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IIT Roorkee

प्रशान्त गर्ग, कुलसचिव
Prashant Garg, Registrar

संख्या:भा0प्रौ0सं0रू0 / एम0एस0 / 60वीं सीनेट /
No. IITR/MS/60th Senate/ 10443
दिनांक: 17 अगस्त 2015
Dated: 17th August 2015

ALL MEMBERS OF THE SENATE
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Subject: Minutes of the 60th Meeting of the Senate held on 8th July 2015

Enclosed herewith please find a copy of the Minutes of the 60th Meeting of the Senate held on 8th July 2015 in the Senate Hall of the Institute, for your perusal. Your comments, if any, on the minutes may please be sent within 15 days.

Encl: As above

(प्रशान्त गर्ग)
(Prashant Garg)
कुलसचिव एवं सचिव, सीनेट
Registrar & Secretary, Senate
17 AUG 2015

सीनेट की 60वीं बैठक का कार्यवृत्त

MINUTES OF THE 60TH MEETING OF THE SENATE

08 जुलाई 2015

08TH JULY 2015

भारतीय प्रौद्योगिकी संस्थान रूड़की

रूड़की – 247 667 (भारत)

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

ROORKEE – 247 667 (INDIA)

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

8 जुलाई 2015 को अपराहन 3.30 बजे संस्थान के सीनेट हॉल में आयोजित 60 वीं बैठक का कार्यवृत्त

Minutes of the 60th meeting of the Senate held on 8th July 2015 at 03.30 P.M. in the Senate Hall of the Institute.

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60.2	27 फरवरी, 2015 को आयोजित अपनी 59 वीं बैठक में सीनेट द्वारा लिये गये निर्णयों के कार्यान्वयन हेतु की गई कार्यवाही की रिपोर्ट प्राप्त किया जाना। To receive a report on the actions taken to implement the decisions taken by the Senate in its 59th meeting held on 27th February 2015.	4
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60.25	सहारनपुर कैम्पस से रूड़की कैम्पस में छात्रों का स्थानांतरण करने के लिए IDD (PEMBA) पंचम वर्ष के शिक्षण में मामूली परिवर्तन के बारे मे रिपोर्ट किया । Reported the minor changes in the teaching of IDD (PEMBA) V year due to shifting of students from Saharanpur Campus to Roorkee Campus.	14

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60.26	इन कार्यक्रमों की नई संरचनाओं में संशोधन के कारण एम.एस्सी. (भौतिकी), एम. एस्सी. (रसायन विज्ञान) तथा एम.एस्सी. (गणित) की संरचनाओं के साथ ही iv v वर्ष के इंटीग्रेटेड एम.एस्सी. (भौतिकी), इंटीग्रेटेड एम.एस्सी. (रसायन विज्ञान) तथा इंटीग्रेटेड एम.एस्सी. (प्रयुक्त गणित) की विद्यमान संरचनाओं के समतुल्य पाठ्यक्रम रिपोर्ट किया। Reported the equivalent courses of existing structures of the Integrated M.Sc. (Physics), Integrated M.Sc. (Chemistry) and Integrated M.Sc. (Applied Mathematics) in IV & V year and also in the Structures of M.Sc. (Physics), M.Sc. (Chemistry) and M.Sc. (Mathematics) due to modifications in the new structures of this programmes.	16
60.27	श्री सुनील कुमार अग्रवाल, निवासी, 195, पुलिस स्ट्रीट, मेरठ छावनी, उ.प्र. से प्राप्त बी.टैक./बी.आर्क. तथा पल्प एवं पेपर टैक्नोलॉजी व डुअल डिग्री इंजीनियरिंग बैचलर कोर्स के अंतिम वर्ष के (एक) पुरुष छात्र तथा एक (महिला) छात्र को " मनोज जैन अवार्ड ऑफ एक्सीलेंस इन ह्यूमन वैल्यूज" के नाम से पच्चीस–पच्चीस हजार रुपये के दो पुरस्कार तथा शील्ड व प्रमाणपत्र हेतु समझौता विलेख पर हस्ताक्षर किए जाने के प्रस्ताव को रिपोर्ट किया। Reported the proposal for signing the agreement deed for Two awards of Rs. 25,000/- each plus Shield & Certificate in the name of "Manoj Jain Award of Excellence in Human Values" for final year of (one) Male students and (One) Female student of B.Tech./ B.Arch. and Pulp & Paper Technology and Dual Degree Engineering Bachelor course received from Mr. Sunil Kumar Agarwal residing at 195, Police street, Meerut Cantt, U.P.	16
60.28	अंतिम वर्ष की परीक्षा में गणित विषय में सर्वाधिक अंक/ग्रेड प्राप्त करने वाली बी. टैक. प्रथम वर्ष की छात्रा हेतु "ओम प्रकाश गुप्ता एवं सुशी देवी" स्मृति छात्रवृत्ति के नाम से रु. 10,000/– प्रति वर्ष की छात्रवृत्ति स्थापित किए जाने हेतु श्री महेन्द्र प्रकाश सिंघल, डी–7411, वसंत कुंज, नई दिल्ली 110070 से प्राप्त प्रस्ताव को रिपोर्ट किया। Reported the proposal received from Sri Mahendra Prakash Singhal, D-7411, Vasant Kunj, New Delhi 110 070 to institute scholarship of Rs. 10,000/- p.a. in the name of "Om Prakash Gupta and Sushi Devi" Memorial scholarship, for a girl student of B.Tech. 1st year obtains highest Marks/grade in Mathematics in final examination.	17

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60.29	तृतीय वर्ष, चतुर्थ वर्ष एवं पंचम वर्ष के छात्रों को रजिष्टर करने के लिए प्रस्ताव पर विचार करना यदि छात्र प्रथम वर्ष, द्वितीय वर्ष या तृतीय वर्ष में केवल एक बैकलोग रखता हो । To consider the proposal of permitting a student to register the courses of III Year or IV Year or V Year if he/she has backlog ONLY in one paper of I Year or II Year or III Year, respectively.	17
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MEETING SECTION
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Minutes of the 60th Meeting of the Senate held on 08.07.2015 in the Senate Hall of the Institute.

Following were present:

1.	Prof. Pradipta Banerji	Director & Chairman
2.	Prof. Vinod Kumar	Dy. Director
3.	Prof. (Mrs.) Pushplata	(Architecture & Planning)
4.	Prof. (Mrs.) Ila Gupta	(Architecture & Planning)
5.	Prof. G.S. Randhawa	(Biotechnology)
6.	Prof. R.P. Singh	(Biotechnology)
7.	Prof. Ramasare Prasad	(Biotechnology)
8.	Prof. Vikas Pruthi	(Biotechnology)
9.	Prof. Partha Roy	(Biotechnology)
10.	Prof. Bikash Mohanty	(Chemical Engineering)
11.	Prof. Vijay Kumar Agarwal	(Chemical Engineering)
12.	Prof. C.B. Majumdar	(Chemical Engineering)
13.	Prof. R.N. Goyal	(Chemistry)
14.	Prof. Ravi Bhushan	(Chemistry)
15.	Prof. Anil Kumar	(Chemistry)
16.	Prof. (Mrs.) Mala Nath	(Chemistry)
17.	Prof. A.K. Singh	(Chemistry)
18.	Prof. M.R. Maurya	(Chemistry)
19.	Prof. Bina Gupta	(Chemistry)
20.	Prof. Deepak Kashyap	(Civil Engineering)
21.	Prof. C.S.P. Ojha	(Civil Engineering)
22.	Prof. Pradeep Bhargava	(Civil Engineering)
23.	Prof. S.K. Ghosh	(Civil Engineering)
24.	Prof. Mahendra Singh	(Civil Engineering)
25.	Prof. M. Parida	(Civil Engineering)
26.	Prof. Praveen Kumar	(Civil Engineering)
27.	Prof. N.K. Samadhiya	(Civil Engineering)
28.	Prof. K.S. Hari Prasad	(Civil Engineering)

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29.	Prof. Akhil Upadhyay	(Civil Engineering)
30.	Prof. Z. Ahmad	(Civil Engineering)
31.	Prof. Kamal Jain	(Civil Engineering)
32.	Prof. B.R. Gurjar	(Civil Engineering)
33.	Prof. P. K. Gupta	(Civil Engineering)
34.	Prof. Vipul Praiash	(Civil Engineering)
35.	Prof. M.L. Sharma	(Earthquake Engineering)
36.	Prof. Pankaj Agarwal	(Earthquake Engineering)
37.	Prof. Manish Shrikhande	(Earthquake Engineering)
38.	Prof. D.C. Srivastava	(Earth Sciences)
39.	Prof. G. J. Chakrapani	(Earth Sciences)
40.	Prof. Sandeep Singh	(Earth Sciences)
41.	Prof. A.K. Sen	(Earth Sciences)
42.	Prof. Pramod Agarwal	(Electrical Engineering)
43.	Prof. Sajjan Pal Singh	(Electrical Engineering)
44.	Prof. S.P. Srivastava	(Electrical Engineering)
45.	Prof. Rajendra Prasad	(Electrical Engineering)
46.	Prof. M.J. Nigam	(Electronics & Communication Engg.)
47.	Prof. N.K. Goel	(Hydrology)
48.	Prof. Himanshu Joshi	(Hydrology)
49.	Prof. D.K. Nauriyal	(Humanities & Social Sciences)
50.	Prof. Sukh Pal Singh	(Humanities & Social Sciences)
51.	Prof. Nagendra Kumar	(Humanities & Social Sciences)
52.	Prof. Y.S. Negi	(Paper Technology)
53.	Prof. Dharam Dutt	(Paper Technology)
54.	Prof. S.C. Sharma	(Paper Technology)
55.	Prof. R.C. Mittal	(Mathematics)
56.	Prof. Kusum Deep	(Mathematics)
57.	Prof. S.C. Sharma	(Mechanical & Industrial Engg.)
58.	Prof. P.K. Jain	(Mechanical & Industrial Engg.)
59.	Prof. Dinesh Kumar	(Mechanical & Industrial Engg.)
60.	Prof. B.K. Gandhi	(Mechanical & Industrial Engg.)
61.	Prof. Ravi Kumar	(Mechanical & Industrial Engg.)
62.	Prof. P.K. Sahoo	(Mechanical & Industrial Engg.)
63.	Prof. Navneet Arora	(Mechanical & Industrial Engg.)
64.	Prof. S.K. Nath	(Metallurgical & Materials Engg.)
65.	Prof. Rajesh Srivastava	(Physics)
66.	Prof. Tashi Nautiyal	(Physics)
67.	Prof. G.D. Varma	(Physics)
68.	Prof. S.K. Mishra	(WRD&M)
69.	Prof. Ramesh Chandra	(Institute Instrumentation Centre)
70.	Dr. D.S. Arya	(Hydrology)
71.	Dr. R. Balasubramanian,	Institute Computer Centre
72.	Dr. P. Jeevanandam	Associate Dean of Students' Welfare (International Students)

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73. Dr. R.K. Peddiniti Associate Dean, Academic Research
74. Dr. Yogendra Singh, Librarian
75. Dr. (Mrs.) Smita Jha, Associate Professor, Humanities & Social Sciences
76. Dr. Pravindra Kumar, Associate Professor, Biotechnology
77. Dr. Inderdeep Singh, Associate Professor, Mechanical & Industrial Engineering
78. Dr. A. Swaminathan, Associate Professor, Mathematics
79. Mr. Prashant Garg, Registrar & Secretary, Senate

Meeting was adjourned at the scheduled start time for 05 minutes for want of quorum. The meeting was then started after 05 minutes, at the time fixed for holding the re-convened meeting of the Senate. By that time, the quorum was also met.

The Chairman (Director) welcomed the members to the 60th 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. Nayan Sharma, W.R.D. & M
2. Prof. S.P. Gupta, Department of Electrical Engineering
3. Prof. G.S. Singh, Department of Physics
4. Prof. A.K. Jain, Department of Physics
5. Prof. A.K. Saxena, Department of Electronics & Comm. Engineering
6. Dr. Kamal, Associate Professor, Department of Earth Sciences and Chief Warden, Radhakrishnan Bhawan

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

1. Dr. R.D. Garg, Associate Professor, Civil Engineering
2. Shri Prashant Garg, Registrar

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

1. Prof. Bhim Singh, IIT Delhi
2. Prof. Bhodh Raj Mehta, IIT Delhi
3. Prof. Girishwar Misra, University of Delhi
4. Prof. Prof. M.L. Kansal, W.R.D. & M.
5. Prof. Deepak Khare, W.R.D. & M
6. Prof. S.S. Jain, Department of Civil Engineering

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7. Prof. M.V. Kartikeyan, Department of Electronics & Commn. Engineering
8. Prof. Manoj Mishra, Department of Computer Science & Engineering
9. Prof. R.G. Sastry, Department of Earth Sciences
10. Dr. A.K. Sharma, Associate Dean, Academic Studies
11. Prof. Yogendra Singh, Department of Earthquake Engineering
12. Dr. R.D .Garg, Associate Professor, Department of Civil Engineering and Chief Warden, Jawahar Bhawan.
13. Prof. Dharmendra Singh, Department of Electronics & Comm. Engineering
14. Prof. K.C. Gupta, Department of Chemistry
15. Prof. B.S.S. Daniel, Department of Metallurgical and Materials Engineering

The Senators were informed that in terms of Statute 5(7), a written notice of the meeting alongwith agenda was sent by the Registrar to all members of the Senate on July 01, 2015 through e-mail.

The Agenda was then taken up:

Item No. 60.1: To confirm the minutes of the 59th meeting of the Senate held on 27th February 2015.

The minutes of the 59th meeting of the Senate held on 27th February 2015 were confirmed.

Item No.60.2: To receive a report on the actions taken to implement the decisions taken by the Senate in its 59th meeting held on 27th February 2015.

The Senate noted the actions taken on the resolutions of the 59th meeting held on 27th February 2015.

Item No. 60.3: To consider the letter No.HOD/HSS/1892 dated 6.4.2015 regarding inclusion of separate paper on Economics in JAM-2016 for admission to M.Sc. programme in Economics.

It was reported that M.Sc. programme in Economics has already been approved by the BOG and included in the JAM-2016 brochure.

Further, the Senate decided that the proposal of Humanities & Social Sciences Department to include both **Mathematics (MA)** and **Mathematical Statistics (MS)** papers, as considered and recommended by the IAPC, for admission to M.Sc. (Economics) instead of Statistical Mathematics be approved.

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Item No. 60.4: **To consider the syllabi of the courses of B.Tech. (Engineering Physics) proposed by the Department of Physics.**

As considered and recommended by the IAPC, the Senate decided that the syllabi of the courses of B.Tech. (Engineering Physics), as proposed by the Department of Physics, be approved with minor corrections. The approved syllabi of the core and elective courses of the programme are given in **Appendix 'A'**

Item No. 60.5: **To consider for inclusion in new structure of PG programme that EQ-563 be made available to SVRA and Soil Dynamics students and EQ-521 to SVRA and Structural Dynamics students as Programme Elective.**

As considered and recommended by the IAPC, the Senate decided that the proposal of Department of Earthquake Engineering to make EQ-563 be available to the students of M.Tech. (Seismic Vulnerability & Risk Assessment) and M.Tech. (Soil Dynamics) and EQ-521 to the students of M.Tech. (Seismic Vulnerability & Risk Assessment) and M.Tech. (Structural Dynamics) as programme electives be approved.

The Senate also accepted the recommendation of the IAPC in principle that courses of a PG programme of any one department be the programme electives to other PG programmes of the other department. However, if any department intends to include the elective(s) of other department in their PG programme, the consent of the other department is required, with intimation to the Academic Section.

Item No. 60.6: **To consider the swapping of two courses HY-526: Deterministic Hydrology from Autumn Semester to Spring Semester and HY-522: Stochastic Hydrology from Spring Semester to Autumn Semester as proposed by the Department of Hydrology.**

As considered and recommended by the IAPC, the Senate decided that the swapping of two core courses **HY-**

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526: Deterministic Hydrology from Autumn Semester to Spring Semester and **HY-522: Stochastic Hydrology** from Spring Semester to Autumn Semester, as proposed by the Department of Hydrology, be approved.

Item No. 60.7: **To consider change in subject PE-311: Engineering Polymer to PE-311: Polymer Composites**

As considered and recommended by the IAPC, the Senate decided that change of subject **PE-311: Engineering Polymer** to **PE-311: Polymer Composites**, as proposed by the Department of Polymer and Processing Engineering, be approved.

Item No. 60.8: **To consider inclusion of the following syllabi for B.Tech. (Engineering Physics) course offered by the Department of Physics, received from the Department of Biotechnology.**

As considered and recommended by the IAPC, the Senate decided that the syllabus of **BTN- 466: Biophysics and its Application,** as proposed by the Department of Biotechnology, for the students of B.Tech. (Engineering Physics) as Departmental Elective be approved. The syllabus of the approved course is given in **Appendix 'B'.**

Item No. 60.9: **To consider the syllabi of B.Tech. (Polymer Science and Engineering) received from various departments:**

As considered and recommended by the IAPC, the Senate decided that the syllabi of the following core courses of B.Tech. (Polymer Science and Engineering) I Year, Autumn Semester, as proposed by the coordinating committee of the programme, be approved:

1. PEN-101: Introduction to Polymer Science and Engineering
2. CYN-009: Polymer Chemistry
3. PEN-103: Computer Programming and Numerical Analysis
4. CHN-102: Material and Energy Balance
5. CHN-106: Thermodynamics and Chemical Kinetics

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The approved syllabi of these courses are given in **Appendix 'C'**. It was also decided that the syllabi of rest of the courses from I Year spring semester to last semester in 4th year (both core and electives) need further examination & deliberations in IAPC before it be placed in the next meeting of the Senate for its consideration.

Item No. 60.10: **To consider the syllabi of the following Pre-Ph.D. courses received from various Departments:-**

As considered and recommended by the IAPC, the Senate decided that the syllabi of the following Pre-Ph.D. courses as proposed by the different departments be approved with suggestions to find and add newer editions of suggested books:

1. PP-915: Polymer Nano-composites
2. PH-920: Quark Gluon Plasma & Finite Temperature Field Theory
3. PH-905: Green's Functions and Many Particle System
4. MA-911: Soboleve Spaces and Applications

The syllabi of these courses are given in **Appendix-D.**

Item No. 60.11: **To consider the courses received from Prof.-In-Charge, Saharanpur Campus.**

As considered and recommended by the IAPC, the Senate decided that the syllabi of the following core and elective courses for B.Tech. (Pulp & Paper) and IDD (Polymer Science and Technology), as proposed by Prof. In-Charge, Saharanpur Campus, be approved with minor corrections:

1. PPN-303: Papermaking-II
2. PPN-305: Process Automation
3. PPN-311: Process Utilities and Cogeneration
4. PPN-313: Industrial Piping

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5. PEN-301: Polymer Product Technology
6. PEN-303: Polymerization Reaction Engineering
7. PEN-305: Polymer Processing
8. PEN-311: Polymer Composites
9. PEN-313: Polymeric Film Technology
10. PEN-315: Polymeric Fiber Technology

The Senate also decided that the syllabi of the following pre-Ph.D. courses as recommended by the IAPC be approved:

1. AS-911: Nanomaterials
2. PP-916: Separation Process
3. PP-917: Cloud Computing and Sensor Network
4. PP-918: Principles of Wireless Network

The syllabi of these courses are given in **Appendix 'E'.**

Further, the Senate opined that Pre-Ph.D. courses and self study courses should clearly be defined.

Item No. 60.12: **To consider the corrections in IDD PEM new structure Programme Elective Courses I, IV and V as Programme Elective Course I and Programme Elective Course IV as Programme Elective Course II recommended by DFC of Saharanpur Campus.**

As considered and recommended by the IAPC, the Senate decided that the syllabi of following Elective Courses under the category of Programme Elective Course I and II for IDD(PEM), as proposed by the Department of Polymer and Process Engineering, be approved:

1. PE-001: Petrochemicals and Petroleum Refining Engineering
2. PE-002: Numerical Methods in Chemical Engineering
3. PE-003: Process Optimization
4. PE-004: Process Equipment Design
5. PE-005: Bioprocess Technology
6. PE-006: Polymer Science and Engineering
7. PE-007: Paint Technology
8. PE-008: Biomaterials and Tissue Engineering

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9. PE-009: Process Utilities and Cogeneration
10. PE-010: Design of Experiments and Parameter Estimation
11. PE-011: Solid Waste Management
12. PE-012: Industrial Safety and Hazards
13. PE-013: Advanced Separation Techniques
14. PE-016: Process Intensification
15. PE-017: Pulp and Paper Technology
16. PE-018: Heterogeneous Catalysis and Reactor Design
17. PE-019: Biofuels
18. PE-020: Polymer Recycling and Environment
19. PE-021: Polymer Product Technology
20. PE-022: Transport of Oil and Gas
21. PE-023: Industrial Piping
22. PE-024: Process Engineering Strategy
23. PE-025: Management Information Systems
24. PE-026: Operations Research
25. PE-027: Business Analytics
26. PE-028: Knowledge Management
27. PE-029: Entrepreneurship Development
28. PE-030: International Business

The syllabi of the above courses are given in **Appendix 'F'**.

Item No. 60.13: To consider the syllabi of B.Tech. 4th year PST (Old) Autumn Semester courses recommended by DFC of Saharanpur Campus.

As considered and recommended by the IAPC, the Senate decided that the syllabi of the following programme core courses for B.Tech. (Polymer Science and Technology) 4th Year Autumn Semester be approved with modifications:

1. PE-411: Polymer Processing
2. PE-413: Process System Analysis and Control
3. PE-415: Functional Polymers
4. PE-417: Rubber and Elastomer Technology
5. PE-421: Advanced Polymeric Composites
6. PE-423: Computational Polymer Science
7. PE-425: Polymers for Smart and Memristive Materials

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8. PE-427: High Performance Polymers

The syllabi of the above courses are given in **Appendix 'G'.**

Further, the Chairman of the Senate shown displeasure with the way the syllabi proposed in pieces & bits. Any course proposed by the department should be placed as full course programme in one capsule.

Item No. 60.14: To consider the syllabi of Programme Core Courses of IDD PEM 3rd year Autumn Semester (New Scheme) as recommended by DFC of Saharanpur Campus.

As considered and recommended by the IAPC, the Senate decided that the syllabi of the following programme core courses, as proposed by the DFC, Saharanpur Campus, for IDD PEM 3rd year Autumn Semester be approved with modifications:

1. PEN-351: Transport Phenomena
2. PEN-353: Process Instrumentation and Control
3. PEN-355: Modelling and Simulation

The syllabi of the above courses are given in **Appendix 'H'.**

Item No. 60.15: To consider the syllabi of the new elective courses for UG and MBA programmes received from Department of Management Studies

As considered and recommended by the IAPC, the Senate decided that the syllabi of the following elective courses for UG and MBA programmes, as proposed by the Department of Management Studies, be approved with modifications:

1. IBM-311: Operations and Supply Chain Management
2. BMN-612: Financial Engineering & Risk Management

The syllabi of the above courses are given in **Appendix 'I'**

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Item No. 60.16: To consider the structure of 2-year M.Tech. (Polymer Science and Engineering) Programme as recommended by DFC of Saharanpur Campus.

As considered and recommended by the IAPC, the Senate decided that the structure of 2-year M.Tech. (Polymer Science and Engineering) Programme, as proposed by the DFC of Saharanpur Campus, be approved. The approved structure of the programme is given in **Appendix 'J'**

Item No. 60.17: To consider the preamble for new M.Tech. + Ph.D dual degree programme in Bioprocess Engineering in Biotechnology Department.

As considered and recommended by the IAPC, the Senate decided that the proposal of the Department of Biotechnology to start new M.Tech. programme in Bioprocess Engineering with 15 seats be approved. The structure of the approved programme is given in **Appendix 'K'**.

Item No. 60.18: To consider the letter dated 23.01.2015 received from Prof. & Head, MMED regarding reduction in number of students of B.Tech. Metallurgical and Materials Engineering as recommended by the DFC.

As considered and recommended by the IAPC, the Senate deliberated on the proposal of the Department of Metallurgical and Materials Engineering to reduce the number of seats in B.Tech. from 110 to 60. After discussion, the Senate decided that the Department of Metallurgical and Materials Engineering continued with same intake this year. At the same time decided that the department be requested to find out reasons as why the employability with B.Tech. (MM) degree is going down (ii) whether course or its contents become irrelevant (iii) Does the employment in material and mineral is really not available.

In the sidelines to discussion on this issue, it has also been suggested that all Heads of the Departments should collect data of M.Tech. placement, specifically of those students, who got less than 6 CGPA & examine the reasons of their poor placement.

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Item No. 60.19: To re-consider the proposal of Mahatma Gandhi Central Library for making all electronic thesis and dissertations available in open domain and submission of thesis and dissertations only in digital format.

As considered and recommended by the IAPC, the Senate decided that the proposal of Mahatma Gandhi Central Library for making all electronic theses and dissertations available in open domain be approved. Henceforth, all PG dissertations and Ph.D. theses will be put on "Shodh Bhagirathi" alongwith abstract of Ph.D. thesis in Hindi after the award of the degree with a provision that thesis and dissertation be available only for reading and not for downloading. However, if the supervisor wants to defer it by a year due to filing of patent or any reason otherwise, a proper justification has to be given by the supervisor.

The Senate also decided that the present practice of submission of Ph.D. theses and dissertations be continued. However, the PG dissertations will also be submitted in digital format alongwith hard bound copy.

Item No. 60.20: To consider the minimum pass grade in Seminar for PG students.

As considered and recommended by the IAPC, the Senate decided that the proposal of keeping 'D' as minimum pass grade in Seminar be approved.

Item No. 60.21: To consider the minimum pass grade in Dissertation in the new structure.

As considered and recommended by the IAPC, the Senate decided that the proposal of keeping **'C'** as minimum pass grade in dissertation at both stages be approved.

Further, to address the problem of shortage of hostel accommodation the M.Tech. dissertation be completed by April & November in spring and autumn semester, respectively, so that before start of next session, additional month be available, before the scholar vacants the accommodation.

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It was also decided that if a student is graded **'D'** in either of the evaluation; he/she shall be given one more month to resubmit the dissertation. In such a case, he/she shall not be awarded grade higher than **'C'**.

Item No. 60.22: To re-consider the mode of examination (open book/ closed book/ open notes/ discussion based/ take home).

As considered and recommended by the IAPC, the Senate decided that the proposal of keeping any subject examination either as open book or closed book be left to the department to decide on the proposal of individual faculty. If the DFC decides to have open book examination of any subject, the same be notified to all concerned students well before the start of the semester with a copy to Dean, Academics for information.

Item No. 60.23: To consider the modifications related to Ph.D. Ordinances and Regulations as recommended by the Executive Committee of the Senate.

As considered and recommended by the IAPC, the Senate decided that the Ph.D. Admission Rules, Ph.D. Ordinances and Regulations, different proforma for Ph.D. and the Guidelines for supervision of Ph.D. students of other Institutes/Universities as proposed after discussing at different forums be approved with minor suggestions from the members.

The approved Ph.D. Admission Rules, Ph.D. Ordinances and Regulations, different proforma for Ph.D. and the Guidelines for supervision of Ph.D. students of other Institutes/Universities are given in **Appendix 'L'.**

Item No. 60.24: To consider the request of Mr. Ashutosh Rungta, B.Tech. (Chemical), II Year to reconsider the policy of lowering the grade on medical grounds.

As considered and recommended by the IAPC, the Senate decided that the proposal of not lowering the grades on medical grounds be approved as below:

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If any student is allowed to appear in second examination of MTE or ETE on medical grounds, the grades awarded shall not be lowered in the following conditions:

1. The student falls sick being in-station and is unable to appear in examination as recommended by the Chief Medical Officer of the Institute Hospital.

2. The student falls sick being out-station with the permission of DOSW and timely informs the Dean, Academics."

In all other cases of second examination of MTE or ETE on medical grounds, a student shall be awarded one grade lower than the one which he/she would have otherwise obtained as per the procedures adopted for normal grading. However, 'D' grade shall not be lowered.

This will be applicable from July 2015 onwards.

Item No. 60.25: Reported the minor changes in the teaching of IDD (PEMBA) V year due to shifting of students from Saharanpur Campus to Roorkee Campus.

The Senate noted the shifting of 5th year students of IDD(Process Engineering with MBA) for Saharanpur Campus to Roorkee Campus as in the 5th year courses are related to Management Studies only.

The Senate further noted the equivalent courses to be taught to the students of 5th year IDD(PEMBA) and other related issues as recommended in the meeting of Head, Department of Management Studies, Professor-In-charge, Saharanpur Campus and Dean, Academics held on 1.4.2015. The following were approved regarding old and new structures:-

Old Structure:

1. There are two management related courses in Autumn Semester and in Spring Semester each upto IDD 4th year and there are two faculty members of Management background at SRE campus. These two courses in each

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semester will be taught by faculty members at SRE Campus.

2. The courses of 5th year IDD (PEMBA) will be taught as per the equivalence given in Table-1 by shifting courses from Autumn to Spring and Spring to Autumn Semester.

3. The students of IDD (MEMBA) will take management electives floated for the students of MBA as their Specialization Electives in both the semesters.

4. The students of IDD (PEMBA) will take HSS based elective from Open Category Elective (New Structure) or HSSMEC Category Electives (Old Structure) as HSSMEC elective required.

5. Total number of credits will increase by 2 in this process.

6. One slot in the time table be kept by DOMS for Management Training and Seminar during which the Management faculty from SRE Campus can come to Roorkee Campus and evaluate the students. It is expected that 6-7 slots in a semester may be sufficient for this course.

New Structure:

1. The management related courses upto IDD 4th year will be taught by the two faculty members of Management background at SRE Campus.

2. The courses of 5th year IDD(PEMBA) will be taught as per the equivalence given in Table-2 by shifting courses from Autumn to Spring and Spring to Autumn Semester.

3. The students of IDD (PEMBA) will take management electives floated for the students of MBA as their Specialization Electives in both the semesters.

4. The MBA Dissertation will be taken by the faculty of both DOMS and SRE Campus.

5. The number of specialization electives be reduced to 6 from 8 as these courses are of 3 credits at Roorkee Campus.

6. Total number of credits will increase by 4 in this process.

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7. One slot in the time table be kept by DOMS for Management Training and Seminar during which the Management faculty from SRE Campus can come to Roorkee Campus and evaluate the students. It is expected that 6-7 slots in a semester may be sufficient for this course.

Item No. 60.26: **Reported the equivalent courses of existing structures of the Integrated M.Sc. (Physics), Integrated M.Sc. (Chemistry) and Integrated M.Sc. (Applied Mathematics) in IV & V year and also in the Structures of M.Sc. (Physics), M.Sc. (Chemistry) and M.Sc. (Mathematics) due to modifications in the new structures of this programmes.**

The Senate noted the equivalent courses of existing structures of the Integrated M.Sc. (Physics), Integrated M.Sc. (Chemistry) and Integrated M.Sc. (Applied Mathematics) in IV & V year **(Appendix 'M')** and also in the Structures of M.Sc. (Physics), M.Sc. (Chemistry) and M.Sc. (Mathematics) due to modifications in the new structures of this programmes as recommended in the meeting of HODs held on 16.12.2014 at 3.30 PM in the Office of Dean (Academics).

Item No. 60.27: **Reported the proposal for signing the agreement deed for Two awards of Rs. 25,000/- each plus Shield & Certificate in the name of "Manoj Jain Award of Excellence in Human Values" for final year of (one) Male students and (One) Female student of B.Tech./ B.Arch. and Pulp & Paper Technology and Dual Degree Engineering Bachelor course received from Mr. Sunil Kumar Agarwal residing at 195, Police street, Meerut Cantt., U.P.**

The Senate noted the proposal received from Mr. Sunil Kumar Agarwal residing at 195, Police street, Meerut Cantt, U.P. According to this deed, the Director, Chairman, Senate has signed the agreement deed for Two award of Rs. 25,000/- each plus Shield & Certificate in the name of "Manoj Jain Award of Excellence in Human Values" for final year of (one) Male students and (One) Female student of B.Tech./ B.Arch. and Pulp & Paper Technology and Dual Degree Engineering Bachelor course

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Item No. 60.28 : Reported the proposal received from Sri Mahendra Prakash Singhal, D-7411, Vasant Kunj, New Delhi 110 070 to institute scholarship of Rs. 10,000/- p.a. in the name of "Om Prakash Gupta and Sushi Devi" Memorial scholarship, for a girl student of B.Tech. 1st year obtains highest Marks/grade in Mathematics in final examination.

The Senate noted the proposal received from Sri Mahendra Prakash Singhal, D-7411, Vasant Kunj, New Delhi 110 070 to institute scholarship of Rs. 10,000/- p.a. in the name of "Om Prakash Gupta and Sushi Devi" Memorial scholarship, for a girl student of B.Tech. 1st year obtains highest Marks/grade in Mathematics in final examination.

Item No. 60.29: To consider the proposal of permitting a student to register the courses of III Year or IV Year or V Year if he/she has backlog ONLY in one paper of I Year or II Year or III Year, respectively.

As considered and recommended by the IAPC, the Senate decided that the proposal of permitting students with back paper be allowed to register as per following be approved:

1. Students of III Year, IV Year and V Year having backlog in **ONE paper only** in I Year, II Year and III Year, respectively are allowed to continue with the registration of current year papers along with back paper.

2. Students having back paper(s) are not allowed to take the courses of current year, if time table of back paper clashes with the courses of current year.

3. The students have to pay one semester additional fee as penalty.

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Item No.60.30: To consider the mercy appeals of students of I Year whose names have been struck off due to less CGPA at the end of I Year.

The Senate considered the mercy appeals of the students of I Year whose names have been struck off due to less than 5.00 CGPA and or total earned credits less than minimum required at the end of I Year. After due deliberations upholds the decision taken for expulsion of 72 students as per UG Ordinances and Regulations.

Item No. 60.31: Reported the new dates for Registration of new entrants.

The Senate noted the registration of all new UG/IMT/UMS students will now be scheduled on 23.7.2015 and Orientation programme of all new entrants including selections of all newly admitted students UG/IMT/IMS for NCC, NSS and Language Proficiency Test will be shifted to 24.7.2015 to 26.7.2015 in place of 16 - 19 July 2015. The classes for new entrants will be started from 27.7.2015. The loss of classes due to this revised schedule will be compensated as per the convenience of the Teacher/ Department concerned.

Item No. 60.32: Reported the revised course codes of Departmental Electives I-VII of M.Sc. (Mathematics).

The Senate noted the revised course codes of Departmental Electives I-VII of M.Sc. (Mathematics) as given at **Appendix 'N'.**

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-101** Course Title: **Introduction to Engineering Physics**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To introduce basic concepts of engineering physics and various specializations in physics

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to engineering physics, need for physics in various streams of engineering, role of physics in multidisciplinary and upcoming areas	3
2.	Introduction to various disciplines in physics: Atomic Molecular and Laser Physics, basics of atomic physics and its engineering applications, basics of lasers and their industrial- engineering- and medical applications, introduction to optoelectronics and photonics	6
3.	Introduction to condensed matter physics and its engineering applications, basics of nanotechnology and its applications in medicine, defense and space	6
4.	Introduction to collider physics, nuclear science and engineering, and, its applications in power generation, food, health and agriculture	6
5.	Basic concepts of atmospheric and space physics and its applications in weather forecasting and satellite communication	4
6.	Role of physics in electronics, telecommunication and software engineering	3
	Total	**28**

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11: Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Hecht Jand Teresi D, “Laser: Light of a Million Uses,” Dover Publications	1998
2.	GhatakA and Thyagarajan K, “Fiber Optics and Lasers : The Two Revolutions,” Macmillan	2006
3.	Shultis J K and Faw R E, “Fundamentals of Nuclear Science and Engineering,” Marcel Dekker	2002
4.	Pradeep T, “Nano: The Essentials,” Mc Graw Hill	2008
5.	Hargreaves J K, "The solar-terrestrial environment", Cambridge University Press	2003
6.	PenroseR and GardnerM, “The Emperor's New Mind” Oxford University Press	2002
7.	PenroseR, “Shadows of the Mind: A Search for the Missing Science of Consciousness”, Oxford University Press	1996

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

4. Relative Weight: **CWS: 15** **PRS: 25** **MTE: 20** **ETE: 40** **PRE: 00**

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

8. Pre-requisite: **Nil**

9. Objective: This course provides students with an entry-level foundation in computer programming

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to computer hardware and software, information storage in computer memory, stored program concept, storage media,computer operating system	4
2.	Basic concepts of FORTRAN95/C/ C++ and program organization,arithmetic expressions, numerical input/output statement, loop instructions, transfer of control through logical statements, arrays and subscripted variables, standard I/O in "Fortran language", fundamental data types and storage classes: character types, integer, short, long, unsigned, single and double-precision floating point, storage classes, automatic, register, static and external, operators and expressions: using numeric and relational operators, mixed operands and type conversion, logical operators, bit operations, operator precedence and associativity	6
3.	Use of functions, subroutines, complex numbers, *COMMON* statement, block data, developing and testing of computer programs for various numerical problems	8
4.	Conditional program execution: applying *IF* and *SWITCH* statements, nesting *IF* and *ELSE*, restrictions on switch values, use of *BREAK* and *DEFAULT* with *SWITCH*, program loops and iteration: uses of *WHILE*, *DO* and *FOR* loops, multiple loop variables, assignment operators, using *BREAK* and *CONTINUE*	8
5.	Array notation and representation, manipulating array elements, using multidimensional arrays, arrays of unknown or varying size, structures: purpose and usage of structures, declaring structures, assigning of structures	6

3

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6.	Solution of linear and quadratic equations, matrix addition, subtraction and multiplication, trace and norm of matrix, inverse of matrix, numerical interpolation, differentiation and integration (Simpson, Trapezoidal and Gauss' Quadrature methods)	10
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	MetcalfM, ReidJ and CohenM, Modern, "Fortran Explained (Numerical Mathematics and Scientific Computation)", 4thEd. Oxford University Press	2011
2.	Clerman N SandSpector W, "Modern Fortran: Style and Usage", Cambridge University Press	2011
3.	Hoffmann J D, "Numerical Methods for Engineers and Scientists", 2nd Ed. Marcel Dekker Inc.	2001
4.	Sastry SS, "Introductory Methods of Numerical Analysis", 5th Ed. PHI Learning	2012
5.	Smolarski D C, "The essentials of FORTRAN", Research and Education Association, USA	1989
6.	Lipschutz S and Poe A, "Theory and problems of Programming with Fortran", Schaum's Series	1982
7.	McCormick J M andSalvodori M G, "Numerical methods in Fortran", Prentice Hall	1964

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-008** Course Title: **Electromagnetic Theory**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To introduce basic concepts of electromagnetism and their applications in engineering

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Vector Calculus:** Review of cartesian, cylindrical and spherical coordinate systems, constant coordinate surfaces, del operator, gradient, divergence of a vector and Gauss divergence theorem, curl of a vector and Stokes theorem, gradient, divergence, curl and Laplacian in the three coordinate systems, Laplacian of a scalar, scalar and vector fields, classification of vector fields	6
2.	**Electrostatics:** Coulomb's law, electric field intensity due to continuous charge distribution, Gauss's law and its applications, electric potential, line integral, electric dipole and flux lines, energy density in an electrostatic field, metallic conductors, conductor properties and boundary conditions, polarization in dielectrics, nature of dielectric materials and related boundary conditions, electrostatic boundary-value problems, Laplace's and Poisson's equations, uniqueness theorem, general procedure for solving Laplace's and Poisson's equation in one-dimension, resistance andcapacitance	12
3.	**Magnetostatics:**Current, current density, Biot-Savart's law, Ampere's circuital law, applications of Ampere's law, magnetic flux and magnetic flux density, scalar and vector magnetic potentials, magnetic dipole, force due to magnetic field on a differential current element, force between two differential current elements, force and torque on a closed circuit, magnetic materials, magnetization and permeability, magnetic boundary conditions, inductors, inductances, magnetic energy, magnetic circuits, potential energy and force on magnetic materials	12

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4.	**Time varying electric and magnetic fields, Electromagnetic waves:** Faraday's law, displacement current, Maxwell's equations for time varying fields, electromagnetic wave equation in free space, plane waves in free space, polarization, Poynting vector and power associated with electromagnetic waves, plane waves in lossless, homogeneous, and isotropic dielectric medium, reflection and transmission of plane waves at dielectric interface, normal and oblique incidence, plane waves in good conductors, skin depth	12
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	SadikuM N O, "Elements of Engineering Electromagnetics", 3rd Ed. Oxford University Press	2003
2.	Griffiths DJ, "Introduction to Electrodynamics", 3rd Ed.Prentice Hall	2000
3.	Hayt W H Jr and Buck J A, "Engineering Electromagnetics", 7th Ed. Tata McGraw Hill	2005
4.	PurcellE, "Electricity and Magnetism", Berkeley Physics Course, Vol. 2	2011
5.	Jackson J D, "Classical Electrodynamics", 3rd Ed. John Wiley	1998

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN- 102** Course Title: **Analog and Digital Electronics**

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

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

4. Relative Weight: **CWS: 15** **PRS: 25** **MTE: 20** **ETE: 40** **PRE: 00**

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

8. Pre-requisite: **Nil**

9. Objective: To introduce basic concepts of electronics

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Semiconductor Diode:** Review of basic *p-n* junction, qualitative theory of the p-n junction, barrier formation in p-n junction diode, current flow mechanism in forward and reverse biased diode, Volt-Ampere characteristics, static and dynamic resistance of diode, Zenerdiode	6
2.	**Bipolar Junction transistors:** *n-p-n* and *p-n-p* transistors, characteristics of CB, CE and CC configurations,current gains α, β and γ, and, relations between them, active, cutoff and saturation regions,biasing of transistors: base bias, emitter bias, voltage divider bias, emitter follower circuit, load line analysis	7
3.	**Amplifiers:** Analysis of a single-stage CE amplifier using dc load line, coupled amplifiers: RC-coupled amplifier and its frequency response of voltage gain, operational amplifiers: inverting and non-inverting amplifiers, feedback in amplifiers: effects of positive and negative feedback on input impedance, output impedance and gain, stability, distortion and noise	5
4.	**Oscillators:** Sinusoidal oscillators:Barkhausen's criterion for self-sustained oscillations, RC phase shift oscillator, determination of frequency, non-sinusoidal oscillators– multivibrators	4
4.	**Field Effect Transistors**: Junction field effect transistors, pinch-off voltage, volt-ampere characteristics of JFET, insulated-gate field-effect transistor(MOSFET), enhancement MOSFET, depletion MOSFET, circuit symbols	5

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5.	**Digital Circuits:** Difference between analog and digital circuits, binary numbers, decimal to binary andbinary to decimal conversion, binary codes, AND, OR and NOT gates, NAND and NOR gates, exclusive OR and exclusive NOR gates, half and full adders, encoders, decoder and multiplexer circuits	7
6.	**Basic concepts of flip-flops:** Flip flops: SR, JK, D and T flip flops; counters, registers,clocks and timers, A/D and D/A converters, realization of basic logic gates using diodes and transistors,transistor-transistor logic (TTL) and CMOS logics	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Streetman B G and Banerjee S, "Solid State Electronic Devices", 6thEd.Prentice Hall	**2006**
2.	Boylestad R L and Nashelsky L, "Electronic Devices and Circuit Theory", 8thEd.Pearson Education	**2004**
3.	Malvino A P, "Electronic Principles", 7th Ed. McGraw Hill	**2006**
4.	Malvino A P and Leach D P, "Digital Principles and Applications", McGraw Hill	**1998**
5.	Dedra A S and Smith K C, " Microelectronic Circuits: Theory and Applications", 6th Ed. Oxford University Press	**2013**
6.	Millman J and Halkias C C, "Integrated Electronics", Tata McGraw Hill	**1995**

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1.Subject Code: **PHN-104** Course Title: **Thermal and Statistical Physics**

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

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

4. Relative Weight: **CWS: 15** **PRS: 25** **MTE: 20** **ETE: 40** **PRE: 00**

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

8. Pre-requisite: **Nil**

9. Objective:The course aims at familiarizing students with laws of thermodynamics and their correspondence with statistical mechanics

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Concept of pressure and radiation thermometry and absolute temperature, internal energy function, heat capacity, hydrostatic system, extensive and intensive parameters, conduction, convection, radiation of heat, Kirchhoff's law of radiated heat and Stefan-Boltzmann law	4
2.	Equation of state of ideal and real gas, quasi-static, adiabatic process, microscopic point of view, irreversible part of the second law, heat and entropy in irreversible and reversible processes, entropy and non-equilibrium states, application of the entropy principle	3
3.	Phase diagram of pure substance: PV, PT, TS diagram, volume expansivity, compressibility, molar heat capacities and its measurement, drawback of equipartition theorem	3
4.	Enthalpy, Helmholtz and Gibb's functions, Maxwell's thermodynamic relations, heat capacity equation, chemical potential, criteria for first- and second-order phase transitions and their study of in terms of thermodynamic potentials/free energies	5
5.	Free expansion of a gas, throttling process and inversion curve, liquefaction of gases, magnetic cooling, phase behavior of helium	4
6.	Phase space and definition of microstates, Liouville's theorem and its consequences, a priori equal probability, microcanonical ensemble, contact between statistics and thermodynamics	7
7.	Isolated system and its contact with a heat reservoir, canonical ensemble, calculation of thermodynamic quantities for an ideal monatomic gas and Gibbs paradox	6

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8.	Density matrix and trace, partition function and its evaluation for different ensembles, revisit of phase transition in terms of partition function	6
9.	Identical particles and symmetry requirements, M-B, B-E and F-D statistics and the corresponding distribution functions, blackbody spectrum	4
	Total	**42**

List of experiments:

I	Measurement of temperature using thermister
II	Specific heat measurements
III	Stefan's constant and work function of a photo cathode using incandescent lamp
IV	Thermal conductivity of metal by Searle's apparatus.
V	Verification of Stefan's law
VI	J by Callendar and Barn's method
VII	Temperature coefficient of resistance by Callendar and Griffiths bridge
VIII	Thermal conductivity of glass (tube form)
IX	Co-efficient of thermal expansion
X	Thermo-emf by potentiometer
XI	Thermal equation of state and critical point

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Reif F, "Fundamentals of Statistical and Thermal Physics", McGraw Hill	1965
2.	ZemanskyM W and Dittman R H, "Heat and Thermodynamics", McGraw Hill	1997
3.	Sears F W and Salinger G L, "Thermodynamics, Kinetic Theory and Statistical Thermodynamics",Narosa Publishers	1998
4.	Huang K, "Statistical Mechanics", John Wiley	1987
5.	Guha E, "Basic Thermodynamics", Narosa Publishers	2002

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-205** Course Title: **Engineering Analysis and Design**

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

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

4. Relative Weight: **CWS: 15** **PRS: 25** **MTE: 20** **ETE: 40** **PRE: 00**

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

8. Pre-requisite: **Nil**

9. Objective: This course will introduce the students to analysis and design of various physical systems using software packages

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Need for simulation in physics problems, logical and physical design, design representation, systems, flowcharts and structured charts, data flow diagrams	3
2.	**System Models:** System environment, stochastic activities, continuous and discrete systems, static and dynamic physical models, static and dynamic mathematical models, principles used in modeling	3
3.	**System Studies:** Subsystems, types of system study, system analysis, system design, system postulation	2
4.	**System Simulation:** Technique of simulation, Monte Carlo method, comparison of simulation and analytical methods, experimental nature of simulations, numerical computational technique for continuous and discrete models	3
5.	**Simulation Software:** Matlab/Mathematica, saving and loading data, programming a function, loops, branches and control flow, input/ output, 2-D and 3-D plots	5
6.	**Simulation of Problems in Mechanics:** 1-D simple harmonic oscillator, projectile motion, motion of a satellite	4
7.	**Simulation of Problems in Waves and Optics:** Plane wave propagation, standing wave, superposition of harmonic waves, Young's double slit experiment	4
8.	**Simulation of Problems in Electricity and Magnetism:** Electric field of- a point charge, n-point charges; charged particle in electric and magnetic fields, electrical circuits	4

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	Total	28

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Gordon G, "System Simulation", Pearson Education	2009
2.	Pratap R, "Getting Started with Matlab 7", Oxford University Press	2006
3.	"Mathematica Tutorial Collection", Wolfram Mathematica	2008
4.	Gilat A, "Matlab: An Intodtuction with Applications", Wiley India	2009

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-207** Course Title: **Mechanics and Relativity**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective:To familiarize the students with the fundamentals of Mechanics and Special Theory of Relativity

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Kinematics of Particles:** Curvilinear motion, relative velocity and acceleration, Newton's laws and applications (to include sliding- , belt- , wedge- friction and rolling resistance)	4
2.	**Kinetics of Particles :** Conservative forces, potential, work-energy theorems, energy-diagrams, conservation of linear and angular momentum, fixed axis rotation, collisions, variable mass problems	8
3.	**Lagrangian Mechanics:** Constraints, principle of virtual work, generalized coordinates, Lagrange's equation, Hamilton's equation	7
4.	**Central Forces:** Gravitation, Kepler's law, hyperbolic, elliptic and parabolic orbits, scattering theory, center of mass and laboratory frames of reference	6
5.	**Rigid Body Motion:** Translation and rotation of rigid bodies- derivative of a vector fixed in moving reference- general relationship between time derivative of a vector for different references, moment of momentum equations- kinetic energy of rigid body, work and energy relations, Euler's equations of motion, gyroscope motion	10
6.	**Special Theory Of Relativity:** Michelson-Morley experiment, Galilean transformation, length contraction, time dilation, Lorentz transformations, simultaneity, relativistic addition of velocities, Doppler Effect, equivalence of mass and energy	7
	Total	**42**

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Kleppner D and KolenkowR, "An Introduction to Mechanics", Cambridge University Press	2013
2.	SpiegelM R, "Theory and Problems of Theoretical Physics", McGraw Hill	1968
3.	RanaNand Joag P, "Classical Mechanics", McGraw Hill	2001
4.	GoldsteinH, "Classical Mechanics", Narosa Publications	2001
5.	ResnickR, "Introduction to Special Relativity", Wiley Publications	2007
6.	Beiser A, "Concepts of Modern Physics", 6^{th} Ed.McGraw Hill	2009

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-209** Course Title: **Mathematical Physics**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To familiarize students with standard techniques in Mathematical Physics

10. Details of the Course:

S. No.	Contents	Contact Hours
1.	**Vectors and Tensors:** Applications of Gauss's and Stokes' theorem; orthogonal curvilinear coordinate systems, covariant and contravariant tensors, covariant derivatives, Christoffel symbols, curvature tensor	8
2.	**Complex variables and applications:** Analytic functions, residue calculus, singularities, contour integration, conformal mapping and its applications, Fourier series, Fourier and Laplace transforms, evaluation of integral transforms and theirinverses using contour integrals	10
3.	**Elements of linear algebra:** Vector space, orthogonal bases, eigenvalues and eigenvectors, diagonalization techniques, Gramm-Schmidt orthogonalization, similarity transformations	6
4.	**Special functions and boundary value problems:** Solutions of Legendre-and associated Legendre-, Hermite-, Laguerre- and associated Laguerre-, Bessel's- and hypergeometric equations; beta and gamma functions; Laplace's equation and its solutions in different dimensions; The Riemann-P symbol approach to second order differential equations in the complex plane	12
5.	**Green's function techniques**: Green's functions and solutions of inhomogeneous differential equations and applications	6
	Total	**42**

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Arfken G B and Weber H J, "Mathematical Methods for Physicists", 5th Ed. Academic Press	2005
2.	Whittaker ETand Watson EW, "A Course of Modern Analysis", Cambridge University Press	2008
3.	Shankar R, "Basic Training in Mathematics: A Fitness Program for Science Students", Springer	1995
4.	Kreyszig E, "Advanced Engineering Mathematics", 9th Ed. Wiley India	2011

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-211** Course Title: **Quantum Physics**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective:To introduce the basic concepts of quantum mechanics and its applications

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Prelude to Quantum Mechanics:** Failures of classical physics; diffraction of matter particles, de Broglie waves and Davisson-Germerexperiment, wave-particle duality, Bohr atom model	04
2.	**Elements of Quantum Mechanics:** Schrodinger equation, interpretation of the wavefunction, wave packets, stationary states; Heisenberg uncertainty principle, basic postulates and meaning of the measurement, observables and operators	08
3.	**Problems in one-dimension:** Particle in a box, potential step, potential barrier: reflection and transmission coefficients; potential well, simple harmonic oscillator	10
4.	**Problems in three-dimension:** Central potential, hydrogen atom, angular momentum and spherical harmonics, addition of angular momenta and Clebsch-Gordon coefficients	08
5.	**Approximate Methods:** Basic idea of WKB approximation and its applications, basic ideas of time-dependent and time-independent perturbation methods and their applications	06
6.	**Scattering Theory:** Scattering amplitude, differential and total cross-section, scattering by a central potential, method of partial waves and the Born approximation	06
	Total	**42**

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Beiser A, "Concepts of Modern Physics", 6th Ed.McGraw Hill	2009
2.	Eisberg R M, and Resnick R, "Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles", Wiley	1985
3.	Gasiorowicz S, "Quantum Physics", John Wiley	2003
4.	Liboff, R L, "Introductory Quantum Mechanics", Addison-Wesley	2002
5.	Shankar R, "Principles of Quantum Mechanics", Plenum Press	1994
6.	Griffiths D J, "Introduction to Quantum Mechanics", Prentice Hall	1995
7.	Tyagi I S, "Principles of Quantum Mechanics", Pearson Education	2013

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-204** Course Title: **Atomic, Molecular and Laser Physics**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective : To introduce basic principles of Atomic and Molecular Spectroscopy and Lasers

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Atomic Spectroscopy-I:** Spectra of one- and two- electron systems, alkali spectra, electron spin and magnetic moment, electric-dipole allowed transition (E1) and selection rules, fine structure splitting: spin-orbit interaction and relativistic corrections; Lamb shift, hyperfine structure and isotope shifts	10
2.	**Atomic Spectroscopy-II:** Many-electron atoms, Pauli exclusion principle, angular momentum coupling schemes: *L-S* and *j-j* coupling, equivalent and non-equivalent electrons, Hund's rules, ground state configurations of elements in periodic table; atoms in electric and magnetic fields (Zeeman-, Paschen-Back and Stark effect), X-ray spectra	10
3.	**Molecular structure:** Born-Oppenheimer approximation, homo and hetero diatomic molecule, role of permanent dipole moment in diatomic molecule	4
4.	**Molecular spectroscopy:** Rotational spectroscopy: rigid-, non-rigid andvibrating rotator; Vibrational spectroscopy: harmonic oscillator, anharmonic oscillator, vibrating rotator or rotating oscillator, dissociation energy of molecules; Raman spectroscopy: classical theory of light scattering and Raman effect, quantum theory of Raman effect, selection rules for Raman spectrum; Electronic spectroscopy: electronic energy and total energy of a molecule, selection rules for electronic spectroscopy, Franck-Condon principle,quantum numbers for molecular spectroscopy	14

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5.	**Lasers:**Spontaneous and stimulated emission, absorption, population inversion, discussion on three-and four-level laser schemes, properties of laser beams: monochromaticity,spatial and temporal coherence, brightness, directionality, intensity profile of laser beam, He-Ne laser	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Bransden B H and Joachian C J, "Physics of Atoms and Molecules", 2nd Ed. Prentice Hall	2012
2.	Haken H and Wolf H C, "The Physics of Atoms and Quanta", 6th Ed. Springer	2007
3.	Herzberg G, "Molecular Spectra and Molecular Structure: Spectra of Diatomic Molecules", Dover Books on Physics	2010
4.	Svelto O, "Principles of Lasers", 5th Ed. Springer	2010

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-206** Course Title: **Elements of Condensed Matter Physics**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To familiarize students with bonding, mechanical properties, crystal structure, lattice vibrations, defects in solids and theory of magnetism

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Crystal Structure:** Point symmetry, translational symmetry, two- and three- dimensional lattices, simple crystal structures, Miller indices, diffraction from periodic structures (X-ray, neutron), reciprocal lattice, Brillouin zones	9
2.	**Bonding:** Covalent bonding, ionic bonding and metallic bonding	3
3.	**Lattice vibrations:** One dimensional lattices (monoatomic and diatomic), quantization of elastic waves, phonon momentum, density of modes, Einstein and Debye theory of specific heat	8
4.	**Electrons in solids:** Free electron gas in metals (Drude and Sommerfeld models), periodic potential and Bloch's theorem, Kronig-Penney model, electrical and thermal conductivity, electronic specific heat	8
5.	**Magnetism:** Langevin theory of dia- and para- magnetism, quantum theory of dia- and para-magnetism, magnetic ordering, Weiss molecular field theory of ferromagnetism and antiferromagnetism, Hund's rules, NMR	8
6.	**Superconductivity:** Zero resistance, Meissner effect, critical fields and currents, Type-I and Type-II superconductors, energy gap, thermodynamics of superconductor	6
	Total	**42**

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

1. Subject Code: **PHN-208** Course Title: **Nuclear Physics and Applications**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To familiarize students with the basic concepts of nuclear physics and its industrial, analytical, medicinal and energy applications

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Nuclear shape, size, radii, matter/charge distributions; nuclear force; concept of isospin; charge independence of nuclear forces in the light of isospin; mass defect and binding energy; liquid drop model; semi empirical mass formula; evidence of shell structure; shell model with harmonic oscillator and spin-orbit potential and its predictions	9
2.	α-decay, its properties, range, range-energy relationship, Geiger-Nuttal law, basic theory of α-decay, β-decay and its classifications, γ-decay: range, properties, pair production, energy spectra and nuclear energy levels	8
3.	Nuclear reaction, kinematics, direct nuclear reaction, compound nuclear reaction, nuclear fission and fusion	7
4.	Gas-, scintillation- and semiconductor detectors; neutron detectors, accelerators: cyclotron and linear accelerator (LINAC)	9
5.	Industrial, analytical and medicinal applications; power from fission, nuclear reactors; source of stellar energy	9
	Total	**42**

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Lilley J S, "Nuclear Physics", John Wiley and Sons	2001
2.	Ghoshal S N, "Nuclear Physics", S Chand and Company Ltd.	2000
3.	Povh B, Rith K, Scholz C and Zetsch F, " Particles and Nuclei", 2^{nd} Ed. Springer	1999
4.	Heyde K, " From Nucleons to the Atomic Nucleus", Springer	1998

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-210** Course Title: **Microprocessors and Peripheral Devices**

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

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

4. Relative Weight: **CWS: 15** **PRS: 25** **MTE: 20** **ETE: 40** **PRE: 00**

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

8. Pre-requisite: **Nil**

9. Objective:To provide in-depth knowledge of the architecture, instruction set and programming of typical 8-bit microprocessor and programmable support chips

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction of Microcomputer System**: CPU, I/O devices, clock, memory, bussed architecture, tri-state logic, address bus, data bus and control bus	3
2.	**Semiconductor Memories**: MROM, ROM, EPROM, EEPROM, DRAM, internal structure and decoding, memory read and write timing diagrams	3
3.	**Intel 8085A microprocessor:** Pin description and internal architecture; timing and control unit, opcode fetch machine cycle, memory read/write machine cycles, I/O read/write machine cycles, interrupt acknowledge machine cycle, state-transition diagram	8
4.	**Instruction Set:** Addressing modes,data transfer, arithmetic, logical, branch, stack and machine control groups of instruction set, macro RTL and micro RTL flow chart of few typical instructions, unspecified flags and instructions	7
5.	**Assembly Language Programming:** Assembler directives, simple examples, subroutines, parameter passing to subroutines	5
6.	**Interfacing:** Interfacing of memory chips, address allocation technique and decoding; interfacing of I/O devices, LEDs and toggle-switches as examples, memory mapped and isolated I/O structure; Input/ Output techniques: CPU initiated unconditional and conditional I/O transfer, device initiated interrupt I/O transfer	5
7.	**Interrupts:** Interrupt structure of 8085A microprocessor, processing of vectored and non-vectored interrupts, latency time and response time	3

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8.	**Programmable Peripheral Interface:** Intel 8255, pin configuration, internal structure of a port bit, modes of operation, bit *SET/RESET* feature, programming; ADC and DAC chips and their interfacing	4
9.	**Programmable Interval Timer:** Intel 8253, pin configuration, internal block diagram of counter, modes of operation, counter read methods, programming, *READ-BACK* command of Intel 8254	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Hall D V, "Microprocessor and Interfacing –Programming and Hardware", 2nd Ed. Tata McGrawHill	2008
2.	Gaonkar R S, "Microprocessor Architecture, Programming and Applications", 5th Ed.Penram International Publishing (India)	2007
3.	Stewart J, "Microprocessor Systems- Hardware, Software and Programming", Prentice Hall International Ed.	1990
4.	Short K L, "Microprocessors and Programmed Logic", 2nd Ed. Pearson Education	2008
5.	Intel Manual on 8-bit Processors	
6.	Intel Manual on Peripheral Devices	

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-214** Course Title: **Applied Optics**
2. Contact Hours: **L: 3** **T: 0** **P: 2**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weight: **CWS: 15** **PRS: 25** **MTE: 20** **ETE: 40** **PRE: 00**
5. Credits: **4** 6. Semester: **Autumn** 7.Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective:To introduce students to elements of optics, i.e., interference, diffraction and polarization and their applications in engineering
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Geometrical optics**: Fermat's principle, the ray equation and its solutions, matrix method in paraxial optics, unit planes, nodal planes, system of thin lenses	8
2.	**Interference:** Huygen's principle and its applications, interference by division of wavefront, two slit interference, Fresnel's biprism, interference with white light, interference by division of amplitude, thin parallel films, wedge shaped films, Newton's rings, Michelson interferometer and its applications, multiple beam interference, Fabry–Pérot interferometer and etalon	10
3.	**Diffraction:** Fraunhofer diffraction, single, double and multiple slit diffraction, diffraction grating, diffraction at a circular aperture, Fresnel diffraction, Fresnel half period zones, the zone plate, diffraction at a straight edge, diffraction of a plane wave by a long narrow slit and transition to Fraunhofer region	10
4.	**Polarization:** Polarization and double refraction, production of polarized light, Brewster's law, Malus's law, double refraction, interference of polarized light, quarter and half wave plates, analysis of polarized light, optical activity	9
5.	**Applications:** Antireflection coatings,ellipsometry and applications of polarization based device, basics concepts of holography, basics concepts and ray optics considerations of optical fiber	5
	Total	**42**

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List of experiments:

S. No.	Experiment	Contact hours
I	Determination of wavelength of sodium light by Fresnel biprism	
II	Determination of Young's modulus of a glass plate by Cornu's method	
III	Determination of wavelength of laser light by Fabry Perot etalon	
IV	Normal dispersion curves and Cauchy's relations	
V	Fresnel equations: rotation of plane of polarization by reflection	
VI	Study of single, double and multiple slit diffractions	
VII	Study of diffraction of light by a thin wire	
VIII	Determination of wavelength of light by Diffraction grating	
IX	Production and analysis of polarized light using quarter wave plates	
X	Nodal Slide Experiment	
XI	$\Delta\lambda$ by Michelson Interferometer	
XII	Thickness of Mica sheet by Michelson Interferometer	
	Total	**28**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Ghatak A, "Optics", 4th Ed. Tata McGraw Hill	2009
2.	Hecht E, "Optics", 4th Ed. Addison Wesley	2001
3.	Jenkins F A and White H E, "Fundamentals of Optics", 3rd Ed. McGraw Hill	1976

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-311** Course Title: **Numerical Analysis and Computational Physics**

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

3. Examination Duration (Hrs.): **Theory: 02** **Practical: 0**

4. Relative Weight: **CWS: 15 PRS: 25 MTE: 20 ETE: 40 PRE: 0**

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

8. Pre-requisite: **Knowledge of any computer programming language**

9. Objective:To introduce numerical tools for computationally solving various problems of engineering physics

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**System of Linear Equations:** Direct methods: LU-decomposition, Gauss-elimination methods without and with partial pivoting,iterative methods: Gauss-Jacobi and Gauss-Seidel methods, matrix norm, condition number and ill-conditioning	4
2.	**Non-linear Equations and Roots of Polynomials:** Bisection method, Newton–Raphson's method, direct Iterative method with convergence criterion	4
3.	**Numerical Interpolation and Curve Fitting:** Lagrange-, Hermite- and cubic spline interpolation methods and discussion on associated errors, Curve fitting by least squares	5
4.	**NumericalCalculus:** *Integral Calculus*:General quadrature formula, Simpson's rules, improper integrals, Gaussian quadrature formulae *DifferentialCalculus*: Numerical differentiation, Richardson extrapolation	7
5.	**Ordinary Differential Equations:** Euler-, RungeKutta- and Numerov methods, second order differential equations, coupled differential equations, finite differences, eigen values via finite differences, power method and eigenvalue problem	8
	Total	**28**

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List of experiments:

1. Black body radiation (computation and graphical representation)
2. Reflection and transmission of an electromagnetic wave
3. Statistical distributions at different temperatures
4. Binding energy curve for nuclei using liquid drop model
5. Eigen-value problem: 1-D square potential well
6. Eigen-values and wave-functions of a simple harmonic oscillator
7. Monte-Carlo simulation
8. Linear/Projectile motion (simulation and solutions)

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	DeVries P L, "A First Course in Computational Physics", John Wiley	1994
2.	Landau R H, Paez M J and Bordeanu C C, "A Survey of Computational Physics", Princeton University Press	2008
3.	Gerald C F and Wheatley O P, "Applied Numerical Analysis", 7th Ed. Addison Wesley	2003
4.	Atkinson K E, "An Introduction to Numerical Analysis", 2nd Ed.Wiley	1989
5.	Sastry S S, "Introductory Methods of Numerical Analysis", Prentice Hall	2005

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-313** Course Title: **Signals and Systems**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective:To provide students an understanding of analysis and processing of signals in various systems including communication systems

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Overview of communication, control and remote sensing systems, properties of systems, classifications of signals, basic operations on signals, elementary signals, exponential and sinusoidal, damped signals, step, impulse and ramp functions, systems as interconnections of operations, properties of systems	6
2.	Convolution, impulse response representation of linear time invariant (LTI) systems, convolution integral, step response	6
3.	Fourier representation of signals, periodic and non-periodic signals, Fourier series and Fourier transform, properties of Fourier representation, relationship between Fourier transform and Fourier series; Generalized Fourier transform; Amplitude and phase spectra, energy and power spectral density, signal bandwidth	8
4.	Laplace transform, relationship of Laplace and Fourier transforms, transfer function and its block diagram representation, convolution integral and the Fourier transfer function	6
5.	Review of Z-transform and its properties, discrete time Fourier transform and its properties,discrete convolution and duality,discrete Fourier transform and its properties,computation of discrete time Fourier transform and discrete Fourier transform, approximation of Fourier transform and discrete convolution using discrete Fourier transform	10
5.	Applications to communication systems, sampling, modulation, multiplexing, phase and group delays	6
	Total	**42**

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Haykin S and Van Been B, "Signals and Systems", 2nd Ed. JohnWiley and Sons	2003
2.	Lathi B P, "Linear Systems and Signals", 2nd Ed. Oxford University Press	2006
3.	Oppenheim A V, Willsky A S and Nawab S H, "Signals andSystems", 2nd Ed. PrenticeHall	1997
4.	Roberts M J, "Fundamentals of Signals and Systems", McGraw Hill	2007
5.	Ziemer R E, Tranter W H and Fannin D R, "Signals and systems: Continuous and Discrete", 4thEd. Pearson Education	2001

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-315** Course Title: **Laser and Photonics**
2. Contact Hours: **L: 3** **T: 0** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weight: **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**
5. Credits: **3** 6. Semester: **Autumn** 7.Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective:To introduce principles of different optoelectronics devices for science and engineering applications
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Light-Matter interaction:** Quantum theory for the evaluation of the transition rates and Einstein's coefficients, interaction of matter with radiation having broad spectrum, interaction of near monochromatic radiation with an atom having broad frequency response	6
2.	**Line broadening:** Line broadening mechanisms, homogeneous and inhomogeneous broadening, natural collision and Doppler broadening mechanisms and line shape functions	3
3.	**Rate equations:** Laser rate equations, two levels, three levels and four levels system, variation of power around threshold, optimum output coupling, quality factor, the ultimate line width of the laser	5
4.	**Laser resonators:** Optical resonators, modes of a rectangular cavity and open planar resonators, confocal resonator system, modes of a confocal resonator using Huygen's principle, planar resonators	6
5.	**Transient effects:** Pulsed lasers, Q-switching techniques, active and passive shutters, mode-locking, various techniques for mode-locking of a laser	4
6.	**Lasersystems:** Mechanism and applications of argon ion-, carbon dioxide-, Nd:YAG-, Ti-sapphire-, dye-, excimer- and diode-pumped solid-state lasers	4

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7.	**Modulation techniques for laser light:** Electro-optic and acousto-optic modulation, electro-optic effect, longitudinal and transverse modes, acousto-optic effect, Raman-Nath and Bragg diffraction	5
8.	**Nonlinear optics:** Nonlinear optical media, nonlinear polarization and susceptibility, second harmonic generation, optical Kerr effect, self-phase modulation, self-focusing	5
9.	**Applications:** Applications of lasers in material processing and micro machining, medicine, communication and information technology, military	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Svelto O, "Principles of Lasers", Springer	2010
2.	Ghatak A K and Thyagarajan K, "Optical Electronics", Cambridge University Press	2003
3.	Yariv A, "Quantum Electronics", John Wiley and Sons	1989
4.	Thyagarajan K and Ghatak A, "Lasers: Theory and Applications", Macmillan	1997
5.	Yariv A, "Optical Electronics", Oxford University Press	1997
6.	Laud B B, "Lasers and Nonlinear Optics", Wiley Eastern Ltd.	1992

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-317** Course Title: **Plasma Physics and Applications**

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

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

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

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

8. Pre-requisite: Undergraduate level knowledge of vector calculus, differential equations, complex analysis, Fourier- and Laplace transforms,contour integration, kinetic theory of gases, electromagnetism and Maxwell's equations

9. Objective: To introduce the basic principles of plasma physics and its applications

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to Plasma Physics:** Formation of plasma, Debye shielding, plasma parameters, criteria for plasma, earth's ionosphere and magnetosphere, laboratory plasma	5
2.	**Single Particle Motions:** Motion of charged particles in uniform and non-uniform **E** and **B** fields, magnetic mirrors and their applications, adiabatic invariants	6
3.	**Plasma as a Fluid:** Relation of plasma physics with ordinary electromagnetics, fluid equation of motion, fluid drift perpendicular and parallel to B, plasma approximation	6
4.	**Waves in Plasma:** Representation of waves, plasma oscillations, electron plasma waves, ion waves, validity of plasma approximation, comparison of ion and electron waves	8
5.	**Diffusion**: Diffusion and mobility in weakly ionized gases, decay of a plasma by diffusion, steady state solution, recombination	3
6.	**Instability:** Plasma instabilities and turbulence ionosphere, two stream instability, gravitational instability, Rayleigh-Taylor instability	6
7.	**Applications:** Effect of plasma instabilities on satellite communications, plasma as an industrial tool, plasma diagnostics, laser produced plasma, thermonuclear plasma, fusion reactions, tokamak reactor	8
	Total	**42**

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Chen F F, "Introduction to Plasma Physics", Plenum Press, New York	1990
2.	Kelley Michael C, "The Earth's Ionosphere: Plasma Physics and Electrodynamics", Elsevier Inc.	2009
3.	John P I, "Plasma Science and the Creation of Wealth", Tata McGraw Hill	2005
4.	Davidson R C, "Physics of Non-Neutral Plasmas",Allied Publishers Pvt. Ltd.	2001
5.	Eliezer S and Eliezer Y, "The Fourth State of Matter: An Introduction to Plasma Science", 2nd Ed. CRC Press	2001
6.	Paul M B, "Fundamentals of Plasma Physics", Cambridge University Press	2004
7.	Bittencourt J A, "Fundamentals of Plasma Physics", 3rd Ed. Springer	2004
8.	Lifshitz E M and Pitaevskii L P, "Physical Kinetics: Volume 10 (Course of Theoretical Physics Series)", 1st Ed. Butterworth-Heinemann	1981

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-310** Course Title: **Applied Instrumentation**

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

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

4. Relative Weight: **CWS: 20** **PRS: 20** **MTE: 20** **ETE: 40** **PRE: 00**

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

8. Pre-requisite: **Nil**

9. Objective: To introduce working principles and characteristics of transducers and analytical instruments commonly used for industrial applications

10.Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Basics of transducers, sensors and actuators; active and passive transducers, generating and parametric transducers; analog-, digital- and pulse outputs of sensors; static and dynamic characteristics of transducer and transducer system	5
2.	**Measurement of Displacement and Strain:** Resistive, inductive and capacitive transducers for displacement; wire, metal film and semiconductor strain gauges; Wheatstone-bridge circuit with one-, two- and four active elements, temperature compensation	5
3.	**Measurement of Speed and Torque:** Electro-magnetic and photo-electric tachometers; torque shaft, strain-gauge, electromagnetic and radio type torque meters	4
4.	**Measurement of Force and Pressure:** Column, ring and cantilever-beam type load cells; elastic elements for pressure sensing; force measurement using displacement sensors and strain gauges	5
5.	**Measurement of Temperature:** Resistance temperature detector, NTC and PTC thermistors, Seebeck effect, thermocouple and thermopile	4
6.	**Measurement of moisture and humidity:** Area and mass flow meters, electromagnetic flow meters	4
7.	**Digital Electronic Instrumentation:** Digital counter-timer and frequency meter, time standards, digital voltmeter and multimeter, accuracy and resolution considerations, comparison with analog electronic instruments, lock-in amplifier	6

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8.	**Analytical Instruments:** X-ray diffractometer and electron microscopy, AFM, TEM, STM, differential thermal analysis and differential scanning calorimetry, thermal gravimetric analysis (TGA), electron probe microanalysis (EPMA), X-ray photoelectron spectroscopy (XPS)	9
	Total	**42**

Experiments based on different types of transducers:

S. No.	Experiment	Contact hours
I	Measurement of pressure, strain and torque using strain gauge	
II	Measurement of speed using electromagnetic transducer	
III	Measurement of speed using photoelectric transducers and compass	
IV	Measurement of angular displacement using potentiometer	
V	Experiment of optocoupler using photoelectric transducers	
VI	Measurement of displacement using LVDT	
VII	Measurement of force using load cells	
VIII	Measurement of pressure using capacitive transducer	
IX	Measurement of pressure using inductive transducer	
X	Measurement of temperature using temperature sensors/resistance temperature detectors(RTD)	
XI	Characteristics of Hall effect sensor	
XII	Measurement of change in resistance using light dependent resistor (LDR)	
	Total	**28**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Rangan C S, Sharma G R and Mani V S V, "Instrumentation Devices and Systems", 2nd Ed. Tata McGraw-Hill	2008
2.	Doebelin E O and Manik D N, "Measurement Systems", 5th Ed. Tata McGraw-Hill	2008
3.	Cooper W D and Helfrick A D, "Modern Electronic Instrumentation and Measurement Techniques", PHI	2008
4.	Anand M M S, "Electronic Instruments and Instrumentation Technology", PHI	2004
5.	Nakra B C and Chaudhry K K , "Instrumentation, Measurement and Analysis",3rd Ed. Tata McGraw Hill	2010
6.	Sayer M andMansingh A, "Measurement, Instrumentation and Experiment Design in Physics and Engineering", PHI	2004
7.	Willard H H, "Instrumental Methods of Analysis", 7th Ed. CBS Publishers and Distributors	2004
8.	CullityB D and Stock S R, "Elements of X-ray Diffraction",3rd Ed. Pearson	2014
9.	Patranabis D, "Principles of Industrial Instrumentation", 2nd Ed. Tata McGraw-Hill	2001

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-312** Course Title: **Physics of Semiconductor Devices**

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

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

4. Relative Weight: **CWS: 20** **PRS: 20** **MTE: 20** **ETE: 40** **PRE: 00**

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

8. Pre-requisite: Elementary knowledge of semiconductor diodes, amplifiers and oscillators

9. Objective: To introduce the physics of semiconductors, p-n junction, bipolar junction transistors, FET and MOSFET

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Semiconductors:** Energy bands, direct and indirect semiconductors, charge carriers, mobility, drift of carriers in field, diamond and zinc-blende structure, bonds and bands in semiconductors, intrinsic and extrinsic semiconductors, law of mass action, Hall effect and cyclotron resonance in semiconductors	12
2.	**Optical Injection:** Carrier life time, direct and indirect recombination of electron and holes, steady state carrier generation, diffusion and drift of carriers, continuity equation, steady state carrier injection and Haynes-Shockley experiment	8
3.	**Junctions:** Metal-semiconductor contact: under equilibrium and non-equilibrium conditions, junction diode theory, tunnel diode, photodiode, LED, solar cell, hetro-junctions and laser diode	10
4.	**Bipolar Junction Transistors:** Charge transport and amplification, minority carrier distribution and terminal currents switching behaviour in bipolar transistor	4
5.	**FET and MOSFET:** Ideal MOS capacitor, effect of work function and interface charge on threshold voltage	6
6.	**Gunn Diode:** Transferred electron mechanism and drift of space charge domain	2
	Total	**42**

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List of Experiments:

S. No.	Experiment	Contact Hours
1.	To draw the I-V characteristics of a p-n junction diode in forward and reverse bias and to determine its DC and AC resistance for a given current	
2.	To study the temperature dependence of the reverse saturation current of a p-n junction diode and to determine the band gap of semiconductor	
3.	To study half wave, full wave and bridge rectifiers and to determine ripple factor	
4.	To design a regulated power supply using Zener diode and fixed voltage regulator	
5.	(a)To draw input and output characteristic of a bipolar transistor (b)To design a CE amplifier and study its frequency response	
6.	To draw input and output characteristic of a JFET and determine g_m, r_d and verify the square law	
7.	To design inverting and non-inverting amplifiers of different gain using operational amplifier and study their frequency response	
8.	To verify truth tables of various logic gates	
9.	To verify Boolean theorems using logic gates	
10.	To design and study of astable, monostablemultivibrators using timer 555	
	Total	**28**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Streetman B G and Banerjee S, "Solid State Electronic Devices", 6th Ed. Prentice Hall	**2005**
2.	Sze S M, "Semiconductor Devices Physics and Technology",2nd Ed.John Wiley and Sons	**2003**
3.	Tyagi M S, "Semiconductor Materials and Devices", John Wiley and Sons	**2000**
4.	ChattopadhyayD and Rakshit P C, "An advanced course in Practical Physics",7th Ed.New Central Book Agency (P) Ltd.	**2005**
5.	Gupta S L and Kumar V, "Practical Physics", 25th Ed. PragatiPrakashan	**2002**
6.	Paul P, Malvino Aand Miller M, " Basic Electronics: A Text-Lab Manual", Tata McGraw Hill	**1999**

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-321** Course Title: **Fabrication and Characterization Techniques**

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

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

4. Relative Weight: **CWS: 15** **PRS: 25** **MTE: 20** **ETE: 40** **PRE: 00**

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of various fabrication and measurement techniques

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Role of thin films in technology and devices, introduction to vacuum, vacuum pumps: rotary pump, diffusion pump, turbomolecular and cryopumps; vacuum systems, vacuum gauges: pirani gauge, penning gauge	4
2.	Thin film synthesis using physical vapor deposition(PVD)andchemical vapor deposition(CVD) techniques, thermal evaporation, sputtering, molecular beam epitaxy (MBE), pulsed laser deposition (PLD), spin and dip coating	6
3.	Introduction and limitation of photolithography, X-ray lithography, electron beam lithography, nanoimprinting and soft nanolithography, dip pen nanolithography	8
4.	Measurement of electrical, dielectric and optical properties, four probe method, UV-visible spectroscopy, ellipsometry, measurement of magnetic properties using vibration sample magnetometer (VSM) and superconducting quantum interference device (SQUID), structural characterization of materials, X-ray diffraction (XRD), field emission scanning electron microscopy (FESEM)	10
	Total	**28**

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List of Experiments:

1) Deposition of Aluminum (Al) thin film using thermal evaporation
2) Measurement of thin film thickness and optical constants using ellipsometry
3) Deposition of Copper (Cu) thin films using DC-sputtering
4) Resistivity measurement of Al and Cu thin film using four probe method
5) Structural characterization of Cu and Al thin films to determine grain size, surface morphology, thickness and crystal structure
6) Preparation of 3-D bulk materials (superconductor, ferromagnetic, ferroelectric) using solid state reaction method
7) Resistivity and AC susceptibility measurements of bulk materials using physical quantities measurement systems
8) Fabrication of printed circuit board from Cu thin films
9) Dielectric constant measurements of $BaTiO_3$ material as a function of temperature
10) I-V measurements of solar cells and determination of fill factor (FF), efficiency and operating point
11) Measurement of pressure in vacuum chambers using rotary and diffusion pumps
12) Measurement of transmittance of thin film by using spectrophotometer

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Madou M, "Fundamentals of Microfabrication", CRC Press	1997
2.	Fahrner W R, "Nanotechnology and Nanoelectronics", Springer	2005
3.	Waits R K, "Thin Film Deposition And Patterning", American Vacuum Society Monograph Series	1998
4.	Tu K N, Mayer J W and Feldman L C, "Electronic Thin Film Science for Electrical Engineers and Materials Scientists", Macmillan USA	1992
5.	Poole C P, "Introduction to Nanotechnology", John Wiley and Sons	2003
6.	M. Ohring, "Materials science of thin films", Academic Press	2002
7.	CallisterDJr., "Materials Science and Engineering: An Introduction", 6th Ed. John Wiley and Sons	2003
8.	Chopra K L, "Thin Film Phenomena", McGraw Hill	1979
9.	Agranovich V, "Thin Films and Nanostructures", Elsevier	2012

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-323** Course Title: **Radiation Detection and Measurements**

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

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

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

5. Credits: 04 6. Semester: Autumn 7. Subject Area: PEC

8. Pre-requisite: Nil

9. Objective: To impart the knowledge on methods of radiation detection,various types of radiation detectors and applications

10. Details of Course:

11.

S. No.	Contents	Contact Hours
1.	Radioactive decay, source of charged and uncharged radiation, interaction of radiation with matter: heavy charged particle, electron, gamma-rays and neutrons, stopping power, Bragg curve, radiation exposure, absorbed dose, equivalent dose, counting statistics, error analysis	10
2.	Properties of radiation detectors: operation mode, pulse height spectra, energy resolution, detection efficiency and dead time; ionization chambers, proportional counters, Geiger Mueller counters; scintillation detectors: inorganic and organic scintillators, photomultiplier tube, response of scintillation detectors to gamma-rays, charged particles and neutrons; application of scintillation detectors	12
3.	Semiconductor diode detectors and its use in alpha spectrometry, fission fragment spectroscopy, particle identification, X-ray spectroscopy; gamma spectroscopy with lithium-drifted silicon (Si(Li)), lithium-drifted germanium (Ge(Li)) and high purity germanium(HPGe) detectors, fast and slow neutron detection;pulse processing electronics: NIM: amplifier, SCA, CFD, CAMAC: ADC, TDC, timing and coincidence measurements	12
4.	Nuclear reactor: neutron source and power generator, applications in tracing, material modification, sterilization, material modification; neutron activation analysis, medicine: CT, PET, SPECT, MRI, therapy	8
	Total	**42**

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12. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Knoll Glenn F, "Radiation Detection and Measurement", 4^{th} Ed. Wiley India Pvt Ltd.	2010
2.	Leo W R, "Techniques for Nuclear and Particle Physics experiments", Springer-Verlag	1994
3.	AhmedS, "Physics and Engineering of Radiation Detection",Academic Press	2007
4.	Kapoor S S and Ramamurthy V, "Nuclear Radiation Detectors", New Age International (P) Ltd.	2005
5.	LamarshJohn R andBarattaAnthony J, "Introduction To Nuclear Engineering", Prentice Hall	2001
6.	Gilmore Gordon R, "Practical Gamma-ray Spectrometry",2^{nd} Ed. John Wiley and Sons	2008

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-325** Course Title: **Atmospheric Physics and Climate Dynamics**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective:To introduce the basics of Atmospheric Physics and familiarize students with dynamics of lower atmosphere and climate

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Atmospheric Evolution:** Solar radiation, early atmosphere and evolution to present day atmosphere, carbon budget, ozone chemistry, variation of temperature, density, ionization and pressure with altitude, hydrostatic equation, hypsometric equation	6
2.	**Thermodynamics of Atmosphere:** Humidity variables, moist air, adiabatic expansion of unsaturated air, various lapse rates, vertical mixing, vertical stability of atmosphere, use of thermodynamic diagrams, role of convective potential energy	6
3.	**Lower Atmosphere:** Atmospheric absorption and greenhouse effect, atmospheric aerosols, origin and classification of aerosols, cloud formation, precipitation, cloud morphology, stability and clouds, growth of cloud droplets, physics of lightning, global radiation budget	6
4.	**Upper Atmosphere:** Introduction to ionosphere, role and features of ionosphere, Chapman theory of layer production, photochemistry of thermosphere, electron, ion and neutral temperatures, negative ions, the composite F layer, airglow and auroral emissions, measurement of ion and electron densities using ground based and space borne techniques	6

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5.	**Atmospheric Circulation:** Equations of motion, Reynold stresses, Ekman's solution, ITCZ, vorticity, inertial instability, barotropic and baroclinic instability, energy and angular momentum transport, circulation theorems and their applications, Helmholtz theorem for split of horizontal wind vector; vorticity, cyclones and divergence equations, scale analysis, split of vorticity and divergence equations into rotational and irrotational terms	10
6.	**Climatology:** Definition of climate, physical factors of climate, El Niño,earth-sunrelationship;Koppen and Thornthwaite classification of climate, climate zones of India, pressure, wind, temperature and rainfall distribution during the four seasons; western disturbances, fog, thunderstorm, hail, cold waves, subtropical jet stream, monsoons	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Salby M L, "Fundamentals of Atmospheric Physics", Academic Press	1996
2.	Wallace J M and Hobbs Peter V, "Atmospheric Science, An Introductory Survey", Academic Press	2006
3.	RatcliffeJ A, "An Introduction to the Ionosphere and Magnetosphere", Cambridge University Press	1972
4.	Holton J R, "An Introduction to Dynamic Meteorology", Elsevier Academic Press	2004
5.	Houghton J, "The Physics of Atmospheres", Cambridge University Press	2002
6.	Tsonis A A, "An Introduction to Atmospheric Thermodynamics", Cambridge University Press	2007
7.	Citchfield H J, "General Climatology", Prentice-Hall of India	1994
8.	Rogers R R, "A Short Course in Cloud Physics", Pergamon Press	1989

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code:**PHN-327** Course Title: **Physics of Nanosystems**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weight: **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**
5. Credits: **4** 6. Semester: **Autumn** 7.Subject Area: **PEC**
8. Pre-requisite: **Fundamental concepts of quantum mechanics**
9. Objective: This course on physics of nanosystems is designed to introduce the emerging area of nanotechnology
10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Introduction:** An overview of quantum mechanical concepts related to low-dimensional systems	2
2.	**Hetrostructures:** Heterojunctions, Type I and Type IIheterostructures, classification of quantum confined systems, electrons and holes in quantum wells, electronic wavefunctions, energy subbands and density of electronic states in quantum wells, quantum wires and quantum dots, effective mass mismatch in heterostructures, coupling between quantum wells, superlattices	5
3.	**Electron states:**Wavefunctions and density of states for superlattices, excitons- in bulk, in quantum structures and in heterostructures, unit cell- for quantum well, for quantum wire and for quantum dot	6
4.	**Nanoclusters and Nanoparticles:** Introduction, metal nanoclusters-magic numbers, geometric structures, electronic structure, bulk to nanotransition, magnetic clusters; semiconducting nanoparticles; rare-gas and molecular clusters	4
5.	**Carbon Nanostructures:**Introduction, carbon molecules, carbon clusters, structure of C60 and its crystal, small and large fullerenes and other buckyballs, carbon nanotubes and their electronic structure	3
6.	**Properties of Nano Materials:** Size dependence of properties, phenomena and properties at nanoscale, mechanical/frictional, optical, electrical transport, magnetic properties	4
7.	**Nanomaterial Characterization:** Electron microscopy, scanning probe microscopies, near field microscopy, micro- and near-field Raman spectroscopy, surface-enhanced Raman spectroscopy, X-ray photoelectron spectroscopy	7

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8.	**Synthesis of nanomaterials:** Fabrication techniques: self-assembly, self-replication, sol-gels;Langmuir-Blodgett thin films, nanolithography, bio-inspired syntheses, microfluidic processes, chemical vapor deposition, pulse laser deposition	8
9.	**Applications of Nanomaterials:**Nanoelectronics, nanosensors, environmental, biological, energy storage and fuel cells	3
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Edelstein A A and Cammarata R C, "Nanomaterials- Synthesis, Properties and Applications", Institute of Physics Publishing, London	1998
2.	Shik A, "Quantum Wells: Physics and Electronics of Two-Dimensional Systems", World Scientific	1999
3.	BenedekG, MilaniP, Ralchenko V G, "Nanostructured Carbon for Advanced Applications", Springer	2001
4.	Harrison P, "Quantum Wells, Wires, and Dots: Theoretical and Computational Physics", John Wiley	2000
5.	Mitin VV, Kochelap V A and Stroscio MA "Quantum Heterostructures: Microelectronics and Optoelectronics", Cambridge University Press	1999
6.	Poole CP Jr. and Owens FJ,"Introduction to Nanotechnology", Wiley	2006

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code:**PHN-329** Course Title: **Superfluidity and Superconductivity**

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

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

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

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

8. Pre-requisite: Undergrad level knowledge of Thermal Physics of Bose and Fermi gases, Solid State Physics

9. Objective: This course introduces advanced concepts of superfluidity and superconductivity and their interrelationship

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Superfluidity:** Basic properties of superfluid ^{4}He and ^{3}He; Bose-Einstein condensation in an ideal Bose gas; Bose-Einstein condensation in interacting gases, condensate wave function	8
2.	**Theory of Bose Fluids:** Landau criterionfor superfluidity, excitations ina uniform gas – Bogoliubov transformation, excitations in a trapped gas – weak coupling, excitations in non-uniform gases	9
3.	**Vortex States:** Quantization of circulation, quantized vortices in He-II; quantized vortices in superconductors; comparison of He-II and superconducting vortices; dynamics of vortex states	9
4.	**Ginzburg-Landau Theory:** Ginzburg Landau (GL) equations, second order critical fields; Abrikosov vortex lattice; relation of GL theory with BCS theory; Ginzburg-Pitaevskii equations for He-II; broken symmetry	8
5.	**High-Tc Superconductivity:** Nature and various mechanisms of high T_c superconductivity; equation for the critical temperature and strong electron-phonon coupling; charge density wave (CDW), spin density wave (SDW)	8
	Total	**42**

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Chaikin P M and Lubensky T C, "Principles of Condensed Matter Physics", Cambridge University Press	1995
2.	Tilley D R and Tilley J, "Superfluidity and Superconductivity", 3rd Ed. Overseas Press	2005
3.	Suneto T and Nakahara M,"Superconductivity and Superfluidity", Cambridge University Press	2005
4.	Pethick C J and Smith H, "Bose-Einstein Condensation in Dilute Gases", Cambridge University Press	2002
5.	Pitaevskii L and Stringari S, "Bose-Einstein Condensation", Clarendon Press	2003

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-331** Course Title: **Nuclear Astrophysics**

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

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

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

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

8. Pre-requisite: g

9. Objective: To introduce the emerging field of nuclear astrophysics

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Astronomy-observing the universe, astrophysics-'explaining' the universe; general characteristics of thermonuclear reactions; sources of nuclear energy; cross sections, stellar reaction rates, mean lifetime; Maxwell-Boltzmann velocity distribution, astrophysical *s* – factor	10
2.	**Determination of reaction rates:** Neutron and charged particle induced non-resonant reactions,reactions through narrow and broad resonances	8
3.	**Hydrogen and Helium burning:** p-p chain, CNO cycles, other cycles like NeNa, MgAl; creation and survival of ^{12}C	9
4.	**Explosive Burning and Nucleosynthesis beyond Iron:** Silicon burning;nucleosynthesis in massive stars,*s* – process, *r* - process	9
5.	**Indirect methods in Nuclear Astrophysics:** Coulomb dissociation, Trojan Horse and ANC methods; neutron stars; radioactive ion beams	6
	Total	**42**

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Rolfs C E and Rodney W S, "Cauldrons in the Cosmos : Nuclear Astrophysics", The University of Chicago Press	2005
2.	Clayton D D, "Principles of Stellar Evolution and Nucleosynthesis", The University of Chicago Press	1984
3.	Glendenning N K, "Compact Stars", Springer	2000
4.	Boyd R, "An Introduction to Nuclear Astrophysics", The University of Chicago Press	2008

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-314** Course Title: **Nanotechnology**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weight: **CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00**
5. Credits: **4** 6. Semester: **Spring** 7.Subject Area: **PEC**
8. Pre-requisite: **Fundamental concepts of quantum mechanics**
9. Objective:To introduce the emerging areas of nanotechnology
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Historical development, scientific revolutions, opportunity at the nano scale, classification of functional nanomaterials	2
2.	**Fundamental Principles:** Size andscale, units, scaling laws, atoms, molecules and clusters, quantum wells, wires and dots – size and dimensionality effects	4
3.	**Properties of Nano Materials:** Size dependence of properties, phenomena and properties at nanoscale, mechanical/frictional, optical, electrical transport, magnetic properties	5
4.	**Nanomaterial Characterization:** X-Ray Diffraction, scanning electron microscopy, transmission electron microscopy, atomic force microscopy, scanning tunneling microscopy, thermogravimetric analysis – differential scanning calorimetry – thermomechanical analysis, X-ray photoelectron spectroscopy	10
5.	**Fabrication Techniques**: Mechanical alloying and mechanical milling, self-assembly, sol-gels; Langmuir-Blodgett thin films, nanolithography, chemical vapor deposition, physical vapor deposition and different types of epitaxial growth techniques- pulsed laser deposition, magnetron sputtering, micro lithography (photolithography, soft lithography, e-beam writing and scanning probe patterning)	10
6.	**Nanomaterials:** Structure and properties of single wall nanotubes (SWNTs), multiwall nanotubes (MWNTs), graphenes and fullerenes; metal/oxide nanoparticles, nanorods, nanowires, nanotubes, and nanofibers, semiconductor quantum dots: excitons, magnetic nanoparticles: nanostructured ferromagnetism	8

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7.	Applications of Nanomaterials:Nanoelectronics, nanosensors, environmental and biological applications, energy storage and fuel cells	3
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Edelstein A A and Cammarata R C, "Nanomaterials- Synthesis, Properties and Applications", Institute of Physics Publishing, London	1998
2.	Nalwa H S, "Handbook of Nanostructured Materials and Nanotechnology", Vols. 1-5, Academic Press	2000
3.	Dresselhaus M S, Dresselhaus G and Eklund P, "Science of Fullerenes and nanotubes", Academic Press	1996
4.	Wolf Edward L, "Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience", 2^{nd} Ed. Wiley-VCH	2006

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-316** Course Title: **Properties of Matter and Acoustics**

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

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

4. Relative Weight: **CWS: 15PRS: 25** **MTE: 20** **ETE: 40** **PRE: 00**

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

8. Pre-requisite: **Nil**

9. Objective:To familiarize students with fundamentals of properties of matter, waves and acoustics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Elasticity:** Hooke's law, stress, strain diagram, elastic moduli, relation between elastic constants, Poisson's ratio, expressions for Poisson's ratio in terms of elastic constants, work done in stretching and twisting a wire, twisting couple on a cylinder, rigidity modulus by static torsion, torsional pendulum, rigidity modulus and moment of inertia, elastic materials, tensor of strain, tensor of elasticity	8
2.	**Bending of beams:** Cantilever, expression for bending moment, expression for depression, cantilever oscillations, expression for time period, experiment to find Young's modulus, non-uniform bending, determine Young's modulus by Koenig's method, uniform bending, expression for elevation, determine Young's modulus using microscope	8
3.	**Fluids:** Definition and dimensions of surface tension, excess of pressure over curved surfaces, application to spherical and cylindrical drops and bubbles, variation of surface tension with temperature, Jaegar's method, steady flow of Newtonian fluids, Poiseuille's equation for incompressible fluids, statement of Stokes law, terminal velocity, effect of temperature on viscosity, Reynold's number, turbulent flow and critical velocity, experiment to determine co-efficient of viscosity of a liquid, applications of viscosity, equation of continuity-Bernoulli's theorem and conservation of energy	10

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5.	**Waves and Oscillations:** Simple harmonic motion: free, damped, forced vibrations and resonance, coupled harmonic oscillator, eigen frequencies and normal modes, transverse vibrations in stretched strings, wave equation for a string, velocity of transverse wave along a string, energy of a vibrating string, Fourier's analysis for plucked and bowed string	10
6.	**Applications:** Spherical waves, shock waves, ultrasonics: production of ultrasonic waves (piezo electric crystal method and magnetostriction method), applications to industry and medical science	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Feynman R P, Leighton R B and Sands M, "The Feynman Lectures on Physics", Narosa	2005
2.	Mathur D S, "Elements of Properties of Matter", 11^{th} Ed.S. Chand and Company	1949
3.	Flowers B H and Mendoza E, "Properties of Matter", Wiley	1991
4.	MaitiS Nand Raychaudhury D P, "Classical Mechanics and General Properties of Matter", New Age International Publisher	2013
5.	Bajaj N K, "The Physics of Waves and Oscillations", Tata McGraw Hill	1988
6.	Ingard K U, "Fundamentals of Waves and Oscillations", Cambridge Univ. Press	1988

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

1. Subject Code: **PHN-318** Course Title: **Atomic and Molecular Collision Physics**

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

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

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

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

8. Pre-requisite: **Knowledge of basic principles of Atomic and Molecular Spectroscopy**

9. Objective: The course aims at introducing the formal scattering theory, and its applications to scattering of projectiles from atoms and molecules

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Potential scattering-I:** General features, partial wave analysis, optical theorem and unitarity relation, the phase shifts, absorption processes, scattering by a complex potential, Coulomb potential in parabolic coordinates, partial wave decomposition, scattering by a modified Coulomb field	12
2.	**Potential scattering-II:** Schrödinger equation as an integral equation, Green's function, Lippmann-Schwinger equation, compact solutions of Lippmann-Schwinger equation, integral representations of scattering amplitude, partial wave analysis of Lippmann-Schwinger equation, Born expansion as a perturbation series, first Born approximation, Born Series	10
3.	**Electron – atom collisions:** Electron scattering: general principles, elastic scattering, excitation of atoms to discrete levels, ionization, resonance phenomena	6
4.	**Atom-atom collisions:** Long range interactions between atoms, the classical approximation, the elastic scattering of atoms at low velocities, electronic excitation and charge exchange	8
5.	**Electron - molecule collisions:** Theory of electron-molecule collisions, calculation of differential and integrated cross sections and illustrative results	6
	Total	**42**

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Joachain C J, "Quantum Collision Theroy", 3rd Ed.North Holland	1983
2.	Bransden B H and Joachain C J, "Physics of Atoms and Molecules", 2nd Ed. Prentice Hall	2003
3.	Gianturco F A, "Atomic and Molecular Collision Theory", Plenum Press	1982
4.	Burke P G and Joachain C J, "Theory of Electron- Atom Collisions: Potential Scattering", Springer	1995
5.	Bransden B H, "Atomic Collision Theory", 2nd Ed. Benjamin	1983
6.	Zettili N, "Quantum Mechanics: Concepts and Applications",2nd Ed. John Wiley	2009

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-320** Course Title: **Fiber and Nonlinear Optics**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weight: **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: Elementary knowledge of optics i.e. interference, diffraction and polarization and their applications in engineering
9. Objective: To introduce applications of lasers in nonlinear optics, optical fiber communication and sensors
10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Fiber optics:** Rectangular-, optical- and planar mirror waveguides, electromagnetic analysis of planar optical waveguides, TE and TM modes of a symmetric and asymmetric planar waveguide, power associated with a mode	12
2.	**Optical fiber**: Optical fiber waveguide, numerical aperture, pulse dispersion in a step-index fiber, scalar wave equation and modes of a fiber, LP modes, single-mode fibers, material and waveguide dispersion for a communication link, attenuation, splice loss, methods of fabrication of optical fibers, optical fiber components, directional coupler, multiplexer, demultiplexer, fiber Bragg gratings, long-period fiber gratings, optical fibers in sensors, photonic crystal fibers	12
3.	**Nonlinear optics:** Nonlinear optical media, nonlinear polarization and susceptibility; second-order nonlinear optics: optical second harmonic generation, sum frequency generation, difference frequency generation, optical parametric amplification and oscillation, three wave mixing	10
4.	**Third order nonlinear optics**: Third harmonic generation, optical Kerr effect, self phase modulation, self focusing, spatial solitons, Raman gain, four wave mixing, optical phase conjugation, Raman and Brillouin scattering	8
	Total	**42**

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Ghatak A K and Thyagarajan K, "Optical Electronics", Cambridge University Press	2003
2.	Ghatak A K and Thyagarajan K, "Introduction to Fiber Optics", Cambridge University Press	1998
3.	Laud B B, "Lasers and Nonlinear Optics", Wiley Eastern	1992
4.	Saleh B E A and Teich M C, "Fundamantals of Photonics", Wiley Interscience	2007
5.	Snyder A and Love J, "Optical Waveguide Theory", Chapman and Hall	1983
6.	Keiser G, "Optical Fiber Communications", McGraw Hill	2000

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-322** Course Title: **Modern Particle Physics**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weight: **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: Knowledge of standard techniques in Mathematical Physics and basic concepts of quantum mechanics and its applications.
9. Objective: To introduce the basics of modern elementary particle physics
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Group Theory and Algebra:** Representation theory of SU(2) and SU(3) groups and Lie algebras, SU(3) flavor symmetry and construction of meson octet, baryon octet anddecuplet	6
2.	**Field Theories:** Klein-Gordon equation, Dirac equation, concept of anti-particles, canonical quantization	6
3.	**Elementary Particles:** Concept of elementary particles and their classification, conservation of the different quantum numbers viz. baryon number strangeness etc. in particle physics, concept of color and quark model, deep inelastic scattering of lepton-hadron scattering: discovery of quarks and gluons	8
4.	**Symmetries**: Noether's Theorem: symmetry and conservation laws, spin and orbital angular momentum, flavor symmetry, parity, charge conjugation, time reversal symmetry, CPT theorem	6
5.	**Weak Interaction**: (i) Phenomenology: parity violation and the V-A form of the weak current, muon decay, pion decay, charged current, neutral currents, Cabibbo angle, weak mixing angle, CP Invariance, CP violation; (ii) electroweak unification (Glashow-Salam-Weinberg model): basic electroweak interaction, effective current-current Interaction, spontaneous symmetry breaking, higgs mechanism, masses of gauge bosons and fermions	10
6.	**Strong Interaction:** Yang-Mills theory, quantum chromodynamics, Feynman rules, asymptotic freedom	4
7.	**Physics of particle production**:Colliders: past, present and future; fragmentation functions, jets, production of vector bosons and heavy quarks	2

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		Total	42

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Griffith D, "Introduction of Elementary Particles", John Wiley	2000
2.	Sarkar U, "Particle and Astro-Particle Physics", Francis and Taylor	2007
3.	Kane G, "Modern Elementary Particle Physics", Addison Wesley	1993
4.	Halzen F and Martin A D, "Quarks and Leptons", John Wiley	2011
5.	Cheng T P and Li L F, "Gauge theory of Elementary Particle Physics", Oxford University Press	1988
6.	Barger and Phillips, "Collider Physics", Addison-Wesley Publishing Company	1996
7.	Perkins D H, "Introduction to High Energy Physics", Cambridge University Press	2000

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN- 425** Course Title: **Superconducting Materials**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weight: **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**
5. Credits: **4** 6. Semester: **Autumn** 7.Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce various properties of superconductors and their applications
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Characteristic properties of superconducting materials:** Zero resistance, Meissner effect, critical magnetic field, critical current density, type-I and type-II superconductors, isotope effect, flux quantization, thermal properties of superconductors, heat capacity, thermal conductivity, energy gap, microwave properties	8
2.	**Theories of superconductors:** London's equations, Pippard theory, outline of Ginzburg Landau theory, Cooper problem, outline of BCS theory	6
3.	**Superconducting Materials:** Superconducting elements, binary alloys and compounds, organic superconductors, high-$T_c$cuprate superconductors, C-based superconductors, MgB_2 superconductors, Fe-based superconductors	6
4.	**Critical current of Type-II superconductors:** Fluxquantization and vortices, Abriksov lattice, flux flow, flux pinning, flux creep, irreversible properties, depairing critical current, hysteresis cycle: Bean model, effects of grain boundaries on J_c in high-T_c superconductors	6
5.	**Measurements of superconducting properties:** Electrical and magnetic measurement to superconductors to determine T_c, J_c, upper critical field (H_{C2}), irreversibility field (H_{irr})	6
6.	**Josephson effects:** Tunnel effect: NIN, NIS and SIS junctions, dc Josephson effect, ac Josephson effect, dc and rf SQUID	6
7.	**Technology and Applications:** Large scale and high current applications of superconductors: superconducting magnets, magnetic levitation, NMR, MRI, superconducting electronics and film applications: digital electronics, microwave applications	4
	Total	**42**

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Michel C and Davor P, "Introduction to Superconductivity and High Tc Materials", World Scientific	1992
2.	Kittel C, "Introduction to Solid State Physics", John Willey	1996
3.	Ramakrishnan T V and Rao C N R, "Superconductivity Today", Pergamon Press.	1992
4.	Poole C P, Farach H A, Creswich R J andProzorov R, "Superconductivity", Academic Press	2007

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-427** Course Title: **Quantum Information and Computing**

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

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

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

5. Credits: **04** 6. Semester: **Autumn** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the basic and advance principles of quantum information and computing to the students

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction, postulates of quantum theory, Dirac notation, quantum circuit model, super-dense coding, quantum teleportation and no-cloning theorem	8
2.	Quantum computing: quantum qubits, quantum logic gates, quantum circuits, universal quantum gates, application of quantum computer; Deutsche's algorithm, Deutsch-Jozsa algorithm, Simon's algorithm, simulation of quantum system	12
3.	Quantum Fourier Transform, Grover's algorithm, phase estimation, quantum factorization, quantum searching, Shor's algorithm, quantum search algorithms	12
4.	Quantum error-correction, quantum error-correcting codes, stabilizer codes, fault-tolerant quantum computation, physical realizations of quantum computation	10
	Total	42

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Nielsen Michael A and Chuang Isaac, "Quantum Computation and Quantum Information", Cambridge University Press	2012
2.	Kaye Phillip, LaflammeRaymond and MoscaMichele, "An Introduction to Quantum Computing", Oxford University Press	2007

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-429** Course Title: **Nuclear Science and Engineering**

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

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

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

5. Credits: 46. Semester: **Autumn** 7.Subject Area: **PEC**

8. Pre-requisite: **Basic concepts of nuclear physics and its applications**

9. Objective: To introduce developments in the fields of nuclear science and technology and their applications

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Nuclear Physics Fundamentals:** Properties of nuclei, nuclear structure and stability, radioactivity, interaction of charged particles, neutrons and gammas with matter, fission and fusion	6
2.	**Reactor Fuels and Fission Based Reactors:** Reactor fuels, conversion and breeding, components of nuclear power plants, light water reactor, pressurized water reactor, boiling water reactor, breeder reactors, nuclear fuel cycles, uranium enrichment, radioactive waste disposal	9
3.	**Reactor Physics:** Neutron flux, diffusion equation and its solution, thermal neutron diffusion, two-group calculation of neutron moderation, fusion based reactors, ITER, confinement of plasma	6
4.	**Accelerators:** Review of relativistic particle motion, Types of particle accelerators – Direct-voltage accelerators (Cockcroft Walton, Van de Graff, Pelletron), radio-frequency [RF] accelerators viz., betatron, synchrotron, cyclotron, linear accelerator [LINAC]	5
5.	**Beam Optics:** Equations of motion for weak and strong focusing, matrix elements for beam optics – dipole, quadrupole and solenoid magnet, focusing-defocussing (FODO) lattice and stability diagrams, RF acceleration dynamics, phase space representation - ensemble of particles, emittance, synchrotron radiation	7
6.	**Modern Accelerators:** Superconducting RF LINACS, novel acceleration schemes – Fixed Field Accelerating Gradient (FFAG) accelerator, Dielectric Wall Accelerator, Laser accelerators	3

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7.	**Applications** : Medical imaging, nuclear physics applications in clinic and medical research, radiation and hadron therapy, radioisotopes in food and health, dosimetry and radiation protection	6
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Knoll Glenn F, "Radiation Detection and Measurement", 4th Ed.John Wiley and Sons	2010
2.	LamarshJohn R andBarattaAnthony J, "Introduction To Nuclear Engineering", 3rd Ed.Prentice Hall	2001
3.	Shultis J K and Faw R E, "Fundamentals of Nuclear Science and Engineering",Marcel Dekker	2002
4.	Stacey W M, "Nuclear Reactor Physics",2nd Ed.Wiley-VCH	2007
5.	Almenas K and Lee R, "Nuclear Engineering: An Introduction",2nd Ed.Springer-Verlag	1992
6.	Conte Mario and Mackay William W "An Introduction to the Physics of Particle Accelerators", 2nd Ed.World Scientific	2008
7.	WilleK, "The Physics of Particle Accelerators: An Introduction", Oxford Univ. Press	2000

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-431** Course Title: **Weather Forecasting**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weight: **CWS: 25 PRS: 00MTE: 25 ETE: 50 PRE: 00**
5. Credits: 46. Semester: **Autumn** 7.Subject Area: **PEC**
8. Pre-requisite: Nil
9. Objective: To familiarize with the dynamic meteorology of earth's atmosphere
10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Atmospheric Dynamics:** Equation of motion, geostrophic approximation, cyclostrophic motion; thermal wind equation; The equation of continuity	8
2.	**The General Circulation:** Symmetric circulation, inertial instability, barotropic instability; baroclinic instability; sloping convection; general circulation of the middle atmosphere	8
3.	**Numerical Modelling of Weather:** Barotropic model; baroclinic models; primitive equation models; moist processes; radiation transfer; forecasting models	10
4.	**Global Observations:** Conventional observations; remote sounding from satellites; remote sounding of atmospheric temperature; remote measurements of composition	8
5.	**Atmospheric Predictability and Climate change:** Short term predictability; variations of climate; atmospheric feedback processes; different kind of predictability	8
	Total	**42**

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Houghton J T, "The physics of atmospheres", Cambridge University Press	1997
2.	Holton J R, "Introduction to dynamic meteorology", Academic Press	1992
3.	Zdunkowski W and Boot A, "Dynamics of the Atmosphere", Cambridge University Press	2003

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-433** Course Title: **Introduction to Superstring Theory**

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

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

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

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

8. Pre-requisite: **Knowledge of standard techniques in Mathematical Physics.**

9. Objective: The main objective of this course is to prepare the student with the basics of superstring theory

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Bosonic string theory: perturbative: free bosonic string in Minkowski space, commutation relation and mode expansion, Virasoro algebra, light-cone gauge, quantization and no-ghost theorem, analysis of spectrum	8
2.	Superstring theory: world-sheet supersymmetry, boundary conditions and mode expansions, light-cone gauge quantization, [no-ghost theorem, GSO condition], extended world-sheet supersymmetry [N=2, 4], super Yang-Mills theory; space-time supersymmetry, superparticle and superstring, type I and II superstrings, light-cone quantization and analysis of open and closed-string spectra; SO(32) and E_8 x E_8 heterotic string theories	14
3.	Basic mathematics of string theory: topological spaces, continuous functions, real (differentiable) manifolds, vector fields, differential forms, Riemannian Geometry, integrals of forms and Stokes theorem, Laplacian on forms, simplicial homology, de Rhamcohomology, fiber bundles, homotopy theory, complex manifolds, Kählerian geometry, Dolbeaultcohomology, Calabi-Yau manifolds and their moduli Spaces	8
4.	Nonperturbative: dualities, basic ideas of M- and F- theories, compactifications, dualities, examples and their tests and interrelation between different duality conjectures, M-theory in 11 dimensions and its compactification, F-theory in 12 dimensions and its compactifications, nonperturbative D-branes and open	12

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	strings in closed string theories	
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Green Michael B, Schwarz John H andWitten Edward, "Superstring Theory: Volume 1, Introduction", Cambridge University Press	1988
2.	Polchinksi J, "String Theory", Cambridge Monographs on Mathematical Physics, Vol. 1and 2	1998
3.	Sen Ashoke, "An Introduction to Nonperturbative String Theory:Duality and Supersymmetric Theories",Cambridge	1997
4.	Greene Brian R, "String theory on Calabi-Yau Manifolds", (Columbia U.) : Lectures given at Theoretical Advanced Study Institute in Elementary Particle Physics (TASI 96): Fields, Strings, and Duality, Boulder, CO, 2-28 Jun 1996, Published in Boulder 1996, Fields, *Strings and* Duality, World Scientific Singapore	1997

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-435** Course Title: **Advanced Characterization Techniques**

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

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

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

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

8. Pre-requisite: Nil

9. Objective: To introduce the various methods of characterization of materials for their structural, electrical, magnetic and optical properties

10.Details of Course:

S.No.	Contents	Contact Hours
1.	**Crystal Structure Determination:** Brief description of crystal lattices; X-ray diffractometer; determination of crystal structure using X-ray diffraction	12
2.	**Electron Microscopes:** Brief description of different microscopes like TEM, SEM, AFM; different modes of operation of microscopes, sample preparation, interpretation of electron diffraction and determination of crystal structure; morphology of the crystals	11
3.	**Thermal Analysis:**Thermogravimetricanalysis, differential thermal analysis and differential scanning calorimetry and methodology; determination of phase transitions using these methods	5
4.	**Electrical and Magnetic Property:**Measurement of electrical conductivity in different materials, e.g. insulators, metals and semiconductors using four-probe and Hall effect method, vibrating sample magnetometer (VSM), superconducting quantum interference devices (SQUID), magnetodielectric effect	8
5.	**Optical Characterization:**Optical characterization of materials using Photoluminescence and UV-visible spectroscopy	3
6.	**Chemical Analysis:**Brief description to X-ray fluorescence, atomic absorption and electronic spin resonance spectroscopy	3
	Total	42

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Culity B D, "Elements of X-ray Diffraction", Addison-Wesley	2001
2.	Grundy P J and Jones G A, "Electron Microscopy in the Study of Materials", Edward Arnold	1976
3.	Egerton R F, "Physical Principles of Electron Microscopy", Springer	2008
4.	Willard, Merritt, Dean and Settle, "Instrumental Methods of Analysis", CBS Publications	1991
5.	Fultz B and Howe J M, "Transmission Electron Microscopy and Diffractometry of Materials", Springer	2007

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-437** Course Title: **A Primer in Quantum Field Theory**

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

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

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

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

8. Pre-requisite: **Knowledge of standard techniques in Mathematical Physics**

9. Objective: To familiarize students with applications of relativistic quantum mechanics

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Basics:** Action principle; Euler-Lagrange equations of motion, second quantization; symmetry (space-time and internal) conserved Nöther charges	4
2.	**Tensors:** Definitions of contravariant, covariant and mixed tensors, need to use tensors in relativistic quantum mechanics	2
3.	**Spin-0 (Klein Gordon Field Theory):** Real scalar field theory and its canonical quantization; normal ordering; charged scalar field theory and its canonical quantization, conserved Nöther current and charge, propagator (also as vacuum expectation value of a time-ordered product), interpretation of negative-energy solutions as anti-matter; recasting Klein-Gordon equation as a Schrödinger equation, Zitterbewegung	7
4.	**Spin-1/2 (Dirac Field Theory):** Dirac Lagrangian for spinor fields, Feynman gamma matrices and related identities; covariance of the Dirac equation; canonical quantization of the spinor fields, positive- and negative-energy spinors, positive- and negative-energy projectors, Lorentz transformations to boost from rest frame to lab frame; propagator (also as vacuum expectation value of a time-ordered product), discrete symmetries: charge conjugation, parity and time reversal symmetries	9
5.	**Spin-1 (Gauge Field Theory):** Covariant formulation of Maxwell's equations, (transverse) canonical quantization of the gauge field (in the	5

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	Coulomb gauge)	
6.	**Scattering**: LSZ reduction (for bosons and fermions), Wick's theorem, S-matrix, cross sections	6
7.	**Quantum Electrodynamics**: Quantization of abelian gauge theories with fermions; Feynman Rules; Compton effect; Møller Scattering, radiative corrections; Anomalous Magnetic Moment; Infrared Divergence; Lamb shift	9
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Michio K, "Quantum Field Theory: A Modern Introduction", Oxford University Press	1993
2.	Claude I and Jean B Z, "Quantum Field Theory", McGraw Hill	2006
3.	Lewis H R, "Quantum Field Theory", Cambridge University Press	2001
4.	Michael E P, "An Introduction to Quantum Field Theory", Perseus Books Publishing	2002
5.	Lahiri A andPal P B,"*A* First Book of Quantum Field Theory", Narosa Publishing House	2005

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-422** Course Title: **Emerging Phenomena in Materials**

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

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

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

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

8. Pre-requisite: Basic knowledge of bonding, mechanical properties, crystal structure, lattice vibrations, defects in solids and theory of magnetism

9. Objective: To introduce students to the research and application potential of the new emerging phenomena in materials

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Spintronics:** Introduction to spintronics, spin injection, spin detection, spin relaxation, spin polarization, giant magnetoresistance (GMR), colossal magnetoresistance (CMR), tunneling magnetoresistance (TMR), magnetic multilayers, exchange bias, spin diode, magnetic tunnel junctions, spin-field effect transistor	10
2.	**Oxide heterostructures:** Band insulator and Mott insulator, properties of transition metal oxides, polar/non-polar nature of thin film interfaces, polar catastrophe, 2D metallic interface, functional properties of oxide interfaces (superconductivity, magnetism etc.), multiferroics	10
3.	**Graphene:** Band structure of graphene, Dirac spectrum and Fermi points at half filling, tunneling and Klein paradox, devices based on graphene	6
4.	**2D electron gas:** Experimental realization of 2D electron gas,integer and fractional quantum Hall effect	4
5.	**Topological insulators:** Fundamentals and materials, experimental observations, idea of edge states, Rashba spin-orbit coupling and its consequences	4
6.	**High Tc superconductors:** Experimental observations: temperature dependence of resistivity and specific heat, deviation from standard BCS behavior, phase diagram and electronic structure of $La_{2-x}Sr_xCuO_4$, ARPES spectra: d-wave symmetry of the order parameter	8
	Total	**42**

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	CahayMarc andBandyopadhyaySupriyo, "Introduction to Spintronics", CRC press	2008
2.	Evgeny Y. Tsymbal, Elbio R A Dagotto, Chang-BeomEom andRamamoorthy Ramesh, “Multifunctional Oxide Heterostructures”, Oxford University Press	2012
3.	MaekawaSadamichi, “Physics of Transition Metal Oxides”, Springer-Verlag	2004
4.	Bernevig B Andrei and Hughes Taylor L, “Topological insulators and topological superconductors”, Princeton University Press	2013
5.	Ashcroft N W andMermin N D, “Solid State Physics”, Harcourt Asia Pvt. Ltd.	2001

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN - 424** Course Title: **Optoelectronics**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weight: **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**
5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge about working principles of different optoelectronics devices for science and engineering applications
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Semiconductors and their Optical Properties** Semiconductors- energy bands and charge carriers, binary, ternary and quaternary semiconductors, generation, recombination and injection processes, junctions, hetrojunctions, quantum wells, superlattices, interaction of photons with electrons and holes, band-to-band absorption and emission, rates of absorption and emission, refractive index	7
2.	**Semiconductor Light Emitting Devices** Light emitting diodes, injection electroluminescence, LED characteristics, quantum efficiency, responsivity, semiconductor laser amplifier, gain, pumping, hetrostructures, semicunductor injection lasers, amplification, feedback and oscillation, power, spectral distribution, mode selection, characteristics of typical semiconductor lasers, quantum well lasers, VCSELS, LCD, plasma display	12
3.	**Photodetectors** Properties of semiconductor photodetectors, quantum efficiency, responsivity, response time, photoconductors- photodiodes, p-n and p-i-n photodiode, avalanche photodiodes, noise in photodetectors, phototransistors, photoconductive gain, CCD and CMOS sensors	8
4.	**Photovoltaics Devices** Solar energy spectrum, device principles, I-V characteristics, equivalent circuit, temperature effects, materials, devices, and efficiencies, organic solar cells, CIGS solar cells, perovskite solar cells	8
5.	**Optical Communication Systems** Characteristics of optical fiber, single and multi-mode fiber, step-index, graded-index, attenuation and dispersion, optical fiber components	7
	Total	**42**

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Saleh B E A and Teich M C, "Fundamentals of Photonics", John Wiley and Sons, Inc.	1991
2.	Ghatak A and Thyagarajan K, "Optical Electronics", Cambridge University Press	2003
3.	Kasap S O, "Optoelectronics and Photonics: Principles andPractices", Prentice Hall	2001
4.	Streetman B G and Banerjee S, "Solid State Electronic Devices", 6th Ed. Prentice Hall	2006
5.	Chuang Shun Lien ,"Physics of Optoelectronic Devices", Wiley	1995
6.	Wilson John and Hawkes John, "Optoelectronics, An Introduction",3rd Ed.Prentice Hall	1998
7.	Singh J, "Optoelectronics: An introduction to Materials And Devices", McGraw-Hill	1996

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-426** Course Title: **Space Technology**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To familiarize students with the basic principles space technology and its applications

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Earth and Orbiting Satellites:** Basic Principles, Keplerian orbits and Kepler equations, orbital elements from velocity and position information, perturbation theory and applications	8
2.	**Rocket and Rockets Propulsion:**Thrust Equation, specific impulse, rocket equation, propulsion options and advanced propulsion concepts, electromagnetic propulsion, ion propulsion, different types of launch vehicles of ISRO, NASA, ESA	8
3.	**Satellite Navigations:**Global navigation satellite systems, GPS, IRNSS, GLONASS, Galileo	5
4.	**Satellite Communications:** Theory of radio wave propagation through ionosphere, earth to satellite communication, laser communication, satellite to satellite communication	7
5.	**Indian Scientific Space Missions:** Chandrayaan-1 and 2, Mars orbiter mission, Astrosat, Aditya-1	5
6.	**Applications of Space Technology:** Physics of the earth's atmosphere, solar observations in infrared, visible and X-rays; communication satellite and applications, earth resource monitoring, remote sensing and others, military applications, weather satellite and applications	9
	Total	**42**

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Hans M, "Space Science and Technology", John Wiley and Sons	2003
2.	Emilio C and Alfredo H, "Fundamentals of Satellite Remote Sensing", Taylor and Francis	2009
3.	Rao K N R, "Fundamentals of Satellite communications", Prentice-Hall of India Pvt. Ltd.	2006
4.	Verger E T, "The Cambridge Enclyopedia of Space, Missions, Applications and Exploration", Cambridge University Press	2003
5.	Garner J T and GonesM, "Satellite Operations, Systems Approach to Design and Control", Ellis Horwood	1990
6.	Kaula W M, "Theory of Satellite Geodesy Applications of Satellite Geodesy", Mineola Dover Publications	2000

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-428** Course Title: **Advanced Electroceramics Technology**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: This course will introduce modern day electoceramic materials, their applications and the underlying physical principles

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Oxide and non-oxide ceramics, their chemical formulae, crystal and defect structures, non-stoichiometry and typical properties	4
2.	**Powder Preparation**: Physical methods (different techniques of grinding), chemical routes - co-precipitation, sol-gel, hydrothermal, combustion synthesis, high temperature reaction (solid state reaction)	6
3.	**Basic Principles And Techniques Of Consolidation And Shaping Of Ceramics**: Powder pressing- uniaxial, biaxial and cold isostatic and hot isostatic, injection moulding, slip casting, tape-casting, calendaring, multilayering	5
4.	**Sintering**: Different mechanisms and development of microstructure (including microwave sintering),preparation of single crystal, thick and thin film ceramics problems of sintering: inhomogeneties and their effects on sintering, constrained sintering; rigid inclusion, thin film, solid solution additives and the sintering, sintering with chemical reaction, viscous sintering with crystallization	5
5.	**Exotic Ceramics**: functionally graded, smart/ Intelligent, bio-mimetic and nanoceramics - basic principles, preparation and applications, ceramic sensors, transparent ceramics, coatings and films: preparation and applications	8

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6.	**Ceramic Capacitors**: Historical Background, ferro electricity in capacitors technology, dielectric properties of multi-phase systems, basic dielectric materials, varieties of ceramic capacitor, capacitor performance parameters, typical ceramic dielectric compositions, fuel cells and batteries	8
7.	**Magnetic Ceramics**: Spinal ferrites, hexagonal ferrites, rare earth-garnet, processing and application in various fields	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication / Reprint
1.	Barsoum, M W, "Fundamental of Ceramics", McGraw Hill	1997
2.	Richardson D W and Lee W E, " Modern Ceramic Engineering", 3rd Ed. Marcel Dekker	1992
3.	Rahman M N, "Ceramic Processing and Sintering", Marcel Dekker	2003
4.	Somiya S, "Handbook of Advanced Ceramics", Academic Press	2003
5.	Somiya S, "Handbook of Advanced Ceramics, Parts 1 and 2, Academic Press	2006

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-430** Course Title: **Solar Terrestrial Physics**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weight: **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: Basics of Atmospheric Physics and dynamics of lower atmosphere and climate
9. Objective: Aspects of solar interaction with Earth's upper atmosphere
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**The sun and interplanetary space:** The sun as a star, solar atmosphere, solar electromagnetic radiations, variance in the solar spectra, solar wind, solar and interplanetary magnetic field, solar cycle variations, cosmic rays in the interplanetary space, interaction of solar wind and other planets	6
2.	**The Physics of Geospace:** Properties of gases, magnetoplasma, gyrofrequency, plasma frequency, waves, radio wave propagation in ionized medium, waves propagation in plasma, Langmuir wave, ion-acoustic wave, electromagnetic wave in unmagnetized plasma, plasma instabilities	10
3.	**Dynamo action:** Equations of motion of terrestrial atmosphere, the atmospheric circulation, heating of upper atmosphere, tidal oscillations of the atmosphere, the lunar tide, the solar tides, tides at theionospheric level, motion of charged particles, conductivities, layer conductivity	10
4.	**Ionosphere:** Physical aeronomy, chemical aeronomy, formation of D, E, F1 and F2 regions in low and mid latitudes, ionospheric electric currents, F-region drifts, ion drag effects, storms, geomagnetic indices, irregularities in ionosphere, travelling ionospheric disturbances	10
5.	**Whistlers:** Whistlers and VLF emissions, emission theories, dispersion relation for whistler mode wave, growth rate calculation, nonlinear effects, quasilinear theory, diffusion into loss cone	6
	Total	**42**

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Seeds M A, "Solar System", Brooks/Cole Thomson Learning	2007
2.	Das A C, "Space Plasma Physics", Narosa Publishing House	2004
3.	Hargreaves J K, "The Solar-Terrestrial Environment", Cambridge Atmospheric and Space Science Series	2003
4.	AkasofuSyun-Ichi, Sydney Chapman, "Solar-Terrestrial Physics", Oxford Press	1972
5.	Kelley M C, "The Earth's Ionosphere", Academic Press	2009

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

1. Subject Code: **PHN-432** Course Title: **Computational Nuclear Physics**

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

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

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

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

8. Pre-requisite:Undergrad level knowledge of nuclear physics- properties of nuclei, nuclearpotentials, mass defect and binding energy, and, anyprogramming language

9. Objective: To understand the concepts of nuclear physics through numerical solutions obtained by writing computer programs

10. Details of the Course:

S. No.	Contents	Contact Hours
1.	Harmonic oscillator, wave functions, evaluation of special functions using recurrence relations and optimization, spherical harmonics, shapes of atomic orbitals, coupling of angular momenta	5
2.	Simulation of Rutherford scattering, semi empirical mass formula, estimation of the constants in mass formulae using atomic mass evaluations, mapping of drip lines, quantum tunneling: application of WKB approach to alpha and proton decays	5
3.	Numerical evaluation of eigenstates for different potentials by solving coupled differential equations with boundary conditions, harmonic oscillator, square-well and Woods-Saxon potentials, complex eigenvalues and resonances	5
4.	Independent particle models, eigenstates, solutions for Nilsson model; single-*j* shell approximation and Cranking model; effective interaction: simple estimates, evaluation of matrix elements in *s-d* shell; superconductivity: solution for BCS equations at T = 0; hot nuclei: application of Fermi-Dirac distribution; quantum hadrodynamics (QHD): Walecka model, equation of state for symmetric, asymmetric and neutron star matter	10
5.	Setting up large codes, parallel and distributed computing, open access codes, libraries	3
	Total	**28**

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Greiner W and Maruhn J A, "Nuclear models", Springer-Verlag	1997
2.	Arfken G B, Weber H J and Harris F E, "Mathematical Methods for Physicists", 7th Ed.Academic Press	2013
3.	Abramowitz M and Stegun I A, "Handbook of Mathematical Functions With Formulas, Graphs And Mathematical Tables", Dover Publications	1972
4.	Giordano N and Nakanishi H "Computational Physics",2nd Ed. Prentice Hall	2006
5.	Pang T, "An Introduction to Computational Physics", Cambridge Univ. Press	2006

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PROGRAM CODE : **122 - B.Tech. Engineering Physics**
DEPARTMENT : **Department of Physics**
YEAR : **I**

Teaching Scheme				Contact Hours/Week				Exam Duration (Hrs.)		Relative Weights (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
		(Autumn)												
1.	MAN-001	Mathematics - 1	BSC	4	3	1	0	3	0	25	0	25	50	0
2.	PHN-101	Introduction to Engineering Physics	DCC	2	2	0	0	0	0	0	0	0	100	0
3.	PHN-103	Computer Programming	ESC	4	3	0	2	3	0	15	25	20	40	0
4.	CYN-001	Physical Chemistry	BSC	4	3	0	2	3	0	15	25	20	40	0
5.	HSN-002	Ethics and Self Awareness	HSSC	2	1	1	0	2	0	25	0	25	50	0
6.	CEN-105	Introduction to Environmental Studies	GSC	3	3	0	0	3	0	25	0	25	50	0
7.	HSN-001A/B	Communication Skills (Basic / Advanced)	HSSC	2	1	0	2	2	0	25	0	25	50	0
		TOTAL		**21**										
		(Spring)												
1.	MAN-010	Optimization Techniques	BSC	4	3	1	0	3	0	25	0	25	50	0
2.	PHN-008	Electromagnetic Theory	DCC	4	3	1	0	3	0	25	0	25	50	0
3.	PHN-102	Analog and Digital Electronics	DCC	4	3	0	2	3	2	15	25	20	40	0
4.	PHN-104	Thermal and Statistical Physics	DCC	4	3	0	2	3	2	15	25	20	40	0
5.	EEN-112	Electrical Science	ESC	4	3	1	0	3	0	25	0	25	50	0
6.	CYN-002	Organic and Inorganic Chemistry	BSC	4	3	1	0	3	0	25	0	25	50	0
		TOTAL		**24**										

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PROGRAM CODE : 122 - B.Tech. Engineering Physics
DEPARTMENT : Department of Physics
YEAR : II

Teaching Scheme				Contact Hours/Week				Exam Duration (Hrs.)		Relative Weights (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
(Autumn)														
1.	MIN-003	Mechanical Engineering Drawing	ESC	4	2	0	4	0	4	0	50	0	0	50
2.	PHN-205	Engineering Analysis and Design	DCC	4	3	1	0	3	0	25	0	25	50	0
3.	PHN-207	Mechanics and Relativity	DCC	4	3	0	2	3	0	15	25	20	40	0
4.	PHN-209	Mathematical Physics	DCC	3	3	1	0	3	0	25	0	25	50	0
5.	PHN-211	Quantum Physics	DCC	3	3	1	0	3	0	25	0	25	50	0
6.	HSN-ELE	HSS Elective Course[1]	HSSMC	3	3	0	0	3	0	25	0	25	50	0
		TOTAL		**21**										
(Spring)														
1.	MTN-105	Electrical and Electronics Materials	ESC	4	3	1	0	3	0	25	0	25	50	0
2.	PHN-204	Atomic Molecular and Laser Physics	DCC	3	3	0	0	3	0	25	0	25	50	0
3.	PHN-206	Elements of Condensed Matter Physics	DCC	3	3	0	0	3	0	25	0	25	50	0
4.	PHN-208	Nuclear Physics and Applications	DCC	3	3	0	0	3	0	25	0	25	50	0
5.	PHN-210	Microprocessors and Peripheral Devices	DCC	5	3	1	2	3	0	15	25	20	40	0
6.	PHN-214	Applied Optics	DCC	4	3	0	2	3	2	15	25	20	40	0
		TOTAL		**22**										

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PROGRAM CODE : 122 - B.Tech. Engineering Physics
DEPARTMENT : Department of Physics
YEAR : III

Teaching Scheme				Contact Hours/Week				Exam Duration (Hrs.)		Relative Weights (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
		(Autumn)												
1.	PHN-311	Numerical Analysis and Computational Physics	DCC	3	2	0	2	3	2	15	25	20	40	0
2.	PHN-313	Signals and Systems	DCC	4	3	1	0	3	0	25	0	25	50	0
3.	PHN-315	Laser & Photonics	DCC	3	3	0	0	3	0	25	0	25	50	0
4.	PHN-317	Plasma Physics and Applications	DCC	3	3	0	0	3	0	25	0	25	50	0
5.	PHN-319	Technical Communication	DCC	2	2	0	0	3	0					
6.	PHN-ELE-1	Depratmental Elective *I	DEC	4	3	1	0	3	0					
7.	OEC/ BM-ELE	Open Elective Course/Management Studies Elective Course[2]	OEC/HSSMEC	3	2	1	0	2	0	25	0	25	50	0
		TOTAL		19/22										
		(Apring)												
1.	PHN-310	Applied Instrumentation	DCC	4	2	0	4	3	2					
2.	PHN-312	Semiconductor Devices	DCC	4	3	1	2/2	3	2	20	20	20	40	0
3.	PHN-ELE2	Depratmental Elective II	DEC	4	3	1	0	3	0	25	0	25	50	
4.	PHN-300	Industry-oriented Problem / Lab-based Project / Software Engineering-based Project	DCC	4	0	0	6	-	100					
5.	OEC/BM-ELE	Open Elective Course/Management Studies Elective Course[2]	OEC/HSSMEC	3	3	2	1	0	2	0	25	0	25	50
6.	PHN-399	Educational Tour	DCC	0	0	0	0	0	0	0	0	0	0	0
7.	MSC1/ DHC1	MSC** - 1/ DHC*** - 1 (optional)	MSC/ DHC	4	3	1	0	3	0	25	0	25	50	0
		TOTAL		16/23										

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PROGRAM CODE : 122 - B.Tech. Engineering Physics
DEPARTMENT : Department of Physics
YEAR : IV

Teaching Scheme					Contact Hours/Week			Exam Duration (Hrs.)		Relative Weights (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
(Autumn)														
1.	PHN-ELE3	Depratmental Elective III	DEC	4	3	1	0	3	0	25	0	25	50	0
2.	PHN-ELE4	Depratmental Elective IV	DEC	4	2	1	0	3	0	25	0	25	50	0
3.	PHN-499	Training Seminar	DCC	2	0	2	0	-	0	100	0	0	0	0
4.	PHN-400A	B.Tech. Project	DCC	4	0	0	0	3	0	0	0	0	0	100
5.	MSC2/DHC2	MSC - 2 / DHC - 2 (optional)	MSC/DHC	4	3	0	0	3	0	25	0	25	50	0
6.	MSC3/DHC3	MSC - 3 / DHC - 3 (optional)	MSC/DHC	4	3	0	0	3	0	25	0	25	50	0
		TOTAL		**14/22**										
(Spring)														
1.	PHN-ELE5	Depratmental Elective V	DEC	4	3	0	0	3	0	25	0	25	50	0
2.	PHN-ELE6	Depratmental Elective VI	DEC	4	3	0	0	3	0	25	0	25	50	0
3.	PHN-400B	B.Tech Project (Contd. from Autumn Semester)	DCC	8	0	0	12	0	0	0	0	0	0	100
4.	MSC4/DHC4	MSC - 4 / DHC - 4 (optional)	MSC/DHC	4	3	1	0	3	0	25	0	25	50	0
5.	MSC5/DHC5	MSC - 5 / DHC - 5 (optional)	MSC/DHC	4	3	1	0	3	0	25	0	25	50	0
		TOTAL		**16/24**										

[1] – Any one course in this category is to be opted either in the Autumn or in the Spring semester in the II year. The course should be selected from the list (basket) of Humanities and Social Sciences Elective Courses.
[2] – One course each from the OEC and the HSSMEC categories is to be opted either in the Autumn or in the Spring semester in the III year. The HSSMEC course should be selected from the list (basket) of Management Studies Elective Courses.

*DEC - Departmental Elective Course
**MSC - Minor Specialization Course
***DHC - Departmental Honours Course

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List of Minor Specialization courses of Physics for other Departments

					Teaching Scheme (Hrs./Week)			
	Subject Code	Course Title	Semester in which the course is running	Subject area	Credits	L	T	P
1	PHN-207	Mechanics and Relativity	Autumn	DCC/MSC	4	3	1	0
2	PHN-211	Quantum Physics	Autumn	DCC/MSC	4	3	1	0
3	PHN-204	Atomic Molecular and Laser Physics	Spring	DCC/MSC	3	3	0	0
4	PHN-206	Elements of Condensed Matter Physics	Spring	DCC/MSC	3	3	0	0
5	PHN-208	Nuclear Physics and Applications	Spring	DCC/MSC	3	3	0	0
				Total	17	15	2	0

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Department Elective Courses DHC (B. Tech - Engineering Physics)

					Teaching Scheme (Hrs./Week)			
	Subject Code	Course Title	Semester in which the course is running	Subject area	Credits	L	T	P
1.	EEN-352	Digital Image Processing	III Year Autumn (Any One)	DEC	4	3	1	0
2.	PHN-321	Fabrication and Measurement Techniques	III Year Autumn (Any One)	DEC	4	2	0	4
3.	PHN-323	Radiation Detection and Measurements	III Year Autumn (Any One)	DEC	4	3	1	0
4.	PHN-325	Atmospheric Physics and Climate Dynamics	III Year Autumn (Any One)	DEC	4	3	1	0
5.	ECN-312	Principles of Digital Communication	III Year Spring (Any One)	DEC	4	3	1	0
6.	PHN-314	Nanotechnology	III Year Spring (Any One)	DEC	4	3	1	0
7.	PHN-316	Properties of Matter and Acoustics	III Year Spring (Any One)	DEC	4	3	0	2
8.	MAN-106	Data Structures	III Year Spring (Any One)	DEC	4	3	0	0
9.	ESN-401	Principles of Remote Sensing	IV Year Autumn (Any Two)	DEC	4	2	1	0
10.	PHN-425	Superconducting Materials	IV Year Autumn (Any Two)	DEC	4	3	1	0
11.	EEN-355	Digital Signal Processing	IV Year Autumn (Any Two)	DEC	4	3	1	2/2
12.	PHN-427	Optoelectronics	IV Year Autumn (Any Two)	DEC	4	3	1	0
13.	PHN-429	Nuclear Science & Engineering	IV Year Autumn (Any Two)	DEC	4	3	1	0
14.	PHN-431	Weather Forecasting	IV Year Autumn (Any Two)	DEC	4	3	1	0

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15.	BTN-466	Biophysics & its Applications	IV Year Spring (Any Two)	DEC	4	3	1	0
16.	PHN-418	Modern Particle Physics	IV Year Spring (Any Two)	DEC	4	3	1	0
17.	PHN-422	Emerging Phenomenon in Materials	IV Year Spring (Any Two)	DEC	4	3	1	0
18.	PHN-424	Quantum Information & Computing	IV Year Spring (Any Two)	DEC	4	3	1	0
19.	PHN-426	Space Technology	IV Year Spring (Any Two)	DEC	4	3	1	0
20.	PHN-428	Advanced Electroceramics Techno	IV Year Spring (Any Two)	DEC	4	3	1	0

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Department Honor Courses DHC (B. Tech - Engineering Physics)

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
Elective-Group-I (VI Semester: One paper to be chosen)														
1.	PHN-601	Advanced Condensed Matter Physics	DHC	4	3	1	0	3	0	25	0	25	50	0
2.	PHN-603	Advanced Atmospheric Physics	DHC	4	3	1	0	3	0	25	0	25	50	0
3.	PHN-605	Advanced Laser Physics	DHC	4	3	1	0	3	0	25	0	25	50	0
4.	PHN-607	Advanced Nuclear Physics	DHC	4	3	1	0	3	0	25	0	25	50	0
5.	PHN-639	Advanced Atomic and Molecular Physics	DHC	4	3	1	0	3	0	25	0	25	50	0
Elective- Group-II(VII Semester: One paper to be chosen)														
6.	PHN-609	Experiments in Condensed Matter Physics	DHC	3	0	0	6	3	0	0	50	0	0	50
7.	PHN-611	Experiments in Atmospheric Physics	DHC	3	0	0	6	3	0	0	50	0	0	50
8.	PHN-613	Experiments in Laser Physics	DHC	3	0	0	6	3	0	0	50	0	0	50
9.	PHN-615	Experiments in Nuclear Physics	DHC	3	0	0	6	3	0	0	50	0	0	50
Elective- Group-III (VII Semester: One paper to be chosen)														
10.	PHN-617	Advanced Characterization Techniques	DHC	3	3	0	0	3	0	25	0	25	50	0
11.	PHN-619	A Primer in Quantum Field Theory	DHC	3	3	0	0	3	0	25	0	25	50	0
12.	PHN-621	Astrophysics	DHC	3	3	0	0	3	0	25	0	25	50	0
13.	PHN-623	General Relativity	DHC	3	3	0	0	3	0	25	0	25	50	0
14.	PHN-625	Particle Physics	DHC	3	3	0	0	3	0	25	0	25	50	0
15.	PHN-627	Quantum Theory of Solids	DHC	3	3	0	0	3	0	25	0	25	50	0
16.	PHN-629	Weather Forecasting	DHC	3	3	0	0	3	0	25	0	25	50	0
17.	PHN-631	Nuclear Instrumentation	DHC	3	3	0	0	3	0	25	0	25	50	0
18.	PHN-633	Physics and Technology of Thin Films	DHC	3	3	0	0	3	0	25	0	25	50	0
19.	PHN-635	Advanced Nuclear reactions	DHC	3	3	0	0	3	0	25	0	25	50	0
20.	PHN-637	Semiconductor Photonics	DHC	3	3	0	0	3	0	25	0	25	50	0

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Elective- Group-IV (VIII Semester: Two papers to be chosen)

21.	PHN-602	Nuclear Astrophysics	DHC	3	3	0	0	3	0	25	0	25	50	0
22.	PHN-604	Physics of Nanosystems	DHC	3	3	0	0	3	0	25	0	25	50	0
23.	PHN-606	Superfluidity and Superconductivity	DHC	3	3	0	0	3	0	25	0	25	50	0
24.	PHN-608	Fiber and Nonlinear Optics	DHC	3	3	0	0	3	0	25	0	25	50	0
25.	PHN-610	Quantum Optics	DHC	3	3	0	0	3	0	25	0	25	50	0
26.	PHN-612	Advanced topics in Mathematical Physics	DHC	3	3	0	0	3	0	25	0	25	50	0
27.	PHN-614	Introduction to Superstring theory	DHC	3	3	0	0	3	0	25	0	25	50	0
28.	PHN-616	Advanced Electroceramics Technology	DHC	3	3	0	0	3	0	25	0	25	50	0
29.	PHN-618	Atomic and Molecular Collision Physics	DHC	3	3	0	0	3	0	25	0	25	50	0
30.	PHN-620	Advanced Quantum Field Theory	DHC	3	3	0	0	3	0	25	0	25	50	0
31.	PHN-622	Solar Terrestrial Physics	DHC	3	3	0	0	3	0	25	0	25	50	0
32.	PHN-624	Computational Nuclear Physics	DHC	3	3	0	0	3	0	25	0	25	50	0

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Appendix 'B'
Item No. Senate/60.8

Appendix-B

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **BTN-466** Course Title: **Biophysics and its applications**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: The objective is to teach the basics of structure-conformation-interactions in biological molecules with concepts of thermodynamics and total potential energy.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Amino acids, Polypeptide Chain Geometry and levels of protein structure, Alpha helix, beta sheets, beta turns, polyproline and collagen, dihedral angles, Ramachandran Map, Potential Energy function: nonbonded interactions, dipolar interactions and intrinsic torsional potential, conformational energy	6
2.	Hydrogen bonding, Hydrophobic and electrostatic interactions, disulfide bonds, molecular dynamics, protein architecture, helix to coil transitions, simple thermodynamic treatment, statistical method, Zipper model, Protein structure, function and folding: equilibrium studies, kinetics and bioenergetics	7
3.	Conformation of sugar, glycoside bond and backbone torsional angles, base pairing, base stacking, thermodynamic parameters, A, B & Z DNA, DNA triplex and quadruplex, transfer RNA, ligand interactions with nucleic acids, DNA melting, stacking-unstacking equilibrium, protein-nucleic acid interaction	6
4.	Polysaccharides, peptidoglycan in bacteria cell wall, glycoproteins, Micelles, Bilayer lipid membrane, membrane transport, Donnan effect, pH across membrane & membrane potential, structure, lateral diffusion and flip flop motion	3

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5.	Structure-conformation-interactions of proteins & nucleic acids by UV-Vis, infrared absorption, dynamic and static light scattering, Raman scattering, atomic absorption, fluorescence, FRET, fluorescence lifetime, circular dichroism spectroscopy. Thermodynamic techniques: isothermal titration calorimetry, differential scanning calorimetry, surface plasmon resonance, mass spectrometry. cryoelectron microscopy	7
6.	Crystallization. Lattices and unit cell, Point and Space Group Symmetry, X-ray diffraction and Bragg equation, scattering factor, structure factor expression, reciprocal lattice. Phase problem and methods for phase determination	6
7.	Nuclear magnetic resonance, chemical shift, spin-spin coupling Nuclear Overhauser effect, multi-dimensional NMR and structure determination, Cell/tissue NMR,metabolomics, Magnetic Resonance Imaging (MRI), Electron spin resonance, hyperfine splitting and applications.	7
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Van Holde K E, Johnson W C and Ho P S, "Principles of Physical Biochemistry", Prentice Hall	1998
2.	Cantor C R and Schimmel P R, "Biophysical Chemistry" Part I, II, and III, W H freeman & Co.	2008
3.	Glasel J A and Deutscher M P, "Introduction to Biophysical Methods for Protein and Nucleic Acid Research" 1st Ed, Academic Press	1995
4.	McPherson A, " Introduction to Macromolecular Crystallography", 2nd Ed, Wiley-Blackwell.	2009
5.	Drenth J, "Principles of Protein X-Ray Crystallography", 3rd Ed, Springer.	2007

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-101** Course Title: **Introduction to Polymer Engineering**
2. Contact Hours: L: **2** T: **0** P: **0**
3. Examination Duration (Hrs.): **Theory:2** **Practical:0**
4. Relative Weightage: **CWS :15** **PRS : 0** **MTE : 35** **ETE : 50** **PRE : 0**
5. Credits: **2** 6. Semester: **Spring** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**

9 Objective: To impart introductory knowledge of polymer engineering

10.Details of Course:

S. No.	Particulars	Contact Hours
1	**Introduction:** Types of polymers; Blends; Composites; Materials and applications of polymers	1
2	**Engineering Polymers:** Types of engineering polymers; Thermoplastics; Thermosets; Elastomers; Polyolefins; Polyethylene; Polypropylene	5
3	**High Performance Polymers:** Types of high performance polymers; Polyesters; Polycarbonate; Polyamide; Polyetherimides; Poly-amide-imide; High temperature; Resistant polymers; Lyotropic and thermotropic liquid crystal polymers	5
4	**Polymer Engineering**: Polymerization engineering; Polymer Processing; Additives; Polymer products; Processing; Introduction to rheology and various polymer processing techniques and equipments	6
5	**Polymeric Systems and Materials** Polymer blends; Polymer Composites; Rubbers and elastomers; Films and fibers; Bio; bio-degradable and bio-medical polymers and functional polymers	6
6	**Applications of Polymers:** Applications of polymers in commodity products as: Engineering materials in automobiles; Aerospace; Electronics; Medical and other applications; Conducting polymers	5
	Total	**28**

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11. Suggested Books

S. No.	Name of Authors / Books / Publisher	Year of Publication
1.	H. S. Kaufman, J. J. Falcetta, "Introduction to Polymer Science & Technology"' SPE Textbook, John Wiley & Sons	2010
2	D. J. Williams, "Polymer Science & Engineering", Prentice Hall, Inc.	2010
3.	V. R. Gowariker, N. V. Vishwanathan, Jaydev Sreedhar, "Polymer Science", New Age (I)	2011

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

1. Subject code: **CYN-009** Course Title: **Polymer 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: **Autumn** 7. Subject Area: **BSC**
8. Pre-requisite: **Nil**
9. Objective: To familiarize students with polymeric materials and its importance.
10. Details of the Course:

S. No.	Contents	Contact Hours
1.	**Polymeric materials:** Historical development of polymers, classification and nomenclature of polymers. Homopolymers, copolymers, block copolymers, polymer blends, inorganic polymers, and composites. Bio- and non-bio-degradable polymers. Soluble and insoluble polymers. Specialty of polymers in comparison to low molecular weight materials. Macromolecules *versus* polymers.	4
2.	**Polymer structures:** Linear, branched and cross-linked polymers. Polymer chain configuration, conformation and tacticity. Size of polymer chains and estimates of polymer chain size. Polymer chain interactions and cohesive energy density. Polymer chain polarity and its effect on physical properties of polymers–density, crystallinity and solubility.	6
3.	**Molecular weights and properties of polymers:** Molecular weight and degree of polymerization, weight average and number average molecular weight, sedimentation and viscosity average molecular weight, polydispersity and size of polymer molecule. Molecular weight dependence physical properties of polymers. Hydrodynamic radii of polymers and its relation with molecular weight of polymers. Amorphous polymers and crystalline polymers. Glass transition and melting temperatures. Degree of crystallinity and mesophase polymers.	8

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4.	**Polymerization methods:** Purity and polymerizability of monomers, common initiators, inhibitors and chain transfer agents used in polymerization, bulk polymerization and auto acceleration Solution polymerization and role of the solvent. Suspension and emulsion polymerization. Interfacial and phase transfer polymerization and its advantages. Effect of methods of polymerization on properties of the polymers.	10
5.	**Polymer reactions and mechanisms of polymerization:** Polymer chain hydrolysis, acidolysis, aminolysis and alcoholysis. Hydrogenation, addition, substitution, cyclization and chemical cross-linking reactions. Polymer chain functionality and gelation, physical and chemical degradation. Classification of polymerization reactions, free radical and ionic chain polymerization, addition and step growth polymerization, coordination polymerization, Zeigler-Natta catalysis and polymer chain tacticity.	8
6.	**Commercial polymers and their applications:** Polyethylene, high and low density polyethylene, ultrahigh molecular weight polyethylenes, polycarbonates, nylons, amino and epoxy based resins and their commercial importance, thermosetting and thermoplastic polymers and their applications.	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/ Publisher	Year of Publication/ Reprint
1	Flory, P.J., "Principles of Polymer Chemistry", Cornell University Press, Ithaca, New York.	1953
2	Fried, J.R., "Polymer Science and Technology", Prentice Hall , U. K.	2002
3	Odean, G., Principles of Polymerization, 4th Edition, John Wiley & Sons, New Jersey	2004
4	Young R.J., Lovell, P.A., "Introduction to Polymers" 3rd Edition, CRC Press, Taylor and Francis Group	2011
5	Carraher, Jr C.E. "Introduction to Polymer Chemistry" 3rd Edition CRC Press, Taylor & Francis group.	2012

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF PROGRAM : POLYMER SCIENCE AND ENGINEERING

1. Subject Code: **PEN-103** Course Title: **Computer Programming and Numerical Analysis**
2. Contact Hours: L: 3 T: 0 P: 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: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**

9 Objective: To introduce object oriented programming using C++ language and numerical analysis

10.Details of Course:

S.No.	Contents	Contact Hours
1	**Basic orientation:** Number representation, Fixed and Floating point numbers, Errors and Approximations	4
2	**Object Oriented Programming:** Introduction to C++, Tokens, Expressions and Control Structures, Functions, Classes and Objects, Constructors and Destructions, Operator Overloading and Type Conversions, Inheritance; extending classes, Pointers, Virtual Functions and Polymorphism, Managing Console I/O Operations, Working with Files, Manipulating Strings	16
3	**Solutions of linear equations:** Direct Methods such as Gaussian Elimination with and without pivoting, LU decomposition, Thomas algorithm for tri-diagonal systems and Iterative Methods such as Jacobi Method, Gauss-Seidel Method	4
4	**Solution of non-linear equation:** single variable using Bisection Method, Secant method, Regula-Falsi, Muller Method and Newton-Raphson method, Application of Newton-Raphson to two variables	4
5	**Numerical interpolation:** Difference tables, forward, central and backward difference interpolation, Interpolating polynomials	3
6	**Numerical differentiation:** Differentiation formulas	2

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7.	**Numerical integration:** Trapezoidal rule, Simpson's rule, weddle rule, Gaussian Quadrature	2
8.	**Solution of ordinary differntial equations:** Initial value problems (IVPs), Euler Method, Runge-Kuktta method	4
9.	**Finite difference method**	3
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication
1.	Balaguruswamy, E, "Object Oriented Programming with C++, Tata McGraw Hill Education, 5th Edition	2011
2	Lafore, R., "Object Oriented Programming with C++, Pearson, 4th Edition	2008
3.	Sastry, S.S., "Introductory Methods of Numerical Analysis", PHI Learning, 5th Edition	2012
4.	Hoffmann, J.D., "Numerical Method for Engineers and Scientists", Marcel Dekker Inc., 2nd Edition	2001
5.	Chapra, S.C., "Applied Numerical Methods with MATLAB for Engineers and Scientists. Tata McGraw Hill Education, 3rd Edition	2012
6.	Burden, R.L. and Faires, J.D., "Numerical Analysis", Cenage Learning, 9th Edition	2011

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CHN-102** Course Title: **Material and Energy Balance**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination 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 provide basic knowledge of principles of material and energy balances applied to chemical engineering systems.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Units and dimension in chemical engineering, units conversion of dimensional equations, stoichiometric and composition relations, concept of degrees of freedom and linear independence of a set of equations.	5
2.	**Material Balance:** Concept of material balance, open and closed systems, steady state and unsteady state, multiple component system, selection of a basis, problem solving strategy.	4
3.	**Material Balance without Chemical Reaction for Single and Multiple Units:** Conservation of mass/atom, material balance for systems without chemical reactions involving single unit and multiple units.	5
4.	**Material Balance with Chemical Reaction for Single and Multiple Units:** Concept of excess reactant, extent of reaction, material balance for systems with chemical reactions involving single unit and multiple units.	6
5.	**Recycle, Bypass, Purge and Industrial Applications:** Calculations for a cyclic processes involving recycle/ purge/ bypass, material balances involving gases, vapors, liquids and solids and use of real gas relationships, material balance involving gases, vapors, liquids & solids and uses of real gas relationships, vapor-liquid equilibrium and concepts of	7

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	humidity & saturation, analysis of systems with bypass, recycle and purge, analysis of processes involving condensation, crystallization and vaporization.	
6.	**Energy Balance:** Conservation of energy with reference to general energy balance with and without chemical reactions, chemical engineering problems involving reversible processes and mechanical energy balance.	4
7.	**Applications of Energy Balance:** Calculations of heat of change of phase (solid – liquid & liqid – vapor), heat of reaction, heat of combustion, heat of solutions and mixing, determination of temperatures for adiabatic and non-adiabatic reactions, use of psychometric and enthalpy- concentration diagrams.	6
8.	**Simultaneous Material and Energy Balances:** Degrees of freedom analysis for multicomponent systems, combined steady state material and energy balances for units with multiple sub-systems.	3
9.	**Unsteady State Material and Energy Balances:** Transient materials and energy balances involving with and without chemical reactions.	2
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Himmelblau D.M. and Riggs J. B.," Principles and Calculations in Chemical Engineering", 8th Ed., Prentice Hall of India.	2012
2.	Felder R.M. and Rousseau R.W., "Elementary Principles of Chemical Processes", 3rd Ed.., John Wiley.	2005
3.	Bhatt B.I. and Vora S.M., "Stoichiometry", 5th Ed., Tata McGraw-Hill	2010
4.	Narayanan K.V. and Lakshmikutty B., "Stoichiometry and Process Calculations", Prentice Hall of India.	2006
5.	Hougen D.A., Watson K.M. and Ragatz R.A., "Chemical Process Principles", Part-I, 2nd Ed., CBS Publishers.	1995

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CHN-106** Course Title: **Thermodynamics and Chemical Kinetics**

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

3. Examination 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 provide basic knowledge of thermodynamics and chemical kinetics to chemical engineering students.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Thermodynamic system, surroundings, state, process, properties, equilibrium, heat and work.	02
2.	**Properties of Pure Simple Compressible Substance:** P-V-T surface, P-V, T-V and T-P diagrams. Equations of state for ideal and real gases. Virial equation of state, van der Waals and Redlich-Kwong equations of state; Use of Thermodynamic tables.	06
3.	**First Law of Thermodynamics:** Energy balance for closed systems. Various forms of energy balance. Specific heat, internal energy, enthalpy, and specific heat of ideal gases. Application of first law to non-flow isochoric, isobaric, isothermal, and adiabatic and polytropic processes. Conservation of mass for a control volume, mass and volume flow rates, mass balance for steady flow processes, flow work, steady flow energy equation. Application to various practical systems viz. nozzles, diffusers, etc. Transient Analysis.	05
4.	**Second Law of Thermodynamics:** Second law, reversible and irreversible processes, Clausius and Kelvin Planck statements. Carnot cycle, Clausius inequality, entropy as a property, principle of increase of entropy. Calculation of entropy change.	06
5.	**Thermodynamic Cycles:** Otto, Diesel, Rankine cycles and their applications.	03
6.	**Rate Expression and Reaction Mechanism:** Use of pseudo steady state approximation to get rate expression from mechanism, temperature-dependence of reaction rate-collision theory, transition state theory, thermodynamics and Arrhenius law.	04

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7.	**Interpretation of Kinetic Data of Batch Reactors:** Constant volume and variable volume batch reactions, Integral and differential methods of analysis of data of uni, bi and tri-molecular irreversible reactions. Reversible reactions, homogeneously catalysed, auto-catalysed, series and parallel reactions. Estimation of rate constants and its temperature-dependence.	08
8.	**Solid-Catalysed Fluid Reactions:** Characterization of catalyst, Physical and chemical adsorption, various reaction steps, Langmuir-Hinshelwood kinetics.	04
9.	**Kinetics of Bio-Chemical Reactions:** Kinetics of enzyme catalysed reactions, substrate and product inhibition, effect of temperature and pH on enzyme catalysed reactions.	04
	Total	**42**

11. Suggested Books:

S. No.	**Name of Books / Authors**	**Year of Publication**
1.	Çengel Y.A. and Boles M.A., "Thermodynamics: An Engineering Approach", 6th Ed., McGraw Hill.	2008
2.	Smith J.M., Van Ness H.C. and Abbott M.M., "Introduction to Chemical Engineering Thermodynamics", 7th Ed., McGraw Hill.	2005
3.	Borgnakke C. and Sonntag R.E., "Fundamentals of Thermodynamics", 7th Ed., John Wiley and Sons.	2009
4.	Levenspiel O., "Chemical Reaction Engineering", 3rd Ed., John Wiley.	2000
5.	Fogler H.S., "Elements of Chemical Reaction Engg.", 4th Ed., Prentice Hall of India.	2005

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Appendix 'D'
Item No. Senate/60.10

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PP-915** Course Title: **Polymer Nanocomposites**

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

3. Examination 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: **Pre-PhD course**

8. Prerequisite : **Nil**

9. Objective: To impart knowledge of Nanotechnology application in polymers industry.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Advancement of nanocomposite, nanofillers, classification of nanofillers, nanoclay, nanosilica, nanoparticles, carbon based nanofillers- synthesis and properties of fillers.	5
2.	**Properties of Various Polymer Nanocomposites**: Nanotube/polymer composites, layered filler polymer composite processing- polyamide matrices, polyimide matrices, polypropylene and polyethylene matrices, liquid-crystal matrices, epoxy and polyurethane matrices, rubber matrices.	7
3.	**Synthesis of Nanocomposites**: Direct mixing, solution mixing, in-situ polymerization, in-situ particle processing ceramic/polymer composites, in-situ particle processing metal/polymer nanocomposites, modification of interfaces, modification of nanotubes, modification of nanoparticles	7
4.	**Mechanical Properties of Nanocomposites**: Mechanical Properties, Modulus and the Load-Carrying Capability of Nanofillers, Failure Stress and Strain Toughness, Glass Transition and Relaxation Behavior, Abrasion and Wear Resistance,	4
5.	**Thermal and Optical Properties of Nanocomposites**: Thermal stability and flammability, electrical and optical properties, resistivity, permittivity, and breakdown strength, refractive index, light-emitting devices	3

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6.	**Biodegradable Polymer Nanocomposites:** properties, biodegradability, foam processing of biodegradable nanocomposites. nanocomposites based on water soluble polymers, crystallization behavior, overview of nanocomposite structure and crystallization behavior	6
7.	**Nanocomposites Containing Functionalized Nanoparticles**: Organic and polymer materials for light-emitting diodes, luminescent polymer for device applications, photo-oxidation of emitting polymers, nanoparticles approaches to enhance the lifetime of emitting polymers	5
8.	**Barrier Properties of Polymer Nanocomposites:** Permeation and diffusion models relevant to polymer nanocomposites, polymer nanocomposites diffusivity, polymer nanocomposites sorption, polymer nanocomposites permeability, wear resisting polymer nanocomposites: preparation and properties, surface treatment, composites manufacturing, wear performance and mechanisms.	5
	Total	**42**

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, USA.	2006
2.	Ajayan PM, Schadler LS, Braun PV, "Nanocomposite Science and Technology" Wiley-VCH Verlag GmbH Co. KGaA, Weinheim.	2003
3.	Nicolais L, Carotenuto G, "Metal-Polymer Nanocomposites" Willy Inter Science	2005
4.	Sergeev GB, "Nanochemistry", Elsevier	2006
5.	Ke YC, Stroeve P, "Polymer-Layered Silicate And Silica Nanocomposites", Elsevier	2005

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. / CENTRE : DEPARTMENT OF PHYSICS

1. Subject Code: **PH-920** Course Title: **Quark Gluon Plasma & Finite Temperature Field Theory**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory : 3** **Practical : 0**
4. Relative Weightage: **CWS :25** **PRS : 0** **MTE : 25** **ETE : 50** **PRE : 0**
5. Credits: **4** 6. Semester: **Autumn/Spring** 7. Subject Area: **Pre-PhD Course**
8. Pre-requisite: **Nil**
9. Objective: To provide basic training to solve advanced problems in QCD at finite temperature
10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Introduction to Quark Gluon Plasma:** Lattice QCD, Hydrodynamics, Jet Quenching, Signatures of QGP	4
2.	**Imaginary and real-time formalism** Matsubara Formalism, Matsubara Frequencies, Closed Time Path Formalism, Propagators, Matrix Structure for Propagators, One Loop Propagators.	8
3.	**Thermo fields Dynamics** General Formalism, Fermionic Oscillator, Bosonic Oscillator, Free Schrodinger Field Theory, Free Klein Gordon Theory, KMS Condition, Dispersion Relations, Goldstone Theorem	8
4.	**Gauge Theories and cutting rules** Gauge Theories at Zero Temperature, BRST Invariance, Ward Identities, Unitarity, Fermionic boundary conditions, Partition function, Ward Identities at $T \neq 0$, Cutting Rules at zero Temperature.	8
5.	**Symmetry Breaking** Global Symmetry, Local Symmetry, Effective potential, One loop potential, Symmetry Restoration, Dynamical Symmetry Breaking, Gauge Problem, Identities at T=0, Verification of identities at $T \neq 0$.	4
6.	**Resummation in Finite Temperature field Theories:** Hard thermal loop perturbation theory and its application in QCD at finite temperature.	10
	Total	**42**

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11. Suggested Books:

S. No	Name of Books/Authors	Year of Publication/ Reprint
1.	Ashok Das, "Finite Temperature Field Theory", World Scientific, Singapore	1997
2.	L S Brown, "Quantum Field Theory", Cambridge University Press	1999
3.	Monographs on mathematical physics by Joseph Kapusta and Charles Gale, "Finite-temperature field theory", (2nd Ed.), Cambridge University Press	2004
4.	Edited By Rudolph C. Hwa (Univ. Of Oregon, USA), & Xin-Nian Wang (Lawrence Berkeley National Lab.), "Quark Gluon Plasma 4", World Scientific, Singapore	2010

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PH-905** Course Title: **Green's Functions and Many Particle 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** **MTE:50** **ETE:0**

5. Credits: **4** 6. Semester: **Autumn/Spring** 7. Subject Area: **Pre-PhD Course**

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge and applications of Condensed Matter Physics and to nurture the student(s) for handling the related problems.

10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Lattice Dynamics:** Harmonic approximation, Concept of central and non-central forces in one and three dimensions, Normal modes, Dynamical matrix for square, b.c.c and f.c.c. lattices.	8
2	**Quantum theory of Lattice Vibrations:** Quantization of phonon modes. Density of States in three and low dimensional systems.	8
3	**Footprints of Anharmonic Approximation**: The need of anharmonic theories, Anharmonic Hamiltonian for Phonons and electrons, Quantum dynamics of phonons.	8
4	**Green's function theory**: Elementary ideas of Green's functions, Zubarev, Matsubara Green's functions, Correlation functions, Spectral Density.	8
5	**Green's functions for Many particle systems:** Development of Green's functions for phonons and electrons, Dyson's equation approach, Widths and shifts of phonons and electrons.	10
	Total	**42**

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11. Suggested Books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/ Reprint
1	G.D. Mahan: Many Particle Physics, Plenum. :Quantum Mechanics in Nut Shell, Princeton Univ. Press	2000 2009
2	A. A. Maradudin, R. F. Wallis, I. P. Ipatova , Theory of Harmonic Approximation, Academic Press.	1975
3.	A. A. Maradudin and G. K. Horton: Dynamical Theory of Crystal Lattices, North Holland.	1980
4.	M.Born, K. Huang: Dynamical Theory of Crystal Lattices, Oxford Univ. Press	1954
5.	J.M. Ziman: Electrons and Phonons, Clarendon Press	1960

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

1. Subject Code: **MA-911** Course Title: **Sobolev Spaces 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: **Autumn/Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Functional Analysis and Partial Differential Equations**

9. Objective: To introduce some basic concepts of Sobolev spaces which are further used in theory of partial differential equations.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Sobolev Spaces:** Introduction to distributions, Definitions and Elementary Properties, Approximation by Smooth Functions, Extension Theorems, Imbedding Theorems, Compactness Theorems, Dual Spaces, Fractional Order Spaces and Trace Spaces, Trace Theory	10
2.	**Weak Solutions to Elliptic Boundary Value Problems:** Existence of Weak Solutions, Regularity, Galerkin Method, Maximum Principle, Eigenvalue Problems	10
3.	**Semigroups and Applications**: Unbounded Linear Operators, C_0 – Semigroups, The Hille Yosida Theorem, Contraction Semigroups on Hilbert Spaces, Heat Equation, Wave Equation, Schrodinger Equation, Inhomogeneous Equation	12
4.	**Some Techniques from Nonlinear Analysis:** Fixed Point Theorems, Galerkin Method, Monotone Iterations, Variational Methods, Pohozaev's Identity for Non-existence of solutions	10
	Total	**42**

11. Suggested References/Books:

S.No.	Title/Authors/Publishers	Year of Publication
1.	Evans, L. C., "*Partial Differential Equations*", American Mathematical Society (2nd Ed.)	2014
2.	Kesavan, J., "*Topics in Functional Analysis and Applications*", New Age International Publishers	2008
3.	Pazy, A., "*Semigroups of Linear Operators and Applications to Partial Differential Equations*", Springer-Verlag, (2nd Ed.)	1983
4.	Lions, J. L. and Magenes, E., "*Non-Homogeneous Boundary Value Problems and Applications*", Vol. I, Springer-Verlag	1972
5.	Adams, R. A., "*Sobolev Spaces*", Academic Press	1975

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-303** Course Title: **Papermaking-II**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory:3** **Practical :0**
4. Relative Weightage: **CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**
5. Credits:**4** 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge of wet pressing and the drying end of paper machine.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Wet Pressing:** Press section, mechanism of pressing, types of presses, operating variables, press felt characteristics; Common paper defects originated in press sections; Hot pressing.	4
2.	**Drying:** Drying theory, conventional cylinder dryers and their modifications, material of construction, steam and condensate handling systems, control of condensate removal systems, hoods and hood exhaust, calculations on drying rates, heat and mass transfer in drying and ventilation systems; Dryer section runnability; Effect of drying parameters on sheet properties; Convective drying, Flakt and infrared drying.	11
3.	**Surface Sizing:** Surface sizing chemicals, size press configurations, modified size press designs, alternatives to the size press.	2
4.	**Yankee Dryers:** Design and construction, steam and condensate handling; Tissue creping.	2
5.	**Calendering and Supercalendering:** Operating variables for calender stacks, sheet variables, supercalenders, gloss calenders, soft calenders, anti-deflection rolls, crowning of rolls.	4
6.	**Winding:** Winding theory, types of winders, roll structure control, slitting operation, roll defects, paper defects.	3
7.	**Broke Systems:** Broke system design and control for different	2

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	types of broke.	
8.	**Cross-Direction Control:** Benefits of improved CD uniformity, online measurement, CD control of grammage, moisture, caliper, and smoothness.	2
9.	**Paper Machine Showers and Doctors:** Showers, shower application, doctors and their applications, installation and maintenance.	2
10.	**Drives:** Types of drives and regulators, power requirements for different sections of paper machine.	2
11.	**Paper Machine Vacuum Systems:** Vacuum generating equipment, vacuum requirement of different sections, vacuum piping design.	3
12.	**Paper Machine Clothing:** Selection of forming, press, and dryer fabrics.	2
13.	**Paper Machine Corrosion, Vibrations and Safety:** Corrosion in paper machine, corrective measures, material selection; Machine vibrations, measurement and control; General practices for operation, maintenance and safety.	3
	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 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.	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
5.	Kocurek M. J., "Pulp and Paper Manufacture, Volume 7: Paper Machine Operations (Ed. Thorp B.)", TAPPI Press.	1991

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-305** Course Title: **Process Instrumentation & 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: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of measurement of process variables, smart sensors, dynamics of process, controllers concepts and their applications to process industries.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Introduction:** Importance of instrumentation in process industries; block diagram; Transducers, their classification and selection criteria; on and offline measurements. Smart and Intelligent sensors and its application.	4
2.	**Static Characteristics of Instruments:** Accuracy, precision, sensitivity, reproducibility, drift, threshold, hysteresis, resolution, repeatability, stability, linearity, span and range, live zero, and errors with examples.	3
3	**Process Parameters and Measurement:** Working principles for the measurement of flow, level, pressure, temperature using mechanical, electrical, ultrasonic methods and their advantages and disadvantages of these measurement methods with reference to process parameters.	10
4.	**Signal Conditioning** and **Output Devices:** Analog and digital signal conditioning units used in measurement systems; display devices, electro-pneumatic converters and pneumatic control valves.	6
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, and PID controllers; feed-forward, feedback, cascade and ratio control systems.	6

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6.	**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.	7
7.	**Applications in Process Industry:** Concept of instrumentation and piping diagram, instrument and control diagram of reactor, heat exchanger, distillation column, mixing & agitator systems.	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.	Coughanour Dnald.R., 3rd Ed., "Process System Analysis and Control", McGraw Hill.	2010
3.	Eckman D.P., "Industrial Instrumentation", John Wiley.	2006
4.	C.D. Johnson, *Process Control Instrumentation Technology*, Prentice Hall of India, 3rd ed., New Delhi, ISBN No: 0137-14783X.	1993
5.	Ghosh A.K., "Introduction to Instrumentation and Control", 4th Ed., Prentice Hall of India.	2005

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-311** Course Title: **Process Utilities and Cogeneration**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination 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: **MIN-101**
9. Objective: To impart knowledge about generation and utilization of steam and power, and other utilities in process industries.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Utilities in process industries and their importance.	2
2.	**Heat Transfer Media:** Classification, characteristic properties, selection criteria for their industrial applications; P V T surfaces for steam, thermodynamic diagrams, quality of steam.	4
3.	**Energy Resources:** Conventional and non-conventional energy sources; Industrial uses of coal, petroleum, gas, biofuel, and hydro-power; Combustion calculations.	4
4.	**Water:** Raw water and its characteristics, treatment and conditioning for use in process industries, recycling and reuse of water.	4
5.	**Steam Generation and Utilization:** Types of boilers, working principles of boilers, boiler mountings and accessories, draught, efficiency of boilers; Steam and condensate handling, steam traps, condensate and flash steam utilization, safety measures.	7
6.	**Air:** Use of air in process industries for conveying, drying and instrumentation; Air compressors and other air handling equipment; Calculation of power requirement.	4
7.	**Power Cycles:** Steam and gas power cycles, Carnot cycle, Rankine cycle, reheat cycle, regenerative cycle, binary vapor cycle, dual and Brayton cycles.	4
8.	**Turbines:** Extraction turbines, fully condensing turbines, steam nozzles, velocity diagrams; Condensers; Gas turbines.	9

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9.	**Cogeneration:** Principles and applications in process industries; Economics of cogeneration.	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Boyce M.P., "Handbook of Cogeneration and Combined Cycle Power", ASME Press.	2002
	Brown R.N., "Compressors Selection and Sizing" 3rd Ed., Elsevier.	2005
2.	Goodall P.M., "The Efficient Use of Steam", Westbury House.	1980
3.	Guyer E.C. and Brownell D.L., "Handbook of Applied Thermal Design", Taylor and Francis.	1999
4.	Nunn R.G., "Water Treatment Essentials for Boiler Plant Operation", McGraw Hill Professional.	1996
5.	Somasundaram S.L, "Thermal Engineering", New Age International	1996
6.	Zemansky M.W and Dittman R.H, "Heat and Thermodynamics", Tata McGraw Hill.	2007

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-313** Course Title: **Industrial Piping**

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

3. Examination 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 for design and selection of pipe lines and piping networks in process industries.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Flow of Fluids:** Frictional loss in pipes, ducts and fittings; Carrying capacity of pipes; Pressure drop and diameter calculations for flow of steam, water, oil and gases.	6
2.	**Vapour-Liquid Piping:** Flow patterns; Piping design for two-phase flow; Design of piping for reboiler and condenser systems.	4
3.	**Hydraulic Transport:** Design of pipes for transport of slurries; Correlations for various flow regimes.	6
4.	**Pneumatic Transport:** Conveying systems; Solid-gas flow patterns in vertical, horizontal and inclined pipe lines; Concept of saltation and choking velocities; Pressure drop calculations in different pipe lines carrying gas solid mixture; Design of feeding systems for pneumatic transport of solids.	8
5.	**Network Design:** Optimum pipe line diameter calculations and optimum pipe network design; Nominal pipe size, schedule numbers; Piping layout considerations, elements of supporting systems, fixtures and pipe attachments, color codes.	8
6.	**Materials of Construction:** Stable and unstable deformation, plasticity, plastic instability, design assumptions, stress evaluation and design limits; Codes and standards; Local components of pipe bends, branch connections and bolted flange connections; Introduction to piping vibration, its prevention and control.	6

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7.	**Simplified Methods for Flexibility Analysis:** Thermal expansion loops, code rules, approximate solutions and flexibility analysis by model tests, approaches to reducing expansion effects, expansions joints.	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Boterman R. and Smith P., "Advanced Piping Design", Gulf Publishing.	2008
2.	Deutsch D.J. "Process Piping Systems", McGraw Hill.	1980
3.	Marcus R.D., Leung L.S., Klinzing G.E. and Rizk F., "Pneumatic Conveying of Solids", Chapman and Hall.	1990
4.	Nayyar M.L., "Piping Handbook", 7th Ed., McGraw Hill.	2000
5.	Shook C.A. and Roco M.C. "Slurry Flow; Principles and Practice", Butterworth Heinemann.	1991
6.	Smith P., "The Fundamentals of Piping Design: Drafting and Design Methods for Process Applications", Gulf Publishing.	2007

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-301** Course Title: **Polymer Product Technology**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory:3** **Practical:0**
4. Relative Weightage: **CWS : 25** **PRS : 0** **MTE : 25** **ETE : 50** **PRE : 0**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective : To impart knowledge of design, manufacturing and applications of polymer products
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Material Selection**: Principles governing selection of a polymer for an engineering product, mechanical, thermal, and environmental properties influencing polymer product.	4
2.	**Additives:** Fillers, plasticizers, softeners, lubricants, antioxidents, stabilizers, flame retardants, colorants, processing agents.	7
3.	**Product Design:** Concept, analysis, loads, performance influencing factors and features, examples of engineered products, versatility.	6
4.	**Product Manufacturing:** Selecting manufacturing process with reference to end use application.	5
5.	**Product Defects:** Adverse effects of additives and contaminants, voids, blisters, surface defects.	5
6.	**Environmental Effects:** Weathering, ageing, radiation influences, stress cracking, discoloration.	5
7.	**Limitations and Degradation:** Chemical, hydrolytic, thermal, oxidative, environmental, and other degradations, ageing, adverse effects of additives, odor, tainting, out gassing.	5
8.	**Testing and Applications:** Testing, quality, applications, uses, performance and failure of polymer products.	5
	Total	**42**

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11. Suggested Books

S. No.	Name of Authors / Books / Publisher	Year of Publication
1.	Cherminisoff N., "Product Design and Testing of Polymeric Materials", Marcel Dekker.	1990
2.	Gordon Jr J., "Industrial Design of Plastic Products", John Wiley and Sons.	2003
3.	Schiers J., "Compositional and Failure Analysis of Polymers".	2000

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-303** Course Title: **Polymerization 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: **PCC**
8. Pre-requisite: **PE-254**
9. Objective: To impart knowledge of application of reactionengineering for polymer production.
10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Mechanism and Kinetics of Polymerization:** Kinetics of A_2+B_2, ARB type condensation polymerization; violation of equal reactivity hypothesis, cyclization, MWD of free radical polymerization, cationic, anionic polymerization.	06
2.	**Reaction Engineering of Step Growth Polymerization:** MWD of ARB polymerization in HCSTR, advanced stage of polymerization, similarity solution of step growth polymerization.	04
3.	**Reaction Engineering of Chain Growth Polymerization:** MWD for chain growth polymerization in PFR, solution of equations describing isothermal radical polymerization.	04
4.	**Heterogeneous Polymerizationprinciples, Engineering:** Industrial examples and simulation of emulsion, dispersion (Fitch theory), pearl or bead polymerization, solution and Ziegler nattapolymerization	08
5.	**Copolymerization:** Reaction engineering of copolymerization, sequence length A2+B2+C2 step wise polymerization, sequence length distribution of free radical copolymerization.	06
6.	**Nonlinear Polymerization:** Paradigm of pregel and postgel regime in homopolymerization, postgel description of other systems, critical gelation theorem, long chain branching	06
7.	**Polymerization Reactor Design:** Homogeneous continuous stirred tank reactor, segregated stirred tank reactor, tubular reactor, reactive extrusion, semibatch or multistep reactors, Denbigh rules on RTD and effect MW on RTD.	08
	Total	**42**

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11. Suggested Books:

S.No.	Name of Authors / Books / Publisher	Year of Publication
1.	Beisenberger J. A. and Sebastian D.H.; "Principles of Polymerization Engineering", John Wiley& Sons.	1983
2.	Odian G., "Principles of Polymerization", John Wiley & Sons.	2002
3.	Anil Kumar and S. K. Gupta, "Fundamentals of Polymer Science & Engineering", TATA McGraw Hill	1978
4.	Gupta S.K. and Kumar A., "Reaction Engineering of Step Growth Polymerization", Plennum.	1987
5.	Doston, N. R., Tirrell, M., Galvan, R., and Laurence, R. L. " Polymerization Process modeling" VCH Publishers, Munich	1996
6.	Billmayer, F. W., Text Bookof Polymer Science 3rd Edition, Willey Inter Science, New York, 1984.	1986

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Department of Polymer & Process Engg

1. Subject Code: PEN-305 Course Title: Polymer Processing

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: ? 7. Subject Area: PCC

8. Pre-requisite: Nil

9. Objective : To impart knowledge of polymer processing and product technology and equipment.

10. Details of the Course:

S.No.	Contents	Contact Hours
1.	**Handling, Transportation and Mixing:** Agglomeration, bins, hoppers, compaction, flow, melting, heat source, sintering; Effects of drag, pressure and deformation; pumps and their types; Mixing equipment, characterization and distribution; Devolatalization equipment, mechanism and principles.	4
2.	**Compounding & Mixing and Extruders:** Methods and mechanisms of mixing and compounding; intensive dry-, batch-, internal- blade and high speed mixers, general features constructional features of dies, mechanism of screw extrusion, effects of screw and die design, breaker and screeches and quality of extrudates of single and twin screw extruders.	8
3.	**Extrusion and Reactive Processing:** Principles of reactive extrusion, reactor classification, mixing of multicomponents miscible, immiscible and compatible systems.	3
4.	**Mixers and Kneaders:** Operating principles of modern machines for continuous mixer, two roll mill & palletizers, underwater pelletizer, screw mixers, kneading and granulating equipment.	3
5.	**Injection Molding:** Working principles of injection molding machine, temperature control, injection systems, starting and shut down procedures, process variables reaction injection molding.	6
6	**Blow Molding, Compression and Transfer Moulding:** Machine descriptions, principles of operations, molding parameters, optimization of processing parameters and troubleshooting, common faults and their correction for blow molding, compression moulding and transfer moulding.	7
6.	**Miscellaneous Processing Technologies:** Principles and operations of casting, thermoforming, rotational molding and foam processing machines and processing of plastic products by these processes.	3

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7.	**Calendaring:** Introduction, calendaring, calendar roll temperature control, calendar configuration and operations, roll deflection and methods of correction.	2
8.	Tooling & Molds Tool making processes, die and die forming, equipment and methods materials for mold making, designing and drafting practice, design details for compression molds, transfer molds, blow and extrusion dies, typical exercises in mold design and production, two plate mold, three plate mold, hot runner mold, insulated runner mold, runners, gates, mold making, mold cooling.	5
	Total	**42**

List of Practicals:

1. Processing of polymer by mini mixer rheocord.
2. Handling, transportation, mixing and pumping in a single screw extruder.
3. Compounding a polymer in a single screw extruder.
4. Processing a polymer in an internal / batch mixer.
5. Processing, compounding and mixing a polymer in a twin screw extruder.
6. Product development by injection moulding
7. Product development by compression moulding

11. Suggested Books:

S.No.	**Name of Authors / Books / Publisher**	**Year of Publication**
1.	Chan R., Hassen P. and Kramer E., "Processing of Polymers", Wiley-VCH	1996
2.	Griskey R., "Polymer Process Engineering", Chapman & Hall	1992
3.	Grulke E., "Introduction to Polymer Process Engineering", Printice Hall.	1993
4.	McCrum N.G., "Principles of Polymer Engineering", Oxford University Press	1988
5.	Osswald T., "Polymer Processing Fundamentals", Hanser-Gardner	1998
6.	Tadmor Z. and Gogos C.G., "Principles of Polymer Processing", Wiley.	2000

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-311** Course Title: **Polymer Composites**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of structure, properties and applications of polymeric composites.

10. Details of the Course:

S. No.	Contents	Contact Hours
1	**Introduction**: Need to reinforce polymers, particulate, short and continuous fiber reinforced composites based on thermoplastic and thermoset matrices.	2
2.	**Particle/Polymer Composites**: Various particulate reinforcements including, mineral, metallic natural and organic, processing of particle reinforced polymer composite, interfacial adhesion of reinforcing particle and polymer in composite, structure and morphology of particulate polymeric composites, semi-empirical equations, mechanics and mechanical properties of the composites, thermal properties of particle/polymer composite, applications	7
3	**Short Fiber/ Polymer Composite**: Short reinforcing fibers: natural and synthetic, mixing short/fibre by extrusion and compounding, processing, and injection moulding of the composite products, structure and morphology of short fiber/polymer composites, semi-empirical equations mechanics and mechanical properties of short fiber/polymer composites, thermal and physical properties of short fiber/polymer composites, applications in automobiles, building materials, and other engineering sectors.	7
4.	**Continuous Fiber/Polymer Composites:** Thermosets including epoxy, and polyesters as matrix polymers, and reinforcing fibres for continuous fibre / thermoset composites, processing of continuous fibre / thermoset by wet pay up, contact molding and pressure bag molding, resin transfer molding and compression molding, properties and applications, continuous fibre/thermoplastic composites, engineering thermoplastics based matrix resins and reinforcing fibres for composites; processing limitations, properties and applications.	9
5	**Polymeric Nano Composites:** Introduction, nano particles, and nano fibres for composites, nano tubes and nano fibres, processing, structure and properties of polymeric nano composites.	3
	Total	**28**

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List of Practical:

1. Extrusion & compounding of a short-fiber / thermoplastic polymer composite by mini mixer / extruder
2. Injection moulding of extruded short-fiber / thermoplastic polymer composite
3. Study of effect of fibre content on tensile properties of short-fiber / thermoplastic polymer composite.
4. Study of effect of fibre content on flexural properties of short-fiber / thermoplastic polymer composite.
5. Study of effect of fibre content on thermal properties of short-fiber / thermoplastic polymer composite.
6. Processing of continuous fibre / thermoset polymer composite by compression moulding
7. Effect of fibre content on mechanical properties of continuous fibre / thermoset polymer composite

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication
1.	Agarwal L. and Bourtman D.J., "Analysis and Performance of Fiber Composites", Wiley.	2000
2	Chung C., "Introduction to Composites", Technomic, Lancaster, PA.	1998
3.	White J. and De S., "Short Fiber Composites", Technomic, Lancaster.	1996
4.	Summerscales J. and Short D., "Fiber Reinforced Polymers", Technomic.	1988

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

1. Subject Code: **PEN-313** Course Title: **Polymeric Film Technology**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs.): **Theory:3 Practical:0**
4. Relative Weightage: **CWS:25 PRS:0 MTE :25 ETE:50 PRE:0**
5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PEC**
8. Pre-requisite: **PPN-451**
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.	6
2.	**Film Blower:** Principle, technology and operation of equipment for processing of blown film, structure and properties of blown films.	8
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.	8
4.	**Multi Layered Films:** Materials and equipment for multi layered films, structure, properties and applications of films multi layered films.	8
5.	**Packaging Materials:** Types of packaging, film, sheet, and boxes, laminated packaging, packaging for electronic goods, commodity materials, medicines and food products.	6
6	**Processing:** Equipment and machinery for processing of packaging materials, principle, technology and operation of equipment, economics of packaging.	6
	Total	**42**

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. and Giles G., (Eds), "PET Packaging Technology", Sheffield Academic Press.	2002

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NAME OF DEPTT./CENTRE: Department of Polymer & Process Engg

1. Subject Code: PEN-315 Course Title: Polymeric Fiber Technology

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Structure, properties and morphology of fiber forming natural and synthetic polymers.	4
2.	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.	8
3.	Post spinning, finishing, drawing and seat setting operations, effect on orientation and crystallization, heat setting and texturing, principles of setting of fibers and fabrics.	8
4.	**Characterization, testing and properties of fibers:** Density, birefringence, tensile, moisture regain, dyeing mechanism, color fastness.	8
5.	Production of staple yarns of natural and synthetic fibers.	4
6.	Manufacturing methods, characterization and applications of fibers based on: polyethylene, polyamide, polypropylene, polyacrilonitrile, polyester, polylactic acid.	10
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books /Publishers	Year of Publication
1.	Gupta V.B. and Kothari V.K., "Manufactures Fiber Technology", Chapman and Hall.	2003
2.	Mark H.F., Atlas S.M. and 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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Applied Science and Engineering**

1. Subject Code: **AS-911** Course Title: **Nanomaterials**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory : 3** **Practical : 0**
4. Relative Weightage: **CWS : 25** **PRS : 0** **MTE : 25** **ETE : 50** **PRE : 0**
5. Credits: **4** 6. Semester: **Autumn/Spring** 7. Subject Area: **Pre PhD Course**
8. Pre-requisite: **Nil**

9 Objective: To impart knowledge of Nanotechnology

10. Details of Course:

Sl.No	Particulars	Hours
1	**Introduction to Nanotechnology**: Introduction; Why Nano?; What do we mean by large and small nanomaterial?; Bottom up and top down approaches, challenges in nanotechnology.	2
2	**Physical Chemistry of Solid Surface** : Introduction, surface energy, chemical potential as a function of surface curvature, electrostatic stabilization, surface charge density, electric potential at the proximity of solid surface, Vanderwaals attraction potential, steric stabilization, solvent and polymer, interaction between polymer layers, mixed steric and electric interaction.	8
3	**Nanostructures:** 0-D nanostructures, introductions, nanoparticles through heterogeneous and homogeneous nucleation, 1-D nanostructures, introduction, inert gas condensation method, 2-D nanostructures, introduction, PVD, CVD, ALD, electochemical deposition, sol-gel method, micro-emulsion method.	10
4	**Characterization and Properties of Nanomaterial:** Introduction, structural characterization (XRD, TEM, SEM, SPM), BET surface area, AFM, chemical characterization (optical spectroscopy), physical properties of nanomaterials, mechanical properties, optical properties, melting point and lattice constant.	12
5	**Special nanomaterials :** Introduction, CNT, micro and mesoporous material, ordered mesoporous structure, crystalline microporous material, nanocomposite and nanograined materials and it's application in energy storage devices.	10
	Total	**42**

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11. Suggested Books:

Sl. No.	Name of Authors / Books / Publisher	Year of Publication
1.	Guozhong Cao, "Nanostructures & Nanomaterials Synthesis, Properties & Applications" Publisher: Imperial College Press London.	2004
2.	Geoffrey A. Ozin, Andre C. Arsenault and Ludovico Cademartiri, "Nanochemistry: A Chemical Approach to Nanomaterials," Publisher: RSC Publishing House, U.K.	2009
3.	Peter J. Goodhew, John Humphreys, Richard Beanland, "Electron Microscopy and Analysis" Publisher: Taylor and Francis London and Newyork.	2001
4.	Bharat Bhusan, "Springer Handbook of Nanotechnology," Publisher: Springer New york.	2003
5.	Javier Garcia-Martinez, "Nanotechnology for the Energy challenge," Publisher: Wiley-VCH Gmbh & CO.KGaA Weinheim.	2010

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Polymer & Processing Engineering**

1. Subject Code: **PP-916** Course Title: **Separation 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 & Spring** 7. Subject Area: **Pre-PhD Course**

8. Pre-requisite: **NIL**

9. Objective: To provide knowledge about different separation processes and its applications

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Novel Separation Processes**: Separation processes in chemical industries and environmental application; Categorization of separation processes, equilibrium and rate governed processes; Introduction to various separation techniques, adsorption, absorption, membrane separation, ion-exchange, foam separation, extraction, supercritical extraction, freeze drying; Terminologies in membrane separation processes, driving forces, type of membranes.	5
2.	**Adsorption:** Historical background and recent advancement, types of adsorptions, advantages and disadvantages, classification, characterization of adsorbent, adsorption isotherms, specific surface area, characteristics of porosity, transport phenomena of pollutant through porous medium, adsorption kinetic modeling in batch mode and fixed column mode.	7
3.	**Ion Exchange:** Basic principles and mechanism of separation, ion exchange resins, regeneration and exchange capacity; Exchange equilibrium, affinity, selectivity and kinetics of ion exchange. Design of ion exchange systems and their uses in removal of ionic impurities from effluents; Introduction to foam separation, extraction and supercritical fluid extraction, and chromatographic separation.	5
4.	**Nano-material as Adsorbent**: Characterization & special features of nano-material as adsorbent, applications, environmental impact, limitation, development of nano-composite material as adsorbent and other applications	4
5.	**Membrane Based Separation Technique (MBSTs)** Historical background and recent advancement, physical and chemical properties of membranes, techniques of membrane	7

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	preparation, membrane characterization, various types of membranes and modules; Osmosis and osmotic pressure; Working principle, operation and design of reverse and forward osmosis, ultrafiltration, microfiltration, electrodialysis and pervaporation; Membrane in wastewater treatment; Composite membrane, preparation and application; Membrane for gas separation	
6.	**Ultrafiltration and Microfiltration:** Membrane properties, concentration polarization and fouling, fouling during protein separation, crossflow and dead-end microfiltration/ultrafiltration, micellar enhanced ultrafiltration, selected application and economics.	4
7.	**Nanofiltration and Reverse and Forward Osmosis:** Membrane selection procedures, osmotic pressure model, membrane fouling, design consideration and models, pretreatment, applications in desalination and wastewater treatment, economic consideration.	5
8.	**Adsorption and 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	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Yang, T.R., "Adsorbents: Fundamentals and Applications", Wiley-Backwell.	2003
2.	King, C.J., "Separation Processes", Tata McGraw-Hill.	1980
3.	Mulder M., "Basic Principles of Membrane Technology", Kluwer Academic Publisher.	1996
4.	Baker R.W., "Membrane Technology & Application", McGraw Hill.	2000
5.	Zeman L.J., & Zydney A.L., " Microfiltration and Ultrafiltration: Principle & Application", Marcel Dekker Inc.	1996
6.	Nath K., "Membrane Separation Processes", Prentice Hall of India.	2008
7.	Scott K., "Handbook of Industrial Membrane" Elsevier.	1995
8.	Henry, J. D. and Li, N. N., "New Separation Techniques", AICHE	1975

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: **Department of Paper Technology**

1. Subject Code : **PP-917** Course Title: **Cloud Computing and Sensor Network**
2. Contact Hours: **L: 3** **T : 1** **P : 0**
3. Examination 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/Spring** 7. Subject area: **Pre Ph.D. Course**
8. Pre- requisite: **Nil**
9. Objective : To provide exposure to the student about Cloud Computing and Sensor Network.
10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Internet of Things (IoT):** Research review of IoT, pillars of IoT, internet of devices, personal navigation devices, internet of objects, application of internet of object, wireless sensor network, sensor network architecture, internet of controllers, components of internet of controllers.	8
2.	**Cloud Computing:** Research review on cloud computing, services of cloud computing, layered architecture of cloud computing, characteristics and challenges of cloud computing, grid computing, layered architecture of grid computing, service oriented architecture, cloud middleware, architecture and cloud standards, cloud service provider and systems.	9
3.	**The Cloud of Things:** Internet of things with cloud computing, mobile cloud computing, cloud of things architecture, deployment models, vertical applications, essential features, technological pillars, three layers of IoT systems, issues and challenges of IoT, foundational technological enablers.	9
4.	**Wireless Communication:** Latest issues & challenges in wireless communication, wireless topology, cellular system, architecture of wireless communication, applications and services of wireless network issues in mobile computing: challenges of mobile computing, function of mobile computing, architecture of mobile computing, applications and services of mobile computing.	8

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5.	**Deployment of Sensor with Cloud:** Development of test-bed, setting up the environment, building the program in visual studio, deployment of various devices: sensors, controller, blinking led, light switch, voltage reader, actuators.	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Book/ Authors/ publisher	Year of Publication
1.	Zhou, H., "The Internet of Things in the Cloud," Publisher: CRC Press Taylor & Francis Group, Edition first.	2012
2.	Pfister, C., "Getting Started With the Internet of Things," Publisher: O'Reilly, Edition first.	2011
3.	Jochen, S., "Mobile Communications," Publisher: Pearson Publications, Edition second.	2012

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARMENT/CENTRE : **Department of Paper Technology**

1. Subject Code: **PP-918** Course Title: **Principles of Wireless Networks**
2. Contact Hours: **L: 3** **T:1** **P : 0**
3. Examination 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/Spring** 7. Subject Area: **Pre-Ph.D. course**
8. Pre-requisite: **Nil**
9. Objective: To acquaint the students with the concepts and the issues involved in the design of wireless networks.
10. Details of the Course:

S. No.	Contents	Contact Hours
1.	**Wireless Network:** Network architecture and design issues, key trends in wireless networking, wireless network topologies, cellular concepts, frequency reuse, channel assignment strategies, interference and system capacity, improving coverage and capacity in cellular systems, latest development in wireless networks.	7
2.	**Radio Propagation Mechanisms:** Basic propagation mechanism, free space propagation model, outdoor propagation model, indoor propagation model, small-scale fading and multipath parameters of mobile multipath channels, types of small scale fading, rayleigh and rician distribution.	8
3.	**Modulation Techniques:** Spread spectrum modulation techniques (pseudo-noise sequences, direct sequence spread spectrum, frequency hopped spread spectrum, performance in fading and multipath channels (performance of digital modulation in slow flat-fading channels, digital modulation in frequency selective mobile channels.	7
4.	**Multiple Access Techniques for Wireless Communications:** Introduction to multiple access, FDMA, TDMA, FHMA, CDMA, SDMA, capacity of cellular CDMA, capacity of CDMA with multiple cells, capacity of space division multiple access.	6
5.	**Mobility Management:** Location and handoff management, classification of handoffs and handoff algorithms, mobile IP, radio resources and power management(power control, power saving mechanisms in wireless networks, energy-efficient software approaches), security in wireless networks, security services, security mechanisms, identification schemes.	8
6.	**Global System for Mobile Communications:** GSM services, reference architecture, mechanisms to support a mobile environment, mapping of GSM layers into OSI layers, IEEE 802.11 standards.	6
	Total	**42**

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11. Suggested Books:

S.No.	Name of Authors /Books/Publishers	Year of Publication
1.	Pahalvan, K. and Krishnamurthy, P., "Principles of Wireless Networks: A Unified Approach," Publisher: Pearson Education, Edition second.	2013
2.	Stallings, W., "Wireless Communications and Networking," Publisher: Pearson Education, Edition second.	2005
3.	Rappaport, T.S., "Wireless Communications: Principles and Practice," Publisher: Pearson Education, Edition second.	2012
4	Prasad, R. and Munoz, L., "WLANs and WPANs: Towards 4G Wireless," Publisher: Wesley, Edition second.	2003
5.	Haykin, S. and Moher, M., "Modern Wireless Communication," Publisher: Pearson Education. Edition first.	2005
6.	Pandya, R., "Mobile and Personal Communication Systems and Services," Publisher: Prentice-Hall of India.	2004

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-001** Course Title: **Petrochemicals and Petroleum Refining Engineering**

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

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/Spring 7. Subject Area: PEC

8. Pre-requisite: Nil

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

10. Details of the Course:

S.No.	Contents	Contact Hours
1.	**Introduction and Crude Processing:** 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; 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.	9
2.	**Cracking Operations**: Principles, recent developments, Feed-stocks, product yield, quality and operating parameters related to Thermal, Hydrocracking and Catalytic Cracking.	7
3.	**Catalytic reforming and Isomerisation** : Principles, technological developments, catalyst types and their performance; Effects of operating parameters; Product improvement through Sulphur and Aromatics removal; Hydrofinishing; Hydrotreating operations; Catalyst regeneration; Catalytic dewaxing; Environmental aspects of refining.	8
4.	**Petrochemicals production and utilization of synthesis gas**: Generation of synthesis gas by steam reforming of naptha 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

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5.	**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
6.	**Synthetic fibres, rubbers, plastics, resins from petrochemicals:** General overview of methods of production of HDPE, LDPE, polyester fibres and SBR.	5
	Total	**42**

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject code: **PEN-002** Course title: **Numerical Methods in Chemical Engineering**

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

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

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

5. Credit: **3** 6. Semester: **Autumn/Spring** 7. Subject area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of numerical methods applied in chemical 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 chemical engineering.	9
2	**Solution of Linear Equations:** Matrix inversion; Gauss Elimination; Gauss-Jordan Method; Gauss-Seidel Iteration Method Jacobi's Method; Gauss-Seidel Method; Applications in Chemical Engineering.	5
3	**Curve Fitting:** Method of Least Squares; Fitting a Straight Line and a Polynomial; Fitting a Non-linear Function; Fitting Geometric and Exponential Curves; Fitting a Hyperbola, Trigonometric Function;	5
4	**Finite Differences & Interpolation:** Finite Differences: Forward, Backward and Divided Differences Table; Central Differences; Newton's Forward, Backward and Divided Difference Interpolation Formula; Interpolation of Polynomials; Lagrange Interpolation Formula; Applications in Chemical Engineering.	5
5	**Numerical Differentiation & Integration:** Differentiation Formula based on Tabulator at Equal and Unequal Intervals; Newton-Cotes Integration Formulas; Trapezoidal Rule and Simpson's 1/3 and 3/8 Rule; Applications in Chemical Engineering.	5
6	**Ordinary Differential Equations:** Taylor's Series and Euler's Method; Modifications and Improvements in Euler's Method;	8

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	Runge-Kutta 2nd Order & 4th Order Methods; Milne's Predictor-Corrector Methods; Boundary Value Problems; Applications in Chemical Engineering.	
7	**Partial Differential Equations:** Parabolic, Hyperbolic and Elliptic (Explicit method-finite difference) equations; Applications of these in Chemical Engineering.	5
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Ward C. and Kincaid D., "Numerical Methods and Computing", 6th Ed., Brooks /Cole,	2008
2.	Rajaraman V., "Computer Oriented Numerical Methods", 3rd Ed., PHI,	2006
3.	Gupta S.K., "Numerical Methods for Engineers", 3rd Ed., New Academic Science.	2013
4.	Mathews J.H., "Numerical Methods for mathematics & science", 2nd Ed., Prentice Hall.	2001
5.	Chapra S.C. and Canale R.P., "Numerical Methods for Engineers", 6th Ed., McGraw-Hill Higher Education,	2010

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-003** Course Title: **Process Optimization**

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: **Autumn/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.	3
2.	**Problem Formulation:** Nature and organization of nonlinear optimization problems; Development of models for optimization with with equality or inequality constraints; Degrees of freedom; Factorial experimental design; Problems related to cost minimization; Profit and production maximization problems for single variable and multivariable problems.	7
3.	**Optimization of Unconstrained Functions:** One-dimensional search, unconstrained multivariable optimization; Geometric, quadratic, integer and stochastic programming.	8
4	**Linear programming:** Simplex method; Linear mixed integer problem; Transportation problem and their applications; Sensitivity analysis	4
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.	**Global optimization for problems with continuous and discrete variables:** Methods of global optimization; Branch-and–Bounds methods and its modifications; Heuristic search methods; Tabu search, Genetic algorithm; Simulated annealing.	5
7.	**Applications:** Fluid flow systems; Heat transfer and energy conservation; Separation processes; Chemical Reactor Design and	7

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	Operation; Optimization in large-scale plant design and operations; Integrated planning, scheduling and control in the process industry.	
	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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-004** Course Title: **Process Equipment Design**

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

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/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 process 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.	6
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.	**Accessories of Pressure Vessels:** Selection and design of nozzles; Elementary idea of compensation for openings; Selection of gaskets; Selection and design of flanges; Pipe thickness calculation under internal and external pressure.	4
4.	**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.	6
5.	**Supports:** Design of lug support and saddle support including bearing plates and anchor bolts.	3
6.	**Storage Tanks:** Filling and breathing losses; Classification of storage tanks; Design of liquid and gas tanks; Design of storage tanks for process industries.	7

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7.	**Application to Design of Plant Equipment:** Design of reactors, evaporators, and drum dryers; Inspection and testing of pressure vessels, radiography; Introduction to flexibility analysis of piping systems.	6
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Brownell L.E. and 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. and 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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-005** Course Title: **Bioprocess Technology**

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: **Autumn/Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **NIL**

9. Objective: To impart knowledge on concepts of enzymatic and microbial processing of raw materials to produce various products.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Overview of Microbiology:** Microorganisms and their classification; Basic aspects of microbiology; Chemical composition of cells; Properties and functions of various biomolecules such as lipids, proteins, carbohydrates, nucleic acids, and vitamins; Classification and nomenclature of enzymes; Comparison of enzymes with catalysts; Chemical energetics of enzymes; Metabolism of microbial cells-assimilatory and dissimilatory processes. Growth of microorganisms; Different stages of growth; Growth in batch and continuous reactor; Growth associated and non-growth associated product.	8
2.	**Industrial Microbiology:** Isolation and screening of microorganisms; Maintenance of isolates; Inoculum development; Sterilization; Strain improvement; Downstream processing and upstream processing; General methodology of bio-product formation.	8
3.	**Microbial Processes:** Production of solvents and chemicals-organic acids, antibiotics, enzymes, polysaccharides, lipids, pigments, and aroma; Equipment and accessories for industrial microbial processes.	6
4.	**Biotechnology in Foods and Beverages:** Fermentation; Organisms and their use in pickling and preservation; Cheese production; Use of enzymes in food and dairy industries;	6

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	Enzymes in fruit juice and brewing industries; Mushrooms; Single cell proteins; Food yeasts; Algal proteins.	
5.	**Biofuels:** Desirable and undesirable features of biofuels; Energy crops such as wood, sugar and starch, and hydrocarbon producing crops; Biogas, bioethanol, biobutanol, biodiesel and biohydrogen..	7
6.	**Environmental Biotechnology:** Aerobic and anaerobic treatment processes for waste water; Microorganisms and reactors for aerobic and anaerobic processes; Biodegradation of xenobiotic compounds; Bioremediation.	4
7.	**Biosafety:** Assessment of risks; Rrisk containment; Biosafety guidelines and regulations.	3
	TOTAL	42

11. Suggested Books:

S. No.	Name of Books / Authors /Publisher	Year of Publication / Reprint
1.	Demain A.L., Davies J.E. and Atlas R.M., "Manual of Industrial Microbiology and Biotechnology", 2nd Ed., ASM Press,	1999
2.	Das H.K., "Text book of Biotechnology", 3rd Ed., Wiley, Dreamtech India.	2008
3.	Prescott S.C. and Dunn C.G., "Industrial Microbiology", 2nd Ed., Agrobios.	2006
4.	Crueger W. and Crueger A., "Biotechnology- A text book of Industrial Microbiology", 2nd Ed., Panima Publishing Corporation.	1990
5.	Rao D.G., "Introduction to Biochemical Engineering", 2nd Ed., Tata McGraw Hill.	2010

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-006** Course Title: **Polymer Science and Engineering**
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: **Autumn/Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge of basic of polymer science and engineering and its synthesis application aspect
10. Details of the Course:

S.No.	Contents	Contact Hours
1.	**Introduction:** History of macromolecular science; Concept of macromolecules; Basic concepts and definitions- monomer and functionality, oligomer, polymer, repeating units and degree of polymerization	3
2.	**Basic concepts in Polymer Science**: Different ways in classification of polymers depending on – a) The origin (natural, Semi-synthetic, synthetic etc.) b) The structure (linear, branched, network, hyperbranched, dendrimer.) c) The type of atom in the main chain (homochain, hetercohain). d) The formation (condensation, addition). e) Homopolymers, copolymers. f) The behaviour on application of heat and pressure (thermoplastic and Thermosetting). g) The form and application (plastics, fiber. elastomers and resin)	5
3.	**Polymerization**: Degree of polymerization; Concept of molecular mass, polydispersity, number average, weight average, viscosity average molecular weight and their statistical equations; Molecular weight distribution in linear polymers (step growth and chain polymers), Nomenclature of polymers, Bulk polymerization; Solution polymerization; Emulsion polymerization; Suspension polymerization; ROP; Interfacial polymerization; Melt polycondensation; Solution polycondensation.	7
4.	**Polymer Rheology and Morphology:** Polymer conformation and configuration; Polymer melts and polymer solutions; Dilute solution properties; Viscosity; Shear and extensional viscosities; Dependence of shear viscosity on temperature, pressure, molecular weight; Flow curve linear viscoelasticity; Newtonian, non-Newtonian, continuous	7

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	theories and related models; non- Newtonian liquid flow	
5.	**Properties:** Tensile and Impact strength; Elongation at break; Water resistance; Hardness; Heat distortion temperature; Brittleness; Flexural strength, and T_m, T_g; Measurement of molecular weight and size; Molecular weight determination of Polymer through end group analysis; Colligative property measurement; Light scattering; Gel permeation chromatography, Fractionation of polymers by solubility, viscometric method, ultracentrifugation and poly –electrolytes	9
6.	**Major Commodity and Engineering Polymers:** Manufacturing, structure, property, modification and applications of Polyolefins and olefin copolymers (LDPE, HDPE, LLDPE, EVA, EPDM, ionomers etc.), Styrene polymers & co-polymers, (PS, HIPS, ABS etc.), PVC, PAN, phenolics, aminoresins, alkyds, unsaturated polyesters, polyacrylates and allied polymers; Production of engineering plastics: Nylon, polyesters, polycarbonates, polyurethanes, epoxy resins and fluoropolymers; Current trends in polymer production.	8
7.	**Application of Polymers:** Applications of polymer in different areas like, general purpose engineering applications, defense applications and applications in agriculture.	3
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication
1.	Billmeyer F.W., " Textbook of polymer science" Wiley-Interscience, N.Y.	1984
2.	Ghosh P., "Polymer Science and Technology of Plastics and Rubbers" Tata Mcgraw Hill, New Delhi	2000
3.	Odian G.," Principles of Polymerization" Wiley, London	2004
4.	McCrum N.G., "Principles of Polymer Engineering", Oxford University Press	1988
5.	Brydson J.A., "Plastics Materials" Butterworths, London	1982

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT./CENTRE: Polymer and Process Engineering

1. Subject Code: PEN-007 Course Title: Paint Technology

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: Autumn/Spring 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 Hrs
1.	**Introduction:** Definition and properties; Classification of paints; Varnishes, lacquers and powder coatings; Industrial Paints; Cement Paints.	8
2.	**Composition of Paints:** Binders and their classification and properties; Synthetic and natural binders; Pigments and their properties, Solvent, their types and properties; Additives for antiskinning, antifoaming, antifouling.	9
3.	**Formulation and Manufacturing of Paints:** Principles of paint formulation; Phenomenon of wetting, grinding and dispersion and steps in paint manufacturing; Paint manufacturing steps; Problems in paint manufacturing and their solutions; Paint preservation methodology.	5
4.	**Equipment Used in Paint Manufacturing:** Ball mills; Pebble mills; Heavy duty mixtures; Double blade mixture; High speed disk disperser; Design and operations of paint manufacturing equipments.	6
5.	**Paint Application, Drying & Curing:** Pretreatment and surface preparation; Acceleration of drying and curing; Drying and curing processes; Factors affecting choice of methods.	7
6.	**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.	4

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7.	**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., Kozo S., "Automotive Painting Technology", 1st Ed., Springer, Netherlands.	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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Polymer & Process Engineering

1. Subject code: PEN-008 Course title: Biomaterials and Tissue Engineering

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. Credit: 3 6. Semester: Autumn/Spring 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	**Tissue Engineering:** Definition; Principles and practices of tissue engineering; Tissue engineering triad; Cells; Structure of cell; Cellular functions; Cell culture techniques; Different types of cells and their applications in tissue engineering; Scaffolds and their properties; Types of scaffolds; Scaffold modifications; Growth factors; pH, temperature, chemical, electrochemical and mechanical stimuli; *In-vitro* and *in-vivo* environmental stimuli.	8
2	**Biomaterials:** Definition and classification of biomaterials; Natural and synthetic polymer system; Bioceramics; Metal based scaffold-materials; Nanomaterials; Physical, mechanical, and chemical properties of biomaterials; Biocompatibility and biodegradation; Tailoring of biomaterial properties; Controlling pore size and porosity.	8
3	**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.	8
4	**Bioreactors for Tissue Engineering:** Ideal bioreactor and its major characteristics; Fabrication of bioreactor.	4
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	**Regulatory and Clinical Issues:** Pre-clinical evaluation of tissue engineered constructs; Cytotoxicity; Trends in food and drug administration.	3

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7	**Future Advancements:** Scale-up possibilities for tissue engineered constructs; Overcoming present drawbacks; Dealing with ethical issues.	3
	TOTAL	42

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-009** Course Title: **Process Utilities and Cogeneration**
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: **Autumn/Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge about generation and utilization of steam and power, and other utilities in process industries.
10. Details of the Course:

S. No.	Contents	Contact Hours
1	**Introduction**: Utilities in process industries and their importance.	2
2	**Heat Transfer Media:** Classification, characteristic properties and selection criteria for their industrial applications; P V T surfaces of steam; Thermodynamic diagrams; Quality of steam and other heating mediums.	3
3	**Energy Resources:** Conventional and non-conventional energy sources; Industrial uses of coal, petroleum, gas, biofuel, and hydropower; Combustion calculations.	4
4.	**Water:** Raw water and its characteristics, treatment and conditioning for use in process industries; Recycling and reuse of water; Cooling tower.	4
5	**Air:** Use of air in process industries for conveying, drying and instrumentation; Air compressors and other air handling equipment; Calculation of power requirement.	4
6	**Steam Generation and Utilization:** Types of boilers; Working principles of boilers; Boiler mountings and accessories; Draught; efficiency of boilers; Steam and condensate handling; Steam traps; Condensate and flash steam utilization; Safety measures.	7
7	**Power Cycles:** Steam and gas power cycles; Carnot cycle; Rankine cycle, Reheat cycle; Regenerative cycle; Binary vapor cycle; Dual and Brayton cycles.	6
8	**Turbines:** Extraction turbines; Impulse and reaction turbines; Fully condensing turbines; Steam nozzles; Velocity diagrams; Condensers; Gas turbine	7
9	**Cogeneration:** Principles and applications in process industries; Cogeneration plant in process industries, sugar mill, pulp and paper mill and other chemical industries; Economics of cogeneration.	5
	Total	**42**

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11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication /Reprint
1.	Boyce M.P., "Handbook of Cogeneration and Combined Cycle Power", ASME Press.	2002
2	Goodall P.M., "The Efficient Use of Steam", Westbury House.	1980
3.	Guyer E.C. and Brownell D.L., "Handbook of Applied Thermal Design", Taylor and Francis.	1999
4.	Somasundaram S.L, "Thermal Engineering", New Age International	1996
5	Nunn R.G., "Water Treatment Essentials for Boiler Plant Operation", McGraw Hill Professional.	1996

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN - 010** Course Title: **Design of Experiments and Parameter Estimation**

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

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

4. Relative Weightage: **CWS : 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 the knowledge about various techniques of model parameter estimation, analysis and statistical design of experiments.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Basic statistical concepts; Hypothesis testing; Confidence interval; Analysis of errors; Sampling and sampling distribution; Inferences about the differences in means; Strategy of experimentation; Basic principles and guidelines for designing experiments.	10
2.	**Parameter Estimation:** Process Identification; Models for parameter estimation; Algebraic methods; Parameter using statistical techniques, Linear and nonlinear regression; Multiple regression models; Estimation of the parameters for stochastic models.	10
3.	**Analysis of Variance**: Concepts and application of one way and two way analysis of variance; Fundamentals of MANOVA and Non-parametric methods.	5
4.	**Methodology of Design of Experiments:** Randomized blocks; Latin squares and related designs; Factorial design; Fractional factorial design; Blocking and compounding in a factorial design; Mixture design; Plackett Burman Design	10
5.	**Response Surface Methods and Other Approaches:** Response surface methodology; Method of steepest ascent;	7

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	Analysis of a second-order response surface; Experimental designs for fitting response surfaces.	
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Antony J..," Design of Experiments for Engineers and Scientists", Butterworth Heinemann	2003
2.	Lazic Z.R., "Design of Experiments in Chemical Engineering: A Practical Guide", Wiley.	2005
3.	Montgomery D.C., "Design and Analysis of Experiments", 5th Ed., Wiley.	2004

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-011** Course Title: **Solid Waste 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: **Autumn/Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

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

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Characterization:** Characterization of industrial and municipal solid wastes - hazardous and non-hazardous wastes; Overview of hazardous waste, battery waste, electronic waste, etc.; Solid waste disposal and management – standards, laws and guidelines; Hazardous waste regulations- national and international codes; Authorization procedure and generator requirement.	5
2.	**Solid Waste Collection, Handling and Transportation:** Generation, collection, handling, separation, storage, transfer and processing of solid waste; Recycling of solid waste; Segregation of hazardous and non-hazardous wastes.	5
3.	**Solid and Hazardous Wastes Processing:** Mechanical volume and size reduction; Component separation; Physico-chemical, biological and thermal methods; Recycling, reprocessing, handling and processing of sludge; Biogasification and manure production; Recent technological advances in composting and thermal gasification.	10
4.	**Reduction and Recovery:** Source reduction; Recycling Programme Elements; Source separation; Drop-off/buy-back; Curbside programme; Processing equipments for recycling; Material recovery facilities (MRF's); Full stream processing; Commonly Recycled Materials and Processes; Description of	5

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	Wastes-Paper and cardboard, glass, ferrous and non-ferrous metal, heavy metal containing spent catalysts, plastic, batteries and tyres, electronic and battery wastes, spent caustic and tannery wastes.	
5.	**Landfill:** Site selection and design criteria; Closure, restoration and rehabilitation of landfills; Remediation of hazardous waste landfill; Common treatment facility concept for hazardous wastes.	6
6.	**Hazardous Waste:** Identification and Classification; Hazardous Waste Management; Generation, storage. collection, transfer, transport, processing and disposal; Hazardous Waste Treatment - physical and chemical treatment, thermal and biological treatment; Pollution Prevention and Waste Minimization.	6
7.	**Case Studies:** Solid and hazardous waste management in sugar, distillery, pulp and paper, fertilizer, petroleum and petrochemical industries; Management of spent catalysts; Mercury emission and control in thermal power plants and cement plants.	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication / Reprint
1.	Tchobanglais G., Theisen H. and Vigil S.A., "Integrated Solid Waste Management: Engineering Principles and Management Issues", McGraw Hill.	1993
2.	Pichtel J., "Waste Management Practices: Municipal, Hazardous and Industrial", CRC Press	2005
3.	Shah K.L., "Basics of Solid and Hazardous Waste Management Techniques", Prentice Hall.	1999
4.	Tedder D.W. and Pohland F.G., "Emerging Technologies in Hazardous Waste Management", American Chemical Society.	1990
5.	Side G.W., "Hazardous Materials and Hazardous Waste Management", Wiley.	1993
6.	Conway R.A. and Ross R.D., "Handbook of Industrial Waste Disposal", Van-Nostrand Reinhold.	1980

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-012** Course Title: **Industrial Safety and Hazards Management**

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

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

4. Relative Weightage: **CWS : 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 regarding safety, hazards and risk aspects for chemical process industry.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Safety and Hazards Regulations:** Industrial processes and hazards potential; Mechanical, electrical, thermal and process hazards; Safety and hazards regulations; Industrial hygiene and the factories act-1948; Hazards identification-toxicity, fire, static electricity, noise and dust concentration; Material safety data sheet; Hazards indices- Dow and Mond indices, hazard operability (HAZOP) and hazard analysis (HAZAN).	12
2.	**Process Safety:** Inherently safer design and other priorities; Process safety analysis; Hazardous materials and conditions; Industrial safety and occupational health management.	4
3.	**Fire and Explosion:** Shock wave propagation; Vapor cloud and boiling liquid expanding vapors explosion (VCE and BLEVE), mechanical and chemical explosion; Multiphase reactions; Transport effects and global rates.	7
4.	**Relief System:** Relief systems and their design; Preventive and protective management; Inerting; Static electricity passivation, ventilation, sprinkling and proofing; Relief systems – relief valves, flares and scrubbers.	7

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5.	**Leaks and Leakages:** Spill and leakage of liquids, vapors, gases and their mixture from storage tanks and equipment; Estimation of leakage/spill rate through hole, pipes and vessel burst; Isothermal and adiabatic flows of gases; Spillage and leakage of flashing liquids; Pool evaporation and boiling; Release of toxics and dispersion; Naturally buoyant and dense gas dispersion models; Effects of momentum and buoyancy; Mitigation.	8
6.	**Case Studies:** Accident management in chemical process industry; Bhopal, Texas, ONGC offshore, HPCL Vizag and Jaipur IOC oil-storage depot incidents; Oil, natural gas, chlorine and ammonia storage and transportation hazards.	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication /Reprint
1.	Crowl D.A. and Louvar J.F., "Chemical Process Safety-Fundamentals with Applications", 2nd Ed., Prentice Hall.	2001
2.	Ashfal C.R., "Industrial Safety and Health Management", Prentice Hall.	2003
3.	Mannan S., "Lee's Loss Prevention in the Process Industries", Vol. I, 3rd Ed., Butterworth-Heinemann.	2004
4.	Mannan S., "Lee's Loss Prevention in the Process Industries", Vol. II, 3rd Ed., Butterworth-Heinemann.	2005
5.	Mannan S., "Lee's Loss Prevention in the Process Industries", Vol. III, 3rd Ed., Butterworth-Heinemann	2005
6.	Flynn A.M and Theodore L., "Health, Safety, and Accident Management in the Chemical Process Industries", Marcel Dekker.	2002

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-013** Course Title: **Advanced Separation Techniques**

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: **Autumn/Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **NIL**

9. Objective: To impart knowledge about different novel separation processes and its applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Separation processes in chemical industries and environmental application; Categorization of separation processes; Equilibrium and rate governed processes; Introduction to various separation techniques- adsorption, absorption, membrane separation, ion-exchange foam separation, extraction, supercritical extraction and freeze drying; Terminologies in membrane separation processes; Driving forces; Type of membranes.	5
2.	**Adsorption:** Historical background; Types of adsorptions; Advantages and disadvantages; Classification; Characterization of adsorbent; Adsorption isotherms; Specific surface area; Porosity; Transport phenomena of pollutant through porous medium; Adsorption kinetic modelling in batch mode and fixed column mode.	7
3.	**Ion Exchange:** History; Basic principle and mechanism of separation; Ion exchange resins-their regeneration and exchange capacity; Exchange equilibrium, affinity, selectivity and kinetics of ion exchange; Design of ion exchange systems and their uses in removal of ionic impurities from effluents; Introduction to foam separation, extraction, supercritical fluid extraction and chromatographic separation.	5

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4.	**Membrane Based Separation Technique (MBSTs):** Historical background; Physical and chemical properties of membranes; Techniques of membrane preparation and membrane characterization; Various types of membranes and modules; Osmosis and osmotic pressure; Working principle; Operation and design of reverse osmosis, ultrafiltration, microfiltration, electrodialysis and pervaporation; Membrane in wastewater treatment; Composite membrane- preparation and application; Membrane for gas separation.	6
5.	**Electrical Driven Processes:** Introduction; Electrodialysis and its process parameters; Membranes for electrodialysis; Membrane electrolysis; Bipolar membranes; Membrane application in fuel cells.	5
6.	**Ultrafiltration and Microfiltration:** Membrane properties; Concentration polarization and fouling; Fouling during protein separation; Cross flow and dead-end microfiltration/ultrafiltration; Micellar enhanced ultra filtration; Selected applications and economics.	4
7.	**Nanofiltration, Reverse and Forward Osmosis:** Membrane selection procedures; Osmotic pressure model; Membrane fouling; Design consideration and models; Pretreatment; Applications in desalination and wastewater treatment; Economic consideration.	5
8.	**Super Critical Fluid (SCF) Extraction and Centrifugal Separation:** Supercritical condition; Commonly used super critical solvents; Important parameters for SCF extraction; Centrifugal separation processes; Settling rate in centrifuge.	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication / Reprint
1	Mulder M., "Basic Principles of Membrane Technology", 2nd Ed., Kluwer Academic Publishers.	1996
2	King C.J., "Separation Processes", 2nd Ed., Tata McGraw-Hill.	1980
3	Noble R.D. and Stern S.A., "Membrane Separations Technology: Principles and Applications", 3rd Ed., Elsevier.	2003
4	Baker R.W., "Membrane Technology and Application", 2nd Ed., McGraw Hill.	2004
5	Wakeman R.J. and Tarleton E.S., "Principles of Industrial Filtration", 1st Ed., Elsevier.	2005

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

1. Subject Code: **PEN-016** Course Title: **Process Intensification**

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: **Autumn/Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge about methods and equipment used for process intensification.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Introduction to process intensification; Principles and advantages; Ways of process intensification, product design, equipment and methods; Green chemistry and Green Engineering, New processing techniques.	5
2	**Heat Transfer Equipments:** Characteristics on rotating surfaces; Surface irregularities; Thin film and polymer coating to enhance heat transfer and energy efficiency; Pollution control; Plant operating costs; Condensation in rotating devices,; Light weight and corrosion resistant compact heat exchanger; Use of polymer materials in construction, such PEEK.	6
3.	**Two-phase Flow Equipments:** Two phase flow in a centrifugal field, countercurrent contact of process fluids, adsorption and ion exchange	6
4.	**Reactors and Separators:** Spinning disc reactors(SDR); Performance characteristics; Microreactors; PTFE; Multifunctional reactors; Hybrid separation; Alternative energy sources and other methods- basic concept, principles, design and application; Cross-corrugated multifunctional membranes.	4
5.	**Mixers:** Static mixers and reactors; Structured and monolithic catalyst and reactors; Spinning disc reactors-basic concept, principles, design and application,	6
6.	**Process Synthesis/ Integration:** Conceptual design; Role of reaction engineering; Design and optimization of network of heat exchangers	5

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7.	**Process Intensification in Industrial Practices:** Energy saving devices; Methodology and application; Case studies in process Industries.	6
8.	**Process Intensification for Safety:** Inherent safety; Layer of protection; Safety strategies, applications and metrics of inherent safety.	4
	Total	**42**

11. Suggested Books:

S. No.	**Name of Books / Authors**	**Year of Publication**
1.	Green A., "Process Intensification for Chemical Industry – Smaller, Cheaper and Safer", Professional Engg. Publishing.	2007
2.	Galip A., "Process Intensification and Miniaturisation: Principles and Applications in Biological, Chemical and Environmental Technologies", Elsevier Technology Books	2007
3.	Stankiewicz A., "Re- Engineering the Chemical Processing Plant: Process Intensification", Dekker incorporated Marcel.	2004
4	BISSCHOPS, M.A.T., Van der Wielen, L.A.M. and Luyben, K. Ch.A.M.- in SEMEL, J (ed.). "Process Intensification in Practice, Application and Opportunities", BHR Group, London.	1999
5	CUSSLER, E.L., and MOGGRIDGE, G.D., "Chemical Product Design", Cambridge University Press, Cambridge.	2001

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-017** Course Title: **Pulp and Paper Technology**

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: **Autumn/Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of pulp and paper manufacturing.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Importance of paper; Chronological developments; Modern pulp and paper operations; Requirements and sources of papermaking fibers; Fiber chemistry; Characteristics of wood; Wood species identifications; Effect of fiber structure and wood chemical composition on pulp and papermaking characteristics.	04
2.	**Wood and Chip Handling and Overview of Pulping Methodology:** Raw materials resource; Chip handling and storage; Various pulping methods; Trends in pulping; Comparision of pulp properties and applications; Mechanical pulping; Mechanical pulping nomenclature; Stone groundwood process; Refiner mechanical pulping; Thermochemical pulping; Chemically modified mechanical pulping; Kraft pulping; Brief history of developments; Kraft process nomenclature; Chemistry of kraft pulping; Process modifications; Sulphite pulping; Nomenclature and definition of terms; Process description; Chemistry of cooking liquor preparation.	08
3.	**Processing and Bleaching of Pulp:** Defibration; Brown stock washing; Screening; Centrifugal cleaning; Thickening; Bleaching sequence; Preparation of bleach chemicals; Chlorination and pulp extraction; Oxygen bleaching; Hypochlorite bleaching; Peroxide bleaching; Ozone bleaching; Pulp brightening	08
4.	**Stock Preparation:** Pulp refining; Sizing; Fillers; Wet-strength resins; Defoamers; Mechanism of flocculation.	06
5.	**Pressing and Drying:** Introduction to paper machine; Approach flow system; Flowspreader and headboxes; Wire part (Fourdrinier); Twin-wire forming; White water system; Broke handling; Pressing; Paper drying; Calendaring; Paper machine drives; Fabrics; Felt conditioning.	06

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6.	**Paper Properties:** Optical properties: brightness, opacity and gloss; Structural properties: grammage, thickness, bulk, porosity, smoothness and surface pick strength; Strength properties: tear index, tensile index, burst index, bending stiffness and folding endurance.	05
7.	**Chemical Recovery:** Black liquor properties; Black liquor oxidation; Evaporation; Recovery boiler; Recaustcizing; By-product recovery; Recovery of sulphite liquor; Alternate kraft recovery.	05
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication/ Reprint
1.	Biermann, Christopher J., "Handbook of Pulping and Papermaking" Publisher: Academic Press	1996
2.	Smook, Gary A., "Handbook for Pulp and Paper Technologists," Publisher: Angus Wilde	2003

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INDIAN INSTITUTE OF TECNNOLOGY ROORKEE

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

1. Subject Code: **PEN-018** Course Title: **Heterogenous Catalysis and Reactor Design**

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

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

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

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

8. Pre-requisite: NIL

9. Objective: To introduce reaction kinetic of heterogeneous catalysis, and analysis and design of catalytic reactor

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	**Solid Catalyst:** Role of catalyst component and other constituents; Characterization of catalyst and its support.	4
2.	**Heterogeneous Catalysis:** Mechanism and kinetic model of surface reaction; Determination of kinetic parameter through experiments; Analysis of complex reaction; Synthesis of kinetic structure.	5
3.	**External and Internal Transport Process:** Effect of heat and mass transfer; Internal effectiveness factor; Generalized effectiveness factor; Point effectiveness; Multiple reactions; Transport criteria.	8
4.	**Deactivation of Catalyst:** Physical deactivation; Surface diffusion; Sintering –mechanism and kinetics; Chemical deactivation –types and kinetics; Regeneration of catalyst.	6
5.	**Selectivity and Stability:** Effect of transport process and deactivation on selectivity and stability of a single pellet.	4
6.	**Multiple Reactions:** Mass transfer coefficients; Effect of transport and global rates.	4
7.	**Design of Catalytic Reactors:** Design and analysis of fixed bed reactors; Autothermic operation and stability; Fluidized bed reactors; Two phase and multiphase models; Introduction to slurry reactors and trickle bed reactors.	11
	Total	42

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11. Suggested Books:

Sl.No.	Name of Authors/ Books/ Publishers	Year of publication
1.	Lee H.H., "Heterogeneous Reactor Design", Buterworth Heinman.	1985
2.	Carberry J.J. and Verma A., "Chemical Reaction and Reactor Engineering", CRC.	1987
3	Doraiswamy L.K. and Sharma M.M. "Heterogenous Reactions" Vol 1 and 2, Wiley.	1984
4	Ramchandran P.A. and Chaudhari R.V. "Three Phase Catalytic Reactors", Gordon and Breach.	1983
5	Froment G.F. and Bischoff K.V." Chemical Reactor Analysis and Design" 2nd Ed., Wiley.	1990
6	Jakobsen H.A., "Chemical Reactor modeling: Multiphase Reactive flows" Springer.	2008

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-019** Course Title: **Biofuels**

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

8. Prerequisite: **Nil**

9. Objective: To impart knowledge about biofuel production and its applications.

10. Details of course:

S. No.	Content	Contact Hours
1.	**Introduction:** Natural resources of energy and their limitations; Bio-fuels; Different types of biofuels; Economic and environmental impacts of biofuels; Technologies; Markets; Government policies and financing strategies for industrial-scale biofuel production and technology development start-ups for promoting biofuel production.	9
2.	**Bio-fuel Feedstocks:** Starch, sugar, lignocellulosic, animal fat and plant oils and other miscellaneous feedstock's; Enhancing primary raw materials for biofuels.	6
3.	**Bioethanol and Biodiesel Production, and their Applications:** Bioethanol production from sugar, starch and lignocellulosic feedstocks; Challenges in bioethanol production; Syngas and ethanol production process; Biodiesel production chemistry; Oil resources for biodiesel; Methods of biodiesel production; Economics and challenges in biodiesel production; Applications of bioethanol and biodiesel.	9
4.	**Biological Production of Hydrogen:** Hydrogen production by fermentation; Photobiological H_2 production and its importance; Syngas production; Hydrogen detection and quantification.	6
5.	**Microbial Fuel Cells:** Definition and importance; Biochemical basis; Fuel cell design; Performance methods of microbial fuel cell.	6
6.	**Biogas:** Definition and composition; Biogas feedstocks; Biogas production technology and microbial reactions and stages of biogas production; Biogas digesters: Types and design aspects; Challenges.	6
	TOTAL	42

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11. Suggested Books:

S. No.	Name of Books / Authors / Publishers	Year of Publication /Reprint
1.	Hayhurst C., "Biofuel Power of the Future: New Ways of Turning Organic Matter Into Energy", 1st Ed., Rosen Publishing Group.	2003
2.	Johanson P., "Biofuels: Sustainable Energy in the 21st Century", 1st Ed., Rosen Publishing Group.	2010
3.	Pahl G., "Biodiesel: Growing a New Energy Economy", 2nd Ed., Chelsea Green Publishing,	2008
4.	Luque R., Campelo J. and Clark J., "Handbook of Biofuels Production: Processes and Technologies", Elsevier1st Ed., Elsevier.	2011
5.	Pandey A., Larroche C., Ricke S.C., Dussap C. and Gnansounou E., "Biofuels: Alternative Feedstocks and Conversion Processes", 1st Ed., Elsevier.	2011

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-020** Course Title: **Polymer Recycling and Environment**

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: **Autumn/Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of adverse effects of polymers on the environment and the degradation of polymers in the environment.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Environment**: Disposed Plastics; Pollution; Environmental issues related to plastic industry; Plastic waste recycle.	4
2.	**Plastic Waste:** Reasons and sources of plastic waste; Plastics in municipal, industrial, agricultural and medical; Waste separation and segregation; Plastic waste accumulation; Commodity plastics disposed as waste, like, polyethylene, polypropylene, polyvinylchloride, polystyrene, polyester, polyurethane, thermosets and thermoplastics.	7
3.	**Environmental Effects on Waste Plastics:** Stability and degradation of polymers in environment; Weather parameters influencing lifetime of waste plastics; Plastics waste in sea and marine environment, and on hills and mountains.	6
4.	**Polymer Degradation:** Degradation of waste plastics in environment; Photo and bio degradation of plastics waste; Effect of plastic degradation on environment.	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.	**Destruction of Plastics Waste:** Methods and processes; Thermal destruction and incineration; Thermal destruction of commodity plastics, like, polyethylene, polypropylene, polyvinylchloride, polystyrene, polyester; Energy requirements for plastic waste destruction; Energy recovery from thermal destruction and	8

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	incineration of plastics waste.	
7	**Sustainability**: Life cycle of plastics; Sustainability, economy, legislation and regulations; Future of plastics.	5
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Books /Publishers	Year of Publication / Reprint
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 and Sons.	1998

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department Polymer & Process Engg.**

1. Subject Code: **PEN-021** Course Title: **Polymer Product Technology**

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: **Autumn/Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of polymer product processing technology and equipment.

10. Details of the Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Introduction to polymer product processing, quantitative aspects of polymer product processing additives and compounding – Fillers, Plasticizers, Antioxidants, Colorants, Flamer retardants, Stabilizers Compounding, Mixing and compounding equipment.	6
2.	**Extrusion**: Constructional details of extruders, Plasticating single-screw extruders, Twin screw extruders, Dies and Take - Off equipment, Post extrusion processing, Calendering, Laminating, Wire-coating extrusion	9
3.	**Fiber Spinning**: Fiber spinning processes, Melt spinning process, Wet and dry spinning process, Other fiber spinning processes, High-speed melt spinning, Spinnability	4
4.	**Molding Technology:** Blow molding technology, Process, Principles, Machine descriptions, Principles of operations, Molding parameters; Optimization of processing parameters and troubleshooting; Common molding faults and their correction, Types product processing technology; Compression molding: Hydraulic presses, Press capacity and pressure calculations, Molding process; Transfer molding: Molding process, Advantages, Disadvantages, Resin transfer molding, Rubber transfer molding technology, Type of product processing	8
7.	**Injection molding:** Working principles of injection molding machine, Temperature control, Injection systems, Starting and shut down procedures, Process variables reaction injection molding, Injection molding of amorphous polymers: Flow pattern and governing system equation, Molecular orientation during mold filling; Injection molding	8

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	of semicrystalline polymers: Crystallization during molding, Governing system equation, Morphology of injected molded semicrystalline polymers, Reaction injection molding	
8.	**Miscellaneous Processing Technologies:** Principles and operations of rotational molding, thermoforming, and foam processing machines and processing of plastic products by these processes; Tooling & Molds: Tool making processes, die and die forming, Compression molds, Ttransfer molds, Blow and extrusion dies, Typical exercises in mold design and production, two plate mold, three plate mold, Hot runner mold, Insulated runner mold, Runners, Gates, Mold making, Mold cooling.	7
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication
1.	Chan R., Hassen P. and Kramer E., "Processing of Polymers", Wiley-VCH	1996
2.	Griskey R., "Polymer Process Engineering", Chapman & Hall	1992
3.	Grulke E., "Introduction to Polymer Process Engineering", Printice Hall.	1993
4.	McCrum N.G., "Principles of Polymer Engineering", Oxford University Press	1988
5.	Osswald T., "Polymer Processing Fundamentals", Hanser-Gardner	1998
6.	Tadmor Z. and Gogos C.G., "Principles of Polymer Processing", Wiley.	2000

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

1. Subject code: **PEN-022** Course title: **Transport of Oil and Gas**

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. Credit: **3** 6. Semester: **Autumn/Spring** 7. Subject area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of efficient transportation of oil and gas, and their conservation.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Pipe Line, Valves and Regulators:** Steel pipes; Plastic pipes; Plastic-lined steel pipes; Wall thickness of pipes; Gate valves; Ball and plug valves; Pressure regulators; Pipeline construction and protection; Internal maintenance of pipelines.	7
2.	**Fluid Flow Measurements:** Measurement of crude volume in tanks; Dump meter; Orifice meter; Critical flow meter; Positive displacement meter; Turbine type flow meters; Pump and compressor stations; Instrumentation and control.	4
3.	**Storage and Conservation**: Storage vessels; Storage losses; Standards and regulations; Conservation of petroleum and its products.	4
4.	**Pipeline Transportation of Oil:** Pressure waves and water hammer; Slug transportation; leaks and rupture in pipelines; Isothermal and non-isothermal transport oil transport.	8
5.	**Methods of Improving Oil-Flow Characteristics:** Heat treatment; Solvent addition; Chemical treatment; Oil transport in water bed.	3
6.	**Pipeline Transportation of Natural Gas:** Physical and physio-chemical properties of natural gas; Temperature of flowing gases; Steady-state and transient flow in pipeline systems; Numerical simulation of the flow in pipeline system; Pipeline Transportation of natural gas and economy.	9
7.	**Safety:** Traffic management; Safety measures; Fire and Safety rules.	3

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8.	**Global supply scenario and quality control:** Global supply scenario of petroleum and petroleum products; Product quality control; Bulk distribution and handling.	4
	TOTAL	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	A. Pál Szilas, "Production and Transport of Oil and Gas: Gathering and transportation", 2nd Ed., Elsevier.	1986
2.	Guoyu Li, "World Atlas of Oil and Gas Basins", 1st Ed., John Wiley and Sons.	2011
3.	Orban J., "Money in The Ground - Insider's Guide to Oil Deals", 4th Ed., Meridian Press.	2006
4.	Turner W.C. and Doty S., "Energy Management Handbook", 6th ed., Taylor and Francis Ltd.	2007
5.	Kennedy J. L., "Oil and Gas Pipeline Fundamentals", 2nd Ed., Penn Well Publishing Company.	1993

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-023** Course Title: **Industrial Piping**

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: **Autumn/Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Fluid Mechanics**

9. Objective: To provide knowledge for design and selection of pipe lines and piping networks in process industries.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Flow of Fluids:** Frictional loss in pipes, ducts and fittings; Carrying capacity of pipes; Pressure drop and diameter calculations for flow of steam, water, oil and gases.	6
2.	**Vapour-Liquid Piping:** Flow patterns; Piping design for two-phase flow; Design of piping for reboiler and condenser systems.	4
3.	**Hydraulic Transport:** Design of pipes for transport of slurries; Correlations for various flow regimes.	6
4.	**Pneumatic Transport:** Conveying systems; Solid-gas flow patterns in vertical, horizontal and inclined pipe lines; Concept of saltation and choking velocities; Pressure drop calculations in different pipe lines carrying gas solid mixture; Design of feeding systems for pneumatic transport of solids.	8
5.	**Network Design:** Optimum pipe line diameter calculations and optimum pipe network design; Nominal pipe size, schedule numbers; Piping layout considerations, elements of supporting systems, fixtures and pipe attachments, color codes.	8
6.	**Materials of Construction:** Stable and unstable deformation, plasticity, plastic instability, design assumptions, stress evaluation and design limits; Codes and standards; Local components of pipe bends, branch connections and bolted flange connections; Introduction to piping vibration, its prevention and control.	6

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7.	**Simplified Methods for Flexibility Analysis:** Thermal expansion loops; Code rules; Approximate solutions and flexibility analysis by model tests; Approaches to reducing expansion effects Expansions joints.	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Boterman R. and Smith P., "Advanced Piping Design", Gulf Publishing.	2008
2.	Deutsch D.J. "Process Piping Systems", McGraw Hill.	1980
3.	Marcus R.D., Leung L.S., Klinzing G.E. and Rizk F., "Pneumatic Conveying of Solids", Chapman and Hall.	1990
4.	Nayyar M.L., "Piping Handbook", 7^{th} Ed., McGraw Hill.	2000
5.	Shook C.A. and Roco M.C. "Slurry Flow; Principles and Practice", Butterworth Heinemann.	1991
6.	Smith P., "The Fundamentals of Piping Design: Drafting and Design Methods for Process Applications", Gulf Publishing.	2007

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-024** Course Title: **Process Engineering Stratgies**

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: **Autumn/Spring** 7. Subject Area: **PEC**

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 experiment; 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.	**Variations in Engineering Processes:** Queuing theory; Parametric pumping of processes; Smoothing of variations.	7
7.	**Simulation Techniques:** Monte Carlo simulation; Industrial simulations; Application of simulation in decision-making.	6
	Total	**42**

11. Suggested Books:

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S. No.	Name of Book / Authors / Publisher	Year of Publication / Reprint
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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-025** **Course Title: Management Information Systems**

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: **Autumn/Spring** 7. Subject Area: **PEC**

8. Pre-requisite: Nil

9. Objective: The objectives of this course is to familiarize the participants about the concept of business information systems, generate appreciation on the need and importance of effective management of information systems.

10. Details of Course:

S. No.	Contents	Contact hours
1.	**Introduction to MIS and Systems Analysis::** Information concepts; Characteristics and value of information; System and Modelling concepts; Understanding Information System; Information System (IS) perspectives; Types of IS in organizations; Application of IS in business; Understanding the importance of IS in Global Business; Identification of Applications; Feasibility analysis; Risk Management; Resource Requirements; Hardware and Capacity Planning; Software Needs; Procurement Options – Make or Buy.	8
2.	**Information Systems in Strategic Management:** Organization Structure; Competitive Strategy; Strategic Role of IS; Integrating IS with Business Strategy; Value Chain Analysis; Strategic IS Framework.	3
3.	**Management Information System Overview:** Input, output and characteristics of MIS; Functional aspects; Components; Types of MIS.	3
4.	**Systems Design and Development:** Logical and Physical design; Overview of Systems development; Introduction to Systems Development Life Cycle (SDLC); Phases, Tools and Techniques for SDLC (Entity Relationship Modeling, Data Modelling Data Flow diagram); Prototyping; Quality Management; Critical Success Factors.	6

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5.	**Systems Maintenance and Review:** Types of Maintenance; Steps involved in maintenance; Financial implications; Relationship between maintenance and design; Types of review procedures; Factors considered during systems review; System performance measurement.	4
6.	**Linking IS with Information Technology:** Information technology architecture; Managing IT infrastructure; Introduction to data centers and networking infrastructure; Technologies for information distribution; Messaging and publishing.	4
6.	**Security:** Security issues relating to information systems; Ethical responsibility: Business ethics; Technology ethics; Threats to information systems; Vulnerability; Cyber Crime and Privacy Issues; Control Measures.	4
7.	**Cross Functional Applications**: Introduction to Enterprise Resource Planning (ERP); Customer Relationship Management (CRM) and Supply Chain Management (SCM); Enterprise Application Integration; Data warehousing; Data Mining.	10
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	James A O'Brien, Marakas G., and Behl R., "Management Information Systems", Tata McGraw Hill.	2010
2.	Jawedkar W.S., "Management Information System: A Global Digital Enterprise Perspective", Tata McGraw Hill, 5th edition.	2013
3.	Laudon K. and Laudon J., "MIS: Managing the Digital Firm", Pearson Education.	2013
4.	Jawedkar W.S., "Management Information System: Text and Cases", Tata McGraw Hill Education.	2011
5.	Stair R.M. and Reynolds G.W., "Principles of Information Systems", Cengage Learning.	2014
6.	Rajaraman V., "Analysis and Design of Information Systems", Eastern Economy.	2004

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-026** Course Title: **Operations Research**

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: **Autumn/Spring** 7.Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: This course is aimed at providing basic knowledge of Operations Research.

10. Details of the Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Definition and scope of operations research; Different type of models, their construction and general methods of solving.	2
2.	**Linear Programming:** Mathematical Formulation of the problem; Convex sets; Graphical method; Simplex method; Artificial variable methods; Dual Problem; Dual simplex method.	10
3.	**Transportation and Assignment Models:** North-West Corner Method; Least Cost Cell Method and Vogel's Approximation Method to find the starting BFS; Method of Multipliers to obtain the optimal solutions of Transportation Models; Hungarian Method; Maximal Assignment Problem.	6
4.	**Job Sequencing Models:** Optimum sequence algorithm; Problems with n jobs and two machines; Problems with n jobs and m machines; Heuristic Method.	5
5.	**Replacement Analysis:** Replacement and Maintenance problems.	4
6.	**Inventory Models:** No shortage purchasing models; No shortage manufacturing models; EOQ system of ordering.	5
7.	**Dynamic Programming:** Introduction to dynamic programming; Recursive nature of computations; Forward and backward recursion; Selected applications; Bellman principle.	5
8.	**Queuing Models:** Exponential distribution; Pure birth and death models; Analysis of queues with Poisson arrival and exponential service time.	5
	Total	**42**

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-027** Course Title: **Business Analytics**
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: **Autumn/Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: This course develops fundamental knowledge and skills for applying statistics to business decision making.

10.Details of Course:

S. No.	Contents	Contact hours
1.	**Basics:** Introduction to data mining and business analytics; Categorization of analytical methods and models (descriptive, predictive and prescriptive).	4
2.	**Data Preprocessing:** Data cleaning; Visualization; Transformation; Dimension reduction techniques (factor models and principal components)	6
3.	**Predictive Analytics:** Introduction to prediction; Linear regression for prediction; Local polynomial regression; Importance of parsimony in statistical modelling; Logistic Regression; Forecasting Techniques.	8
4.	**Clustering:** Introduction and basic issues in clustering; Similarity and distance measures; k-means clustering; Hierarchical clustering procedures.	4
5.	**Classification:** Introduction; Statistical based algorithms; Distance based algorithms; Decision tree; Rule based algorithms.	8
6.	**Association Rules:** Motivation and terminology; Correlation analysis; Market Basket Analysis.	5
7.	**Introduction to Tools:** SAS and R software.	5
	Total	42

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11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Evan J., "Business Analytics", PHI	2013
2.	Schniederjans M., Schniederjans D. and Starkey C., "Business Analytics Principles, Concepts and Applications, What, Why and How", Pearson FT Press.	2014
3.	Drake M., "Applies Business Analytics Casebook:The Applications in Supply Chain Management, Operations Management and Operations Research", Pearson Higher Education	2013
4.	Ohri A., "R for Business Analytics", Springer-Verlag.	2013

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-028** Course Title: **Knowledge Management**
2. Contact Hours: L:3 T:0 P: 0
3. Examination Duration (Hrs.): **Theory: 3** **Practical:0**
4. Relative Weightage: **CWS : 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 acquaint the students with various aspects related to the framework, infrastructure, technologies and applications of knowledge management.
10. Details of Course:

S. No.	Contents	Contact hours
1.	**Introduction:** Motivation and Need for knowledge management (KM); Forces driving KM, KM Life Cycle; Implications and Issues in KM.	3
2.	**Understanding Knowledge**: Introduction to Data, Information, Knowledge and Business Intelligence; Attributes and Expression of Knowledge; Types of Knowledge; Human Thinking and Learning; Knowledge: a driver of creativity and innovation; Organizational impact of knowledge management on people, processes, products and organizational performance, business benefits of knowledge.	5
3	**KM Design and Architecture:** KM Cycle; Generic model of Knowledge Management System; KM system design and architecture; Knowledge construction architecture; implementation of KMS.	4
4.	**Knowledge Creation and Capture:** Nonaka's model of knowledge creation, Capturing tacit knowledge; Protocol Analysis; Other knowledge capturing techniques like Repertory Grid, Nominal Group Technique, Delphi Method and Concept Mapping; Creation of Intellectual Capital -Human, Customer and Organizational.	6
5.	**Knowledge Codification and System Implementation:** Need for codification; Modes of knowledge conversion; Codifying tacit knowledge; Codification tools and procedures; Types and approaches of testing,; KM system deployment; Issues related to	6

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	deployment.	
6.	**Knowledge Transfer and Sharing:** Knowledge transfer process; Methods of transfer; Role of internet in knowledge transfer.	4
7.	**KM Tools:** Role of information and communication technology in KM; Learning from data; Data Warehouse and Data Mining; Data Management; Knowledge Portal; Knowledge Products.	5
8.	**Ethical, Legal and Managerial Issues:** Knowledge owners; Legal issues; Ethics Factor; Managing the Knowledge workers; Managing Knowledge Projects.	5
9.	**Case Studies:** KM In Indian organizations and MNC.	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Awad E. and Ghazini, H.M., "Knowledge Management", Prentice Hall India.	2010
2.	Jawadekar W.S., "Knowledge Management: Text and Cases", Tata McGraw-Hill.	2011
3.	Dalkir K., "Knowledge Management in Theory and Practice", PHI-MIT.	2012
4.	Tiwana A., "Knowledge Management Tool Kit", Pearson Education, New Delhi.	2002

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-029** **Course Title: Entrepreneurship Development**
2. Contact Hours: **L : 3** **T : 0** **P : 0**
3. Examination Duration (Hrs.): **Theory : 3** **Practical : 0**
4. Relative Weightage: **CWS : 25** **PRS : 0** **MTE : 25** **ETE : 50** **PRE : 0**
5. Credits : **3** 6. Semester: **Autumn/Spring** 7. Subject Area: **PEC**
8. Prerequisite : **Nil**
9. Objective: The course aims at providing the students with a basic framework for understanding the process of entrepreneurship and developing capabilities in creation, development and operation of entrepreneurial ventures.
10. Details of Course:

S.No	Contents	Contact Hours
1	**Introduction**: Definition and concept of Entrepreneurship and intrapreneurship; Characteristics and skills of entrepreneurs; Classification and types of Entrepreneurs; Entrepreneurial Competencies and Leadership; Factor Affecting Entrepreneurial Growth – Economic, Non-Economic Factors; EDP Programmes; Entrepreneurial Training; Traits/Qualities of an Entrepreneurs; Manager Vs. Entrepreneur. –Introduction and Role of entrepreneurship in economic Development; Women Entrepreneurs; Social entrepreneurship.	8
2	**Entrepreneurial Challenges:** Importance of innovation; Source of innovative ideas; Entrepreneurship and creativity; Techniques for generating ideas; Impediments to creativity; Developing the Business Plan Generating Business Ideas; Selecting a Business Idea; Elements of a Business Plan; Building Competitive Advantage; Conducting feasibility Analysis.	5
3	**Sources of Finance**: Equity vs. Debt Capital; Sources of Equity Finance; Institutional finance; Venture Capital; Lease Finance; Venture Capital; Criteria for evaluating new- venture proposals; Evaluating the Venture Capital- process; Sources of financing for Indian entrepreneurs; Franchising- how a franchise works; Franchising law; Evaluating of franchising opportunities; Forms of Business Ownership Sole Proprietorship, Partnership, Corporations and other forms of ownership.	8
4	**Legal issues**: Patents, Tradesecrets, Copyrights and Trademarks in Small Businesses; Introduction to laws relating to IPR in India;	6

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	International entrepreneurship- opportunities and challenges; Intrapreneurship. Intellectual Property Management; Licensing.	
5	**Institutional Support for Small Businesses**: Support in areas of Technology, Finance, Infrastructure, Marketing, Director of Industries; DIC; SIDO; SIDBI; Small Industries Development Corporation (SIDC); SISI; NSIC;ISBUD; State Financial Corporation SIC;	6
6	**Introduction to Functional Area in Business and Management**: Marketing Management; Production Management; Finance Management; Human Resource Management; Export Marketing	9
	Total	**42**

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Desai Vasant., "Small-Scale Industries and Entrepreneurship", Himalaya Publishing House, Delhi.	2003
2.	Chandra R.,"Entrepreneurial Success: A Psychological Study", Sterling Publication Pvt.Ltd., New Delhi	2003
3.	Balaraju T., "Entrepreneurship Development: An Analytical Study", Akansha Publishing House, Uttam Nagar, New Delhi.	2004
4.	David, O., "A Guide to Entrepreneurship". Jaico Books Publishing House, Delhi.	2004
5.	Taneja, A. "Entrepreneurship". Galgotia Publishers	2004

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

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

1. Subject Code: **PEN-030** **Course Title: International Business**
2. Contact Hours: **L : 3** **T : 0** **P : 0**
3. Examination Duration (Hrs.): **Theory : 3** **Practical : 0**
4. Relative Weightage: **CWS : 25** **PRS : 0** **MTE : 25** **ETE : 50** **PRE : 0**
5. Credits : **3** 6. Semester: **Autumn/Spring** 7. Subject Area: **PEC**
8. Prerequisite : **Nil**
9. Objective: The purpose of this course is to acquaint the students with nature, scope, structure and operations of international business and familiarise them with trends and developments in India's foreign trade and investments and policy framework
10. Details of Course:

S.No	Contents	Contact Hours
1	**International Business**: Importance of International Business (IB); Nature and scope; Modes of entry into international business; Management of international business operations –complexities and issues; India's involvement in International Business; Theoretical Foundations of International Trade; Reasons for international trade; Theories of international trade; Gains from trade; Foreign trade multiplier; Terms of trade.	8
2	**Environmental Context of International Business**: International Business Environment; Framework for analyzing international business environment; Domestic and foreign environments and their impact on international business decisions; World trading environment – Pattern and structure of world trade in goods and services; Country Risk Analysis: Political, Social and Economic, Technological, Cultural and Ethical practices, technology transfer, pricing and regulations; Economic crisis of Brazil, Mexico, India, South East Asia and Argentina:	8
3	**International Financial Environment**: Exchange rate mechanism; Financial Markets and Instruments; International money market and capital markets; Foreign investment flows– Pattern, structure and effects; Movements in foreign exchange and interest rates and their impact on trade and investment flows; Balance of Trade and Balance of Payment; International Monetary Fund.	8
4	**International Economic Institutions and Agreements**: General Agreement on Trade and Tariffs, (GATT); World Trade Organization (WTO) - Seattle and Doha round of talks - Dispute settlement mechanism under WTO - Problems of Patent Laws - International convention on competitiveness; WTO, IMF, World Bank UNCTAD, Agreement on Textiles and Clothing (ATC), GSP, GSTP and other International agreements;	6
5	**International Marketing** - Entry strategies; Market selection; Barriers; Global sourcing and its impact on Indian Industry; Globalization and internal reform process;	7

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	India's competitive advantage in industries like IT, Textiles, Gems and Jewellery; Opportunities and threats	
6	**Regional Economic Integration**: Free trade area; Customs union and common market; Theory of customs union; Trade creation and diversion effects; Regionalism vs. multilateralism; Structure and functioning of EC and NAFTA; Regional Economic Cooperation.	5
	Total	42

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Danoes, J.D.R, Lee H., and Sullivan D.P., "International Business: Environment and Operations", 12th ed., Prentice Hall	2009
2.	Griffin, R.W. and Pustay, M.W., "International Business: A Managerial Perspective", Prentice Hall	2009
3.	Charles, W.L., "International Business", McGraw Hill Company, New York	2009
4.	Ball D., Wendall H.M., Geringer M., Minor M.S. and McNett J.M., "International Business : The Challenge of Global Competition", 12th Ed., 2009, McGraw Hill Co.	2009

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Appendix 'G'
Item No. Senate/60.13

Appendix-G

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PE-411** Course Title: **Polymer Processing**
2. Contact Hours: L: 3 T: 0 P: 3/2
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: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite:**Nil**
9. Objective : To impart knowledge of polymer processing technology and equipment.
10. Details of the Course:

S.No.	Contents	Contact Hours
1.	**Introduction:** Introduction and Overview of Polymer Processing and equipment for Processing.	2
2.	**Handling, Transportation, Mixing & Pumping**: Agglomeration; Bins and hoppers; Compaction, flow, melting, heat source, sintering, effects of drag, pressure and deformation, pumps and their types. Mixing equipment; Characterization and distribution devolatalization equipment: mechanism and principles.	5
3.	**Compounding & Mixing:** Introduction to methods of compounding; Intensive dry mixers; Batch and internal mixers; Methods of mixing; Mechanism of mixing; Mixing variables; Blade mixers; High-speed mixer. Operating principles, modern machines and applications. Continuous mixer, two roll mill and pelletizers; Underwater pelletizer; Screw mixers; Kneading and granulating equipment.	8
4.	**Extruders Extrusion and Reactive Processing:**: General features of single and twin screw extruders; Constructional features of dies; Mechanism of screw extrusion; Effects of screw and die design; Breaker and screeches and quality of extrudates co-rotating and counter rotating twin screw extruder. Principles of reactive extrusion, reactor classification, mixing of multicomponent miscible, immiscible and compatible systems.	8
5	**Molding**: Working principles of injection molding machine; Temperature control; Injection systems: starting and shut down procedures and process variables reaction injection molding. Process, principles, Machine descriptions, principles of operations and molding parameters; Optimization of processing parameters and troubleshooting; Common molding faults and their correction; Types of product processing technology.	8
6	**Miscellaneous Processing Technologies:** Principles and operations of rotational molding; Calendaring; Calender roll temperature control; Calendar configuration and operations; Roll deflection and methods of correction; Casting, thermoforming, and foam processing machines and processing of plastic products by these processes.	6

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7	**Tooling and Molds:** Tool making processes; Die and die forming; Compression molds; Transfer molds; Blow and extrusion dies; Typical exercises in mold design and production; Two plate mold; Three plate mold; Hot runner mold; Insulated runner mold; Runners, gates; Mold making; Mold cooling.	5
	Total	**42**

List of Practical:

1. Processing of polymer by mini mixer rheocord.
2. Handling, transportation, mixing and pumping in a single screw extruder.
3. Compounding a polymer in a single screw extruder.
4. Processing a polymer in a batch mixer.
5. Processing a polymer in an internal mixer.
6. Compounding a polymer in a twin screw extruder.
7. Processing a polymer in a twin screw extruder.
8. Processing a polymer in a continuous mixer.
9. Processing a polymer in a two roll mill.

11. Suggested Books:

S.No.	Name of Authors / Books / Publisher	Year of Publication / Reprint
1.	Chan R., Hassen P. and Kramer E., "Processing of Polymers", Wiley-VCH	1996
2.	Griskey R., "Polymer Process Engineering", Chapman & Hall	1992
3.	Grulke E., "Introduction to Polymer Process Engineering", Printice Hall.	1993
4.	McCrum N.G., "Principles of Polymer Engineering", Oxford University Press	1988
5.	Osswald T., "Polymer Processing Fundamentals", Hanser-Gardner	1998
6.	Tadmor Z. and Gogos C.G., "Principles of Polymer Processing", Wiley.	2000

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PE-413** Course Title: **Process System Analysis and Control**

2. Contact Hours: **L: 3 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: **4** 6. Semester: **Autumn** 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.	**Modes of Control Action:** P, PI, PD and PID controllers; Feed-forward, feedback, cascade and ratio control systems.	5
3.	**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
4.	**Stability Analysis:** Routh Hurwitz stability criterion; Root locus technique.	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:** Block diagram and architecture of pneumatic, 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; Introduction to advanced control systems.	8
	Total	**42**

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11. Suggested Books:

S.No.	Name of Books / Authors	Year of Publication
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.	Johnson C.D., "Process Control Instrumentation Technology", 7th Ed., Prentice Hall of India.	2005
4.	Kant K., "Computer Based Industrial Control", Prentice Hall of India.	2005
5.	Seborg D.E., Edgar T.F. and Mellichamp D.A., "Process Dynamics Control", 2nd Ed., John Wiley & Sons.	2008
6.	Stephanopoulos G., "Chemical Process Control- An Introduction to Theory and Practice", Prentice Hall of India.	2008

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PE- 415** Course Title: **Functional Polymers**

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: **Polymer Chemistry**

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

10. Details of Course:

Sl. No	Contents	Contact Hours
1.	**Introduction:** General introduction to Functional Polymers: Conducting, electronic, bio-polymers and energy storage polymers	4
2.	**Different Kinds of Functional Polymers:** Synthesis and Characterization of different functional polymers *viz.* Block copolymers, Self-assembled polymers, Dendrimers, Hyperbranched Polymers and Organo gels.	3
3.	**Polymers for Energy Storage:** Structure, properties of Polymers used in energy storage, Principal of energy storage: Li-ion batteries, supercapacitors and fuel cell. Mechanism of ion conduction and diffusion in Polymers.	5
4.	**Lithium Polymer Electrolytes:** Metal-polymer interaction; Solid-solid Interfacing; Types of polymer electrolytes (Gel, Glass, Ceramic and Polymer composite) and properties; Electrochemical stability; Electrochemical characterization by cyclic voltammetry and electrochemical Impedance spectroscopy.	6
5.	**Polymers for Solar Cell:** Solar cell: Principles and design; Application of polymer electrolyte in dye sensitized solar cell; Nano-composite polymer Electrolytes: Synthesis and characterization of dye sensitized polymer electrolyte.	5
6.	**Functional Polymers in Food Science:** Functional polymeric membrane in Agriculture; Interaction of synthetic polymers with bio molecules during food processing; Antioxidant Polymers: Engineered Materials as Food Preservatives and Functional Foods.	5
	Total	**28**

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11. Suggested Books:

S. No	Name of Authors/ Books/ Publisher	Year of publication / Reprint
1.	Brydson J.A., "Plastic Materials", Butterworth-Heinemann	1999
2.	Theato P., Klok H.N, "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, Scriviner Publishing	2014
4.	Bergbreiter D.E and Martin R., "Functional Polymers", Springer	1989

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PE-417** Course Title: **Rubber and Elastomer Technology**
2. Contact Hours: **L: 2 T: 0 P: 3/2**
3. Examination Duration (Hrs.): **Theory : 2** **Practical : 3**
4. Relative Weightage: **CWS : 15** **PRS : 15** **MTE L 15** **ETE : 40** **PRE: 15**
5. Credits: **3** 6. Semester: **Autumn** 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.	**Natural Rubber**: Rubber separation process: Structure and properties; Theory of mastication and mechanochemistry; Modification by epoxidation; Diene-based rubbers monomers.	**3**
2	**Homopolymer and Copolymer Rubbers**: Isomerism, methods of synthesis, structure and properties; Cross-linking mechanism; Chloroprene and butyl rubber polymerization.	**5**
3	**Other Elastomers**: Ethylene-propylene rubbers; Chlorinated and fluorinated rubbers; Acrylic rubbers; Polyesters; Silicones; Polyurethanes and thermoplastics elastomers.	**5**
4	**Compounding of Rubber and Elastomers:** Process and principles; Reinforcing and nonblack (loading type) fillers; Other compounding ingredients.	**6**
5.	**Vulcanization and Mastication:** Principles and theory; Sulphur and its role in vulcanization; Technology of vulcanization.	**6**
6.	**Applications**: Latex; Tyre and other applications.	**3**
	Total	**28**

List of Practicals:

1. Processing of rubber in a two roll mill.
2. Processing of rubber with carbon black filler.
3. Processing of rubber with non black loading type filler.
4. Compounding of rubber with ingredients.
5. Vulcanization of rubber.
6. Mastication of rubber.
7. Mechanical properties of vulcanized rubber.

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11. Suggested Books:

S.No.	Name of Authors /Books/Publishers	Year of Publication / Reprint
1.	Johnson P., "Rubber Processing: An Introduction", Hanser-Gardner.	2001
2.	Mark J.E., Erman B. and Eirich F.R., "Science & Technology of Rubber", Elsevier.	2003
3.	Morton M., "Rubber Technology", Van Norstrand-Reinhold.	1987

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: PE-421 Course Title: Advanced Polymeric Composites

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: PEC

8. Pre-requisite: Nil

9. Objective: The course will impart knowledge of advanced composites for high-tech applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** High Tech polymeric composites in modern engineering.	2
2.	**Particulate Filled Polymeric Composites:** Principles and parameters for selection of a filler and a particulate reinforcement; Coupling agents for improving particle/polymer adhesion; Incorporation, packing, and distribution of particle in composite for isotropy and anisotropy; Processing of isotropic and anisotropic particulate/polymer composites; Advanced engineering applications.	6
3.	**Short Fiber Reinforced Polymeric Composites:** Fiber selection, orientation and reinforcement efficiency of short fibre; Fibre length and fibre length distribution; Compatibilizer, matrix modification and fiber treatment to improve fibre/polymer interactions and interfacial adhesion; Processing parameters to impart isotropy or anisotropy and uniform fibre distribution; Effect of fibre on crystallization of matrix in composites; Advanced engineering applications.	6
4.	**Continuous Fiber Reinforced Thermoset Composites:** Phenolic and polyimides as matrix resins thermoset composites; Surface modification and treatment of continuous glass and carbon fibres for improvement of fibre/thermoset adhesion; Forms of fibres: woven, non woven and mat forms of fibres; Processing of continuous fibre/ thermoset composites by advanced techniques- pultrusion, filament winding, dough sheet and bulk molding, autoclaving; Advanced engineering applications	7
5	**Continuous Fiber Reinforced Thermoplastic Composites:** Polyetherimide and polyetheretherketone as matrix resins for the composites; Improvement of fibre/thermoplastic matrix adhesion;	4

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	Processing of long continuous fibre/thermoplastic composites; Structure and morphology of the composites; Engineering and potential advanced applications.	
6.	**Nano Composites:** Fillers: Plate, equi-axed, inorganic fillers, carbon and other nano tubes; Matrices: Engineering, high tech and liquid crystal polymer matrices; Processing: Direct, solution mixing and in-situ polymerization.	3
	Total	**28**

11. Suggested Books:

S.No.	Name of Books / Authors / Publisher	Year of Publication / Reprint
1.	Ajayan P. M., Schadler L. S. and Braun P. V., "Nanocomposite Science and Technology", Wiley-VCH.	2003
2.	De S. and White J., "Short Fiber Composites", Technomic.	1996
3.	Palsule S., "Polymer Composites", New Age International.	2008
4.	Summerscales, J. and Short D., "Fiber Reinforced Polymers", Technomic.	1988

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PE-423** Course Title: **Computational Polymer Science**

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: **PEC**

8. Pre-requisite: **Nil**

9. Objective: Knowledge of procedures of molecular modeling and simulations and their applications for polymers

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Molecular Simulations Overview:** Concept of molecular simulations and their applications; Polymer Chain Conformations: models for polymer chains- Random walk/random flight, freely jointed/freely rotating; The Gaussian Chain; Chain Conformation under an External Field; Excluded Volume Effect and Theta Condition; Bead-spring model for a polymer; Rouse theory; Hydrodynamic interactions and the Zimm model; Concentrated polymer solutions and melts; Polymer Entanglement and Tube/Reptation theory.	6
2	**Procedures for Simulating Isolated and Melt Chains–** 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
3.	**Coarse-grain Modeling:** General Concepts of Coarse-graining and procedure with examples and advantages; Dissipative Particle Dynamics and other mesoscale techniques.	3

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4.	**Dynamic Properties Estimation**– 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.	5
5	**Scope of Molecular Simulation Software Packages:** Software package, such as DLPOLY, LAMMPS, Material studio, Z-code; Applications to solve polymer design problems; Examples to understand entanglement length variation with chain length, to determine characteristic static and dynamic properties (tube diameter (a_{pp}), entanglement/contour length, etc) of some commodity polymers such as PE, PET; Applications of molecular simulations to solve practical polymer product design problems in coatings and adhesives industry.	4
6	**Modeling of 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.	4
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication / Reprint
1	Flory P.J, "Statistical Mechanics of Chain Molecules", Interscience, New York.	1989
2	Mattice W. L. and Suter U. W., "Conformational Theory of Large Molecules: The Rotational Isomeric State Model in Macromolecular Systems", Interscience, New York.	1994
3	Flory P.J, "Principles of Polymer Chemistry", Cornell University Press, Ithaca, NY.	2015
4	Frenkel D. and Smit B., "Understanding Molecular Simulation: From Algorithms to Applications", Academic Press: San Diego.	1996
5	Treloar L.R.G., "The Physics of Rubber Elasticity", Clarendon Press, Oxford.	1975
6	Doi M. and Edwards S.F., "The Theory of Polymer Dynamics", Oxford Science Publications, Clarenden Press, Oxford.	1986

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PE- 425** Course Title: **Polymers for Smart and Memristive Materials**

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: PEC

8. Pre-requisite: **Electronic and Conducting Polymers**

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

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	**Introduction:** Definition of memeristive and smart materials and their classification; Class of polymers having these properties.	2
2.	**Memristive Materials: Electrical Memory Switching Polymers:** Volatile memory & Non-volatile memory: definition and classification; I-V characteristics; Capacitor, transistor, memristor, reversibility and memory sustaining capability.	4
3.	**Memristive Devices with Different Polymeric Materials:** Organic devices; Inorganic devices; Metal doped organic devices; Organic-metallic hybrid devices; Switching and carrier transport mechanism; Shape Memory Polymers: definition, classification and application.	4
4.	**Smart Materials:** Chromogenic Systems: (a) Electrochromic materials and their application in e-paper, smart glass window, display; Different types of electrochromic materials: their advantages and disadvantages; (b) Photochromic materials: definition, classification and application; (c) Halochromic Materials: definition, classification and application; (d) pH-sensitive Material: definition, classification, application; (e) Self-healing Materials: definition, classification and application; (f) Piezoelectric Materials: definition, classification and application.	8
5.	**Manufacturing Methods and Characterization of Smart and Memristive Materials:** Synthetic procedure for different polymers; Characterization, advantages and disadvantages; Device Characterization: Characterization by AFM and SEM techniques.	4
6.	**Device Fabrication Techniques and Characterization of Device:** Memristive device: sandwich and lateral devices; Advantages and disadvantages; Smart materials: electrochromic	4

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: PE- 427 Course Title: High Performance Polymers

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: 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	**Advanced Thermoplastics**: Study of semi-rigid and rigid molecular structure and properties governing high technology applications of following advanced thermoplastics- polyamides, polyesters, polycarbonates, polyethers.	8
2	**High Performance Thermoplastics**: Study of semi rigid and rigid molecular structure and properties governing high technology applications of following advanced thermoplastics- poly-ether-ether-ketone, polyphenylene sulphide, polysulphones, polyphenylene-oxides.	8
3	**Advanced High Performance Polyimides:** Study of semi rigid and rigid molecular structure and properties governing high technology and high temperature applications of following - poly-amide-imide, polyimides, including polyesterimides, polyetherimides, polybismelimides, ptomellitic-di-anhydride-oxydianiline.	8
4	**Liquid Crystalline and Fibre and Film Forming Polymers:** Influence of semi rigid molecular structure of polymers on liquid crystalline nature and their structure-property co-relations governing their high tech applications; Structure and properties governing applications of polymers for advanced fibres and films.	4
	Total	**28**

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", Hänser Gardner.	2001

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-351** Course Title: **Transport Phenomena**

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

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

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

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

8. Pre-requisite: Nil

9. Objective: To provide knowledge of Cell balances in steady/unsteady state transport processes involving momentum, energy, mass.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Introduction:** Preliminaries from mathematics: differential equations, partial differential equations and common solution techniques.	04
2.	**Fluid Mechanics (Isothermal Systems):** Shell balances and velocity distributions in laminar flow; Axial tube flow of adjacent immiscible liquids; Interfacial B.C's; Flow through a slit (math. approx.); Interrelationship between slit and annulus.	06
3.	**Equation of Change for Isothermal Systems:** Equation of Continuity; Substantial derivative; Equation of motion; Navier Stokes equation; Creeping flow; Lubricating flows; Application of Newtonian and non-Newtonian; Cone and plate viscometer.	08
4.	**Energy Transport and Heat Transfer:** Energy generalized balance and heat equation; Conductivities and heat capacities; Temperature and Pressure dependence of conductivity; Convection; Shell balances, applications and temperature distribution in solids and fluids; Heat conduction with viscous source and chemical heat source; Forced convection.	06
5.	**Equation of Change for Non-isothermal Systems:** Special forms of heat equation; Bossiness equation for forced and free convection; Application of steady state (SS) problems; Pure fluids in terms of fluxes; Boundary layer theory for Non-isothermal flow; Laminar flow heating-Von Karman, Von Karman integral method.	06
6.	**Mass Transport:** Mass transfer by convection; Molar fluxes; Ficks law; Diffusion in binary liquids and gases at low density; Multi-component diffusion in gases at low density; Corrections for higher density; Concentration distributions in solids; Shell balances, BC's;	06

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	Examples of diffusion into falling liquid film, gas absorption with chemical reaction in an agitated tank.	
7.	**Equations of Change**: Continuity for multicomponent mixture-reduction to various cases: species continuity, constant mass density case, constant molar density case and binary systems with constant D_{AB} with zero velocity; Examples of situation with simultaneous diffusion, convection and chemical reaction; Steady-state boundary layer theory for diffusion with flow around objects.	06
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors / Publishers	Year of Publication / Reprint
1.	Bird R.B., Stewart W.E. and Lightfoot E.N., Transport Phenomena McGraw Hill Second Edn.	2002
2.	Deen W.M., Analysis of Transport Phenomena, Oxford University Press.	1998
3.	Whitaker, S., Fundamental Principles of Heat Transfer, Pergamon	1997

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-353** Course Title: **Process Instrumentation 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: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge about process control systems and instruments used for measurement of process parameters in any process industry.

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.	2
2.	**Modes of Control Action:** P, PI, PD and PID controllers; Feed-forward, feedback, cascade and ratio control systems.	4
3.	**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.	4
4.	**Stability Analysis:** Routh Hurwitz stability criterion; Root locus technique.	5
5.	**Frequency Response Analysis:** Frequency response; Control system design by frequency response; Bode plots; Gain and phase margin.	5
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.	6
7.	**Advanced Control Strategies with Process Industry Examples:** Cascade Control; Feed-forward Control; Dead-Time Compensation and Internal Model Control; Adaptive and Predictive Control; Introduction to Multi-variable Control and Theoretical Analysis of Complex processes such as Steam-Jacketed Kettle, Absorber, Double-pipe heat exchanger	6
8	**Instrument Characteristics:** Static and dynamic characteristics of instruments; Instrument characteristics such as accuracy, precision, sensitivity, reproducibility, drift, threshold, hysteresis, resolution, repeatability and stability;	3

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	Principles of measurement of process parameters.	
9.	**Process Parameter Measurement Instruments:** Pressure measurement instruments: manometers, diaphragm gauges bellows and Bourden gauge; Vacuum pressure measurements: Mcleod, Pirani and Knudsen gauge; Temperature measurements: thermal expansion methods, bimetallic thermometer, Resistance thermometers, Radiation thermometers and optical pyrometers; Differential pressure flowmeters: Pitot tube, orifice, Venturi, flow nozzle, rotameter, etc.	7
	Total	**42**

List of Practicals:

1. To verify first order characteristics of mercury thermometer, and determine its time constant.
2. To verify the first order characteristics of an RC circuit, and determine its time constant.
3. To verify the characteristics of a second order *non-interacting system*, and determine its process parameters.
4. To verify the characteristics of a second order *interacting system*, and determine its process parameters.
5. To understand control actions of P, PI, PID controlling actions using a temperature control trainer
6. To understand control actions of P, PI, PID controlling actions using a level control trainer
7. To understand control actions of P, PI, PID controlling actions using a flow control trainer
8. To understand the valve characteristics of a linear control valve, equal % valve and quick opening valve.

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication
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.	Johnson C.D., "Process Control Instrumentation Technology", 7th Ed., Prentice Hall of India.	2005
4.	Seborg D.E., Edgar T.F. and Mellichamp D.A., "Process Dynamics Control", 2nd Ed., John Wiley & Sons.	2008
5.	Stephanopoulos G., "Chemical Process Control- An Introduction to Theory and Practice", Prentice Hall of India.	2008
6.	Eckman, D.P., "Industrial Instrumentation", Wiley	2006

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PEN-355** Course Title: **Modeling and Simulation**

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

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

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

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

8. Pre-requisites: **Nil**

9. Objective: To provide comprehensive view of modeling and simulation of chemical process systems.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Introduction to Process Modeling and Simulation:** Steps for problem solving.	3
2.	**Review of Mathematical Methods for Solving Process Engineering Models**: Mathematical forms, their analytical and numerical techniques.	4
2.	**Models and their Classifications**: Transport phenomena; Population balance, stochastic, and empirical models; Examples from unit operations related to chemical and Biochemical processes.	10
3.	**Development of Steady State and Dynamic Models of Chemical Process**: Operations and equipments involving fluid flow; Heat exchangers; Evaporators; Equipments based on mass transfer with or without chemical reactions, viz. columns, absorption towers, reactors, crystallizers.	10
4.	**Simulation of Process Equipment and Systems**: Program development and numerical solution through MATLAB	10
5.	**Introduction to Chemical Process Flow sheeting and Industrial Simulators**.	5
	Total	42

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11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication
1.	Denn M.M., “Process Modeling”, Longman Press.	1986
2.	Gordon G., “System Simulation”, 2nd Ed., Prentice Hall of India.	2008
3.	Law A.M. and Kelton W.D., 4th Ed., “Simulation Modeling and Analysis”, Tata McGraw Hill.	2008
4.	Luyben W.L., “Process Modeling Simulation and Control for Chemical Engineers”, 2nd Ed., McGraw Hill.	1990

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Appendix-I

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **IBM-311** Course Title : **Operations and Supply Chain 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: **PEC**
8. Pre-requisite: **Nil**
9. Objective: The course is designed to explain and evaluate the current thinking in operations and supply.
10. Details of the Course:

Sl.No.	Contents	Contact Hours
1	Introduction to the field, operations and supply chain strategy, project management, product and service design, case study	8
2	Strategic capacity management, process analysis, manufacturing process, facility layout, service process, waiting line analysis, six-sigma quality, case study	8
3	Logistics and facility location, designing the supply chain network, supply chain coordination, service supply chain, case study	8
4	Enterprise resource planning systems, demand management and forecasting, aggregate sales and operations planning, inventory control, material requirement planning, scheduling, simulation, constraints management, case study	10
5	Lean supply chain management, supply chain information systems and electronic commerce, supplier evaluation and selection, supply chain performance measurement, case study	8
	Total	42

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11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1	Richard B. Chase, Ravi Shankar, F. Robert Jacobs, Nicholas J. Aquilana, "Operations and Supply Chain management", 12 Edition, Tata McGraw-Hill	2010
2	Sunil Chopra and Peter Meindel, "Supply Chain Management: Strategy, Planning, and Operations", Pearson India	2012
3	Krajewski, "Operations Management : Processes and Supply Chains", Pearson India English), 9th Edition	2011
4	Ronald H. Ballou and Samir K Srivastav, "Business Logistics/Supply Chain Management", Pearson	2014

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code : **BMN-612** Course Title: **Financial Engineering & Risk 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 : **PEC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge on various aspects of financial risk management and provide exposure to the tools and techniques of financial engineering for design of new financial products.
10. Details of Course:

S.No.	Contents	Contact Hours
1.	Introduction to the various measures of financial risk and their mathematical and statistical properties.	6
2.	Financial products for hedging / risk management and the risk-return trade-off embedded therein. Payoff profiles of these instruments. Trading strategies.	5
3.	Option Greeks and their relevance in risk management	4
4.	Management of interest rate risk: instruments and strategies	5
5.	Concept of volatility in financial management. Measurement & management of volatility	5
6.	Value at risk: measurement and application by financial institutions and banks for portfolio optimization.	6
7.	The BASEL Accords	5
8.	Basic knowledge of credit risk and operational risk in relation to banks and financial institutions.	6
	Total	42

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11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Hull, John, C., "Risk Management & Financial Institutions", Wiley Finance	2012
2.	Neftci, Salih, N. "Principles of Financial Engineering", Academic Press	2008
3.	Saunders, Anthony & Cornett, Marcia Millon, "Financial Institutions Management: A Risk Management Approach" McGraw Hill/Irwin	2008
4.	Marshall, John, F & Bansal, Vipul, "Financial Engineering" PHI Learning	1992
5.	Cuthbertson, Keith & Nitzsche, Dirk, " Financial Engineering: Derivatives & Risk Management" John Wiley	2001

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DEPARTMENT OF POLYMER & PROCESS ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Program Code: 41 M.Tech. (Polymer Science & Engineering)
Department: PE Department of Polymer & Process Engineering
Year: I

S. No.	Subject Code	Course Title	Subject Area	Credits	Contact Hours/Week L	T	P	Exam Duration Theory	Practical	Relative Weight (%) CWS	PRS	MTE	ETE	PRE
		Semester- I (Autumn)												
1.	PEN-501	Macromolecular Chemistry and Physics	PCC	5	3	1	2	3	-	15	25	20	40	-
2.	PEN-503	Polymeric Materials	PCC	3	3	0	0	3	-	25	-	25	50	-
3.	PEN-505	Polymer Rheology	PCC	4	3	1	2/2	3	-	20	20	20	40	-
4.		Program Elective-I	PEC	4	3	1	0	3	-	25	-	25	50	-
5.		Program Elective-II	PEC	3	3	0	2/2	3	-	20	20	20	40	-
		Total		19	15	4	4							
		Semester-II (Spring)												
1.	PEN-502	Advanced Characterization Technique of Polymers	PCC	4	3	1	2/2	3	-	20	20	20	40	-
2.	PEN-504	Polymer Blends and Composites	PCC	4	3	1	2/2	3	-	20	20	20	40	-
3.	PEN-700	Seminar	SEM	2	0	0	2	-	-	-	-	-	100	-
4.		Programe Elective-III	PEC	3	3	0	0	3	-	25	-	25	50	-
5.		Programe Elective-III	PEC	3	3	0	0	3	-	25	-	25	50	-
6.		Programe Elective-III	PEC	3	3	0	0	3	-	25	-	25	50	-
		Total		19	15	2	2							

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DEPARTMENT OF POLYMRER & PROCESS ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Program Code: 41 **M.Tech. (Polymer Science & Engineering)**
Department: PE **Department of Polymer & Process Engineering**
Year: II

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
Semester- I (Autumn)														
1.	PEN-701A	Dissertation Stage–I (to be continued next semester)	DIS	12	-	-	-	-	-	-	50	-	-	50
		Total		12										
Note: Students can take 1 or 2 audit courses as advised by the supervisor, if required.														
Semester-II (Spring)														
1.	PEN-701B	Dissertation Stage–II (contd. From III semester)	DIS	18	-	-	-	-	-	-	50	-	-	50
		Total		18										

Summary				
Semester	1	2	3	4
Semester-wise Total Credits	19	19	12	18
Total Credits	68			

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Program Elective Courses M.Tech. (Polymer Science & Engineering)

S. No.	Subject Code	Course Title	Subject Area	Credits	Contact Hours/Week L	Contact Hours/Week T	Contact Hours/Week P	Exam Duration Theory	Exam Duration Practical	Relative Weight (%) CWS	PRS	MTE	ETE	PRE
		Program Elective-I Autumn Semester												
1.	PEN-511	Advanced Engineering Mathematics	PEC	4	3	1	0	3	-	25	-	25	50	-
2.	PEN-513	Design of Experiments	PEC	4	3	1	0	3	-	25	-	25	50	-
3.	PEN-515	Advanced Numerical Methods	PEC	4	3	1	0	3	-	25	-	25	50	-
4.	PEN-517	Advanced Optimization Techniques	PEC	4	3	1	0	3	-	25	-	25	50	-
		Program Elective-II Autumn Semester												
5.	PEN-521	Rubber Product Manufacturing	PEC	3	3	0	2/2	3	-	20	20	20	40	-
6.	PEN-523	Advanced Polymeric Coatings	PEC	3	3	0	2/2	3	-	20	20	20	40	-
7.	PEN-527	Polymer Degradation & Stability	PEC	3	3	0	2/2	3	-	20	20	20	40	-
8.	PEN-529	Tissue Engineering	PEC	3	3	0	2/2	3	-	20	20	20	40	-
9.	PEN-531	Polymer Reaction Engineering	PEC	3	3	0	2/2	3	-	20	20	20	40	-
10.	PEN-533	Advanced Polymer Rheology	PEC	3	3	0	2/2	3	-	20	20	20	40	-
		Program Elective-III Spring Semester												
11.	PEN-512	Polymer Processing	PEC	3	3	0	0	3	-	25	-	25	50	-
12.	PEN-514	Advanced Aerospace Polymeric Materials	PEC	3	3	0	0	3	-	25	-	25	50	-
13.	PEN-516	Modeling and Simulation of Polymers	PEC	3	3	0	0	3	-	25	-	25	50	-
14.	PEN-522	Polymer for Packaging	PEC	3	3	0	0	3	-	25	-	25	50	-
15.	PEN-524	Adhesive Science & Technology	PEC	3	3	0	0	3	-	25	-	25	50	-
16.	PEN-526	Advanced Functional Polymers	PEC	3	3	0	0	3	-	25	-	25	50	-
17.	PEN-528	Advanced Polymer Composites	PEC	3	3	0	0	3	-	25	-	25	50	-
18.	PEN-530	Polymer Crystallization	PEC	3	3	0	0	3	-	25	-	25	50	-
19.	PEN-532	Bio-medical applications of Polymers	PEC	3	3	0	0	3	-	25	-	25	50	-
20.	PEN-536	Polymeric Membrane Technology	PEC	3	3	0	0	3	-	25	-	25	50	-
21.	PEN-538	Fiber Science and Technology	PEC	3	3	0	0	3	-	25	-	25	50	-
22.	PEN-540	Polymer Nanocomposites	PEC	3	3	0	0	3	-	25	-	25	50	-
23.	PEN-542	Advanced Polymer Blends	PEC	3	3	0	0	3	-	25	-	25	50	-

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Appendix 'K'
Item No. Senate/60.17

Appendix-K

DEPARTMENT OF BIOTECHNOLOGY
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

M.Tech. (Bioprocess Engineering)

Duration: 2 years (Four Semesters)

S.No.	Course Components	Proposed Credits
1.	Program core courses (including course on Advanced mathematical and modeling and simulation, if required)	18
2.	Program Elective Courses	20
3.	Seminar	2
4.	Dissertation stage I	12
5.	Dissertation stage II	18
	Total	**70**

Eligibility: B.E./B.Tech. or equivalent degree in Biochemical Engineering/Bioprocess Engineering, Chemical Engineering, Chemical Technology, Food Technology, Agricultural Engineering, Biomedical Engineering, Bioengineering, Biotechnology or in allied field.

Necessary Requirements: a) Percentage marks and/or CGPA etc. at B.E./B.Tech. or equivalent degree level must be as per Institute's criterion. D) Candidate must qualify GATE Examination.

Process of Admission: The students who will fulfill minimum eligibility and necessary requirement criterion, a screening criterion will be fixed by the department for sending Interview call letter. Interview will be two tier process: a) a written examination will be conducted; b) those will be passing through the written test a viva will be conducted for final selection.

Total number of seat: 15

M.Tech. (Bioprocess Engineering) degree requirement: Total credit point requirement: 70, CGPA requirement: 5.5

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DEPARTMENT OF BIOTECHNOLOGY
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Program Code: XX M.Tech. (Bioprocess Engineering)
Department: BT Department of Biotechnology
Year: I

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
		Semester- I (Autumn)												
1.	MA-501F	Numerical Methods, Statistics and Probability	PCC	4	3	1	-	3	-	25	-	25	50	-
2.	BTN-531	Bioreaction Engineering	PCC	4	3	1	-	3	-	25	-	25	50	-
3.	BTN-532	Downstream Processing	PCC	4	3	1	-	3	-	25	-	25	50	-
4.		Program Elective I	PEC	4	3	1	-	3	-	25	-	25	50	-
5.		Program Elective II	PEC	4	3	1	-	3	-	25	-	25	50	-
		Total		**20**										
		Semester-II (Spring)												
1.	BTN-533	Bioreaction Theory and Analysis	PCC	4	3	1	-	3	-	25	-	25	50	-
2.	BTN-534	Bioprocess Engineering Laboratory	PCC	2	-	-	4	-	-	0	50	0	0	50
3.	BTN-700	Seminar	PCC	2	-	-	-	-	-	-	-	-	100	-
4.		Programme Elective –III	PEC	4	3	1	-	3	-	25	-	25	50	-
5.		Programme Elective –IV	PEC	4	3	1	-	3	-	25	-	25	50	-
6.		Programme Elective –V	PEC	4	3	1	-	3	-	25	-	25	50	-
		Total		**20**										

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DEPARTMENT OF BIOTECHNOLOGY
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Program Code: XX **M.Tech. (Bioprocess Engineering)**
Department: BT **Department of Biotechnology**
Year: II

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
Semester- I (Autumn)														
1.	BTN-701A	Dissertation Stage I	DIS	12	-	-	-	-	-	-	-	-	40	-
		Total		12										
Semester-II (Spring)														
1.	BTN-701B	Dissertation Stage II	DIS	18	-	-	-	-	-	-	-	-	60	-
		Total		18										

Summary				
Semester	1	2	3	4
Semester-wise Total Credits	**20**	**20**	**12**	**18**
Total Credits	70			

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Program Elective Courses (M.Tech. (Bioprocess Engineering)

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
		Program Elective I												
1.	BTN-651	Microbiology and Biochemistry	PEC	4	3	-	-	3	-	25	-	25	50	-
2.	BTN-652	Property of Biomolecules	PEC	4	3	-	-	3	-	25	-	25	50	-
3.	BTN-653	Biomaterials and Bionanaotechnology	PEC	4	3	-	-	3	-	25	-	25	50	-
4.	BTN-654	Thermodynamics of Biological System	PEC	4	3	-	-	3	-	25	-	25	50	-
5.	BTN-655	Reaction Kinetics and Reactor Design	PEC	4	3	-	-	3	-	25	-	25	50	-
		Program Elective II												
1.	BTN-656	Molecular Genetics	PEC	4	3	-	-	3	-	25	-	25	50	-
2.	BTN-657	Recombinant DNA Technology	PEC	4	3	-	-	3	-	25	-	25	50	-
3.	BTN-658	Advanced Transport Process	PEC	4	3	-	-	3	-	25	-	25	50	-
4.	BTN-659	Bioprocess Calculations	PEC	4	3	-	-	3	-	25	-	25	50	-
5.	BTN-660	Chemical Reactor Theory and Analysis	PEC	4	3	-	-	3	-	25	-	25	50	-
		Program Elective III												
1.	BTN-661	Plant Cell Technology	PEC	4	3	-	-	3	-	25	-	25	50	-
2.	BTN-662	Animal Cell Technology	PEC	4	3	-	-	3	-	25	-	25	50	-
3.	BTN-663	Protein Engineering	PEC	4	3	-	-	3	-	25	-	25	50	-
4.	BTN-664	Computational Biology	PEC	4	3	-	-	3	-	25	-	25	50	-
5.	BTN-665	Bioprocess Optimization	PEC	4	3	-	-	3	-	25	-	25	50	-
6.	BTN-666	Bioprocess Integration	PEC	4	3	-	-	3	-	25	-	25	50	-
		Program Elective IV												
1.	BTN-667	Heat Transfer Operation and Design	PEC	4	3	-	-	3	-	25	-	25	50	-
2.	BTN-668	Mass Transfer Operation and Design	PEC	4	3	-	-	3	-	25	-	25	50	-
3.	BTN-669	Bioprocess Equipment Design	PEC	4	3	-	-	3	-	25	-	25	50	-
4.	BTN-670	Bioprocess Economics and Plant Design	PEC	4	3	-	-	3	-	25	-	25	50	-
5.	BTN-671	Computational Fluid Dynamics	PEC	4	3	-	-	3	-	25	-	25	50	-
		Program Elective V												
1.	BTN-672	Bioprocess Dynamics and Control	PEC	4	3	-	-	3	-	25	-	25	50	-
2.	BTN-673	Industrial Safety and Regulations	PEC	4	3	-	-	3	-	25	-	25	50	-

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3.	BTN-674	Biotech Recourses Planning and IPR Issues	PEC	4	3	-	-	3	-	25	-	25	50	-
4.	BTN-675	Biological Waste Treatment	PEC	4	3	-	-	3	-	25	-	25	50	-
5.	BTN-676	Metabolic Regulations and Engineering	PEC	4	3	-	-	3	-	25	-	25	50	-

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Ph.D. Admission Rules

PREAMBLE

Indian Institute of Technology (I.I.T.) Roorkee offers academic programmes leading to the award of Ph.D. degree through its Departments/Centres. The award of Ph.D. degree is in recognition of high academic achievements, independent research and application of knowledge to the solution of technical and scientific problems in Science, Technology, Architecture & Planning, Humanities & Social Science and Management; creative and productive inquiry is the basic concept underlying the research work.

The academic programme leading to the Ph.D. degree is broad-based and involves a prescribed course credit requirement and a research thesis. The institute also encourages interdisciplinary areas through a system of Co-supervision and provides excellent opportunities for such programmes. The institute undertakes sponsored research and development projects from industrial and other organizations in the public as well as private sector.

The degree of Doctor of Philosophy shall be abbreviated as Ph.D. The Degree of Doctor of Philosophy is granted for research work in areas recognized by the Academic Departments/centres of the Institute subject to the conditions and regulations contained hereinafter.

The research work shall be an original work characterized either by the discovery of facts, or by a fresh approach towards the interpretation and application of facts, or development of innovative products and technologies. It shall evince the candidate's capacity for critical examination and sound judgment and shall represent original contribution to the existing knowledge.

The degree of doctor of philosophy (Ph.D.) of the Indian Institute of technology, Roorkee shall be conferred on a candidate who successfully completes all the requirements specified in these ordinances and regulations, which were approved by Board of Governors/Senate.

1. Definitions

(i) "DRC/CRC" shall mean the Research Committee of the Department/Centre.

(ii) "Applicant" shall mean an individual who applies for admission to the Ph.D. programme of Indian Institute of Technology, Roorkee on a prescribed Application Form.

(iii) "IRC" shall mean the Institute Research Committee of Indian Institute of Technology, Roorkee

(iv) "Candidate" shall mean a person registered for the Ph.D. Degree and who has successfully completed the course requirement, the written and oral comprehensive examinations, and has submitted and presented the research plan and approved as per clauses R.5 and R.6 of the Regulations.

(v) "DA" shall mean the Dean, Academics.

(vi) "Research Student" shall mean a person registered for the Ph.D. programme of Indian Institute of Technology, Roorkee before becoming the candidate.

(vii) "Supervisor(s)" shall mean member(s) of the academic staff of the Institute approved by Competent Authority to guide/supervise the research/ academic work of the research student/candidate.

(viii) "Co-supervisor(s)" shall mean member(s) of the academic staff of the Institute or any person from other organization recommended by SRC, DRC, Head of the Department/Centre and approved by Competent Authority to guide/supervise the research/ academic work of the research student/candidate.

(ix) "Caretaker Supervisor" shall mean a member of the academic staff appointed to look after the administrative interests of a research student/candidate in the absence of the Supervisor(s) and after the submission of the thesis, if necessary as per clause R.3.5 of the Regulations.

(x) "Course Work" shall mean courses of study prescribed by the Department/Centre through the Student Research Committee, to be undertaken by a research student registered for the Ph.D. Degree.

(xi) "Degree" shall mean the Degree of Doctor of Philosophy (Ph.D.) of the Indian Institute of Technology, Roorkee.

(xii) "Educational Institution" shall mean those Institutes, which offer Bachelor's or higher Degree.

(xiii) "Institute" shall mean the Indian Institute of Technology, Roorkee (IIT Roorkee).

(xiv) "Full-time Research Student/Candidate" shall mean a person registered for the Ph.D. Degree devoting full time at the Institute for completing the degree requirements.

(xv) "Part time Research Student/Candidate" is a person who is registered for the Ph.D. degree and has been allowed to devote part of his time towards this pursuit.

(xvi) "Registration Period" shall mean the length of time span commencing with the date of initial registration at the Institute.

(xvii) "ODC" shall mean Oral Defence Committee.

(xviii) "Residency" shall mean the minimum period for which a student/candidate must attend the institute.

(xix) "SRC" shall mean Student Research Committee.

(xx) "Sponsored Research Student/Candidate" shall mean a research student/candidate sponsored by an organization /his employer who provides full financial support for doing Ph.D.

(xxi) "Competent Authority" shall mean the Director of IIT, Roorkee or any officer to whom the Director delegates the authority.

NOTE: 'HE' & 'HIS' IMPLY 'HE'/'SHE' AND 'HIS'/ 'HER' RESPECTIVELY.

A.1 ADMISSION CATEGORIES

1. The applicant for admission to the Ph.D. programme shall be classified under any one of the following categories which will be decided and recommended by DRC/CRC.

   (I) Full-time Research student/Candidate

   a) Research student/Candidate getting Institute MHRD assistantship.
   b) Research student/Candidate including foreign nationals getting financial support from Govt. / Semi Govt. agencies (QIP, CSIR, UGC, NET, DAE, DST, DBT, NBHM, ICCR, ICAR, ICMR, GPAT, NDF, INSPIRE etc.)
   c) Research student/Candidate including foreign nationals sponsored by an organization, the applicant (Sponsored Research Student/ Candidate) having TWO years' experience out of which at least ONE year experience with the sponsoring agency at the time of registration for Ph.D. program.
   d) Self-Financed Sponsored Research student/ Candidate

      (i) **Foreign:** Admission of Foreign nationals to Ph.D. programme will be made as per Institute Policy and directions received from Govt. of India from time to time.

      (ii) **Study Leave:** This category refers to persons who are released from governmental or educational institutions on study leave for a period of not less than three years for pursuing Ph.D. programme. They will be admitted along with the regular research students through the usual admission procedure.

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e) *Research student / Candidate regularly working full time in an R&D project at IITR. His Ph.D. topic shall confirm to the project as certified by the SRC.

II) Part-time Research Student/ Candidate:

a) Research student/Candidate working as a regular employee in the Institute

b) * Research student / Candidate working regularly full-time in an R&D project in the institute. The project must have tenure of at least next 1½ years at the time of admission.

c) Research student / Candidate working in other organizations/ institutes, approved by IIT Roorkee as Research Centre or having MoU for research purposes.

*The research student / candidate working in a project will be given full time status, provided his research for Ph.D. is related to the project as certified by the SRC. However, part time research student/candidate may be given full time status when the project tenure is completed.

A.2 ADMISSION ELIGIBILITY

1. An applicant belonging to the above admission categories in clause A.1 should possess the following qualifications in appropriate areas to be eligible to apply for admission for the Ph.D. programme of the Institute.

   a) Masters degree or equivalent in respective discipline with a minimum Cumulative Grade Point Average (CGPA) of 6.50 on a 10 point scale or equivalent as determined by the Institute wherever letter grades are awarded; or 60% marks in aggregate (of all the years/semesters) where marks are awarded, for the GENERAL (UR) category and qualified national level graduate entrance test: GATE/UGC-NET/CSIR-NET or equivalent or holding a national level fellowship. The condition for national level graduate admission test is not applicable to sponsored full-time and part-time research candidates.

   OR

   b) B.Tech. / B.Arch. degree or equivalent in respective discipline from CFTIs with excellent academic record (with a minimum CGPA of 7.00 on a 10 point scale or 75% marks) with GATE.
   Graduates from the IITs getting a CGPA score of 8.00 or above (on scale of 10) would be entitled to the assistantship without having to appear in GATE.

   OR

   The candidates pursuing master's programs in Engineering or Architecture from IIT Roorkee having CGPA of at least 8.50 on a 10 point scale (after first year/ completing all courses) shall have a choice of internal lateral entry in to Ph.D. programme after completing all requirements of the first two semesters of first year of the Master's programme.

2. The admission eligibility requirements may be relaxed to 5.5 on a 10 point scale or equivalent, or to 55% marks to the following categories:
   a. SC/ST candidates with Master's degree or equivalent degree.
   b. Any category of PD (Persons with different abilities) candidate holding Master's degree or equivalent degree.

3. **Eligibility for Part-time Ph.D.**
   a) The applicant possesses the minimum entry qualifications for the degree as given in clause A.2.1;

b) The applicant proves that his official duties permit him to devote sufficient time to research;

c) He / She will be required to reside at the Institute for a period till he/she is admitted for candidacy. (This condition of minimum residency period will be automatically waived for candidates who are working in Roorkee or in Organizations / Institutions located within a distance of 100 km from the Institute).

d) The facility of part time registration will also be available to all employees of the IIT Roorkee or candidates working in organizations having MoU with IITR or organizations approved by IIT Roorkee as Research Centres. Such applicants are exempted from the requirement of having GATE/NET/GPAT.

e) The applicants must have been in continuous service with the sponsoring organization for at least two years at the time of registration.

f) The candidates working in Institute/ University awarding Ph.D degree itself are not eligible for admission as part-time or full-time candidate, if facilities are not available except QIP candidates.

4. Employee seeking admission to the Ph.D. programme with minimum of two years service in an organization or confirmed regular employee shall submit 'No Objection Certificate' from the employer to the effect that the duties allotted by the employer will allow the required time for this pursuit.

5. The candidate seeking admission to Ph.D. programme as project fellow (JRF/SRF) either as full-time or part-time research scholar, shall be allowed to register for Ph.D. in the beginning of the next semester, if the candidate is selected in project as project fellow through proper selection, i.e, proper advertisement of project fellowship and selection by the committee constituted as per Institute rules. The candidate shall register with the PI as supervisor.

   If the candidate is not selected in project through proper advertisement or the candidate wants to switch over to MHRD assistance, he/she has to appear for Ph.D selection along with other candidates provided he/she has 'No-Objection Certificate' from the PI.

   The project fellows shall be allowed to register for Ph.D. only if the remaining period of the project is at least 1½ years at the time of admission. These candidates are also eligible for MHRD assistantship for a maximum period of TWO years once their project is completed provided the essential qualifications for MHRD assistantships are met.The candidate has to apply for MHRD assistantship through SRC.

A.3 RESERVATION

15% (Fifteen percent) of seats are reserved for Scheduled Caste applicants, 7.5% for Scheduled Tribe applicants and 27% for Other Backward Classes. A total of 3% of the sanctioned strength will be reserved horizontally for PD (Persons with different abilities) Applicants in the Ph.D. programme of the Institute put together. The reservation is extended to research students/candidates of reserve categories as per the policy of the Government of India, Ministry of Human Resource Development.

A.4 SHORT LISTING AND SELECTION

1. The short listing of applications for the purpose of admission will be carried out by the DRC/CRC of the concerned department/centre.
2. The DRC/CRC of the concerned department/centre may set the short-listing criteria, if considered necessary, higher than the minimum eligibility criteria defined in clause A.2.
3. The basic guidelines/instructions for short listing and selection are given below:

a) A merit list of all candidates shall be prepared on the basis of UG and PG marks only for short listing the candidates. The list shall include all PG candidates both from IITs and non-IITs. GATE, Inspire, ICAR, ICMR, GPAT or their equivalent shall be considered only as qualifying criteria.

b) Depending on the number of seats, the departments may decide cut-off marks and call the candidates as per institute policy. (i.e, if 'X' is the cut-off marks for GEN category, 0.90*X will be the cut-off for OBC category and (2/3)*X will be the cut-off for SC/ST/PD categories). The departments must ensure that sufficient numbers of candidates from reserved categories are called for admission.

c) All candidates holding bachelor's degree from CFTIs including IITs and NITs having CGPA more than 7.00 on a 10 point scale shall be called, even if they have not done PG but qualified GATE.

d) All candidates holding bachelor's degree from IITs having CGPA more than 8.00 on a 10 point scale shall be called, even if they have not appeared in GATE.

e) All candidates holding master's degree from IITs having CGPA of 8.00 shall be called for interview/written test or both as applicable.

f) The final selection of candidates will be on the basis of either interview only or written test-shortlisted-interview as decided by the departments.

g) If the departments are selecting the candidates only on the basis of interview, department may put a higher cut-off criteria to restrict the number of candidates called for selection. However, all candidates as per point (c) to (e) must be called.

h) If the departments are conducting written test, the candidates are shortlisted on the basis of their performance in written test and only these shortlisted candidates are to be interviewed. The final selection of candidates will be done on the basis of performance both in written test and interview (40% written test + 60% interview).

A.5 DUAL DEGREE (M.TECH. + Ph.D) Programme

A.5.1 <u>General Guidelines</u>

1. This program is applicable only to major Engineering Departments and Department of Architecture and Planning engaged in undergraduate teaching.
2. After completing two semesters of M.Tech. I Year, the students having CGPA more than **8.50** will be given the choice to apply for Ph.D. programme, if he/she desires.
3. The candidate should have been registered for TWO semesters of I Yr of M.Tech. program and successfully completed all courses of I Yr including seminar.
4. Once admitted for Ph.D. program, normal Ph.D. rules, including fellowship, leaves etc., will be applicable.
5. These students will get two degrees both M.Tech. and Ph.D. after successful completion of Ph.D.
6. The students admitted for Ph.D. may have to do extra courses if recommended by SRC to carry out the research work.
7. These students will have to go through comprehensive written and comprehensive oral examination after completing the extra courses, if any.
8. Only after successfully completing the comprehensive examination, the students can present the research proposal.
9. The comprehensive examination and the presentation of research proposal should have been completed within a year from the date of switching over to Ph.D. program
10. These students will not be eligible for campus placement along with M.Tech. students. However, they can appear for campus placement alongwith Ph.D. students.

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11. If the student fails in comprehensive examination, he/she may continue with M.Tech.
12. In case, if a student is asked to leave the Ph.D. program in between due to some reason, after the candidacy, he/she can leave the program with M.Tech. degree only provided he/she submits the work completed till then as M.Tech. dissertation work satisfying the requirement of M.Tech. degree. However, if a student leaves the program on his/her own, he/she will not be entitled for any degree.

A.5.2 <u>Procedure for Switching over to Ph.D.</u>

1. Online application will be invited in the month of May every year. Students aspiring to switchover from M.Tech. to Ph.D. will apply online.
2. The department will constitute a committee to interview the candidates applied for dual degree.
3. The merit list will be prepared considering 40% weight to CGPA and 60% weight to interview and the final selection will be done on the basis of performance both in masters' programme and interview.

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Guidelines for Supervision of Ph.D. Students of Other Institutes/ Universities

A faculty member of IIT Roorkee may supervise and guide Ph.D. students of other institutes/universities subject to following conditions:

a) The host Institution/University is recognized by MHRD-UGC/AICTE or a foreign Institute/University of repute.
b) The request must be forwarded by the competent authority of the host institution.
c) The concerned faculty should have guided/guiding at least one Ph.D. student registered at IIT Roorkee.
d) The total number of such externally enrolled Ph.D. students under any faculty of IIT Roorkee, should not be more than 2 (two) at any point of time.
e) Due to extension of this facility to the host institution, the work of the IIT Roorkee should not suffer.
f) If the concerned faculty of IIT Roorkee, as supervisor of thesis of students of another institute/university is required to visit outside, he/she shall seek specific approval for the visit on Casual Leave/leave as due, by the competent authority and shall not be on duty for the visit. Further, the expenses, facilities etc. in this regard shall not be borne by the IIT Roorkee.
g) If the external candidate wishes to avail the facilities at IIT Roorkee, he/she shall register as casual student for a period not exceeding six months by paying tuition fee being charged from the research student/candidate of IIT Roorkee as per rules and regulations and pay for all other facilities here.
h) The host Institution/University as per regulations appoints a foreigner as one of the examiners for Ph.D. thesis or else it is recognized by IIT Roorkee for this purpose. Wherever, the foreign examiner is not appointed, the Director is authorized to take such a decision. A Standing committee of Dean, Academics, Dean (Faculty Affairs) and the concerned Head of the Department/Centre is constituted to consider such requests from the host institution.

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Ph.D. Ordinances and Regulations

PREAMBLE

Indian Institute of Technology (I.I.T.) Roorkee offers academic programmes leading to the award of Ph.D. degree through its Departments/Centres. The award of Ph.D. degree is in recognition of high academic achievements, independent research and application of knowledge to the solution of technical and scientific problems in Science, Technology, Architecture & Planning, Humanities & Social Science and Management; creative and productive inquiry is the basic concept underlying the research work.

The academic programme leading to the Ph.D. degree is broad-based and involves a prescribed course credit requirement and a research thesis. The institute also encourages interdisciplinary areas through a system of Co-supervision and provides excellent opportunities for such programmes. The institute undertakes sponsored research and development projects from industrial and other organizations in the public as well as private sector.

The degree of Doctor of Philosophy shall be abbreviated as Ph.D. The Degree of Doctor of Philosophy is granted for research work in areas recognized by the Academic Departments/centres of the Institute subject to the conditions and regulations contained hereinafter.

The research work shall be an original work characterized either by the discovery of facts, or by a fresh approach towards the interpretation and application of facts, or development of innovative products and technologies. It shall evince the candidate's capacity for critical examination and sound judgment and shall represent original contribution to the existing knowledge.

The degree of doctor of philosophy (Ph.D.) of the Indian Institute of technology, Roorkee shall be conferred on a candidate who successfully completes all the requirements specified in these ordinances and regulations, which were approved by Board of Governors/Senate.

1. Definitions

(i) "DRC/CRC" shall mean the Research Committee of the Department/Centre.

(ii) "Applicant" shall mean an individual who applies for admission to the Ph.D. programme of Indian Institute of Technology, Roorkee on a prescribed Application Form.

(iii) "IRC" shall mean the Institute Research Committee of Indian Institute of Technology, Roorkee

(iv) "Candidate" shall mean a person registered for the Ph.D. Degree and who has successfully completed the course requirement, the written and oral comprehensive examinations, and has submitted and presented the research plan and approved as per clauses R.5 and R.6 of the Regulations.

(v) "DA" shall mean the Dean, Academics.

(vi) "Research Student" shall mean a person registered for the Ph.D. programme of Indian Institute of Technology, Roorkee before becoming the candidate.

(vii) "Supervisor(s)" shall mean member(s) of the academic staff of the Institute approved by Competent Authority to guide/supervise the research/ academic work of the research student/candidate.

(viii) "Co-supervisor(s)" shall mean member(s) of the academic staff of the Institute or any person from other organization recommended by SRC, DRC, Head of the Department/Centre and approved by Competent Authority to guide/supervise the research/ academic work of the research student/candidate.

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(ix) "Caretaker Supervisor" shall mean a member of the academic staff appointed to look after the administrative interests of a research student/candidate in the absence of the Supervisor(s) and after the submission of the thesis, if necessary as per clause R.3.5 of the Regulations.

(x) "Course Work" shall mean courses of study prescribed by the Department/Centre through the Student Research Committee, to be undertaken by a research student registered for the Ph.D. Degree.

(xi) "Degree" shall mean the Degree of Doctor of Philosophy (Ph.D.) of the Indian Institute of Technology, Roorkee.

(xii) "Educational Institution" shall mean those Institutes, which offer Bachelor's or higher Degree.

(xiii) "Institute" shall mean the Indian Institute of Technology, Roorkee (IIT Roorkee).

(xiv) "Full-time Research Student/Candidate" shall mean a person registered for the Ph.D. Degree devoting full time at the Institute for completing the degree requirements.

(xv) "Part time Research Student/Candidate" is a person who is registered for the Ph.D. degree and has been allowed to devote part of his time towards this pursuit.

(xvi) "Registration Period" shall mean the length of time span commencing with the date of initial registration at the Institute.

(xvii) "ODC" shall mean Oral Defence Committee.

(xviii) "Residency" shall mean the minimum period for which a student/candidate must attend the institute.

(xix) "SRC" shall mean Student Research Committee.

(xx) "Sponsored Research Student/Candidate" shall mean a research student/candidate sponsored by an organization /his employer who provides full financial support for doing Ph.D.

(xxi) "Competent Authority" shall mean the Director of IIT, Roorkee or any officer to whom the Director delegates the authority.

NOTE: 'HE' & 'HIS' IMPLY 'HE'/'SHE' AND 'HIS'/ 'HER' RESPECTIVELY.

R.1 REGISTRATION, APPOITNMENT OF SUPERVISOR AND SRC

1. Fresh research students admitted to the Ph.D. programme are required to report to the Head of the Department/Centre one week in advance before the scheduled date of opening the Institute. Their registration will also take place one week in advance.
2. During the admission process, faculty members who do not have Ph.D scholar under MHRD fellowship working under their supervision, shall be given the highest priority to facilitate reasonable uniform distribution of MHRD scholars amongst the faculty members of Departments/Centres.

   The candidates are required to give their choice for supervisors based on his/her area of interest and the supervisor is allocated to him/her at the time of recommending the candidates for admission. The candidates shall be informed about the supervisor allocated in the admission letter. The candidates shall have to work with the supervisor allocated.

   Only one MHRD scholar shall be taken by a faculty in a semester, in general. In case, if the faculty member wants to take another MHRD scholar in a semester, no-objection from other faculty members of the concerned academic group is required.
3. The research supervisor of a student after the registration shall be approved by the Head of the Department/ Centre. Proforma Ph.D-0, given in Appendix-A, is to be filled for the approval of supervisor(s). In case of joint supervision, supervisors shall be approved by the competent authority as determined from time to time.

4. The Student Research Committee (SRC) for a research student shall be appointed within a week but not later than a month from the date of initial registration by HoD on the recommendation of supervisor through the Chairman, DRC. The SRC shall consist of:
   a) Any Senator from the department (preferably subject area expert but not necessarily from DRC) can be nominated as Chairman SRC.
   b) One expert in the field from the department/centre.
   c) One institute faculty expert, preferably in the concerned area, from outside the department/ centre to which the student belongs.
   d) Supervisor(s)

   Proforma Ph.D-I, given in Appendix-A, is to be filled for the appointment of SRC of the candidate.

Note 1: Names for 4(b) and 4(c) shall be proposed by the supervisor(s) and nominated by the Chairman, DRC and Head of the Department.

Note 2: Once approved, the member of SRC committee can be changed only under exceptional circumstances on recommendation from the department by competent authority.

5. Every research student/candidate will be required to carry out online subject registration prior to candidacy during stipulated dates and register for the Ph.D. degree programme every semester till the submission of the thesis irrespective of their category and status. However, after candidacy on-line registration is not required. Proforma Ph.D-III, given in Appendix-A, is to be filled in every semester for the continuation of registration.If there is a revision of thesis, registration is required again at the time of next submission.

R.2 Minimum and Maximum Time for Thesis Submission

a) All candidates shall be required to be registered for the entire duration of Ph.D. in every semester till submission of thesis.
b) The candidates of all categories shall submit their thesis within a period of five years from the date of their initial registration for the Ph.D. Programme. However, as a special case, this limit may be extended on specific recommendation of SRC to a maximum of six years for Full time research candidate and seven years for Part time research candidate by the competent authority after which the registration shall stand cancelled automatically. However, if the candidate has converted his/her status from full time to part time before the expiry of five years, the maximum duration for thesis submission shall be seven years.
c) For all students the minimum duration for submitting the thesis is TWO years from the date of candidacy. The date of candidacy will be considered as the date on which the research proposal is presented by the student and accepted by the SRC.

R.3 SUPERVISOR(S)

1. Supervisor(s) can be any full-time faculty member/ scientific officer of the Institute with a Ph.D. degree.
2. Supervisor has to be decided at the time of selection of candidates depending on the candidate's area of interest and the choice for the supervisors. The choices for the supervisors shall be taken by Chairman, selection committee, prior to the interview.
3. The competent authority on the recommendations of the SRC, may appoint one or more Supervisor(s) not exceeding a total of three to supervise the research student/candidate. These may be from inside or outside the Institute and there should not be more than two supervisors from within the Institute and not more than

one supervisor from outside Institute. **However, Emeritus Fellows are allowed to supervise a student only jointly as co-supervisors.** Addition/ deletion of Supervisor(s) would not be made after the lapse of 12 months from the date of admission to candidacy. In such cases, the minimum association period of new supervisor shall not be less than one and a half year.

4. The maximum number of Scholars supervised by a faculty member at any time at IIT Roorkee shall not be more than 12 jointly or singly or a combination of both with a maximum of 6 MHRD supported scholars. However, this number may be changed by the Senate from time to time.
5. Requirement of Co-supervisor in case of Part-time candidate:
   a) If the research scholar is registered as full time candidate and later on converted to part time after completing 3 years, co-supervisor is not required.
   b) If the research scholar is registered as full time candidate and after completing candidacy joined an organization within 100 km from Roorkee and converted to part time, co-supervisor from host organization is not required.
   c) If the research scholar is teacher trainee (sponsored faculty) from an institute having MoU with institute, co-supervisor may not be required if there is no possible co-supervisor at that institute. However, the candidate has to complete residential requirement for completing the course work and for candidacy and will have to be present at IIT Roorkee during all vacations for interaction with the supervisor.
   d) If the research scholar is registered as full time candidate and after completing candidacy joined an organization at a distance of more than 100 km from Roorkee and status is converted to part time, co-supervisor from host organization is required at the time of conversion.
   e) If the research scholar from an organization, at a distance of more than 100 km from Roorkee, is registered as part time candidate in the beginning, co-supervisor is required from that organization from the beginning.
   f) In either case of (d) and (e) above, the organization has to give an undertaking that the research scholar will continue to work on project or in area relevant to his/her Ph.D.

6. Change of Supervisor(s) and Appointment of Caretaker Supervisor for Ph.D. students:

   A faculty member appointed as a Ph.D. Supervisor(s) is expected to be available to a research student/candidate in the Institute till the thesis is submitted. However, under unavoidable circumstances, such as: long leave of more than 12 months, resignation, retirement, death or change of the supervisor, a new Supervisor(s) may be appointed following regulations as under:

A. Supervisor proceeding on long leave but less than 12 months

   a. If he/she is the only supervisor for a research student/candidate, a caretaker supervisor may be appointed to look after the administrative interest of the student provided the student has completed the requirement of candidacy. HoD can also act as caretaker supervisor only for administrative purposes and faculty supervisor continues for academic purposes.
   b. If he/she is the only supervisor for a research student/candidate and the student has yet not completed the requirement of candidacy, a co-supervisor shall be appointed by the SRC.

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B. Supervisor(s) proceeding on long leave of more than 12 months

a) (i) Where there is more than one Supervisor for a research student/candidate and one of the supervisors is proceeding on long leave for more than 12 months other supervisor(s) shall take care of the candidate. The supervisor proceeding on leave continue to be the supervisor of the candidate, if the candidate has completed the minimum duration of submitting thesis as per clause R.2 (c).

(ii) Where only one Supervisor exists for a research student/candidate, another supervisor shall be appointed by the SRC in cases where SRC has not yet found the research work fit for submission following clause R.8 sub-clause 1d) in the area of his research work.

b) (i) If SRC has recommended the research work for submission following clause R.8 sub-clause 1d) before the supervisor proceeds on leave, a caretaker supervisor will be appointed for administrative purpose only.

(ii) If the thesis has been submitted before the supervisor proceeds on leave, only a caretaker supervisor will be appointed.

(iii) Further, if a major revision becomes necessary, and the supervisor(s) is (are) on leave, he should be asked to specifically state whether he would effectively help the Research Scholar in carrying out the major revisions within a reasonable period. In case the supervisor(s) expresses his inability due to one reason or the other, the caretaker supervisor, if he/she provides the required help in carrying out the major revision, will automatically be treated as a co-supervisor of that candidate.

c) If a supervisor(s) proceeds on leave for a period less than 12 months initially, but later extends his leave beyond 12 months, the above procedure as applicable for leave beyond 12 months, will be followed. The extension granting authority will inform the competent authority accordingly.

d) If a new supervisor needs to be appointed in case of supervisor proceeding on long leave, his/her signature is required before granting leave to the faculty. The existing supervisor will continue as co-supervisor only if the candidate has completed the minimum duration of submitting thesis as per clause R.2 (c). .

e) If the supervisor(s) proceeds on leave for more than 24 months during the Ph.D. registration of a research student/candidate and in the opinion of SRC, he has not contributed significantly to the thesis, he/she will cease to be the supervisor(s).

C. A Supervisor retiring

1. A faculty member on retirement may continue as a co-supervisor till the completion of work and submission of thesis by the candidate. Another supervisor shall be appointed as in "B" above in similar circumstances.
2. A faculty member who is due to retire within the next two years may be appointed only as co-supervisor and may continue to be the co-supervisor even after his retirement provided the SRC is convinced of his availability/continued guidance to the student.

D. A Supervisor(s) resigning

A new supervisor shall be appointed at the time of acceptance of resignation by a supervisor as in "B" above. However, if the supervisor has associated with the student for TWO years after candidacy, he/she shall continue to be co-supervisor otherwise he/she shall cease to be supervisor.

E. Death of Supervisor(s)

A new supervisor(s) shall be appointed on the recommendation of SRC as in "B" above.

F. Supervisor(s) declining to supervise

Once a supervisor agrees to supervise a student, he/she cannot decline to supervise the student later on.

G. Change/drop of Supervisor(s) by the research candidate

(a) If the research student has requested for change of supervisor before the admission to candidacy and both the outgoing and incoming supervisors have consented then the change of supervisor will be considered by the competent authority on the recommendation of DRC/CRC.

In case, research student wishes to change the area of research with new supervisor, SRC be constituted a fresh.

(b) If a research student before admission to candidacy wants to drop one of the supervisors, in case of more than one supervisor, the same will be considered by competent authority on the recommendation of SRC and the HoD. However, a supervisor cannot be dropped by the student after the candidacy.

(c) If the candidacy has already taken place and student has requested for change of supervisor but the supervisor is not willing to give NOC, the matter shall be sorted out first in the DRC and then in the DFC at the department level.

If the department is unable to resolve the issue then the student has to continue with the same supervisor or leave the Ph.D. program.

H. (a) If a new SRC has been constituted due to change of supervisor and the research area, the new SRC may ask the research student to do more courses related to new research area provided candidacy has not taken place.

(b) If the candidacy has already taken place but the research area has changed, the SRC may ask the candidate to appear for written examination, oral examination before going for candidacy again.

R.4 COURSE CREDIT REQUIREMENTS

1. Each research student shall satisfy the credit requirements as given in Table-1 by crediting courses as advised by course supervisor and recommended by SRC. The minimum CGPA requirement for pre-Ph.D. courses will be 7.00 calculated taking all courses recommended by SRC including seminar.
2. If any subject-class is having a more than 80% research scholar, absolute grading be carried out. Proforma Ph.D-II, given in Appendix-A, is to be filled for the approval of courses to be registered by Dean, Academics.
3. Each research student has to do all the courses recommended by the SRC in the beginning. If the student could not get the passing grade in any course or the CGPA as calculated in clause R.4.1 is less than 7.00, the student has to leave the program.
4. SRC may recommend additional course(s) as Audit course(s), if required, in a particular case. A research student is deemed to have fulfilled the requirement of additional course(s) as Audit Course(s) if he/she obtains 'Audit Pass' for successfully completing each of such course(s).
5. The pre-Ph.D. courses including Audit course are to be completed successfully in first 1 to 2 semesters by research students having masters degree and in 2 to 3 semesters by research students having bachelor's degree. These semesters are counted from the date of initial registration and this clause is applicable both for full

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time/part time research students.

6. The courses offered other than minimum theory courses for the Ph.D. programmes may be Laboratory Courses, Design Courses and Project.
7. No self-study course shall be offered as part of the requirement of minimum theory courses. However, extra courses may be offered as self-study courses.

A. Self-study Courses shall satisfy the following conditions:

a) A self-study course should be preferably outside the courses listed in the Courses of Study and offered to a research student/candidate following sub-clause d) below.

b) A course listed in Courses of Study but not offered in a semester due to lack of sufficient number of students registering for it, may be offered as a self-study course in that semester with the prior approval of Dean, Academic .

c) A course already running in a semester shall not be offered as a self-study course.

d) The SRC shall examine proposals for self-study courses, not listed in the course of study, along with the course contents, textbooks, mode of assessment and name(s) of the instructor(s) and shall recommend the proposal and the credit to be assigned to Dean, Academics for his approval.

e) All self-study courses shall carry a maximum of four credits.

f) A student shall not take more than one self-study course during the entire Ph.D. programme.

g) If the supervisor/SRC feels that a course is essential for the student which is not available, the same may be designed by SRC and recommended by the DRC under the code and title "**XX-999: Special Topics**" and approved by competent authority.

B. Seminars shall satisfy the following conditions:

a) Seminar in a semester shall be of two credits and every research student must deliver a seminar as a part of course requirement and beyond the minimum limit of credits for course requirement.

b) Seminar shall be treated **as additional** course for the purpose of registration and evaluation.

c) Supervisor shall act as seminar coordinator and decides the topic of seminar in accordance with the area of research. Supervisor shall arrange the seminar and forward the grade awarded by the SRC to the competent authority by the end of the semester.

d) A student shall not get credits for more than one Seminar during the entire Ph.D. programme.

e) All research scholar students are required to be adjudged in proficiency in English while delivering seminar which is mandatory for everyone. The SRC will give its recommendation alongwith the result of seminar whether the candidate has qualified examination for proficiency in English or not. In case, the candidate's proficiency in English is not found satisfactory, the candidate is required to do a course on Communication Skills.

Table 1 COURSE CREDIT REQUIREMENTS

S. No.	Candidate Having	Range of Credit Requirements	Remarks
1.	M.Tech, M.Arch./MURP, MCA or M.Tech. (Integrated/ IDD) or Equivalent Degree	– minimum 3 theory courses or minimum of 9 credits theory courses – should earn 2 more credits by delivering seminar	Course From the existing M.Tech and/or pre-Ph.D. courses offered by own Deptt./ other Deptts.
2.	M.Sc/M.A./M.B.A. or equivalent admitted to Science/ HSS/ Management department	– 12-15 credits theory courses. – should earn 2 more credits by delivering seminar	Course From the existing PG level and/or pre-Ph.D. courses offered by own Deptt./ other Deptts.
3.	B.Tech. or equivalent, or M.Sc. or equivalent, admitted to anyone of the Engg. Disciplines	– 34-38 credits equivalent to credits earned by M.Tech. students – should earn 2 more credits by delivering seminar	Course Form the existing PG level and/or pre-Ph.D. courses offered by own Deptt./ other Deptts.

NOTE : The research scholars having M.Tech./MCA or equivalent degree have to take either minimum three theory courses (irrespective of credits) or minimum 9 credits theory courses (may be two courses, one of 4 credits and another of 5 credits).

R.5 Comprehensive Examination

1. Soon after successfully completing the pre-Ph.D. course requirements, each research student will request through proforma Ph.D-IV, given in Appendix-A, for and appear in a comprehensive examination which has three segments:
   (i) written comprehensive examination
   (ii) oral comprehensive examination to test comprehension of the research student in the broad area of study, and
   (iii) submission of research plan and its oral presentation to SRC, which will examine his/her academic preparation and potential to carry out the proposed research plan.

   Comprehensive examination shall be conducted by the SRC of the research student appointed under clause R.1 sub-clause 4. The comprehensive examination method has to be governed by DRC. The student having Masters degree or Bachelors degree has to present the research proposal within the stipulated time frame of 15 months or 20 months respectively from the date of initial registration. It is applicable to both Full Time and Part Time research scholar.

   The syllabus for comprehensive written and oral examination is to be defined by SRC including the courses student has completed as pre-PhD courses and approved by Chairman, DRC.

2. On the basis of the performance of student in the comprehensive examination, SRC will make one of the following recommendations under each a), b) and c), to the Dean, Academics:
   a) Written comprehensive examination
      (i) passed
      (ii) to reappear in the written comprehensive examination after a certain period of time specified by the SRC and/ or after taking additional courses recommended by it, if any.
      (iii) failed

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b) Oral comprehensive examination
   (i) passed
   (ii) to reappear in the oral comprehensive examination after a certain period of time specified by the SRC.
   (iii) failed

c) Research plan and its oral presentation
   (i) approved
   (ii) not approved

3. Oral examination shall be conducted only after successful completion of written examination, i.e., the student has secured at least 'B' grade (or 64% marks) in written examination.
4. Research proposal shall be presented before the SRC only if the student has successfully cleared the oral examination,i.e.,the student has been declared passed.
5. Notifications for different components of comprehensive examination shall be issued separately through proforma Ph.D-V, given in Appendix-A, and only after the successful completion of previous component(s).
6. Report on Comprehensive Examination - written and oral and Candidacy for Ph.D. Degree will be submitted by SRC through proforma Ph.D-VI, given in Appendix-A.
7. Progress report of Ph.D scholar for the candidacy will be submitted by SRC through proforma Ph.D-VIII, given in Appendix-A, alongwith comprehensive examination report for the approval of Dean, Academics.
8. At the time of presentation of research proposal, SRC/DRC may identify the ISI/Scopus indexed journals of his/her proposed area where publication is required.

NOTE: A student will be provided a maximum of two attempts to qualify in each segment of the comprehensive examination, to obtain the SRC recommendation of 2.a(i), 2.b(i) and 2.c(i). However, two failures in any of the comprehensive examination will require a student to leave the program.

R.6 ELIGIBILITY FOR THE CANDIDACY

1. The Dean, Academics will approve admission of a research student to candidacy on the recommendation of SRC which will satisfy that a research student has fulfilled the following:
   a) completed the required course work;
   b) passed the written and oral comprehensive examination
   c) submitted a research plan and defended it to the satisfaction of SRC.

   Thereafter, the research student will be admitted to candidacy from the date on which SRC recommended and be called a research candidate.
2. If a research student fails to get admission to candidacy within the 15/20 months with Masters degree/ Bachelors degree, his/ her registration for the Ph.D. Programme will be terminated.

R.7 RESEARCH PERFORMANCE MONITORING

1. The research progress of each research candidate in each semester will be monitored by the supervisor(s), who will assess the performance to be 'satisfactory' or 'unsatisfactory' at the end of each semester. For this purpose, each research candidate will be asked to submit a progress report to the supervisor(s) by the dates stipulated in R11.6.

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2. In addition, the candidate shall have to give seminar once in an academic year before the SRC for progress evaluation. If the candidate has been admitted in July, the seminar presentation has to be completed by July 15 and if the candidate has been admitted in January, the seminar presentation has to be completed by December 31.
3. The supervisor(s)/SRC shall forward the recommendation regarding the performance of the research candidate to the Chairman, DRC/CRC before the beginning of the next semester. The Chairman, DRC/CRC will forward the recommendation to the competent authority for necessary action.
4. The progress of a research candidate in each semester is evaluated as 'satisfactory' or 'unsatisfactory' by the supervisor(s)/SRC and forwarded to competent authority through Chairman DRC and Head of the Department/Centre..
5. If the progress is evaluated as 'unsatisfactory' by the supervisor(s) for the first time, a warning will be issued to the Research Candidate by the competent authority.
6. If the performance is evaluated unsatisfactory in two consecutive semesters to a research candidate, his/her registration for Ph.D. programme will stand terminated.
7. A special meeting of SRC may be called by the supervisor at any time during the entire period of Ph.D. for the following:
   a) Any type of change of topic or research area
   b) Addition or deletion of supervisor.
   c) To consider the request of student for doing work in industry or in some other institute for short period.
   d) To consider the extension of period
   e) To consider the enhancement of fellowship or change of status from JRF to SRF.

   Proforma Ph.D-VIII need to be filled every time by the SRC for the approval of Dean, Academics.

R.8 THESIS SUBMISSION

1.a) The research candidate is required to publish at least two papers or accepted for publication in refereed journal of repute (preferably journals included in SCI) as decided by the SRC at the time of presentation of research proposal or at least one patent filed.

b) When the supervisor is of the opinion that the research work as planned in the research proposal has been completed and the quality of work is up to the mark for submission of Ph.D., he/she will ask the research candidate to prepare a draft copy of the thesis ans submit to the Chairman, SRC with the request to convene the meeting of SRC.

c) The candidate shall submit 8 soft bound copies and one soft copy of the synopsis after the SRC recommends submission of synopsis.

d) The research candidate will deliver a seminar on his research work and the seminar shall be adequately notified by the Chairman, SRC, so as to enable interested staff members and students to attend it. If the SRC is satisfied about the quality of the work and considers it fit for submission as a Ph.D. thesis, it will send its recommendation to competent authority along with five soft bound copies and one soft copy of the synopsis and the proposed panel of examiners. Proforma Ph.D-IX, given in Appendix-A, is to be filled by the supervisor(s) to be sent for the approval of Dean, Academics.

e) At the time of delivery of seminar for pre-submission, student has to present the rough draft of the thesis to the SRC.

f) If candidate feels that supervisor is not allowing him to submit thesis, the student can approach Chairman SRC or HoD and request to convene the special meeting of SRC to consider the work done by him. The candidate may or may not be allowed to submit thesis by the SRC.

The research candidate shall be required to submit his thesis within 4 months of SRC recommendation for submission of thesis. However, in case a candidate fails to submit his thesis within the stipulated time and has suitable justification for the same, the competent authority may, on recommendations made by the SRC and DRC and on individual merits of each case, grant him extension in time beyond more than four more months, i.e. the candidate may be allowed to submit his thesis within a period not exceeding 8 months from the date of SRC meeting recommending submission. No further extension will be given beyond 8 months for the submission of thesis.

2. Panel of Examiners

A panel of at least ten experts in the area of the Ph.D. thesis would be suggested by the supervisor(s) and recommended by the SRC while forwarding its recommendation for submission of thesis. The panel so recommended would include at least 50% of the examiners from outside India and be out of the bibliography list of references as submitted by the candidate with synopsis with one reference of each expert in cited journal. Any person working in the laboratory(ies)/ Institution(s) where the research candidate or supervisor(s) from outside the institution, if any, is employed, cannot, however, appear in the panel of examiners. Any person related to the candidate or supervisor(s) should not appear in the panel of examiners.

3. Board of Examiners

On receipt of the recommendation of SRC for submission of thesis along with synopsis and panel of examiners, the Dean, Academics (DA) will seek consent of the examiners and appoint the Board of Examiners for each research candidate. The Board will consist of internal examiners - the Supervisor(s), and three external examiners – two from within India and the other from abroad, who shall be experts in the subject of the thesis except for cases covered under clause R.8.2 (b). These external examiners shall be chosen from the panel of examiners recommended by the SRC.

4. Submission of Thesis

(i) The thesis shall be written in English in the specific format available in the office of Dean, Academics / Department. The specifications of the thesis are given in Proforma Ph.D-X, given in Appendix-A.

(ii) The thesis shall contain a critical account of the candidate's research. It should be characterized by discovery of facts or fresh approach towards interpretation of facts and theories or significant contribution to knowledge or development of innovative products and technologies or a combination of these. It should bear evidence of the candidate's capacity for analysis and judgment as well as his ability to carry out independent investigation, design or development.

(iii) The Ph.D. thesis must contain the following copyright certificate in the beginning of the thesis, on a separate page on the left side:

© INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE, 200..
ALL RIGHTS RESERVED

(iv) The research candidate shall submit initially n+4 copies of the thesis in a spiral bound form with a soft cover, where 'n' is the number of supervisor(s), and also a soft copy (pdf file) on a CD. One copy each for office record, for foreign examiner, for Indian examiner and for supervisor(s).

(v) The candidates declaration page will have signature of only the student and supervisor(s).The format of the declaration page will have the format as given in proforma Ph.D- XI-A, given in Appendix-A.

(vi) The candidate will have to fill proforma Ph.D-XII, given in Appendix-A, for the submission of thesis.

R.9 THESIS EVALUATION

1. The thesis will be sent to the examiners by the office of the Dean, Academics with the request for a detailed assessment report and his/her recommendations on the prescribed proforma within six weeks of the date of receiving the thesis.

2.a) Examiners will examine the thesis individually with a view to judge that the thesis is a piece of research work characterized by;
   - i) The discovery of facts, or
   - ii) A fresh approach towards interpretation and application of facts or theories, or
   - iii) Development of innovative products and technologies

b) Each examiner will send detailed comments on the research work along with a clear recommendation stating one of the following:
   - i) The thesis is satisfactory and recommended for the award of Ph.D., or
   - ii) The thesis is recommended for the award of Ph.D. Degree subject to the candidate giving satisfactory answers to queries specifically mentioned in the report at the time of oral defence, or
   - iii) The thesis is recommended for the award of Ph.D. Degree subject to the candidate revise the thesis as per suggestions made and presents during oral defence, or
   - iv) The candidate is required to resubmit the thesis in the revised form, as per suggestions made and the thesis be sent for re-evaluation.
   - v) The thesis is rejected.

3. The Dean, Academics will, on the basis of the recommendations of the examiners will take one of the following actions:
   - i) If all the examiners recommend acceptance of the thesis, their recommendations shall be accepted.
   - ii) If out of three external examiners, only two external examiners have sent the report in time and recommend the acceptance of the thesis and all internal examiners also recommend acceptance of the thesis, their recommendation may be accepted. However, the academic section shall wait till the last date of sending the reports by all external examiners from the date of dispatch of Ph.D. thesis (i.e., 8 weeks) and after that give at least one reminder to examiner to send the report in next 4 weeks.
   - iii) If the report of one out of two external examiners (received till last date) is negative, the report of third examiner is must.
   - iv) In case reports have come from both the Indian examiners, any one of them may be included in the examination board for viva-voce examination.
   - v) If majority of the external examiners recommend rejection, their decisions would be accepted. The candidate may, however, be allowed to resubmit the thesis at least after one year, provided the title of the thesis remains unchanged. Normal procedure will be followed for the evaluation of the resubmitted thesis. In case of resubmission of the thesis, a fresh fee for the examination shall be paid by the candidate. No candidate shall be allowed to resubmit the same thesis more than once.
   - vi) If more than one examiner recommends rejection, the candidate's replies to the comments made by the examiners shall be sent to these examiners and their clear verdict sought. The examiners may then recommend acceptance, rejection or

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revision of the thesis.

In case the thesis is accepted, sub-clause 3(i) above will be applicable. In case of recommendation for revision, sub-clause 3(vii) below will apply. However, if these examiners still recommends rejection, alternate examiners would be appointed from the panel of the examiners recommended by SRC by the Dean, Academics. In such cases sub-clause 4(viii) will apply.

vii) In case some examiners recommend revision of the thesis, the thesis would be revised normally within one year, if the candidate so desires. The revised version of the thesis with new date of submission on thesis would be sent to all the examiners for their recommendations.

If the candidate does not agree for revision, he may ask for appointment of another examiner(s) under sub-clause 4(viii) below.

viii) A new examiner, if appointed, shall be Indian or Foreign depending on whether the thesis was rejected/to be revised on the recommendation by an Indian or a Foreign examiner in the first instance. The reports of all the examiners will be sent to the new examiner without revealing the identity of the previous examiners, along with the response of the candidate, if any, to the grounds for such recommendation as given in the detailed comments. The thesis shall be deemed to be acceptable if majority of the examiners including the new examiner recommend acceptance.

If the newly appointed examiner recommends revision, the thesis would be suitably revised and resubmitted at least after 3 months and sent for examination to all the examiners except the ones in whose place the new examiner was appointed.

In case the newly appointed examiners recommend rejection or their recommendations for revision is not accepted by the candidate, the thesis would be rejected. The candidate may then avail the benefit of sub-clause 3(v) above.

ix) If the majority of examiners recommend revision of the thesis, the candidate may revise the thesis accordingly and resubmit it within a period of one year for the evaluation by the same set of examiners.

x) If there is no clear majority opinion and there are recommendations for rejection by some and also, revision of the thesis by some others, the candidates may revise the thesis and resubmit it within a period of one year, for evaluation by the same set of examiners.

xi) Any doubt arising out of following the procedure laid down in clause R.9.3 shall be referred to the Director for a decision.

xii) In case of ambiguous recommendations by the examiner, Dean, Academics will approach the examiner for a clear recommendation. In case clear recommendation is not forthcoming, the matter may be referred to the Director for his decision.

xiii) In case any examiner gives comments to be incorporated in the thesis and also states that the revised thesis need not be sent again to him / her, the revised thesis will not be sent to the examiner. The supervisor(s) shall certify that the comments have been incorporated, before the viva-voce examination.

R.10 ORAL DEFENCE OF THESIS

1. If the thesis is recommended for the award of degree, the candidate shall be required to defend his / her work / thesis orally (Oral Defence) before a duly constituted committee hereinafter referred to as the Oral Defence Committee (ODC). The Dean, Academics shall request the thesis supervisor and Chairman, SRC to arrange the conduct of oral thesis defense. The copies of the report of the thesis examiners shall be sent to the supervisor with the request to provide them to the candidate so that he/she may prepare to answer the queries raised in the report during oral defense. The oral thesis defence

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shall be adequately notified so as to enable interested staff members and students to attend it.

2.(i) The ODC shall be chaired by the Head of the department / centre or his nominee and shall consist of Chairman SRC, supervisor(s) and one Indian external examiner. The Chairman, SRC and the supervisor(s) in the capacity of internal examiner(s) shall arrange for the oral defence of the candidate and the Head of the department/centre will notify it. The oral defence of the thesis of the candidate shall be arranged as early as possible and normally within two months from the date of receipt of communication from the Dean, Academics for holding the viva-voce examination.

(ii) The Dean Academics will decide that out of two Indian external examiner who should be included in the panel of examiner for ODC.

(iii) In case of the inability of the supervisor to arrange the conduct of the oral defence of the thesis due to any reason whatsoever, the Dean, Academics may appoint Chairman, SRC or internal expert, as recommended by Head of the Department/Centre concerned, another Internal Examiner for oral defence of the thesis. In such cases also, the Ph.D. work will be deemed to have been carried out under the guidance of the supervisor only.

3. a) In case of non-availability of the Indian External Examiner in conducting the viva-voce examination, the Dean Academics may appoint another examiner to conduct the oral defence of the thesis from the panel of Indian examiners recommended by SRC. If need be, the SRC may suggest a fresh panel of examiners.

b) The examiners in Oral Defence Committee (ODC) shall be provided with the comments made by the examiners before the oral defence.

c) If there is a difference of opinion among the viva-voce examiners in Oral Defence Committee (ODC), the recommendations of the ODC will be put up to the Director for a decision who may either direct that a fresh oral defence be held with a new ODC or recommend acceptance or otherwise to the Senate.

d) On the completion of the oral defence, the Oral Defence Committee shall recommend to the Dean, Academics, one of the following courses of action:

(i) that the degree be awarded;

(ii) that the research candidate be re-examined at a later specified time in a specified manner;

The Oral Defence Committee shall also provide to the research candidate a list of all corrections and modifications in the thesis (if required) including suggestions made by the examiners during the thesis evaluation.

The second oral defence may be held in case of (ii) normally after a period of 3 months.

Any other matter not explicitly provided herein or of an exceptional nature, may be referred to the Director for his decision.

e) After the successful completion of oral defence, the candidate is required to make all the changes suggested by the examiners or members of viva defence committee.

(i) The final submission of thesis shall be in hard bound form incorporating all the changes in the thesis after successful completion of oral defence. The candidate declaration page will have the format as given in proforma-XI-B, given in Appendix-A.

(ii) The candidate's declaration page in the final thesis will have the signature of the candidate, supervisor(s), Indian examiners and Chairman, SRC. The supervisor will take the signature of all the members of Oral Defense Committee on required number of sheets at the time of viva-voce examination to be place in the final thesis.

(iii) Before signing the thesis in the hard bound form, the supervisor(s) will certify that the candidate has made all the changes as suggested by the examiner(s).

(iv) The research candidate shall prepare n+2 copies of the final thesis in hard bound, where 'n' is the number of supervisor(s), after successful completion of Oral Examination. One copy each is for Central Library, Departmental Library and for supervisor(s).

(v) One copy of the thesis shall be given to each supervisor(s) by the candidate.

(vi) One copy of thesis shall be submitted in Departmental Library by the candidate to get 'No Dues' from the Departmental Library.

(vii) The candidate shall submit one copy of thesis meant for Central Library, synopsis of the thesis, additional one page synopsis for Hindi translation, 'No Dues' certificate and a soft copy (pdf file) on a CD to supervisor(s) for sending to Academic Section.

(viii) Supervisor will send the above alongwith Report of the thesis to Academic Section for approval of the competent authority.

R.11 AWARD OF Ph.D. DEGREE

1. The Degree of Ph.D. shall be awarded by the Senate, provided that:
   a) The Oral Defence Committee so recommends;
   b) The candidate produces a 'No dues Certificate' in the prescribed form.
   c) The candidate has submitted one soft and two hard cover copies of the thesis; one for the Library of the Department/Centre and the other for the Central Library. The thesis should incorporate all necessary/ corrections/ modifications listed by the Oral Defence Committee (ODC).

R.12 FINANCIAL ASSISTANCE (Institutional Assistantship)

1.a) Those students who are admitted on full-time basis are considered for the award of Institutional MHRD Assistantship of the amount as decided by the Government of India from time to time, under specified terms and conditions.

b) The students getting Institute MHRD Assistantship will provide 8-10 hours of assistance per week in teaching, laboratory development, and research.

c) The total number of MHRD assistantships in a department will be as decided by the institute from time to time.

2. The maximum duration for which assistantship can be awarded to any Ph.D. research student is 4 years for MHRD and UGC/CSIR fellows or till the end of the semester in which the thesis is submitted, whichever is earlier. Continuation of the fellowship is contingent on satisfactory academic and research performance and satisfactory performance in the discharge of responsibilities for assistance assigned under the scheme.

MHRD or UGC/CSIR fellowship can be given to the students in the 5th year provided the SRC or the three member assessment committee respectively strongly recommends with a justification for fellowship after the candidate delivers a seminar before the committee, to show progress. The committee has to specify the date beyond 4th year upto which fellowship can be given.

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It is to be noted that admission to the Programmes and award of assistantship are not linked. Admission to any programme does not guarantee the award of fellowship/ assistantship. Those who are not awarded assistantship can continue with the programmes as a self financing student.

R.13 TUITION FEE WAIVER TO Ph.D. STUDENTS

Tuition Fee Waivers is given to research students/ candidates following the policy of the Government of India, Ministry of Human Resource Department.

R.14 LEAVE AND ATTENDANCE

A research student/candidate will be entitled to avail leave as approved by the Head of the department/centre following Leave Rules/Attendance Rules formulated and amended from time to time by the Senate. Presently these are as under:

1. Leave Rules

A full-time research student/candidate, during his/her stay at the Institute will be entitled a total of 30 days leave per academic year, in addition to Public Holidays including leave on medical grounds. He/she will not be entitled to mid-semester breaks, summer and winter vacation. The leave due can be carried over to the next year and accumulated up to 90 days.

Leave beyond 30 days in an academic year may be granted to a Research student/ candidate in exceptional circumstances, on the recommendation of the supervisor, by the Head of the Department/Centre concerned, subject to the following conditions:

a) The leave beyond 30 days will be without Assistantship/Scholarship/ Fellowship.
b) An extension of leave up to additional 30 days will be granted only once during the programme of the scholar.
c) A proper leave account of each research student/ candidate shall be maintained by the Department/ Centre concerned.
d) Women scholars are entitled for maternity leave with full fellowship/assistantship as applicable, for a period not exceeding 135 days, once during the tenure of their award. The application for maternity leave should be supported by medical certificate.
e) Male Scholars are entitled for 15 days paternity leave once during the tenure of their award. The application for paternity leave should be supported by medical certificate.
f) Special leave may be granted with the permission of Dean, Academic, to attend Seminars/ Conferences in India /abroad and present paper.
g) Research student/candidate supported by a Government/ semi-Government agencies may be governed by their own rules as applicable.

2. Attendance

A research student/candidate irrespective of the source of support including self financing, while pursuing course work, must have at least 75% attendance in each course in which he/she is registered. A research student falling short of 75% attendance in a course shall not be permitted to appear in the examination of that course and asked to leave the program.

A research student/candidate after having completed the course work must attend to his/her research work on all the working days and mark attendance except when he/she is away from the campus on duty/sanctioned leave. The requirement of 75% attendance will apply as above on daily attendance on monthly basis except in the cases where longer leave have been duly sanctioned within the leave entitlement of the research

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student/candidate.

In case the attendance of a research student/candidate falls below 75% during a month, he/she will not be paid his assistantship/support, if applicable, for that month. Further, if his/her attendance again falls short of 75% in any subsequent months in the same semester his/her studentship/candidacy and support will be terminated.

For the above purpose, if 75% works out to be a number which is not a whole number, the immediate lower whole number will be treated as the required 75% attendance.

R.15 WITHDRAWAL FROM SEMESTER/COURSES

1. A research student/candidate may be permitted by the Dean, Academicsto withdraw from all the courses registered by her/him in the entire semester, on medical grounds supported by a medical certificate from the Institute Medical Officer. The medical certificate issued by a registered Medical Practitioner will also be acceptable in those cases where the research student/candidate has valid reasons for his absence from the Institute. Withdrawal may also be granted by the Dean, Academics provided he/she is convinced that the research student/candidate cannot pursue his studies for the reasons beyond his control.
2. Research Student/Candidate should present the medical certificate in support of his absence on health reasons within two days of his rejoining the Institute, if not produced already. Under no circumstances a request for semester withdrawal from a research student/candidate will be entertained after the major tests in courses have begun. Withdrawal will not be granted retrospectively.
3. The period of authorized absence in the semester should not be less than three weeks in a Semester, for which withdrawal is to be granted. Regularity in attending the classes / department and satisfactory performance in research/ the mid-term examinations, if any, held prior to the date of application for withdrawal are the factors which would be taken into account while recommending/ granting withdrawal.
4. Any semester withdrawal will count towards the maximum limit of registration for six years for full time /seven years for part time research student/candidate as clause R.2(b).

R.16 CANCELLATION OF REGISTRATION

1. Registration of a Research student/candidate shall be cancelled in any one of the following eventualities, after due approval of Dean, Academics:
   a) If he/she absents himself for a continuous period of four weeks without prior intimation/sanction of leave and is duly recommended by the supervisor/ Chairman, DRC/CRC/HoD
   b) If he/she resigns from the Ph.D. Programme and the resignation is duly recommended by the supervisor/ Chairman, DRC/CRC/HoD.
   c) If he/she fails to renew his/her registration in any semester following the provision contained in clause R.1.5.
   d) If his/ her academic and research progress is not as per requirement clauses R.7.4 and R.7.5.
   e) If all the prescribed courses including Audit course(s) are not successfully completed within the stipulated time frame of 15/20 months by Research students with Masters' Degree/ Bachelors' Degree both for full time/part time student from initial registration following provisions of clause R.4.
   f) If he/she does not clear the comprehensive examination as stipulated in clauses R.5.2 and R.6.2.
   g) If he/she is found involved in an act of misconduct and/or indiscipline and termination has been recommended by a competent authority.

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R.17 TO TAKE UP JOBS/ASSIGNMENTS

The Full time research student/candidate cannot take up any regular job/assignment during Ph.D. programme.

If he/she takes up a job / assignment, his/her status will be converted from Full-time to Part-time student in accordance with clause A.2.3. Conversion of status from Full-time to Part-time is admissible only after the candidacy.

R.18 GENERAL

1. Notwithstanding anything contained in these Ordinances & Regulations, all categories of the research students/candidates shall be governed by the regulations, guidelines and procedures framed by the Senate in this regard, and in force from time to time.
2. Unfair means and Plagiarism

a) In case a research student/candidate is found adopting or suspected of adopting unfair means before, during and after the examination or lifting of some other's work(s) and inserting it in his/her project, seminar and dissertation, etc. without proper acknowledgment, credit and reference or plagiarizing the dissertation/project report etc., such penal action shall be taken by the Institute as may be necessary to uphold the sanctity and integrity of the examination system and the credibility of the Institute.

b) All such cases may be taken suo-moto cognizance of by the Institute Standing Committee (ISC) appointed by the Senate for this purpose. Such cases may also be reported by examiners/invigilators/ supervisor(s)/ Chairman, DRC/CRC or any person to Dean, Academics and or the Institute Standing Committee for consideration. After giving an opportunity to the concerned research student(s) /candidate(s) to explain the conduct/defend against the charge, the Chairman, Senate on the recommendation of Institute Standing Committee shall take action to impose on the concerned research student(s) /candidate(s) appropriate penalty including termination of registration or award of F Grade in the concerned course(s) etc.

R.19 INTERPRETATION

1. Any doubt or dispute about the interpretation of these Ordinances and Regulations shall be referred to the Chairman, Senate whose decisions shall be final.
2. Eligibility for admission to Ph.D. programmes in different disciplines is summarized in **Annexure-I**. This may be reviewed from time to time by the concerned department/centre and approved by the Senate.

   Note: The recommendations of SRC in respect of a research student are to be made on prescribed proforma available in the office of concerned department / centre as well as institute website.

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Appendix-A

Ph.D - O

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Department of: ______________________________

APPLICATION FOR FINALIZATION OF SUPERVISOR(s)

1. Name of the Research Scholar : ....

2. Date of Registration : .... 3. Status: Full-Time ☐ Part-Time ☐

4. Sponsored/Self Finance/IITR Assistantship /Assistantship from other sources. ______________

5. Proposed area of research : ....

6. Supervisor 1 Name: ....
Designation: ....
Department: ....
Supervisor 2 Name: ....
Designation: ....
Department: ....
Supervisor 3 Name: ....
Designation: ....
Department: ....

Note: 1. Please enclose the justification in case of joint supervision.
2. Third Supervisor, if any, shall be from outside IITR.

DATED: **Signature of Research Scholar**

Quantum of supervision in case of Joint Supervision

Supervisor 1..................... Supervisor 2 .... Supervisor 3.........................

Signature of the Supervisor (s)

Approved/Recommended

Chairman, DRC/CRC **HEAD OF THE DEPARTMENT/CENTRE**

DATED:

Note 1: The Proforma-0 is to be sent to Academic Section for record.
2: Approval is required, by Director/ Dean, Academics in case of Joint Supervision only.

ORDER OF DEAN, ACADEMICS

Approved/Non Approved

Dean (Academics)

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Ph.D. - I

Department of: ______________________

STUDENT RESERCH COMMITTEE

1. Name of the Research Scholar : ....

2. Date of Registration : ....

3. Proposed area of research : ....

4. Supervisor (s) : ....
   : ....

5. Panel of the Experts proposed by the supervisor (s):
   (i) Experts in the field from the department
      1. ....
      2. ....
      3. ....
   (ii) Institute faculty experts, preferably in the concerned area, from outside the department.
      1. ....
      2. ....
      3. ....

Signature of the Supervisor (s)

- Experts from above the panels and Chairman, SRC nominated by Chairman DRC/CRC
  1. Internal : ....
  2. External : ....
- Chairman, SRC : ....

Chairman, DRC/CRC
DATED:

HEAD OF THE DEPARTMENT/CENTRE

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Ph.D. - II

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

APPLICATION FOR COURSES TO BE COMPLETED

A.1 Name of the Research Scholar ______________________ Enrollment No. __________

2. Department/Centre (1) ______________________ (2) ______________________
(Where Enrolled) (Where Working)

3. Date of Initial Registration ______________________

4. Status: Full-Time ☐ Part-Time ☐

5. Sponsored/Self Finance/IITR Assistantship /Assistantship from other sources. __________

6. Proposed Area of Research ______________________

____

B.1 Particulars of Proposed Supervisor (s)

Name & Designation	Deptt./Center/ Organization	No. of Students Supervising Excluding this Student and Including candidate of other institution(s).						Signature of Supervisor (s)
		Single			Jointly			
		With IITR Assistantship	Without IITR Assistantship	Other Institution(s)	With IITR Assistantship	Without IITR Assistantship	Other Institution(s)	

Following was discussed by SRC:

(a) Candidate's educational back ground, (b) Research Proposal in brief, (c) Credits requirements

C.1. Total No. of Credits to be completed __________

2. Courses proposed to be completed

Semester	Session	Course No.	Title	Credits	Remarks

Certified that the courses as mentioned above have not been taken by me during earlier studies for my Degrees/Diplomas etc.

Dated: __________ **Signature of Research Scholar**

*Candidates having

- M.Tech./M.U.R.P./M.Arch./MCA or equivalent degree — minimum 3 theory courses or a minimum of 9 credits theory courses
- M.Sc./MA/MBA or equivalent. — 12-15 credits
- B.Tech/M.Sc. or equivalent admitted to Engineering Disciplines — 34-38 credits
- Seminar of 2 credits has to be taken by every student over and above the course credit requirement.

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NOTE: 1. Student has to clear all the courses recommended by SRC in one attempt.
2. The minimum CGPA requirement for pre-Ph.D. courses will be 7.00 calculated taking all courses recommended by SRC including seminar.
3. Student has to do all the courses as regular courses running in the proposed semester to complete the minimum requirement of credits. However, he/she can take an extra course, if required, as self study course provided that course is not running in the proposed semester and it is recommended by SRC.

Names of Members of Student Research Committee (SRC) in accordance with Ph.D. Regulation

a. Chairman:________________________ b. Internal Expert: ____________________

c. External Expert:____________________ d. Supervisor(s) 1. __________________

2. __________________

3. __________________

The SRC/CRC recommends that the candidate should complete the courses as per details mentioned given under C.2.

Signature of Member(s)

1. Internal Expert: ____
2. External Expert: ____
3. Supervisor: ____
4. Supervisor ____
5. Supervisor ____

Chairman, SRC

Chairman, DRC/CRC **HEAD OF THE DEPARTMENT/CENTRE**

DATED:

FOR USE OF ACADEMIC RESEARCH SECTION

- Particulars of the Research Scholar have been verified.
- Recommendations of the SRC are submitted for approval of the Dean, Academics.

Dealing Assistant **Asst. Registrar (Academic Research)**

ORDERS OF DEAN, ACADEMICS

Approved/Not Approved

DEAN (Academics)

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Ph.D - III

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

PROGRESS REPORT OF Ph.D. SCHOLAR FOR AUTUMN/SPRING SEMESTER OF THE SESSION________

1 Name of the Research Scholar ______________________ Enrollment No.__________

2. Department/Centre (1) ______________________ (2) ______________________
(Where Enrolled) (Where Working)

3. Date of Initial Registration ______________________

4. Status: Full-Time ☐ Part-Time ☐

5. Sponsored/Self Finance/IITR Assistantship /Assistantship from other sources. __________

6. Date of Candidacy (if applicable) ______________________

7. Brief report of the work for the period from __________ to __________
(Please attach separate sheet)

8. Any other information regarding work done ______________________

Dated:

Signature of Student

PART B: PERFORMANCE REPORT AND RECOMMENDATIONS FROM DEPARTMENT /CENTRE

PERIOD : From__________________ To__________________

(a) Performance: Satisfactory/Unsatisfactory

(b) Recommended for registration: Yes/No

(c) Date on which seminar was delivered (if applicable): ....

(d) Remarks, if any ______________________

____

Signature of Supervisor (s) **Chairman, SRC**

Chairman, DRC/CRC **Head of the Department/Centre**

Date:__________

Note 1: Every student has to deliver a seminar once in every session.
Note 2: The proforma is to be submitted in every semester to Academic section through department failing which the registration of the student will be terminated.
Note 3: Registration of a student is terminated if there are two consecutive '**Unsatisfactory**' progress reports.

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FOR USE OF ACADEMIC RESEARCH SECTON ONLY

Name of Candidate________________________**Deptt**________________________________

Checked and the recommendations of the Department/Centre are submitted for consideration of Dean, Academics.

Dealing Assistant **Asst. Registrar (Academic Research)**

ORDERS OF DEAN, ACADEMICS

Approved/Not Approved

DEAN (Academics)

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Ph.D. - IV

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

REQUEST BY STUDENT FOR COMPREHENSIVE EXAMINATION

CHAIRMAN, SRC
Name of Research Scholar ____________________________

Deptt. / Centre ______________________________________

Through : SUPERVISOR(s)

I have earned the required number of credit(s) in each Pre Ph. D. Course and CGPA as per details given below:

Sl.No.	Course No.	Title	Semester/ Session	Credit(s) Earned	Grade Obtained
1.					
2.					
3.					
4.					
5.					
6.					
				CGPA	

Note: Self attested photocopies of the grades sheets are enclosed.

My date of initial registration is ___________________________

It is requested that my comprehensive examination may kindly be arranged.

Date: ____________________

Signature___________________________

Name of Scholar__________________

Forwarded

Enrolment No._____________________

Supervisor(s)

The comprehensive written examination may be fixed on ....The syllabus for the comprehensive written and oral examination is enclosed.

Chairman, SRC

13 AUG 2015

Ph.D. - V

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NOTIFICATION

DEPARTMENT /CENTRE:____

The written comprehensive/oral comprehensive examination/presentation on research plan of

Mr./Ms. ______________________________Research Scholar Enrollment No. ___________

in this Deptt. will be held as follows:

A* **Written comprehensive examination:**

1. Date____________________ 2. Time _____________________

3. Venue ____

B* **Oral comprehensive examination:**

1. Date____________________ 2. Time _____________________

3. Venue ____

C* **Presentation on the proposed research plan:**

1. Date____________________ 2. Time _____________________

3. Venue ____

CHAIRMAN, SRC

Copy to:

1. Dean, Academics
2. All members of SRC

CHAIRMAN, SRC

*** Note:** Separate notification is to be issued for each component of comprehensive examination/presentation. Please delete whichever is not applicable.

13 AUG 2015

Ph.D. - VI

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

(Report on Comprehensive Examination - written and oral and Candidacy for Ph.D. Degree)

1 Name of the Research Scholar ____________________ Enrollment No. __________

2. Department/Centre (1) ____________________ (2) ____________________
(Where Enrolled) (Where Working)

3. Report of Comprehensive Examination:

(i) Date of Written Examination: ____________________

Result of Written Examination: Passed / Failed / To reappear after ________ months

(ii) Date of Oral Examination: ____________________

Result of Oral Examination: Passed / Failed / To reappear after ________ months

Note: The student is required to obtain at least B grade in each component (Written and oral) of Comprehensive examination

4. <u>CANDIDACY FOR Ph.D. DEGREE</u>

* Date of presentation of research proposal ____________________

* Has the candidate completed review work included in the patent search in his/her area of research. Yes/ No.

* The SRC considered the research proposal entitled ____________________

____

(Copy attached)

* The research proposal is Approved/Not Approved

The student has successfully completed all requirement for the candidacy as per regulations and the SRC/CRC recommends that he/she be accepted as a candidate for Ph.D. work at the Institute with effect from date of presentation of research proposal i.e., ____________.

* SCI/Scopus indexed journals of proposed area where publication is required before submission of thesis ____________________

Member, SRC (External Expert) **Member, SRC (Internal Expert)**

Supervisor **Supervisor** **Chairman, SRC**

Copy to:-

1. Dean, Academics
2. Chairman, DRC/CRC

Chairman, SRC

13 AUG 2015

Ph.D. - VII

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

PROGRESS REPORT OF Ph.D. SCHOLAR FOR THE CANDIDACY

PART A:TO BE COMPLETED BY THE RESEARCH SCHOLAR (ALL COLUMNS ARE TO BE FILLED)

1. Name of the Research Scholar ____________________ Enrollment No. __________
2. Department/Centre (1) ____________________ (2) ____________________
   (Where Enrolled) (Where Working)
3. Date of Initial Registration ____________________
4. Status: Full-Time/Part-Time ____________________
5. Sponsored/Self finance/IITR Assistantship/Assistantship from other source __________
6. Scheme: (Please √ Tick)

IITR	CSIR	UGC	PROJECT	QIP	FOREIGN	SELF FINANCING	DEFENCE Services	ANY OTHER(mention)

7. Name (s) of Supervisor (s)

Sl. No.	Name	Designation	Department/Center/Organization
1.			
2.			
3.			

8. Grades obtained in Approved Courses:

Sl. No.	Course				Session	Semester	Deptt./ Center
	Code	Title	No. of credits	Grade Obtained			
1.							
2.							
3.							
4.							
5.							

9. Date and Result of Comprehensive Examination: Written __________ Oral __________
10. Date of Candidacy (as recommended by Comprehensive Exam Board) ____________________
11. Title of Research (Limited to 80 characters)
    (In English) ____________________

    ____

    Any other information regarding work done ____________________

    ____

Dated: **Signature of Candidate**

13 AUG 2015

PART B: PERFORMANCE AND RECOMMENDATION FROM DEPARTMENT/CENTRE FOR THE PERIOD (From date of initial registration ____________________to____________________)

(a) Performance: .... Satisfactory / Unsatisfactory

(b) Recommended for candidacy.. Yes/No

Signature of Supervisor(s) **Signature of Chairman, SRC**

Dated: __________

Signature of Chairman DRC/CRC

FOR USE OF ACADEMIC RESEARCH SECTON

PART C. Checked and the recommendations of the Department/Centre are submitted for consideration of Dean, Academics. Date of candidacy………………. be approved.

Dealing Assistant **Asst. Registrar (Academic Research)**

ORDERS OF DEAN, ACADEMICS

Approved/Not Approved

DEAN (Academics)

13 AUG 2015

Ph.D. - VIII

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

REPORT OF MID TERM REVIEW / SPECIAL STUDENT RESEARCH COMMITTEE MEETING

1. Name of the Research Scholar ____________________ Enrollment __________

2. Department/Centre (1) ____________________ (2) ____________________
(Where Enrolled) (Where Working)

3. Title of Research (Limited to 80 characters).
(In English) ______________________________
____

4. Name (s) of the Supervisor (s) 1.____________________
2.____________________
3.____________________

5. Date of Initial Registration ____________________ Status __________

6. Date of Candidacy ____________________

7. Members of the Student Research Committee
i.__________ ii.__________
iii.__________ iv.__________
v.__________ vi.__________
vii.__________ viii.__________

8. Is the meeting held for Mid Term Review? YES/NO
Period of Performance Review: From __________ to __________
Report ______________________________
____
____

9. Is it a Special Research Committee? YES/NO

(A) Is there change of topic? YES/NO
Revised Topic (Limited to 80 characters)
(In English) ______________________________
____

Justification:
____
____
____

13 AUG 2015

(B) Is there change of Supervisor(s)? YES / NO

Deletion of Supervisor(s) ____________________

Additional Supervisor(s) ____________________

(Enclosed Bio-data of proposed supervisor other than IITR)

Following information is required if proposed additional supervisor is from IITR.

Name & Designation	Deptt./Center/ Organization	No. of Students Supervising Excluding this Student and Including candidate of other institution(s).						Signature Of Supervisor
		Single			Jointly			
		With IITR Assistantship	Without IITR Assistantship	Other Institution(s)	With IITR Assistantship	Without IITR Assistantship	Other Institution(s)	

Justification ____________________

____

(Enclosed detailed justification in case of joint supervision)

(C) Whether a case for extension of time for submission YES/NO

Initial due date of submission ____________________

Previous extension, if any ____________________

Proposed extension up to ____________________

Reasons: ____________________

(D) Whether a case of up gradation from JRF to SRF YES/NO

(E) Any Other: ____________________

Member, SRC (External Expert) **Member, SRC (Internal Expert)**

Supervisor **Supervisor** **Chairman, SRC**

Chairman, DRC/CRC **HEAD OF THE DEPARTMENT/CENTRE**

DATED:

FOR USE OF ACADEMIC RESEARCH SECTON ONLY

The recommendations of the Department/Centre are submitted for consideration of Dean, Academics.

Dealing Assistant **Asst. Registrar (Academic Research)**

ORDERS OF DEAN, ACADEMICS

Approved/Not Approved

DEAN (Academics)

13 AUG 2015

Ph.D. - IX

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
FINAL REPORT OF THE STUDENT RESEARCH COMMITTEE

1. Name of the Scholar
(English) ______________________ Enrollment No.: ______________
(Hindi) ______________________

2. Department/Centre (1) ______________ (2) ______________
(Where Enrolled) (Where Working)

3. Status: Full-Time/Part-Time ______________________

4. Title of Thesis (Limited to 80 characters).
In **English** (In Capital Letters) ______________________
____
In **Devanagari** ______________________
____

5. Name (s) of the Supervisor (s) 1. ______________
2. ______________
3. ______________

6. Date of Initial Registration ______________ Extension (s), if any ______________

7. Date of Candidacy ______________________

8. Members of the Student Research Committee
i. ______________ ii. ______________
iii. ______________ iv. ______________
v. ______________ vi. ______________
vii. ______________ viii. ______________

9. Whether the candidate's Research Papers have published in the refereed journals as per clause R.12 of the regulations: YES / NO

10. If not reasons therefore ______________________

11. Recommendation of the Student Research Committee
(a) Work is satisfactory, and
(i) Recommended for submission ....YES / NO
(ii) The title of the thesis remains unchanged......................................YES / NO
(iii) Is reworded for clarity as specified below (limited to 80 characters)
In **English** (In Capital Letters) ______________________
____
In **Devanagari** ______________________
____

1 3 AUG 2015

(iv) Recommended list of Examiners
(At least five from India and five from abroad).

LISTS ATTACHED

(Indicate Designation, Address Telephone No., Fax No., E-Mail and Serial Number of references from the Bibliography of panel of examiners in the format attached)

(b) (i) Work is not adequate. Another SRC of the candidate may be held after a period of ________ months.

(ii) Suggestions Made ____

____

(c) Rough draft of thesis submitted..YES / NO

(d) Likely submission date of thesis: ____

SRC certifies that the names given above are actively involved in Research. The concerned candidate has submitted 8 copies of synopsis (not exceeding five pages) and electronic version (C.D.)

Member, SRC (External Expert) **Member, SRC (Internal Expert)**

Supervisor **Supervisor** **Chairman, SRC**

Chairman, DRC/CRC **HEAD OF THE DEPARTMENT/CENTRE**

DATED:

(Note: All members of SRC should sign on each page of the Final report & list of Examiners)

FOR USE OF ACADEMIC RESEARCH SECTON ONLY

Reworded topic of thesis may be accepted.

Dealing Assistant **Asst. Registrar (Academic Research)**

APPROVED/NOT APPROOVED

DEAN (Academics)

Board of Examiners may please be appointed.

Dealing Assistant **Asst. Registrar (Academic Research)**

Appointed Priority-wise

DEAN (Academics)

13 AUG 2015

(a) Panel of Examiners from India

1. Name ______________________ Telephone No. ______________________
   Designation ______________________ Fax. No. ______________________
   Address ______________________ E-Mail Address. ______________________
   ______________________ Publication/Reference of Bibliography______
   ____

2. Name ______________________ Telephone No. ______________________
   Designation ______________________ Fax. No. ______________________
   Address ______________________ E-Mail Address. ______________________
   ______________________ Publication/Reference of Bibliography______
   ____

3. Name ______________________ Telephone No. ______________________
   Designation ______________________ Fax. No. ______________________
   Address ______________________ E-Mail Address. ______________________
   ______________________ Publication/Reference of Bibliography______
   ____

4. Name ______________________ Telephone No. ______________________
   Designation ______________________ Fax. No. ______________________
   Address ______________________ E-Mail Address. ______________________
   ______________________ Publication/Reference of Bibliography______
   ____

5. Name ______________________ Telephone No. ______________________
   Designation ______________________ Fax. No. ______________________
   Address ______________________ E-Mail Address. ______________________
   ______________________ Publication/Reference of Bibliography______
   ____

Member, SRC (External Expert) **Member, SRC (Internal Expert)**

Supervisor **Supervisor** **Chairman, SRC**

Chairman, DRC/CRC **HEAD OF THE DEPARTMENT/CENTRE**

DATED:

13 AUG 2015

(b) Panel of Foreign Examiners

1. Name ______________________ Telephone No. ______________________
   Designation ______________________ Fax. No. ______________________
   Address ______________________ E-Mail Address. ______________________
   ______________________ Publication/Reference of Bibliography______
   ____

2. Name ______________________ Telephone No. ______________________
   Designation ______________________ Fax. No. ______________________
   Address ______________________ E-Mail Address. ______________________
   ______________________ Publication/Reference of Bibliography______
   ____

3. Name ______________________ Telephone No. ______________________
   Designation ______________________ Fax. No. ______________________
   Address ______________________ E-Mail Address. ______________________
   ______________________ Publication/Reference of Bibliography______
   ____

4. Name ______________________ Telephone No. ______________________
   Designation ______________________ Fax. No. ______________________
   Address ______________________ E-Mail Address. ______________________
   ______________________ Publication/Reference of Bibliography______
   ____

5. Name ______________________ Telephone No. ______________________
   Designation ______________________ Fax. No. ______________________
   Address ______________________ E-Mail Address. ______________________
   ______________________ Publication/Reference of Bibliography______
   ____

Member, SRC (External Expert) **Member, SRC (Internal Expert)**

Supervisor **Supervisor** **Chairman, SRC**

Chairman, DRC/CRC **HEAD OF THE DEPARTMENT/CENTRE**

DATED:

13 AUG 2015

Ph.D. - X

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

SPECIFICATIONS FOR THESIS

1. The thesis shall be typed or printed on 21 cms ×28 cms size paper. No hand written thesis will be accepted.
2. The thesis shall be typed on both side with 1½ spacing with a margin of 3.5 cms on the left 2.5 cms on the top and 1.25 cms on the right and bottom.
3. The thesis must contain the following copyright certificate in the beginning of the thesis, on a separate page on the left side:

© INDIAN INSTITUTE OF TECHNOLOGY ROORKEE, 20___ ALL RIGHTS RESERVED

4. In a thesis, the title page should be given first, then the certificate by the candidate and the supervisors followed by an abstract of the thesis not exceeding 1500 words. This should be followed by acknowledgement and a table of contents.
5. The references should be given at the end of the thesis preferably in alphabetic order of the authors' nmames.
6. In the body of the text, a reference should be indicated by a number in parenthesis such as [5]. These references should be listed giving (i) the author's name and his initials (ii) the title of the paper and the name of the journal (iii) the name of the book and the publisher (iv) the number of volume, page numbers and the year of publication. Standard abbreviations may be used in the names of the journals.
7. The diagrams should be all in ink or should be printed on a light background. Tabular matter should be clearly arranged. Decimal points may be indicated by a full-stop.
8. The thesis shall be spiral bound at the time of initial submission.
9. After the viva-voce examination the thesis shall be submitted in hard bound. The thesis shall be bound in card sheet paper of 18.6 kg. Weight of cover page with soft binding (size 22 cms × 29 cms) in green colour. The name of the candidate, the degree and the year shall be printed in bold on the cover and in gold on the bound edge.

Note: Soft copy of the thesis on R-CD should also be submitted after final viva-voce examination.

13 AUG 2015

Ph.D. - XI

APPENDIX-A

(To be used in initial submission)

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
ROORKEE

CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the thesis entitled ....
....
in partial fulfillment of the requirements for the award of the Degree of Doctor of Philosophy and submitted in the Department of ....
of the Indian Institute of Technology Roorkee is an authentic record of my own work carried out during a period from .... to ....
under the supervision of ....

The matter presented in the thesis has not been submitted by me for the award of any other degree of this or any other Institute.

Signature of the Candidate

This is to certify that the above statement made by the candidate is correct to the best of my (our) knowledge.

Dated: ____________ **Signature of Supervisor(s)**

13 AUG 2015

Ph.D. - XI

APPENDIX-B

(To be used in final submission)

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
ROORKEE

CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the thesis entitled ....
....
in partial fulfillment of the requirements for the award of the Degree of Doctor of Philosophy and submitted in the Department of ....
of the Indian Institute of Technology Roorkee is an authentic record of my own work carried out during a period from .... to ....
under the supervision of ....

The matter presented in the thesis has not been submitted by me for the award of any other degree of this or any other Institute.

Signature of the Candidate

This is to certify that the above statement made by the candidate is correct to the best of my (our) knowledge.

Signature of Supervisor (s)

The Ph. D. Viva-Voce Examination of ...., Research Scholar, has been held on ....

Chairman, SRC **Signature of External Examiner**

This is to certify that the student has made all the corrections in the thesis.

Signature of Supervisor (s) **Head of the Department**

Dated: ____________

13 AUG 2015

Ph.D. - XII

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

SUBMISSION OF THESIS FOR DOCTOR OF PHILOSPHY

1. Name of the Research Scholar:
   (English)________________ Enrollment No.________
   (As printed in Master's degree)
   (Hindi)________________
2. Department/Centre (1) ________ (2) ________
   (Where Enrolled) (Where Working)
3. Date of Initial Registration ________
4. Status: Full-Time/Part-Time________
5. Sponsored/Self finance/IITR Assistantship/Assistantship from other source ________
6. Date of Final SRC ________
7. Date of Thesis Submission ________
8. Title of Research
   In English ________
   In Devanagari ________
9. Name(s) of Supervisor/Co-supervisor(s):1. ________ 2. ________
   3.________
10. Address for Correspondence:________

    Phone No. with STD Code________ Mobile No. ________
    E.mail ID ________
    Note: Copy of plagiarism check enclosed.

Signature of Research Scholar

Countersigned:

Signature of Supervisor(s) **Signature of Chairman, SRC**

Signature of Chairman, DRC/CRC **Head of the Department/Centre**

13 AUG 2015

Appendix-A

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 and Title Changed
6.	-	-	CY-509 Coordinate Chemistry	3	Shifted from spring to autumn with change in title
V 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 and Title 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	-	-	Shifted to spring semester
3.	-	-	CYN-603 Seminar	3	Shifted from spring semester
V year Spring Semester					
1.	Departmental Elective-VII	3	Departmental Elective-VII	3	No Change
2.	CY-681 Seminar	4	-	-	Shifted to autumn semester
3.	-	-	CYN-602 Project	6	Shifted from autumn semester
3.	CY-692 Dissertation	14	CYN-604 Dissertation	14	No Change

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

S.No.	Course under Old Structure during IV and V Yrs.	Cr.	Recommended Course Under New Structure	Cr.	Remark
			Integrated M.Sc. (Physics)		
IV year Autumn Semester					
1.	PH-501 Semiconductor Devices	3	PHN-501 Semiconductor Devices	3	No Change in code or title. However, the codes will gradually be changed with suffix 'N' as the students admitted in structure move to IV Yr and V Yr. Till then the courses may be taught together with M.Sc. students if the course contents are same but the grades will be sent separately. The code of seminar will also be changed to PH-699 when these students move to V Yr.
2.	PH-503 Quantum Mechanics-I	4	PHN-503 Quantum Mechanics-I	4	
3.	PH-505 Mathematical Physics	3	PHN-505 Mathematical Physics	3	
4.	PH-507 Classical Electrodynamics	4	PHN-507 Classical Electrodynamics	4	
5.	PH-509 Classical Mechanics	3	PHN-509 Classical Mechanics	3	
6.	PH-511 Computational Physics	3	PHN-511 Computational Physics	3	
IV year Spring Semester					
1.	PH-502 Laboratory-II	3	PHN-502 Laboratory-II	3	
2.	PH-504 Condensed Matter Physics	3	PHN-504 Condensed Matter Physics	3	
3.	PH-506 Statistical Mechanics	3	PHN-506 Statistical Mechanics	3	
4.	PH-508 Quantum Mechanics-II	3	PHN-508 Quantum Mechanics-II	3	
5.	PH-510 Nuclear and Particle Physics	2	PHN-510 Nuclear and Particle Physics	2	
6.	PH-512 Physics of Earth's Atmosphere	2	PHN-512 Physics of Earth's Atmosphere	2	
7.	PH-514 Molecular Spectroscopy and Lases	2	PHN-514 Molecular Spectroscopy and Lases	2	
V year Autumn Semester					
1.	Departmental Elective-Group A/B/C/C/C/	-	Departmental Elective-Group A/B/C/C/C/	-	No Change
2.	Institute Elective-III (ESEC)	4	Institute Elective-III (ESEC)	4	No Change
3.	-	-	PHN-608 Seminar	3	Shifted from spring semester
V year Spring Semester					
1.	Departmental Elective-Group D	4	Departmental Elective-Group D	4	No Change
2.	PH-608 Seminar	4	-	-	Shifted to autumn semester
3.	PH-610 Dissertation	14	PHN-610 Dissertation	14	No Change

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13 AUG 2015

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

S.No.	Course under Old Structure during IV and V Yrs.	Cr.	Recommended Course Under New Structure	Cr.	Remark
			Integrated M.Sc. (Applied Mathematics)		
IV year Autumn Semester					
1.	MA-501 Theory of Ordinary Differential Equations	4	MAN-501 Theory of Ordinary Differential Equations	4	No Change in code or title. However, the codes will gradually be changed with suffix 'N' as the students admitted in structure move to IV Yr and V Yr. Till then the courses may be taught together with M.Sc. students if the course contents are same but the grades will be sent separately. The code of seminar will also be changed to MA-699 when these students move to V Yr.
2.	MA-503 Real Analysis-II	3	MAN-503 Real Analysis-II	3	
3.	MA-505 Mechanics-II	3	MAN-505 Mechanics-II	3	
4.	MA-507 General Topology	3	MAN-507 General Topology	3	
5.	MA-509 Mathematical Methods	3	MAN-509 Mathematical Methods	3	
6.	Institute Elective-III (ESEC)	4	Institute Elective-III (ESEC)	4	
IV year Spring Semester					
1.	MA-504 Advanced Numerical Analysis	3	MAN-504 Advanced Numerical Analysis	3	
2.	MA-504 Theory of Elasticity	3	MAN-504 Theory of Elasticity	3	
3.	MA-506 Theory of Partial Differential Equations	3	MAN-506 Theory of Partial Differential Equations	3	
4.	MA-508 Non-Linear Programming	3	MAN-508 Non-Linear Programming	3	
5.	MA-510 Functional Analysis	3	MAN-510 Functional Analysis	3	
6.	Departmental Elective-III	3	Departmental Elective-III	3	
V year Autumn Semester					
1.	MA-601 Multivariate Techniques	3	MAN-601 Multivariate Techniques	3	
2.	MA-603 Fluid Dynamics	3	MAN-603 Fluid Dynamics	3	
3.	MA-605 Mathematical Modeling	3	MAN-605 Mathematical Modeling	3	
4.	Departmental Electives-IV/V/VI	3	Departmental Electives-IV/V/VI	3	
5.	-	4	MAN-602 Seminar	4	Shifted from spring semester
V year Spring Semester					
1.	Departmental Elective-VII	3	Departmental Elective-VII	3	No Change
2.	MA-602 Seminar	4	-	-	Shifted to autumn semester
3.	MA-604 Dissertation	12	MAN-604 Dissertation	12	No Change

13 AUG 2015

Appendix 'N'
Item No. Senate/60.32

Appendix-N

DEPARTMENT OF MATHEMATICS
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
(To be implemented from 2015-2016 academic session)

Program Code : XXX M.Sc. (Mathematics)
Department : MA Mathematics
Year : I

Teaching Scheme					Contact Hours/Week			Exam. Duration		Relative Weight (%)				
S.No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
		Semester-I (Autumn)												
1.	MAN-511	Theory of Ordinary Differential Equations	PCC	3	3	0	0	3	0	25	-	25	50	-
2.	MAN-513	Real Analysis	PCC	4	3	1	0	3	0	25	-	25	50	-
3.	MAN-515	Topology	PCC	3	3	0	0	3	0	25	-	25	50	-
4.	MAN-517	Abstract Algebra	PCC	4	3	1	0	3	0	25	-	25	50	-
5.	MAN-519	Computer Programming	PCC	4	3	0	2	3	0	15	25	20	40	-
6.	HSN-501	Technical Communication	PCC	2	2	0	0	2	0	25	-	25	50	-
		Total		**20**	**17**	**2**	**2**	-	-	-	-	-	-	-
		Semester-II (Spring)												
1.	MAN-512	Numerical Analysis	PCC	4	3	1	0	3	0	25	-	25	50	-
2.	MAN-514	Linear Algebra	PCC	4	3	1	0	3	0	25	-	25	50	-
3.	MAN-516	Probability & Statistics	PCC	4	3	1	0	3	0	25	-	25	50	-
4.	MAN-518	Theory of Partial Differential Equations	PCC	3	3	0	0	3	0	25	-	25	50	-
5.	MAN-520	Complex Analysis	PCC	4	3	1	0	3	0	25	-	25	50	-
6.	-	Departmental Elective-I	PEC	3	-	-	-	-	-	-	-	-	-	-
		Total		**22**	**15**	**4**	**0**							

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DEPARTMENT OF MATHEMATICS
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Program Code : XXX **M.Sc. (Mathematics)**
Department : MA **Mathematics**
Year : II

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S.No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
		Semester-III (Autumn)												
1.	MAN-611	Functional Analysis	PCC	3	3	0	0	3	0	25	-	25	50	-
2.	MAN-613	Operations Research	PCC	4	3	1	0	3	0	25	-	25	50	-
3.	MAN-615	Seminar	PCC	2	-	-	-	-	-	-	-	30	70	-
4.		Departmental Elective-II	PEC	3	-	-	-	-	-	-	-	-	-	-
5.		Departmental Elective-III	PEC	3	-	-	-	-	-	-	-	-	-	-
6.		Departmental Elective-IV	PEC	3	-	-	-	-	-	-	-	-	-	-
		Total		**18**	**6**	**1**	**0**							
		Semester-IV (Spring)												
1.	MAN-612	Project	PCC	8	-	-	-	-	-	-	-	30	70	-
2.		Departmental Elective-V	PEC	3	-	-	-	-	-	-	-	-	-	-
3.		Departmental Elective-VI	PEC	3	-	-	-	-	-	-	-	-	-	-
4.		Departmental Elective-VII	PEC	3	-	-	-	-	-	-	-	-	-	-
		Total		**17**										

Summary

Semester	I	II	III	IV
Semester-wise Total Credits	20	22	18	17
Total Credits	77			

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DEPARTMENT OF MATHEMATICS
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
List of Departmental Electives (M.Sc. Mathematics)

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S.No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
		Elective I												
1.	MAN-531	Fuzzy Sets and Fuzzy Logic	PEC	3	3	0	0	3	0	25	-	25	50	-
2.	MAN-532	Graph Theory	PEC	3	3	0	0	3	0	25	-	25	50	-
3.	MAN-533	Integral Equations and Calculus of Variations	PEC	3	3	0	0	3	0	25	-	25	50	-
4.	MAN-534	Mechanics	PEC	3	3	0	0	3	0	25	-	25	50	-
		Elective II-VII												
5.	MAN-641	Abstract Harmonic Analysis	PEC	3	3	0	0	3	0	25	-	25	50	-
6.	MAN-642	Advanced Numerical Analysis	PEC	3	3	0	0	3	0	25	-	25	50	-
7.	MAN-643	Algebraic Topology	PEC	3	3	0	0	3	0	25	-	25	50	-
8.	MAN-644	Approximation Theory	PEC	3	3	0	0	3	0	25	-	25	50	-
9.	MAN-645	Coding Theory	PEC	3	3	0	0	3	0	25	-	25	50	-
10.	MAN-646	Combinatorial Mathematics	PEC	3	3	0	0	3	0	25	-	25	50	-
11.	MAN-647	Control Theory	PEC	3	3	0	0	3	0	25	-	25	50	-
12.	MAN-648	Dynamical Systems	PEC	3	3	0	0	3	0	25	-	25	50	-
13	MAN-649	Financial Mathematics	PEC	3	3	0	0	3	0	25	-	25	50	-
14.	MAN-650	Fluid Dynamics	PEC	3	3	0	0	3	0	25	-	25	50	-
15	MAN-651	Measure Theory	PEC	3	3	0	0	3	0	25	-	25	50	-
16	MAN-652	Number Theory	PEC	3	3	0	0	3	0	25	-	25	50	-
17.	MAN-653	Numerical Optimization	PEC	3	3	0	0	3	0	25	-	25	50	-
18.	MAN-654	Orthogonal Polynomials and Special Functions	PEC	3	3	0	0	3	0	25	-	25	50	-
19.	MAN-655	Stochastic Processes	PEC	3	3	0	0	3	0	25	-	25	50	-
20.	MAN-656	Wavelet Theory	PEC	3	3	0	0	3	0	25	-	25	50	-

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