सीनेट की इकहत्तरवीं बैठक का कार्यवृत्त

MINUTES OF 71st MEETING OF THE SENATE

28 दिसम्बर 2017

28th DECEMBER 2017

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

ROORKEE – 247 667

I N D E X/सूची

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71.6	प्रवीणता के नियमों के संशोधन के प्रस्ताव पर विचार करना। To consider the proposal regarding revision of rules of proficiency.	4
71.7	सीजीपीए में उच्चतम वृद्वि प्राप्त करने के लिए डीन द्वारा प्रशंसा और एसजीपीए में उच्चतम वृद्वि प्राप्त करने के लिए विभागाध्यक्ष द्वारा प्रशंसा को शामिल करने के प्रस्ताव पर विचार करना। To consider the proposal for introducing "Dean's Appreciation for Achieving Highest Increase in CGPA & HoD's Appreciation for Achieving Highest Increase in SGPA".	4
71.8	शैक्षिक वर्ष 2017–18 के लिए अपने अध्ययन को जारी रखने के लिए छात्रों की दूसरी दया अपील पर विचार करना। To consider the 2nd mercy appeals of students to continue their study for this academic year 2017-18.	4
71.9	रसायन विज्ञान विभाग द्वारा प्रस्तावित द्वितीय वर्ष तक एकीकृत एमएससी के शैक्षिक कार्यक्रम पर विचार करना: सीवाईएन–101 रसायन विज्ञान का परिचय सीवाईएन–103 कम्पयूटर प्रोग्रामिंग सीवाईएन–102 फिजिकल रसायन विज्ञान–प्रथम सीवाईएन–104 सामान्य कार्बनिक और अकार्बनिक रसायन विज्ञान सीवाईएन–106 बेसिक अनालिटिकल रसायन विज्ञान सीवाईएन–201 थर्मोडायनामिक्स सीवाईएन–203 समन्वयन रसायन विज्ञान और ऑर्गेमेटेलिक्स सीवाईएन–205 कार्बनिक रसायन विज्ञान–प्रथम सीवाईएन–202 मुख्य समूह और कलस्टर रसायन विज्ञान सीवाईएन–204 जैव रसायन विज्ञान–द्वितीय सीवाईएन–206 रासायनिक काईनेटीक्स To consider the academic program of Integrated M.Sc. Chemistry upto 2nd year as proposed by Chemistry Department. CYN-101: Introduction of Chemical Science CYN-103: Computer Programming CYN-102: Physical Chemistry-I CYN-104: General Organic and Inorganic Chemistry CYN-106: Basic Analytical Chemistry CYN-201: Thermodynamics CYN-203:Coordination Chemistry and Organometallics CYN-205: Organic Chemistry-I CYN-202: Main Group and Cluster Chemistry CYN-204: Organic Chemistry-II CYN-206: Chemical Kinetics	4

71.10	एकीकृत एमएससी (भौतिकी) के शैक्षिक कार्यक्रम पर विचार करना। To consider the academic program of Integrated M.Sc.(Physics).	5
71.11	एमटेक (सोलिड स्टेट इलेक्ट्रोनिक मैटिरीयल) और एमटेक (फोटोनिक्स) के इलेक्टिव कोर्सो के शैक्षिक कार्यक्रम पर विचार करना। To consider the academic program of the elective courses of M.Tech. (Solid State Electronic Materials) and M.Tech. (Photonics).	5
71.12	श्री गोकुल कृष्णन (अनुक्रमांक सं0 1211034) को वर्तमान सत्र में अपनी डिग्री की आवश्यकताओं को पूरा करने के लिए बीटीएन–302 और बीटीएन–300 को स्व–अध्ययन पाठयक्रम के रूप में अपनाने के अनुरोध पर विचार करना। To consider the request of Mr. R. Gokul Krishnan (En.No. 1211034) for allowing BTN-302 and BTN-300 as self study courses in the current semester to complete his degree requirements.	5
71.13	एमटेक (इलेक्ट्रिक ड्राइवज और पावर इलेक्ट्रॉनिक्स) के शैक्षिक कार्यक्रम में संशोधन के लिए विद्युत अभियांत्रिकी विभाग के अनुरोध पर विचार करना। To consider the request of Electrical Engineering Department for modifications in the academic program of M.Tech. (Electric Drives & Power Electronics)	5
71.14	पीएचडी उम्मीदवारी में कोर्स केडिट आवश्यकताओं में, ऐसे बीटेक डिग्री धारक प्रार्थी जो कि नयूनतम विशेषज्ञता/विभागीय कोर्सो में आनर्स की आवश्यकताओं को पूर्ण करते हों, छूट के बारें में विचार करना। To consider relaxation in course credit requirements for candidacy of Ph.D. if the candidate has B.Tech. Degree and has completed requirements for Minor Specialization/ Honours Departmental courses.	5
71.15	थीसिस प्रस्तुत करते समय और थीसिस मूल्यांकन के समय लागू पीएचडी नियमों के मानदंड के प्रायोज्यता पर विचार करना। To consider the criteria regarding applicability of Ph.D. rules at the time of submission of thesis and regarding evaluation of the thesis.	6
71.16	पूर्णकालिक से अंशकालिक पीएचडी के रूपांतरण के समय स्थानीय पर्यवेक्षक के निर्धारण संबंधी विसंगतियों पर विचार करना। To consider operational discrepancies observed at the time of conversion from Full Time to Part-time Ph.D. with respect to fixing of local supervisor.	6

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71.17	बीटेक या समकक्ष योग्यता के साथ लम्बें व्यवसायिक अनुभव वालें उम्मीदवारों के लिए प्रवेश पात्रता मानदंड, श्रेणी नामकरण, प्रवेश प्रकिया और पूर्व पीएचडी कोर्स की आवश्यकताओं पर विचार करना। To consider admission eligibility criteria, category nomenclature, process of admission and pre-Ph.D. course requirements for candidates having long professional experience with qualification as B.Tech. or equivalent.	6
71.18	पीएचडी प्रोग्राम में प्रवेश के लिए संस्थान के संविदागत कर्मचारी के अनुरोध पर विचार करना। To consider request of a contractual employee of the Institute for admission in the Ph.D. program.	6
71.19	उन छात्रों को अनंतिम पी0एच0डी0 उपाधि प्रदान करने की पुष्टि किया जाना, जिन्होंने विभिन्न पाठ्यक्रमों में 25 सितम्बर 2017 से अब तक उपाधि प्राप्त किए जाने की अर्हता प्राप्त की है। To ratify the award of the provisional Ph.D. Degrees certificate to the students who have completed the requirements for the award of the Ph.D. Degree in various disciplines w.e.f. 25th September 2017 to date.	6
71.20	(i) एप्लाइड साइंस एंड इंजीनियरिंग विभाग, पल्प एंड पेपर टेक्नोलॉजी विभाग, पॉलिमर एडं प्रोसेस इंजीनियरिंग विभाग, सहारनपुर कैम्पस और सैंटर फॉर नैनोटेक्नोलॉजी में पीएचडी में प्रवेश के लिए न्यूनतम शैक्षिक योग्यता में सत्र 2017–18 के लिए परिवर्तन की पुष्टि करना। (ii) बाद के वर्षो के लिए उसी पर विचार करना और स्वीकृति देना। (i) To ratify change in minimum education qualification for admission to Ph.D. programme in the Department of Applied Science & Engineering, Department of Pulp & Paper Technology, Department of Polymer & Process Engineering, Saharanpur Campus and Centre for Nanotechnology for the session 2017-18. (ii) To consider and approve the same for subsequent years.	7
71.21	(i) पीएचडी में प्रवेश के लिए एमएचआरडी की अधिसूचना एफ सं0 17–2–2014–टीएसआई दिनांक 2 मार्च 2015 को अपनाने की पुष्टि करना। (ii) बाद के वर्षो के लिए उसी पर विचार करना और स्वीकृति देना। (i) To ratify adopting MHRD notification F.No. 17-2/2014-TS.I dated 2nd March 2015 regarding the eligibility criteria for Ph.D. admission. (ii) To consider and approve the same for subsequent years.	7

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MEETING SECTION
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Minutes of the 71st Meeting of the Senate held on 28.12.2017 at 3.30 P.M. in the Senate Hall of the Institute.

Following were present:

1.	Prof. Ajit K. Chaturvedi	Director
2.	Prof. (Mrs.) Pushplata	(Architecture & Planning)
3.	Prof. R.P. Singh	(Biotechnology)
4.	Prof. Ramasare Prasad	(Biotechnology)
5.	Prof. Vikas Pruthi	(Biotechnology)
6.	Prof. Partha Roy	(Biotechnology)
7.	Prof. B. Prasad	(Chemical Engineering)
8.	Prof. C.B. Majumdar	(Chemical Engineering)
9.	Prof. Ravi Bhushan	(Chemistry)
10.	Prof. Anil Kumar	(Chemistry)
11.	Prof. (Mrs.) Mala Nath	(Chemistry)
12.	Prof. U.P. Singh	(Chemistry)
13.	Prof. M.R. Maurya	(Chemistry)
14.	Prof. Bina Gupta	(Chemistry)
15.	Prof. S.S. Jain	(Civil Engineering)
16.	Prof. C.S.P. Ojha	(Civil Engineering)
17.	Prof. Mahendra Singh	(Civil Engineering)
18.	Prof. M. Parida	(Civil Engineering)
19.	Prof. Praveen Kumar	(Civil Engineering)
20.	Prof. Kamal Jain	(Civil Engineering)
21.	Prof. M.L. Sharma	(Earthquake Engineering)
22.	Prof. Yogendra Singh	(Earthquake Engineering)
23.	Prof. B.K. Maheshwari	(Earthquake Engineering)
24.	Prof. Pankaj Agrawal	(Earthquake Engineering)
25.	Prof. J.P. Narayan	(Earthquake Engineering)
26.	Prof. Manish Shrikhande	(Earthquake Engineering)
27.	Prof. A.K. Sen	(Earth Sciences)
28.	Prof. R. Krishnamurthi	(Earth Sciences)
29.	Prof. S.P. Singh	(Electrical Engineering)
30.	Prof. N.P. Padhy	(Electrical Engineering)
31.	Prof. Biswarup Das	(Electrical Engineering)
32.	Prof. M.J Nigam	(Electronics & Communication Engg.)
33.	Prof. Dharmendra Singh	(Electronics & Communication Engg.)
34.	Prof. Y.S. Negi	(Paper Technology)
35.	Prof. S. Rangenekar	(Management Studies)

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36. Prof. Sunita Gakkhar (Mathematics)
37. Prof. Tanuja Srivastava (Mathematics)
38. Prof. N. Sukavanam (Mathematics)
39. Prof. S.C. Sharma (Mechanical & Industrial Engg.)
40. Prof. Dinesh Kumar (Mechanical & Industrial Engg.)
41. Prof. B.K. Gandhi (Mechanical & Industrial Engg.)
42. Prof. B.K. Mishra (Mechanical & Industrial Engg.)
43. Prof. Ravi Kumar (Mechanical & Industrial Engg.)
44. Prof. Navneet Arora (Mechanical & Industrial Engg.)
45. Prof. S.K. Nath (Metallurgical & Materials Engg.)
46. Prof. Anjan Sil (Metallurgical & Materials Engg.)
47. Prof. Rajesh Srivastava (Physics)
48. Prof. (Mrs.) Tashi Nautiyal (Physics)
49. Prof. M.L. Kansal (WRD&M)
50. Prof. Deepak Khare (WRD&M)
51. Prof. R.P. Saini (Alternate Hydro Energy Centre)
52. Prof. Arun Kumar (Alternate Hydro Energy Centre)
53. Prof. P.S. Chani, Head, Department of Architecture & Planning
54. Prof. P. Gopinath, ADOAA (Admission)
55. Prof. Vipul Rastogi, ADOAA (Curriculum)
56. Prof. Rajat Rastogi, ADOAA (Evaluation)
57. Prof. M.K. Pathak, Associate Dean Infrastructure (Electrical and A/C)
58. Prof. Aalok Mishra, Associate Dean of Students' Welfare (Students' Wellness)
59. Prof. M.K. Barua, Associate Dean Students' Welfare (Students Activities)
60. Prof. C. Jayakumar, Librarian, M.G. Central Library
61. Prof. Manish Mishra, Associate Professor, Dept. of Mech. & Indl. Engineering
62. Prof. K.R. Justin Thomas, Associate Professor, Department of Chemistry
63. Prof. Rajat Agarwal, Associate Professor, Department of Management Studies
64. Mr. Rajesh Kumar Vishwakarma - Students' representative
    General Secretary Academic Affairs (PG)
65. Mr. Prashant Garg
    Registrar & Secretary, Senate

At the outset, the Senate observed 02 minutes silence to pay tribute to late Prof. B.C. Mathur, Department of Earthquake Engineering and late Prof. Shashi, Department of Chemical Engineering.

The Chairman welcomed the members to the 71st meeting of the Senate.

The Chairman thanked and placed on record the valuable contributions of the under-mentioned outgoing Senate members in the meetings of the Senate:

1. Prof. A.K. Ahuja, Department of Civil Engineering
2. Prof. R.C. Mittal, Department of Mathematics
3. Prof. Vir Singh, Department of Physics

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The Senate noted the communications received from the following members for their inability to attend the current meeting:

1. Prof. Himanshu Joshi, Department of Hydrology
2. Prof. M.P. Sharma, A.H.E.C.
3. Prof. N.K. Goel, Department of Hydrology
4. Prof. R. Balasubramanian, Head, Institute Computer Centre
5. Prof. D.C. Srivastava, Department of Earth Sciences
6. Prof. (Mrs.) Rama Bhargava, Department of Mathematics
7. Prof. Umesh K. Sharma, Department of Civil Engineering
8. Prof. S.K. Ghosh, Department of Civil Engineering
9. Prof. P.P. Kundu, Department of Chemical Engineering
10. Prof. Anand Joshi, Department of Earth Sciences
11. Prof. K.L. Yadav, Department of Physics
12. Prof. V. Devdas, Department of Architecture & Planning
13. Prof. (Mrs.) Ila Gupta, Department of Architecture & Planning
14. Prof. Nagendra Kumar, Department of Humanities & Social Sciences
15. Prof. B.S.S. Daniel, Department of Metallurgical & Materials Engineering
16. Prof. B.R. Gurjar, Department of Civil Engineering
17. Prof. Pradeep Bhargava, Department of Civil Engineering

The Agenda was then taken up:

Item No. 71.1: To confirm the minutes of the 69th meeting and 70th meeting (Special meeting) of the Senate held on 28.07.2017 and 19.09.2017, respectively.

Minutes of the 69th meeting and 70th meeting (Special meeting) of the Senate held on 28.07.2017 and 19.09.2017, respectively as recorded and circulated vide e-mail 29.08.2017 and 18.10.2017, respectively were confirmed.

It was decided that suggestions regarding Item No. 70.3 may be taken up by IAPC for consideration.

Item No.71.2: To report on the actions taken to implement the decisions taken by the Senate in its 69th meeting and 70th meeting (Special Meeting) held on 28.07.017 and 19.09.2017, respectively.

The Senate noted the actions taken on the said minutes.

Item No. 71.3: To consider finalization of title at the time of thesis submission for Masters' students.

The Senate approved the proposal.

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Item No. 71.4: **To consider the proposal of closing the following proficiencies:**

1. **Gardening**
2. **Philately and Numismatics**

The item was withdrawn in view of item No. 71.6.

Item No. 71.5: **To consider the proposal regarding rules/norms for change of branch.**

The Senate approved the proposal with minor changes. The approved proposal is given at **Appendix 'A'.**

Item No. 71.6: **To consider the proposal regarding revision of rules of proficiency.**

The Senate approved the proposal.

Item No. 71.7: **To consider the proposal for introducing "Dean's Appreciation for Achieving Highest Increase in CGPA & HoD's Appreciation for Achieving Highest Increase in SGPA".**

The Senate approved the proposal. The format of certificates is given at **Appendix 'B'.**

A proposal for Masters' programs be also brought before the Senate.

Item No. 71.8: **To consider the 2nd mercy appeals of students to continue their study for this academic year 2017-18.**

The Senate approved the proposal.

Item No. 71.9: **To consider the academic program of Integrated M.Sc. Chemistry upto 2nd year as proposed by Chemistry Department.**

CYN-101: Introduction of Chemical Science
CYN-103: Computer Programming
CYN-102: Physical Chemistry-I
CYN-104: General Organic and Inorganic Chemistry
CYN-106: Basic Analytical Chemistry
CYN-201: Thermodynamics
CYN-203:Coordination Chemistry and Organometallics
CYN-205: Organic Chemistry-I
CYN-202: Main Group and Cluster Chemistry
CYN-204: Organic Chemistry-II
CYN-206: Chemical Kinetics

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The Senate approved the academic program as given at **Appendix 'C'**

Item No. 71.10: To consider the academic program of Integrated M.Sc.(Physics).

The Senate approved the academic program with minor changes. The approved academic program is given at **Appendix 'D'**.

Item No. 71.11: To consider the academic program of the elective courses of M.Tech. (Solid State Electronic Materials) and M.Tech. (Photonics).

The Senate approved the academic program.

Item No. 71.12: To consider the request of Mr. R. Gokul Krishnan (En. No. 1211034) for allowing BTN-302 and BTN-300 as self study courses in the current semester to complete his degree requirements.

The Senate approved the request.

Item No. 71.13: To consider the request of Electrical Engineering Department for modifications in the academic program of M.Tech. (Electric Drives & Power Electronics).

The Senate approved the academic program as given in **Appendix 'E'**.

Item No. 71.14: To consider relaxation in course credit requirements for candidacy of Ph.D. if the candidate has B.Tech. Degree and has completed requirements for Minor Specialization/ Honours Departmental courses.

The Senate approved the proposal with the following change:

Based on SRC's recommendation, upto a maximum of 12 credits can be waived.

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Item No. 71.15: To consider the criteria regarding applicability of Ph.D. rules at the time of submission of thesis and regarding evaluation of the thesis.

The Senate approved the following:

(i) Eligibility criteria for submission of thesis regarding minimum duration of submission and number of papers to be published shall be as per the Ordinances & Regulations in force at the time of admission.

(ii) Criteria to be adopted for evaluation of thesis shall be as per the Ordinances & Regulations in force at the time of submission of the thesis.

Item No. 71.16: To consider the operational discrepancies observed at the time of conversion from Full Time to Part-time Ph.D. with respect to fixing of local supervisor.

The Senate approved that an-organization as a whole and not one of its units be considered while approving change of status from full time to Part-Time. Further, there shall not be any requirement of obtaining NOC nor having a local supervisor mandatory.

Item No. 71.17: To consider admission eligibility criteria, category nomenclature, process of admission and pre-Ph.D. course requirements for candidates having long professional experience with qualification as B.Tech. or equivalent.

The Senate accepted the proposal in principle. Further, suggested that keeping in view the suggestions received the matter be reconsidered by the Committee and revised recommendations be brought before the Senate for consideration.

Item No. 71.18: To consider request of a contractual employee of the Institute for admission in the Ph.D. program.

The proposal was not accepted.

Item No. 71.19: To ratify the award of the provisional Ph.D. Degrees certificate to the students who have completed the requirements for the award of the Ph.D. Degree in various disciplines w.e.f. 25th September 2017 to date.

The Senate ratified the item.

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Item No: 71.20: **(i) To ratify change in minimum education qualification for admission to Ph.D. programme in the Department of Applied Science & Engineering, Department of Pulp & Paper Technology, Department of Polymer & Process Engineering, Saharanpur Campus and Centre for Nanotechnology for the session 2017-18.**

(ii) To consider and approve the same for subsequent years.

The Senate ratified the item and approved the same for subsequent years.

Item No: 71.21: **(i) To ratify adopting MHRD Notification F.No. 17-2/2014-TS.I dated 2nd March 2015 regarding the eligibility criteria for Ph.D. admission.**

(ii) To consider and approve the same for subsequent years.

The Senate ratified the item and approved the same for subsequent years. Further, the Senate decided that MBA may not be considered as a professional course for Ph.D. admission in Engineering Departments.

Item No: 71.22: **(i) To ratify guidelines for Ph.D. admission through Rolling Advertisement.**

(ii) To consider and approve the same for subsequent years.

The Senate ratified the item and approved the same for subsequent years.

Item No. 71.23: **To ratify replacement of the course WR-572 (Soil and Agronomy) by WR-575 (On Farm Development) of P.G. Diploma and M.Tech. (I.W.M.) programme as proposed by Head, W.R.D.M.**

The Senate ratified the item.

Item No. 71.24: **To ratify the continuation of studies and striking off name of UG/IDD students.**

The Senate ratified the item.

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

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Guidelines for Change of Branch/Programme

1) A student admitted through JEE (Advanced), except those in B.Arch. Programme, shall be eligible for change of branch/programme at the end of the autumn semester of the first year provided that the student satisfies the following criteria:

a) He/She has earned all the specified credits in the programme structure at the end of the autumn semester.
b) He/She has not failed in any course
c) He/She has not been penalized for indiscipline.

2) The change of branch/programme shall be strictly against the number of vacancies or 10% of the **sanctioned strength** of the branch/programme (to which the change is sought), whichever is higher.

3) In making a change of branch/programme, the resulting strength of the branch/programme from which the transfer is being made should not fall by more than twenty five percent of **existing strength.**

4) If a student of Branch/Programme-A with SGPA X is denied change to Branch/Programme-B because of Rule 3, change to Branch/Programme-B cannot be offered to any other student (From branches/programmes other than Branch/Programme-A also) having SGPA less than or equal to X. However, the students (From other than Branch/Programme-A) can be offered a branch/programme other than B. The students with SGPA equal to X but having higher JEE rank than the student of Branch/Programme-A can, however, be allowed to move to Branch/Programme-B.

5) The eligible candidates should be allowed change of branch/programme, strictly on the basis of their inter-se-merit, as reflected in their SGPA. In case, the SGPA of more than one student seeking the change of branch/programme is equal, their inter-se-merit should be decided on the basis of their rank in JEE (Advanced).

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(On Head of the Department's Letter Head)

LETTER OF APPRECIATION

It is a matter of immense pleasure to award this Letter of Appreciation to Mr./Ms./Mrs. ....., Enrolment No. ..... son/daughter of ..... for achieving **Highest Improvement in Semester Grade Point Average** in the B.Tech. programme of the Department of .....from ....to ..... in the Autumn/Spring Semester .....

Dated: Signature

(On Dean Academic Affair's Letter Head)

LETTER OF APPRECIATION

It is a matter of immense pleasure to award this Letter of Appreciation to Mr./Ms./Mrs. ....., Enrolment No. ..... son/daughter of ..... for achieving **Highest Improvement in Cumulative Grade Point Average** in the B.Tech. programme of the Department of .....from ....to ..... in the Academic Year .....

Dated: Signature

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CYN-101** Course Title: **Introduction to Chemical Science**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To develop interest and aptitude in chemistry

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	**Chemistry, then and now**: Evolution of chemistry starting from alchemist to the modern chemistry, opportunities in chemistry, important discoveries in chemistry and their impact in society	4
2.	**Safety and hazards :** Introduction to a chemistry laboratory, general safety precautions, understanding and handling of air and moisture sensitive, pyrophoric, spontaneously flammable and shock sensitive compounds, case studies of laboratory accidents	4
3.	**Chemistry inspired by nature:** Colors: Origin of colors, natural and artificial colors. Foods and drugs: Ripening of food, food stabilizers, non-nutritional sweeteners, important drugs and their action, Flavors and fragrances. Polymers: Natural and synthetic polymers, biodegradable polymers, conducting polymers and their applications. Artificial photosynthesis.	8
4.	**Chemical reactions in life processes:** Redox chemistry in cell, trans-amination in amino acids, carbonate insertion in cell, antioxidants in cell, ribose chemistry, neurotransmitters	4
5.	**Recent advances and future prospects in chemistry:** Green chemistry, combinatorial chemistry lasers in chemistry, multifunctional molecules and materials, liquid crystals, light emitting diodes, molecular machines, nanomaterials, enzyme engineering for energy, fluorescent proteins, new methods of drug discovery, anti-aging projects, biomimetic analogues in medicines, personalized medicines, catalytic processes in energy conversions.	8
	Total	28

Q1

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11.Suggested Books

Sl. No.	Authors/ Title/ Publisher	Year of Publication/ Reprints
1.	LoweD.B., "The Chemistry Book: From Gunpowder to Graphene, 250 Milestones in the History of Chemistry", Sterling Publishing Company,	2016
2.	Hill Jr.R.H., and Finster, D.C., "Laboratory Safety for Chemistry Students",John Wiley& Sons, Inc.	2010
3.	Clayden J. , Greeves, N., Warren S., and Wothers, P., "Organic Chemistry", Oxford University Press	2009

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Q2

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide students with an entry-level foundation in computer programming.

10. Details of Course:

Sl. No	Contents	Contact Hours
1	Introduction to computer hardware and software, computer operating systems, algorithms, flow charts and programs, programming languages.	4
2	Standard I/O in Fortran/C languages, comments, fundamental data types- character types, integer, short, long, unsigned, single and double-precision. Floating point, declaration, arithmetic instruction, operators-hierarchy and associativity of operators.	6
3	Decision control instructions, conditional operators, loop instructions, complex loops, case control instructions.	8
4	Functions: Use of functions, passing value between functions, library functions, pointer notations, function calls, recursion functions.	8
5	Array notation and representation, manipulating array elements, pointers and arrays, multidimensional arrays. Structures: Purpose and usage of structures, declaring structures,assigning of structures.	8
6	Introduction to numerical methods: Solution of linear and quadratic equations, differentiation and integration, computer programs for chemistry.	8
	Total	42

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Q3

11. Suggested Books:

Sl. No.	Authors/ Title/ Publisher	Year of Publication/ Reprint
1.	KanetkarY. "Let us C", 14th Edition, BPB publications.	2016
2.	Clemen N.S. and Spector, W.,"Modern Fortran: Style and Usage", Cambridge University Press India Pvt. Ltd.	2011
3.	Press W.H., Flannery B.P., Teukolsky S.A., and Vetterling, W.T., "Numerical Recipes in C-The art of Scientific Computing", 2nd Edition, Cambridge University Press India Pvt. Ltd.	2013
4	Sastry S.S.,"Introductory Methods of Numerical Analysis", 5th Ed., PHI Learning, New Delhi.	2012

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Q4

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CYN-102** Course Title: **Physical Chemistry-I**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide theoretical and experimental knowledge of fundamental physical chemistry to undergraduate students

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	**IntroductoryQuantum Chemistry**: Failure of classical mechanics and birth of quantum mechanics, postulates, commuting and non-commuting operators, Schrödinger equation, particle in one, two and three dimensional box and their implications, introduction to rigid rotor and harmonic oscillator, H-atom-radial and angular wave functions, shapes of orbitals (s, p and d), applications of quantum chemistry concepts to hydrogen-likesystems.	9
2.	**Basic Thermodynamics and Chemical Equilibria**: Laws of thermodynamics- zeroth, first, second and third, heat capacity of solids, description of equilibrium, feasibility of chemical reaction, Gibbs-Helmholtz equation, phase transition-Clapeyron equation, Clapeyron-Clausius equation, free energy and entropy changes in reversible and irreversible processes, chemical potential, partial molar quantities, activity coefficient and fugacity.	8
3.	**Chemical Kinetics**:Types and classification of reactions, integrated and differential rate laws, rate laws of consecutive, parallel, chain and complex reactions, collision theory of bimolecular reactions and its drawbacks, introduction to transition state theory.	8
4.	**Catalysis**: Homogeneous and heterogeneous catalysis, kinetics of acid, base and enzyme catalysis with suitable examples, principle of adsorption, differences between physisorption and chemisorption, derivation of Langmuir adsorption isotherm, Langmuir-Hinshelwood and Rideal-Eley mechanisms.	6

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5.	**Solid State Chemistry**: Unit cell, Miller indices, directions and planes in crystals, packing types, packing fraction, simple crystal structures, determination of structure of solids-X-ray diffraction and Bragg's Law, defects in solids.	**5**
6.	**Physical Properties of Molecules**: Dipolemoments and their determination, dielectric constants, interactions between molecules, molar refraction, optical rotation and rotatory dispersion, circular dichroism, transport properties, parachor, magnetic susceptibility and its temperature dependence inpara-, ferro- and antiferro-magnetic materials.	**6**
	Total	**42**

List of Experiments: Determination of iron using potassium dichromate (Internal indicator method)

1. Heat of neutralization of a strong base by a strong acid
2. Determination of surface excess of 1-butanol in aqueous solution
3. To study kinetics of a redox reaction
4. Blue Printing using sunlight
5. pH metry/ potentiometry titrations
    a) Strong acid – strong base;
    b) Strong acid – weak base
    c) Weak acid – strong base;
    d) Redox titration: Fe^{2+} or Mn^{2+}
6. Spectrophotometry: Determination of Fe (III) by colorimetry
7. Determination of hardness of water by EDTA-complexometry titration
8. Determination of the composition of mixtures of liquids using viscometry
9. Acid-base titrations using conductivity meter
    a) Strong acid – strong base;
    b) Strong acid – weak base
    c) Weak acid – strong base

11. Suggested Books:

Sl. No.	Authors/ Title/ Publisher	Year of Publication/ Reprints
1.	Silbey R.J., Alberty R.A. and Bawendi M.G., "Physical Chemistry", 4th Ed., John Wiley & Sons, Inc.	2005
2.	Atkins P.W., and de Paula, J., "Physical Chemistry", 9th Ed., Oxford University Press.	2010
3.	West A.R., Solid State Chemistry and its Applications, Wiley-India Edition	2003
4.	Levine I. N., "Quantum Chemistry", 7th Ed., Pearson Education	2014

Q6

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CYN-104** Course Title: **General Organic and Inorganic Chemistry**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart basic concepts of organic and inorganic chemistry

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	**Structure and bonding in organic molecules**: Introduction to localized bonding, delocalized bonding, homolytic and heterolytic cleavage of bonds, nucleophiles, electrophiles, amphiphiles.	7
2.	**Isomerism and stereochemistry**: Definitions of configuration and conformation, optical isomerism, asymmetric carbon and molecular chirality (biphenyl and allenes), R/S notations, geometrical isomerism, E/Z nomenclature, conformational analysis of alicyclic and cyclic systems.	7
3.	**Organic reactions & intermediates**: Types of organic reactions, generation, structure, stability and reactivity of intermediates such as carbocations, cabanions, free radicals, carbenes, arynes and nitrenes.	10
4.	**Periodic properties of elements:**Ionization potential, electron affinity, electronegativity and electronegativity scales with their measurements, ionic,covalent and van der Waals radii and their measurements, ionic potential and work function. Periodic trends in chemical properties.	4
5.	**Inorganic molecules and their chemical bonding:** Electronic theory of valency, chemical bond, bond energy, ionic bond and ionic character, Fajan's rule and lattice energy, ionic ratio, Born-Haber cycle, energetics of covalent bond in hydrogen molecule-valence bond theory. Hybridization and VSEPR theory and geometry of molecules. Molecular orbital theory for homo and heteronuclear diatomic molecules with examples B_2, C_2, N_2, O_2, F_2, CO, NO, CN^-. Inter- and intra-molecular forces, H-bonding, metallic bonding: band theory.	14
	Total	42

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Laboratory Experiments

i. Determination of sodium carbonate in baking/washing soda
ii. Estimation of Copper by Iodometry
iii. Estimation of Pb as PbSO4 by gravimetry
iv. Preparation of Copper tetraammine complex
v. Synthesis of potassium trioxalatochromate(III)
vi. Qualitative analysis of given Inorganic salt mixture containing 4 radicals.
vii. Determination of λ_{max} and concentration of $KMnO_4/K_2Cr_2O_7$
viii. Identification of functional groups in an organic compound
ix. Determination of equivalent weight of organic acid
x. Synthesis of phthalic acid from waste PET bottle
xi. Preparation of p-nitroacetanilide and determination of its melting point
xii. Oxidative coupling reaction of β-naphthol
xiii. Synthesis of azo dye
xiv. Synthesis of a polymer

11. Suggested Books:

Sl. No	Authors/ Title/ Publisher	Year of Publication/ Reprints
1.	Solomons T.W.G., Fryhle C.B. and Snyder S.A. "Organic Chemistry", 11th Ed., Wiley, ISBN: 9788126556847	2015
2.	Bruice P.Y., "Organic Chemistry", 8th Ed., Pearson, ISBN: 9780134042282	2017
3.	Volhardt K.P.C., and Schore N.E., "Organic Chemistry Structure and Function", 7th Ed., Macmillan, ISBN: 9781464120275.	2015
4	Eliel E.L.S., and Wilen H., "Stereochemistry of Organic Compounds", 1st Ed., Wiley, 2008, ISBN, 9788126515707.	2008
5.	Lee J.D., "Concise Inorganic Chemistry" 5th Ed. Blackwell Sciences.	2010
6.	Shriver D.F., and Atkins, P.W., "Inorganic Chemistry" 3rd Edition, Oxford University Press.	1999

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject code: **CYN-106** Course Title: **Basic Analytical Chemistry**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart the fundamental knowledge in different areas of analytical chemistry

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	**Measurement Basics:** Data domain, detector, transducer and sensors, signal and noise, sensitivity and detection, basic electronics, optical components and circuits for instrumentation used in chemical analysis.	5
2.	**Data handling**: Accuracy and precision, types of error, statistical data treatment, significant figures and propagation of errors, use of spreadsheet and data treatment software, control chart, confidence limit, test of significance, outliers, calibration methods, linear and non-linear data fitting.	7
3.	**Gravimetric analysis:** Properties of precipitates. Nucleation and crystal growth, factors influencing completion of precipitation. Co-precipitation and post-precipitation, purification and washing of precipitates. Precipitation from homogeneous solution, a few common gravimetric determinations.	6
4.	**Volumetric analysis:** Acid base titration,complexometric titration, redox titration, precipitation titration,	6
5.	**Potentiometry:** Fundamentals of potentiometry, different types of electrodes – e.g., indicator and ion selective electrode, membrane electrode, glass electrode.Polarography – principle, instrumentation and applications to qualitative and quantitative analysis, amperometric and biamperometric titrations	6
6.	**Separation methods**: Solvent extraction: Partition law and its limitations, distribution ratio, separation factor, factor influencing extraction, multiple extractions,	12

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	solid phase extraction, cloud point extraction. Chromatography: classification, theory of column chromatography, retention time, retention volume, capacity factor, concept of plate and rate theory, resolution, column performance, paper and thin layer chromatography, Ion exchangers	
	Total	**42**

11. Suggested Books:

Sl. No.	**Name of Authors/Book/ Publisher etc.**	**Year of Publication/ Reprint**
1.	Christian G.D., Dasgupta P.K., Schug K.A., "Analytical Chemistry" 7th Ed., Wiley	2013
2.	Mendham J., Denny R.C., Barnes J.D. and Thomas M.J.K., "Vogel's Text Book of Quantitative Chemical Analysis" 6th Ed., Pearson Education	2004
3.	Skoog D.A., West D.M., Holler F.J. and Crouch S.R., "Fundamentals of Analytical Chemistry" 8th Ed., Thomson Brooks/Cole.	2004
4.	Fifield F.W., and Kealey D., "Principles and Practice of Analytical Chemistry", 5th Ed., Blackwell Science.	2000
5.	Ewing G.W., "Instrumental Methodsof Chemical Analysis", 5th Ed., McGraw Hill.	2004

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CYN-201** Course Title: **Thermodynamics**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge of thermodynamics in chemical systems

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	**Classical Thermodynamics:** Phase rule, phase diagram of simple systems, chemical potential of real gases and solutions, thermodynamic treatment of ideal and non-ideal solutions, thermodynamics of reversible and irreversible systems, thermodynamic theory of ionic interactions, Debye-Huckel theory, interpretation of electrical conductance of electrolytes, thermodynamic treatment of diffusion potential, membranes-artificial and natural, Donnan membrane equilibrium.	10
2.	**Statistical Thermodynamics:** Concept of microstates and ensembles, micro-canonical, canonical and grand canonical ensemble, average distribution, partition functions and their relation with thermodynamic properties, Maxwell-Boltzmann, Bose-Einstein, Fermi-Dirac statistics, molecular partition functions, translational, vibrational and rotational partition functions, ideal monoatomic and diatomic gases and their thermodynamic properties	12
3.	**Surface and Interfaces:** Types of interfaces, surface phenomenon, adsorption isotherms-BET theorem, temperature dependence of adsorption isotherms and determination of surface area of adsorbents, electrical phenomenon of interphases, thermodynamics of surfaces, adsorption by porous, non-porous and microporous solids, adsorption from liquid phase	10
4.	**Colloids and Dispersed Systems:** Colloids-Electrical double layer and its structure, electrokinetics and zeta potential, surface of shear, properties and structure of gels, rheology, clay colloids, dispersed systems-classification, micellization, thermodynamics of micellization, dispersion and aggregation of solids by surfactants.	10
	Total	42

Q11

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11. Suggested Books:

Sl. No.	Authors/ Title/ Publisher	Year of Publication/ Reprints
1.	Silbey R.J., Alberty R.A. and Bawendi, M.G., "Physical Chemistry", 4th Ed., John Wiley & Sons, Inc.	2005
2.	Atkins P.W., and de Paula, J., "Physical Chemistry", 9th Ed., Oxford University Press.	2010
3.	McQuarrie D.A., "Statistical Mechanics", Student Edition, Viva Books.	2013
4.	Bockris J.O'M. and Reddy A.K.N. "Modern Electrochemistry" Vol 1, Springer.	1998

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CYN-203** Course Title: **Coordination Chemistry and Organometallics**

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 basic knowledge in coordination chemistry and organometallics

10. Details of Course:

Sl. No	Contents	Contact Hours
1	**Coordination chemistry:** Introduction, ligands and denticity, stability of coordination compounds, types of isomerism, nomenclature.	6
2	**Bonding in coordination compounds:** Crystal field theory involving d-orbital splitting in linear, trigonal, octahedral, square planar, tetrahedral, square pyramidal, trigonal bipyramidal and cubic complexes, measurement of CFSE in weak and strong ligand fields, Jahn-Teller distortion, variation of lattice energy, ionic radii and heat of hydration across 1^{st} row transition metal ions.	10
3	**Organometallic chemistry:** Factors affecting M-C bond formation, general methods for synthesis of organometallic compounds, 18-electron rule, metal carbonyl and nitrosyl complexes, metal-alkyls, -aryls and -carbenes.	8
4	**Reactions and applications of organometallic compounds:** Kinetics and mechanism of ligand substitution, oxidative addition, reductive elimination, transmetallation, migratory insertions, reactivity at metal bound ligand.Hydrogenation, hydroformylation, Zeigler–Natta catalysis, olefin metathesis, carbonylation and de-carbonylation.	10
5	**Organotransition compounds with multicenter bonds:** Concept of hapticity, transition metal complexes of alkenes, Zeise's salt, allenes, alkynes, allyls, cyclic π-metal complexes, reaction and bonding in ferrocene.	8
	Total	42

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11. Suggested Books:

Sl. No.	Authors/ Title/ Publisher	Year of Publication/ Reprints
1.	Huheey J.E., Keiter E.A., Keiter R.L., Medhi O.K. Inorganic Chemistry: Principles of Structure and Reactivity, 4 Ed. Pearson	2008
2.	Douglas B.E., McDaniel D.H. and Alexander J.J., "Concepts and Models in Inorganic Chemistry", 3rd Ed., John Wiley & Sons.	2001
3.	Lever A.V.P., "Comprehensive Coordination Chemistry-II From Biology to Nanotechnology", McCleverty J.A. and Meyer T.J., Eds., Volume 1, Elsevier	2003
4.	Hill A.F., "Organotransition Chemistry",RSC Cambridge.	2002
5.	Bochmann M. (Ed.), "Oxford Premier Series on Organometallics", Vol. 1 and 2. Oxford Press.	2002

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CYN-205** Course Title: **Organic Chemistry-I**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart basic concepts in chemistry of hydrocarbons

10. Details of Course:

Sl No.	Contents	Contact Hours
1.	**Alkanes**: Synthesis of alkanes, Wurtz reaction, Kolbe reaction, Corey-House synthesis, decarboxylation of carboxylic acids. Reactions of alkanes, halogenation, reactivity and selectivity. Cycloalkanes, ring strain, Baeyer's strain theory, theory of strainless rings, banana bonds, synthesis and reactivity.	6
2.	**Alkenes and Alkynes**: Methods of synthesis, reactivity, electrophilic and nucleophilic addition, oxidation (epoxidation, dihydroxylation, ozonolysis, hydroboration-oxidation, regioselectivity and stereoselectivity), oxymercuration reduction, metal-ammonia reductions, reactivity of vinyl and allylic systems. Synthesis and reactivity of conjugated and cumulated alkenes, 1,2 *vs.* 1,4 addition, polymerization reactions.	10
3.	**Arenes and aromaticity**: Structure of benzene, molecular orbital theory, Hückel rule, aromaticity, antiaromaticity, non-aromaticity, aromatic electrophilic substitutions, activating and deactivating substituents and their *o*-,*p*- and *m*- orientation, Birch reduction, nucleophilic substitution reactions, addition-elimination mechanism, leaving group effect, S_N1 mechanism, benzyne mechanism.	12
4.	**Alkyl, vinyl and allyl halides**: Nucleophilic substitution reactions, S_N1 vs S_N2, structure and stability of carbocations, transition state for S_N2 reactions, stereochemistry of substitutions, steric and solvent effects; effect of nucleophiles and leaving groups. Elimination reactions, role of nucleophile and leaving group in eliminations, E1 and E2 mechanisms, substitution vs elimination, stereoslectivity and regioselectivity in eliminations, E2 eliminations of cyclohexyl and vinyl halides, E1cB mechanism, reactions with Gilman	14

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	reagents, S_N2' reactions and their stereochemistry.	
	Total	**42**

11. Suggested Books:

Sl. No	Authors/ Title/ Publisher	Year of Publication/ Reprints
1.	Solomons T.W.G., Fryhle C.B. and Snyder S.A. "Organic Chemistry", 11th Ed., Wiley, ISBN: 9788126556847	2015
2.	Bruice P.Y., "Organic Chemistry", 8th Edition, Pearson, ISBN: 9780134042282	2017
3.	Wade L.G., and Simek J.W., "Organic Chemistry", 9th Edition, Pearson, ISBN: 9780321971371.	2016
4.	Carey F.A., and Giuliano, R.M., "Organic Chemistry", 10th Edition, McGraw-Hill, ISBN: 9780073511214	2016
5.	SmithJ.G., "Organic Chemistry",5th Edition, McGraw Hill,ISBN: 9780078021558	2016
6.	McMurry, J. E., "Organic Chemistry", 9th Edition, Brooks Cole, ISBN: 9781305080485	2015

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CYN-202** Course Title: **Main Group and Cluster Chemistry**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of main group elements, their compounds and structure-property relationship.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Group 1 (Li, Na, K, Rb, Cs):**Origin of flame colour and spectra, reactivity with water, air, and dinitrogen, anomalous reactivity of Li, dissolution in liquid ammonia, solvated electrons, oxides, hydroxides, peroxides and superoxides, sulphides, oxo salts, halides and hydrides, carbides and intercalation compounds, complexes of crown ethers and cryptands, soap formation, biological importance.	4
2.	**Group 2 (Be, Mg, Ca, Sr, Ba):**Reactivity with water, acids and bases, anomalous behaviour of Be, hydrides,oxides, peroxides, hydroxides, sulphates, nitrates, halides, nitrides, carbides. Biological importance of Ca and Mg.Catalytic activity.	4
3.	**Group 13 (B, Al, Ga, In, Tl):**Inert pair effect, oxides of boron and their properties, amphoteric behaviour of $Al(OH)_3$, reactions of Ga, In and Tl, borohydrides and aluminium hydrides as reducing agents, borides and halides of group 13 elements, hydroboration reactions, reactions with ammonia, low-oxidation boron compounds such as borylene, diborene, diboryne.	4
4.	**Group 14 (C, Si, Ge, Sn, Pb):**Carbides, silicides,and graphenes, their applications, oxides of carbon and carbon cycle, sulphides of carbon, oxides of Si, Ge, Sn and Pb, silicates and their applications, silicones, organosilicon compounds and polymers, structure and bonding of organosilicon compounds, silanes and polysilanes, halides, Freons, clusters and Zintl phases, low-valent and hypervalent silicon and comparison with carbon.	8
5	**Group 15 (N, P, As, Sb, Bi):**Structure and bonding of N and P	8

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	compounds, hydrides, hydrazines and hydroxylamines, azides, trihalides and pentahalides, nitrogen fixation, urea, phosphate fertilizers, oxides of N,P, As and Bi, oxoacids of nitrogen and P, sulphides of P, low-valent N and P such as nitrenes and phosphinidene,phosphazenes, cyclophosphazenes and their polymers.	
6.	**Group 16 (O, S, Se, Te):**Structures and allotropes, oxides, peroxides, suboxides, neutral,basic, acidic and amphoteric oxides, oxoacids of S, Se and Te, halides,oxohalides, hydrides.	**4**
7.	**Group 17 (F, Cl, Br, I):**Oxidizing power, reactivity, hydrogen halides, halogen oxides, oxoacids, interhalogen compounds, polyhalides, pseudohalogens, pseudohalides.	**4**
8.	**Main Group Organometallics:** Preparative routes for metal carbon bond formation of main group elements, general reactivity patterns, organometallic compounds of I, II, III, IV and V group elements. Grignard reagents and their reactivity, electron deficient organometallic compounds, structure and bonding of some important main group organometallic compounds.	**6**
	Total	**42**

11. Suggested Books:

S. No.	Authors/ Title/ Publisher	Year of Publication/ Reprints
1.	Cotton F.A., Wilkinson G., Murillo C.A. and Bochmann M., "Advanced Inorganic Chemistry", 6th Ed. John Wiley & Sons.	2016
2.	Greenwood N.N., and Earnshaw A. "Chemistry of the Elements" 2nd Ed.Butterworth-Heinemann,	2015
3	Purcell, K.F., and Kotz, J.C. "Inorganic Chemistry" Cengage Learning, Second Indian reprint.	2012
4.	Housecroft C.E., and Sharpe A.G., "Inorganic Chemistry", 4th Ed. Pearson	2012
5.	Shriver, D.F., Atkins, P.W., and Langford, C.H., "Inorganic Chemistry", 2nd Ed. ELBS	1994

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CYN-204** Course Title: **Organic Chemistry-II**

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

3. Examination Duration (Hrs.): **Theory 3** **Practical0**

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge about functionalgroups in organic chemistry and their reactivity.

10. Details of Course:

Sl. No	Contents	Contact Hours
1.	**Acidity and basicity**: Acids and bases, conjugate base and acid, pK_a and pK_b; factors affecting acidity and basicity, amphoteric compounds.	**6**
2.	**Alcohols, phenols, ethers and epoxides**: Synthesis of alcohols from aldehydes, ketones, carboxylic acids and esters, hydrogen bonding, acidity and reactivity, pinacol-pinacolone rearrangement, nucleophilic substitution on alcohols, Misunobu reaction. Preparation of phenols, acidity comparison between alcohols and phenols, reactivity of phenols, Fries and Claisen rearrangement, Gatterman synthesis, Hauben-Hoesch reaction, Lederer-Manasse reaction, oxidation of phenols. Synthesis of ethers and epoxides, acid and base-catalyzed ring opening, ring opening with organometallic reagents (organolithium, Grignard and Gilman reagents), reductive ring opening, nucleophilic and solvolytic ring opening, rearrangement of epoxides to carbonyl compounds Payne rearrangement	**14**
3.	**Carbonyl chemistry**: Synthesis of aldehydes from acid chlorides, 1,3-dithianes, nitriles, carboxylic acids and their derivatives; mechanism of nucleophilic addition to carbonyl group, benzoin, Perkin, Knoevenagel and Dieckmann condensations, Mannich reaction, Julia olefination, acetal formation, Baeyer-Villiger oxidation, Cannizaro reaction, Meerwein-Ponndorf-Verley, Clemenson and Wolf-Kishner reductions, reductions with $LiAlH_4$ and $NaBH_4$.	**12**
4.	**Enolate Chemistry**: Halogenation of enolizable ketones, aldol,	**10**

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	Mukayama aldol, reactions of α,β-unsaturated carbonyl compounds, Michael addition. Nucleophilic substitutions of carboxylic acid derivatives, Claisen condensation, acidity of α-hydrogen, alkylation and acylation of enolates, enamines.	
	Total	**42**

11. Suggested Books:

Sl. No.	Authors/ Title/ Publisher	Year of Publication/ Reprints
1.	Solomons T.W.G., Fryhle, C.B., and Snyder S.A. "Organic Chemistry", 11th Edition, Wiley, ISBN: 9788126556847	2015
2.	Bruice P.Y., "Organic Chemistry", 8th Edition, Pearson, ISBN: 9780134042282	2017
3.	Wade L.G., and Simek J.W., "Organic Chemistry", 9th Edition, Pearson, ISBN: 9780321971371.	2016
4.	Carey F.A., and GiulianoR.M., "Organic Chemistry", 10th Edition, McGraw-Hill, ISBN: 9780073511214	2016
5.	Smith J.G., "Organic Chemistry",5th Edition, McGraw Hill,ISBN: 9780078021558	2016

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CYN-206** Course Title: **Chemical Kinetics**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of kinetics and photochemistry

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	**Theories of Reaction Rates:** Theories of unimolecular and bimolecular reactions, thermodynamic formulation of transition state theory, applications of transition state theory,theoretical calculation of potential energy surfaces.	7
2.	**Kinetics of Complex Reactions:** Thermal and photochemical reactions, derivation of rate equations for complex reactions, chain reactions, kinetics of organic and inorganic reactions, kinetics of polymerization reactions.	7
3.	**Reactions on Surfaces:**Mechanisms of surface reactions, unimolecular and bimolecular surface reactions, transition state theory of surface reactions.	7
4.	**Reactions in Solutions:** Solvent effects, ion-ion, ion-dipole and dipole-dipole reactions, salt effect in acid base catalysis, kinetic isotope effects.	7
5.	**Photochemistry:** Primary photophysical processes of atoms and diatomic molecules, Jablonski diagram, Franck-Condon principle and its applications, rates of absorption and emission, quantum efficiencies, life time of electronically excited states, electron and energy transfer processes, quenching mechanisms, delayed fluorescence, ultra fast kinetic techniques -laser flash photolysisand radiation chemical techniques.	14
	Total	42

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11. Suggested Books:

Sl. No.	Authors/ Title/ Publisher	Year of Publication/ Reprints
1.	Silbey R.J., Alberty R.A., and Bawendi M.G., "Physical Chemistry", 4th Ed., John Wiley & Sons, Inc.	2005
2.	Atkins P.W., and de Paula J., "Physical Chemistry", 9th Ed., Oxford University Press.	2010
3.	Laidler K.J., "Chemical Kinetics", 3rd Ed., Pearson Education	2008
4.	LakowitzJ.R., "Principles of fluorescence spectroscopy", 3rd Ed., Springer	2006

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-101A** Course Title: **Introduction to Physical Science**

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: **DCC**

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,	6

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	structures: purpose and usage of structures, declaring structures, assigning of structures	
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 S S, "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 and Salvodori 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: 0** **MTE: 25** **ETE: 50** **PRE: 0**

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

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

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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**
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 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: **DCC**

8. Pre-requisite: **Nil**

9. Objective:To introduce concepts and applications of analog electronics

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Semiconductor Diodes and Basic Diode Circuits:** Basic properties of Si, Ge and GaAs from diode perspective, Intrinsic and extrinsic semiconductors, Formation of *p-n* junction, Qualitative theory of the p-n junction, Current flow mechanism in forward and reverse biased diode, Volt-Ampere characteristics, Static and dynamic resistance of diode, Junction capacitance, Diode equivalent circuits, Load line analysis, p-n junction as a rectifier, Rectifier circuits (Half wave, Full wave, Bridge), Clippers and Clampers, Zener diode, Zener regulator, Loaded Zener regulator.	10
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	8
3.	**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, n-MOS, p-MOS, CMOS, FET biasing as covered in BJTs	8
4.	**Amplifiers:** Small signal analysis of a transistor, h parameters, h parameter equivalent circuits; CE, CB, CC amplifiers and their analysis and comparison, Frequency effects in amplifiers, Differential amplifiers: A.C. and D.C. analysis, Common mode gain and CMRR; Operational amplifiers: inverting and non-inverting amplifiers, feedback in amplifiers: effects of positive and negative	12

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	feedback on input impedance, output impedance, gain, stability, distortion and noise, Op-amp applications: Addition, subtraction, differentiation and integration.	
5.	**Oscillators:** Sinusoidal oscillators:Barkhausen's criterion for self-sustained oscillations, RC phase shift oscillators, LC Oscillators, Non-sinusoidal oscillators– multivibrators	**6**

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	2006
2.	Boylestad R L and Nashelsky L, "Electronic Devices and Circuit Theory", 8th Ed.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: **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: **DCC**

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

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Kleppner D and Kolenkow R, "An Introduction to Mechanics", Cambridge University Press	2013
2.	SpiegelM R, "Theory and Problems of Theoretical Physics", McGraw Hill	1968
3.	Rana N and 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", 6th Ed.McGraw Hill	2009

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1.Subject Code: **PHN-207** 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: **DCC**

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
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.	Zemansky M 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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN- 209** Course Title: **Digital Electronics and Circuits**

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

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

4. Relative Weight: **CWS: 20** **PRS: 0** **MTE: 30** **ETE: 50** **PRE: 00**

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

8. Pre-requisite: **PHN 102 (Analog Electronics)**

9. Objective: To introduce concepts of Digital Electronics and Circuits

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Digital Principles and Logic :** Analog vs digital signals, Digital waveforms, Digital Operations, Digital Integrated Circuits, Basic Logic Gates, Universal Logic Gates, Introduction to HDL	6
2.	**Combinational Logic Circuits:**Boolean laws and theorems, Standard representations for logic functions(SOP and POS), Karnaugh map representation of logic functions, Simplification of logic functions using K-map, Don't care conditions	5
3.	**Data Processing Circuits:** Multiplexers, De-multiplxers, Decoders, Encoders, Parity generators and checkers	4
4.	**Digital Logic Families:** Bipolar and Unipolar logic families, Characteristics of Digital ICs, Resistor-Transistor logic, Transistor-Transistor Logic, Emitter-coupled logic, MOS logic, CMOS logic.	4
5.	**Number Systems and Codes:**Binary, Octal, Hexadecimal Numbers systems; Conversion from Binary, Octal, Hexadecimal to Decimal number system, Inter-conversion amongst Binary, Octal and Hexadecimal numbers. ASCII code, Excess code, Gray code	6
6	**Arithmatic Circuits:**Binary addition, subtraction, Unsigned and signed binary numbers, 2's compliment-representation and operations, Arithmetic building blocks, Arithmetic logic unit	6
7	**Flip-flops:** Concept of 1-bit memory cell, S-R, J-K, D, T flip-flops, Master-Slave J-K flip flop, Applications of flip-flops: Latch, Registers, Counters, Memories	7
8	**Timing Circuits :** Applications of logic gates in timing circuits, Schmitt trigger ICs, 555 timer	4

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Leach DP, Malvino Ap, Saha G, "Digital Principles and Applications", 8th Ed. (third re-print). McGraw Hill Education	2015
2.	Jain RP, "Modern Digital Electronics", 4th Ed. McGraw Hill Education	2014
3.	Mano MM and Ciletti MD., "Digital Design", 4th Ed., Prentice-Hall	2006
4.	Floyd TL, " Digital Fundamentals ", 8th Ed., Pearson Education.	2005
5.	Kumar A.A., "Pulse and Digital Circuits", 2nd Ed., Prentice-Hall of India	2008

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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: 3** **Practical: 0**

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

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

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; Energy quantization, Black body radiation, diffraction of matter particles, de Broglie waves and Davisson-Germer experiment, wave-particle duality, Angular momentum quantization: Stern-Gerlach experiment	08
2.	**Elements of Quantum Mechanics:** Time-dependent and time-independentSchrodinger equation, interpretation of the wave function, wave packets, stationary states; Heisenberg uncertainty principle, basic postulates and meaning of the measurement, expectation value, observables and operators, Hermitian operators, commutation relations, Dirac notation	12
3.	**Problems in one-dimension:** Particle in a box, potential step, potential barrier: reflection and transmission coefficients, tunnelingthrough multiple barriers: resonant tunneling; potential well, simple harmonic oscillator, raising and lowering operators	10
4.	**Problems in two dimension:** Two-dimensional electron gas in a perpendicular magnetic field, Landau levels	04
5.	**Problems in three-dimension:** Symmetry and conservation laws in quantum mechanics,Central potential, hydrogen atom, angular momentum and spherical harmonics	08
	Total	42

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Nouredine Zettili, "Quantum Mechanics: Concepts and Applications", 2nd Edition, Wiley	2009
2.	Griffiths D J, "Introduction to Quantum Mechanics", Prentice Hall	1995
3.	Beiser A, "Concepts of Modern Physics", 6th Ed. McGraw Hill	2009
4.	Gasiorowicz S, "Quantum Physics", John Wiley	2003
5.	Eisberg R M, and Resnick R, "*Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles*", Wiley	1985
6.	Tyagi I S, "Principles of Quantum Mechanics", Pearson Education	2013
7.	Y. B. Band and Y. Avishai, "Quantum Mechanics with application to nanotechnology and information science", Academic Press	2013
8.	Jasprit Singh, " Quantum Mechanics: Fundamentals and Applications to Technology", John Wiley and Sons, Inc.	1997
9.	A. F. J. Levi, "Applied Quantum Mechanics", 2nd Edition, Cambridge University Press; 2nd edition	2006

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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: 0** **MTE: 25** **ETE: 50** **PRE: 0**

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

8. Pre-requisite: **Nil**

9. Objective of Course: 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	14

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	spectroscopy	
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: **DCC**

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

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Kittel C, "Introduction to Solid State Physics", 8th Ed. Wiley Eastern Ltd.	2004
2.	Ashcroft N M and Mermin N D, "Solid State Physics",2nd Ed. Holt-Saunders	2004
3.	Hook J R and Hall H E, "Solid State Physics", John Wiley	2001
4.	Blundell S, "Magnetism in Condensed Matter", Oxford University Press	2001
5.	Ibach H and Lueth H, "Solid State Physics", Springer	2009

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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: **DCC**

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", 2nd 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 OF PHYSICS**

1. Subject Code: **PHN-210** 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: **DCC**

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.	**Vector Analysis:** Vectors in 3D spaces, coordinate transformations, rotations in R^3, differential vector operators, vector integrations, integral theorems, orthogonal curvilinear coordinate systems.	8
2.	**Matrices and Determinants:** Representing Vectors and Operators, Operations on Matrices, Orthogonal bases, Change of Basis, Determinant of a Matrix, Adjoint, Inverse and Trace, Direct products, Systems of linear equations, matrix eigen value problems, matrix diagonalization techniques.	8
3.	**Complex Analysis:** Complex variables and functions,Cauchy-Riemann Conditions, analytic and harmonic functions, Cauchy's Integral Theorem, singularities, Calculus of Residues, contour integration.	8
4.	**Integral Transforms and Gamma Functions:**Fourier series, Fourier and Laplace transforms, their properties and convolution theorems, evaluation of integral transforms and their inverses; beta and gamma functions.	8

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4.	**Special Functions:**Bessel and modified Bessel Functions, Legendre- and associated Legendre equations and their solutions, Spherical Harmonics; Hermite Functions, Laguerre- and associated Laguerre- functions; Applications.	10
	Total	**42**

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.	Hassani, S., "Mathematical Physics: A modern Introduction to its foundations", 2nd Ed. Springer	2013
3.	Whittaker E T and Watson E W, "A Course of Modern Analysis", Cambridge University Press	2008
4.	Shankar R, "Basic Training in Mathematics: A Fitness Program for Science Students", Springer	1995
5.	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-212** 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: **DCC**

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: **DCC**

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

9. Objective :To introducenumerical tools forcomputationally 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**

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-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: **DCC**

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
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: 0** **MTE: 25** **ETE: 50** **PRE: 0**

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

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,	8

	tokamak reactor	
	Total	**42**

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: **DCC**

8. Pre-requisite: **Nil**

9. Objective: To introduce working principles and characteristics of transducers and analytical instruments commonly usedfor 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

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 and Mansingh 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: **Properties of Matter and Acoustics**

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

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

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

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

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 - Experiment to determine Young's modulus by Koenig's method - Uniform bending - Expression for elevation - Experiment to determine Young's modulus using microscope	4
3.	**Fluids:**Surface Tension: 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. Viscosity: Steady flow of Newtonian fluids – Poiseuille's equation for incompressible fluids: Statement of Stoke's law– Terminal velocity-Effect of temperature on viscosity-Reynold's number –Turbulent flow and critical velocity-Experiment to	12

	determine co-efficient of viscosity of a liquid - Applications of viscosity. Condition of equilibrium of a fluid-Fluid dynamics-Equation of continuity-Bernoullie's theorem& conservation of energy Physics of Low Pressure. Production and Measurement of low pressure - Grades' molecular pump - Rotary pump - Knudsen absolute gauge - Detection of leakage.	
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.	Spherical waves, Large amplitude and Shock waves-Ultrasonics: Production of ultrasonic waves - Piezo electric crystal method - Magnetostriction method - Properties - Application to science industry and medicine.	**8**
	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", Vols. I, Narosa	2005
2.	Chakrabarthy P K, "Mechanics and General Properties of Matter", ***Allied Publishers***Pvt. Ltd	2001
3.	Flowers B H and Mendoza E, "Properties of Matter", Wiley Publisher	1991
4.	Bajaj N K, "The Physics of Waves and Oscillations", Tata MC Graw Hill	1988
5.	Ingard K U, "Fundamentals of Waves and Oscillations", CambridgeUniv. Press	1988

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-314** 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: 0**

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

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
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-324** 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: 0** **MTE: 25** **ETE: 50** **PRE: 0**

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

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 and scale, 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

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", 2nd Ed. Wiley-VCH	2006

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-503** Course Title: **Quantum Mechanics-I**

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

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

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

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

8. Pre-requisite: **PH-303**

9. Objective: To apply quantum mechanics to the dynamics of single particle in one-, two- and three- dimensional potential fields.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Postulates of Quantum Mechanics and meaning of measurement, Operators and their expectation values, Schrodinger equation, Particle in a box, Orthogonality of eigen functions, Dirac rotations, Hilbert space.	6
2.	**Matrix Formulation:** Matrix formulation of 1-dimensional harmonic oscillator problem; creation and annihilation operators; Equation of motion and classical correspondence, Heisenberg equation of motion, Schrodinger, Heisenberg and Interaction picture, Motion in a one-dimensional periodic potential, Kroning-penny model.	8
3.	**Motion in a Central Potential:** Angular momentum operator, expressions of $L^2$and L_z, eigen values and eigen functions of $L^2$and L_z, hydrogen atom, solution of radial equation, energy eigen values, eigen functions of H atom, orthogonality of eigen functions, rigid rotator, matrix representation L^2, L_x, L_y, L_z, generalized angular momentum, generator of rotation and their commutation relations, spin – ½ matrices, coupling of angular momenta, Clebsch-Gordon Coefficients.	10

4.	**Scattering Theory:** Scattering amplitude, differential and total cross-section, scattering by a central potential, method of partial waves, phase-shift analysis, optical theorem, scattering by a square-well potential, integral equation, the Born approximation.	10
5.	**Approximate Methods:** WKB approximation, WKB expansion, connecting formulas, variational principle and its application to Helium atom and hydrogen molecule	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	Schiff L.I., "Quantum Mechanics", 3rd Ed, McGraw Hill Book Co.	1990
2.	Merzbacher E, "Quantum Mechanics", 2nd Ed., John Wiley & Sons	1996
3.	Gasiorowicz S, "Quantum Physics", John Wiley	2000
4.	Mathews P. M. and Venkatesan K, "A Text Book of Quantum Mechanics", Tata McGraw Hill	2000

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-505** Course Title: **Advanced Mathematical Physics**

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** 7.Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To familiarize the students with the standard techniques in modern mathematical physics

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review of Special functions: Legendre, Bessel, Hermite and Laguerre functions and their applications.	6
2.	Green's functions and solutions to inhomogeneous differential equations of one-, two- and three-dimensions and their applications.	6
3.	Tensors, inner and outer products, contraction, symmetric and antisymmetric tensors, covariant and contravariant tensors, metric tensor, covariant derivatives, affine connections Christoffel symbols.	8
4.	Finite Groups: Classification and examples, subgroups, conjugacy classes, cosets, invariant subgroups, homomorphic and, isomorphc mappings, direct products.	8
5.	Representation theory for finite groups, reducible and irreducible representations, Schur's Lemma and orthogonality theorem.	6
6.	Continuous Groups: Characters; Lie Groups: SO(2), SO(3), SU(2), SU(3), Vector Spaces; Hilbert Space and operators.	8
	Total	**42**

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.	Hassani, S., "Mathematical Physics: A modern Introduction to its foundations", 2nd Ed. Springer	2013
3.	Duffy, D. "Green's Functions with Applications", 2nd Ed. CRC Press	2015
4.	Bourne, D. E. and Kendall, P. C., "Vector Analysis and Cartesian Tensors", 3rd Ed., Springer Science	1992
5.	Cornwell, J. F., "Group Theory in Physics: An Introduction", Academic Press	1997
6.	Hammermesh M., "Group Theory and Applications to Physical Problems", Dover publications, NY.	1989
7.	Akhiezer N. I. and Glazman I. M., " Theory of Linear Operator in Hilbert Space", Dover Publications	1993

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-507** Course Title: **Classical Electrodynamics**

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: **PH-202**

9. Objective: To emphasize electric and magnetic phenomena and introduce the covariant formulation of Maxwell's theory of electromagnetism

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Maxwell's Equation:** Maxwell's equation, vector and scalar potentials, Gauge transformation, Poynting theorem., plane electro-magnetic waves, waves in non-conducting and conducting medium; Linear and Circular polarization, reflection and refraction.	12
2.	**Covariant Formulation of Vacuum Electrodynamics:** Space-Time symmetry of the field equations; Covariant formulation; Four-vector potential; Electromagnetic field tensor and its invariants; Lorentz-Force equation in a covariant form.	12
3.	**Radiation from Accelerated Charges:** Retarded potentials; Lienard-Wiechert potentials; Fields produced by a charge in uniform and arbitrary motion, radiated power; Angular and frequency distribution of radiation, radiation from charged particle with co-linear velocity and acceleration; Synchrotron radiation; Thomson scattering; Cherenkov radiation.	14
4.	**Multipole Fields:** Inhomogeneous wave equation, multipole expansion of electromagnetic fields, angular distribution, multipole moments.	4

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		Total	42

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	Jakson J D, "Classical Electrodynamics", John Wiley	2002
2.	Griffiths D J, "Introduction to Electrodynamics", Prentice Hall	1999
3.	Capri A.Z. and Panat P.V., "Introduction to Electrodynamics" Narosa Publication House	2002
4.	Franklin J., "Classical Electromagnetism", Pearson Education	2007

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-509** Course Title: **Classical Mechanics**

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 25ETE 50PRE 0**

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

8. Pre-requisite: **PH-203**

9. Objective: To familiarize students with the various methods of solving problems in classical mechanics using the techniques of Lagrange, Hamilton, Hamilton-Jacobi and Poisson Brackets.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Lagrange's Equation:** Constraints; D'Alembert's principle and Lagrange's equation of motion, dissipation function, Hamilton's principle, calculus of variations, nonholonomic systems, conservation laws, relativistic and covariant formulation.	10
2.	**Hamilton's Equations:** Hamilton's equation of motion, cyclic co-ordinates, Routh's procedure, relativistic formation, variational principle, principle of least action.	8
3.	**Canonical Transformations:** Equations of canonical transformations and examples, sympletic approach, Poisson brackets and equation of motion, conservation laws, angular momentum, symmetry groups & Louville's theorem.	8
4.	**Hamilton-Jacobi Theory:** Hamilton-Jacobi equation's of motion, harmonic oscillations, separation of variables, action-angle variables, Kepler problem, geometrical optics and wave mechanics.	8
5.	**Canonical Perturbation Theory:** Time-dependent perturbation, examples, time-independent theory in first order and higher orders, applications to celestial and space	8

	mechanics, Adiabatic invariants.	
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	Goldstein H, "Classical Mechanics", Narosa	2001
2.	Rana W.C. and Jog P.S, "Classical Mechanics" , Tata McGraw Hill	1991
3.	Gupta K.C., "Classical Mechanics of particles and Rigid Bodies", Wiley Eastern	2001

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-513** Course Title: **Semiconductor Devices and Applications**

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

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

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: **PH-110**

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, the continuity equation, steady state carrier injection, The Haynes-Shockley experiment.	8
3.	**Junctions:** Metal-Semiconductor contact: under equilibrium, and non-equilibrium conditions, the 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**

List of Practical

S. No.	Particulars	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 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, monostable multivibrators using Timer 555	

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 & Sons	2003
3.	Tyagi M S, "Semiconductor Materials and Devices", John Wiley & Sons	2000
4.	Chattopadhyay D. and Rakshit P. C. , "An advanced course in Practical Physics" 7th Edition New Central Book	2005

	Agency (P) Ltd.	
5.	Gupta S. L. and Kumar V., "Practical Physics" 25th Ed. Pragati Prakashan	2002
6.	Paul P., Malvino A. and Miller M., " Basic Electronics: A Text-Lab Manual, Tata McGraw Hill	1999

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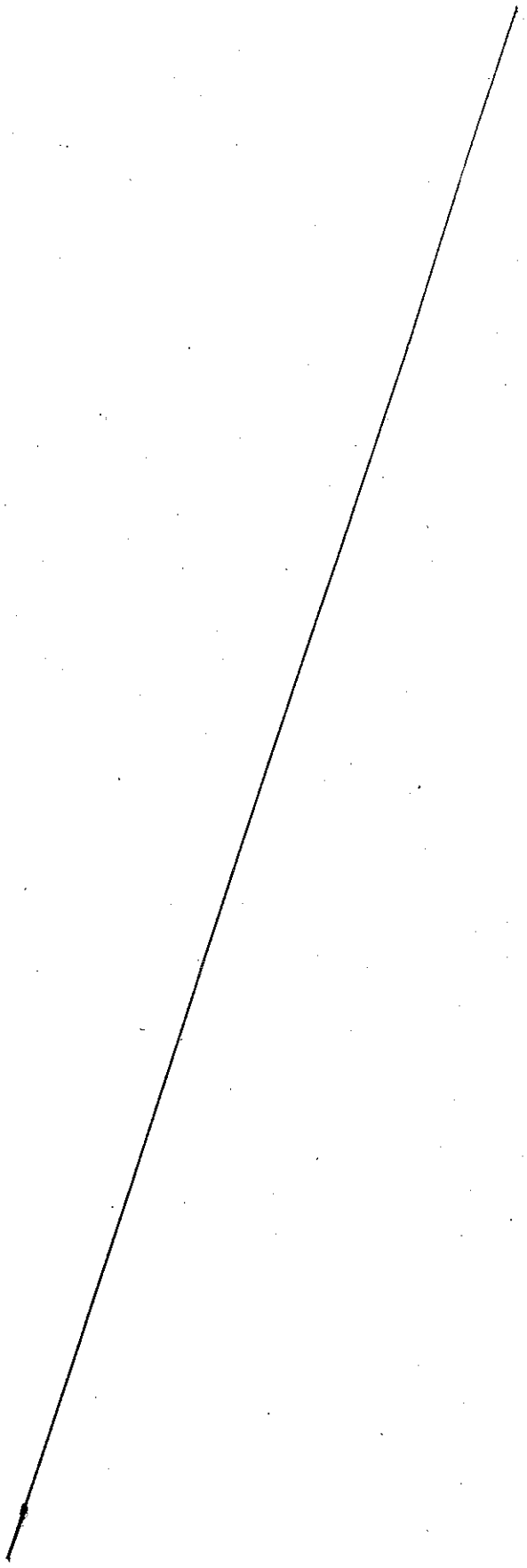

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-502** Course Title: **Laboratory Work**

2. Contact Hours: **L: 0** **T: 0** **P: 6**

3. Examination Duration (Hrs.): **Theory :0** **Practical: 4**

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

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

8. Pre-requisite: **Nil**

9. Objective: To familiarize with the basic experiments in Solid State Physics, Nuclear Physics, Laser Physics and Atmospheric Physics.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Study of Hall effect and to determine the Hall coefficient	14 x 6
2	To measure resistivity of semiconductor by Four Probe method and determination of band gap.	
3	To determine reverse saturation current, material constant and band gap of PN Junction	
4	To ascertain of the Random nature of nuclear radiation	
5	To study G.M. tube characteristics and to calculate the dead time,	
6	To determine the relative beta counting of two strong β-sources of nuclear radiation and to determine the absorption coefficients,	
7	To determine the distribution of the size of Aerosol.	
8	To measure the attenuation of laser radiation in varying atmospheric condition.	

9	The measurement of precipitation rate of water using rain gauge.	
10	To determine the numerical aperture of a given multimode fiber using the far field measurements.	
11	To measure the spot size and the angle of divergence of a laser beam, to produce the elliptically and circularly polarized light from an unpolarized laser beam and study their angular intensity profiles.	
12	Design of counter using JK flip flop and a relaxation oscillator with given frequency and duty cycle	
13.	Design a Schmitt trigger with given UTP LTP and hysteresis	
14.	To design a binary/BCD up-down counter using IC 74190/74191	
	Total	**84**

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	Nakra B.C. &. Chaudhery K.K , " Instrumentation Measurements & Analysis", Tata McGraw Hill	2002
2.	Sayer M. & Mansingh A., "Measurement, Instrumentation & Experiment Design in Physics and Engineering", Prentice Hall India	2000
3.	Melissinos A.C. and Napolitano J, "Experiments in Modern Physics", Academic Press	2000
4.	W.R. Runyan , "Semiconductor Measurements and Instrumentation", McGraw Hill	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-504** Course Title: **Condensed Matter Physics**

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

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

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

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

8. Pre-requisite: **PH-304**

materials and their dynamical properties.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Crystalline Materials:** Scattering of x-ray, neutrons and electrons from solids; Atomic scattering factor; Lattice planes and Miller indices.	6
2.	**Lattice Dynamics:** Harmonic and adiabatic approximations; Lattice vibrations of three dimensional crystals; Periodic boundary conditions; Normal modes. Quantization of lattice vibrations; Lattice heat capacity (Einstein and Debye theories) anharmonicity of thermal expansion.	9
3.	**Electronic Energy Bands:** Resume of free-electron model; Fermi energy; Fermi surface and electronic heat capacity, electrical and thermal conductivity, nearly free electron model; Periodic potential and Bloch theorem, extended and reduced zone scheme, tight binding model.	9
4.	**Superconductivity:** Experimental evidence (Meissner effect, heat capacity, energy gap, microwave properties and isotope effect), Thermodynamics of superconductors; London equation; Elementary BCS theory.	9
5.	**Non-crystalline Materials:** Non-crystalline solids – diffraction pattern and radial distribution function, Elementary idea of	9

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	glass transition, Quasi crystals, Liquid crystals – idea of orientational order and Landau theory of isotropic-nematic phase transition, Physics of Polymers.	
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	Taylor P. L. and Heinonen O., "A Quantum Approach to Condensed Matter Physics", CambridgeUniversity Press	2004
2.	Ashcroft N W and Mermin N D, "SolidState Physics", Holt-Saunders	2000
3.	Chaikin P M and Lubensky T C, "Principles of Condensed Matter Physics", CambridgeUniversity Press	2000
4.	Hamleyl. W., "An Introduction to Soft Matter: Polymers, Colloids, Amphiphiles and Liquids" John Wiley	2000

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-506** Course Title: **Statistical Mechanics**

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 25ETE** **50PRE 0**

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

8. Pre-requisite: **PH-503 & PH-509**

9. Objective: To understand the macroscopic behaviour of the classical and quantum thermodynamic systems.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Classical Statistical Mechanics:** Macro and microstates, connection between statistics and thermodynamics, phase space; Liouville's Theorem. Microcanonical, canonical and grand canonical ensembles; Energy and Density fluctuations; equivalence of various ensembles. Equipartition and virial theorem, partition function; Derivation of thermodynamic properties; some examples including (i) classical ideal gas (ii) system of classical harmonic oscillators, (iii) system of magnetic dipoles in magnetic field.	10
2.	**Quantum Statistical Mechanics:** Quantum mechanical ensembles theory, the density matrix and partition function with examples including (i) an electron in a magnetic field (ii) a free particle in a box (iii) a linear harmonic oscillator. Symmetric and Antisymmetric Wavefunctions. Microcanonical ensemble of ideal Bose, Fermi and Boltzmann gases, derivation of Bose, Fermi and Boltzmann statistics; Grand Partition function of ideal Bose and Fermi gases; Statistics of the occupation.	12

3.	**Ideal Bose and Fermi Systems:** Thermodynamic behaviour of an ideal Bose gas; Bose condensation; Liquid Helium; Blackbody radiation and Planck's law of radiation; Thermodynamic behaviour of an ideal Fermi gas; Electrons in metals, specific heat and Pauli susceptibility of electron gas.	10
4.	**Phase Transitions and Critical Phenomenon :** Order parameter, Ist and IInd order phase transitions. Ising model in zeroth and first approximation. Critical exponents, thermodynamic inequalities, Landau theory of phase transitions.	10
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors/ Books/Publishers	Year of Publication/ Reprint
1.	Patharia R K "Statistical Mechanics" (2nd Ed.), Pergaman press	2001
2.	Huang K "Statistical Mechanics" (2nd Ed., 2nd reprint), John Wiley & Sons	2003
3.	Landau L.D. and Lifshitz E M "Statistical Mechanics", Butteworth-Heinemaun	1998
4.	McQuarrie D A "Statistical Mechanics", Harper & Row	2003

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-508** Course Title: **Quantum Mechanics-II**

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

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

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

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

8. Pre-requisite: **PH-503**

9. Objective: To introduce various approximation methods for stationary and time-dependent problems; two-particle systems, basic ideas of self-consistent field theories and relativistic quantum mechanics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Time-independent Perturbation Theory:** Non-degenerate and degenerate perturbation theory, its application to Stark effect, Zeeman effect, spin-orbit coupling, fine structure and to anharmonic oscillator.	10
2.	**Time-dependent Perturbation Theory:** Transition probability, harmonic perturbation, Fermi-golden rule, semi-classical theory of radiation, stimulated emission cross-section.	10
3.	**Identical Particles:** Indistinguishability, permutation symmetry, two-particle system; Helium atoms, simple idea of Hartee self-consistent field method, Hartee-Fock method.	10
4.	**Relativistic Quantum Mechanics:** Klein-Gordon equation and its applications, Dirac theory of electron, spin of the electron, solution of Dirac equation for free particles, hole (positron)-Dirac equation for Hydrogen atom.	12
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	Schiff L I, "Quantum Mechanics", 3rd Ed, McGraw Hill Book Co.	1990
2.	Griffiths D J, "Introduction to Quantum Mechanics", 2nd Ed, Pearson Eduction	2005
3.	Bransden B H and Joachain C J, "Quantum Mechanics", 2nd Ed, Pearson Eduction	2000
4.	Zettili N, "Quantum Mechanics: Concepts and Applications", 2nd Ed, John Wiley	2009
5.	Bjorken J D and Drell S D, "Relativistic Quantum Mechanics", McGraw Hill Book Co.	1998

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-512** Course Title: **Physics of Earth's Atmosphere**

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: **None**

9. Objective: To introduce the basics of atmospheric physics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Atmospheric Evolution:** Solar radiation, present atmospheric constituents, evolution of the atmosphere, formation of ozone. Variation of temperature, density, ionization and pressure with altitude, Classification of atmosphere on the basis of temperature and pressure, hydrostatic equation, hypsometric equation.	8
2.	**Thermodynamics of Atmosphere:** Humidity variables, Moist air, adiabatic expansion of unsaturated air, various lapse rates, vertical mixing, vertical stability in the atmosphere, use of thermodynamic diagrams, role of convective available potential energy, Atmospheric radiation, hydrostatic equilibrium.	12
3.	**Lower Atmosphere:** Atmospheric absorption and greenhouse effect, Atmospheric aerosols and their origin, physical and chemical characteristics of aerosols, cloud formation and precipitation, cloud morphology, Growth of cloud droplets and rain droplets, physics of lightning, Radiative transfer and budget, Atmospheric equations of motion.	10
4.	**Upper Atmosphere:** Ionosphere as plasma, Concept of Plasma, Single particle motion in homogeneous and inhomogeneous E and B fields, Chapman theory of layer production, formation of ionosphere, electron, ion and neutral temperatures in the thermosphere, airglow and auroral emissions, measurements of ion and electron densities using ground based and space borne techniques.	12
	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.	Houghton J.T. "Physics of Atmosphere", CambridgeUniv. Press	2002
3.	Rogers R R, "A Short Course in Cloud Physics", Pergamon Press	1989
4.	Anastasios A. Tsonis., "An Introduction to Atmospheric Thermodynamics", Cambridge University Press	2007
5.	Pruppacher, H.R. & J.D. Klett, "Microphysics of Cloud and Precipitation", Springer,	2010
6.	H.J. Critchfield, "General Climatology", Prentice-Hall of India.	1994
7.	Murray L. Salby , Fundamentals of Atmospheric Physics, Academic Press.	1996
8.	Ratcliffe, J.A, "An Introduction to Ionosphere and Magnetosphere", Cambridge University Press	1972
9.	Chen F F, "Introduction to Plasma Physics", Plenum Press New York	1990

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-518** Course Title: **Elements of Nuclear and Particle Physics**

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

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

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

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

8. Pre-requisite: **PH-505**

9. Objective: **To introduce the elements of introductory nuclear and particle physics**

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Two nucleon problem: General symmetry properties of two nucleon Hamiltonian and two nucleon states, General forms of two nucleon interaction; Nuclear global properties: the N-Z chart, nuclear masses, densities, radii, spin, parities, electric and magnetic moments.	10
2.	Semi empirical (liquid drop) model, Fermi-gas model, nuclear shell model (with the harmonic oscillator potential), spin-orbit coupling and magic numbers.	6
3.	Introduction to nuclear reactions: Kinematics, conservation laws, angular distributions and cross sections, simple models of direct and compound reactions.	5
4.	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	5
5.	Representation theory of SU(2) and SU(3) and its generators, preliminary idea of lie algebra, SU(3) flavour symmetry and construction of meson octet, baryon octet & decuplet and calculation of magnetic moments using their wave functions.	5
6.	Fermi theory and V-A theory of β-decay, concept of parity, helicity, non-conservation of parity in β-decay and its experimental verifications. , Klein-Gordon equation, Dirac equation (derivation not required), Concept of anti-particle. Qualitative descriptions of Feynman diagram and the cross sections for processes *e.g.* Compton scattering, Moller scattering etc.	8
7.	A brief introduction to the electromagnetic, weak and strong interactions Gauge theory: Abelian gauge theory (QED) and its extension to non-abelian gauge theory. Spontaneous symmetry breaking and electroweak unification	3
	Total	**42**

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11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	Heyde, K., "Basic Ideas and concepts in Nuclear physics, An introductory approach", Institute of Physics Publishing	2004
2.	Bertulani, C.A. and Danielewicz, P, "Introduction to Nuclear reactions", Institute of Physics Publishing	2004
3.	Ghoshal, S.N., "Nuclear Physics", S. Chand and Company	2000
4.	Griffith D, "Introduction of Elementary Particles", John Wiley	2000
5.	Halzen, F. and Martin, A.D. "Quarks and Leptons" John Wiley	2011
6.	T.-P. Cheng and L.-F.Li, "Gauge theory of Elementary Particle Physics"Oxford University Press	1988

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-601** Course Title: **Advanced Condensed Matter Physics**
2. Contact Hours: **L: 3** **T: 0** **P: 3**
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: **PEC**
8. Pre-requisite: **PH-504**
9. Objective: To introduce the general aspects of phase transition, electronic transport phenomena, superconductivity, dielectric, optical and magnetic properties of solids.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Surface and Interfaces:** Work function and contact potential; Thermoionic emission; Low-energy electron diffraction; Electronic surface levels; Super lattices; Quantum wells; Quantum wires, Quantum dots and carbon Nanotubes.	9
2.	**Magnetism:** Magnetic properties of insulators, Langevin diamagnetism and Van Vleck paramagnetism, Curie paramagnets and Curie-Weiss ferromagnets, Neel Antiferromagnets, Heisenberg model; Spin Waves, Ising model; Elements of magnetic properties of metals, Landau diamagnetism, Pauli paramagnetism, Stoner ferromagnetism; Magnetic resonance; NMR and EPR.	9
3.	**Transport Properties:** Boltzmann equation; Relaxation time approximation; General transport coefficients; Electronic conduction in metals; Thermoelectric effects; Transport phenomena in magnetic field; Magnetoresistance; Hall effect and Quantum Hall effect.	8
4.	**Phase Transitions:** Order parameter; Critical points; First and second order phase transitions; Mean field theory; Properties near critical point; Landau theory; Bragg-Williams theory; Liquid-gas transition and Isotropic-mematic transition.	8
5.	**Superconductivity:** Cooper pairing and BCS theory; Ginzburg-Landau theory; Flux quantization; Supercurrent tunneling; DC and AC Josephson effects; High-Tc superconductors.	8
	Total	**42**

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S. No.	List of Experiments	Contact Hours
1	Study of variation of resistivity of metal and highly resistive materials with temperature by Four Probe Technique.	14 x 3
2	Mapping and analysis of the resistivity of large samples (thin films, superconductors. etc) by Four probe Technique.	
3	To study the temperature dependence of Hall coefficient of N and P type semiconductors	
4	(a) To measure the dielectric constant and Curie temperature of given ferroelectric samples. (b) To measure the coercive field (E_c), Remanent Polarization (P_r), Curie Temperature (T_c) and Spontaneous Polarization (P_s) of Barium Titanate ($BaTiO_3$).	
5	Thermoluminescence in alkali halides crystals. (a) To produce F centers in the crystal exposing to X-ray /UV source. (b) To determine activation energy of the F-centers from initial rise method.	
6	Verification of Bragg's law and determination of wavelength/energy spectrum of X-rays.	
7	Study of Solar Cell characteristics and to determine (i) Open circuit voltage 'V_{oc}' (ii) Short circuit current 'I_{sc}', (iii)Efficiency 'η',(iv) Fill factor, (v) Spectral characteristics and (vi) Chopper characteristics.	
8	To measure the magnetoresistance of semiconductor and analyze the plots of $\Delta R/R$ and log-log plot of $\Delta R/R$ Vs magnetic field.	
9	To determine the coercivity, saturation magnetization and retentivity of ferromagnetic samples using Magnetic Hysteresis Loop Tracer	
10	To study the temperature dependence of Laser diode characteristics	
11	To determine transition temperature of given superconducting material and study Meissner effect.	
12	To measure critical current density of given superconductor and study its field dependence.	
13	To determine the value of Lande's 'g' factor using ESR spectrometer.	
14	To study C-V characteristics of various solid state devices & materials. (like p-n junctions and ferroelectric capacitors	
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	Kittel C, "Introduction to Solid State Physics", 6th Ed. Wiley eastern Ltd	2004
2.	Ashcroft N W and Mermin N D, "SolidState Physics", Holt-Saunders	2000
3.	Chaikin P M and Lubensky T C, "Principles of Condensed Matter Physics", CambridgeUniversity Press	1995
4.	Harrison P, "Quantum Wells, Wires and Dots", Wiley & Sons Ltd.	2005
5.	Melissinos A.C. and Napolitano J, "Experiments in Modern Physics", Academic Press	2003
6.	S.M. Sze, "Semiconductor devices Physics & Tech.", Wiley	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-603** Course Title: **Advanced Atmospheric Physics**
2. Contact Hours: **L: 3** **T: 0** **P: 3**
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: **PEC**
8. Pre-requisite: **PH-512**
9. Objective: To provide the knowledge of advances in atmospheric physics.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Atmospheric Dynamics:** Apparent forces, effective gravity, coriolis force, pressure gradient force, gradient wind, thermal wind, continuity equation, perturbation theory and atmospheric waves, sound waves, gravity waves and Rossby waves, Momentum and energy transports by waves in the horizontal and the vertical.	12
2.	**Atmospheric Instabilities** Atmospheric instabilities, dynamical instabilities, barotropic instability, baroclinic inertial instability, Necessary condition of barotropic and baroclinic instability. Combined barotropic andbaroclinic instability. Kelvin-Helmholtz instability	10
3.	**Ionosphere:** Formation of Ionosphere,Chemical processes, Ionospheric conductivity, Planetary ionospheres, Ionospheric exploration using rockets and satellites, langmuir probe, temperature measurements, airglow and aurora, radio wave propagation in the ionosphere.	10
4.	**Magnetosphere:** Earth as a magnet, solar wind, types and theory of solar wind, frozen-in magnetic field, interaction of solar wind with Earth's magnetic field and formation of magnetosphere, inter planetary magnetic field (IMF), geomagnetic storms, van-allen radiation belts, plasmasphere,coronal holes, CMEs, satellite observations of various plasma domains and plasma instabilities.	10
	Total	42

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Sl.No.	Contents	Contact Hours
1	To measure fair weather electric field and do atmospheric electric field simulation	14 x 3
2	To measure the concentration of salts in the ground water and rain water using Flame Photometer	
3	To measure the rain water precipitation rate and to find rain drop size distribution using Rain Gauge:	
4	To measure attenuation coefficient of a gas for a given wave length of electromagnetic radiation.	
5	To measure the size distribution of aerosol particles.	
6	To measure solar constant using Solarimeter and study the diuranal variation of solar flux in the visible spectrum.	
7	To measure the diuranal variation of sound noise: A case study.	
8	To study and analysis of VLF generated by lightning.	
9	Study and assessment of ambient air quality using spectrophotometer.	
10	To analyze Ionosonds data and obtain electron density is the ionosphere.	
	Total	42

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	Vallace J and Hobbs, P V, "Atmospheric Science", Academic Press	1997
2.	Rees M H, "Physics & Chemistry of Upper Atmosphere", CambridgeUniv. Press	1989
3.	Ratcliffe J A, "An Introduction to the Ionosphere & Magnetosphere, CambridgeUniv. Press	1972
4.	Smithson P, "Fundamentals of Physical Environment", Ken Addison and Attrinson,	2008
5.	Rogers R R, " A short course in Cloud Physics", Pergamon Press	1989
6.	McCartney E J, "Optics of the Atmosphere", Wiley	1976
7.	Hulst H C, "Light Scattering by Small Particle", Courier Dover Pub	1964
8.	Lab Manual for Flame Photometer, Elico Ltd.	
9.	Lab Manual for Aerosol Size distribution, Scientific India	
10.	Lab Manual for Attenuation Constant, Spectra Laser	
11.	Lab Manual for Rain Gauge, Weather Measure Corp.	
12.	Lab Manual for Electric Field Simulation, Atmospheric Lab, IITR	

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-605** Course Title: **Advanced Laser Physics**

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

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: **PEC**

8. Pre-requisite: **PH-518**

9. Objective: To introduce the concept of laser physics and its applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	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 mechanisms, homogeneous and inhomogeneous broadening, natural collision and Doppler broadening mechanisms and line shape functions.	4
3.	Laser rate equations, the 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.	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, Fox and Li theory.	6
5.	Pulsed lasers, Q-switching techniques, active and passive shutters, mode-locking, various techniques for mode-locking of a laser.	5
6.	Mechanism and applications of Ar-ion, CO_2, Nd:YAG, Ti:Sapphire, Dye, Excimer and free electron lasers.	5
7.	Semiconductor lasers, p-n junction diode lasers, hetrojunction lasers.	5
8.	Modulation techniques for laser light, electro-optic and acousto-optic modulation, electro-optic effect in KDP crystal, longitudinal and transverse modes, acousto-optic effect, Raman-Nath and Bragg diffraction, small and large angle Bragg diffraction.	6
	Total	**42**
S. No.	**Contents**	**Contact Hours**
1.	To determine the mode field diameter (MFD) of the fundamental mode of a given single-mode fiber using the far field technique.	

2.	To measure the near field intensity profile of a multimode fiber and thereby its refractive index profile.	
3.	To measure the propagation constants of a given optical waveguide using the prism coupling technique.	
4.	To study electrical and optical characteristics of LED and LD.	
5.	To measure power loss at a splice between two multimode fibers and study the variation of splice loss with transverse, longitudinal and angular offsets.	
6.	To study bend-induced loss in a single mode fiber.	**14 x 3**
7.	To study faraday effect and to measure the angle of rotation as a function of mean flux density at different wavelengths thereby evaluate Verdet's constant as a function of wavelength.	
8.	To study Kerr effect and to determine Kerr constant of a given material.	
9.	To study fiber grating based pressure sensor.	
10.	To construct EDF ring laser and characterize it in terms of slope	
11.	efficiency, lasing threshold and intra-cavity loss.	
12.	To record and reconstruct holograms.	
13.	To characterize a WDM based optical communication system in terms of insertion/return loss, isolation/extinction ratio, narrowband	
14.	wavelength response of WDM components and chromatic dispersion.	
	To construct and characterize a diode pumped Nd:YVO4/Nd:YAG laser and to do second harmonic generation.	
	To study the acousto-optic effect and determine the velocity of acoustic waves in a given medium using a laser beam	
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	Laud B B, "Lasers and Nonlinear Optics", Wiley Eastern Ltd.	1992
2.	Ghatak A K and Thyagarajan K., "Optical Electronics", CambridgeUniversity Press	2003
3.	Yariv A, "Quantum Electronics", John Wiley & Sons	1989
4.	Thyagarajan K. and Ghatak A. "Lasers: Theory and Applications", Macmillan	1997
5.	Yariv A, "optical Electronics", Oxford University Press	1997
6.	Ghatak and Shenoy, "Fiber Optics through experiments", Viva Books	1994
7.	Laud B B, "Lasers and Nonlinear Optics", Wiley Eastern Ltd.	**1992**
8.	Ghatak A.K., Pal, B.P., Shenoy M. R. and Khijwania S.K, " Fiber Optics through Experiment", Viva Books	**2009**
9.	Ghatak A. K. and Thyagrajan K., " Optical Electronics", CambridgeUniversity Press	**2003**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-607** Course Title: **Advanced Nuclear Physics**

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

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: **PEC**

8. Pre-requisite: **PH 516**

9. Objective: To introduce the advanced concepts of nuclear physics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Yukawa theory of nuclear forces, Deuteron problem and tensor forces, n-p, p-p scattering and partial wave theory, effective range theory.	6
2.	Shell Model and its predictions: magnetic moments of nuclei and Schmidt lines, quadrupole moments; Even-even, odd-even, odd-odd nuclei, pairing interaction; Many-body basis states, Hartree-Fock single-particle Hamiltonian, selection of shell model space and effective Hamiltonian.	8
3.	Deformed nuclei and their shapes; Colletive model Hamiltonian, vibrational and rotational spectra, Nilsson model. High spin phenomena (back bending), superdeformation, octopole deformation Giant dipole resonances.	7
4.	Kinematics of nuclear reaction, reciprocity theorem, compound nuclear reaction, direct reaction and derivation of the crossections in these processes; Statistical theory of nuclear reaction and concept of nuclear temperature and entropy	7
5.	Shape-elastic, compound elastic scattering and dispersion relations, Electromagnetic transitions in nuclei, multipole expansion of the electromagnetic field; Transition probability in semiclassical treatment, Weisskopf estimate.	7
6.	Angular correlation studies; Lifetime measurements; Detection of gamma rays; Hp-Ge and other detectors; Gamma arrays.	7
	Total	**42**

S. No.	Experiment list	Contact Hours
1.	To do the energy analysis of an Unknown Gamma Source by Gamma Ray Spectroscopy using NaI(Tl) - Single Channel Analyzer (i) Energy Calibration (ii) Energy Analysis of an Unknown Gamma Source.	

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	(iii) Energy Resolution.	
2.	To do Spectrum Analysis of ^{60}Co and ^{137}Cs by Gamma Ray Spectroscopy using NaI(Tl) - Multi Channel Analyzer and study the Energy resolution dependence on detector size.	14 x 3
3.	To find the Mass Absorption Coefficient of lead for 662 KeV gamma ray	
4.	Alpha Spectroscopy with surface barrier detectors (i) Alpha spectrum and energy calibration. (ii) Energy determination of an Unknown alpha source of alpha particles.	
5.	Spectrum expansion with Multi-channel Analyzer and decay ratios of ^{241}Am.	
6.	Beta spectroscopy (i) Calibration with a pulser (ii) Beta end point determination for ^{204}Tl (iii) Conversion electron ratio.	
7.	Compton Scattering (i) Simple Compton Scattering (Energy Determination) (ii) Simple Compton Scattering (Cross-section Determination)	
8.		
9.	To study Rutherford Scattering of alpha particles from thin gold foil and Al foil.	
10.	To determine Half-Lives of Radioactive sources prepared by neutron activation – In and Ag isotopes To study Gamma-gamma coincidence by (i) Overlap coincidence method – ^{22}Na (ii) Time to pulse height converter method – ^{22}Na	
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	Roy R R and Nigam B P, "Nuclear Physics", John Wiley	2002
2.	Srivastava B B, "Fundamentals of Nuclear Physics", Rastogi Publications	2006
3.	Eisenberg J M and Greiner W, "Nuclear Theory", Vols. 1, North Holland	2002
4.	Eisenberg J M and Greiner W, "Nuclear Theory", Vols. 2, North Holland	2002
5.	Eisenberg J M and Greiner W, "Nuclear Theory", Vols. 3, North Holland	2002
6.	Leo W R, "**Techniques for Nuclear & Particle Physics Experiments**", Narosa	2000
7.	Kapoor S S and Ramamurthy V "**Nuclear Radiation Detectors**", New Age Publishers	1986
8.	ORTEC Lab Manual, "**Experiments in Nuclear Science**", ORTEC	1992

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-617** Course Title: **Advanced Characterization Techniques**

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

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

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

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

8. Pre-requisite: **PH-201, PH-202**

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:** Thermogravimetric analysis, Differential thermal analysis and Differential scanning calorimetry and methodology; Determination of phase transitions using these methods.	05
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

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5	**Optical Characterization:** Optical characterization of materials using Photoluminescence and UV-visible spectroscopy.	**03**
6	**Chemical Analysis:** Brief description to X-ray fluorescence, Atomic absorption and electronic spin resonance spectroscopy.	**03**
	Total	**42**

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-619** 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 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: **PH-503**

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 Coulomb gauge),	5
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, OxfordUniversity Press.	1993
2.	Claude I and Jean B. Z., "Quantum Field Theory, McGrawHillCollege Div.	2006
3.	Lewis H R, "Quantum Field Theory", CambridgeUniversity Press	2001
4.	Michael E. P, "An Introduction to Quantum Field Theory, Perseus Books Publishing	2002
5.	Lahiri A, ***Pal 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-621** Course Title: **Astrophysics**

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: **PH-202 and PH-303**

9. Objective: The course exposes the students to a broad field of astrophysics and cosmology at the introductory level.

10. Details of Course:

S.No.	Particulars	Contact Hours
1	**Introduction:** Celestial sphere, elliptical orbits, Newtonian mechanics, Kepler's laws, Virial theorem, magnitude scales, color index, stellar parallax, distance measurements, astronomical instruments.	8
2	**Physics of Sun:**Spectralclassification of stars,structure of the Sun, solar cycle, sun spots, properties and structure of our solar system, extrasolar planets.	6
3	**Physics of Stars:** Star formation, stellar evolution from pre-main sequence throughthe main sequence,binaries, clusters.Final stages of stellar evolution and stellar remnant:giants, white dwarfs, supernovae, neutron stars, pulsars, blackholes.	10
4	**Physics of Galaxies:** Galactic structure and classification, our galaxy, active galactic nuclei, quasars, galactic rotation curves and dark matter, galaxy clusters and large-scale structure.	10
5.	**Cosmology:**Big bang cosmology, redshift and expansion of the universe,the cosmic microwave background,physics of the early universe.	8
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Carroll B W &Ostlie D A, "An introduction to modern astrophysics", 2nd ed., Pearson Education	2007
2.	Basu B,Tanuka C, &Nath B S, "An introduction to astrophysics", 2nd ed., Prentice Hall of India,	2010
3.	Abhyankar K D, "Astrophysics: Stars and Galaxies", 1st ed., Universities Press (India) Limited.	2000
4.	Shu Frank, "The Physical Universe: An Introduction to Astronomy",1st ed., University Science Books	1982
5.	Padmanabhan T, "Theoretical Astrophysics: vol.1,2,3", Cambridge University Press	2010

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-623** Course Title: **General Relativity**

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: **PH-505**

9. Objective: To introduce the basics of non-Euclidean Geometry and Einstein's theory of general relativity and its applications.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Inertial mass and gravitational mass, gravitational redshift, action in relativity	3
2.	Principle of equivalence, metric tensor and the affine connection, geodesics.	5
3.	Covariant differentiation, analogy with electromagnetism, p-forms, generalized Stokes theorem.	5
4.	Curvature tensor, parallel transport, algebraic properties of the curvature tensor, Bianchi identities.	7
5	Lorentz transformation, representation of Lorentz group, conserved currents and energy momentum tensor	5
6	Einstein's field equations and some of their solutions: Robertson-Walker metric, Schwarzschild metric, black holes, deflection of light by Sun, precession of perihelia of planets.Expanding universe	8
7.	Expanding universe, Tetrad formalism, Killing vectors, maximally symmetric spaces.	5
8.	Kaluza-Klein theories an approach towards unification of, e.g., electromagnetism and gravity.	4
	Total	**42**

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11.	Suggested Books:	
S.No.	**Name of Authors/ Books/Publishers**	**Year of Publication/ Reprint**
1.	Landau L D and Lifshitz E M, "The Classical Theory of Fields", 4th Ed. Elsevier.	**2005**
2.	Weinberg S, "Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity", Wiley	**1972**
3.	Kaku M, "Quantum Field Theory: A Modern Introduction", OxfordUniversity Press.	**1993**

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-625** Course Title: **Particle Physics**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory:3** **Practical: 0**
4. Relative Weightage: **CWS:25** **PRS:0** **MTE : 25** **ETE:50** **PRE:0**
5. Credits: **4** 6. Semester: **Autumn/Spring** 7.Subject Area: **PEC**
8. Pre-requisite: **PH-516**
9. Objective: To introduce the basics of elementary particle physics.
10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Qualitative preview**: Apreview of particle physics, basic ideas of the four interactions – gravitational, electromagnetic, strong and weak.	2
2.	**Tools** (i) **Tensors:** Definitions of contravariant, covariant and mixed tensors, need to use tensors in relativistic quantum mechanics and particle physics;(ii)**Relativistic Kinematics**: Lorentz transformations, 4-Vectors, energy and momentum, collisions; (iii) **Scattering**: Lifetimes and Cross Sections, Fermi's Golden Rule, Feynman Rules, evaluation of scattering amplitudes and cross sections using Feynman Rules.	8
3.	**Symmetries**: Symmetries, Groups and Conservation Laws; Spin and Orbital Angular Momentum, Addition of Angular Momentum; Flavor symmetries; Parity; Charge Conjugation; CP violation; Time reversal symmetry; CPT Theorem; Noether's Theorem: Symmetry and conservation laws.	6
4.	**Electromagnetic Interaction**: (i) **Gauge Field Theory**: Covariant formulation of Maxwell's equations, (transverse) canonical quantization of the gauge field (in the Coulomb gauge); (ii) **QED** (quantization of abelian gauge theories with fermions): Feynman Rules, Compton effect, Møller Scattering, radiative corrections, Anomalous Magnetic Moment, Lamb shift.	8

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5.	**Strong Interaction**: (i) **Pre-QCD**: The structure of Hadrons, Probing a charge distribution with electrons: Inelastic electron -proton scattering, Partons and Bjorken scaling; (ii) **QCD** (quantization of non-abelian gauge theories with fermions): Yang-Mills theory, Parton model revisited, Feynman rules, Asymptotic freedom.	8
6.	**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)**: The basic electroweak interaction, effective current-current Interaction, Spontaneous symmetry breaking, Higgs mechanism and choice of the Higgs field, masses of gauge bosons and fermions, the complete Lagrangian.	10
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors/ Books/Publishers	Year of Publication/ Reprint
1	Halzen F and Martin A D,"Quarks and Leptons: Introductory Course in Modern Particle Physics", John Wiley and Sons, Inc	1990
2	Griffiths D, "Introduction to Elementary Particles", John Wiley and Sons Inc.	1987
3	Perkins D H, "Introduction to High Energy Physics", CambridgeUniversity Press	2000
4	Georgi H, "Weak Interactions and Modern Particle Theory", Benjamin-Cummings Pub Co	1984
5	Kane G L and Kane G, "Modern Elementary Particle Physics", Westview Press	1993

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-627** Course Title: **Quantum Theory of Solids**

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: **PH-504 and PH-508**

9. Objective: To provide deeper understanding of cooperative phenomenon in solids using the many body technique.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Many Body Techniques and the Electron Gas:** Creation and annihilation operators, many particle wave function in occupation number representation, commutation relations, N-electron Hamiltonian in creation- annihilation operators form; One electron and two-electron, parts. Hartree-Fock ground state energy, free electron gas; Ground State energy in Ist order. Elementary idea of Greens functions.	12
2.	**Plasma Oscillations in Free Electron Gas:** Resume of plasma theory, quantum mechanical plasma theory, Energy of the ground state; Correlation Energy; Short range and long range correlation energy.	10
3.	**Magnetism:** Magnetism in Insulators; Heisenberg model; Spin waves; quantization of spin waves; Acoustic and optical magnons; Magnon specific heat; Antiferromagnitic Magnons; Magnetism in metals; Itinerant Ferromagnetism.	10
4.	**Superconductivity:** Electron-phonon interactions; Bound electron-pairs in a Fermi gas; Superconducting ground state; Hamiltonian solution of BCS equation for the energy-gas; Electrodynamics of superconductors, coherence length.	10
	Total	**42**

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11. Suggested Books:

S.No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	Raimes S, "Many Electron Systems", North Holland Publishing Co.	2000
2.	Kittel C, "Quantum Theory of Solids", John Wiley and Sons	1987
3.	Ziamn J M, "Principles of Theory of Solids", Cambridge Univ. Press	2000
4.	Chaikin P M and Lubensky T C, "Principles of Condensed Matter", CambridgeUniv. Press	2000
5.	Kantorovich L, "Quantum Theory of the Solid State:An Introduction", Kluwer Academic Publishers	2004

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NDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-629** Course Title: **Weather Forecasting**

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

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

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

5. Credits: **4** 6. Semester: **Autumn/Spring** 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, the geostrophic approximation, cyclostrophic motion; The thermal wind equation; The equation of continuity.	8
2.	**The General Circulation:** A symmetric circulation, Inertial instability, Barotropic instability; Baroclinic instability; Sloping convection; The general circulation of the middle atmosphere.	8
3.	**Numerical Modelling of Weather:** A 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**

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", CambridgeUniversity Press,	**2003**

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-631** Course Title: **Nuclear Instrumentation**

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

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

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

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

8. Pre-requisite: Nil

9. Objective: To provide comprehensive knowledge on instrumentation related to nuclear physics.

10. Details of Course:

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	9
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 and neutrons. Application of scintillation detectors	11
3.	Semiconductor diode detector and its use in alpha spectrometry, fission fragment spectroscopy, particle identification, X-ray spectroscopy. Gamma spectroscopy with Silicon(Si(Li)) and Germanium (Ge(Li), HPGe) detectors, Fast and slow neutron detection Pulse processing electronics: NIM: Amplifier, SCA, CFD, CAMAC: ADC, TDC, Timing and coincidence measurements.	12
4.	Linear and circular accelerators, Nuclear reactor: neutron source and power generator. Applications in tracing, material modification, sterilization, material modification; neutron activation analysis, medicine:	10

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	CT, PET, SPECT, MRI, therapy	
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Glenn F. Knoll, "**Radiation Detection and Measurement" 4th Ed.**	2010
2.	W.R. Leo, "**Techniques for Nuclear and Particle Physics experiments**", Springer-Verlag	1994
3.	S Ahmed, **"Physics and Engineering of Radiation Detection"** Academic press	2007
4.	S.S. Kapoor, V. Ramamurthy, "**Nuclear Radiation Detectors**" New Age International (P) Ltd.	2005
5.	John R. Lamarsh, Anthony J. Baratta, "**Introduction To Nuclear Engineering"**, Prentice Hall.	2011
6.	Gordon R. Gilmore, **"Practical Gamma-ray Spectrometry"**, John Wiley & Sons (2nd Ed.)	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-633** Course Title: **Physics and Technology of Thin Films**
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: **Nil**
9. Objective: To familiarize students with basic understanding of science and technology of thin films and their potential device applications.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Vacuum Technology:** Role of Thin films in Technology and Devices; Introduction to Vacuum, Gas impingement on surfaces, Gas transport and pumping, Vacuum Pumps: Rotary pump, Diffusion Pump, Turbomolecular and Cryopumps.Vacuum systems, Vacuum gauges: Pirani gauge, Pennning gauge.	10
2.	**Thin Film Deposition:** PVD & CVD, Evaporation: Thermal & Electron beam evaporation , Glow discharge and plasmas-Plasma structure, Sputtering processes-Mechanism and sputtering yield, DC, RF & Reactive Sputtering, Pulsed laser deposition, Molecular beam epitaxy, Atomic layer deposition, CVD film growth, Thermal CVD Processes: Atmospheric Pressure CVD, Low Pressure CVD, Metalorganic CVD, Plasma enhanced CVD	12
3.	**Nucleation & Growth Kinetics**: Adsorption, Surface diffusion, Film growth modes, models for 3D and 2D nucleation, coalescence and depletion, grain structure and microstructure and its dependence on deposition parameters. Role of energy enhancement in nucleation; Characterization methods: XRD, SEM, AES, STM & thickness measurement. Epitaxy, homo- and hetero-epitaxy, lattice misfit and imperfections, superlattice structures	12
4.	**Applications & Emerging Technologies:**Semiconductor thin films for Micro and Nanoelectronics, Superconducting thin films for Josephson devices, Magnetic Multilayers for GMR & Spintronics, Quantum Well devices, Thin film solar cells, Sensor & Actuators.	08
	Total	**42**

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11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications/ Reprint
1	J.L. Vassen, W. Kem, Thin Film Process, Academic Press	1990
2	R.K. Waits, Thin film deposition and patterning, American Vacuum Society	1998
3	J.A. Venables, Introduction to Surface and thin film processes, Academic Press	2000
4	M. Ohring, Materials science of thin films, Academic Press	2006
5	W.R. Fahrner, Nanotechnology and Nanoelectronics, Springer	2005
6	Thin Film Phenomena by K. L. Chopra, McGraw Hill	1979
7	H. Luth, Solid Surfaces, Interfaces and Thin Films, Springer	2010
8	V. Agranovich, Thin Films & Nanostructures, Elsevier	2012
9	G.Decher, J.B.Schlenoff, Multilayer Thin Films, Wiley-VCH Verlag GmbH & Co. KGaA	2012

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-635** Course Title: **Advanced Nuclear Reactions**
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: **Nil**
9. Objective: The course is designed to provide the advance knowledge of nuclear reactions and its applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Formal Scattering theory: introduction, Lipmann-Schwinger equation, operator algebra, Born series, Analytic properties of the S-matrix: Jost-function, Analytic continuation in the complex plane, bound states, resonances, Kinematics (non relativistic) of two- and three bodies, 2 body and 3-body phase space of scattering processes	8
2.	Direct reaction theory: Two-potential formula, DWBA, various applications: rearrangement reactions, inelastic scattering, breakup reactions: post, prior and alternate prior form. Various models of breakup reactions, Coupled channel formalism, Introduction to transfer reactions: angular momentum transfer and single particle structure information, Introduction to the theory of Coulomb excitation.	10
3.	Intermediate energy collisions: Relativistic Kinematics: Use of invariants in calculations of energy momentum and velocity relations among various frame of references, Transformation of differential cross sections, variables and coordinates systems of elastic scattering (s-, u- and t-channel variables), Eikonal approximation, Coulomb corrected eikonal approximation	8
4.	Compound reaction theory: Compound reaction formation, R-matrix, Compound nucleus decay, Reciprocity theorem, Hauser-Feshbach theory	6
5.	Nuclear physics at the extremes of stability: weakly bound quantum systems and exotic nuclei, nuclear halos, neutron skins, proton rich nuclei, Radioactive ion beams as a new experimental technique, ISOL and in-flight fragment separation	7
4.	Nuclei in the Cosmos: thermonuclear cross sections and nuclear reaction rates in non-degenerate stars, Gamow peak, nuclear burning stages in stars.	3
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	Bertulani, C.A. and Danielewicz, P, "Introduction to Nuclear reactions", Institute of Physics Publishing	2004
2.	Glendenning, N.K., Direct Nuclear Reactions, World-Scientific	2004
3.	Thompson, I.J., Nunes F.M., "Nuclear Reactions for Astrophysics", Cambridge	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-637** Course Title: **Semiconductor Photonics**
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: **Nil**
9. Objective: The course is aimed at introducing to students the concepts of semiconductor photonic devices and various devices based on these.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Interaction of photons with atoms, spontaneous emission, stimulated emission and absorption, semiconductors, energy bands and charge carriers, semiconductor materials, elemental, binary, ternary and quaternary semiconductors, interaction of photons with semiconductors, generation, recombination and injection processes, junctions, hetrojunctions, quantum wells, superlattices, interaction of photons with electrons and holes, band-to-band absotption and emission, rates of absorption and emission, refractive index.	8
2.	Light emitting diode (LED), operation of LED, carrier injection and spontaneous emission, internal quantum efficiency, external quantum efficiency, P-I characteristics, slope efficiency, output spectrum, radiation pattern, temperature dependence, modulation of LED, temporal response, advanced LED structures, heterojunction LED, edge and surface emitting LEDs, applications of LEDs as light sources, displays, and in communication.	10
3.	Semiconductor optical amplifier (SOA), basic configuration , stimulated emission in a semiconductor, optical gain, effect of optical reflections, limitations of SOA	3
4.	Laser diode (LD), semiconductor laser basics, optical gain in forward biased p-n junction, laser oscillations and threshold current, P-I characteristics, slope efficiency, differential external quantum efficiency, temperature dependence, output spectrum, longitudinal modes, single frequency operation, DFB laser, DBR laser, radiation pattern, modulation, heterojunction LD, quantum well laser	7
5.	Properties of semiconductor photodetectors, quantum efficiency, responsivity, response time, photoconductors, photodiodes, p-n	7.

	photodiode, p-i-n photodiode, hetrostructure photodiodes, array detectors, avalanche photodiodes, noise in photodetectors.	
6.	Solar photovoltaic,solar energy spectrum,photovoltaic device principle,p-n junction photovoltaic, I-V characteristics, series resistance and equivalent circuit, temperature effects, solar cell materials, devices and efficiencies.	**7**
	Total	**42**

11. Suggested Books:

S. No.	Authors/Name of Books/Publisher	Year of Publication
1.	Saleh B E A and Teich M C, "**Fundamentals of Photonics**", John Wiley & Sons, Inc.	1991
2.	Jaspreet Singh, " **Optoelectronics: An Introduction to Materials and Devices**". McGraw Hill International Edition	1996
3.	Safa O. Kasap, "**Optoelectronics and Photonics**", Pearson.	2009
4.	Streetman B G and Banerjee S K, **"SolidState Electronic Devices,"** Pearson Prentice Hall	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-626** Course Title: **Advanced Atomic and Molecular Physics**

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

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

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

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

8. Pre-requisite: **PH-503, PH-518**

9. Objective: To introduce the mean-field methods necessary for studying the physics of many electron systems, to study interaction of atoms with electromagnetic radiation, molecular spectroscopy and the applications of group theory.

10. Details of Course:

Sl.No	Contents	Contact Hours
1.	**Many-electron Atoms :** The central field approximation, Thomas-Fermi potential, Hartree- and Hartree-Fock approximation, self-consistent field procedure, Dirac-Hartree-Fock method, Breit interaction, electron correlation effects, basic concepts of post-mean field methods, Qualitative ideas of density functional theory.	12
2.	**Interaction of atoms with radiation :** Transition rates, Einstein coefficients, electric dipole (E1) approximation, E1 selection rules, oscillator strengths, line intensities, line shapes and line widths; retardation effects, magnetic dipole and electric quadrupole transitions, lifetimes of excited states; photoelectric effect, Bremsstrahlung.	08
3.	**Molecular rotations and vibrations:** Spectroscopic transitions, rotational spectra of molecules, rotational selection rules; vibrational spectra of diatomic molecules, vibrational selection rules, vibration-rotation spectra of diatomic molecules.	08
4.	**Molecular electronic transitions :** Vibronic transitions, Franck-Condon principle, rotational structure of vibronic transitions, Fortrat diagram, dissociation energy of molecules, continuous spectra, Raman transitions and Raman spectra.	08
5.	**Molecular Symmetry and Symmetry Groups :** Symmetry elements and symmetry operations, symmetry classification of molecules, point groups; reducible and irreducible representations; character tables for point groups; normal modes of molecular vibrations; applications of group theory to molecular vibrations.	06
	Total	42

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11. Suggested Books:

S.No.	Name of Authors/ Books/Publishers	Year of Publication /Reprint
1.	Bransden B. H. and Joachain C. J., "Physics of Atoms and Molecules", 2nd edition, Pearson Education	2004
2.	Atkins P. and Friedman R., "Molecular Quantum Mechanics", 5th edition, Oxford University Press	2011
3.	Haken H and Wolf H. C., "Molecular Physics and Elements of Quantum Chemistry", 2nd edition Springer-Verlag	2004
4.	Hollas J. M., "Modern Spectoscopy", 4th edition, Wiley	2004
5.	Atkins P. and Paula J. D., "Physical Chemistry", 9th edition, Oxford University Press	2010
6.	Cotton F. A., "Chemical Applications of Group Theory", 3rd edition, Wiley 1990	1990

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-602** Course Title: **Nuclear Astrophysics**

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: **PH-503**

9. Objective: To introduce the emerging field of nuclear astrophysics which attempts to understand how nuclear processes generate the energy of stars over their lifetimes and synthesize heavier elements.

10. Details of Course:

S. No.	Particulars	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**

11. Suggested Books:

Sl. 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-604** Course Title: **Physics of Nanosystems**

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: **PH-303**

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 II heterostructures, 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, The 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

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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
8.	**Synthesis of nanomaterials:** Fabrication techniques: Self-Assembly, Self-Replication, Sol-Gels. Langmuir-Blodgett thin films, Nanolithograph, 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.	Benedek et al G., "Nanostructured Carbon for advanced Applications", Kluwer Academic Publishers	2001
4.	Harrison, P, "Quantum Wells, Wires, and Dots: Theoretical and Computational Physics", John Wiley	2000
5.	Mitin, VV, Kochelap, VA and Stroscio, MA "Quantum Heterostructures: Microelectronics and Optoelectronics", CambridgeUniversity Press	1999
6.	Poole, Jr. CP and Owens, FJ,"Introduction to Nanotechnology", Wiley India.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-606** Course Title: **Superfluidity and Superconductivity**

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: **PH-504**

9. Objective: It 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 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 Tc superconductivity; Equation for the critical temperature and strong electron-phonon coupling; SDW and CDW.	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", CambridgeUniversity 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", CambridgeUniversity Press	2005
4.	Pethick C J and Smith H, "Bose-Einstein Condensation in Dilute Gases", CambridgeUniversity 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-608** 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 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: **PH-201 and PH-202**

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 waveguides:optical waveguides, 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, the 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 2^{nd} order nonlinear optics: optical second harmonic generation, sum frequency generation, difference frequency generation, optical parametric amplification and oscillation, three wave mixing.	10

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4.	3rd 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**

11. Suggested Books:

S.No.	Name of Authors/ Books/Publishers	Year of Publication/ Reprint
1.	Ghatak A K and Thyagarajan K, "Optical Electronics", CambridgeUniversity Press	2003
2.	Ghatak A K and Thyagarajan K, "Introduction to Fiber Optics", CambridgeUniversity 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", Chapmann 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-610** Course Title: **Quantum Optics**

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: **PH-201 and PH-202**

9. Objective: The course provides an understanding of the physical principles of quantum optics and its use in laser cooling trapping of atoms.

10. Details of Course:

S.No.	Contents	Contact Hours
1	Two-level atom and classical electric field. Rabi solutions. Comparison to Lorentz atom. Multi-level atoms, selection rules for electric dipole transitions, Raman coupling in 3-level systems, optical pumping.	6
2	Density-matrix formalism: Application to two-level atom , optical Bloch equations, the Bloch vector, Ramsey fringes, photon echoes, adiabatic following, optical Bloch equations with dissipation (Relaxation. Spontaneous emission and collisions).	10
3	Dressed states: ac Stark effect, the Mollow triplet, Electromagnetically Induced Transparency (EIT), "slow light", Coherent Pouplation Trapping (CPT), cavity QED, Jaynes-Cummings model.	10
4	Laser cooling and trapping: scattering force (Light forces on two-level atoms), Doppler cooling limit, magneto-optic trap (MOT), Optical lattices, Polarization gradient cooling overview, Raman transitions,	10
5	Magnetic trapping, evaporative cooling and Bose–Einstein condensation	6
	Total	42

11. Suggested Books:

S.No.	Name of Authors/ Books/Publishers	Year of Publication /Reprint
1	Foot C. J.,"Atomic Physics", Oxford University Press	2005
2	Loudon R., "The Quantum Theory of Light", Oxford University Press	2001
3	Metcalf H. J. and Straten P. der , "Laser Cooling and Trapping", Springer-Verlag New York, Inc.	2001

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-612** Course Title: **Advanced Topics in Mathematical Physics**

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

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

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

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

8. Pre-requisite: **PH-505**

9. Objective: The objective of this course is to familiarize the students with techniques that are part and parcel in a variety of fields in theoretical physics, specially, theoretical high energy physics, cosmology, etc.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Topology**: topological spaces, connectedness and compactness of spaces, continuous functions, homeomorphisms	8
2.	**Real Manifolds**: definition, vector fields, differential forms, frames, connection, curvature, torsion, integration of differential forms, Stokes theorem, Laplacian on forms.	8
3.	**Homology And Cohomology**: Simplicial Homology and De-Rham Cohomology	6
4.	**Homotopy:** Loops and homotopies, fundamental and higher homotopy groups.	6
5.	**Fibre Bundles**: the concept, tangent and cotangent bundles, vector and principal bundles.	6
6.	**Complex Manifolds And Cohomology**: Definition, Dolbeault Cohomology of complex forms, harmonic analysis, basic ideas about Kähler and Calabi-yau manifolds.	8
	Total	42

11. Suggested Books:

S.No.	Name of Authors/ Books/Publishers	**Year of Publication /Reprint**
1.	Brian R. Greene, " String Theory on Calabi-Yau Manifolds", Lectures given at Theoretical Advanced Study Institute in Elementary Particle Physics (TASI 96) Published in *Boulder 1996, Fields, strings and duality* 543-726	1996
2.	Mukhi S. and Mukunda N., "Introduction to Topology, Differential Geometry and Group Theory for Physicists", Wiley Eastern, New Delhi.	1990

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-614** 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 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: **PH-505, PH-619**

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.	14
	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.	
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 Rham Cohomology, Fiber Bundles, Homotopy theory, Complex Manifolds, Kählerian geometry, Dolbeault Cohomology, 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 strings in closed string theories.	12
	Total	42

11. Suggested Books:

S.No.	Name of Books/Authors	Year of Publication
1.	Superstring Theory: Volume 1, Introduction by Michael B. Green, John H. Schwarz, Edward Witten Cambridge University Press	1988
2.	String Theory (Cambridge Monographs on Mathematical Physics) (Volumes 1,2), J.Polchinksi	1998
3.	An Introduction to Nonperturbative String Theory, By Ashoke Sen, In *Cambridge 1997, Duality and supersymmetric theories* 297-413	1997
4.	*String theory on Calabi-Yau manifolds*, Brian R. Greene, (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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-616** Course Title: **Advanced Electroceramics 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/Spring** 7.Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: This course will introduce the students to modern day electoceramic materials and their applications and will enable the students to learn about modern applications of electroceramic materials 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 nano- ceramics - basic principles, preparation and applications, Ceramic Sensors, Transparent ceramics, coatings and films: preparation and applications	8
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 & application in various fields.	6
	Total	**42**

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11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Michel W. Barsoum, M. W., "Fundamental of Ceramics", McGraw Hill International edition	1997
2.	Richerson, D.W., "Modern Ceramic Engineering", Mercel Dekker NY	1992
3.	Rahman, M. N.,"Ceramic Processing and Sintering", Mercel 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-618** 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 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: **PH-516**

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:

Sl.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, the 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", North Holland, 3rd Edition, Amsterdam	1983
2.	Bransden B. H. and Joachain C. J., "Physics of Atoms and Molecules" 2nd Edition, Prentice Hall	2003
3.	Gianturco F. A., "Atomic and Molecular Collision Theory", Plenum Press, New York and London	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*", 2d Ed., Benjamin, New. York	1983
6.	Zettili N, "Quantum Mechanics: Concepts and Applications", 2nd Ed, John Wiley	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

Subject Code: **PHN-620** Course Title: **Advanced Quantum 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: **PEC**

8. Pre-requisite: **PH-619, PH-505**

9. Objective: The main objective of this course is to prepare the student in terms of techniques extremely useful in a variety of areas in theoretical physics

10. Details of Course:

S.No.	Particulars	Contact Hours
1.	**Path Integrals:** (a) Nonrelativistic QM: Multi-dimensional path integral, time-ordered product, n-point functions, generating functional (b) Field Theory: Generating functional and Green's function, Generating functional for interacting fields, 1 PI graphs, Effective actions, Path integrals for scalar quantum fields, Path integrals for fermion fields	6 8
2.	Non-abelian gauge theories, canonical quantization, path integral quantization and Fadeev-Popov ghost fields, BRST invariance	10
3.	Supersymmetry, superspace formalism: supersymmetry and supersymmetric actions, superspace formalism, supersymmetric Feynman rules, Nonrenormalization theorems, N=1 Supergravity.	10
4.	Conformal field theory: Operator product expansion, Ward identities, Noether's theorem, conformal invariance, free CFT's, Virasaro algebra, vertex operators, operator-state correspondence.	8

11. Suggested Books:

S.No.	Name of Books/Authors	Year of Publication
1.	W. Greiner, J. Reinhardt and D.A.Bromley, "Field Quantization", Springer, 2nd edition	1997
2.	Ashok Das, "Lectures on Quantum Field Theory", World Scientific	2008
3.	H.J.W.Muller- Kirsten, A. Wiedemann and H. Muller-Kirsten "Supersymmetry: An Introduction with Conceptual and Calculational Details", World Scientific Publishing Co Pte Ltd	1987
4.	J.Polchinnksi, "String Theory" (Cambridge Monographs on Mathematical Physics) (Volume 1),	1998

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-622** Course Title: **Solar Terrestrial Physics**

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

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

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

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

8. Pre-requisite: **PH-603**

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 the ionospheric 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**

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.	A. C. Das, "Space Plasma Physics", Narosa Publishing House.	2004
3.	J. K. Hargreaves, "The solar-terrestrial environment", Cambridge Atmospheric and Space Science Series.	2003
4.	Syun-Ichi Akasofu, Sydney Chapman, Solar-Terrestrial Physics, Oxford Press	1972
5.	M.C. Kelley, "The Earth's Ionosphere", Academic Press	2009

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-624** Course Title: **Computational Nuclear Physics**

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

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

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

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

8. Pre-requisite: Introductory course in nuclear physics and in computer programming

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 Eigen states for different potentials by solving coupled differential equations with boundary conditions, harmonic oscillator, square-well and Woods-Saxon potentials. Complex Eigen values and resonances	5
4.	Independent particle models, Eigen states, Solutions for Nilsson model. Single-*j* shell approximation and Cranking model. Effective interaction: Simple estimates, Evaluation of matrix elements in sd shell. Superconductivity: Solution for BCS equations at $T = 0$. Hot nuclei: Application of Fermi-Dirac distribution. Quantum Hadrodynamics: 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**

11. Suggested Books:

S. No.	Name of Books/Authors	Year of Publication
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 7ed", 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, 2ed", Pearson/Prentice Hall	2006
5.	Pang T, "An Introduction to Computational Physics", Cambridge Univ. Press	2006

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-638** Course Title: **Advanced Light Sources**

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

8. Pre-requisite: Undergraduate level knowledge of classical electrodynamics

9. Objective: To familiarize the students with the basic theory of synchrotron radiation and its sources, insertion devices and understanding the limitations to radiation brightness

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Characteristics of synchrotron radiation:** Qualitative treatment of synchrotron radiation, potentials and fields of a moving charge, radiation from a charge moving on a circular orbit	6
2.	**Introduction of Modern Light Sources:** Free Electron Laser, Synchrotron Storage Rings, Energy Recovery LINACs (Linear Accelerators)	6
3.	**Electron beam dynamics in storage rings:** Radiation effects in electron storage rings, synchrotron oscillations, damping of betatron oscillations, quantum fluctuations-equilibrium beam sizes	6
4.	**Introduction to insertion devices:** Wiggler (W) and Undulator (U) field, Equation of motion in W/U-magnets, undulator radiation, radiation from insertion devices	6
5.	**Lattices and beam emittances:** Lattice types, low-emittance lattices and related problems, high brilliance to low brilliance, effects of insertion devices on beam	6
6.	**Current and brightness limits:** Concept of beam current measurement and typical values, fields of relativistic electrons, effects of beam-vacuum chamber walls interaction, brightness of a synchrotron radiation source, brightness limitations	6
7.	**Lifetime and beam quality:** Concepts of brightness, stability, dynamic aperture, quantum lifetime, Touschek effect, instabilities and ion trapping	6
	Total	42

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Hofman A., "The Physics of Synchrotron Radiation (Cambridge Monographs on Particle Physics, Nuclear Physics and Cosmology), Cambridge University Press	2007
2.	Mobilio S., Boscherini C. M., "Synchrotron Radiation: Basics, Methods and Applications", Springer	2014
3.	Duke P., "Synchrotron Radiation: Production and Properties (Oxford Series on Synchrotron Radiation), Oxford University Press	2009
4.	CERN Accelerator School Lectures	http://cas.web.cern.ch/cas/

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-639** Course Title: **Superconducting Radio Frequency for particle accelerators**

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

8. Pre-requisite: Undergrad level knowledge of superconductivity

9. Objective: The aim is to provide students with ideas and approaches enabling them to evaluate and solve problems related to application of superconducting cavities to accelerators, and actively participate in engineering of SRF systems for various accelerators.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to particle accelerators- DC and RF machines; Concept of Luminosity and Beam Brightness; Review of Electromagnetic Theory	6
2.	Review of Special Theory of Relativity; Kinematics of particle Beams	4
3.	Particle motion in electromagnetic (EM) fields; One-turn maps, Symplectic condition, Beam emittance, Beam transport in drift space, solenoid, dipole, quadrupole and sextupole magnets	6
4.	Advantages and limitations of SRF technology; Fundamentals of RF microwave engineering; Basic concepts of RF superconductivity: RF losses and related figures of merits, Q vs. E	6
5.	Related phenomena: field emission, multipacting, ponderomotive effects; SRF systems: requirements and challenges; Beam-cavity interaction: fundamental mode beam loading, wake fileds and higher-order modes, instabilities and cures	8
6.	Systems engineering approach to SRF system design: interconnectedness, cost optimization; Cavity design	6
7.	Fundamental Power Couplers; higher-order-modes (HOM) dampers; Tuners.	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	S. Ramo, J. R. Whinnery, and T. Van Duzer, "Fields and Waves in Communication Electronics", John Wiley & Sons	1994
2.	H. Padamsee, J. Knobloch, and T. Hays, "RF Superconductivity for Accelerators", John Wiley & Sons	2008
3.	P. B. Wilson, "Fundamental-Mode RF Design in e^+-e^- Storage Ring Factories", SLAC-PUB-6062	1993
4.	CERN Accelerator School Lectures	http://cas.web.cern.ch/cas/

31 JAN 2012

Appendix

DEPARTMENT OF ELECTRICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Program Code: 25 M.Tech. (Electric Drives & Power Electronics)
Department: EE Department of Electrical Engineering
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.	EEN-580	Advanced Linear Control Systems	DCC	4	3	1	2/2	3	-	20	20	20	40	-
2.	EEN-540	Advanced Power Electronics	PCC	4	3	1	2/2	3	-	20	20	20	40	-
3.	EEN-541	Analysis of Electrical Machines	PCC	4	3	0	2	3	-	15	25	20	40	-
4.	EEN-542	Power Electronic Controlled Electric Drives	PCC	4	3	1	2/2	3	-	15	25	20	40	-
5.	EEN-xxx	Program Elective Course-I	PEC	4	-	-	-	-	-	-	-	-	-	-
		Total		20	12	2	6	-	-	-	-	-	-	-
Semester-II (Spring)														
1.	EEN-543	FACTS Devices	PCC	4	3	1	0	3	-	25	-	25	50	-
2.	EEN-xxx	Program Elective Course-II	PEC	4	-	-	-	-	-	-	-	-	-	-
3.	EEN-xxx	Program Elective Course-III	PEC	4	-	-	-	-	-	-	-	-	-	-
4	EEN-xxx	Program Elective Course-IV	PEC	4	-	-	-	-	-	-	-	-	-	-
3.	EEN-700	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
		Total		18	6	1	2	-	-	-	-	-	-	-

DEPARTMENT OF ELECTRICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Program Code: 25 M.Tech. (Electric Drives & Power Electronics)
Department: EE Department of Electrical 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.	EEN-701A	Dissertation Stage–I (to be continued next semester)	DIS	12	-	-	-	-	-	-	-	-	100	-
		Total		12										
Note: Students can take 1 or 2 audit courses as advised by the supervisor, if required.														
Semester-II (Spring)														
1.	EEN-701B	Dissertation Stage–II (contd. From III semester)	DIS	18	-	-	-	-	-	-	-	-	100	-
		Total		18										

Summary				
Semester	1	2	3	4
Semester-wise Total Credits	20	18	12	18
Total Credits	68			

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Program Elective Courses (EDPE)

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
1.	EEN-640	Advanced Electric Drives	PEC	4	3	0	2	3	-	20	20	20	40
2.	EEN-641	Microcontroller and Its Applications to Power Converters	PEC	4	3	0	2	3	-	15	25	20	40
3.	EEN-642	DSP Controlled Electric Drives	PEC	4	3	0	2	3	-	15	25	20	40
4.	EEN-643	Electric Drives for Hybrid Vehicles	PEC	4	3	1	0	3	-	25	-	25	50
5.	EEN-644	Design of Electric Drives	PEC	4	3	1	0	3	-	25	-	25	50
6.	EEN-645	Instrumentation in Electric Drives	PEC	4	3	1	0	3	-	25	-	25	50
7.	EEN-646	Drive System in Electric Traction	PEC	4	3	1	0	3	-	25	-	25	50
8.	EEN-647	Control Techniques in Power Electronics for AC Drives	PEC	4	3	0	2	3	-	15	25	20	40
9.	EEN-648	Pulse Width Modulation for Power Converters	PEC	4	3	1	0	3	-	25	-	25	50
10.	EEN-649	Enhanced Power Quality AC-DC Converters	PEC	4	3	0	2	3	-	15	25	20	40
11.	EEN-650	Switch Mode Power Supply	PEC	4	3	1	0	3	-	25	-	25	50
12.	EEN-651	Power Quality Improvement Techniques	PEC	4	3	0	2	3	-	15	25	20	40
13.	EEN-652	CAD of Power Apparatus	PEC	4	3	1	0	3	-	25	-	25	50
14.	EEN-653	Selected Topics in Machines and Transformers	PEC	4	3	0	2	3	-	15	25	20	40
15.	EEN-654	Synchronous Machines and System Stability	PEC	4	3	1	0	3	-	25	-	25	50
16.	EEN-655	Special Machines	PEC	4	3	1	0	3	-	25	-	25	50
17.	EEN-656	Testing and Commissioning of Electrical Equipment	PEC	4	3	1	0	3	-	25	-	25	50

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18.	EEN-564	HVDC Transmission Systems	PEC	4	3	1	0	3	-	25	-	25	50	
19.	EEN-690	Advanced Computer Controlled Systems	PEC	4	3	1	0	3	-	25	-	25	50	
20.	EEN-657	Digital Control of Power Converters	PEC	4	3	1	0	3	-	25	-	25	50	
21.	EEN-658	Communication Techniques in Smart Grid	PEC	4	3	1	0	3	-	25	-	25	50	
22.	EEN-659	Control and Management of Smart Grid	PEC	4	3	1	0	3	-	25	-	25	50	
23.	EEN-660	Power Converter Topologies in Smart Grid	PEC	4	3	1	0	3	-	25	-	25	50	

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