resources for moving into executive education programmes. Therefore, it is proposed to initiate Executive-MBA programme for working professionals. This programme is designed to attract working professionals who want to learn modern management principles for their career growth as well as for developing competitiveness of their organizations.

All peer institutions (IITs offering MBA and IIMs) offer EMBA programmes. Some of them offer E MBA in their permanent campus while some others offer in different campus. Considering the resources and availability of candidates, it is proposed to start E MBA.

Under the rapid infrastructure development plan around NCR and Uttarakhand, it is expected that commercial and industrial activities will further grow in NCR and Uttarakhand. This will require more persons who are well trained in managerial skills. Therefore, it is expected that this course will have a good potential right from the beginning.

The programme will be done in weekend mode with online and offline classes.

Programme Objective: At the outset, following objectives are decided for this proposed course:

(1) To create visibility of the department among the working professionals.
(2) To provide stronger linkages of department with industries.
(3) To extend academic offerings from the department
(4) To leverage good ranking of the department
(5) To offer the course as "degree" so that it can be used by participants for pursuing future studies.

Programme Duration and Mode:

24 months. It will have blend of Online and offline classes. In each term/ semester, two sessions of 2-3 days each should be organized as boot camp at Roorkee/ Greater Noida campus.

Eligibility for Admission

A candidate seeking admission for the Programme must possess Bachelor's Degree with 65 % marks or equivalent grade points (for SC/ST 60% marks or equivalent grade points) with four years' relevant Work Experience after graduation.

Further, she/he should also fulfil one of the following condition:

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(i) The experience should be in a company having turnover of more than INR 300 crore for last three years continuously. OR in state, central government departments. OR in a reputed NGO having PAN India or Global operations.

(ii) Graduation is completed from any Statutory University (Within top 500 NIRF in latest ranking data) or any other recognized Foreign University (Within 1000 QS latest ranking).

(iii) Qualified CAT/GMAT/ XAT (latest examination is applicable).

Selection Procedure: The selection of the students shall be on the basis of Personal Interview only.

Intake: 30 seats

Programme Duration: The programme structure consists of 8 terms.

Programme Fees: Rs. 11 lacs payable in two instalments yearly.

Programme Commencement: January 2021.

Course Structure

Department of Management Studies

Executive Master of Business Administration (EMBA)

Course No.	Course Title	Subject Area	Credit	L	T	P	Exam Dur. (Hrs)		Relative Weightage (%)				
							T	P	CWS	PRS	MTE	ETE	PRE
1st Year	**1st Term**												
BMN-501	Principles and Practices of Management	PCC	**1.5**	3	0	0	2		50	---	---	50	--
BMN-502	Micro Economics	PCC	**1.5**	3	0	0	2	-	50	---	---	50	--
BMN-503	Operations Research	PCC	**2**	3	1	0	3	-	50	---	---	50	--
BMN-505	Financial Accounting I	PCC	**1.5**	3	0	0	2	-	50	---	---	50	--
BMN-506	Business Environment	PCC	**2**	4	0	0	3	-	50	---	---	50	--
BMN-507	Innovation and Entrepreneurship	PCC	**1.5**	3	0	0	2	-	50	---	---	50	--
BMN-508	Marketing Management I	PCC	**2**	4	0	0	3	-	50	---	---	50	--
	Sub Total		**12**	23	1	0							

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	2nd Term												
BMN-510	Macro Economics	PCC	**1.5**	3	0	0	2	-	50	---	---	50	--
BMN-511	Marketing Management 2	PCC	**2**	4	0	0	3	-	50	---	---	50	--
BMN-512	Managerial Communication	PCC	**2**	3	0	2	2	-	50	20	---	30	--
BMN-513	Organization Behaviour	PCC	**1.5**	3	0	0	2	-	50	---	---	50	--
BMN-514	Data Analysis for Managers	PCC	**2**	3	0	2	2	-	50	20	---	30	---
BMN-515	Management Accounting	PCC	**2**	4	0	0	3	-	50	---	---	50	--
BMN-518	Production and Operations Management 1	PCC	**1.5**	3	0	0	2	-	50	---	---	50	--
Sub Total			**12.5**	23	0	4							
	3rd Term												
BMN-517	IT and Organization	PCC	**1.5**	3	0	0	2	---	50	---	---	50	
BMN-519	Production and Operations Management- 2	PCC	**2**	4	0	0	3	-	50	---	---	50	--
BMN-520	Human Resource Management	PCC	**2**	4	0	0	3	-	50	---	---	50	--
BMN-521	Financial Management -1	PCC	**1.5**	3	0	0	2	-	50	---	---	50	--
BMN-525	Digital Transformation and Business	PCC	**1.5**	3	0	0	2	--	50	---	---	50	--
BMN-526	Project Management	PCC	**1.5**	3	0	0	2	-	50	---	---	50	--
BMN-527	International Business	PCC	**1.5**	3	0	0	2	-	50	---	---	50	--
	Sub Total		**11.5**	23	0	0							
	4th Term												
BMN-521	Financial Management -1	PCC	**1.5**	3	0	0	2	-	50	---	---	50	--
BMN-528	Data Science and Big Data Analytics	PCC	**1.5**	3	0	0	2	--	50	---	---	50	--
BMN-530	Marketing Research	PCC	**2**	3	1	0	3	-	50	---	---	50	--
BMN-531	Legal Aspects of Business	PCC	**2**	4	0	0	3	-	50	---	---	50	--
BMN-533	Strategy and Business Policy	PCC	**2.0**	4	0	0	3	-	50	---	---	50	--
BMN-534	Supply Chain Management	PCC	**1.5**	3	0	0	2	-	50	---	---	50	--
	Elective I	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
	Sub Total		**12**	23	1	0							

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2nd Year	**5th Term**												
BMN-535	Business Simulation from Capstone I	PCC	**6**	--	--	--	--	--	--	--	--	--	--
BMN-536	New Product Development	PCC	**1.5**	3	0	0	2	-	50	---	---	50	--
BMN-602	Summer Training	PCC	**2**	--	-	--	--	-	---	--	---	---	100
	Elective II	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
	Elective III	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
	Elective IV	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
	Elective V	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
	Sub Total		**15.5**	15	0	0							
	6th Term												
	Elective VI	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
	Elective VII	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
	Elective VIII	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
	Elective IX	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
	Elective X	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
	Elective XI	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
	Term Paper/ Seminar Presentation	PEC	**6**	--	-	--	--	-	--	---	---	---	100
	Sub Total		**15**	18	0	0							
	7th Term												
	Elective XII	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
	Elective XIII	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
	Elective XIV	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
	Elective XV	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
	Elective XVI	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
	Capstone II	PCC	**6**	--	-	--	--	-	---	---	---	---	---
	Sub Total		**13.5**	15	0	0							
	8th Term												
BMN-610	Major Project	RP	**7**	--	-	--	--	-	---	---	---	---	---
Sub Total			**7**										
	TOTAL		**99**										

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Important Points :

(1) Summer Training will be evaluated area wise. Students need to submit a report and presentation will be made by them.
(2) Students will start working for their final year project during 7th term. They can spend some time in industry for project completion in 8th term. Project evaluation will also be done after making presentation in front of a duly constituted committee.
(3) To complete specialization in one area, a student has to earn minimum 12 credits in that area.

Open Electives

S.No.	Subject Code	Subject Name	Subject area	Credit	L	T	P	Exam Dur. (Hrs)		Relative Weightage (%)				
								T	P	CWS	PRS	MTE	ETE	PRE
1	BMN-611	Knowledge Management	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
2	BMN-612	Entrepreneurship Development	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
3	BMN-613	Industrial Waste Management	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
4	BMN-614	Management of Large Systems	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
5	BMN-615	Environment Management	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
6	BMN-616	Advanced Optimization Techniques for Management	PEC	**1.5**	3	0	0	2	- - -	50	---	---	50	--
7	BMN-617	Basics of Management of Information	PEC	**1.5**	3	0	0	2	- - -	50	---	---	50	--
8	BMN-618	Soft Computing Techniques for Management	PEC	**1.5**	3	0	0	2	- - -	50	---	---	50	--
9	BMN-619	Technology Management	PEC	**1.5**	3	0	0	2	- - -	50	---	---	50	--

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Specialization Electives

(1) Human Resource Management

S.No.	Subject Code	Subject Name	Subject Area	Credit	L	T	P	Exam Dur. (Hrs)		Relative Weightage (%)				
								T	P	CWS	PRS	MTE	ETE	PRE
1	BMN-631	Human Resource Planning and Development	PEC	**1.5**	3	0	0	2	--	50	---	---	50	--
2	BMN-632	Organisational Development	PEC	**1.5**	3	0	0	2	--	50	---	---	50	--
3	BMN-633	Labour Legislation and Industrial Relations	PEC	**1.5**	3	0	0	2	--	50	---	---	50	--
4	BMN-634	Career Planning and Performance	PEC	**1.5**	3	0	0	2	--	50	---	---	50	--
5	BMN-635	Management of Training and Talent Development	PEC	**1.5**	3	0	0	2	--	50	---	---	50	--
6	BMN-636	Compensation Management and Reward System	PEC	**1.5**	3	0	0	2	--	50	---	---	50	--
7	BMN-637	Management of Change	PEC	**1.5**	3	0	0	2	--	50	---	---	50	--
8	BMN-638	Managing Innovation and Creativity	PEC	**1.5**	3	0	0	2	--	50	---	---	50	--
9	BMN-639	Management of Self and Interpersonal Dynamics	PEC	**1.5**	3	0	0	2	--	50	---	---	50	--
10	BMN-640	Strategic Human resource Management	PEC	**1.5**	3	0	0	2	--	50	---	---	50	--
11	BMN-641	H R Analytics		**1.5**	3	0	0	2	--	50	---	---	50	--

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(2) Operations

S.No.	Subject Code	Subject Name	Subject Area	Credit	L	T	P	Exam Dur. (Hrs)		Relative Weightage (%)				
								T	P	CWS	PRS	MTE	ETE	PRE
1	BMN-651	Manufacturing Strategy	PEC	**1.5**	3	0	0	2	---	50	---	---	50	--
2	BMN-652	Service Operations Management		**1.5**	3	0	0	2	---	50	---	---	50	--
3	BMN-653	Supply Chain Analytics		**1.5**	3	0	0	2	---	50	---	---	50	--
4	BMN-654	Computer Integrated Manufacturing	PEC	**1.5**	3	0	0	2	---	50	---	---	50	--
5	BMN-655	Operations Planning and Control Systems	PEC	**1.5**	3	0	0	2	---	50	---	---	50	--
6	BMN-656	Total Productive Maintenance	PEC	**1.5**	3	0	0	2	---	50	---	---	50	--
7	BMN-657	Productivity Management	PEC	**1.5**	3	0	0	2	---	50	---	---	50	--
8	BMN-658	Quality Management	PEC	**1.5**	3	0	0	2	---	50	---	---	50	--

(3) Information Technology

S.No.	Subject Code	Subject Name	Subject Area	Credit	L	T	P	Exam Dur. (Hrs)		Relative Weightage (%)				
								T	P	CWS	PRS	MTE	ETE	PRE
1	BMN-661	Management of Information Technology	PEC	**1.5**	3	0	0	2	---	50	---	---	50	--
2	BMN-662	Enterprise Business Applications	PEC	**1.5**	3	0	0	2	---	50	---	---	50	--
3	BMN-663	Information Technology Project Management	PEC	**1.5**	3	0	0	2	---	50	---	---	50	--

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4	BMN-664	Software Engineering and Management of Software Development	PEC	**1.5**	3	0	0	2	- - -	50	---	---	50	--
5	BMN-665	Design of On-Line Systems	PEC	**1.5**	3	0	0	2	- - -	50	---	---	50	--
6	BMN-666	Decision Support and Experts Systems	PEC	**1.5**	3	0	0	2	- - -	50	---	---	50	--
7	BMN-667	Business Process Management	PEC	**1.5**	3	0	0	2	- - -	50	---	---	50	--
8	BMN-668	Electronic Commerce and Electronic Governance	PEC	**1.5**	3	0	0	2	- - -	50	---	---	50	--

(4) Marketing

S.No.	Subject Code	Subject Name	Subject Area	Credit	L	T	P	Exam Dur. (Hrs)		Relative Weightage (%)				
								T	P	CWS	PRS	MTE	ETE	PRE
1	BMN-671	Internet Marketing	PEC	**1.5**	3	0	0	2	- -	50	---	---	50	--
2	BMN-672	Product and Brand Management	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
3	BMN-673	Integrated Marketing Communications	PEC	**1.5**	3	0	0	2	- -	50	---	---	50	--
4	BMN-674	Sales and Distribution Management	PEC	**1.5**	3	0	0	2	- -	50	---	---	50	--
5	BMN-675	International Marketing	PEC	**1.5**	3	0	0	2	- -	50	---	---	50	--
6	BMN-676	Industrial Marketing	PEC	**1.5**	3	0	0	2	- -	50	---	---	50	--
7	BMN-677	Services Marketing	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--

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8	BMN-524	Consumer Behaviour Analysis	PEC	**1**	2	0	0	2	-	50	---	---	50	--
9	BMN-691	Marketing Metrics	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--

(5) Financial

S.No.	Subject Code	Subject Name	Subject Area	Credit	L	T	P	Exam Dur. (Hrs)		Relative Weightage (%)				
								T	P	CWS	PRS	MTE	ETE	PRE
1	BMN-681	Quantitative Analysis for Financial Management	PEC	**1.5**	3	0	0	2	- - -	50	---	---	50	--
2	BMN-682	Working Capital Management	PEC	**1.5**	3	0	0	2	- - -	50	---	---	50	--
3	BMN-683	Security Analysis and Portfolio Management	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
4	BMN-684	Indian Financial System	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
5	BMN-685	International Financial Management	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
6	BMN-686	Financial Management Control Systems	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
7	BMN-687	Taxation and Tax Planning	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
8	BMN-688	Merchant Banking and Financial Services	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
9	BMN-689	Financial Statement Analysis and Reporting	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--
10	BMN-690	Banking and Bank Finance	PEC	**1.5**	3	0	0	2	-	50	---	---	50	--

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Senate approved PDC List

Appendix 'A'

Sl.No.	Name	Deptt.	Topic	Supervisor	Examiner (For./Ind.)	ODC Approval Date
1	Ms. Astha Chauhan	ASE	ANALYTICAL AND NUMERICAL SOLUTIONS OF SELECTED NON-LINEAR PDEs	Prof. Rajan Arora	Prof. Abdul-Majid Wazwaz, saint Xavier Univ., USA Prof. V. D. Sharma, IIT Gandhinagar Prof. Lal Pratap Singh, IIT Varanasi	03.02.21
2	Mr. Manish Kumar	BT	ROLE OF NF-KAPPAB DIMER DYNAMICS IN NF-KAPPAB DRIVEN TRANSCRIPTION	Prof. S. P. Mukherjee	Prof. Tom Huxford, San Dego State Univ., USA Dr. Soumen Basak, NII Dew Delhi	24.12.20
3	Mr. Mohammad Suhaib Ahmad	CE	BOND BEHAVIOUR OF STEEL IN CONCRETE UNDER FLEXURE WHEN EXPOSED TO FIRE	Prof. Pradeep Bhargava	Prof. Sriman Kumar Bhattacharyya, IIT Kharagpur Prof. J. M. Chandra Kishen, IISc Bangalore Prof. Konjengbam D. Singh, IIT Guwahati	21.01.21
44	Mr. Muskan Mayank	CE	EXPERIMENTAL STUDY OF SOLUTE TRANSPORT THROUGH THREE-DIMENSIONAL POROUS MEDIA	Prof. P. K. Sharma	Prof. J. H. Pu, University of Bradford, UK Prof. Anirban Dhar, IIT Kharagpur	02.02.21
5	Ms. Gunjan Joshi	DoMS	EMPLOYABILITY OF HANDICRAFT WORKERS: MEDIATING ROLE OF SKILL DEVELOPMENT	Prof. R. L. Dhar	Prof. Pooja Purang, IIT Bombay Prof. Rupashree Baral, IIT Madras	10.12.20
6	M. Rahul Kumar Jaiswal	ECE	TERAHERTZ INTEGRATED CIRCUITS USING SPOOF SURFACE PLASMON POLARITONS	Prof. N. P. Pathak	Prof. Shiban K. Koul, IIT Delhi Prof. M. Jaleel Akhtar, IIT Kanpur Prof. Girish Kumar, IIT Bombay	12.01.21
7	Mr. Raj Kumar	ECE	INVESTIGATION ON RADIATING ELEMENTS FOR ELECTRONICALLY STEERED PHASED ARRAY ANTENNA FOR AIRBORNE SATCOM	Prof. M. V. Kartikeyan	Prof. D. Anagnostou, Heriot Watt Univ., Scotland Dr. Anil Kumar Singh, DRDO Hyderabad	12.01.21
8	Mr. Alok Raj Gupta	ES	A GRAIN CONDUCTIVITY APPROACH FOR WATER SATURATION ESTIMATION OF SHALY SANDS	Prof. Kamal	Prof. Andre Revil, Universite Savoie Mont-Blanc Edytem CNRS UMR, France Prof. Kumar Hemant Singh, IIT Bombay	14.01.21
9	Mr. Charmala Suresh	HRE	STUDY OF COMBINED SENSIBLE AND LATENT HEAT SOLAR THERMAL ENERGY STORAGE SYSTEM	Prof. R. P. Saini	Prof. K. Srinivas Reddy, IIT Madras Prof. P. Mathukumar, IIT Guwahati	19.01.21
10	Mr. Abdul Haq	MA	APPROXIMATE CONTROLLABILITY OF INFINITE DIMENSIONAL SEMILINEAR CONTROL SYSTEMS	Prof. N. Sukavanam	Prof. Dhirendra Bahuguna, IIT Kanpur Prof. Subir Das, IIT Varanasi	28.12.20

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Appendix-F
Item No. Senate/86.20

11	Mr. T. Sudhakar	MIE	UNDERSTANDING INTERFACIAL EVOLUTION OF A TAYLOR DROP IN LIQUID FILLED PIPE JUNCTION USING LATTICE BOLTZMANN METHOD	Prof. Arup Kumar Das	Prof. Prasanta Kumar Das, IIT Kharagpur Prof. Gautam Biswas, IIT Kanpur	08.01.21
12	Mr. Aditya Kumar	MIE	NATURAL CONVECTION IN MAGNETIC NANOFLUIDS	Prof. Sudhakar Subudhi	Prof. Milind V. Rane, IIT Bombay Prof. Kirti Chandra Sahu, IIT Hyderabad	14.01.21
13	Mr. Ranjeet Singh Rathore	MIE	INVESTIGATIONS ON ULTRASONIC ASSISTED ELECTROCHEMICAL DISCHARGE MACHINING PROCESS	Prof. Akshay Dvivedi	Prof. J. Ramkumar, IIT Kanpur Prof. Somashekhar S. Hiremath, IIT Madras Prof. Pulak Mohan Pandey, IIT Delhi	29.01.21
14	Mr. Jimmy Karloopia	MIE	SOME STUDIES ON SYNTHESIS AND CHARACTERIZATION OF IN-SITU Al-12%Si-TiB_2 METAL MATRIX COMPOSITES	Prof. P. K. Jha	Prof. Somashekhar S. Hiremath, IIT Madras Prof. J. Ramkumar, IIT Kanpur	30.01.21
15	Mr. Surendra K. Chourasiya	MME	CHARACTERIZATION OF WARM ROLLED SPRAY FORMED ALUMINIUM-SILICON GRAPHITE COMPOSITE	Prof. S. K. Nath Prof. Devendra Singh	Prof. Sunil Mohan, IIT Varanasi Prof. Sudarsan Ghosh, IIT Delhi	19.01.21
16	Mr. Sumit Kumar	MME	HOT DEFORMATION AND PROCESSING MAPS OF ROTOR STEELS	Prof. S. K. Nath Prof. G. P. Chaudhari	Prof. R. Devesh K. Misra, Univ. of Texas at El Paso, USA Prof. Debalay Chakrabarti, IIT Kharagpur	04.02.21
17	Mr. Uma Shanker Tripathi	PH	LIQUID CRYSTAL BASED INTEGRATED OPTIC COMPONENTS AND DEVICES	Prof. Vipul Rastogi	Prof. Pascal Baldi, Univ. Nice-Sophia Antipolis, France Prof. Aloka Sinha, IIT Delhi	07.01.21
18	Mr. Shiv Dutt Purohit	PPE	NANOCOMPOSITE SCAFFOLDS FOR BONE TISSUE ENGINEERING	Prof. N. C. Mishra	Prof. Abhay Pandit, National Univ. of Ireland Galway Prof. Durba Pal, IIT Ropar	21.01.21
19	Prof. Anil Kumar	PPE	DESIGN, SYNTHESIS AND CHARACTERIZATION OF NOVEL LIGANDS AND CORRESPONDING METALLOPOLYMERS AND THEIR APPLICATION AS LUMINESCENT FUNCTIONAL MATERIALS	Prof. A. Bandyopadhyay	Prof. P. S. Mukherjee, IISc Bangalore Prof. Priyadarsi De, IISER Kolkata	01.02.21

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