सीनेट की तरेसठवी बैठक का कार्यवृत्त

MINUTES OF THE 63rd MEETING OF THE SENATE

11 जनवरी 2016
11th JANUARY 2016

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

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

I N D E X

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63.21	उन छात्रों को पी0 एच0डी0 उपाधि प्रदान करने पर विचार किया जाना, जिन्होंने विभिन्न पाठ्यकमों में 4 अक्तूबर 2015 से अब तक उपाधि प्राप्त किए जाने की अर्हता प्राप्त की है। To consider award of the Ph.D. Degrees to the students who have completed the requirements for the award of the Ph.D. Degree in various disciplines w.e.f. 4th October 2015 to till date.	15

MEETING SECTION
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Minutes of the 63rd Meeting of the Senate held on 11.01.2016 in the Senate Hall of the Institute.

Following were present:

Following were present:

1.	Prof. Pradipta Banerji	Director & Chairman
2.	Prof. (Mrs.) Pushplata	(Architecture & Planning)
3.	Prof. V. Devdas	(Architecture & Planning)
4.	Prof. (Mrs.) Ila Gupta	(Architecture & Planning)
5.	Prof. R.P. Singh	(Biotechnology)
6.	Prof. Ramasare Prasad	(Biotechnology)
7.	Prof. Partha Roy	(Biotechnology)
8.	Prof. Shishir Sinha	(Chemical Engineering)
9.	Prof. Ravi Bhushan	(Chemistry)
10.	Prof. Anil Kumar	(Chemistry)
11.	Prof. (Mrs.) Mala Nath	(Chemistry)
12.	Prof. A.K. Singh	(Chemistry)
13.	Prof. U.P. Singh	(Chemistry)
14.	Prof. M.R. Maurya	(Chemistry)
15.	Prof. K.C. Gupta	(Chemistry)
16.	Prof. Deepak Kashyap	(Civil Engineering)
17.	Prof. C.S.P. Ojha	(Civil Engineering)
18.	Prof. S.K. Ghosh	(Civil Engineering)
19.	Prof. M. Parida	(Civil Engineering)
20.	Prof. Praveen Kumar	(Civil Engineering)
21.	Prof. N.K. Samadhiya	(Civil Engineering)
22.	Prof. B.R. Gurjar	(Civil Engineering)
23.	Prof. P. K. Gupta	(Civil Engineering)
24.	Prof. Manoj Mishra	(Computer Science & Engineering)
25.	Prof. (Mrs.) Amita Sinvhal	(Earthquake Engineering)
26.	Prof. R.G.S. Sastry	(Earth Sciences)
27.	Prof. Sandeep Singh	(Earth Sciences)
28.	Prof. R. Krishnamurthi	(Earth Sciences)
29.	Prof. Pramod Agarwal	(Electrical Engineering)
30.	Prof. S.P. Srivastava	(Electrical Engineering)
31.	Prof. M.V. Kartikeyan	(Electronics & Communication Engg.)
32.	Prof. Dharmendra Singh	(Electronics & Communication Engg.)
33.	Prof. D.S. Arya	(Hydrology)

34.	Prof. D.K. Nauriyal	(Humanities & Social Sciences)
35.	Prof. Nagendra Kumar	(Humanities & Social Sciences)
36.	Prof. Y.S. Negi	(Paper Technology)
37.	Prof. S.C. Sharma	(Paper Technology)
38.	Prof. S.P. Sharma	(Mathematics)
39.	Prof. R.C. Mittal	(Mathematics)
40.	Prof. V.K. Katiyar	(Mathematics)
41.	Prof. Kusum Deep	(Mathematics)
42.	Prof. Tanuja Srivastava	(Mathematics)
43.	Prof. N. Sukavanam	(Mathematics)
44.	Prof. Dinesh Kumar	(Mechanical & Industrial Engg.)
45.	Prof. Ravi Kumar	(Mechanical & Industrial Engg.)
46.	Prof. P.K. Ghosh	(Metallurgical & Materials Engg.)
47.	Prof. S.K. Nath	(Metallurgical & Materials Engg.)
48.	Prof. B.S. S. Daniel	(Metallurgical & Materials Engg.)
49.	Prof. Tashi Nautiyal	(Physics)
50.	Prof. K.L. Yadav	(Physics)
51.	Prof. Davinder Kaur Walia	(Physics)
52.	Prof. G.D. Varma	(Physics)
53.	Prof. M.L. Kansal	(WRD&M)
54.	Prof. Ramesh Chandra	(Institute Instrumentation Centre)
55.	Prof. R.P. Saini	(Alternate Hydro Energy Centre)
56.	Prof. M.P. Sharma	(Alternate Hydro Energy Centre)
57.	Prof. Arun Kumar	(Alternate Hydro Energy Centre)
58.	Dr. R. Balasubramanian,	Institute Computer Centre
59.	Dr. P. Jeevanandam	Associate Dean of Students' Welfare (International Students)
60.	Dr. R.K. Peddiniti	Associate Dean, Academic Research
61.	Dr. A.K. Sharma	Associate Dean, Academic Studies
62.	Dr. N.K. Nawani	Associate Dean of Students' Welfare (Bhawans)
63.	Dr. Inderdeep Singh	Associate Dean of Students' Welfare (Discipline)
64.	Dr. R.D. Garg	Chief Warden, Jawahar Bhawan
65.	Dr. Vipul Rastogi, Associate Professor, Department of Physics	
66.	Dr. Barjeev Tyagi, Associate Professor, Department of Electrical Engineering	
67.	Dr. Umesh Sharma, Associate Professor, Department of Civil Engineering	
68.	Dr. K.R. Justin Thomas, Associate Professor, Department of Chemistry	
69.	Dr. Rajat Agarwal, Associate Professor, Department of Management Studies	
70.	Dr. A. Swaminathan, Associate Professor, Mathematics	
71.	Mr. Prashant Garg, Registrar & Secretary, Senate	

The Chairman (Director) welcomed the members to the 63rd Meeting of the Senate.

Before taking up the agenda, the Chairman thanked the under-mentioned outgoing Senate members and recorded its appreciation for their valuable contributions in the meetings of the Senate:

1. Prof. A.K. Jain, Department of Civil Engineering
2. Prof. P.K. Gupta, Department of Earth Sciences
3. Prof. Shri Chand, Department of Chemical Engineering
4. Mr. Yogendra Singh, Librarian
5. Dr. (Mrs.) Smita Jha, Associate Professor, Department of Humanities & Social Sciences
6. Dr. Pravindra Kumar, Associate Professor, Department of Biotechnology
7. Dr. Anil K. Gourishetty, Assistant Professor, Department of Physics
8. Dr. Rajat Rastogi, Associate Professor, Department of Civil Engineering

The Chairman also welcomed the under-mentioned new members to the Senate and hoped for their valuable contributions and active participation in its functioning:

1. Prof. Debashish Ghosh, Department of Electronics & Communication Engineering
2. Prof. D.S. Arya, Department of Hydrology
3. Prof. S. Rangenekar, Department of Management Studies
4. Prof. (Mrs.) Shashi, Department of Chemical Engineering
5. Prof. R.P. Saini, Alternate Hydro Energy Centre
6. Prof. Arun Kumar, Alternate Hydro Energy Centre
7. Prof. M.P. Sharma, Alternate Hydro Energy Centre
8. Dr. Vipul Rastogi, Associate Professor, Department of Physics
9. Dr. Barjeev Tyagi, Associate Professor, Department of Electrical Engineering
10. Dr. Manish Mishra, Associate Professor, Department of Mechanical & Industrial Engineering
11. Dr. Umesh Sharma, Associate Professor, Department of Civil Engineering
12. Dr. K.R. Justin Thomas, Associate Professor, Department of Chemistry
13. Dr. Rajat Agarwal, Associate Professor, Department of Management Studies

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

1. Prof. Bhim Singh, IIT Delhi
2. Prof. Vinod Kumar, Dy. Director
3. Prof. B.K. Maheshwari, Department of Earthquake Engineering
4. Prof. Dharm Dutt, IIT Roorkee Saharanpur Campus
5. Prof. N.K. Goel, Department of Hydrology
6. Prof. Rajesh Srivastava, Department of Physics
7. Prof. Deepak Khare, W.R.D. & M.
8. Prof. Kamal Jain, Department of Civil Engineering

9. Prof. S.S. Jain, Department of Civil Engineering
10. Prof. B. Mohanty, Department of Chemical Engineering
11. Prof. V.K. Agarwal, Department of Chemical Engineering

The Agenda was then taken up:

Item No. 63.1: To confirm the minutes of the 62nd meeting of the Senate held on 29.09.2015.

The minutes of the 62nd meeting of the Senate held on 29.09.2015 were confirmed. The relative weights of the following courses were modified as per approved Senate guidelines:

S. No.	Subject Code	Subject Area	Credits	Contact Hours/Week			Exam. Duration (Hrs.)		Relative Weights				
				L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1.	PEN-102	PCC	4	3	0	2/2	3	0	20	20	20	40	0
2.	CYN-013	BSC	2	0	0	4	0	0	0	50	0	0	50
3.	PEN-206	PCC	3	3	0	0	3	0	25	0	25	50	0
4.	PEN-208	PCC	3	2	0	3/2	2	0	20	20	20	40	0

Item No.63.2: To receive a report on the actions taken to implement the decisions taken by the Senate in its 62nd meeting held on 29.09.2015.

The Senate noted the actions taken on the resolutions of the 62nd meeting held on 29.09.2015.

Item No. 63.3: To consider the policy for conversion of status from Full-time to Part-Time of students of PG Programme for working on dissertation.

The Senate considered the proposal of IAPC to modify the policy of converting status from Full-Time to Part-Time of students of PG programme for working on Dissertation and decided the following:

1. If the student submits NOC within TWO months of joining the job before completing Dissertation Stage-I, he/she will be allowed to complete both the stages of dissertation in next two years but not before 18 months (9 months for each stage of dissertation).

2. If the student submits NOC within TWO months of joining the job after completing Dissertation Stage-I, he/she will be allowed to complete second stage of dissertation in the next one year but not before NINE months.

3. If the student is unable to submit NOC within TWO months of joining the job before completing Dissertation Stage-I, he/she will not be allowed to complete the dissertation. He/she will be allowed to complete dissertation only after he/she submits NOC and works for at least 18 months (9 months for each stage of dissertation) but within 24 months from the date of NOC. In such cases, the maximum duration for completing M.Tech. degree may exceed 3 years.

It was also decided that the conversion of status from full-time to part-time even during the course work be also considered by IAPC and bring as separate item in the next Senate meeting.

Item No. 63.4: **To consider the Inter-IIT Semester Exchange Programme as proposed by IIT Bombay.**

The Senate considered the proposal of Inter-IIT Semester Exchange Programme as proposed by IIT Bombay and the recommendations of the IAPC and decided that, in principle, the student exchange programme between IIT Bombay and IIT Roorkee be approved as both have signed an MoU in 2012 with the following conditions:

a) Equal number of students shall be exchanged between the two Institutes in any semester.

b) Students shall be allowed to go under exchange programme only after completion of the 2nd year.

c) The equivalence of the courses to be studied shall be decided before permitting the student to go under exchange programme.

d) Dean, Academics of both the Institutes will formulate a policy for student exchange.

Item No. 63.5: **To consider the syllabi of programme core and programme electives of B.Tech. (Polymer Science and Technology) to be floated for III Year Spring Semester onwards as received from Prof. In-charge, SRE Campus.**

The Senate considered the syllabi of following programme core and programme electives of B.Tech. (Polymer Science and Technology) from III Year spring semester onwards as recommended by the IAPC and decided that the same be approved:

1. PEN-302: Rubber Material and Chemistry
2. PEN-304: Process System Analysis and Control
3. PEN-312: High Performance and Specialty Polymers
4. PEN-314: Biomedical Polymers
5. PEN-316: Functional Polymers
6. PEN-411: Rubber Processing and Applications
7. PEN-412: Chemical Engineering Thermodynamics
8. PEN-413: Paint Technology
9. PEN-414: Numerical Methods
10. PEN-415: Polymer and Tissue Technology
11. PEN-416: Process Optimization
12. PEN-421: Electronic and Conducting Polymers
13. PEN-422: Polymers Recycling and Environment
14. PEN-423: Membrane Technology
15. PEN-424: Polymer Degradation and Stability
16. PEN-425: Polymer for Packaging Technology
17. PEN-426: Adhesives and Sealants
18. PEN-427:Applications of Nanotechnology in Polymers
19. PEN-428: Polymers for Smart and Memristive Materials
20. PEN-429: Polymers and Advanced Technologies
21. PEN-430: Computation Fluid Dynamics of Polymers
22. PEN-431: Application of Polymers in Drug Delivery

The syllabi of the approved courses are given in **Appendix 'A'**.

Item No. 63.6: **To consider the syllabi of following two Departmental Electives received from the Department of Computer Science and Engineering:**

1. **CSN-524: Algorithms and Foundation of Chip Design** (New Course)

2. **CSN-382: Machine Learning** (Modified Course)

The Senate considered the syllabi of following

programme core courses as proposed by the Department of Computer Science & Engineering and recommended by the IAPC. The Senate decided that the same be approved:

1. **CSN-524: Algorithms and Foundation of Chip Design**
2. **CSN-382: Machine Learning**

The syllabi of all these subjects are given in **Appendix 'B'.**

Item No. 63.7: To consider the proposed changes regarding Chairman, SRC.

The Senate considered the proposed changes regarding Chairman, SRC as recommended by the IAPC and decided that clause R.1.4(a) be modified as given below:

"Any senator preferably subject area expert either from the department or outside can be nominated as chairman, SRC."

After detailed discussion it was also decided that, henceforth, the supervisor shall propose three names each of Internal and External experts after taking their written consent for the formation of SRC. Out of these six names at least two shall be the members of the Senate. The Chairman, DRC and Head of the Department shall decide one of the Senators as Chairman, SRC.

Further, it was decided that this rule will be applicable from July 2016 admission.

Item No. 63.8: To consider the minimum Educational Qualification for admission to Ph.D. Programme of the following centres:

(a) Institute Instrumentation Centre
(b) Centre for Transportation (CTRANS)

The Senate considered the minimum Educational Qualification for admission to Ph.D. Programme of the following centres as proposed by these centres and recommended by the IAPC. The Senate decided that M.Tech. in URBAN Engineering be also included as minimum Educational Qualification for admission to Ph.D programme

in CTRANS.

(a) **Institute Instrumentation Centre**

M.Sc./ M.Tech. in Physics, Applied Physics, Material Science, Chemistry, Electronics & Nanotechnolgy with NET/GATE.

(b) **Centre for Transportation (CTRANS)**

M.Tech./ M.Arch./M.Planning/ M. Des./ MBA or equivalent degree in Civil Engineering/ Mechanical Engineering/ Industrial Engineering/ Production Engineering/ Computer Science & Engineering/ Chemical Engineering/ Infrastructure Systems/ Biotechnology/ Architecture/ Planning/ Urban Engineering/ Business Administration.

Item No. 63.9: To consider the Educational Qualification for admission to Ph.D. Programme in the Disaster Mitigation & Management Centre.

The Senate considered the minimum Educational Qualification for admission to Ph.D. Programme of the Disaster Mitigation & Management as proposed by the centre and recommended by the IAPC. The Senate decided that the following be approved:

Disaster Mitigation & Management

M. Tech. (Civil, Mechanical & Industrial, Chemical, Computer Science), M. Arch & M. Planning or equivalent.

OR

M.Tech. in Geological Technology, Geophysical Technology, Biotechnology or equivalent

OR

M.B.A. or M.C.A. in computer Science or M.Sc. in Physics, Geophysics, Geology, Mathematics, Environmental Sciences (with Maths in B.Sc.), M.Tech. Bio-technology or equivalent.

Item No. 63.10: To consider the request of students for relaxation in grading system for self study course.

The Senate considered the request of students and the recommendation of IAPC for relaxation in grading system for self-study course and decided that, henceforth, there shall be no restriction on maximum grade to be awarded to any student in a self-study course. However, rest of the conditions on self-study course shall remain in force.

It was also decided that students, who intend to go to any other Organization/Institute later on for a semester, may plan their courses such that they need not to take any course as self-study after their return. They may take-up course(s) in previous semester(s).

This will be effective from the session 2016-17.

Item No. 63.11: To consider the procedure of awarding grades in Seminar, Project, Laboratory course and Dissertation.

The Senate considered the procedure of awarding grades in Seminar, Project, Laboratory courses and Dissertation and decided that grades be awarded in Seminar, Project, Laboratory course and Dissertation using Absolute Grading System as per table-given below:

Marks	Grade (Old System)	Grade (New System)	Marks
91 ≤	A+	A or O	-
82 ≤	A	B+	≤ 90
73 ≤	B+	B	≤ 81
64 ≤	B	C+	≤ 72
55 ≤	C+	C	≤ 63
46 ≤	C	D+	≤ 54
35 ≤	D	D	≤ 45
-	F	F	≤ 34

The minimum passing grade in Dissertation shall be C (in old system) and C+ (in new system). This will be effective from January 2016.

Item No. 63.12: To consider the grades of Educational Tour.

The Senate considered the grading of Educational Tour and decided that students shall be graded either as AP (Audit Pass) if they have gone on educational tour or AF (Audit Fail) if they have skipped educational tour. These students shall have to go for educational tour later on to complete the requirement of degree.

Item No. 63.13: To consider the syllabi of B.Tech. 3rd year , Autumn Semester (PP, PEM), B.Tech. 4th year, Autumn Semester (PST, old scheme), corrected code numbers of Departmental Elective II in the teaching scheme of B.Tech. 3rd year (Pulp & Paper) and inclusion of PP-428 in the teaching scheme of B.Tech. (Pulp & Paper) 4th year, Spring Semester.

The Senate considered the syllabi of following programme core and programme electives of different UG programme at SRE campus as proposed by the departments at SRE and recommended by the IAPC. The Senate decided that the same be approved:

B.Tech. (P&P) new 3rd year and 4th year

1. PPN-212: Chemical Reaction Engineering
2. PPN-214: Chemical Engineering Thermodynamics
3. PPN-216: Transport Phenomena
4. PPN-218: Process Optimization
5. PPN-302: Strategy of Process Engineering
6. PPN-304: Paper Properties
7. PPN-306: Printing and Packaging Papers
8. PPN-401: Environmental Management
9. PPN-411: Modelling and Simulation in Pulp and Papermaking Processes
10. PPN-412: Paper Mill Calculations
11. PPN-413: Computer Based Control System
12. PPN-414: Process Integration in Paper Industry
13. PPN-415: Process Dynamics and Control
14. PPN-417: Microprocessor and Its Applications
15. PPN-418: Applications of Biotechnology in Paper Industry
16. PPN-419: Recovery Process Calculations
17. PPN-421: Pulp Mill Calculations
18. PPN-422: Coated and Specialty Papers

19. PPN-423: System Closure in Paper Industry
20. PPN-416: Converting Operations
21. PPN-424: Papermaking Chemistry
22. PPN-425: Paper Physics
23. PPN-426: Packaging Papers
24. PPN-427: Secondary Fibre Processing

Process Engineering and Management

1. PEN-352: Pollution Control Engineering
2. PEN-354: Chemical Plant Design and Economics
3. PEN-356: Financial and Management Accounting
4. PEN-401: Financial Management
5. PEN-402: Operations Management
6. PEN-403: Marketing Management
7. PEN-404: Human Resource Management

Polymer Science and Technology (Old) 4th Year

1. PE-422: Numerical Methods and Optimization in Polymer Engineering
2. PE-424: Petrochemical Technolog
3. PE-426: Polymeric Fibre Technology
4. PE-428: Polymeric Nanomaterials
5. PE-430: Molecular Simulation of Polymers
6. PE-432: Polymeric Film and Packaging Technology
7. PE-434: Equipment Design
8. PE-436: Polymer Product Technology

The syllabi of the approved courses are given in **Appendix 'C'**

Item No. 63.14: To consider the syllabi of new courses proposed by the Department of Management Studies.

The Senate considered the syllabi of the following Institute Elective courses for UG students as proposed by the Department of Management Studies and recommended by the IAPC. The Senate decided that the same be approved:

1. IBM-312: Data Mining for Business Intelligence
2. IBM-313: Project Management
3. IBM-314: Financial Statement Analysis and Reporting

The approved syllabi are given in **Appendix 'D'**. It was also decided that Department of Management Studies should propose the comprehensive list of programme electives for consideration of departmental electives.

Item No. 63.15: To consider the minor change in passing criteria of comprehensive examination.

The Senate considered the minor change in passing criteria of comprehensive examination and decided that Absolute Grading System as given below be continued to award the grade in Comprehensive Written Examination:

Marks	Grades (new system)	Marks
91 ≤	**A**	-
82 ≤	**B+**	≤ 90
73 ≤	**B**	≤ 81
64 ≤	**C+**	≤ 72
55 ≤	**C**	≤ 63
46 ≤	**D+**	≤ 54
35 ≤	**D**	≤ 45
-	**F**	≤ 34

The minimum passing grade in Comprehensive Written Examination shall be **'C+'.** It was also decided that in Comprehensive Oral Examination no grade be awarded. Instead the candidate be declared Pass/Fail/Re-appear after ..... months.

Further, it was also decided that the departments may keep the comprehensive written examination of all research scholars on one day in a semester so that invigilation may not be a problem. The comprehensive written examination may be kept during July-August in autumn semester or in January-February in spring semester and be notified in advance so that every scholar can prepare well in advance.

Item No. 63.16: Reported the mode of implementation of slow pace programme for undergraduate students as recommended by the IAPC and approved by Chairman, Senate. One minor change is made in point 4.

The Senate accepted and noted that if the undergraduate student of 1st Year is unable to get a SGPA of 5.00 at the end of autumn semester OR the student has failed to secure passing grades in one or more sujects, he/she shall be put on slow pace programme as per the following procedure:

1. If the student SGPA is less than 5.00 at the end of 1st Year, autumn semester and he/she has secured passing grades in all subjects, he/she shall be allowed to register for all but ONE courses of spring semester.

2. If the student SGPA is more than or equal to 5.00 at the end of 1st Year, autumn semester but he/she has failed to secure passing grade in one course after ETE and before re-examination, he/she shall be allowed to register for all but ONE courses of spring semester.

3. If the student has failed to secure passing grades in one or more subjects after ETE and before re-examination, he/she shall be allowed to register for all but TWO courses of spring semester.

A NOTE below table in Appendix 'J' be removed accordingly.

4. The courses for the 1st Year, spring semester and for subsequent semesters shall be decided by the mentors of the students.

5. Later on, in any semester, if the student is able to secure SGPA 6.50, he/she shall be allowed to move to normal pace programme.

6. The duration of such students may increase automatically from 4 years to 5 or 6 years.

Item No. 63.17: Reported the modified format of degree certificate for awarding to the Ph.D. scholars of the Institute.

The Senate accepted and noted the modified format of Ph.D. degree certificate indicating the date of PDC as given at **Appendix 'E'**.

The Senate further noted that there is no change in the format of other degree as rest of the programmes are year based and students get their degrees after completing all the courses in a year.

Item No. 63.18: Reported the minor changes in the course for Integrated M.Sc. (Chemistry) final year.

The Senate accepted and noted the minor changes in the course for Integrated M.Sc. Chemistry final year as pointed out by the Head, Department of Chemistry in the beginning of the Semester. **(Appendix 'F').**

Item No. 63.19 Reported for signing the agreement deed for award of scholarship of the value of Rs. 25,000/- (Rs. Twenty Five Thousand only) per year in the name of "Prof. Dr. S.R. Gupta Memorial Scholarship" for student of B.Tech. (Mechanical Engineering) Programme for Economically Weaker Section whose CGPA & Income as per Institute rule applicable for MCM Scholarship and no involvement in acts of Indiscipline received from Mrs. Veena Gupta residing at Am See 8, 65795 Hattersheim, Germany.

The Senate accepted and noted signing of the agreement deed for award of scholarship of the value of Rs. 25,000/- (Rs. Twenty Five Thousand only) per year in the name of "Prof. Dr. S.R. Gupta Memorial Scholarship" for student of B.Tech. (Mechanical Engineering) Programme for Economically Weaker Section whose CGPA & Income as per Institute rule applicable for MCM Scholarship and no involvement in acts of Indiscipline received from Mrs. Veena Gupta residing at Am See 8, 65795 Hattersheim, Germany. **(Appendix 'G')**

Item No. 63.20: Reported for signing the agreement deed for award of Travel Grant for Internship of the value of Rs. 30,000/- (Rs. Thirty thousand only) per year in the name of "Smt. Gomti Devi Travel Grant for Internship" for Any Full Time Student of I.I.T. Roorkee to be decided by the Director, IIT Roorkee received from Sri Indra Prakash Gupta residing at # B 702, Aravali Heights, Sector 21-C, Faridabad 121001, Haryana.

The Senate accepted and noted the signing the agreement deed for award of Travel Grant for Internship of the value of Rs. 30,000/- (Rs. Thirty thousand only) per year in the name of "Smt. Gomti Devi Travel Grant for Internship" for Any Full Time Student of I.I.T. Roorkee to be decided by the Director, IIT Roorkee received from Sri Indra Prakash Gupta residing at # B 702, Aravali Heights, Sector 21-C, Faridabad 121001, Haryana. **(Appendix 'H')**

Item No. 63.21: To consider award of the Ph.D. Degrees to the students who have completed the requirements for the award of the Ph.D. Degree in various disciplines w.e.f. 4th October 2015 to till date.

The Senate considered the award of the Ph.D. Degrees to the students who have completed the requirements for the award of the Ph.D. Degrees in various disciplines w.e.f. October 04, 2015 to till date and approved. The list of the Ph.D. Degree is given in **Appendix 'I'.**

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

Appendix 'A'
Item No. Senate/ 63.5

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF PROGRAMME: **POLYMER AND PROCESS ENGINEERING**

1. Subject Code: **PEN-302** **Course Title: Rubber Material and Chemistry**

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

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

4. Relative Weightage: **CWS : 20** **PRS: 20** **MTE : 20** **ETE : 40** **PRE: 0**

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of structure, properties, processing and applications of elastomers and rubbers.

10. Details of the Course:

S.No.	Contents	Contact Hours
1.	**Introduction:** Definition of elastomers; Effect of molecular weight and glass transition temperature (Tg); Interpreting the properties of elastomers.	6
2	**Essential Properties of Specific Elastomers**: Properties of natural rubber, styrene butadiene rubber, nitrile rubber, ethylene-propylene rubbers, polychloroprene rubber, butyl rubber, fluorocarbon rubber, polybutadiene rubber, polyurethane rubber, chlorosulfonated polyethylene, polyurethanes, silicone rubber and thermoplastic elastomers.	8
3	**Rubber Compounding:** Definition of rubber compounding, process and principles of compounding, basic compound formula, function of different compounding ingredients: gum rubber, curing agents, ZnO, stearic acid, fillers (black and non black), accelerators, antioxidants and anti-degradants, plasticizers and miscellaneous.	8
4	**Vulcanization of Elastomers:** Principles and theory of vulcanization; Definitions of different terms like scorch; Cure/ over cure & study of curing; Different types of vulcanization systems, sulfur and its role in vulcanization; Measurement of Mooney viscosity and state of cure for rubber compound.	8
5.	**Mastication and Mixing of Rubber:** Definition, objective of mixing and mastication, mixing equipments, different mixing process.	3
6.	**Engineering Aspects of Rubber Product Manufacturing:** Applications of rubber in tyre technology, conveyer belt technology, sealing ring technology and hose technology, rubber Latex products, rubber foot ware.	9
	Total	42

List of Practicals:

1. Identification of different rubbers by chemical and spectroscopy methods
2. Processing of rubber in a two roll mill.
3. Processing of rubber with carbon black filler.
4. Processing of rubber with non black loading type filler.
5. Compounding of rubber with ingredients.
6. Vulcanization of rubber.
7. Mechanical properties of vulcanized rubber.

11. Suggested Books:

S.No.	Name of Authors /Books/Publishers	Year of Publication
1.	Johnson P., "Rubber Processing: An Introduction", Hanser-Gardner.	2001
2.	Mark J.E., Erman B. and Eirich F.R., "Science and Technology of Rubber", Elsevier.	2003
3.	Morton M., "Rubber Technology", Van Norstrand-Reinhold.	1987
4.	Bhowmick A.K. and Stephens H.L., "Handbook of elastomers", CRC Press, 2nd Edition	2000
5.	Andrew Ciesielski, "An Introduction to Rubber Technology", Rapra Technology Limited, UK	1999
6.	Blow C.M., "Rubber Technology & manufacture" Buttenvorths, London	1982

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **POLYMER AND PROCESS ENGINEERING**

1. Subject Code: **PEN-304** Course Title: **Process System Analysis and Control**

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

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

4. Relative Weightage: **CWS: 20** **PRS: 20** **MTE: 20** **ETE : 40** **PRE: 0**

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

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge about process control systems and its analysis.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Introduction**: Overview of control system; Classification of process control strategies; Process stability; Transient regulation; Review of Laplace transform methods.	5
2.	**Control Systems**: Response of first order, first-order system in series and second order systems; Interacting and non-interacting systems; Closed-loop transfer functions; Transient response of control systems.	5
3.	**Modes of Control Action:** P, PI, PD, PID and on-off controllers; Feed-forward, feedback, cascade, selective and ratio control systems.	5
4.	**Stability Analysis:** Routh Hurwitz stability criterion; Root locus technique; Polar plots.	5
5.	**Frequency Response Analysis:** Frequency response; Control system design by frequency response; Bode plot; Gain and phase margin.	6
6.	**Controller Tuning:** Controller tuning relations; Tuning relations based on integral error criteria; Comparison of controller design and tuning relations; Ziegler-Nichols and Cohen-Coon methods.	8
7.	**Computer Based Control Systems:** Introduction to advanced control systems; Block diagram and architecture of pneumatic,	8

	electronic, microprocessor; Programmable and distributed control systems; PLC and DCS based systems and their advantages and limitations; Performance analysis of PLC, MP's and DCS based systems.	
	Total	**42**

List of Practicals:

1. Study of Transient response to single tank system with storage and flow to (a) step change (b) impulse change in put.
2. Study of characteristics and transient response of non-interacting tanks in series using (i) Step Input and (ii) Impulse Input
3. Study of characteristics and transient response of interacting tanks in series using (i) Step Input and (ii) Impulse Input
4. Study of the performance of RTD/Hg thermometer, analyze the variation of resistance with temperature, and verify the first order response.
5. To study the control actions: ON/OFF, P, PI and PID on a temperature control trainer.
6. To study the control actions: ON/OFF, P, PI and PID on a Level control trainer.
7. To study the control actions: ON/OFF, P, PI and PID on a Flow control trainer.
8. To study controlling actions of Response (ii) ON/OFF controller (iii) P-controller (iv) PI controller and to determine open loop response.
9. To study the control valve characteristics (i) Valve Flow co-efficient (ii) Installed characteristics.

11. Suggested Books:

S.No.	Name of Books / Authors / Publisher	Year of Publication / Reprint
1.	Bequette B.W., "Process Control – Modeling, Design and Simulation", Prentice Hall of India.	2003
2.	Coughanour D.R., 2nd Ed., "Process System Analysis and Control", McGraw Hill.	1991
3.	Seborg D.E., Edgar T.F. and Mellichamp D.A., "Process Dynamics Control", 2nd Ed., John Wiley & Sons.	2008
4.	Stephanopoulos G., "Chemical Process Control- An Introduction to Theory and Practice", Prentice Hall of India.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **POLYMER AND PROCESS ENGINEERING**

1. Subject Code: **PEN-312** Course Title: **High Performance and Specialty Polymers**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of structure, properties, processing and manufacturing of the polymeric materials.

10. Details of Course:

S.No.	Contents	Contact Hours
1	**Engineering Polymers:** Polymerization and industrial processing; Unit operations, catalysts, flow chart of industrial production, structure, properties and applications of engineering polymers – polyolefins, vinyl and stryrene based polymers: poly (vinyl chloride), polystyrene, styrene co-polymers, ABS, SAN, polyisobutylene, poly(1-Butylene), polyacrylics; Polyethylene, polypropylene.	8
2	**Macromolecular Structure of High Performance Polymers:** Semi rigid, quasi-rigid and rigid rod macromolecules; Macromolecular chain rigidity and rotational hindrance; Effect of chain rigidity on thermal and mechanical properties of high performance polymers.	6
3	**High Performance Thermoplastics**: Structure, properties, engineering and high-tech applications of following high performance polymers: polyamides, polyesters, polycarbonate, polyethers, poly-ether-ether-ketone, polyphenylene sulphide, polysulphones, polyphenylene-oxides.	8
4	**Thermally Stable Polymers:** Structure, properties, engineering and high-tech applications of high performance polymers, polyesterimides, polyetherimides, polybismelimides, polyamide, polyimide, poly-amide-imide.	6
5	**High Performance Matrix Resins for Composites:** Molecular structure, physical, thermal, mechanical properties of thermosetting and thermoplastic polymers forming matrix resins for composites, applications of high tech composites.	8
6	**High Performance Polymers for Engineering Applications:** High performance polymers for applications: automobile, aerospace, transportation and other engineering and high tech applications.	6
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors / Books / Publisher	Year of Publication
1.	Brydson J. A., "Plastic Materials", Newnes Butterworth	1989
2.	Campbell I.M. , "Introduction to Synthetic Polymers", Oxford University Press	2000
3.	Erhstein G., "Polymeric Materials", Hanser Gardner.	2001
4.	Fin J. K., "High performance polymers", Elsevier, 2nd Edition.	2014

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT./CENTRE: **POLYMER AND PROCESS ENGINEERING**

1. Subject Code: **PEN-314** Course Title: **Biomedical Polymers**

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

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

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

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

8. Pre-requisite: **NIL**

9. Objective: To impart knowledge about biopolymers and their applications, engineering and processing.

10. Details of Course:

S.No.	CONTENTS	Contact Hours
1.	**Introduction:** Definition, examples, applications and classification of biopolymers based on different sources; General characteristics of biopolymers, advantages and disadvantages of biopolymers.	5
2.	**Synthesis and Characterization of Bio-polymers:** Structure and properties of proteins, polysaccharides, DNA, RNA, glycoproteins, proteoglycans, glycosaminoglycans.	8
3.	**Biodegradation of Biopolymers:** Mechanism of biodegradation; Biodegradation kinetics.	4
4.	**Engineering of Biopolymers:** Principles of engineering the properties of biopolymer molecules; Chemical modification; Biopolymer based composites and blends.	8
5.	**Biopolymer Processing:** Process technology for the production of biopolymeric nanoparticles, nanofibers, nanofilms, microfilms, 3D architecture of any shape.	8
6.	**Application of Biopolymers**: Application of biopolymers in tissue engineering, medical surgery, drug delivery, wound healing, packaging, automobile industry, electronics industry, household items etc.	9
	TOTAL	42

11. Suggested Books:

S. No.	Name of Books / Authors /Publisher	Year of Publication / Reprint
1.	Dumitriu S., "Polymeric Biomaterials", Marcel Dekker.	2002
2.	Hyon S. H., "Polymeric Biomaterials", Plennum Press.	1984
3.	Mark H. F., (Ed.) "Encyclopaedia of Polymer Science and Engineering", John Wiley & Sons.	1989
4.	Shuiz S. and Bhirmer K., "Principles of Protein Structure", Academic Press.	2003
5.	Guilak F., Butler D.L., Goldstein S.A. and S.A. Mooney, "Functional Tissue Engineering", Springer-Verlag New York, 1st Edition.	2003
6.	Migonney V., "Biomaterials", Wiley-ISTE, 1st Edition.	2014

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **POLYMER AND PROCESS ENGINEERING**

1. Subject Code: **PEN-316** Course Title: **Functional Polymers**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge of synthesis, device fabrication and application of smart materials

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Introduction:** General introduction to functional polymers: Conducting, electronic, bio-polymers, energy storage polymers	5
2.	**Different kind of Functional Polymers:** Synthesis and characterization of different functional polymers *viz.* block copolymers, self-assembled polymers, dendrimers, hyperbranched polymers, organo gels.	7
3.	**Polymers for Energy Storage:** Structure, properties of polymers used in energy storage; Principal of energy storage, supercapacitors and fuel cell; Mechanism of ion conduction and diffusion in polymers.	7
4.	**Lithium Polymer Electrolytes:** Metal-polymer interaction, solid-solid interfacing; Types of polymer electrolytes (gel, glass, ceramic and polymer composite), properties, electrochemical stability; Electrochemical characterization by cyclic voltammetery and electrochemical impedance spectroscopy; Li-ion batteries.	8
5.	**Polymers for Solar Cell:** Principal and design of solar PV cells; Application of polymer electrolyte in dye sensitized solar cell; Nano-composite polymer electrolytes; Synthesis and characterization of dye sensitized polymer electrolyte.	8
6.	**Functional Polymers in Food and Environmental Engineering:** Functional polymers in food processing and pollution control; Interaction of synthetic polymers with bio-molecules during food processing; Engineered materials as food preservatives.	7
	Total	42

11. Suggested Books:

S.No.	Name of Authors/ Books/ Publisher	Year of publication
1.	Brydson J.A., "Plastic Materials", Butterworth-Heinemann	1999
2.	Theato P. and Klok, H.A., "Functional Polymers by Post-Polymerization Modification: Concept", Wiley-VCH	2013
3.	Cirillo G., Spizzirri, U.G. and Iemma, F., "Functional Polymers in Food Science: From Technology to Biology", Volume 1	2014
4.	Bergbreiter D.E. and Martin, R., "Functional Polymers", Springer	1989

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF PROGRAMME: **POLYMER AND PROCESS ENGINEERING**

1. Subject Code: **PEN-411** Course Title: **Rubber Processing and Applications**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of processing and applications of different rubbers.

10. Details of the Course:

S.No.	Contents	Contact Hours
1.	**Introduction:** Machinery used for rubber mixing- two roll mills, internal mixers and continuous mixers; Master batch preparation, blending and mixing on mills, internal mixers and continuous mixers; Calendaring technology; Fabric coating using calendar and spreading machine.	5
2	**Rubber Compounding:** Principles of rubber compounding; Compounding to meet processing and vulcanisate properties; Reinforcement of elastomers by fillers; Factors influencing reinforcement and mechanism of reinforcement; Compounding and manufacture of cycle tyres and tubes, solid tyres, mechanical seals, sports goods, surgical products and miscellaneous moulded, extruded and calendered rubber products.	8
3	**Rubber Moulding**: Compression, transfer and injection moulding of rubbers; Flashless moulding; Finishing of moulded articles; Calculation of mould shrinkage; Molding defects and its remedies; Machinery used for extrusion: Ram and screw extruders, crosshead extruders and strainers; Vulcanization methods other than moulding; Batch curing and continuous curing method; Open steam autoclaves, hot air, fluidized bed, LCM, molten salt bath and high energy radiation curing.	7
4	**Tyre Technology:** Different types of tyres; bias belted, radial, tubed and tubeless tyres: their basic features and performance comparison; Different components of a tyre, its geometry and functions; Manufacturing techniques of tyres for various vehicles like 2- and 4-wheeler, OTR farm and air craft; Method of building bias belted, radial and tubeless tyres, green tyre treatments; Tyre curing methods, post cure inflation, quality control tests.	9
5.	**Engineering Aspects of Rubber Product other than Tyre:** Manufacturing techniques of conveyer belt technology, sealing ring technology, V-belt, footwear	9

	technology, hose technology, rubber coated roll, cable technology, vibration isolation and mounts.	
6.	**Recent Trends in Rubber Manufacturing Technology:** Some recent trends of rubber processing technology; Electron beam curing of rubber products; Computer aided rubber product design; Coated fabric technology.	4
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors /Books/Publishers	Year of Publication
1.	Bhowmick A.K., "Rubber Product Manufacturing Technology" CRC Press.	1994
2.	Johnson P., "Rubber Processing: An Introduction", Hanser-Gardner.	2001
3.	Morton M., "Rubber Technology", Van Norstrand-Reinhold.	1987
4.	Bhowmick A.K., "Current Topics in Elastomer Research" CRC Press.	2008
5.	Ciesielski A., "An Introduction to Rubber Technology" Rapra Technology Limited, UK.	1999
6.	Blow C.M., "Rubber Technology & Manufacture" Buttenworths, London.	1982

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **POLYMER AND PROCESS ENGINEERING**

1. Subject Code: **PEN-412** Course Title: **Chemical Engineering Thermodynamics**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge on the concepts and application of thermodynamics to various chemical engineering systems and processes.

10. Details of Course:

S.No.	Contents	Contact Hours
1	**Introduction:** Laws of thermodynamics; Closed system and open system; Internal energy, enthalpy, entropy and free energy; PVT behavior of fluids; Gibb's phase rule.	4
2	**Thermodynamic Properties of Fluids:** Virial and cubic equations of state; Theorem of corresponding states; Generalized correlations for gases and liquids; Property relations for homogeneous phases; Concept of residual properties; Property relations for two-phase systems; Thermodynamic diagrams.	8
3	**Phase Equilibria:** Nature of equilibrium; Phase rule; Duhem's theorem; Qualitative behavior of vapour liquid equilibria (VLE); VLE by modified Raoult's law; osmotic pressure.	6
4	**Solution Thermodynamics:** Chemical potential and phase equilibriums; Ideal-gas mixtures; Partial properties; Fugacity coefficients; Ideal solution, excess properties and activity coefficients; Margules, Redlich-Kister, NRTL, UNIQUAC and UNIFAC models for excess Gibbs free energy; Property changes in mixing and heat effects; VLE for miscible, partially miscible and immiscible systems.	8
5	**Chemical-Reaction Equilibriums:** Application of equilibrium criteria to chemical reactions; Standard Gibbs-energy change and the equilibrium constant; Evaluation of equilibrium constants; Equilibrium conversions for single reactions; Heterogeneous reactions; Adiabatic reaction temperature.	8
6	**Introduction to Molecular Thermodynamics:** Molecular theory of fluids; Second virial coefficients from potential functions; Molecular basis for mixture behavior; Monte-Carlo simulation of interacting particles; Isobaric-isothermal ensemble, grand canonical ensemble.	8
	- 28 - **Total**	42

11. Suggested Books:

S.No.	Name of Books / Authors	Year of Publication
1	Kyle B.G., "Chemical and Process Thermodynamics", 3rd Ed., Prentice Hall of India.	2008
2	Rao Y.V.C., "Chemical Engineering Thermodynamics", Universities Press.	2011
3	Sandler S.I., "Chemical, Biochemical, and Engineering Thermodynamics", 4th Ed., John Wiley.	2008
4	Smith J. M., Van Ness H.C. and Abbott M.M., "Introduction to Chemical Engineering Thermodynamics", 6th Ed., Tata McGraw Hill.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT./CENTRE: **POLYMER AND PROCESS ENGINEERING**

1. Subject Code: **PEN-413** Course Title: **Paint Technology**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge about paint, paint formulation and paint manufacture.

10. Details of Course:

S.No.	CONTENTS	Contact Hours
1.	**Introduction:** Definition and properties; Importance of paints; Classification of paints; Varnishes, primer, emulsion paint, lacquers and powder coatings, inks; Industrial paints: automobile, marine, luminous, antifouling and cement paints.	5
2.	**Basic Paint Ingredients:** Binder classification, properties and sources; Synthetic and natural resins, acrylics, vinyl acrylics, polyurethane, polyester, melamine resins, epoxy, oils; Classification of binder based on drying and curing mechanism; Pigments, Classification and their properties; Solvent, types and properties; Fillers; Paint additives.	6
3.	**Formulation and Manufacturing of Paints:** Principles of paint formulation; Phenomenon of wetting, grinding and dispersion; Steps in paint manufacturing; Problems in paint manufacturing and their solutions; Paint preservation methodologies.	6
4.	**Equipment used in Paint Manufacturing:** Principle, design and operations of paint manufacturing equipments, Ball mills, pebble mills, heavy duty mixtures, double blade mixture, high speed disk disperser.	7
5.	**Paint Applications, Drying, and Curing:** Pretreatment and surface preparation; Application methods; Acceleration of drying and curing; Drying and curing processes; Factors affecting choice of methods.	6
6.	**Common Paint Defects, Causes and Prevention:** Defects, peeling, clouding, dirt inclusions, sanding marks, runs, pinholes in topcoats and substrates, solvent pop, blistering, edge mapping, water spotting; Causes of defects and methods of prevention.	4
7.	**Paint Testing**: Important paint properties; Scrape adhesion test; Pull-off test; Cross cut test; Wedge-cut method for determination of film thickness (scribe and drill method); Determination of scratch resistance by constant-loading and variable method; Evaluation of degradation of coatings.	5

8.	**Safety Measures:** Pollution from solvent, pigment and binders; Safety measures in paint industry and pollution control.	3
	TOTAL	**42**

11. Suggested Books:

S.No.	Name of Books / Authors /Publisher	Year of Publication/ Reprint
1.	Morgans W. M., "Outlines of Paint Technology", 3rd Ed., .CBS Publishers.	1990
2.	Bentley J. and Turner G. P. A., "Introduction to Paint Chemistry and Principles of Paint Technology", 4th Ed., CRC Press.	1997
3.	Toda K., Abraham S. and Kozo S., "Automotive Painting Technology", 1st Ed., Springer.	2013
4.	Koleske J. V., "Paint and Coating Testing Manual", 15th Ed., ASTM International.	2012
5.	Klebstoffe I., "Adhesives Technology Compendium", 1st Ed., Springer.	2013

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **POLYMER AND PROCESS ENGINEERING**

1. Subject Code: **PEN- 414** Course Title: **Numerical Methods**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge of numerical tools to solve problems related to polymer science and process engineering.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Linear algebraic equations; Cramer's rule; Gauss elimination method; Gauss-Jordan elimination; LU decomposition method; Jacobi, and Gauss-Siedel iterative and Relaxation methods; Eigen values and Eigen vectors of matrices.	05
2.	**Solution of Non-linear Algebraic Equations:** Fixed point method; Secant and modified Secant method; Regula-falsi method; Bisection method; Single and multivariable Newton-Raphson and Applications to computationally solving non-linear equations from problems of polymeric systems, heat transfer.	05
3.	**Function Evaluation:** Least squares curve-fit procedure; Newton, Lagrange and Hermite Interpolation formulae; Newton's divided difference interpolation polynomial; Inverse interpolation; Cubic Spline and Piecewise interpolation; Applications to solving problems in heat and mass transfer, thermodyanamics and reaction engg.	05
4.	**Numerical Integration and Differentiation:** Newton's Cotes Formulae; Trapezoidal, Simpson's rules- one third, the composite, and three-eighth rule; Numerical integration of functions-Romberg integration; Gauss-Legendre, and Integral equations; Adaptive Quadrature; Numerical differentiation; Richardson extrapolation; Accuracy of differentiation formulae; Application to various chemical engg. problems pertaining to- fluid particle mechanics, Heat and Mass transfer, Environmental engg.	05

5.	**Ordinary Differential Equations – Initial Value Problems (ODE-IVPs):** Introduction to ODE-IVPs; Picard-, Euler- and Milne's method; Muller- Runge–Kutta Methods; Explicit and implicit Adams-Bashforth and Adam-Moulton methods; Multiple-step integration error methods; Step-Size control and Estimates of Error; Algorithm stability; ODE-IVPs with Coupled Algebraic Equations; Application examples from polymeric systems, heat and mass transfer:	07
6.	**Ordinary Differential Equations – Boundary Value Problems (ODE-BVPs):** Introduction to ODE-BVPs; Finite Difference technique; Overview of Rayleigh-Ritz, Collocation and Galerkin methods; Orthogonal Collocation (OC); Orthogonal Collocation on Finite Elements (OCFE); Galerkin Finite Element (GFE) technique; Shooting techniques; Examples of computationally solving problems in polymeric systems, heat and mass transfer;	07
7.	**Partial Differential Equations (PDEs):** Finite Difference technique; Method of weighted residuals and variational methods; Orthogonal collocation (OC) and double orthogonal collocation (DOC); Orthogonal collocation on finite elements (OCFE); Application examples, unsteady-state reaction-diffusion problem in spherical porous catalyst particle, steady-state flow problem of reacting fluid in tubular reactor, steady-state heat conduction problem in two or more directions.	08
	Total	**42**

11. Suggested Books:

S.No.	Name of Books / Authors	Year of Publication
1	Chapra S. and Canale R., "Numerical Methods for Engineers", 5th Ed., McGraw Hill.	2007
2	Gerald C. F. and Patrick O. Wheatley, "Applied Numerical Analysis" 5th Ed., Addition-Wesley.	1998
3.	Gupta S. K., "Numerical Methods for Engineers", New Age Intl. Publishers.	2005
4.	Rao K. S., "Numerical Methods for Scientists and Engineers", PHI Learning Pvt. Ltd.	2007
5.	Ghosh P., "Numerical Methods with Computer Programs in C++", PHI Learning Pvt. Ltd.	2006
6	Grewal B.S. and Grewal J.S., "Numerical Methods in Engineering and Science with programs in C & C++", 9th Ed., Khanna Publishers, Delhi	2011

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **POLYMER AND PROCESS ENGINEERING**

1. Subject code: **PEN-415** Course title: **Polymer and Tissue Technology**

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

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

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

5. Credit: **4** 6. Semester: **Both** 7. Subject area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of tissue engineering and biomaterials.

10. Details of course:

S.No.	Contents	Contact Hours
1	**Introduction:** Definition, principles and practices of tissue engineering; Tissue engineering triad;	2
2	**Cells, Scaffolds and Growth Factors:** Structure of cell; Cellular functions; Cell culture techniques; Different types of cells and their applications; Types and properties of scaffolds; Scaffold modifications; Growth factors; pH, temperature, chemical, electrochemical and mechanical stimuli; *In-vitro* and *in-vivo* environmental stimuli.	7
3	**Polymers and Biomaterials for Tissue Engineering:** Definition and classification of biomaterials and polymers; Natural and synthetic polymer system; Smart polymers; Polymer blends and composites; Bioceramics; Metal based scaffold-materials; Nanomaterials; Physical, mechanical, and chemical properties of biomaterials; Biocompatibility and biodegradation; Tailoring of polymers and biomaterial properties.	8
4	**Scaffold Fabrication Techniques:** Solvent casting; Porogen leaching; Gas foaming; Self assembly; Electrospinning; Phase-separation; Rapid prototyping/hybrid printer; Fiber mesh and fiber bonding; Melt molding; Freeze drying; Decellulerization; Controlling pore size and porosity of the scaffold.	7
5	**Scaffold Characterisation and Cell Behaviour on Scaffold:** Determination of porosity, pore size, hydrophilicity, mechanical strength, roughness, toxicity, biocompatibility and biodegradability of the scaffold; Determination of shape, size, growth, proliferation and differentiation of cells.	8
6	**Bioreactors for Tissue Engineering:** Ideal bioreactor and its major characteristics; Fabrication of bioreactor; Scale-up possibilities for tissue engineered constructs.	4

7	**Regulatory and Clinical Issues:** Pre-clinical evaluation of tissue engineered constructs; Trends in food and drug administration; Ethical issues; Dealing with ethical issues.	3
8	**Future Advancements:** Overcoming present drawbacks; Dealing with ethical issues.	3
	TOTAL	**42**

11. Suggested Books:

S.No.	Name of Books / Authors	Year of Publication
1.	Lanza R.P., Langer R. and Vacanti J., "Principles of Tissue Engineering", Academic Press, 4th Edition.	2014
2.	Guilak F., Butler D.L., Goldstein S.A. and Mooney S.A., "Functional Tissue Engineering", Springer-Verlag, New York, 1st Ed.	2003
3.	Migonney V., "Biomaterials", Wiley-ISTE, 1st Ed.	2014
4.	Shi D., "Biomaterials and Tissue Engineering" Springer-Verlag, New York, 1st Ed.	2004
5.	Helsen J. A. and Missirlis Y., "Biomaterials", Springer-Verlag, New York, 1st Ed.	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **POLYMER AND PROCESS ENGINEERING**

1. Subject Code: **PEN-416** Course Title: **Process Optimization**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge of optimization of Chemical Processes

10. Details of Course:

S.No.	Contents	Contact Hours
1	**Introduction to Process Optimization:** Chemical processes and need of optimization, examples of various application of optimization.	02
2	**Optimization using Search Techniques:** Introduction, developing models, objective function formulation, bisection, golden-section, Fibonacci search, simplex, box-complex methods, applications to polymer engineering	08
3	**Optimization using Gradient Techniques:** Steepest descent, conjugate gradient, Newton's method, TRUST algorithm	06
4	**Mathematical Programming:** Linear Programming, Sequential quadratic programming, constraint programming, Branch and Bound algorithms, Mixed integer linear programming, Application to polymer engineering.	08
5	**Multi-objective optimization and Meta-heuristic Algorithms:** Introduction, □-constraint method, Pareto Optimal Front, Genetic Algorithm, Particle-swarm Algorithm, application to polymer engineering	08
6	**Application to Polymer Engineering:** Case studies of polymers: nylon, PMMA, PET, Poly Styrene, PE; Case studies of monomer production: phthalic anhydride, maleic anhydride; Case studies of polymer supply chain: PVC, PET, Crude oil	10
	Total	42

11. Suggested Books:

S.No.	Name of Books / Authors	Year of Publication
1.	Edgar T.F., Himmelblau, D.M. and Lasdon L.S., "Optimization of Chemical Processes", 2nd Ed., McGraw Hill, New York.	2001
2	Beveridge G.S.G. and Schechter, R. S., "Optimization: Theory and Practice", McGraw Hill, New York	1970
3.	Rao S. S., "Engineering Optimization: Theory and Practice", New Age Intl. Publishers.	2005
4.	Deb K., "Multi-objective optimization using evolutionary algorithms", Wiley.	2001
5.	Coello C. A., Veldhuizen D.A.V. and Lamont G. B., "Evolutionary algorithms for solving multi-objective problems", Springer, New York	2007
6.	Rangaiah G.P., "Multi-Objective Optimization Techniques and Applications in Chemical Engineering (Advances in Process System Engineering", Vol. 1, World Scientific, Singapore.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **POLYMER AND PROCESS ENGINEERING**

1. Subject Code: **PEN-421** Course Title: **Electronic and Conducting Polymers**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: The course will impart knowledge of electronic and conducting polymers

10. Details of Course:

S.No.	Particulars	Contact Hours
1.	**Introduction:** Conducting polymers, structurally different conducting polymers and their general applications.	3
2.	**Conducting Polymers:** Structure and preparation of conducting polymers, polyacetylene, polydiacetylene, polyphenylene, polypyrrole, polythiophene, polyaniline, poly(phenylene sulphide) and poly(1,6-heptadiyne); Properties and applications; Mechanism of conduction.	9
3.	**Photoconducting and Photoresist Polymers**: Molecularly designed synthesis and characterization of light sensitive and photo conducting polymers and their applications; Positive and negative polymer resists for lithographic process, semiconductor fabrication by LB films and spin coatings techniques	9
4.	**Polymers for Optoelectronics:** Synthesis of Guest-Host type and side chain liquid crystalline polymers; LASER and its mechanism; NLO chromophore-functionalized polymers; Light sensitive polymers exhibiting second harmonic and third harmonic generation; Poling of Guest- Host polymers; Optical characterization and applications.	9
5.	**Piezoelectric, Pyroelectric and Ferroelectric Polymers:** Synthesis, characterization and typical applications of these polymers.	6
6.	**Applications:** Polymers in telecommunications, microelectronics, insulations, submarine cable insulation, optical fiber cables.	6
	Total	42

11. Suggested Books:

S.No.	Name of Authors /Books /Publishers	Year of Publication
1.	Goosey M.T. "Plastic for Electronics", Elsevier, Applied Science Publishers	1985
2.	Licari J.J. "Hand book for Polymer Coatings for Electronics Chemistry, Technology and Applications", Noyes Publications	1985
3.	Mark H.F., "Encyclopedia of Polymer Science and Engineering," John Wiley and Sons	1989
4.	Nalwa H.S. and Miyata, S., "Nonlinear Optics of Organic Molecules and Polymers", CRC Press, Inc.	1997
5.	Skotheim T.A. and Reynolds, J.R. "Conjugated Polymers; Processing and Applications", CRC Press	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **POLYMER AND PROCESS ENGINEERING**

1. Subject Code: **PEN-422** Course Title: **Polymers Recycling and Environment**

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

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

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

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

8. Pre-requisite: **Nil**

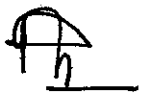
9. Objective : To impart knowledge of adverse effects of polymers on the environment and recycling of waste polymers.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Introduction to Polymer Recycling:** Disposed plastics, pollution, environmental issues related to plastic industry, plastic waste recycle.	4
2.	**Plastic Waste:** Sources of plastic waste: municipal, industrial, agricultural and medical; Plastic waste accumulation; Separation and segregation of plastics waste: Polyethylene, polypropylene, polyvinylchloride, polystyrene, polyester, polyurethane, thermosets and thermoplastics.	7
3.	**Environmental Effects on Waste Polymers:** Stability and degradation of polymers in environment; Photo and bio degradation of plastics waste, effect of plastic degradation on environment; Weather parameters influencing lifetime of waste plastics; Polymer waste in sea and marine environment, and on hills and mountains.	6
4.	**Polymer Degradation Mechanism:** Solid phase degradation of polymers through catalytic, UV, oxidative, hydrolytic, thermal and pyrolytic processes; Polymer degradation in solution; Mechanism and kinetics of polymer degradation.	5
5.	**Waste Plastics Recycling**: Collection of plastics waste for recycling; Reuse of plastics; Processes for recycling of thermoplastics and thermosets; Recycling of plastic waste based on an individual plastic; Recycling of mixed thermoplastics and thermosets; Recycling of mixtures of both thermoplastics and thermosets.	7
6.	**Thermal Treatment of Plastics Waste:** Methods and processes; Thermal degradation, incineration and energy recovery from waste plastics: Polyethylene, polypropylene, polyvinylchloride, polystyrene, polyester; Energy requirements for plastic waste destruction.	8
7.	**Sustainability**: Life cycle of plastics; Sustainability, economy, legislation and regulations for waste polymers, future of plastics.	5
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors /Books /Publishers	Year of Publication
1.	Andrady A.L., "Plastics and The Environment", Wiley Interscience.	2003
2.	Bisio A.L. and Xanthos M., (Eds.), "How to Manage Plastics Waste: Technology and Market Opportunities", Carl Hanser Verlag.	1994
3.	Brandrup J. "Recycling and Recovery of Plastics", Hanser Gardner.	1996
4.	Scheirs J. "Polymer Recycling, Science, Technology and Applications", John Wiley & Sons.	1998



INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **POLYMER AND PROCESS ENGINEERING**

1. Subject Code: **PEN-423** Course Title: **Membrane Technology**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge about polymeric membranes and its application in separation processes.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Introduction**: Separation concepts: diffusion across a membrane, terminologies in membrane separation processes, driving forces, type of membranes.	2
2.	**Transport Mechanism through Membrane:** Concentration and process gradients, solution-diffusion model, concentration polarization, gel layer concentration.	4
3.	**Membrane Materials:** Polyethylene, polytetrafluroethylene, polypropylene, cellulose acetate, cellulose nitrite, polyacrylonitrile, polyimide, polyamide, polysulfone, polyethersulfone, block copolymeric materials; Bi-polar membrane materials; Inorganic membranes.	6
4.	**Polymeric Membrane Preparation, Testing and Applications:** Sintering, stretching, track-etching, template leaching, phase inversion techniques (diffusion-induced phase separation & thermally-induced phase separation), phase inversion membrane and interfacial polymerization; Membrane testing and morphology; Applications, haemodialysis, beverage, food industry, water treatment and fuel cell.	6
5.	**Microfiltration and Ultrafiltration:** Membrane properties, concentration polarization and fouling, fouling during protein separation, cross-flow and dead-end microfiltration/ultrafiltration, micellar enhanced ultrafiltration, selected application and economics.	5
6.	**Nanofiltration and Reverse Osmosis:** Membrane properties, osmotic pressure model, membrane fouling, design consideration, pretreatment, applications in desalination and wastewater treatment, economic consideration.	6

7.	**Pervaporation:** Membrane properties, process diagram, mechanism, selectivity and flux, model consideration, application (alcohol concentration, VOC and other pollutant separation).	4
8.	**Membrane Reactor:** Membrane separation with chemical reaction; Membrane bioreactor, catalytic membranes, equilibrium limited reaction, membrane reactor for hazardous pollutant degradation, functionalized membrane.	5
9.	**Membrane Application for Water/Wastewater Treatment and System Design:** Hydride processes and novel application, selected environmental applications involving for water reuse and material recovery, membrane flux, fouling and separation optimization.	4
	Total	**42**

11. Suggested Books:

S.No.	Name of Books / Authors	Year of Publication
1.	Mulder M., "Basic Principles of Membrane Technology", Kluwer Academic Publisher.	1996
2.	Baker R.W., "Membrane Technology & Application", McGraw Hill.	2000
3.	Zeman L. J. and Zydney A. L., " Microfiltration and Ultrafiltration: Principle & Application", Marcel Dekker Inc.	1996
4.	Nath K., "Membrane Separation Processes", Prentice Hall of India.	2008
5.	Scott K., "Handbook of Industrial Membrane", Elsevier.	1995
6.	Schaefer A., "Nanofiltration, Principle & Application", Elsevier.	2004
7.	Drioli E. Criscuoli A. and Curcio, E., "Membrane Contactors: Fundamentals, Applications and Potentialities", Elsevier.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **POLYMER AND PROCESS ENGINEERING**

1. Subject Code: **PEN-424** Course Title: **Polymer Degradation and Stability**

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

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

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

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

8. Pre-requisite: **NIL**

9. Objective: To impart knowledge on various factors influencing stability and degradation of polymers

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Introduction:** Polymer degradation by various means: Heat, oxygen, light/UV, ozone, chemical, mechanical and biological; Role of chemical structure towards degradation; Advantages and disadvantages of polymer degradation; Case studies from various industries; Polymer stabilization.	4
2.	**Thermo-Oxidative Degradation:** Mechanisms of thermal degradation: Radical and non-radical de-polymerization, cyclization with elimination; Mechanisms of oxidative and thermo-oxidative degradation: Auto oxidation, oxidative chain reaction, chemical changes in polymers during oxidative degradation; Effect of chemical structure on oxidation rate. Degradation during manufacturing and service; Degradation effects on product performance with case studies.	6
3.	**Photo-degradation:** Mechanism of photo-oxidative degradation and photo-degradation of important polymers: polyolefins, acrylates and its copolymers, methyl vinyl ketone, polystyrene, polymers with heteroatoms in main chain and condensation polymers.	6
4.	**Antioxidants and Stabilizers:** Mechanism of antioxidant action; Chain breaking antioxidants; Preventive antioxidants; Synergism and antagonism; Chain breaking acceptor antioxidants; Metal deactivators; UV screens and filters; Stabilization of polymers during manufacture and in service; Melt stabilization; Thermal oxidative stabilization; Polymer bound antioxidants; UV stabilizers.	6
5.	**Degradation in Special Environments:** Polymers under stress; Degradation in harsh environments: Nitrogen dioxide, sulfur dioxide, ablation, mechanical and ultrasonic degradation; Quantitative aspects of ultrasonic degradation and changes in molecular weight; Degradation by high energy radiation and radiation protection; hydrolytic degradation.	6

6.	**Degradation of Polymeric Biomaterials:** Introduction to degradation of biomaterials; Controlling degradation rate and drug release in biomaterials; Degradation through oxidation, hydrolysis, enzymolysis, photolysis, stimuli-sensitive; Immune response to degradation.	6
7.	**Polymer Degradation Kinetics:** Random chain scission, mid chain scission, end chain scission; Kinetics based on mode of chain scission; Kinetics of solid phase thermal degradation (pyrolysis): order of reaction, rate constant, effect of temperature, reactive gas, radical donor, catalyst on rate constant, energy of activation; Kinetics of solution degradation of polymer: rate constants, role of radical donor, Lewis acid, catalyst on rate constant; Stoichiometric carnal, molecular weight distribution, population balance of polymer chains, integro-differential equation and it's analytical solution; Optimum temperature in degradation with initiator.	5
8.	**Biodegradable Polymers and Polymer Recycling:** Biodegradation of polymers in soil and water; Case studies of biodegradable polymers; Recent trends in biodegradability. Limitations to polymer recycling; Case studies: Polyolefins, PET, PVC, PS, nylon, PU, polymer composites, tyres.	3
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors / Books / Publisher	Year of Publication
1.	Hamid S. H., "Handbook of Polymer Degradation", 2nd Ed., CRC Press, Taylor and Francis Group	2000
2.	Billingham N. C., "Degradation and Stabilization of Polymers", Wiley Online Library	2013
3.	Jellenick H.H.G., "Polymer Degradation and Stability", 1st Edition, Elsevier Amsterdam, the Netherlands	1983
4.	Ranby. B. and Rabek. J. F., "Photo-degradation, Photo oxidation and photo-stabilisation of polymers", Wiley and Sons.	1975
5.	Denisov E. T. and Denisova. T. G., "Handbook of Antioxidants, Second edition, CRC Press, Taylor and Francis Group	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **POLYMER AND PROCESS ENGINEERING**

1. Subject Code: **PEN-425** Course Title: **Polymer for Packaging Technology**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge about polymers used in packaging industry.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Introduction:** Packaging technology raw materials, types of forms, products, applications and consumption pattern, evaluation of films; Comparison of polymer packaging with paper, metal and glass materials.	2
2.	**Packaging Materials and Properties:** Major polymers used for packaging applications, polyethylene, EVA, ionomers, HDPE, LLDPE, PP, PVC, PVDC, PS, PVOH, EVOH, nylon, polyester, polycarbonate, fluoropolymers, acrylonitrile copolymers, thermoplastic elastomer, cellophane and cellulose plastics, polymer blends; Adhesives for packaging; Properties for packaging: MVTR, OTR, mechanical, thermal, optical, chemical.	8
3.	**Packaging Converting Processes:** Blown film extrusion, Cast film extrusion, films co-extrusion; Coating and lamination; Manufacturing of flexible packaging; Thermoforming; Injection molding; Blow moulding: extrusion and injection blow moulding; Calendering; Foam manufacturing; Sealing methods.	8
4.	**Biobased Packaging:** Edible and biobased food packaging materials; Edible, polysaccharide, lipid and protein based coating; First, second and third biobased packaging materials; Permeability of thermoplastic polymers; Multilayer films, processing, degradation, deteriorative reaction in foods; Enzyme reactions; Chemical reactions; Physical and biological change.	8
5.	**Food Packaging:** Asceptic packaging of foods; Sterilization of packaging materials; Packaging of ready-to-eat and microwavable foods; Active and intelligent packaging; Modified atmospheric packaging; Packaging of horticultural products, dairy products, cereals, snack foods and confectionary, beverages; Shelf life of foods and factors controlling shelf life; Safety and legislative aspects of packaging.	8

6.	**Package Printing Technologies:** Print production workflow, typography, graphic design, artwork, prepress, printing, post press/finishing; Materials: Substrates, ink; Drying methods; Recent trends; Printing methods, lithography, flexography, gravure.	8
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors/ Books/ Publisher	Year of Publication
1.	Susan E.M., Selke J., Culter D. and Ruben J. "Plastics Packaging: Properties, Processing, Applications and Regulations", Hanser.	2004
2.	Pringer O.G. and Baner A.L. "Plastic Packaging Materials for Food: Barrier Function, Mass Transport, Quality Assurance and Legislation", John Wiley and Sons.	2008
3.	Sina E., "Plastic Films in Food Packaging: Materials, Technology and Applications", Elsevier.	2012
4.	Robertson G.L., "Food Packaging Principles and Practice", Second Edition, CRC Press.	2006
5.	Nayak S.K., "Fundamental of Plastic Testing", Springer.	2010
6.	Kipphan H., "Handbook of Print Media", Springer.	2004
7.	Johansson K., Lundberg P. and Ruberg R., "A Guide to Graphic Print Production", Wiley.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **POLYMER AND PROCESS ENGINEERING**

1. Subject Code: **PEN-426** Course Title: **Adhesives and Sealants**

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

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

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

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

8. Pre-requisite: **NIL**

9. Objective: To provide knowledge of various polymeric adhesives and sealants.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Introduction:** Theory and mechanism of adhesion; Types of polymeric adhesives; Advantages and disadvantages of adhesive bonding over conventional joining techniques; Industrial examples of adhesion and adhesive joints; Release coatings; Adhesive coating equipments'.	5
2.	**Performance Properties:** Description of performance properties of adhesives and their determination, peel strength, shear strength, tack (green tack, etc), creep and visco-elastic properties.	5
3.	**Adhesive Types:** Properties, formulation principle, production techniques, additives and applications of the following adhesives, pressure sensitive adhesives, structural adhesives, one part and multi-part adhesives, hot-melt adhesives, natural rubber adhesives, butyl and polyisobutylene adhesives, vinyl-ether adhesives, urea-formaldehyde adhesives, melamine-formaldehyde and resorcinol based adhesives.	8
4.	**Adhesive Characterization:** Characterization of degree of branching, crystallinity, side-chain substitution, cross-linking, molecular weight, backing material; Identification of elastomer, tackifier, plasticizer, antioxidant and fillers.	5
5.	**Additives and its Effects:** Tackifiers, cross-linkers, antioxidants, plasticizers, colorants, fillers and scents used to enhance mechanical performance, ageing characteristics, ease of use and application performance.	3

6.	**Surface Preparation:** Surface treatment procedures of substrates to improve adhesive bonding; Mechanical preparation, priming, corona treatment and chemical etching.	3
7.	**Specialty Adhesives:** Anaerobic adhesives, bio-adhesives, reactive adhesives and adhesives that get activated using light/UV and heat; Adhesives examples for various industries viz. electronics, wood industry, healthcare, construction, packaging, textiles, automotive, consumer, abrasives and friction material shoes, electrical, paper and aerospace.	5
8.	**Introduction to Sealants**: Introduction to sealants, caulks and mastics; Advantages and disadvantages of sealant bonding over conventional joining techniques.	2
9.	**Sealant Performance, Characterization and Applications:** Sealant types, reactive sealants, sealants based on water or solvent; Properties and formulation of sealants relevant to different application; Curing process of sealants; Characterization of sealants; Additives and its effects on sealant performance; Performance testing; Surface preparation; Specialty sealants; Production processes and equipments; Sealant application in various industries; Major trends in technology and markets.	6
	Total	**42**

11. Suggested Books:

S.No.	Name of Books / Authors	Year of Publication
1.	Satas D., "Handbook of Pressure Sensitive Adhesive Technology" 2nd Edition, Kamal Book International Publications.	2014
2.	"Handbook of Adhesive Technology", Taylor and Francis Group, 2nd Edition, LLC.	2003
3.	Benedek I., "Pressure Sensitive Adhesive and Applications", Marcel Dekker Publications.	2004
4.	Petrie E. M., "Handbook of Adhesives and Sealants", 2nd edition, The McGraw-Hill Companies, Inc.	2007
5.	Flick E. W., "Handbook of Adhesives Raw Material", Noyel Publication.	1989

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **POLYMER AND PROCESS ENGINEERING**

1. Subject Code: **PEN-427** Course Title: **Applications of Nanotechnology in Polymers**

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

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

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

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

8. Pre-requisite: **NIL**

9. Objective: To impart knowledge of nanotechnology applications in polymer industry.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Advancement of nanocomposite, nanofillers; Classification of nanofillers, nanoclay, nanosilica, nanoparticles, carbon based nanofillers; Synthesis and properties of fillers.	6
2.	**Synthesis of Nanocomposites**: Direct mixing, solution mixing, in-situ polymerization, ex-situ processing; Ceramic/polymer composites; Metal/polymer nanocomposites; Modification of interfaces; Modification of nanofillers.	6
3.	**Mechanical Properties of Nanocomposites**: Stress-strain properties - tensile, modulus, elongation at break; Flexural properties; Load-carrying capability; Toughness; Impact resistance; Relaxation behavior; Wear resistance.	7
4.	**Thermal and Optical Properties of Nanocomposites**: Thermal stability and flammability; Dynamic mechanical thermal properties; Glass transition; Electrical properties: Resistivity, permittivity, breakdown strength; Optical properties: Refractive index, transparency.	8
5.	**Morphological Aspect of Nanocomposites**: Characterization of nanocomposites by XRD, TEM, AFM and FESEM.	7
6.	**Barrier Properties of Polymer Nanocomposites:** Permeation and diffusion models relevant to polymer nanocomposites; Diffusivity, sorption, permeability.	5
7.	**Applications:** Some examples of advanced applications of polymer nanocomposites; Space, automobiles, defence and modern life.	3
	- 50 - Total	42

11. Suggested Books:

S.No.	Name of Book / Authors	Year of Publication
1.	Mai Y.W. and Yu Z.Z., "Polymer Nanocomposites", Woodhead Publishing Limited and CRC Press LLC, USA.	2006
2.	Ajayan P.M., Schadler, L.S. and Braun, P.V., "Nanocomposite Science and Technology" Wiley-VCH Verlag GmbH Co. KGaA, Weinheim.	2003
3.	Nicolais L. and Carotenuto G., "Metal-Polymer Nanocomposites" Willy Inter Science	2005
4.	Sergeev G.B., "Nanochemistry" Elsevier	2006
5.	Ke Y.C. and Stroeve P., "Polymer-Layered Silicate and Silica Nanocomposites" Elsevier	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **POLYMER AND PROCESS ENGINEERING**

1. Subject Code: **PEN-428** Course Title: **Polymers for Smart & Memristive Materials**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge of synthesis, device fabrication and application of smart materials

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Introduction:** Definition of memristive and smart materials and their classification; Class of polymers having said properties.	2
2.	**Memristive Materials:** Electrical memory switching polymers; Volatile memory and non-volatile memory: definition and classification, I-V characteristics; Transistor, Reversibility and memory sustaining capability.	6
3.	**Synthesis and Characterization of Smart and Memristive Materials:** Synthetic procedure for different polymers, characterization, advantages and disadvantages; Device fabrication techniques; Detailed characterization by AFM, SEM techniques.	8
4.	**Memristive Devices with Different Polymeric Materials:** Organic, inorganic, metal doped organic and organic-metallic hybrid devices; Switching and carrier transport mechanism; Shape memory polymers: Definition, classification and applications.	8
5.	**Smart Materials:** Definition, classification, advantages and disadvantages of electrochromic materials; Applications in e-paper, smart glass window, display; Definition, classification and applications of halochromic, pH sensitive, self-healing, piezoelectric and photochromic materials.	8
6.	**Device Fabrication Techniques and Characterization:** Memristive device: Sandwich and lateral device, advantages and	6

	disadvantages; Electrochromic materials; Use of supporting electrolyte in device fabrication and its importance, different types of supporting electrolytes, detailed device fabrication for other smart devices.	
7.	**Real Life Applications:** Applications in memory chip, glass window, display system and others; Advantages and limitations of such devices.	**4**
	Total	**42**

11. Suggested Books:

Sl. No	Name of Authors/ Books/ Publisher	Year of publication
1.	Tu C.-H., "Electrical Switching and Memory Behaviors in Organic-based Devices", ProQuest.	2008
2.	Burghartz J.N., "Guide to State-of-the-art Electronic Devices", John Wiley & Sons.	2013
3.	Dai L., "Intelligent Macromolecules for Smart Devices: From Materials Synthesis to Device Applications", Springer.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **POLYMER AND PROCESS ENGINEERING**

1. Subject Code: **PEN-429** Course Title: **Polymers and Advanced Technologies**

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

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

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

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

8. Pre-requisite: **NIL**

9. Objective: To provide knowledge of advanced polymer technologies.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Introduction:** Processing of thermosetting and thermoplastic high performance products, 3D printing, polymers in defense and aerospace applications, computer aided product design, polymers in non-linear optics, light emitting polymers, photovoltaic applications.	4
2.	**Advanced Thermoset Processing Technologies:** Operating principles, process controls and applications of resin transfer molding, pultrusion, filament winding, prepeg layup and compression moulding of thermosets; Processing of unsaturated polymers, polyesters, epoxy resins, phenolics, polyurethanes, polyimides and polyaramides; Reinforcements; Glass fiber, aramid fiber, carbon fiber and nanoclay; Dimensional stability and tolerance of thermoset products.	8
3.	**Advanced Thermoplastic Processing Technologies:** Operating principles, process controls and applications of reactive injection molding and reactive extrusion; Processing of thermoplastic polymers; Ultra high molecular weight PE, teflon, PEEK and polyimides; Fiber spinning of vectran, kevlar, polyimides and polyaramides; Electospinning process; Nano-impregnation; 3D-printing; Metal inserts.	6
4.	**Polymers in Defense and Aerospace Applications:** Criteria for defense and space standard polymeric materials, composites applications and challenges for light weight design of aircraft	8

	structure and defense vehicles, self healing of fibre reinforced polymer composites, shape memory alloys integrated into composites for improved damage tolerance and lightening strike protection, carbon fibre based composites in aerospace and defence applications, multifunctional composites with carbon nanotubes and nanoclay for space applications, polymers for ballestic protection, fire retardant polymeric coatings, polymer actuators.	
5.	**Computer Aided Polymer Design:** Methodology, CAMD approach, polymer property prediction models, GC+ Models, Marrero/Gani group contribution method atom-connectivity index method, CAMD algorithm for polymer design, computer-aided polymer design using group contribution plus property models, some case studies.	8
6.	**Polymers in Optical Applications:** Nonlinear optical properties in polymers; Design and fabrication of polymeric nonlinear optical devices; Polymers for electro-optic modular waveguides; Light emission from semiconducting polymer; Electrical and optical properties of polymer for biomedical applications; Polymers for photovoltaic applications.	8
	Total	**42**

11. Suggested Books:

S.No.	Name of Books / Authors	Year of Publication
1.	Chris R, "Polymer Extrusion", 5th Edition, Hanser Publications, Hanser.	2014
2.	Cheremisinoff N. P., "Advanced Polymer Processing", 2nd Edition, Noyes Publications,	1998
3.	Shonaike G O, Advani S G, "Advanced Polymeric Materials", CRC Press	2003
4.	Ajayan P. M., Schadler L. S., Braun P. V., "Nanocomposite Science and Technology" Wiley-VCH	2003
5.	Wise D.L., Wnek G. E., Trantola, D. J., Copper T. M., Gresser J. D., "Electrical and Optical Polymer Systems", 1st Edition, Marcel Dekker Inc.	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **POLYMER AND PROCESS ENGINEERING**

1. Subject Code: **PEN-430** Course Title: **Computational Fluid Dynamics of Polymers**

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

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

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

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

8. Pre-requisite: **NIL**

9. Objective: To provide knowledge of computational procedures for understanding fluid (polymer) dynamic behavior

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Introduction:** Conservation laws of fluid motion and boundary conditions; Conservation equations: mass, momentum and energy equations; Convective forms of the equations and general description; Governing equations of fluid flow and heat transfer; Overview of numerical methods.	4
2.	**Turbulence and its Modeling:** Transition from laminar to turbulent flow; Effect of turbulence on time averaged Navier-Stokes equations; Characteristics of simple turbulent flows, free turbulent flows, flat plate boundary layer and pipe flow; Turbulence models; Mixing length model; Reynolds stress equation models; Algebraic stress equation models.	5
3.	**Grid Generation:** Structured and unstructured grids; Choice of grid; General transformation of equations; Some modern developments in grid generation in solving the engineering problems related to polymer industry.	5
4.	**Finite Volume Method for Diffusion Problems:** Finite volume methods; Different types of finite volume grids; Approximation of surface and volume integrals; Interpolation methods; One, two- and three-dimensional steady state diffusion problems; Discretised equations for diffusion problems.	6

5.	**Finite Volume Method for Convection-Diffusion Problems**: Steady one dimensional convection and diffusion; The central differencing scheme; Properties of discretisation schemes-conservativeness, boundedness, and transportiveness; Assessment of the central differencing scheme for convection-diffusion problems.	6
6.	**Finite Volume Method for Unsteady-state Flows and Implementation of Boundary Conditions**: One-dimensional unsteady state heat conduction; Discretisation of transient convection-diffusion equation; Solution procedures for unsteady flow calculations; Implementation of inlet, outlet and wall boundary conditions; Constant pressure boundary condition; Applications to the engineering problems for polymer industries.	6
7.	**Finite Difference Method:** Discretization of ordinary and partial differential equations; Approximation of first, second and mixed derivatives; Implementation of boundary conditions; Discretization errors; Applications to the engineering problems for polymer industries.	5
8.	**Finite Element Methods:** Finite element methods; Rayleigh-Ritz, Galerkin and least square methods; Interpolation functions; Applications to the polymer industry engineering problems.	5
	Total	**42**

11. Suggested Books:

S.No.	Name of Books / Authors	Year of Publication
1.	Versteeg H.K. and Malalasekera W., "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", Longman Scientific and Technical publishers.	2007
2.	Anderson J.D., "Computational Fluid Dynamics: The Basics with Applications", McGraw-Hill, New York.	1995
3.	Fletcher C.A.J, "Computational Techniques for Fluid Dynamics, Vol. 1: Fundamental and General Techniques", Springer-Verlag.	1998
4.	Fletcher C.A.J, "Computational Techniques for Fluid Dynamics, Vol. 2: Specific Techniques for Different Flow Categories", Springer-Verlag.	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **POLYMER AND PROCESS ENGINEERING**

1. Subject Code: **PEN-431** Course Title: **Application of Polymer in Drug Delivery**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge on various polymers used in drug delivery applications

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Introduction:** Polymers used in drug delivery, synthetic and natural polymers: cellulose, poly-ethylene glycol, poly-n-vinyl pyrilidone, PCL, PLA, PLGA, HMPA.	04
2.	**Conventional Techniques of Drug Delivery:** Compression, spray, dip-coating and encapsulation, diffusion controlled systems, solvent activated system, bio-degradable system.	04
3.	**Responsive Polymers for Drug Delivery:** Responsive systems based on temperature, pH and redox potential, polymer therapeutics, polymer-drug conjugates, protein-polymer conjugates	04
4.	**Polyelectrolytes:** Polyelectrolytes, characterization of polyelectrolytes application of polyelectrolyte complexes; Soluble drug carriers, polymeric micelles, liposomes, microgel, nanogel, nanoparticles, dendrimers, examples	06
5.	**Current Thrust in Drug Delivery:** Endosomolytic polymers and macromolecules, role of poly (ethylene glycol), peptide and protein drugs, microencapsulation of polymeric drug e.g. RNA, protein; drug –polymer interactions.	08
6.	**Polymeric Biomaterial and its Stability:** Polymer stability with pH, temperature, oxido-reductive, and phagocyte effect; Adsorption of polymers from solution; Macromolecular adsorption over polymer interface; Protein adsorption; Colloid stability, Control of protein adsorption	08
7.	**Novel Drug Delivery Systems:** Mucosal, transdermal drug delivery system (TDDS), bio-degradable polymeric stent, parenteral implants, ophthalmic insets, micro encapsulation, intrauterine delivery system (IUDs); Targeted drug delivery systems.	08
	Total	42

11. Suggested Books:

S.No.	Name of Authors / Books / Publisher	Year of Publication
1	Lachman L. and Lieberman H.A., "The Theory and Practice of Industrial Pharmacy", CBS publishers, India.	2005
2.	Avis K. E. and Lieberman H.A., "Pharmaceutical dosage forms, Parenteral medications", 2 nd ed,Vol I,II and III, Marcel Dekiker	1993
3.	Tyle P., "Drug Delivery System", 1st Ed, Marcel Decker	1988
4.	Jain N. K., "Advances in controlled and novel drug delivery", 1 st Ed., CBS Publication	2001
5.	Robinson J.R. and Lee V.L. "Controlled Drug Delivery: Fundamental and Applications", Marcel Dekker, USA.	2003
6.	Radomsky M., Liu L. and Iwamoto Z., "Sustained Release Injectable Products, Interpharm Englewood, Colorado.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CSN-524** Course Title: **Algorithms and Foundations of Chip Design**

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

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

4. Relative Weightage: **CWS: 20** **PRS: 20** **MTE: 20** **ETE: 40** **PRE: 0**

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

8. Pre-requisite: Knowledge of digital logic design, computer architecture and microprocessors, design and analysis of algorithms

9. Objective: To introduce the concepts and techniques used in computer-aided-design of VLSI chips, embedded system design, fault-tolerant system design and in other emerging technologies, e.g., microfluidic chips, 3D ICs, quantum computers, etc.

10. Details of the Course:

Sl.No.	Contents	Contact Hours
1.	**Introduction:** VLSI design flow, challenges	3
2.	**Verilog/VHDL:** introduction and use in synthesis, modeling combinational and sequential logic, writing test benches	5
3.	**Logic synthesis:** two-level and multi-level logic optimization of combinational circuits, state assignment of finite state machines	4
4.	**Basic concepts of high-level synthesis:** architectural models, scheduling, allocation and binding	5
5.	**Physical design automation algorithms:** partitioning, floorplanning, placement and routing. layout compaction, design rule check, power and delay estimation, clock and power routing, etc., special considerations for analog and mixed-signal designs	8
6.	**Technology mapping:** review of MOS/CMOS fabrication technology, VLSI design styles: full-custom, standard-cell, gate-array and FPGA	4
7.	**Testability issues:** fault modeling and simulation, test generation, design for testability, built-in self-test, testing SoC's	4
8.	**Related topics:** basic concepts of verification, embedded system design techniques, hardware-software codesign, fault-tolerant system design	4
9.	**EDA for emerging technologies:** CAD for microfluidic biochips, 3D ICs, Quantum computers, etc.	5
	Total	42

11. Suggested Books:

Sl.No.	Name of Books / Authors	Year of Publication
1.	J. Bhasker, Verilog HDL Synthesis: A Practical Primer, B S Publications.	2001
2.	G. D. Micheli, Synthesis and Optimization of Digital Circuits. McGraw Hill	2003
3.	D. D. Gajski, N. D. Dutt, A. C. Wu and A. Y. Yin, High-level Synthesis: Introduction to Chip and System Design, Kluwer Academic Publishers.	2012
4.	S. M. Sait and H. Youssef, VLSI Physical Design Automation: Theory and Practice, World Scientific.	2010
5.	M. L. Bushnell and V. D. Agrawal, Essentials of Electronic Testing, Kluwer Academic Publishers.	2005
6.	Frank Vahid and Tony Givargis, Embedded System Design: A Unified Hardware/Software Introduction, Wiley-Press.	2006
7.	Israel Koren and C. Mani Krishna, Fault-Tolerant Systems, Morgan-Kaufman Publishers.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CSN-382** Course Title: **Machine Learning**

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

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

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

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

8. Pre-requisite: **NIL**

9.Objective: To provide an understanding of the research advances and different techniques of pattern recognition and machine learning.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	**Introduction:** Overview of learning, Supervised vs Unsupervised learning, Patterns and Features, Pattern Recognition approach and its applications.	06
2.	**Classification Techniques:** Nearest Neighbors, Decision Trees, Perceptrons, Neural Network, Support Vector Machine.	08
4.	**Unsupervised Methods:** Curse of Dimensionality, Principal Component Analysis, Linear Discriminant Analysis, K-Means, Expectation Maximization, Vector Quantization, SOM.	08
5.	**Bayesian Network Fundamentals:** Probability basics, Inference and Learning in Bayesian Networks, Belief Propagation, Graphical Models, Hidden Markov Models.	08
6.	**Classifier Ensembles:** Bagging, Boosting, AdaBoost, Random Forests.	06
7.	**Evolutionary Algorithms:** Genetic Programming, Evolutionary strategies, Particle swarm optimization, Ant Colony Optimization.	06
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Books / Authors	Year of Publication
1.	C.M. Bishop. "Pattern Recognition and Machine Learning", Springer	2013
2.	R. Duda, P. Hart and D. Stork. "Pattern Classification", Wiley	2001
3.	A. E. Eiben, J. E. Smith, "Introduction to Evolutionary Computing" Springer.	2008
4.	T. Mitchell. "Machine Learning", McGraw Hill	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN-212** Course Title: **Chemical Reaction Engineering**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge on the kinetics, design and operation of chemical reactors.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Reaction rate, rate expression, reaction mechanism, temperature dependence of reaction rate, interpretation of kinetic data from batch reactors.	5
2.	**Reactor Design:** Ideal reactor models, mixed flow reactors, plug flow reactors, multiple reactor systems, recycle reactor, autocatalytic reaction, parallel and series reactions, reversible and irreversible reactions, temperature and pressure effects.	8
3.	**Non-ideal Flow:** Non-ideal flow patterns, E-, F-, and C-curves, mean residence time, models for non-ideal flow, tanks in series model, conversion in a reactor using residence time distribution (RTD) data; Mixing of two fluids.	8
4.	**Heterogeneous Process:** Global rates of reaction, types of heterogeneous reactions; Catalysis, the nature of catalytic reactions, mechanisms of catalytic reactions, classification of catalysts. catalysts' deactivation, fluid-solid catalytic reactions, rates of adsorption, surface reaction, and desorption, rate limiting step, power law, Langmuir-Hinshelwood mechanism, Eley-Rideal mechanism.	9
5.	**Reactors:** Packed bed reactors, fluidized bed reactors, slurry reactors, trickle–bed reactors, three-phase fluidized beds, single and multi-bed adiabatic reactors; Non-isothermal operation and stability of reactors.	8

6.	**Bio-chemical Reaction Engineering:** M-M kinetics, Monod kinetics, enzymatic and microbial fermentation, bio-reactors, substrate and product limiting systems.	4
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Carberry J. J., "Chemical and Catalytic Reaction Engineering", Courier Dover.	2001
2.	Davis M. E. and Davis, R. J., "Fundamentals of Chemical Reaction Engineering", McGraw Hill.	2002
3.	Fogler H. S., "Elements of Chemical Reaction Engineering", 4th Ed., Prentice Hall of India.	2008
4.	Hayes R. E., "Chemical Reactor Analysis", Taylor and Francis.	2001
5.	Holland C. D. and Anthony R. G., "Fundamentals of Chemical Reaction Engineering", Prentice-Hall.	1989
6.	Levenspiel O., "Chemical Reaction Engineering", 3rd Ed., John Wiley.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN-214** Course Title: **Chemical Engineering Thermodynamics**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge on the concepts and application of thermodynamics to various chemical engineering systems and processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Laws of thermodynamics, PVT behavior of fluids – Gibb's phase rule, cubic equations of state and generalized correlations	2
2	**Thermodynamic Properties of Fluids:** Virial and cubic equations of state, theorem of corresponding states, acentric factor, generalized correlations for gases and liquids; Property relations for homogeneous phases; Concept of residual properties, residual properties by equations of state; Property relations for two-phase systems; Thermodynamic diagrams.	6
3	**Phase Equilibria:** Nature of equilibrium, the phase rule, Duhem's theorem, qualitative behavior of vapour liquid equilibria (VLE), Raoult's law, Henry's law, VLE by modified Raoult's law and from K-value correlations.	8
4	**Solution Thermodynamics:** The chemical potential and phase equilibria, partial properties, ideal-gas mixtures, fugacity coefficients for pure species and species in solution, generalized correlations for the fugacity coefficients; The ideal solution, excess properties, activity coefficients; Models for the excess Gibbs energy: Margules, van Laar, Wilson, UNIQUAC, and UNIFAC equations, Property changes of mixing, heat effects; VLE for miscible, partially miscible and immiscible systems, VLE calculations at low and high pressures.	10

5	**Chemical-Reaction Equilibria:** Application of equilibrium criteria to chemical reactions, the standard Gibbs-energy change and the equilibrium constant, effect of temperature on the equilibrium constant, evaluation of equilibrium constants; Equilibrium conversions for single reactions.	6
6	**Thermodynamic Analysis of Processes:** Work and free energy, availability, analysis of mixing, separation processes, heat exchange, lost work calculations	6
7	**Introduction to Molecular Thermodynamics:** Molecular theory of fluids, second virial coefficients from potential functions, molecular basis for mixture behavior.	4
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1	Kyle B. G., "Chemical and Process Thermodynamics", 3rd Ed., Prentice Hall of India.	2008
2	Koretsky M.D., "Engineering and Chemical thermodynamics", John Wiley	2004
3	Rao Y. V. C., "Chemical Engineering Thermodynamics", Sangam Books.	2007
4	Sandler S.I. "Chemical, Biochemical, and Engineering Thermodynamics", 4th Ed., John Wiley.	2008
5	Smith J. M., Van Ness H. C. and Abbott M. M., "Introduction to Chemical Engineering Thermodynamics", 6th Ed., Tata McGraw Hill.	2008
6	Narayanan, K.V., "Chemical Engineering Thermodynamics", Prentice Hall.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN -216** Course Title: **Transport Phenomena**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of momentum, heat and mass transport problems in process industries.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Molecular Transport Phenomena:** Molecular transport of momentum, heat and mass, law of molecular transport, Newton's law of viscosity, Fourier's law of conduction and Fick's law of diffusion. Transport coefficients-viscosity, thermal conductivity and mass diffusivity; Estimation of transport coefficients and temperature/pressure dependence	8
2	**Non-Newtonian Fluids:** Time independent, time-dependent and viscoelastic fluids, constitutive equations and rheological characteristics.	4
3	**Equations of Change Under Laminar Flow Conditions:** Equation of continuity, motion, mechanical energy, energy and mass transport; Simple shell balance method for momentum, heat, and mass transport, velocity distribution in circular conduits and parallel plates; Generalized form of equations and simplifications.	8
4	**Turbulence Phenomena:** Basic theory of turbulence, time averaging, intensity and correlation coefficients, isotropic turbulence; Equations of continuity, motion and energy for turbulent condition; Reynolds stresses. Phenomenological theories of turbulence, velocity profile in circular conduits; Temperature distribution in turbulent flow.	7

5	**Methods of Analysis of Transport Problems:** General integral balance using macroscopic concepts, interphase transport in isothermal systems, macroscopic balances for isothermal flow systems, polymeric liquids, integral balance for mass, momentum, energy and mechanical energy.	5
6	**Convective Transport:** Free and forced convective heat transfer and mass transfer.	4
7	**Transport Past Immersed Bodies:** Laminar and turbulent boundary layers, Momentum, heat and mass transfer during boundary layer flow past a flat plate and flow over a sphere; Drag coefficient correlations.	6
	Total	42

11. Suggested books:

S No.	Name of Authors/Book /Publisher	Year of Publication/Reprint
1.	Bird R.B., Stewart W. E. and Lightfoot E. N., "Transport Phenomena" 2nd ed., John Wiley.	2003
2.	Geankoplis C.J., "Transport Processes and Unit Operations", 4th ed., PHI.	2008
3.	Plawsky J. L. "Transport Phenomena Fundamentals" Marcel Dekker	2001
4.	Dean W.M., "Analysis of Transport Phenomena", Oxford University Press.	1998
5.	Leal L.G., "Advanced Transport Phenomena: Fluid Mechanics and Convective Transport Processes", Cambridge University Press.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN-218** Course Title: **Process Optimization**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge on the principles of optimizing the processes and operations in chemical process plants.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Basic concepts of process optimization and application to various process industries; Definition and scope of operation research; Different type of models, their construction and general methods of solving.	5
2.	**Linear Programming :** Formulation of the problem and applications; Simplex method, dual simplex method, sensitivity analysis; Parametric programming; Transportation, transshipment and assignment models and their application to capacity planning and process control in process plants.	10
3.	**Problem Formulation:** Nature and organization of nonlinear optimization problems, development of models for optimization.	4
4.	**Optimization of Unconstrained Functions:** One-dimensional search, unconstrained multivariable optimization; Geometric, quadratic and integer programming.	7
5.	**Nonlinear Programming**: Nonlinear programming with constraints; Mixed-integer programming; Global optimization for problems with continuous and discrete variables; Introduction to dynamic programming.	8
6.	**Applications:** Heat transfer and energy conservation, separation processes, fluid flow systems; Optimization in large-scale plant design	8

	and operations.	
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Book/ Publisher	Year of Publication
1.	Edger T. F. and Himmelblau D. M., "Optimization of Chemical Processes", 2nd Ed., McGraw Hill.	2001
2.	Liptak B. G. and Black J. H., "Optimization of Industrial Unit Processes", 2nd Ed., John Wiley.	2004
3.	Nicholson T. A. J., "Optimization in Industry: Optimization Techniques", Aldine Transaction.	2007
4.	Rao S. S., "Engineering Optimization: Theory and Practice", 3rd Ed., New Age Publishers.	2000
5.	Hiller F. S. and Liberman G. J., "Introduction to Operations Research", 8th Ed., McGraw Hill.	2008
6.	Wagner H. M., "Principles of Operations Research with Application to Managerial Decision", 2nd Ed., Prentice Hall.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN-302** Course Title: **Strategy of Process Engineering**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge about the basics of the design processes under uncertainties and various strategies on the optimization of the processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Creation and assessment of alternatives; Degrees of freedom in a system, design variables; Economic design criteria.	5
2.	**Statistical Analysis in Design:** Probability distributions; Estimation theory; Testing and statistical inference, regression; Statistical design of experiments, Box-Behnken and Taguchi's methodology, analysis of variance.	7
3.	**Accommodating to Future Developments:** Anticipating the future, accommodating to a linear demand forecast, nonzero initial demand; Parametric sensitivity.	4
4.	**Accounting for Uncertainty in Data:** Propagation of uncertainty through design; Expected value criterion; Overdesign criterion by Ygal Volkman model; Analysis of risk.	6
5.	**Failure Tolerance:** Theory of reliability, reliability through redundancy, optimum allocation of redundancies; Disaster propagation.	7
6.	**Engineering around Variations:** Queuing theory; Parametric pumping of processes; Smoothing of variations.	7
7.	**Simulation:** Monte Carlo simulation, industrial simulations, application of simulation in decision-making.	6
	Total	42

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Antony J," Design of Experiments for Engineers and Scientists", Butterworth Heinemann.	2004
2.	Calafiore G. and Dabbene, F., "Probabilistic and Randomized Methods for Design under Uncertainty", Springer.	2006
3.	Dimian A.C., "Integrated Design and Simulation of Chemical Processes", Elsevier.	2003
4.	Edgar T.F., Himmelblau D.M. and Lasdon L.S., "Optimization of Chemical Processes", 2nd Ed., McGraw Hill.	2001
5.	Jones D.R.H, "Failure Analysis Case Studies II", Elsevier.	2001
6.	Jones D.R.H, "Failure Analysis Case Studies III", Elsevier.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN-304** Course Title: **Paper Properties**

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

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

4. Relative Weightage: CWS [20] PRS [20] MTE [20] ETE [40] PRE [0]

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of properties of paper and their measurement.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Different grades of papers, boards and newsprint, and their specifications; BIS and ISO standards of paper; Paper properties and their dependence on paper making processes; Calibration of instruments.	4
2.	**Physical Properties**: Definitions and methods of determination of grammage, caliper, bulk, smoothness and porosity; Standardization of size.	4
3.	**Mechanical Properties:** Definitions and methods of determination of tensile strength, tear strength, burst strength, folding endurance, and bending stiffness.	6
4.	**Optical Properties**: Interaction of light with paper, reflectance; Definitions and methods of determination of brightness, opacity, gloss and color.	5
5.	**Resistance Properties:** Permeation of fluid through paper, water absorbancy, Cobb test, oil absorbancy, air/gas permeability.	4
6.	**Interrelation between Properties**: Dependence of properties on water content and temperature; Standard test conditions.	3
7.	Statistical treatment of measured data.	2
	Total	28

List of Experiments:

1. Evaluation of grammage, density, and bulk of paper
2. Evaluation of porosity, smoothness, and softness of paper
3. Evaluation of tensile strength, stretch, modulas of elasticity of paper
4. Evaluation of burst, tear and double fold of paper
5. Evaluation of compression strength and delamination resistance of paper board
6. Evaluation of brightness, opacity and color of paper
7. Evaluation of water absorbency and oil absorbency of paper

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Casey J.P., "Pulp and Paper Chemistry and Chemical Technology", 3rd Ed., Vol 3, John Wiley & Sons.	1984
2.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 17: Pulp and Paper Testing (Ed. Levlin J.-E. and Söderhjelm L.)", Finnish Paper Engineers' Association and TAPPI.	1999
3.	Hunter R.S. and Harold R.W. "Measurement of Appearance", John Wiley & Sons.	1987
4.	Mark R. E., "Handbook of Physical and Mechanical Testing of Paper and Paperboard", Vol. 1, Marcel Dekker.	2002
5	Mark R. E., "Handbook of Physical and Mechanical Testing of Paper and Paperboard", Vol. 2, Marcel Dekker.	2002
6.	Scott W.E., Abbott J.C. and Trosset S., "Properties of Paper: An Introduction", TAPPI Press.	1995

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN-306** Course Title: **Printing and Packaging Papers**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge on the required properties of paper and board for different printing and packaging applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Printing Processes**: Letterpress, flexography, gravure, lithography, and screen printing; Halftone printing; Color reproduction; Printing plates; Printing presses, printing inks, Reprography.	8
2.	**Printability:** Ink transfer; Print quality, Paper and paperboard properties required for printing.	7
3.	**Pigment Coating:** Raw materials for paper coating, base stock, pigments, binders, and additives; Coating mixture preparation, pigment coating formulations; Pigment coating processes; Drying of pigment coated paper; Calendering and finishing of pigment coated papers; Properties of pigment coated papers.	10
4.	**Packaging:** Elements of packaging technology, approaches to package development; Requirement of paper and paperboard for different types of packages: sacks, cartons, and aseptic packaging.	6
5.	**Paper Board Manufacturing:** Cylinder mold machines and other cylindrical formers, multi-fourdrinier machines for board manufacture.	4
6.	**Converting:** Corrugating, laminating, paper laminates, aqueous and solvent coatings, extrusion coating, hot melt coating.	7
	Total	42

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Casey J.P., "Pulp and Paper-Chemistry and Chemical Technology", Vol. 4, Pergamon Press.	1981
2.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 12: Paper And Paperboard Converting (Ed. Savolainen A.)", Finnish Paper Engineers' Association and TAPPI.	1999
3.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 13: Printing (Ed. Oittinen P. and Saarelma H.)", Finnish Paper Engineers' Association and TAPPI.	1998
4.	Kocurek M. J., "Pulp and Paper Manufacture, Volume 8: Coating, Converting, and Speciality Papers (Ed. Kouris M.)", TAPPI Press.	1990

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN-401** Course Title: **Environmental Management**

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

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

4. Relative Weightage: CWS 20 PRS 20 MTE 20 ETE 40 PRE 0

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

8. Pre-requisite: **Nil**

9. Objective: To make the students conversant about various environmental issues and management aspects related to Process Industries.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Environmental issues for process industries; Emissions and effluents; Environmental policy of India, environmental laws and standards, corporate responsibility for environmental protection.	7
2.	**Pollution Prevention:** Process modification; Recovery of by-products from industrial emissions and effluents, principles of 3 R, reduction, recycle and reuse of wastes; Energy and fresh water minimization, energy recovery; Preventive maintenance and housekeeping for limiting fugitive emission and leakages; Pollution dispersion and diffusion.	11
3.	**Pre and Primary Treatment:** Dilution, neutralization, sedimentation, coagulation and flocculation.	4
4.	**Biological Treatment:** Anaerobic and aerobic treatment of carbonaceous matter; Various treatment systems such as trickling filters, lagoons, UASB reactors and activated sludge processes; Sludge disposal and management; Tertiary treatment methods.	10
5.	**Air Pollution Control:** Particulate emission control by mechanical separation and electrostatic precipitation, wet gas scrubbing, gaseous emission control by adsorption and adsorption.	4
6.	**Solids Wastes:** Solids disposal; Decontamination and sterilization;	6

	Compositing, landfill and briquetting; Pyrolysis, gasification and incineration.	
	Total	42

List of Experiments:

1. Determination of water quality.
2. Determination of COD.
3. Determination of Dissolved Oxygen and BOD.
4. Measurement of Color.
5. Measurement of TDS, SS, volatile and non volatile fraction.
6. Determination of inorganic chlorine in wastewater.
7. Study of high volume sampler and determination of suspended particulate matter.
8. Demonstration for measurement of AOX.

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Eckenfelder W.W. and Ford D., "Water Pollution Control" 3rd Ed., Jonkins Publishing Company.	2000
2.	Pollution Control Acts, Rules and Notifications, Central Pollution Control Board, New Delhi.	2003
3.	Pichtel J, "Waste Management Practices: Municipal, Hazardous and Industrial", CRC Press.	2005
4.	Tchobanoglous G., Burton B.L., Metcalf L., and Stensel H.D., "Waste Water Engineering" 4th Ed., McGraw Hill.	2008
5.	Vallero D, "Fundamentals of Air Pollution", 4th Ed., Academic Press.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN-411** Course Title: **Modeling and Simulation in Pulp and Papermaking Processes**

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

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

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

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

8. Pre-requisite:

9. Objective: To impart knowledge on development of detailed mathematical models of various pulp and paper making processes and their solution.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Introduction to process modeling, models and their classification, physical, mathematical, statistical, empirical, and stochastic models; Interrelationships; Overview of modeling applications in pulp and paper manufacture.	7
2.	**Models of Pulping and Bleaching Processes:** Development of models for , chipper and screens, cooking, liquor impregnation, blow-heat recovery, liquor heating and recirculation, washing, pulp screening and cleaning, pulp chests and bleaching.	8
3.	**Models for Papermaking:** Development of for models for refining, blending, flow distribution, headbox, sheet forming, de-watering of paper web, backwater management, broke handling, wet pressing, drying and calendaring.	10
4.	**Models for Recovery and ETP Systems:** Development of models for multiple-effect evaporators, recovery boiler, causticizers, lime kiln, and Effluent treatment plant.	7
5.	**Simulation Software for Pulp and Paper Processes (ASPEN/MATLAB/WinGEMS):** Overview, creating a diagram, solving a model, steady state simulation, dynamic simulation, integration of models.	10
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Aris R, "Mathematical Modeling, Vol. 1: A Chemical Engineering Perspective (Process System Engineering)", Academic Press.	1999
2.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 6: Chemical Pulping (Ed. Gullichsen J and Fogelholm C-J.)", Finnish Paper Engineers' Association and TAPPI.	1999
3.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 7: Recycled Fiber and Deinking (Ed. Göttsching L. and Pakarinen H.)", Finnish Paper Engineers' Association and TAPPI.	2000
4.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 8: Papermaking Part 1, Stock Preparation and Wet End (Ed. Paulapuro H.)", Finnish Paper Engineers' Association and TAPPI.	2000
5.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 9: Papermaking Part 2, Drying (Ed. Karlsson M.)", Finnish Paper Engineers' Association and TAPPI.	2000
6.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 10: Papermaking Part 3, Finishing (Ed. Jokio M.)", Finnish Paper Engineers' Association and TAPPI.	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN-412** Course Title: **Paper Mill Calculations**

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

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

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

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

8. Pre-requisite:

9. Objective: To impart knowledge regarding basic calculations in paper mill and design aspects of various parts of a paper machine.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Approach Flow System:** Basic Mass balance calculations in approach flow system, sizing of chests and piping, design parameters of screens, cleaners, and fan pumps, deaerator, flow distributors; Estimation of electrical power consumption	6
2	**Headbox:** Calculations for the required head, pressure and thrust in the headbox, selection of perforated rolls, no-wake distance for the nozzle, calculations for the pressurized and hydraulic headbox, characterization of turbulence; Calculations for jet angle, slice opening, volumetric flow rate from the head box	4
3	**Formers:** Drainage rate calculations, wire tension, selection of forming fabrics, dimensions of wire, sizing of different rolls, drainage elements and suction boxes on wire table; Calculation of vacuum, drag load, and other parameters for wire part; Design of cylinder mold machines; Calculation of drive load.	7
4	**Overall Water and Fiber Balance:** Mass balance for white water and	4

	fiber systems, broke handling, first pass retention, savealls, water requirement for showers and other cleaning devices, Concepts of system closure	
5	**Vacuum Systems:** Vacuum producing devices; Sizing of vacuum pumps, piping, foils and separators; Calculation of energy requirements	3
6	**Press Part:** Water removal rate calculations; Dimensioning of press rolls and water drainage elements; Selection of press fabrics; Calculation of press parameters; Calculation of drive load	4
7	**Dryer Part:** Material and energy balance for multi-cylinder and Yankee dryers; Calculations of drying rate, surface area of dryers, air and steam requirement; Steam and condensate handling systems, sizing of steam piping; Calculation of drying rate for surface sized and pigment coated papers, calculations for IR and air impingement dryers, calculation for dryer hoods; Calculation of drive load; Calenders and super calenders	10
8	**Stock Pumps and Piping:** Sizing of piping and pumps for stock flow in different sections of a paper mill, power requirement for pumping	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 8: Papermaking Part 1, Stock Preparation and Wet End (Ed. Paulapuro H.)", Finnish Paper Engineers' Association and TAPPI.	2000
2.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 9: Papermaking Part 2, Drying (Ed. Karlsson M.)", Finnish Paper Engineers' Association and TAPPI.	2000
3.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 10: Papermaking Part 3, Finishing (Ed. Jokio M.)", Finnish Paper Engineers' Association and TAPPI.	1999
4.	Kocurek M.J., "Pulp and Paper Manufacture", Vol. 7, TAPPI Press.	1994
5.	McDonald R.G. and Franklin J.N., "Pulp and Paper Manufacture" Vol. 2, McGraw Hill.	1969
6.	TAPPI Technical Information Papers, TAPPI Press.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN- 413** Course Title: **Computer Based Control System**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide advanced knowledge of process control.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Introduction to process control and computer based control, terminology & definitions, block diagrams of control system, industrial control, process control & its objectives, developments in control, examples of control System	4
2.	**Control Systems:** Dynamic characteristics of control systems, interacting and non-interacting systems; response of first order, first-order system in series and second order systems; Closed-loop transfer functions; transient response of control systems; Stability of systems.	8
3.	**Block Diagrams of Control Systems:** Analog and digital control, electronic control, PC based, direct digital, programmable, centralized & distributed based, fuzzy and neural based control system.	8
4.	**Control Valves:** Functions of control valves (CV), types, selection, application, and comparison of different types of control valves, actuators	4
5.	**Programmable Logical Controllers and SCADA:** PLC over relay control, PLC overview, PLC features and benefits, PLC applications, supervisor control and data acquisition (SCADA), hardware and software architecture, bus structure, input output modules.	6

6.	**Distributed Control Systems:** Introduction to DCS, centralized vs distributed control advantages of DCS, selections of DCS, requirement of DCS for plant, maintenance, design and development, DCS for manager and supervisors, comparison between PLC and DCS	6
7.	**Fuzzy Logic System:** Crisp set and Fuzzy set, basic concepts of fuzzy sets, membership functions; Basic operations on fuzzy sets, properties of fuzzy sets, fuzzy relations; fuzzy if – then rules, fuzzy mapping rules and fuzzy implication functions, applications of fuzzy controllers.	6
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	C.D. Johnson, "Process Control Instrumentation Technology", 3rd ed., Prentice Hall of India.	1993
	Coughnour D.R., "Process System Analysis and Control", McGraw-Hill.	1991
2.	Bequette B. W., "Process Control – Modeling, Design and Simulation", Prentice Hall of India.	2003
3.	Krishan Kant, "Computer Based Industrial Control," Prentice Hall of India.	2002
4.	Stephanopoulos G., "Chemical Process Control-An Introduction to Theory and Practice", Prentice Hall of India.	2008
5.	B.G.Liptek, "Process Measurement and Analysis" by Instrument Engineers Handbook, fourth Edition, (v-1), CRC Press, (ISA)	2009
6.	J. Yen, R. Langari, "Fuzzy Logic, Intelligence, Control, and Information", 3rd ed., Prentice Hall of India.	2006
7.	Chander Mohan, "An Introduction To Fuzzy Set Theory And Fuzzy Logic", Publisher: Mv Learning.	2015

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN-414** Course Title: **Process Integration in Paper Industry**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge about the applications of process integration aspects in pulp and paper industry.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Concept of process integration and its applications to various process operations; Role of thermodynamics in process design; Targeting of energy, area, number of units and cost, super targeting, Concept of water networking; Optimization using pinch.	10
2.	**Pinch Technology:** Concepts, heat exchanger network analysis, maximum energy recovery (MER) network for multiple utilities and multiple pinches, optimum design of heat exchanger network, tank and mass integration.	10
3.	**Applications:** Heat integrated distillation columns, evaporators, dryers, reactors; Waste and waste water minimization; Flue gas emission targeting; Heat and power integration.	10
4.	**Process Intensification:** Introduction; Applications: corelations with process integration.	3
5.	**Case Studies:** Black liquor evaporator, MF and MG cylinder drying, distillation column; Water networking using pinch analysis.	9
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	El Halwagi M. M., "Process Integration", 7th Ed., Academic Press.	2006
2.	Kemp I.C., "Pinch Analysis and Process Integration: A User Guide on Process Integration for the Efficient Use of Energy", 2nd Ed., Butterworth Heinemann.	2007
3.	Shenoy U.V., "Heat Exchanger Network Synthesis", Gulf Publishing Company.	1995
4.	Sinnot R. K., "Coulson & Richardson's Chemical Engineering, Volume 6: Chemical Engineering Design", 4th Ed., Butterworth Heinemann.	1999
5.	Smith R., "Chemical Process Design", 2nd Ed., McGraw Hill.	2005
6.	David Reay, Colin Ramshaw and Adam Harvey, "Process intensification: Engineering for Efficiency, Sustainability and Flexibility, 2nd Ed., Butterworth Heinemann	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN- 415** Course Title: **Process Dynamics and Control**

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

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

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

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

8. Pre-requisite: Nil

9. Objective: To provide knowledge about measurement of various parameters and instrumentation. Control concepts and automation techniques, and their applications to pulp and paper technology.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Importance of control and instrumentation in process industries; Block diagram; Transducers and their classification and selection criteria; On and offline measurements.	3
2.	**Static Characteristics of Instruments:** Static and dynamic parameters, accuracy, precision, sensitivity, reproducibility, drift, threshold, hysteresis, resolution, repeatability, stability, linearity, span and range, live zero, and errors with examples; Rise time, settling time, overshoot, undershoot etc.	4
3.	**Control Systems:** Dynamic characteristics of control systems, interacting and non-interacting systems; Response of first order, first-order system in series and second order systems; Closed-loop transfer functions; Transient response of control systems; Fundamental concepts of stability of control systems.	10
4.	**Control Block:** Block diagram of different control systems like pneumatic, electronic digital, PLC, DCS and their brief description.	7
5.	**Modes of Control Action:** Overview of the control system, classification of process control strategies, transient response; two position control, multi-position control, proportional (P), integral (I), derivative (D), PI, PD,	7

	and PID controllers; feed-forward, feedback, cascade and ratio control systems.	
6.	**PLC and DCS:** Architecture, comparison, application of PLC and DCS	5
7.	**Applications in Pulp and Paper Industry:** Concept of instrumentation and piping diagram Piping and instrument diagram for digester, lime-kiln, bleach plant, washing and paper machine.	6
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Andrew W.G., "Applied Instrumentation in the Process Industries", Vol. I, 3rd Ed., Gulf Publishing Company.	1993
2.	Lavigne J.R., "Introduction to Paper Industry Instrumentation" Miller Freeman.	1996
3.	Andrew W.G., "Applied Instrumentation in the Process Industries", Vol. II, 3rd Ed., Gulf Publishing Company.	1993
4.	Eckman D.P., "Industrial Instrumentation", John Wiley.	2006
5.	C.D. Johnson, "Process Control Instrumentation Technology", Prentice Hall of India, 3rd ed., New Delhi.	1993
6.	Ghosh A.K., "Introduction to Instrumentation and Control", 4th Ed., Prentice Hall of India.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN-417** Course Title: **Microprocessor and its Applications**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide exposure to the students about fundamental and design of digital electronics circuits, microprocessor architecture and programming, application of digital and microprocessor circuits in process industry.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Analog and digital signals, digital logic families, characteristics of digital logic families, microprocessor and its duties, difference between different processor of Intel, features and comparisons of popular 8-bit,16-bit and 32 bit and 64-bit processor.	5
2.	**Combinational Circuits:** Simplification of Boolean function using algebraic and K-map methods up to 4-variables, do-not care conditions, design of half, full, binary adder and sub-tractor, design of encoder and decoder circuits; Multiplexer & de-multiplexer; NAND and NOR gate implementations.	10
3.	**Architecture of Microprocessor:** Microprocessor architecture, pin description of 8085, instruction set of 8085, bus structure of 8085 MP's, multiplexed address & data bus, arithmetic and logical unit, general and special purpose register array of different 8-bit processors, flags, control and interrupts signal, memory and input-output signals, clock and utility signals.	10
4.	**Microprocessor Programming:** Basic guidelines of designing instructions and symbols, opcode, description, flags and examples of data transfer, arithmetic, logical, branching, groups, stacks, I/O and machine control, assembly language programming to solve problems on arithmetic, logical and control examples.	10
5.	**Microprocessor Interface and Applications:** Interface circuits and its applications, programmable peripheral interface of 8255, operational modes of 8255, control word format for 8285, application of microprocessor in industry.	7

		Total	42

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	John A. Seeger, "Introduction to microprocessor with the Intel 8085", Harcourt College Publication.	1988
3.	Ramesh S. Gaonkar, "Microprocessor Architecture, Programming, and Applications With the 8085", 4th edition, Prentice Hall of India.	1988
4.	Anil Swarnkar, "8085 Microprocessor", 8th ed, Genius Publication.	2014
5.	M. Morris Mano, Michael D. Ciletti, "Digital Design", Pearson Prentice-Hall.	2007
6.	Surendra K. Gupta, "Microprocessors System Design and Interfacing", 3rd ed, Pragati Prakashan.	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN-418** Course Title: **Applications of Biotechnology in Paper Industry**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge regarding application of bio-technology in pulp and paper industry.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Importance, interdisciplinary pursuit, product safety, public perception; Characterization of microbes and enzymes.	5
2.	**White-rot Fungi:** Taxonomy, production of fungal inoculum, enzymology and molecular genetics, wood degradation by white rot fungi.	6
3.	**Raw Material Preparation**: Wood pretreatment to remove toxic extractives, biodebarking, bio-retting of flax, biodepithing.	6
4.	**Pulping and Bleaching:** Advantages and principles of biopulping and biobleaching, fungal pretreatment of wood chips for chemical pulping, production of dissolving pulp, removal of shives, bleaching with xylanases, and enzymes of white rot fungi.	10
5.	**Fiber Modification:** Use of enzymes in beating, refining, deinking, and other applications.	6
6.	**Effluent Treatment:** Treatment of wastewaters with aerobic and/or anaerobic techniques; Decolorization and detoxification of bleached kraft effluents; Purification of process water in closed-cycle mills; Management of wastewater treatment sludges.	9
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Bajpai P. and Bajpai P.K., "Biotechnology in the Pulp and Paper Industry", PIRA International.	1997
2.	Bajpai P., Bajpai P.K. and Kondo R. "Biotechnology for Environmental Prptection in the Pulp and Paper Industry", Springer.	1999
3.	Raymond A.Y. and Akhtar M., "Environmentally Friendly Technologies for the Pulp and Paper Industry", John Wiley.	2003
4.	Smith J.E., "Biotechnology" 3rd Ed., Cambridge University Press.	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN-419** Course Title: **Recovery Process Calculations**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of process design calculations in chemical recovery systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Multiple Effect Evaporators:** Material and energy balance calculations for different types of evaporators, calculation for area requirement and efficiency, process design calculations for condensers and steam-jet ejectors.	9
2.	**Recovery Boiler:** Material and energy balance calculations for recovery boilers, performance calculations, effect of various parameters on performance, calculations of effective cooling area for water walls.	9
3.	**Electrostatic Precipitator:** Process design calculations.	4
4.	**Causticizing Section:** Process design calculations for slakers, causticizers, clarifiers, mud washers and filters.	9
5.	**Lime Mud Reburning Systems:** Process design calculations, energy efficiency, performance calculations.	6
6.	**Fluidized Bed Combustion:** Material and energy balance, performance calculations.	5
	Total	42

11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication
1.	Abrams T.L., "Process Engineering Design Criteria Hand Book: Pulp and Paper Normal Design Criteria," TAPPI Press.	1996
2.	Adams T.N., Frederick W.J., Grace T.M., Hupa M., Iisa K., Jones A.K., Tran H.N., "Kraft Recovery Boiler" TAPPI Press.	1997
3.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 6B: Chemical Pulping (Ed. Gullichsen J and Fogelholm C-J.)", Finnish Paper Engineers' Association and TAPPI.	1999
4.	Tappi Kraft Recovery Short Notes, TAPPI Press.	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN-421** Course Title: **Pulp Mill Calculations**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of process engineering design aspects of pulping, screening, cleaning, washing and bleaching systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Raw Material Preparation:** Material and energy balance calculations for raw material preparation section.	4
2.	**Pulping Processes:** Process calculations for batch and continuous digesters; Modeling of soda and kraft pulping; Calculation of H and modified H-factors; Use of empirical models for prediction of various parameters; Calculation for blow-heat recovery, digester and liquor heater, Process design calculations for pulp mills based on batch, continuous digesters and their modifications; SuperBatch, RDH, MCC, and EMCC processes; Steam and power calculations.	9
3.	**Screening and Cleaning Systems:** Performance of screening and cleaning systems and their process design aspects, mass balance and efficiency for single and multiple stage systems, screening and cleaning equipment sizing, power consumption calculations.	6
4.	**Washing Systems:** Material and energy balance calculations for different types of washing systems, washing losses and washing efficiency, calculation of washing efficiency for varying dilution factor, displacement ratio, and number of stages; Norden efficiency.	6
5.	**Bleaching Systems:** Calculations involving bleach liquor analysis;	7

	Material and energy balance for various single and multiple stage bleaching sequences; Process design of tower, mixer and reactors; Calculations for bleaching efficiency, target brightness, shrinkage and environmental impact.	
6.	**Stock Pumps and Piping:** Sizing of piping and pumps for stock flow in different sections of a pulp mill, power requirement for pumping.	5
7.	**Wastepaper Pulping and Deinking:** Process calculation for hydrapulper, floatation,cell, and washing.	5
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Dence C.W. and Reeve D.W., "Pulp Bleaching: Principles & Practice", TAPPI Press.	1996
2.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 6: Chemical Pulping (Ed. Gullichsen J and Fogelholm C-J.)", Finnish Paper Engineers' Association and TAPPI.	1999
3.	Kocurek M. J., "Pulp and Paper Manufacture, Volume 5: Alkaline Pulping (Ed. Grace T. M. and Melcolm E. W.)", TAPPI Press.	1989
4.	McDonald R.G. and Franklin J.N., "Pulp and Paper Manufacture" Vol. 2, McGraw Hill.	1969

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN-422** Course Title: **Coated and Specialty Papers**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge on the characteristics of various constituents used in aqueous pigment coating processes, and characteristics and applications of various specialty paper grades.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Base Paper and Coating Ingredients:** Requirements of coating base paper, mechanical and wood free papers; Coating pigments, kaolin, GCC, PCC, talc, titanium dioxide, gypsum, aluminum trihydrate, synthetic plastic pigments; Coating binders, latex, synthetic co-binders and thickeners, starch, soy-protein, CMC, polyvinyl alcohol; Coating additives, characteristics and application of dispersants, viscosity modifiers, insolubilizers, lubricants, and others.	9
2.	**Coating Processes:** Coating color preparation, coating techniques, multiple coating of paper, coating of board, drying of coated paper, process control and automation, rheology of pigment slurries.	9
3.	**Printing and Writing Papers:** Characteristics of various grades such as newsprint, SC papers, coated mechanical papers, uncoated fine papers, coated fine papers, special fine papers.	5
4.	**Paperboard Grades:** Carton boards classification and quality requirements for various applications, containerboards and linerboard, corrugating medium, special boards, wallpaper base, core board and plaster board.	6

5.	**Tissue and Air-laid Papers:** Tissue converting, embossing, printing and perforation; Process of manufacture of air-laid papers, their characteristics and applications.	5
6.	**Characteristics of Specialty Grades:** Electrical papers, absorbent papers, filter papers, special strong papers, release papers, copy and imaging papers, packaging papers, building papers, cigarette papers, and other functional papers.	8
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 11: Pigment Coating and Surface Sizing of Paper (Ed. Lehtinen E.)", Finnish Paper Engineers' Association and TAPPI.	2000
2.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 18: Paper and Board Grades (Ed. Paulapuro H.)", Finnish Paper Engineers' Association and TAPPI.	2000
3.	Kocurek M. J., "Pulp and Paper Manufacture, Volume 8: Coating, Converting, and Speciality Papers (Ed. Kouris M.)", TAPPI Press.	1990

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN-423** Course Title: **System Closure in Paper Industry**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge on methodology for achieving near zero effluent discharge from a paper mill for conserving water and energy.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Inputs and outputs of pulp and paper manufacturing process; Discharge standards for liquid, solid and gaseous emissions; Energy usages; Paper use and disposal.	4
2.	**Sustainability and System Closure:** Concepts, issues and challenges of sustainability, legislative approaches, the Earth summit and other protocols, EIA, eco-labeling, green rating, LCA; Open, partially closed, and closed systems, examples; Clean development mechanism.	10
3.	**Water Needs of Pulp and Paper Industry:** Water sourcing; Closed system operations in fiber preparation, pulping, bleaching, papermaking and chemical recovery; Condensate recovery, management of non process elements; Problems of closed water cycle operations, process issues, issues related to paper quality.	10
4.	**Treatment Techniques for System Closure:** Liquid effluent discharges, tertiary treatment methods; Issues of TDS, Color, and AOX; Zero liquid discharge, concept, issues and challenges; Solid waste management, incineration and land fill; Air emission control for SO_x, NO_x, HCl, NCG's, TRS, and VOC.	10

5.	**Energy Management in Pulp and Paper Mills:** Renewable and non-renewable energy sources, increasing use of bio-mass, cogeneration, development of energy efficient processes, GHG emission, concept of PTA, process integration.	8
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Brune D., Chapman D.V., Gwynne M.D., and Pacyna J.M., "The Global Environment: Science, Technology and Management", Marcel Dekker.	1996
2.	Environmental Issues and Technology in Pulp and Paper Industry – TAPPI Press Anthology of Published Papers, 1991-94.	1995
3.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 19: Environmental Control (Ed. Hynninen P.)", Finnish Paper Engineers' Association and TAPPI.	1998
4.	Nebel B.J., Adams C.E., and Wright N., "Environmental Science – The Way World Works", 4th Ed., Prentice Hall.	1999
5.	Boyce, M. P., "Handbook of Cogeneration and Combined Cycle Power", ASME Press	2002
6.	Charter for Water Recycling and Pollution Prevention in Pulp and Paper Industries of Ganga Basin, ADSORBES/44/2014-15, CPCB	2014

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: PPN-416 Course Title: **Converting Operations**

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

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

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

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

8. Pre-requisite: Nil

9. Objective: To impart knowledge on the principal features of web converting, typical unit operations involved, and the converted products.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Converting; Product groups.	2
2.	**Wetting and Adhesion:** Theories of adhesion- mechanical interlocking, diffusion theory, electrostatic theory, thermodynamic adsorption and surface energy theory, chemical adhesion, weak boundary layer theory, Measuring wetting, adhesion, and peel strength, Adhesion in different converting processes.	6
3.	**Web Fed Converting Operations:** Flexible packaging line, tape machines, industrial wrappings, unit operations in un-winders and re-winders, tension control, edge guiding, coating, drying, curing, and lamination.	6
4.	**Dispersion Coating:** Polymer dispersion as barrier coating, Polymerization and formulation, film formation, Rheology, Recycling.	5
5.	**Extrusion Coating:** Processes and equipment, Coating plastics, Substrates and main applications such as liquid packaging, flexible packaging, and photographic papers.	4
6.	**Metalizing and Lamination:** Characteristics of metalized products and process of metalizing; Types of laminated paper products, characteristics of papers, films, and foils used in laminating, laminating process, pressure sensitive adhesive label laminates.	6
7.	**Carton-board Package Manufacturing:** Packaged products and	5

	requirements for cartons, carton manufacturing and requirement for board.	
8.	**Corrugated Board Manufacturing:** Corrugated board qualities, production of corrugated board, adhesives for corrugating, factors affecting gluing behavior, requirements of the linerboard and fluting medium, testing of corrugated board.	8
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 12: Paper And Paperboard Converting (Ed. Savolainen A.)", Finnish Paper Engineers' Association and TAPPI.	1999
2.	Kocurek M. J., "Pulp and Paper Manufacture, Volume 8: Coating, Converting, and Speciality Papers (Ed. Kouris M.)", TAPPI Press	1990
3.	Casey J.P., "Pulp and Paper: Chemistry and Chemical Technology", Vol. 4, 3rd Ed., John Wiley & Sons.	1981

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN-424** Course Title: **Papermaking Chemistry**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge regarding advances in chemistry aspects in stock preparation and papermaking.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Importance of papermaking chemistry; Fiber-fiber-water bonding; Rheology, surface energy, and surface tension of colloidal systems.	6
2.	**Sorption and Swelling:** Sorption and swelling of cellulosic materials in water and other media, types of adsorption, physical- and chemi-adsorption, surface area of cellulose and cellulosic materials.	7
3.	**Electrokinetic Properties of Cellulose:** Ion exchange, electrokinetic phenomena, effects of chemical environment and processing operations such as pulping, bleaching, and refining on electrokinetic properties.	9
4.	**Coagulation and Flocculation in Papermaking:** Coagulation with electrolytes, theory of flocculation and dispersion of colloidal materials, effects of additives on fiber flocculation.	6
5.	**Retention Mechanisms:** Charge neutralization, patch model, bridging, complex flocculation, dissolved and colloidal substances; Influence of shear.	8
6.	**Foam and Slime Control:** Nature of foam, foam formation and stabilization, effect of additives on foam stability, theory of antifoam action; Micro-organisms and slime formation, chemical slime control.	6
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Eklund D. and Lindstrom T.D., "Paper Chemistry: An Introduction", TAPPI Press.	1991
2.	Gess J.M "Retention of Fines and Fillers During Papermaking", TAPPI Press.	1998
3.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 4: Papermaking Chemistry (Ed. Neimo L.)", Finnish Paper Engineers' Association and TAPPI.	1999
4.	Kocurek M. J., "Pulp and Paper Manufacture, Volume 6: Stock Preparation (Ed. Hagemeyer R. W. and Manson D. W.)", TAPPI Press.	1992
5.	Roberts J.C. "Paper Chemistry", Blackie Academic & Professional.	1996
6.	Swanson J., "Colloid Chemistry of Papermaking Materials", TAPPI Press.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN-425** Course Title: **Paper Physics**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge on the structure of paper and its correlation with paper properties and papermaking process.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Structure of Paper:** Two- and three-dimensional network geometry, formation, concept of orientation and flocculation, porous structure.	6
2.	**Theories of Paper Strength:** Fiber properties, strength of fibers and its correlation with strength of paper, fiber bonding, correlation of strength of paper with fiber network, in-plane strength properties, bending stiffness, compressive strength, out-of-plane strength.	9
3.	**Surface and Sorption Properties:** Methods of characterization of surface structure, surface friction, interaction of paper surface with aqueous and oily liquids, resistance of paper to passage of liquids and gases.	9
4.	**Optical Properties:** Physics of light scattering in paper, Kubelka-Munk equations, effect of paper structure and composition on optical properties, measurement of color.	9
5.	**Dimensional Stability:** Relative humidity, hysteresis and dynamic phenomena, hygroexpansion, curl, cockling.	9
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Bristow J. A.W. and Kolseth P., "Structure of Paper and Properties" Marcel Dekker.	1986
2.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 16: Paper Physics (Ed. Niskanen K.)", Finnish Paper Engineers' Association and TAPPI.	1998
3.	Mark R.E., Habeger Jr C.C., Borch J. and Lyne M.B. "Handbook of Physical Testing of Paper" Vol. 1, Marcel Dekker.	2002
4.	Mark R.E., Habeger Jr C.C., Borch J. and Lyne M.B. "Handbook of Physical Testing of Paper" Vol. 2, Marcel Dekker.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN-426** Course Title: **Packaging Papers**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To familiarize the students with various types of packaging paper and boards

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Paper and Board for Packaging:** Use of paper and paperboard in flexible and rigid packaging, comparison with other packaging materials, kraft paper, flexible packaging paper, extensible kraft; Grades of paperboard, multilayer boards, solid bleached board, unbleached kraft paperboard, uncoated recycled paperboard, coated recycled paperboard, application of various board in packaging	7
2.	**Paper Board Manufacture:** Forming section, wet pressing, drying, and calandering, paperboard properties and their control during manufacture	6
3.	**Pigment Coating:** Pigments, binders, additives, coating formulations and preparation of coating mixture, coating techniques, properties of coated paper and board	4
4.	**Corrugating:** Corrugated board types and properties; Production of corrugated board; Gluing; Quality control; corrugated board box making and their performance evaluation.	6
5.	**Manufacturing of Packages:** Pouches, sacks, boxes, cartons, composite cans and fiber drums, aseptic drink boxes, package printing, sealing and gluing, liquid packaging	5
6.	**Polymer Dispersions as Barrier coatings:** Properties of the polymers used, application techniques, rheology of polymer dispersions, properties of polymer dispersion films.,	6
7.	**Extrusion Coating:** Extrusion coating plastics, substrates, extrusion coating process, properties and applications of extrusion coated products.	4
8.	**Lamination:** laminating methods, laminating substrates, adhesives, properties of laminated paper and board products	4
	Total	42

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 12: Paper And Paperboard Converting (Ed. Savolainen A.)", Finnish Paper Engineers' Association and TAPPI.	2012
2.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 13: Printing (Ed. Oittinen P. and Saarelma H.)", Finnish Paper Engineers' Association and TAPPI.	2012
3.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 17: Pulp and Paper Testing (Ed. Levlin J.-E. and Söderhjelm L.)", Finnish Paper Engineers' Association and TAPPI.	2012
4.	Mark R. E., "Handbook of Physical and Mechanical Testing of Paper and Paperboard", Vol. 1&2, Marcel Dekker.	2002
5.	Campbell I.M., "Introduction to synthetic polymers", Oxford University Press	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPN-427** Course Title: **Secondary Fiber Processing**

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

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

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

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

8. Pre-requisite: NIL

9. Objective: To impart knowledge about availability, collection, utilization and environmental aspects of secondary fibers.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**General Aspects**: Utilization, collection, and recovery rate, future utilization of recovered paper, legislation for use of recycled fibers; Quality control of recovered paper, recyclability of paper products, economics of secondary fiber utilization..	3
2.	**Recycled Versus Virgin- Fiber Characteristics:** Comparison, General effect of recycling, Effect of furnish and initial beating of virgin pulp, Interaction between fiber properties and process variables. Discussion related fiber strength, Coarseness & freeness change of recycled fibers.	4
3.	**Stickies in Recycled Fiber Pulp:** Type and size of stickies, origin and behaviour of stickies, characterization of stickies; Print quality of recycled fiber papers; Impact of secondary fiber on the paper machine, and fiber reactivity versus chemical use.	8
4.	**Unit Operations and Equipment:** Secondary fiber processing, batch and continuous pulpers, slushing, deflaking, fractionation, dispersion and kneading, dewatering, refining, screening and cleaning; Effect of variables like temperature, pressure, agitation, consistency, and	12

	chemicals on pulp properties.	
5.	**Deinking:** Deinking operations, washing and floatation, advances in deinking techniques.	8
6.	**Environmental Aspects:** Characterization of wastes and emissions from mills using recovered fiber, Process water clarification, Reject handling and sludge pressing in recycling and deinking systems	5
7.	**Flow Sheet Considerations:** Process parameters that influence the design of flow-sheets, simple system, crude cleaning, OCC system, systems for deinking newsprint and magazine papers, deinking of printing and writing grades.	2
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 7: Recycled Fiber and Deinking (Ed. Göttsching L. and Pakarinen, H.)", Finnish Paper Engineers' Association and TAPPI.	2000
2.	Kocurek M. J., "Pulp and Paper Manufacture, Volume 3: Secondary Fibers and Non-wood Pulping (Ed. Hamilton F. and Leopold B.)", TAPPI Press.	1987
3.	McKinney R.W.J., "Technology of paper Recycling", Blackie and Academic Professional.	1995
4.	Spangenberg R.J., "Secondary Fiber Recycling", TAPPI Press.	1993

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT./CENTRE: Polymer and Process Engineering

1. Subject Code: **PEN-352** Course Title: **Pollution Control Engineering**

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

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

4. Relative Weightage: CWS 20 PRS 20 MTE 20 ETE 40 PRE 0

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

8. Pre-requisite: NIL

9. Objective: To impart knowledge about air, water, and land pollution and its preventive measures.

10. Details of Course:

S. No.	CONTENTS	Contact Hrs
1.	**Introduction:** Environment and environmental pollution from process industries, characterization of emission and industrial effluents, Indian and EPA laws and standards for environmental analysis; Pollution due to nano-materials, Corporate responsibility for the environmental protection; Water-energy nexus.	3
2.	**Minimization of Pollution :** Process modification, alternative raw material, recovery as by-product from industrial emission effluents, recycle and reuse of waste, energy recovery and waste utilization; Cleaner production concept: Cleaner production practise, appropriate design of products and processes; Fugitive emission/effluents and leakages/wastage prevention.	5
3.	**Air Pollution:** Theory of air pollution control: Particulate emission control by mechanical separation and electrostatic precipitation, wet gas scrubbing, gaseous emission control by absorption and adsorption; Design of air pollution control systems: Design of cyclones, ESP, fabric filters and absorbers, carbon dioxide adsorption.	6
4.	**Wastewater Pollution Control:** Constituents in wastewater; Primary and Secondary treatment: Pre-treatment, solids removal by setting and sedimentation, filtration centrifugation, coagulation and flocculation; Biological treatment: Anaerobic and aerobic treatment; Bioreactor design and analysis for wastewater treatment; .	9
5.	**Waste Management:** Management of concentrated carbondioxide. Sludge treatment and disposal; Decontamination and sterilization; Compositing, landfill, briquetting. pyrolysis, gasification and incineration; Leaching protocols and testings.	5
	TOTAL	28

11. List of Experiments

a). Determination of water quality.
b). Determination of COD.
c). Determination of Dissolved Oxygen and BOD.
d). Measurement of TDS, SS, volatile and non volatile fraction.
e). Determination of inorganic chlorine and alkaninty in wastewater.
f). Study of high volume sampler and determination of suspended particulate matter.
g). Demonstration for measurement of AOX.
h). Leaching test soild waste according to TCLP protocol.

12. Suggested Books:

S. No.	Name of Books / Authors /Publisher	Year of Publication / Reprint
1.	Eckenfelder W.W., and Ford D., "Water Pollution Control", 3rd Ed., Jonkins Publishing Company.	2000
2.	Tchobanoglous G., Burton B.L., Metcalf L., and Stensel H.D., "Waste Water Engineering", 4th Ed., McGraw Hill.	2008
3.	Pollution Control Acts, Rules and Notifications, Central Pollution Control Board, New Delhi.	2003
4.	Vallero D, "Fundamentals of Air Pollution", 4th Ed., Academic Press.	2007
5.	Pichtel J; "Waste Management Practices: Municipal, Hazardous and Industrial", CRC.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Polymer and Process Engineering**

1. Subject Code: **PEN-354** Course Title: **Chemical Plant Design and Economics**

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

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

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

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

8. Pre-requisite: **PP-211**

9. Objective: To impart knowledge on design and operation of various chemical processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** General overall design considerations, practical consideration in design, project documentation; Codes and standards; Design factors, engineering ethics in design, health and safety hazards; Loss prevention, fault-tree analysis, environmental protection, plant location, plant layout, plant operation and control, site selection, site layout; Patent considerations, significance of process intensification; Industrial examples.	5
2.	**Process Design Development:** Development of Design database, process design, process creation and process synthesis, process flow diagrams; Piping and instrumentation diagrams, equipment design and specifications; Scale-up techniques	5
3.	**Flowsheet Synthesis and Development:** Flowsheet synthesis and development, process information, input/output structure, functions diagram, operations diagrams, process flowsheet, principles of algorithmic flowsheet generation, comparison of hierarchical and algorithmic results; Software use in process design, flowsheet analysis and evaluation.	6
	Cost analysis : Cash flow for industrial operations, factors affecting	5

	investment and production costs, fixed and working capital; Estimation of capital investment for chemical and biochemical plants; Cost indices cost components in capital investment; Methods for estimating capital investment; Estimation of revenue; Estimation of total product cost; Break-even point, cut-over point.	
5	**Engineering Economic and Profitability Analysis**: Interests, time value of money, taxes, and fixed charges, various methods of calculating depreciation, methods for profitability evaluation, cash flow, rate of return on investment, discounted cash-flow, capitalized cost; Effect of inflation, alternative investments, replacements, practical factors in alternative investments and replacement analysis.	6
6	**Optimum Design and Design Strategy:** Overview of optimization processes; Optimization solution methodologies; Optimization applications; Economic balance in process plants, economic optimum conditions for processes and operations, optimum production rates, cyclic and semicontinuous operations; Economic pipe diameter equipments; Pinch technology, heat exchanger network, multiple pinches and multiple utilities, targeting and super-targeting, threshold problems.	10
6.	**Materials and Fabrication Selection**: Factors contributing to corrosion and its prevention, properties of materials, selection, fabrication of equipment, selection for process equipments including pressure vessels, estimating cost of equipments for chemical process industries through graphs and equations.	5
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Peters M.S., and Timmerhaus K.D., "Plant Design and Economics for Chemical Engineers", 5th Ed., McGraw Hill.	2003
2.	Sinnot R.K., "Coulson & Richardson's Chemical Engineering, Volume 6: Chemical Engineering Design", 6th Ed., Butterworth Heinemann.	2002
3.	Smith R., "Chemical Process Design and Integration", John Wiley.	2005
4.	Kemp I.C., "Pinch Analysis and Process Integration: A user Guide on Process Integration for the Efficient Use of Energy", 2nd Ed., Butterworth Heinemann.	2007
5	Turton R., Bailie, C.R., Whiting, B.W., Shaeiwitz, J.A., Bhattacharyya D., "Analysis, Synthesis, and Design of Chemical Processes", 4th Ed., Prentice Hall.	2012
6.	Seider W.D., Seader J.D., Lewin D.R., Widagdo, S.,, "Product and Process Design Principles, Synthesis, Analysis and Evaluation", 3rd Ed., Wiley.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Polymer and Process Engineering**

1. Subject Code: **PEN-356** Course Title: **Financial and Management Accounting**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To familiarize the students with the system of financial reporting of a business enterprise, and cost accounting information for managerial decision making.

10. Details of Course:

S. No.	Contents	Contact Hours
Financial Accounting:		
1.	Introduction to financial accounting; Generally accepted accounting principles, accounting convention and concepts; Revenue recognition and measurement, matching of revenues and expenses.	3
2.	Inventory valuation; Fixed assets and depreciation accounting; Intangible assets.	2
3.	Balance sheet and related concepts; Profit and loss account and related concepts.	4
4.	Accounting mechanics, basic records, preparation of financial statements.	5
5.	Analysis of financial statements, financial ratio analysis; Analysis related to movement of funds.	8
6.	Legal requirements relating to accounting and auditing.	2
Management Accounting:		
7.	Structure and analysis of cost; Cost-volume-profit analysis.	3
8.	Budgets and budgetary control, framework for budgeting, types of budgets.	3
9.	Standard costing and variance analysis; Elements of cost; Cost sheet; Process costing.	8
10.	Accounting for pricing decisions; Differential costing: relevant and irrelevant cost; Marginal costing	4
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Bhattacharya H., "How to Read Balance Sheet: An ILO Programme Book", Oxford & IBH Publication.	2007
2.	Bhattacharya S.K. and Deardon J., "Accounting for Management: Text and Cases", Vikas Publishing House.	2005
3.	Grewal T.S., "Introduction to Accounting" Sultan Chand.	2005
4.	Horngreen C.T. and Surdern G.L., "Introduction to Financial Accounting", 13th Ed., Prentice Hall.	2007
5	Shukla M.C., Grewal T.S. and Gupta M.P., "Cost Accounting Text and Problems", Sultan Chand Ltd.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Polymer and Process Engineering**

1. Subject Code: **PEN-401** Course Title: **Financial Management**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To acquaint the students with the planning and controlling of the firm's financial resources with a view to maximize the firm's wealth.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Aims and objectives of financial management.	2
2.	Concept of business and financial risk; Operating and financial leverage.	2
3.	Investment and capital budgeting decisions: estimation of cash flows, capital budgeting techniques.	6
4.	Cost of different sources of raising capital, weighted average cost of capital; Concept of optimum capital structure.	6
5.	Management of working capital.	2
6.	Management of cash; Accounts receivable; Inventories; Accounts payable.	5
7.	Long term financing; Internal financing and dividend policy.	3
8.	An Introduction to recent trends in Indian money and capital markets.	2
	Total	28

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Mcmenamin J., "Financial Management: An Introduction", Prentice Hall of India.	1999
2.	Reddy R.J., and Reddy R.J.P., "Advanced cost and Management Accounting", APH Publishers.	2004

3.	Van Home, J.C., "Financial Management and Policy", 12th Ed., Prentice Hall of India.	2008
4.	Van Home, J.C and Wachowicz J.M., "Fundamentals of Financial Management", 11th Ed., Prentice Hall of India.	2008
5.	Jain P.K and Khan M.Y., "Financial Management: Text, Problems and Cases", 6th Ed., Tata McGraw-Hill Education Private Limited.	2013

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Polymer and Process Engineering**

1. Subject Code: **PEN-402** Course Title: **Operations Management**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge of Operations Management and its role in the total enterprise management.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	System concept; Role of operations management in enterprise management; Concept of product life cycle; Manufacturing strategy.	2
2.	Forecasting techniques; Facility location and layout.	6
3.	Method study and work measurement; Concepts and principles of value engineering.	4
4.	Production scheduling and control; Aggregate production planning, Just in time; Materials requirements planning.	7
5.	Project management: Introduction, Critical Path Method (CPM), Project Evaluation and Review Techniques (PERT).	3
6.	Quality management: Statistical Process Control (SPC), benchmarking; Six sigma; Quality circles and introduction to ISO 9000.	4
7.	Advanced manufacturing technologies, JIT/TQC; Synchronous production.	2
	Total	28

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Adams E. and Ebert R, "Production and Operations Management", 5th Ed., Prentice Hall of India.	2008

2.	Buffa E.S. and Sarain R K, "Modern Production/Operations Management", 8th Ed., Wiley and Sons.	2008
3.	Gaither N. and Frazier G., "Operations Management", 9th Ed., Thompson Publishing.	2007
4.	Heizer J. and Render B., "Operations Management", 8th Ed., Prentice Hall.	2006
5	Stevenson W.J and Hojati M., "Production Operations Management", 9th Ed., McGraw Hill.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Polymer and Process Engineering**

1. Subject Code: **PEN-403** Course Title: **Marketing Management**

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

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

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

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

8. Pre-requisite: **NIL**

9. Objective: To develop basic analytical skills, conceptual abilities and substantive knowledge in the field of marketing.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Critical role of marketing in organization/society; Marketing planning & research.	2
2.	**Analyzing Marketing Opportunities:** Analyzing marketing environment; Consumer behavior; Industries and competitors.	3
3.	**Developing Marking Strategies:** Segmentation and targeting; Differentiation and positioning; New product marketing; Life cycle; Designing marketing strategies; Advertising strategies, product and brand management; Product hierarchy and classification, product mix and product line decisions; Brand decisions, brand equity, brand name, extensions, and brand strategy.	7
4.	**Marketing in Specific Areas:** International marketing; Industrial marketing; Services marketing.	3
5.	**Planning Marketing Programs:** Functional aspects; Pricing decisions; Channel management; Sales force management; Communication and promotion decisions, advertising, direct marketing, sales promotion and public relations; Internet marketing.	4
6.	**Implementation & Control of Marketing Efforts:** Organizing and implementing marketing programs; Evaluating and controlling marketing performance.	3
7.	**Marketing Research:** Problem definition, objective setting, decision problem, and research problem; Research design, research matrix data	6

	collection approaches, measurement and scaling; Research instrument preparation; Analysis and interpretation of data, univariate/ bivariate techniques, measuring and forecasting market demand.	
	Total	28

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Dholakia N., Wolfhang F., Dholakia R.R. and Mundrof N., "Global E-Commerce and Online Marketing, Greenwood Publisher.	2002
2.	Kotler P., "Marketing Management – Analysis, Planning, Implementation and Control", 12th Ed., Prentice Hall India.	2008
3.	Kotler P., Kotler, L.B. and Armstrong A.S., "Principles of Marketing" Prentice Hall.	2006
4.	Lancaster P. and Reynold P., "Management of Marketing", Elsevier Butterworth Heinemann.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Polymer and Process Engineering**

1. Subject Code: **PEN-404** Course Title: **Human Resource Management**

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

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

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

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

8. Pre-requisite: **NIL**

9. Objective: To familiarize the students with the various facets of management of human resource and organizational behavior.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Concepts and perspective on human resource management; Role of HRM in a competitive business environment; Environment affecting HRM at the enterprise level.	3
2.	HR planning and job analysis; Recruitment, selection, placement, induction and socialization of the employee.	3
3.	Manpower training and development.	2
4.	Appraising employee performance and potential evaluation.	2
5.	HR accounting, inventory and information system.	2
6.	Compensation and reward administration; Grievance management.	4
7.	Collective bargaining; Trade unions; Industrial relation; Overview of labour laws.	4
8.	External environment of organizations, organizational design and structure, departmentation.	2
10	Group dynamics; Leadership processes and styles; Managing organizational change and development.	4
11.	Organizational conflict; Stress management.	2
	Total	28

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Dessler G., "Framework for Human Resource Management", 11th Ed., Prentice Hall of India.	2008
2.	De Cenzo D. A., and Robbins S. P., "Human Resource Management", 8th Ed., John Wiley.	2008
3.	Newstrom J.W. and Davis K., "Organizational Behavior: Human Behavior at Work", Tata McGraw Hill.	2008
4.	Robbins S.P., "Organizational Behavior Concepts, Controversies, Applications", 12th Ed., Prentice Hall of India.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Polymer and Process Engineering**

1. Subject Code: **PE-422** Course Title: **Numerical Methods & Optimization in Polymer Engineering**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge on the numerical methods and optimization polymer engineering

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Approximations and Errors and Solution of Algebraic and Transcendental Equations:** Types of errors; Significant figures; Accuracy of numbers; Precision; Error propagation; Basic properties of equations; Relations between roots and coefficients; Bracketing methods (bisection, secant, method of false position or regula falsi); Convergence of iterative methods; Newton-Raphson method, Newton-Raphson method for non linear equations; Applications in polymer engineering	7
2	**Solution of Linear Equations:** Matrix inversion; Gauss elimination; Gauss-Jordan method; Gauss-Seidel iteration method, Jacobi's Method; Gauss-Seidel method; Applications in polymer engineering.	5
3.	Curve fitting; Basic of finite differences & interpolation; Numerical differentiation & integration; Ordinary differential equations; Partial differential equations	6
4.	Basic concepts of process optimization and application to various process industries.	3
5.	**Problem Formulation:** Nature and organization of nonlinear optimization problems; Development of models for optimization with equality or inequality constraints; Degrees of freedom; Basic of optimization of unconstrained functions; Linear programming; Nonlinear Programming; Global optimization for problems with continuous and discrete variables	7
	Total	28

11. Suggested Books:

S. No.	Name of Authors /Book/ Publisher	Year of Publication
1.	Edger T.F., Himmelblau D.M., "Optimization of Chemical Processes", 2nd Ed., McGraw Hill.	2001
2.	Gupta S.K., "Numerical Methods for Engineers", 3rd Ed., New Academic Science	2013
3.	Nicholson T.A.J., "Optimization in Industry: Optimization Techniques", Aldine Transaction.	2007
4.	Chapra S.C., Canale R.P., "Numerical Methods for Engineers", 6th Ed., McGraw-Hill Higher Education,	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Department Polymer and Process Engineering

1. Subject Code: **PE-424** Course Title: **Petrochemical Technology**
2. Contact Hours: **L: 2** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0
4. Relative Weightage CWS 25 PRS 0 MTE 25 ETE 50 PRE 0
5. Credits: 3 6. Semester: **Autumn/Spring** 7. Subject Area: PEC
8. Pre-requisite: **Nil**

9. Objective: To impart knowledge on petroleum and petrochemicals produced from petrochemical industries.

10. Details of the Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Origin, exploration and production of petroleum; Types, characteristics and products pattern of crudes; Engineering aspects of refining; Crude heating; Storage and handling of crude products. Lube oil and wax processing;.	4
2.	**Crude Processing** Solvent extraction; Desalting; Dewaxing; Deasphalting; Clay contacting; Principles, technologies and operating parameters; Feed and product qualities and yields; Asphalt manufacture; Product quality control; Air blowing technology; Primary distillation; Separation of cuts; Gaps/ overlaps; Stripping; Heat balance in distillation; Energy input and recovery; Vacuum distillation; Types of trays; Draw offs; Intermediate product quality control; Fischer-Tropsch process	5
3.	**Petrochemicals Production and Utilization of Synthesis Gas:** Generation of synthesis gas by steam reforming of naphtha and natural gas; Fuel oil partial oxidation; Chemicals from synthesis gas- methanol, formaldehyde, chloromethane, trichloroethylene and perchloroethylene; Petrochemical products based on methane, ethylene, acetylene, propylene, butane, methanol, VAM, acrylonitrile, isopropanol, propylene oxide, glycerine, acrylonitrile, acrylic acid, butadiene.	8
4.	**Separation and Utilization of Aromatics:** General overview of separation of aromatics- benzene, toluene and xylene; Alkylation of benzene; Production of pthalic anhydride and synthetic detergents, dyes and perfumes.	5
5.	**Synthetic Fibres, Rubbers, Plastics, Resins from Petrochemicals:** General overview of methods of production of HDPE, LDPE, polyester fibres and SBR.	6
	Total	28

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication / Reprint
1.	Brownstein A.M., "Trends in Petrochemical Technology" Petroleum Publishing Company.	1976
2.	Mall I.D., "Petrochemical process technology" Macmillan	2006
3.	Meyers R., "Handbook of Petrochemicals production Processes" McGraw Hill Handbooks.	2004
4.	Nelson W.L., "Petroleum Refinery Engineering" McGraw Hill Publishing Company Limited.	1985
5.	Watkins R.N., "Petroleum Refinery Distillation", 2nd Edition, Gulf Publishing Company, Texas.	1981
6.	Hobson G.D., "Modern petroleum Refining Technology" 5th Edition, John Wiley Publishers.	1984

NAME DEPT: Polymer & Process Engineering

1. Subject Code: PE-426 Course Title: **Polymeric Fiber Technology**

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

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

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

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

8. Pre-requisite: **NIL**

9. Objective: The course is intended to provide understanding about technology of polymeric fibers.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Structure, properties and morphology of fiber forming natural and synthetic polymers.	4
2.	**Processing**: Melt and solution spinning operation, general principles of fluid flow, spinning and extrusions, dry and wet spinning of fibers, spinneret size, rate of extrusion, effect of spinning on filament structure and properties; Die design.	6
3.	**Post-processing**: Post spinning, finishing, drawing and seat setting operations, effect on orientation and crystallization, heat setting and texturing, principles of setting of fibers and fabrics.	4
4.	**Characterization**: Testing of fibers; density, birefringence, tensile, moisture regain, dyeing mechanism, color fastness.	6
5.	**Yarn Synthesis:** Production of staple yarns of natural and synthetic fibers.	3
6.	**Production and Applications**: Manufacturing methods and applications of fibers based on: polyethylene, polyamide, polypropylene, polyacrilonitrile, polyester, polylactic acid.	5
	Total	**28**

11. Suggested Books:

S. No.	Name of Authors /Books /Publishers	Year of Publication
1.	Gupta V.B., Kothari V.K., "Manufactures Fiber Technology", Chapman and Hall.	2003
2.	Mark H.F., Atlas S.M., Cernia E., "Man Made Fibres Science and Technology", Wiley Interscience.	1968
3.	Moncrieff R.W., " Man Made Fibres" , Haywood Books.	1975

4.	Vaidya A. A., "Production of Synthetic Fibers", Prentice Hall.	2001
5.	Deopura B. L., Alagirusamy R., Gupta B., Joshi M., "Fibrous Materials: Polyesters and Polyamides", Woodhead Publishing Ltd and CRC Press.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE:- **Polymer and Process Engineering**

1. Subject Code: **PE-428** Course Title: **Polymeric Nanomaterials**
2. Contact Hours: L:2 T: 1 P: 0
3. Exam Duration (Hrs.): Theory 2 Practical 0
4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0
5. Credit: 3 6. Semester: **Spring/ Autumn** 7. Subject Area: **PEC**
8. Prerequisite **Nil**

9. Objective: To impart knowledge of nanotechnology applications in polymer industry.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Advancement of nanocomposite, nanofillers; Classification of nanofillers, nanoclay, nanosilica, nanoparticles, carbon based nanofillers; Synthesis and properties of fillers.	4
2.	**Synthesis of Nanocomposites**: Direct mixing, solution mixing, in-situ polymerization, ex-situ processing; Ceramic/polymer composites; Metal/polymer nanocomposites; Modification of interfaces; Modification of nanofillers.	5
3.	**Mechanical, Thermal and Optical Properties of Nanocomposites**: Stress-strain properties - tensile, modulus, elongation at break; Flexural properties; Load-carrying capability; Toughness; Impact resistance; Relaxation behavior; Wear resistance; Thermal stability and flammability; Dynamic mechanical thermal properties; Glass transition; Electrical properties: Resistivity, permittivity, breakdown strength; Optical properties: Refractive index, transparency.	6
5.	**Morphological Aspect of Nanocomposites**: Characterization of nanocomposites by XRD, TEM, AFM and FESEM.	5
6.	**Barrier Properties of Polymer Nanocomposites:** Permeation and diffusion models relevant to polymer nanocomposites; Diffusivity, sorption, permeability.	5
7.	**Applications:** Some examples of advanced applications of polymer nanocomposites: Space, automobiles, defence and modern life.	3
	Total	28

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Mai Y.W., Yu Z.Z., "Polymer Nanocomposites", Woodhead Publishing Limited and CRC Press LLC.	2006
2.	Ajayan P.M., Schadler, L.S., Braun, P.V., "Nanocomposite Science and Technology" Wiley-VCH Verlag GmbH Co. KGaA.	2003
3.	Nicolais L., Carotenuto G., "Metal-Polymer Nanocomposites" Willy Inter Science	2005
4.	Sergeev G.B., "Nanochemistry" Elsevier	2006
5.	Ke Y.C., Stroeve P., "Polymer-Layered Silicate and Silica Nanocomposites" Elsevier	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Dept. of Polymer and Process Engineering**

1. Subject Code: PE-430 Course Title: **Molecular Simulation of Polymers**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge of procedures of molecular modeling and simulations and their applications for polymers

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to Molecular Simulations:** Concept of molecular simulations and their applications; Polymer chain conformations; The Gaussian chain, chain conformation under an external field; Excluded volume effect and theta condition	3
3	**Molecular Simulation Techniques** – RIS-Monte Carlo (RIS-MC); Rotational Metropolis-Monte Carlo (RMMC); Molecular dynamics (MD); On lattice and off-lattice Monte Carlo simulations; Monte carlo Simulations in various ensembles; Molecular dynamics in various ensembles.	6
5	**Estimation of Dynamic Properties through Molecular Simulations**– Concepts of primitive path and tube model; Simulation protocols for determination of dynamic properties such as entanglement length, tube diameter, contour length, etc; Models for chain entanglement; Primitive path analysis through contour length/energy minimization procedures.	7
6	**Modeling and Simulations for understanding Elasticity and Photoelasticity (Birefringence-strain) Relationships of Polymer Networks:** Relationships between stress-strain and birefringence-strain with examples from PET Film networks, SBS/SIS thermoplastic elastomeric networks and Poly-isoprene elastomeric networks.	6
7	Scope and Applications of available Molecular Simulation Software Packages- Employing software packages such as DLPOLY,	6

	LAMMPS, material studio, Z-code, to solve polymer design problems, examples - entanglement length variation with chain length, determining characteristic static ($<R^2>$/M, etc) and dynamic properties (tube diameter (a_{pp}), entanglement/contour length, etc) of some commodity polymers such as PE, PET.	
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1	Daan Frenkel, Berend Smit, "Understanding Molecular Simulation: From Algorithms to Applications", Academic Press.	1996
2	P. J. Flory, "Principles of Polymer Chemistry", Cornell University Press.	1953
3.	P. J. Flory, "Statistical Mechanics of Chain Molecules", Interscience.	1989
4.	W. L. Mattice, U. W. Suter, "Conformational Theory of Large Molecules: The Rotational Isomeric State Model in Macromolecular Systems", Interscience.	1994
5.	M. Doi, S.F. Edwards "The Theory of Polymer Dynamics", Oxford Science Publications, Clarenden Press.	1986
6	L. R. G. Treloar, "The Physics of Rubber Elasticity", Clarendon Press.	1975

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT: Polymer and Process Engineering

1. Subject Code: PE-432 Course Title: Polymeric Film & Packaging Technology

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

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

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

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

8. Pre-requisite: NIL

9. Objective: The course will impart knowledge of polymeric films and packaging materials and their processing.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Polymers for Films and Sheets**: Structure, properties and morphology of film and sheet forming polymers.	3
2.	**Blown Film:** Principle, technology and operation of equipment for processing of blown film, structure and properties of blown films.	5
3.	**Melt Processed Film:** Materials, processes, equipment and machinery for melt processing of film, effect of processing parameters on structure and properties of melt processed film applications.	6
4.	**Multi Layered Films:** Materials and equipment for multi layered films, structure, properties and applications of films multi layered films; Tetra-packs.	6
5.	**Packaging Materials:** Types of packaging, film, sheet, and boxes, laminated packaging, packaging for electronic goods, commodity materials, medicines and food products.	4
6	**Processing:** Equipment and machinery for processing of packaging materials, principle, technology and operation of equipment, economics of packaging; Die design for film making.	4
	Total	28

11. **Suggested Books**

S. No.	Name of Books / Authors / Publisher	Year of Publication
1.	Bryston J. H., "Plastic Films", Longman.	2003
2.	Osswald J., "Polymer Processing Fundamentals", Hanser Gardner.	2004
3.	Brooks D., Giles G., (Eds), "PET Packaging Technology", Sheffield Academic Press.	2002

4.	Lagarón J., "Multifunctional and Nanoreinforced Polymers for Food Packaging", Woodhead Publishing.	211
5.	Hashim A.A., "Polymer Thin Films", InTech.	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Polymer and Process Engineering**

1. Subject Code: **PE-434** Course Title: **Equipment Design**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of mechanical design aspects of various pressure vessels and storage tanks used in polymer industries.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Mechanics of Materials:** Stress-strain relationship for elastic bodies; Theories of failure; Thermal stresses; Torsion of solid and hollow cylindrical shafts; Thin and thick cylinders under stress.	5
2.	**Pressure Vessels:** Introduction of codes for pressure vessel design; Classification of pressure vessels; Design of cylindrical and spherical shells under internal and external pressure; Selection and design of closures; Optimum length to diameter ratio of pressure vessel using common types of closures; Design of jacketed portion of vessels.	10
3.	**Tall Tower Design:** Design of shell, skirt, bearing plate, and anchor bolts for tall towers used at high wind and seismic conditions; Examples of design of tall towers, such as bleaching towers, and chimneys.	7
4.	**Storage Tanks:** Filling and breathing losses; Classification of storage tanks; Design of liquid and gas tanks; Design of storage tanks for process industries.	6
	Total	28

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Brownell L.E., Young H.E., "Process Equipment Design" 2nd Ed., John Wiley.	2004
2.	Bhattacharya B.C., "Introduction of Chemical Equipment Design", CBS.Publishers.	2003
3.	Joshi M.V., Mahajani V. V., "Process Equipment Design", MacMillan India.	1996
4.	I.S: 2825-1969 (Reaffirmed), "Code for Unfired Pressure Vessels", BIS, New Delhi.	2007
5.	I.S: 803-1976 (Reaffirmed), "Code of Practice for Design, Fabrication and Erection of Vertical Mild Steel Cylindrical Welded Oil Storage Tanks", BIS, New Delhi.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: POLYMER AND PROCESS ENGINEERING

1. Subject Code: PE-436 Course Title: Polymer Product Technology

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

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

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

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

8. Pre-requisite: NIL

9. Objective: To provide knowledge of advanced polymer product technologies.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Processing of thermosetting and thermoplastic high performance products, 3D printing, polymers in defense and aerospace applications, computer aided product design, polymers in non-linear optics, light emitting polymers, photovoltaic applications.	6
2.	**Advanced Thermoset Processing Technologies:** Operating principles, process controls and applications of resin transfer molding, pultrusion, filament winding, prepeg layup and compression moulding of thermosets; Processing of unsaturated polymers: Polyesters, epoxy resins, phenolics, polyurethanes, polyimides and polyaramides; Reinforcements: Glass fiber, aramid fiber, carbon fiber and nanoclay; Dimensional stability and tolerance of thermoset products.	8
3.	**Advanced Thermoplastic Processing Technologies:** Operating principles, process controls and applications of reactive injection molding and reactive extrusion; Processing of thermoplastic polymers: Ultra high molecular weight PE, Teflon, PEEK and polyimides; Fiber spinning of vectran, kevlar, polyimides and polyaramides. Electospinning process; Nano-impregnation; 3D-printing; Metal inserts.	6
4.	**Polymers in Defense and Aerospace Applications:** Criteria for	8

	defence and space standard polymeric materials, composites applications and challenges for light weight design of aircraft structure and defence vehicles, self healing of fibre reinforced polymer composites, shape memory alloys integrated into composites for improved damage tolerance and lightening strike protection, carbon fibre based composites in aerospace and defence applications, multifunctional composites with carbon nanotubes and nanoclay for space applications, polymers for ballestic protection, fire retardant polymeric coatings, polymer actuators.	
	Total	28

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Chris R, "Polymer Extrusion", 5th Edition, Hanser Publications, Hanser.	2014
2.	Cheremisinoff N. P., "Advanced Polymer Processing", 2nd Edition, Noyes Publications,	1998
3.	Shonaike G O, Advani S G, "Advanced Polymeric Materials", CRC Press	2003
4.	Ajayan P. M., Schadler L. S., Braun P. V., "Nanocomposite Science and Technology" Wiley-VCH	2003
5.	Wise D.L., Wnek G. E., Trantola, D. J., Copper T. M., Gresser J. D., "Electrical and Optical Polymer Systems", 1st Edition, Marcel Dekker Inc.	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **IBM- 312** Course Title: **Data Mining for Business Intelligence**
2. Contact Hours: **L: 2 T: 1 P: 0**
3. Examination Duration (Hrs.): **Theory: 2** **Practical: 0**
4. Relative Weightage: **CWS: 25 PRS: 0 MTE : 25 ETE : 50 PRE: 0**
5. Credits: **3** 6. Semester: **Both** 7. Subject Area: **HSSMEC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge on use of data mining techniques for deriving business intelligence to achieve organizational goals.
10. Details of Course:

S. No.	Contents	Contact hours
1.	**General Overview of Data Mining and its Components** Data Mining definitions, applications, origins, growth, terminology and notation. Data Mining Process: core ideas, overview of classification, prediction, association rules, predictive analytics, data reduction, data exploration, data visualization, supervised and unsupervised learning, and steps in data mining.	3
2.	**Data Exploration and Preparation** Data Visualization: basic charts, multidimensional visualization, and specialized visualizations. Dimension Reduction: Data summaries, correlation analysis, and principal component analysis	3
3.	**Performance Evaluation** Judging classification performance: naïve rule, class separation, classification matrix, accuracy measures, cutoff, unequal importance of classes, and asymmetric misclassification. Evaluating predictive performance: average, prediction accuracy measures	4
4.	**Supervised Learning Methods: Model Based Methods** Multiple Linear Regression, Logistic Regression: modeling, evaluation, and analysis.	4
5.	**Supervised Learning Methods: Data-Driven Methods** k-Nearest Neighbors (k-NN), Classification and Regression Trees: modeling, evaluation, and analysis. Neural Nets: concept and structure, fitting a network to data.	6

6.	**Unsupervised Learning** Association Rules: A priori algorithm, support and confidence. Cluster Analysis: distance measures, hierarchical clustering, and nonhierarchical clustering.	4
7.	**Forecasting Time Series** Handling Time Series: time series components, data partitioning. Regression-Based Forecasting: model with trend, model with seasonality, model with trend and seasonality. Smoothing Methods: moving average, simple exponential smoothing.	4
	Total	**28**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Galit Shmueli, Nitin Patel, and Peter Bruce, Data Mining for Business Intelligence: Concepts, Techniques, and Applications in Microsoft Office Excel with XLMiner, Second Edition	2015
2.	Ian H. Witten, Eibe Frank, and Mark A. Hall, Data Mining: Practical Machine Learning Tools and Techniques, Third Edition	2011
3.	Anand Rajaraman, and Jeffrey David Ullman, Mining of Massive Datasets, First Edition	2011
4.	Jiawei Han, Micheline Kamber, and Jian Pei, Data Mining: Concepts and Techniques, Third Revised Edition	2011
5.	Foster Provost, and Tom Fawcett, Data Science for Business: What you need to know about data mining and data-analytic thinking, First Edition	2013

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **IBM- 313** Course Title : **Project Management**
2. Contact Hours: **L: 3** **T: 0** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits: **3** 6.Semester: **Both** 7. Subject Area: **HSSMEC**
8. Pre-requisite: **Nil**
9. Objective: To provide an integrative approach to management of projects, detailing the concepts of various phases of the Project life cycle.
10. Details of the Course:

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

11. Suggested Books:

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **IBM-314** Course Title: **Financial Statement Analysis and Reporting**
2. Contact Hours: **L:** 3 **T:** 0 **P:** 0
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weightage: **CWS: 25 PRS : 0 MTE : 25 ETE : 50 PRE : 0**
5. Credits: **3** 6. Semester: **Both** 7. Subject Area: **HSSMEC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge of tools, techniques and approaches for financial statement analysis based on qualitative and quantitative information.
10. Details of Course:

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

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Ormiston, Aileen, Fraser and Lyn, M., "Understanding Financial Statements", 9th Edition ,Prentice Hall of India	2014
2.	Gupta, Ambrish, "Financial Accounting for Management - An Analytical Perspective", 4th Edition, Pearson Education.	2012
3.	Narayanaswamy, R., "Financial Accounting – A Managerial Perspective", 5th Edition , Prentice Hall of India	2015
4.	Subramanyam, K. R. and John, J.W., "Financial Statement Analysis", 12th Edition, Tata McGraw Hill	2014
5.	Penman, S.H., "Financial Statement Analysis and Security Valuation", 4th Edition, Tata McGraw Hill	2014
6.	Erich, A. H., "Techniques of Financial Analysis: A Guide to Value Creation", 16th Edition ,Tata McGraw Hill	2014

Serial No. 151930

Enrolment No. 10913016

भारतीय प्रौद्योगिकी संस्थान रुड़की

अभिषद् की अनुशंसा पर

विद्या वाचस्पति

की उपाधि

अददंकी वेंकटेस्वरावव

को, जिन्होंने इस उपाधि की अवाप्ति हेतु विनियम विहित अपेक्षाओं को दिनांक जून 20, 2015 को सफलतापूर्वक पूरा कर लिया है, एतद्द्वारा प्रदान करता है।

शोध प्रबन्ध शीर्षक: कार्बाज़ोल-बेस्ड ऑर्गेनिक डाईज़ फॉर डाई-सेन्सिटाईज़्ड सोलर सेल्स

भारतीय गणराज्य के अन्तर्गत रुड़की में आज, दिनांक अक्टूबर 03, 2015, संस्थान की मुद्रा अंकित यह उपाधि दी गई।

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

On the recommendation of the Senate hereby confers the degree of

Doctor of Philosophy

upon

ADDANKI VENKATESWARARAO

who has successfully completed on the June 20, 2015 the requirements prescribed under the regulations for the award of this degree

Thesis Title: CARBAZOLE-BASED ORGANIC DYES FOR DYE-SENSITIZED SOLAR CELLS

Given this day, the October 03, 2015, under the seal of the Institute at Roorkee in the Republic of India.

अध्यक्ष, अभिशासक परिषद्
Chairman, Board of Governors

निदेशक एवं अध्यक्ष, अभिषद्
Director & Chairman, Senate

कुलसचिव
Registrar

Correct

Table-I Modified Courses of IV and V Year Integrated M.Sc. Programmes

S.No.	Course under Old Structure during IV and V Yrs.	Cr.	Recommended Course Under New Structure	Cr.	Remark
			Integrated M.Sc. (Chemistry)		
IV year Autumn Semester					
1.	CY-511 Quantum Mechanics, Bonding, Symmetry & Group Theory	4	CYN-501 Quantum Mechanics, Symmetry and Group Theory	3	Code & Credit Changed. Minor change in Title
2.	CY-521 Thermodynamics & Surface Chemistry	4	CYN-503 Thermodynamics and Surface Chemistry	3	Code & Credit Changed.
3.	CY-531 Analytical Techniques	3	CYN-505 Analytical Techniques	3	Code changed
4.	CY-541 Advanced Organic Chemistry-I	4	CYN-507 Advanced Organic Chemistry-I	3	Code & Credit Changed.
5.	CY-551 Laboratory-III	6	CYN-511 Advanced Laboratory-I	6	Code & Credit Changed.
6.	-	-	CY-509 Coordinate Chemistry	3	Shifted from spring to autumn with change in title
IV year Spring Semester					
1.	CY-512 Advanced Coordinate and Organometallic Chemistry	4	CYN-502 Organometallic Chemistry	3	Divided in two parts. One shifted to autumn sem.
2.	CY-522 Kinetics and Photochemistry	4	CYN-504 Kinetics and Photochemistry	3	Code & Credit Changed.
3.	CY-532 Advanced Organic Chemistry-II	4	CYN-506 Advanced Organic Chemistry-II	3	Code & Credit Changed.
4.	CY-542 Laboratory-IV	6	CYN-508 Advanced Laboratory-II	6	Code & Credit Changed.
5.	Departmental Elective-I	3	Departmental Elective-I	3	No Change
6.	Institute Elective-III (HSSMEC)	3	Institute Elective-III (HSSMEC)	3	No Change
V year Autumn Semester					
1.	Departmental Elective-II/III/IV/V/VI	3	Departmental Elective-II/III/IV/V/VI	3	No Change
2.	CY-671 Project	6	CYN-601 Advanced Laboratory-III	6	Project replaced by laboratory
V year Spring Semester					
1.	Departmental Elective-VII	3	Departmental Elective-VII	3	No Change
2.	CY-681 Seminar	4	CYN-602 Seminar	4	Credit changed.
3.	CY-692 Dissertation	14	CYN-604 Project	14	Dissertation replaced by project.

Appendix 'G'
Item No. Senate/ 63.19

AGREEMENT EXECUTED BETWEEN THE DONOR FOR SCHOLARSHIPS/AWARDS/PRIZES AND THE DIRECTOR, INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

An agreement made on ...23rd.....day ...JULY.....month of Two Thousand ~~Thirteen~~ FIFTEEN between ...MRS. VEENA GUPTA..... residing at ...AM SEE 8, 65795 HATTERSHEIM, GERM (Hereinafter called "Donor" which expression shall include his/her legal representative(s) and assignees of the one part) and the Director, Indian Institute of Technology Roorkee (herein called the Director, which expression shall include his legal representative and assignees of the other part).

Whereas a Scholarship/Award/Prize fund has been created by the Indian Institute of Technology Roorkee with the object and purpose to help the deserving and meritorious students of the Institute by way of instituting scholarships/awards/cash prizes/fellowships on merit-cum-means/merit basis and the donor desires to donate a sum of ...3,75,000/-..... for the institution of one scholarship at the Institute in the name of "*.....". The Director has agreed to accept the donation on the terms and conditions contained herein.

* PROF. DR. S.R. GUPTA MEMORIAL SCHOLARSHIP

(1) The Donor desires that the scholarship be instituted as follows:

Candidate(s) Eligibility, Number and Name of Scholarships, Criterion and Amount

Name of Scholarship "*....."

Eligibility Description	Numbers of Scholarships	Criterion	Amount (Rs.)
B.E. (MECH.)	ONE	1. (@) STUDENT SHOULD BE FROM ECONOMICALLY WEAKER SECTION 2. (@) CGPA ABOVE 3. NO INVOLVEMENT IN ACTS OF INDISCIPLINE	25,000/- PER YEAR

(@) CGPA & income as per Institute rule applicable for MCM scholarship.

(2) Name and Address of a person who will represent the Donor in his absence

Full Name SHASHANK GUPTA Occupation SERVICE

Address – AM SEE 8, 65795 HATTERSHEIM, GERMANY

Telephone No. +49-6190-8875872 Email SHASHANK_GUPTA@YAHOO.COM
+49-17624638441

IT IS HEREBY AGREED between the parties hereto that in consideration of the sum of (in figure) 3,75,000/- (in words) Three Lac Seventy five Thousand only given by the Donor to the Institute (the receipt of which the Institute hereby acknowledges), the Donor hereby agrees with the Director:

1. That the Director shall be free to frame the rules and regulations for institution of the scholarship with the value of the award depending on the income of the Trust and for carrying on the purpose and objects of the Trust.

2. That the Director shall have the power to invest the amount of donation as he considers proper and just for the furtherance of the purposes and objects of the Trust with some scheduled/nationalized bank or a Government undertaking against Fixed Deposit Receipt/Bonds yielding high rate of interest so as to get the maximum amount for the award.

3. That the scholarship will not be awarded on the basis of caste, creed, religion and region.

4. That the decision of the Director regarding the rules and regulations of the Trust or value of the award shall be final and shall not be questioned or challenged in any court of law by the Donor or his representatives and assignees.

In witness, where-of, the agreement has been signed by me in the presence of the following witnesses:

Date 23/07/2015

Gupta

Signature of the Donor/ Representative

Full Name VEENA GUPTA Occupation HOUSEWIFE

Address – AM SEE 8, 65795 HATTERSHEIM, GERMANY

Telephone No. +49-6190-8875872 Email SRGUOR@REDIFFMAIL.COM

(For Donor)
WITNESS No. 1 Shashank Gupta **Date.** 23/07/2015
Signature of the Witness

FULL NAME ..... SHASHANK GUPTA .....

ADDRESS .....

Telephone No ..... Email .....

WITNESS No. 2 Smriti **Date.** 23/07/2015
Signature of the Witness

FULL NAME ..... SMRITI GUPTA .....

ADDRESS .....

Telephone No ..... Email .....

(Prof. Pradipta Banerji)
DIRECTOR
IIT ROORKEE

Date.....

Sandeep Singh

(For Institute)
WITNESS No. 1
Signature of the Witness

Prof. Sandeep Singh
Dean Alumni Affairs and International Relations
Indian Institute of Technology Roorkee
Roorkee - 247 667, Uttarakhand, INDIA

Date.....

FULL NAME .....
ADDRESS .....
Telephone No .....
Fax..... E-mail: .....

WITNESS No. 2
Signature of the Witness

Date.....

Dean, Academics
Indian Institute of Technology Roorkee
Roorkee-247 667, Uttarakhand, INDIA

FULL NAME .....
ADDRESS .....
Telephone No .....
Fax.....E-mail: .....

AGREEMENT EXECUTED BETWEEN THE DONOR FOR SCHOLARSHIPS/AWARDS/PRIZES AND THE DIRECTOR, INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

An agreement made on ...12th.....day July.....month of Two Thousand ~~Thirteen~~ Fifteen between SRI INDRA PRAKASH GUPTA..... residing at #.B.702, ARAVALI HEIGHTS, SECTOR 21C (X) FARIDABAD, 121001, HARYANA (Hereinafter called "Donor" which expression shall include his/her legal representative(s) and assignees of the one part) and the Director, Indian Institute of Technology Roorkee (herein called the Director, which expression shall include his legal representative and assignees of the other part).

Whereas a Scholarship/Award/Prize fund has been created by the Indian Institute of Technology Roorkee with the object and purpose to help the deserving and meritorious students of the Institute by way of instituting scholarships/awards/cash prizes/fellowships on merit-cum-means/merit basis and the donor desires to donate a sum of INR. 1,50,000/- for the institution of one scholarship at the Institute in the name of "SMT. GOMTI DEVI.....". The Director has agreed to accept the donation on the terms and conditions contained herein.

(1) The Donor desires that the scholarship be instituted as follows:

Candidate(s) Eligibility, Number and Name of Scholarships, Criterion and Amount

Name of Scholarship "....."
" SMT. GOMTI DEVI TRAVEL GRANT FOR INTERNSHIP"

Eligibility Description	Numbers of Scholarships	Criterion	Amount (Rs.)
Any Full Time Student of IIT, Roorkee	ONE	To be decided by Director, IIT, Roorkee	30,000/-

(2) Name and Address of a person who will represent the Donor in his absence

Full Name SUSHIL GUPTA ..... Occupation Retired Govt. Officer

Address – # B-702, ARAVALI HEIGHTS, SECTOR 21-C, FARIDABAD -12100 1

Telephone No. +91 9999744061 Email SUSHIL.ANITAGUPTA@YAHOO.COM

IT IS HEREBY AGREED between the parties hereto that in consideration of the sum of (in figure) 4,50,000/- (in words) Rs. four lakh fifty thousand only given by the Donor to the Institute (the receipt of which the Institute hereby acknowledges), the Donor hereby agrees with the Director:

1. That the Director shall be free to frame the rules and regulations for institution of the scholarship with the value of the award depending on the income of the Trust and for carrying on the purpose and objects of the Trust.

2. That the Director shall have the power to invest the amount of donation as he considers proper and just for the furtherance of the purposes and objects of the Trust with some scheduled/nationalized bank or a Government undertaking against Fixed Deposit Receipt/Bonds yielding high rate of interest so as to get the maximum amount for the award.

3. That the scholarship will not be awarded on the basis of caste, creed, religion and region.

4. That the decision of the Director regarding the rules and regulations of the Trust or value of the award shall be final and shall not be questioned or challenged in any court of law by the Donor or his representatives and assignees.

In witness, where-of, the agreement has been signed by me in the presence of the following witnesses:

Date..12.7.15.....

Signature of the Donor/ Representative

Full Name INDRA PRAKASH GUPTA Occupation Retired

Address – # B-702, Aravali Heights, Sector 21-C, Faridabad - 12100 1

Telephone No. 09999744061 Email SUSHIL.ANITA GUPTA@YAHOO.COM

(For Donor)
WITNESS No. 1
Signature of the Witness Sushil Gupta **Date**..12.7.15.....

FULL NAME ...SUSHIL GUPTA.....

ADDRESS B-702, Aravali Heights, 21-C Faridabad.....

Telephone No 09999744061.... Email SUSHIL.ANITA.GUPTA@YAHOO.COM

WITNESS No. 2
Signature of the Witness RC Jain **Date**..12.7.15.....

FULL NAME ...RATAN CHAND JAIN.....

ADDRESS B-502, CREATIVE HUTS, SEC-21-C, FARIDABAD-12100

Telephone No 9868103960 Email ratan.jain@gmail.com.

(Prof. Pradipta Banerji)
DIRECTOR
IIT ROORKEE

Date.....

Sandeep Sin

(For Institute)
WITNESS No. 1
Signature of the Witness

Prof. Sandeep Singh
Dean Alumni Affairs and International Relations
Indian Institute of Technology Roorkee
Roorkee - 247 667, Uttarakhand, INDIA

Date.....

FULL NAME .....
ADDRESS .....
Telephone No .....
Fax..... E-mail: .....

WITNESS No. 2
Signature of the Witness

Date.....

FULL NAME .....
ADDRESS .....
Telephone No .....
Fax.....E-mail: .....

S.	Name	Deptt.	Topic	Supervisor	Examiner (For./Ind.)	PDC Date
1	Mr. Srinivasa Kishore T.	AHEC	COST OPTIMIZATION OF POWER TRANSMISSION LINES IN HILLY AREAS	Dr. Sunil K. Singhal	Dr. Mohd. Reza Hesamzadeh / Swden Prof. D. Das / IITKgh	20.11.15
2	Mr. Gohil Pankaj kumar Paragbhai	AHEC	STUDY OF CAVITATION IN FRANCIS TURBINE FOR SMALL HYDRO POWER PLANTS	Dr. R. P. Saini	Prof. Eduard Doujak / Australia Prof. S. A. Channiwala / SVNIT Surat Prof. V. S. Moholkar / IITG	07.01.16
3	Ms. Monalisa	AR	METHODOLOGY FOR APPRAISAL OF PHYSIO-SPATIAL CHARACTER OF HILL STATIONS	Dr. Pushplata	Prof. Brian Goodey / UK Prof. Mandeep Singh / SPA Delhi Prof. Meenakshi Dhote / SPA Delhi	30.12.15
4	Mr. Rajendra Kumar	ASE	TUNABLEJOSEPHSON TRANSPORTIN SUPERCONDUCTORS DOUBLE COUPLEDQUANTUM DOTSJUNCTIONS: A MODEL STUDY	Dr. Ajay	Prof. Janez Bonca / Slovenia Prof. Saurabh Basu / IITG	05.11.15
5	Mr. Divesh Kumar	BM	SUSTAINABILITY ADOPTION THROUGH RELATIONSHIP MARKETING ACROSS SUPPLY CHAIN IN INDIAN FIRMS	Dr. Z. Rahman	Prof. Kannan Govindan / Denmark Prof. Sanjeev Prashar / IIM Raipur	21.10.15
6	Mr. Vikas Kumar	BM	EXAMINING THE ROLE OF DESTINATION PERSONALITY IN PREDICTING TOURIST BEHAVIOUR	Dr. J. K. Nayak	Prof. Ian Phau / Australia Prof. Narendra K.Sharma / IITK Prof. Sanjeev Prashar / IIM Raipur	24.11.15
7	Ms. Mobin Fatma	BM	MEASURING THE INFLUENCE OF CORPORATE SOCIAL RESPONSIBILITY ON CONSUMER RESPONSES	Dr. Z. Rahman	Prof Felix T. S. Chan / Hong Kong Dr. Surya Prakash Singh / IITD Dr. Ruppal W. Sharma / IIFT Delhi	22.12.15
8	Ms. Ridhi Arora	BM	PERSONALITY FACTORS AND MENTORING RELATIONSHIPS AS DETERMINANTS OF CAREER COMMITMENT	Dr. S. Rangnekar	Dr. Yanki Hartijasti / Indonesia Prof. M. P. Gupta / IITD	31.12.15
9	Ms. Sahalini Pareek	BT	PHYSIOLOGICAL, BIOCHEMICAL AND MOLECULAR STUDIES ON EFFECT OF SALT STRESS IN CLUSTER BEAN	Dr. G.S. Randhawa Dr. S. K. Tripathi	Prof. Gurmukh S. Johal / USA Dr. Manjit Singh / ICAR Solan	16.12.15
10	Mr. Tarun Kumar	CE	STUDIES ON FACTORS AFFECTING VERMIFILTRATION FOR WASTEWATER TREATMENT	Dr. K.S. Hari Prasad	Prof. Rajeev K. Sinha / Australia Prof. Ligy Philip / IITM	05.10.15
11	Ms. Susheela	CE	DEVELOPMENT OF AN APPROACH FOR BUILDING EXTRACTION USING SATELLITE IMAGES	Dr. P. K. Garg Dr. M. K. Jat	Prof. Xulin Gup / Canada Dr. Anil Kumar / IIRS Dehradun Dr. V. K. Dadhwal / NRSC Hyderabad	10.11.15
12	Mr. Ajay Singh Lodhi	CE	SCOUR AROUND SPUR DIKES AND BRIDGE PIERS FOUNDED IN COHESIVE SEDIMENT MIXTURES	Dr. P. K. Sharma Dr. G.J. Chakrapani Dr. R. K. Jain	Prof. Stefano Pagliara / Italy Prof. Rajeh Srivastava / IITK	24.11.15
13	Mr. Bhupesh Jain	CE	INVESTIGATION ON SWIRL IN PUMP SUMP INTAKES AND IT'S CONTROL	Dr. Z. Ahmad Dr. K. M. Singh	Prof. J. J. Williams / UK Prof. B. R. Chahar / IIT Delhi Dr. V. K. Ghlot / MANIT Bhopal	14.12.15

14	Mr. Manish Kumar Rathore	CE	THEORY AND DESIGN AIDS FOR SUSPENSION BRIDGES WITH REVERSE CABLES	Dr. Vipul Prakash	Prof. Lars Damkilde / Denmark Dr. Sushanta Chakraborty / IITKgh	17.12.15
15	Mr. Praveen Kumar	CH	SYNTHESIS AND CHARACTERIZATION OF CATALYSTS FOR DIMETHYL CARBONATE PRODUCTION	Dr. V. C. Srivastava Dr. I. M. Mishra	Prof. Paolo De Filippis / Italy Prof. K. K. Pant / IITD	05.10.15
16	Mr. Hiwarkar Ajay Devidas	CH	REMOVAL OF NITROGENOUS HETEROCYCLIC COMPOUNDS FROM AQUEOUS SOLUTION	Dr. V. C. Srivastava Dr. I. D. Mall	Prof. Ramin Farnood / Canada Prof. Z. V. P. Murthy / NIT Surat Dr. P. K. Bhattacharya / IITK	05.10.15
17	Mr. Desavath Viswanatha Naik	CH	COPROCESSING OF PYROLYSIS OIL WITH VGO IN FCC UNIT TO PRODUCE LPG AND GASOLINE	Dr. Vimal Kumar Dr. B. Prasad Dr. M. O. Garg	Prof. S. R. A. Kersten / Netherlands Prof. K. K. Pant / IITD	22.12.15
18	Ms. Anuradha Ravi	CSE	ENERGY EFFICIENT SEAMLESS SERVICE PROVISIONING IN MOBILE CLOUD COMPUTING	Dr. P.Sateesh Kumar	Dr. Pradeep K. Atrey / USA Prof. A. K. Tripathi / BHU Varansi Prof. Skumar Nandi / IITG	30.12.15
19	Ms. Nagamani Kompelli	CY	INTERACTION OF ORGANOTIN MOIETIES WITH DNA AND NUCLEIC ACID CONSTITUENTS	Dr. Mala Nath	Prof. Mohamed M. Shoukry / Arabia Prof. H. B. Singh / IITB	05.01.16
20	Mr. Ravi Kumar	CY	SYNTHESIS AND APPLICATIONS OF β- AND *MESO*-SUBSTITUTED PORPHYRINS	Dr. M. Shankar	Prof. Mathias O. Sengelreland / Japan Prof. M. Ravikanth / IITB Prof. Rajneesh Misra / IIT Indore Dr. V. G. Anand / IISER Pune	06.10.15
21	Mr. Mergu Naveen	CY	DESIGN AND SYNTHESIS OF FLUORESCENCE TURN-ON CHEMOSENSORS FOR SOME METAL IONS	Dr. V. K. Gupta Dr. A. K. Singh	Prof. Gary Christian / USA Prof. Imran Ali / JMI Delhi Prof. P. C. Pandey / BHU Varansi	03.12.15
22	Mr. Lokesh K. Kumawat	CY	ASSESSMENT OF METAL SENSING ABILITIES OF SOME OPTICAL CHEMOSENSORS	Dr. V. K. Gupta Dr. A. K. Singh	Prof. Shaobin Wang / Australia Prof. Nand Kishore / IITB Prof. Dinesh Mohan / JNU Delhi	30.12.15
23	Mr. Sachin Singh	EE	DESIGN AND EVALUATION OF ENHANCEMENT TECHNIQUES FOR SINGLE-CHANNEL SPEECH	Dr. Manoj Tripathi Dr. R. S. Anand	Dr. Roman Jarina / Europ Dr. Sudeshna Sarkar / IITKgh	05.11.15
24	Ms. Swati Sondhi	EE	FRACTIONAL ORDER BASED TECHNIQUES FOR STABILITY ANALYSIS AND CONTROLLER DESIGN	Dr. Yogesh Vijay Hote	Prof. Rama Yedavalli / Columbus Prof. P. C. V. Nataraj / IITB Prof. Somanath Majhi / IITG	02.12.15
25	Mr. Nagashettappa Biradar	EE	DENOISING AND SEGMENTATION OF ECHOCARDIOGRAPHIC IMAGES IN MULTILPE VIEWS	Dr. M. L. Dewal Dr. Manoj K. Rohit	Prof. Jai You / Hong Kong Prof. A. K. Nandi / UK Prof. P. K. Bora / IITG	16.12.15
26	Mr. Arif Iqbal	EE	ANALYSIS OF SIX-PHASE SYNCHRONOUS MOTOR	Dr. G. K. Singh Dr. Vinay Pant	Prof. Ming Cheng / China Dr. Bhim Singh / IITD	17.12.15
27	Mr. Nitesh Ahir	EQ	ANN FOR STRUCTURAL HEALTH MONITORING OF RC BUILDINGS: EXPERIMENTAL VALIDATION	Dr. Ashok Kumar Dr. Sashikant Thakkar	Prof. Jamshid Ghaboussi / USA Prof. Shankar Krishnapillai / IITM Prof. Anjan Dutta / IITG	11.12.15

28	Mr. Kamal	EQ	FINITE-DIFFERENCE MODELLING OF 3D BASIN EFFECTS ON GROUND MOTION CHARACTERISTICS	Dr. J. P. Narayan	Dr. Marcel Grehner / Switzerland Prof. J. N. Tripathi / A. U. Allahabad Dr. P. K. Khan / ISM Dhanbad	04.01.16
29	Ms. Rohita Sharma	HSS	A CRITICAL EVALUATION OF MURAL DEPICTION DURING MUGHAL ERA ARCHITECTURE	Dr. D. K. Nauriyal Dr. Illa Gupta	Prof. Mustafa Othman / Bahrain Prof. Anupama Sharma / MNIT Bhopal Prof. Deb K. Chakrabarti / IITG	23.12.15
30	Ms. Shashi Sharma	MA	MATHEMATICAL MODELING FOR MAGNETIC DRUG TARGETING	Dr. V. K. Katiyar Dr. Uaday Singh	Prof. J. Mazumdar / Australia Prof. Naveen Kumar / BHU Varansi Dr. Paras Ram / NIT Kurukshetra	02.11.15
31	Ms. Alka	MA	A STUDY OF SOME FUNCTIONAL IFFERENTIAL EQUATIONS OF FRACTIONAL ORDERS	Dr. D. N. Pandey	Prof. G. S. Ladde / USA Prof. Bahuguna Dhrendra / IITK	03.11.15
32	Ms. Sanjukta Das	MA	A STUDY ON EXISTENCE OF SOLUTION AND CONTROLLABILITY OF DELAY DI_ERENTIAL SYSTEMS	Dr. D. N. Pandey Dr. N. Sukavanam	Prof. Poul G. Hjorth / Denmark Prof. Bahuguna Dhrendra / IITK	01.12.15
33	Ms. Yashi Vishwakarma	MA	RELIABILITY BEHAVIOR ANALYSIS OF SOME INDUSTRIAL SYSTEMS USING IFS THEORY	Dr. S. P. Sharma	Dr. Ammar M. Sarhan / Canada Prof. U. Dinesh Kumar / IIM Bangalore Prof. A. K. Verma / IITB	04.12.15
34	Mr. Mani V.	MA	SOCIAL SUSTAINABILITY IN THE SUPPLY CHAIN OF INDIAN MANUFACTURING INDUSTRIES	Dr. Rajat Agarwal	Dr. Thanos Papadopoulos / UK Prof. G. S. Dangayach / MNIT Jaipur Dr. Sangeetha / IITKgh	04.01.16
35	Ms. Kumkum Bharti	MA	CONCEPTUALIZING AND MEASURING VALUE CO-CREATION FOR THE BOTTOM OF THE PYRAMID MARKET IN INDIA	Dr. Rajat Agarwal	Dr. Kamal Nayan Agarwal / USA Prof. A. H. Sequeira / NIT Karnataka Dr. Balvir Talwar / BHEL Noida	04.01.16
36	Mr. Sivasakthivel T.	MIE	STUDY OF THERMAL PERFORMANCE OF A GROUND SOURCE HEAT PUMP SYSTEM	Dr. K. Murugesan Dr. P. K. Sahoo	Prof. Hywel Rhys Thomas / UK Prof. P. K. Das / IITKgh	13.10.15
37	Mr. Anand K. Gupta	MIE	MECHANICAL PROPERTIES ANALYSISOF CARBON NANOTUBE REINFORCED POLYMER COMPOSITES	Dr. S. P. Harsha	Prof. Dane Quinn / United State Prof. S. P. Singh / IITD	03.12.15
38	Mr. Sandesh Trivedi	MIE	DYNAMICS OF BORON NITRIDE NANOTUBE BASED NANORESONATORS	Dr. S. P. Harsha Dr. S. C. Sharma	Prof. Dane Quinn / United State Prof. S. K. Dwivedu / IITG Dr. B. V. Ravindra / IIT Jodhpur	11.12.15
39	Mr. Sachin Kumar	MIE	ANALYSIS AND MANAGEMENT OF RISKS IN GREEN SUPPLY CHAIN	Dr. Pradeep Kumar Dr. M. K. Barua	Prof. Mario T. Tabucanon / Thailand Prof. Ravi Shanker / IITD Prof. Kripa Shanker / IITK	02.12.15
40	Mr. Md. Irfanul Haque Siddiqui	MIE	INVESTIGATION ON GRADE INTERMIXING IN TUNDISH DURING LADLE CHANGE OVER	Dr. P. K. Jha	Prof. A. H. Castillejos Escobar / Mexico Prof. P. S. Robi / IITG Dr. Prabal Talukdar / IITD	22.12.15
41	Mr. Ravi Panwar	MME	BROADBAND RADAR ABSORBING MATERIALS USING FRACTAL FSS FOR STEALTH APPLICATION	Dr. Vijaya Agarwala Dr. Dharmendra Singh	Prof. Werner Wiesbeck / Germany Prof. K. B. S. Rao / MGIT Hyderabad Prof. K. P. Singh / BHU Varansi	12.10.15

42	Mr. Vipin Sharma	MME	FABRICATION AND TRIBOLOGY OF FRICTION STIR PROCESSED Al ALLOY SURFACE COMPOSITES	Dr. Ujjwal Prakash Dr. B.V. Manoj Kumar	Prof. T. S. Srivatsan / UK Prof. Jayashree Bijwe / IITD Prof. Bikramjit Basu / IISc Bangalore	22.12.15
43	Ms. Rajni Sharma	MME	POLYMER BASED NANOCOMPOSITE ELECTROLYTES FOR Li-ION BATTERIES	Dr. Anjan Sil Dr. S. Ray	Prof. Suprakas Sinha Ray / South Africa Dr. Arvind Sinha / NML Jamshedpur Prof. Pralay Maiti / BHU Varanasi	30.12.15
44	Ms. Reena Gupta	PH	STATISTICAL THERMODYNAMICS OF SYNTHETIC SPIN-ORBIT-COUPLED QUANTUM GASES	Dr. G. S. Singh	Dr. Axel Pelster / Germany Prof. K. N. Pathak / P.U. Chandigarh	04.01.16
45	Mr. Amit Kumar	PT	PRODUCTION OF CELLULASES AND XYLANASES AND THEIR APPLICATIONS IN INDUSTRIAL PROCESSES	Dr. Dharm Dutt	Prof. Arthur J.Ragauskas / Atlanta Prof. Vinay Sharma / B.V. Rajasthan Prof. Jitendra Sharma / K.U. Kurukshetra	28.12.15
46	Mr. Arun Mondal	WRDM	IMPACT ASSESSMENT OF CLIMATE AND LANDUSE CHANGES ON SOIL EROSION AND CARBON LOSS	Dr. Deepak Khare	Dr. Chris Renschler / USA Prof. N. S. Raghuwanshi / IITKgh	20.11.15
47	Ms. Sananda Kundu	WRDM	ASSESSMENT OF CLIMATE AND LANDUSE CHANGE IMPACTS ON WATER BALANCE	Dr. Deepak Khare	Dr. Leif Wolf / Germany Prof. B. R. Char / IITD Dr. S. P. Aggarwal / IIRS Dehradun	11.12.15
48	Mr. Dheeraj Kumar	WRDM	HYDROLOGICAL MODELLING OF A RIVER BASIN USING MULTI-SATELLITE PRECIPITATION ESTIMATES	Dr. Ashish Pandey Dr. Nayan Sharma Dr. Wolfgang-Albert Flugel	Prof. Anton J. Schleiss / Swtzerland Prof. M. S. Mohan K. / IISc Bangalore Prof. Eldho T. I. / IITB	17.12.15