सीनेट की 64वीं बैठक का कार्यवृत्त

MINUTES OF THE 64TH MEETING OF THE SENATE

19 अप्रैल 2016

19TH APRIL 2016

भारतीय प्रौद्योगिकी संस्थान रूड़की

रूड़की – 247 667 (भारत)

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

ROORKEE – 247 667 (INDIA)

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE
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I N D E X

64.6	अधिसंख्य आधार पर सभी आईआईटी मे अंतर्राष्टीय छात्रों के लिए स्नातकोत्तर छात्रों की स्वीकृत संख्या का 20 प्रतिशत प्रवेश लेने की मानव संसधान विकास मंत्रालय द्वारा अग्रेषित प्रो0 देवांग वी0 खख्खर, निदेशक, आईआईटी बाम्बे की रपोर्ट पर विचार करना। To consider the report of Prof. Devang V. Khakhar, Director, IIT Bombay forwarded by MHRD to take admission upto 20% of sanctioned strength of postgraduate students for International students in all the IITs on supernumerary basis.	5
64.7	आगामी सत्र 2016–17 से मानविकी और सामाजिक विज्ञान विभाग द्वारा चलाए जाने वाले प्रथम वर्ष एम0एससी0 अर्थशास्त्र के पाठयक्रम और पाठयक्रम सामग्री पर विचार करना। To consider the syllabus and course content of 1st year M.Sc. Economics programme to be run by the Department of Humanities & Social Sciences from upcoming session 2016-17	6
64.8	शरद और स्प्रिगं सेमेस्टर 2016–17 सत्र के लिए शैक्षणिक कैलेंडर पर विचार करना। To consider the Academic Calendar for the Autumn and Spring Semester 2016-17 session.	6
64.9	विभागाध्यक्ष, भूकम्प अभियांत्रिकी विभाग द्वारा संस्तुत एक वैकल्पिक कोर्स के रूप मे सीईएन–642 (विश्लेषण और पुलों के डिजाईन) एम0टैक0 के स्टक्चरर में (स्टक्चरल और गतिशीलता) कोर्स को शामिल किए जाने को रिपोर्ट करना। To report the inclusion of subject CEN-642 (Analysis and Design of Bridges) in the structure of M.Tech. (Structural & Dynamics) as an Elective course as recommended by Head, Department of Earthquake Engineering.	7
64.10	विभागाध्यक्ष, वास्तुकला और योजना विभाग द्वारा संस्तुत एक वैकल्पिक कोर्स सीटीएन–611 (परिवहन प्रणाली के प्रबंधन) के रूप में शहरी एवं ग्रामीण योजना के स्टकचर में शमिल किए जाने को रिपोर्ट करना। To report the inclusion of subject CTN-611 (Management of Transport Systems) in the structure of Master of Urban and Rural Planning, as an Elective course as recommended by Head, Department of Architecture & Planning.	7
64.11	डिसरटेसन में न्यूनतम पासिगं ग्रेड में किए गए परिवर्तन को रिपोर्ट करना। To report the change in the minimum passing grade in Dissertation.	7

64.12	स्नातकोत्तर कार्यक्रम 2016 में प्रवेश के लिए किए गए परिवर्तनों को रिपोर्ट करना। To report the changes for admission to PG programmes 2016	7-9
64.13	शैक्षिक दौरे के लिए छात्रों को वित्तिय सहायता प्रदान करने के प्रस्ताव को रिपोर्ट करना। To report the proposal for providing the financial help to students for Educational Tour.	9
64.14	दिनांक 10.03.2016 को आयोजित हुई सीनेट की कार्यकारी समिति के 52वी बैठक के कार्यवृत्त को रिपोर्ट करना। To report the of the minutes of the 52nd Meeting of the Executive Committee of the Senate held on 10.03.2016.	9
64.15	उन छात्रों को पी0 एच0डी0 उपाधि प्रदान करने पर विचार किया जाना, जिन्होंने विभिन्न पाठ्यक्रमों में 1 जनवरी 2016 से अब तक उपाधि प्राप्त किए जाने की अर्हता प्राप्त की है। To consider award of the Ph.D. Degrees to the students who have completed the requirements for the award of the Ph.D. Degree in various disciplines w.e.f. 1st January 2016 to till date.	9
64.16	भू विज्ञान विभाग द्वारा प्रस्तावित निम्नलिखित दो विभागीय एंच्छिक पाठयक्रम पर विचार करना : 1. ईएसन–456: फील्ड जियोलोजी फार आईएमटी (भूवैज्ञानिक प्रौद्योगिकी) 2. ईएसन–628: फील्ड जियोलोजी फार एमएससी (एप्लाईड जियोलोजी) To consider the syllabi of following two Departmental Electives proposed by the Department of Earth Sciences: (i) ESN-456: Field Geology for IMT (Geological Technology) (ii) ESN-628: Field Geology for M.Sc. (Applied Geology)	10
64.17	विभागीय वैकल्पिक पाठयक्रम ईएसएन–581: एडवांसड सिसमीक प्रोस्पेक्टिग को 9वे समेस्टर से 7वे समेस्टर में स्थानानंतरण और ईएसएन–पैट्रोफिजिक्स और सिसमिक रोक करकटराईजेशन के नए पाठयक्रम के लिए भूविज्ञान विभाग की डीएफसी की सिफारिश पर विचार करना । To consider the recommendation of the DFC of Department of Earth Sciences for shifting Departmental Elective Course ESN-581: Advanced Seismic Prospecting from 9th semester to 7th semester and the syllabi of new course ESN-xxx: Petrophysics and Seismic Rock Characterization.	10

64.18	मानविकी और सामाजिक विज्ञान विभाग द्वारा प्रस्तावित निम्नलिखित एमएससी अर्थशास्त्र प्रोग्राम कोर कोर्स के पाठयक्रम पर विचार करना। To consider the syllabus of following programme core course of M.Sc. Economics proposed by the Department of Humanities & Social Sciences.	10
64.19	ईटीई उत्तर लिपियों में पृष्ठों की संख्या को कम करने के लिए कागज बचाने के प्रस्ताव पर विचार करना। To consider the proposal of reducing the number of pages in ETE answer scripts to save paper.	11
64.20	रसायन विज्ञान विभाग द्वारा प्रस्तावित एमएससी (कैमिस्ट्री) के लिए परिवर्तित पाठयक्रम की संरचना और कोर्स के पाठयक्रम पर विचार करना। To consider the revised curriculum structure for M.Sc. (Chemistry) and syllabi of courses as proposed by the Department of Chemistry.	11
64.21	एक वैकल्पिक विषय में छात्रों की न्युनतम संख्या को कम करने के प्रस्ताव पर विचार करना। To consider the proposal of reducing the minimum number of students in an elective.	12
64.22	गणित विभाग द्वारा प्रस्तावित प्री–पीएचडी के पाठयक्रमों पर विचार करना। To consider the syllabi of Pre-Ph.D. courses proposed by the Department of Mathematics.	12
64.23	इलैक्ट्रोनिक्स एवं संचार अभियांत्रिकी विभाग द्वारा प्रस्तावित ईसीएन–5––डिजिटल सिस्टम डिजाईन के पाठ्यक्रम पर विचार करना। To consider the syllabus of ECN-5xx: Digital System Design proposed by the Department of Electronics and Communication Engineering.	12
64.24	आईएफएम द्वारा दिए गए सुझाव के अनुसार बाहरी परीक्षक द्वारा नोन डिस्क्लोजर एग्रीमेंट लेकर पीएचडी थिसिस के गोपनीय बौद्विक सम्पदा के ओपन और क्लोजड हिस्से को चिन्हित करने पर विचार करना। To consider identifying "Open" and "Closed" portions of Ph.D. thesis having confidential intellectual property and taking "Non-Disclosure Agreement" from the external examiners as suggested in IFM.	13
64.25	पेपर की स्वीकृति के अभाव में पीएचडी के लिए अधिकतम अवधि के अंत में थीसिस जमा करने पर विचार करना। To consider the submission of thesis at the end of the maximum duration for Ph.D. in the absence of acceptance of paper.	13
64.26	आयुष से पोस्ट ग्रेजुएट स्तर के पाठयक्रम, बायोटेक्नोलोजी में पीएचडी प्रवेश के लिए आयुर्वेद में एमडी/एमएस को भी एक योग्य मानदंड को सम्मलित करने पर विचार करना। To consider including Post Graduate level course from AYUSH leading to MD/MS in Ayurveda also an eligible criteria for Ph.D. admission in Bio –Technology.	13

64.27	प्रो0 एम0पी0 वार्ष्णेय, तत्कालीन थोमसन इंजिनियरिंग कालेज रूड़की से प्रथम पी0एच0डी0 उपाधि प्राप्त करने वाले और थोमसन कालेज के अलुमनस ने रू0 1.11 करोड़ इंडोमेंट फंड स्थापित करने के लिए दिये और निदेशक महोदय ने इस आफर को स्वीकार किया । यह इंडोमेंट फंड विद्युत अभियांत्रिकी विभाग की एक प्रयोगशाला के लिए कुछ यंत्र प्राप्त करनें, निश्चित पी0एच0डी फैलोशीप और एक आनरफिक लेक्चर के लिए प्रयोग किये जाने के बारे मे रिपोर्ट करना। To report that Prof. M.P. Varshney, an alumnus of erstwhile Thomason College of Engineering Roorkee and the first alumnus of Thomason College to obtain a Ph.D. degree has offered a sum of Rs. 1.11 crore to establish an endowment fund and the Director has accepted the offer. The endowment fund will be used to acquire some equipment for one of the laboratories in Electrical Engineering Department, creation of Ph.D. fellowship and an honorific lecture.	14
64.28	शैक्षणिक वर्ष 2016–17 से स्नातक कार्यक्रम के लिए टयूशन फीस रू0 2.00 लाख प्रति वर्ष किये जाने के सम्बन्ध में एक ई–मेल दिनांक 11.04.2016 जिसके साथ स्कैन किया हुआ पत्र सं0 24–2/2016 टीएस दिनांक 08.04. 2016 जो कि सभी आईआईटी के निदेशकों को सम्बोधित है को रिपोर्ट करना। To report the e-mail dated 11.04.2016 alongwith a scan copy of letter F.No. 24-2/2016 TS-1 dated 08.04.2016 addressed to the Director of all IITs regarding revision of tuition fee for the undergraduate programme to Rs. 2.00 lakhs a year from the Academic Year 2016-17.	14
App. 'A'	आगामी सत्र 2016–17 से मानविकी और सामाजिक विज्ञान विभाग द्वारा चलाए जाने वाले प्रथम वर्ष एम0एससी0 अर्थशास्त्र के पाठयक्रम और पाठयक्रम सामग्री। Syllabus and course content of 1st year M.Sc. Economics programme to be run by the Department of Humanities & Social Sciences from upcoming session 2016-17	15-36
App. 'B'	शरद और स्प्रिगं सेमेस्टर 2016–17 सत्र के लिए शैक्षणिक कैलेंडर। Academic Calendar for the Autumn and Spring Semester 2016-17 session.	37-45

MEETING SECTION
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Minutes of the 64th Meeting of the Senate held on 19.04.2016 in the Senate Hall of the Institute.

Following were present:

1.	Prof. Vinod Kumar, Dy. Director	In the Chair in lieu of Director (medical leave)
2.	Prof. (Mrs.) Pushplata	(Architecture & Planning)
3.	Prof. V. Devdas	(Architecture & Planning)
4.	Prof. (Mrs.) Ila Gupta	(Architecture & Planning)
5.	Prof. R.P. Singh	(Biotechnology)
6.	Prof. Ramasare Prasad	(Biotechnology)
7.	Prof. Partha Roy	(Biotechnology)
8.	Prof. Vijay Kumar Agarwal	(Chemical Engineering)
9.	Prof. B. Prasad	(Chemical Engineering)
10.	Prof. C.B. Majumdar	(Chemical Engineering)
11.	Prof. R.N. Goyal	(Chemistry)
12.	Prof. Ravi Bhushan	(Chemistry)
13.	Prof. Anil Kumar	(Chemistry)
14.	Prof. (Mrs.) Mala Nath	(Chemistry)
15.	Prof. U.P. Singh	(Chemistry)
16.	Prof. K.C. Gupta	(Chemistry)
17.	Prof. S.S. Jain	(Civil Engineering)
18.	Prof. Deepak Kashyap	(Civil Engineering)
19.	Prof. C.S.P. Ojha	(Civil Engineering)
20.	Prof. S.K. Ghosh	(Civil Engineering)
21.	Prof. M. Parida	(Civil Engineering)
22.	Prof. Praveen Kumar	(Civil Engineering)
23.	Prof. N.K. Samadhiya	(Civil Engineering)
24.	Prof. Z. Ahmad	(Civil Engineering)
25.	Prof. Kamal Jain	(Civil Engineering)
26.	Prof. B.R. Gurjar	(Civil Engineering)
27.	Prof. Manoj Mishra	(Computer Science & Engineering)
28.	Prof. M.L. Sharma	(Earthquake Engineering)
29.	Prof. (Mrs.) Amita Sinvhal	(Earthquake Engineering)
30.	Prof. Yogendra Singh	(Earthquake Engineering)
31.	Prof. B.K. Maheshwari	(Earthquake Engineering)
32.	Prof. Pankaj Agrawal	(Earthquake Engineering)
33.	Prof. Manish Shrikhande	(Earthquake Engineering)

34.	Prof. D.C. Srivastava	(Earth Sciences)
35.	Prof. G.J. Chakrapani	(Earth Sciences)
36.	Prof. Sandeep Singh	(Earth Sciences)
37.	Prof. Anand Joshi	(Earth Sciences)
38.	Prof. R. Krishnamurthi	(Earth Sciences)
39.	Prof. Pramod Agarwal	(Electrical Engineering)
40.	Prof. S.P. Srivastava	(Electrical Engineering)
41.	Prof. N.P. Padhy	(Electrical Engineering)
42.	Prof. Debashish Ghosh	(Electronics & Communication Engg.)
43.	Prof. D.S. Arya	(Hydrology)
44.	Prof. D.K. Nauriyal	(Humanities & Social Sciences)
45.	Prof. S.P. Singh	(Humanities & Social Sciences)
46.	Prof. Y.S. Negi	(Paper Technology)
47.	Prof. S.C. Sharma	(Paper Technology)
48.	Prof. (Mrs.) Rama Bhargava	(Mathematics)
49.	Prof. R.C. Mittal	(Mathematics)
50.	Prof. V.K. Katiyar	(Mathematics)
51.	Prof. Kusum Deep	(Mathematics)
52.	Prof. Tanuja Srivastava	(Mathematics)
53.	Prof. N. Sukavanam	(Mathematics)
54.	Prof. S.P. Yadav	(Mathematics)
55.	Prof. Pradeep Kumar	(Mechanical & Industrial Engg.)
56.	Prof. S.C. Sharma	(Mechanical & Industrial Engg.)
57.	Prof. Dinesh Kumar	(Mechanical & Industrial Engg.)
58.	Prof. B.K. Gandhi	(Mechanical & Industrial Engg.)
59.	Prof. Ravi Kumar	(Mechanical & Industrial Engg.)
60.	Prof. S.K. Nath	(Metallurgical & Materials Engg.)
61.	Prof. Anjan Sil	(Metallurgical & Materials Engg.)
62.	Prof. B.S.S. Daniel	(Metallurgical & Materials Engg.)
63.	Prof. Rajesh Srivastava	(Physics)
64.	Prof. Vir Singh	(Physics)
65.	Prof. G.D. Varma	(Physics)
66.	Prof. M.L. Kansal	(WRD&M)
67.	Prof. R.P. Saini	(Alternate Hydro Energy Centre)
68.	Prof. Arun Kumar	(Alternate Hydro Energy Centre)
69.	Dr. R. Balasubramanian	Institute Computer Centre
70.	Dr. A.K. Sharma	Associate Dean, Academic Studies
71.	Dr. Inderdeep Singh	Associate Dean of Students' Welfare (Discipline)

72. Dr. Barjeev Tyagi, Associate Professor, Department of Electrical Engineering
73. Dr. Manish Mishra, Associate Professor, Department of Mech. & Ind. Engg.
74. Dr. Umesh Sharma, Associate Professor, Department of Civil Engineering
75. Dr. K.R. Justin Thomas, Associate Professor, Department of Chemistry
76. Dr. Rajat Agarwal, Associate Professor, Department of Management Studies
77. Mr. Prashant Garg, Registrar & Secretary, Senate

The Chairperson welcomed the members to the 64th Meeting of the Senate.

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

1. Prof. R.G.S. Sastri, Department of Earth Sciences
2. Prof. V.K.Nangia, Department of Management Studies.
3. Dr. P. Jeevanandam, Associate Dean of Students' Welfare (Foreign Students)

The Chairperson also welcomed the under-mentioned new member to the Senate and hoped for his valuable contribution and active participation in its functioning:

Dr. Z. Rahman, Head, Department of Management Studies

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

1. Prof. Girishwar Misra, Vice-Chancellor, Mahatma Gandhi Antarrashtriya Hindi Vishwavidyalaya, Wardha.
2. Prof. P.K. Ghosh, Department of Metallurgical & Materials Engg.
3. Prof. M.P. Sharma, Alternate Hydro Energy Centre
4. Prof. M.R. Maurya, Department of Chemistry
5. Prof. Prof. K.S. Hariprasad, Department of Civil Engineering
6. Prof. Mahendra Singh, Department of Civil Engineering
7. Prof. (Mrs.) Shashi, Department of Chemical Engineering
8. Prof. Pradeep Bhargava, Department of Civil Engineering

The Agenda was then taken up:

Item No. 64.1: To confirm the minutes of the 63rd meeting of the Senate held on 11.01.2016.

As no comments were received, the minutes of the 63rd meeting of the Senate held on 11.01.2016 were confirmed. While confirming the minutes, the issue of Educational Tour was raised by a member. It was informed that as the Educational Tour was made part of the curriculum structure of undergraduate programme at 3rd Year level first time, some of the departments could not arrange the tours in time during session. After discussion, it was decided that such departments may award **'I'** grade to the students in the Spring Semester 2015-16 session and allowed to schedule their Educational Tour in the beginning of the next semester

to complete this requirement by 30th September 2016. The 'I' grade be converted to actual grade (AP/AF) once the tour is organized.

It was also decided that this has to be completed before MTE of the next semester.

Item No.64.2: To receive a report on the actions taken to implement the decisions taken by the Senate in its 63rd meeting held on 11.01.2016.

The Senate noted the actions taken on the resolutions of the 63rd meeting held on 11.01.2016. The issue of constitution of Oral Defence Committee was again raised by a member. After due discussion it was decided that there will be no change in the constitution of Oral Defence Committee as mentioned in the Ph.D. Ordinances and Regulations.

Item No. 64.3: To consider the proposal of admitting Consultancy Project Fellows in Ph.D. programme

Considered the proposal of admitting Consultancy Project Fellows in Ph.D. programme as recommended by the IRC and decided that fellows selected in a Consultancy Project shall not be admitted in the Ph.D. programme directly. However, they can take admission in Ph.D. programme, only if selected in regular selection alongwith MHRD candidates.

Further, it was reiterated that Project Fellows selected in Sponsored Projects by the extended selection committee (having two more members from the department) can be admitted in the Ph.D. programme subject to satisfying the conditions notified earlier.

Item No. 64.4: To consider the request of Mr. Sanjeev Manhas, Faculty-in-Charge, TIEDS regarding provisions of study break for approval and incorporation in Academic rules and regulations for students' having start-ups companies incubation in TIEDS centre.

Considered the recommendations of the IRC on the proposal of Faculty-in-Charge, TIEDS regarding provisions of study break for students having start-ups companies incubation in TIEDS Centre and decided that no study break shall be given to any research scholar as there will be conflict of interests of student and supervisor.

Item No. 64.5: To consider the Minimum Educational Qualifications for admission to Ph.D. Programme of the Centre of Nanotechnology.

Considered the recommendation of the IRC regarding minimum educational qualification as given below, for admission to Ph.D. programme of Centre of Nanotechnology and decided the same be approved.

Centre of Nanotechnology: B.E./B.Tech./B.Pharm from relevant disciplines and higher.

All other standards for admission as given in Ph.D. Ordinances & Regulations will be applicable.

Item No. 64.6: To consider the report of Prof. Devang V. Khakhar, Director, IIT Bombay forwarded by MHRD to take admission upto 20% of sanctioned strength of postgraduate students for International students in all the IITs on supernumerary basis.

Considered the recommendation of the IAPC to take admission of International students in postgraduate programmes as proposed by MHRD and decided that, in principle, the proposal is accepted with the following additional points:

1. The number of International students shall be on supernumerary basis subject to availability of accommodation in campus.

2. The admission in M.Tech./Ph.D. in Engineering Departments shall be done only through GATE.

3. The GATE cut-off for International students for M.Tech. programme shall be decided by the Admission Committee.

4. There shall be annual contingency fund for the international students in addition to fees.

The candidates be admitted only from the session 2017-18 onwards.

Item No. 64.7: **To consider the syllabus and course content of 1st year M.Sc. Economics programme to be run by the Department of Humanities & Social Sciences from upcoming session 2016-17**

As considered and recommended by the IAPC, the Senate decided that the syllabi of the following programme core courses of M.Sc. Economics proposed by the Department of Humanities & Social Sciences as given at **Appendix 'A'** be approved with minor modification as suggested by the members:

1. HSN-502 : Microeconomics I
2. HSN-503 : Macroeconomics I
3. HSN-504 : Mathematics for Economists
4. HSN-505 : Development Economics
5. HSN-506 : Money, Banking and Financial Markets
6. HSN-507 : Microeconomics II
7. HSN-508 : Macroeconomics II
8. HSN-509 : Basic Econometrics
9. HSN-510 : International Economics
10. HSN-511 : Environmental Economics
11. HSN-512 : Advanced Econometrics

Item No. 64.8: **To consider the Academic Calendar for the Autumn and Spring Semester 2016-17 session.**

Considered the Academic Calendar for the Autumn and Spring Semesters of 2016-17 session as suggested by the committee and decided that the same be approved. The approved Academic Calendar is given in **Appendix 'B'.** After discussion, the following were also decided:

(a) Only the following students' events shall be organized in an academic session:

1.	Cultural Festival	-	THOMSO
2.	Technical Festival	-	COGNIZANCE
3.	Hobbies Club Annual Function	-	SRISHTI
4.	Annual Sports Meet	-	SANGRAM

(b) All other students' events shall be clubbed with any one of the above events.

Item No. 64.9: **Reported the inclusion of subject CEN-642 (Analysis and Design of Bridges) in the structure of M.Tech. (Structural & Dynamics) as an Elective course as recommended by Head, Department of Earthquake Engineering.**

The Senate accepted and noted the recommendation of Head, Department of Earthquake Engineering for inclusion of **CEN-642: Analysis and Design of Bridges** in the structure of **M.Tech. (Structural & Dynamics)** as an Elective course.

Item No. 64.10: **Reported the inclusion of subject CTN-611 (Management of Transport Systems) in the structure of Master of Urban and Rural Planning, as an Elective course as recommended by Head, Department of Architecture & Planning.**

The Senate accepted and noted the recommendation of Head, Department of Architecture & Planning for inclusion of **CTN-611: Management of Transport Systems** in the structure of **Master of Urban and Rural Planning** as an Elective course.

Item No. 64.11: **Reported the change in the minimum passing grade in Dissertation.**

The Senate accepted and noted that the minimum passing grade in Dissertation in the new system should be **'D+'** in place of 'C+'.

Item No. 64.12: **Report the changes for admission to PG programmes 2016**

The Senate accepted and noted the following changes for admission to PG programmes 2016

1. The changes suggested by the Centre for Transportation Systems regarding distribution seat GATE discipline wise and recommended the same as under:

Academic Deptt/ Centre & (Code)	Academic Programmes		Main Gate Discipline(s)					Other GATE Disciplines				
	Name	Code	GATE Discipline Code	GEN	OBC	SC	ST	GATE Discipline Code	GEN	OBC	SC	ST
CTRANS (TSC)	M.Tech. (Infrastructure Systems)	49	CE (7)	4	2	1	0	ME/PI/CH/EE/ EC/CS/AR (8)	4	2	1	1

2. The GATE disciplines suggested by the Botechnology Department for its new M.Tech.+Ph.D. programme to be started from 2016 and recommended the same as under:

Academic Deptt/ Centre & (Code)	Academic Programmes		Main Gate Discipline(s)					Other GATE Disciplines				
	Name	Code	GATE Discipline Code	GEN	OBC	SC	ST	GATE Discipline Code	GEN	OBC	SC	ST
Botechnology (BTD)	M.Tech. (Bioprocess Engineering)	50	CH/BT (12)	6	3	2	1	AG/XE(3)	1	1	1	0

3. Changes suggested by the Hydrology department is not accepted and it will remain the same as existing.

Academic Deptt/ Centre & (Code)	Academic Programmes		Main Gate Discipline(s)					Other GATE Disciplines *				
	Name	Code	GATE Discipline Code	GEN	OBC	SC	ST	GATE Discipline Code	GEN	OBC	SC	ST
Hydrology (HYD)	M.Tech. Hydrology	33	CE/AG (12)	6	3	2	1	ME/GG/XE/ PH/EY(3)	1	1	1	0

* To be filled from main GATE discipline in case candidates are not available from other GATE disciplens.

4. M.Tech. Polymer Science & Engineering in the Department of Polymer & Process Engineering (SRE Campus) which was approved by BOG to be started from the year 2016 will not start this year as the syllabi are not yet prepared by the Department.

5. The sponsored candidates be admitted in the Deptt of Electronics and Communication Engineering this year as recommended by the Department.

6. The sponsored candidates will not be admitted in the Deptt of Computer & Science Engineering this year as recommended by the Department except Army/DRDO/QIP.

7. The candidates working in Institute/ University awarding PG degree itself are not eligible for admission as part-time or full-time candidate, if facilities are not available except QIP candidates.

8. The tentative schedule of the PG Admission was discussed and decided the following :-

IMPORTANT DATES	
GATE Result will be announced	**March 19, 2016 (Saturday)**
Online Application Process **(Open)**	**March 21, 2016 (Monday)**
Last Date for Applying Online	**April 10, 2016 (Sunday)**
Last date for deposit of fee	**April 12, 2016 (Tuesday)**
Last date for receiving of completed Application at PG Admission Office, IIT Roorkee	**April 18, 2016 (Monday)**
Last date for uploading of call letters for Interview/Written Test/Counselling	**May 09, 2016 (Monday)**
Medical Examination for Persons with different abilities (PD) Candidates by the Medical Board	**June 07, 2016 (Tuesday)**
Interview/Written Test	**June 08, 2016 (Wednesday)**
Announcement of merit list after interview/written test	**June 09, 2016 (Thursday night)**
Counselling for admission	**June 09-11, 2016 (Thu-Sat)**
Last date for Withdrawal of Admission Offered	**June 24, 2016 (Friday)**
Display of 1st upgraded list including Waitlisted Candidates (on Institute Website)	**June 27, 2016 (Monday)**

Display of 2nd upgraded list including Waitlisted Candidates (on Institute Website)	**July 04, 2016 (Monday)**
Date of Registration	**July 14, 2016 (Thursday)**
Classes Begin	**July 18, 2016 (Monday)**
Final Counselling cum Registration of the Waitlisted Candidates in Merit for the vacant seats, if any	**July 22, 2016 (Friday)**

Item No. 64.13: Reported the proposal for providing the financial help to students for Educational Tour.

The Senate accepted and noted the following norms for Educational Tour:

(a) Travelling Allowance by bus/ train only upto maximum of 3rd AC.

(b) Accommodation charges as per actual or subject to maximum of @ Rs. 125/- per day.

(c) DA or Food bill @ Rs. 100/- per day.

The above rules are applicable to pending cases also.

Item No. 64.14: Reported the of the minutes of the 52nd Meeting of the Executive Committee of the Senate held on 10.03.2016.

The Senate accepted and noted the minutes of the 52nd meeting of the Executive Committee of the Senate held on 10.03.2016 as given at **Appendix 'C' .**

Item No. 64.15: To consider award of the Ph.D. Degrees to the students who have completed the requirements for the award of the Ph.D. Degree in various disciplines w.e.f. 1st January 2016 to till date.

The Senate decided that the award of the Ph.D. Degrees to the students who have completed the requirements for the award of the Ph.D. Degree in various disciplines w.e.f. 1st January 2016 to till date of this Senate meeting be approved. The list of the Ph.D. Degrees is given at **Appendix 'D'.**

It was also decided that henceforth, only the table indicating the details (name of candidate, supervisor(s), examiners, department and title of the thesis) shall be put

before the Senate for approval and not the vive-voce examination report.

Item No. 64.16: **To consider the syllabi of following two Departmental Electives proposed by the Department of Earth Sciences:**

(i) ESN-456: Field Geology for IMT (Geological Technology)
(ii) ESN-628: Field Geology for M.Sc. (Applied Geology)

As considered and recommended by the IAPC, the Senate decided that the proposal of Department of Earth Sciences to include Departmental Electives **ESN-628 Field Geology** for the students of IMT (Geological Technology) and M.Sc.(Applied Geology) for strengthening the field geology component and imparting advance training on structural analysis in field be approved. The syllabus of the said course is given at **Appendix 'E'.**

Item No. 64.17: **To consider the recommendation of the DFC of Department of Earth Sciences for shifting Departmental Elective Course ESN-581: Advanced Seismic Prospecting from 9th semester to 7th semester and the syllabus of new course ESN-xxx: Petrophysics and Seismic Rock Characterization.**

As considered and recommended by the IAPC, the Senate decided that the recommendation of Department of Earth Sciences for shifting Departmental Elective Course **ESN-581: Advanced Seismic Prospecting** from 9th semester to 7th semester be approved.

As considered and recommended by the IAPC, the Senate further decided that the syllabus of new elective course **ESN-583: Petrophysics and Seismic Rock Characterization** as proposed by the department as given at **Appendix 'F'** be approved.

Item No. 64.18: **To consider the syllabus of HSN-513: Public Policy-Theory and Practice programme core course of M.Sc. Economics proposed by the Department of Humanities & Social Sciences:**

As considered and recommended by the IAPC, the

Senate decided that the syllabus of Programme Core Course **HSN-513: Public Policy- Theory and Practice** for M.Sc. (Economics) as proposed by the Department of Humanities & Social Sciences be approved.

The Senate further decided that the syllabus as given in **Appendix 'G'** be approved.

Item No.64.19: To consider the proposal of reducing the number of pages in ETE answer scripts to save paper.

Considered the recommendations of IAPC of reducing the number of pages in ETE answer scripts to save paper and decided that the following be approved:

(i) Number of pages of ETE answer script shall be reduced to 24.
(ii) Extra sheets, as supplementary answer scripts (4 pages at a time), shall be provided to students as and when required.
(iii) Cover page of answer script shall be modified to include the signature of student.
(iv) Number of pages in MTE shall be kept same as 16 but extra sheets shall be provided as supplementary answer scripts.

The modified cover pages both for End Term and Mid Term Examinations and cover page for supplementary sheet are given in **Appendix 'H'**.

Item No. 64.20: To consider the revised curriculum structure for M.Sc. (Chemistry) and syllabi of courses as proposed by the Department of Chemistry.

Considered the revised curriculum structure for M.Sc. (Chemistry) as recommended by the IAPC in view of the phasing out of their Integrated M.Sc. (Chemistry) programme and decided that the same be approved. The Senate also considered the syllabi of the modified courses as recommended by IAPC and decided that the same be approved. The modified structure of M.Sc. (Chemistry) and the syllabi of all the courses are given in **Appendix 'I'**

Item No. 64.21: To consider the proposal of reducing the minimum number of students in an elective.

Considered the recommendations of IAPC of reducing the minimum number of students in an elective so that Departments can run more number of electives to facilitate UG students to take extra electives for Departmental Honours Degree and decided that the minimum number of students required to run any Departmental Elective or Open Elective be reduced as below:

(a) Minimum number of students required to run a Departmental Elective for UG shall be reduced to **5**.

(b) Minimum number of students required to run an Open Elective shall be reduced to **15**.

Item No. 64.22: To consider the syllabi of Pre-Ph.D. courses proposed by the Department of Mathematics.

As considered and recommended by the IAPC, the Senate decided that the syllabi of the following Pre-PhD courses proposed by the Department of Mathematics be approved with minor specifications:

(i) MAN-901: Selected topics in Analysis
(ii) MAN-902: Advanced Numerical Analysis
(iii) MAN-903: Theory of Differential Equations
(i) MAN-904: Selected Topics in Algebra

The syllabi of the recommended courses are given in **Appendix 'J'**

Item No. 64.23: To consider the syllabus of ECN-5xx: Digital System Design proposed by the Department of Electronics and Communication Engineering.

As considered and recommended by the IAPC the Senate approved the replacement of existing **ECN-574: Semiconductor Materials, Devices and Characterization** of Autumn Semester for the students of M.Tech. (Microelectronics and VLSI) with the proposed course **ECN-578: Digital System Design**. This shall be applicable form the session 2016-17. The syllabus of the proposed course is given in **Appendix 'K'**

Item No. 64.24: To consider identifying "Open" and "Closed" portions of Ph.D. thesis having confidential intellectual property and taking "Non-Disclosure Agreement" from the external examiners as suggested in IFM.

Considered the issue of identifying "Open" and "Closed" portions of Ph.D. thesis having confidential intellectual property as suggested in IFM and decided that there is no need to identify "Open" and "Closed" portions of Ph.D. thesis having confidential intellectual property" as recommended by the IRC.

The Senate also considered the recommendations of the IRC of taking "**Non-Disclosure Agreement**" from the external examiners and decided that the same be approved. It was also decided that this agreement proforma shall be sent to examiner while taking his/her consent to act as examiner. This will be made effective from the beginning of the next session.

Item No. 64.25: To consider the submission of thesis at the end of the maximum duration for Ph.D. in the absence of acceptance of paper.

The Senate considered the recommendations of the IRC that if the research scholar has completed 4½ years and has finished his/her work as proposed at the time of candidacy and submitted papers in journals of repute but acceptance has not come, the candidate may be allowed to present pre-submission seminar for possible submission and after detailed discussion decided that the matter be referred to the departments to deliberate on this issue and give suggestions. The then revised recommendations of IRC based on the suggestions of the Departments will be considered in the next meeting of the Senate.

Item No. 64.26: To consider including Post Graduate level course from AYUSH leading to MD/MS in Ayurveda also an eligible criteria for Ph.D. admission in Bio –Technology.

Considered the recommendations of the IRC of including Post Graduate level recognized courses leading to MD/MS in Ayurveda also an eligible criteria for Ph.D. admission in Bio –Technology and decided that the same be approved.

Item No. 64.27: **Repoted that Prof. M.P. Varshney, an alumnus of erstwhile Thomason College of Engineering Roorkee and the first alumnus of Thomason College to obtain a Ph.D. degree has offered a sum of Rs. 1.11 crore to establish an endowment fund and the Director has accepted the offer. The endowment fund will be used to acquire some equipment for one of the laboratories in Electrical Engineering Department, creation of Ph.D. fellowship and an honorific lecture.**

The Senate accepted and noted that Prof. M.P. Varshney, an alumnus of erstwhile Thomason College of Engineering Roorkee and the first alumnus of Thomason College to obtain a Ph.D. degree has offered a sum of Rs. 1.11 crore to establish an endowment fund and the Director has accepted the offer. The endowment fund will be used to acquire some equipment for one of the laboratories in Electrical Engineering Department, creation of Ph.D. fellowship and an honorific lecture.

UNDER ANY OTHER ITEMS:

Item No. 64.28: **Reported the e-mail dated 11.04.2016 alongwith a scan copy of letter F.No. 24-2/2016 TS-1 dated 08.04.2016 addressed to the Director of all IITs regarding revision of tuition fee for the undergraduate programme to Rs. 2.00 lakhs a year from the Academic Year 2016-17.**

The Senate accepted and noted the e-mail dated 11.04.2016 alongwith a scan copy of letter F.No. 24-2/2016 TS-1 dated 08.04.2016 addressed to the Director of all IITs regarding revision of tuition fee for the undergraduate programme to Rs. 2.00 lakhs a year from the Academic Year 2016-17**(Appendix 'L')**.

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

Appendix-B

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT. /CENTRE: **Humanities and Social Sciences**

1. Subject Code: **HSN - 502** Course Title: **Microeconomics 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 provide an understanding of consumer and producer behavior, concept of markets and competition, and tools of comparative statics and their application to price theory.

10. Details of Course:

S. No.	Contents	Contact hours
1	**Consumer Behaviour:** Theories of consumer behavior, preference orderings, demand, duality theory, revealedpreference& aggregate demand	6
2	**Producer Behaviour:** Technology and production sets, costs and production functions (for competitive firm),cost minimization, profit maximization & duality theoryonce more, aggregate supply	8
3	**Competitive Market:** Equilibrium in a competitive market, stability and comparative static properties, general equilibrium and Pareto optimality - fundamental theorems of welfare economics, externalities and market failures	8
4	**Imperfect Markets:** Imperfect competition and market structure, bilateral monopoly, single product monopoly, discriminating monopoly, durable goods monopoly, recycling, leasing versus selling & the Coase conjecture; Monopsony and monopolistic market structure	6
5	**Game Theory with Applications to Oligopoly Theory:** Game Theory: Extensive and normal form representation of games, Nash equilibrium (in pure and mixed strategies), definition and existence; subgame perfection in dynamic games. Applications: strategic behaviour of firms in a market (Bertrand, Cournot and Stackelberg models) and entry deterrence.	8

6	**Markets for Inputs:** Price and employment of inputs, the firm's demand curve-one variable input and several variable inputs, market demand curve and supply curve, equilibrium price and employment of an input, rent, imperfectly competitive output markets	6
	Total	42

11. Suggested Books:

S. No.	Name of Books/Author/Publisher	Year of Publication/ Reprint
1	Hal R. Varian, *Microeconomic Analysis*, W. W. Norton & Company, 3rd Edition	2010
2	Andreu Mas-colell, Michael D. Whinston and Jerry R. Green John, *Microeconomic Theory*, Oxford University Press, 1st Edition	2012
3	Geoffrey Alexander Jehle and Philip J. Reny, *Advanced Microeconomic Theory*, Financial Times Prentice Hall, 3rd Revised Edition	2011
4	Hal R. Varian, *Intermediate Microeconomics with Calculus*, W. W. Norton & Company, International Student Edition	2014
5	H. Gravelle and R. Rees, *Microeconomics*, Pearson India, 3rd Edition	2007
6	E. Mansfield and G. Yohe, *Microeconomics*, Viva-Norton, 11th Edition	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT. /CENTRE: **Humanities and Social Sciences**

1. Subject Code: **HSN - 503** Course Title: **Macroeconomics 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 knowledge of working of the whole economy: the determination of income, output, employment, savings, interest rates, inflation and macroeconomic policies.

10. Details of Course:

S. No.	Contents	Contact hours
1	**Introduction:** Macroeconomic concepts and issues	2
2	**National Income Accounting:** National income accounting structure, key concepts, measurements and difficulties, and circular flow of income- for closed and open economy; GNP and welfare, Inter-temporal and international comparisons of national income, Social accounting and its significance, Green GDP, Beyond GDP	7
3	**Income and Employment Theory:** Aggregate Demand and aggregate supply; Schools in Macroeconomics: Classical to Neo-Keynesian, Multiplier and accelerator principles; Equilibrium in the product, labour and money markets	6
4	**IS-LM Model:** Adjustment towards equilibrium, multiplier analysis, role of government in terms of monetary and fiscal policy	5
5	**Consumption and Saving:** Consumption under certainty- Life-Cycle and Permanent Income Hypothesis; Consumption under uncertainty-The Modern Approach, Random Walk Hypothesis; Consumption and Risky Asset; Beyond the Permanent Income Hypothesis	7

6	**Inflation and Unemployment:** Inflation- theories, measurement, causes, effects and social costs; Unemployment, the demand for and the supply of labour, Wage rigidity; Inflation-unemployment trade-off, Phillips curve, inflation targeting, Seignorage and Inflation Problems, Non-accelerating inflation rate of unemployment, Inflationary expectations- Adaptive and rational expectations hypothesis	8
7	**Investment Theories:** Keynesian, Post-Keynesian, Neo-Keynesian (Jorgenson approach), Lags in investment function	7
	Total	**42**

11. Suggested Books :

S. No.	Name of Books/Author/Publisher	Year of Publication/ Reprint
1	Gregory Mankiw, *Macroeconomics,* Macmillan, 8th Edition	2013
2	Bernanke B.S., Olekalns, N. and H. R. Frank, *Principles of Macroeconomics,* McGraw-Hill, 4th Edition	2014
3	Errol D'Souza, *Macro Economics*, Pearson Education, Pearson, 2nd Edition.	2012
4	Richard T. Froyen, *Macroeconomics: Theories and Policies*, Pearson Education, Pearson, 10th Edition.	2014

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT. /CENTRE: **Humanities and Social Sciences**

1. Subject Code: **HSN - 504** Course Title: **Mathematics for Economists**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To introduce the mathematical tools and techniques necessary for understanding economic theories and their real-life applications.

10. Details of Course:

S. No.	Contents	Contact hours
1.	**Introduction to Mathematical Economics**: Economic models; Review of fundamental concepts- Real number system, sets, relations and functions	2
2.	**Linear Models and Matrix Algebra:** Solving univariate and Multivariate Systems of Linear Equations, Basic matrix operations, Determinant; Applications to analysis of Markets and National Income Accounting	6
3.	**Use of Differentiation in Economic Analysis:** Partial & Total Derivatives; Tests of continuity and monotonicity of a function; Average and Marginal concepts; Elasticity	5
4.	**Optimization and Equilibrium:** Maxima and minima; Unconstrained optimization techniques; Constrained optimization techniques - Lagrange Multiplier Method; Application to consumer behavior, production and costs.	5
5.	**Integral Calculus and Dynamic Analysis**: First and higher order ordinary differential equations; Simultaneous differential equations-Dynamic Input-output models; Integral calculus application to welfare analysis	5
6.	**Mathematical Programming**: Simple linear programming models; Duality Theorem; Non-Linear Programming	5
	Total	28

11. Suggested Books :

S. No.	Name of Books/Author/Publisher	Year of Publication/ Reprint
1.	Alpha C Chiang & Kevin Wainwright, *Fundamental Methods of Mathematical Economics*, McGraw Hill Education, 4th Edition	2013
2.	Carl P. Simon, *Mathematics for Economists*, Viva Books	2010
3.	Sydsaeter, K., Hammond, P. J. and Strom, A., *Essential Mathematics for Economic Analysis*, Pearson, 4th Edition	2012
4.	Sydsaeter, K., Hammond, P. J. and Strom, A., *Further Mathematics for Economic Analysis*, Pearson, 2nd Edition	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT. /CENTRE: **Humanities and Social Sciences**

1. Subject Code: **HSN - 505** Course Title: **Development Economics**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of various development theories, strategies and issues.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Basic concepts of growth and development, inclusive growth, change in the meaning of development over a period of time, socio-economic development indicators	4
2	**Growth, Poverty and Inequality:** Uni- and multi-dimensional concepts of poverty, poverty indicators, poverty and vulnerability, inequality and development; Inverted-U Hypothesis; Measurement of inequality (Lorenz curve, Gini coefficient, Theil index); Inequality axioms	6
3	**Theories of Economic Growth:** Classical, Keynesian, post-Keynesian, Neo-Keynesian and Neo-Classical	7
4	**Strategies of Economic Development:** The Big Push theory of industrialization; the Rostow's Theory of Stages of Growth; the Balanced versus Unbalanced Growth theories; Economic Dualism.	6
5	**Institutions and Economic Development:** Types of institutions- Formal and informal, government, private and non-governmental; Property rights, legal systems, rule of law; Contribution of institutions to economic growth and efficiency; Role of civil societies in economic development, The rights-based approach to development; social capital and development	7
6	**Population and Economic Development:** Role of population growth in the development process, Population growth and living standards, Low Level Equilibrium trap; Demographic dividend; Migration and development	6
7	**Structural Adjustment and Development:**	6

	The fall of the centrally planned economies; State versus Market; Effects of Structural Adjustment on economic growth; Structural adjustment and stabilization policies of IMF and World Bank	
	Total	**42**

11. Suggested Books:

S. No.	Author (s)/Title/ Publisher	Year of Publication/ Reprint
1	A.P. Thirlwall, *Growth and Development*, Palgrave Macmillan, 8th Edition	2006
2	Michael P. Todaro and Stephen C. Smith, *Economic Development,* Prentice Hall, 11th Edition	2011
3	K. Staudt, *Managing Development*, Sage Publications	1991
4	Subrata Ghatak, *Introduction to Development Economics*, Routledge, 4th Edition	2003
5	Ray, Debraj, *Development Economics*, Princeton University Press	1998
6	Word Development Reports, World Bank	Annual

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT. /CENTRE: **Humanities and Social Sciences**

1. Subject Code: **HSN - 506** Course Title: **Money, Banking, and Financial Markets**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge of economic principles that underlies the role of money in the economy: the operation of banks and other financial institutions and the impact of credit and monetary policies on the economy.

10. Details of Course:

S. No.	Contents	Contact hours
1	**Introduction:** Understanding 'money'- Functions, Evolution and Measures of Money; Overview of financial system and markets	2
2	**Demand for and Supply of Money:** Money Demand function- Classical and Keynesian approaches to money demand, Quantity theory of money, Keynes' liquidity preference theory; Neutrality of money; Friedman's modern quantity theory of money, Baumol-Tobin Model; Money in IS-LM framework	5
3	**Structure of Interest Rates:** Behaviour and term structure of interest rates, Changes in Equilibrium Interest rate, Yield curve and Theories on Term Structure of Interest rates- Expectations Theory, Segmented Market, Liquidity Premium	5
4	**Money and Capital Markets:** Instruments, targets and functions, Banking Industry- structure, role and performance; NBFIs and NBFCs; Development Financial institutions, Financial reforms and policies	7
5	**Advanced Topics in Banking Finance:** Market micro-structure, Role of regulation and incentives, International standards	3
6	**Central Banking and Monetary Policy:** Role and functions of Central Bank; Credit policy, Monetary policy- tools, strategy and effects, Policy rules vs. discretion,	6

-20-

	Optimal monetary policy	
	Total	**28**

11. Suggested Books :

S. No.	Name of Books/Author/Publisher	Year of Publication/ Reprint
1	Frederic S. Mishkin, *Economics of Money, Banking, and Financial Markets,* Prentice Hall, 10th Edition.	2012
2	Carl E.Walsh, *Monetary Theory and Policy*, MIT Press, 3rd Edition.	2010
3	Bennett T. McCallum, *Monetary Economics: Theory and Policy*, Macmillan, Facsimile Edition	1989
4	L M Bhole, and Jitendra Mahakud, *Financial Institutions and Markets*, Tata McGraw-Hill Education, 5th Edition	2009
5	Annual Reports, Reserve Bank of India	Annual

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT. /CENTRE: **Humanities and Social Sciences**

1. Subject Code: **HSN - 507** Course Title: **Microeconomics II**

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

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

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

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

8. Pre-requisite: Elementary knowledge of mathematics and intermediate microeconomics.

9. Objective: To develop understanding on decision making under uncertainty, advance game theory, role of information in economic analysis and current topics in microeconomic theory.

10. Details of Course

:

S. No.	Contents	Contact hours
1	**Decision-making under Uncertainty:** Decision making under risk, decision making under uncertainty, attitudes towards risk - applications of theories to understand lotteries and gambling, stochastic dominance, expected utility theorem, critiques of expected utility theory, measurement of risk aversion.	8
2	**Game Theory under Incomplete Information:** Static and Dynamic Games of Incomplete information - Concepts and applications Principal agent models - Hidden action and hidden information	8
3	**Information Economics:** Market Failure under adverse selection, signaling models, screening models (will address price discrimination by a monopolist when buyer type is "private" information), optimal contact design in a moral hazard (hidden action model), applications	9
4	**Special Topics 1:** (i) Mechanism design with money and without money (ii) Applications: Spectrum auctions, coal auctions, school choice, kidney exchange, etc.	9
5	**Special Topics 2:** (i) Network economics (ii) Law and Economics	8
	Total	42

11. Suggested Books:

S. No.	Name of Books/Author/Publisher	Year of Publication/ Reprint
1	Hal R. Varian, *Microeconomic Analysis*, W. W. Norton & Company, 3rd Edition	2010
2	James Bergin, *Microeconomic theory: A concise course*, Oxford University Press, 1st Edition	2005
3	Martin J Osborne, *An Introduction to Game Theory*, Oxford University Press	2003
4	Nicholas Barr, *Economics of the Welfare State*, Oxford University Press, 5th Edition	2012
5	Sanjeev Goyal, *Connections: An Introduction to the Economics of Networks*, Princeton University Press,	2009
6	Robert D. Cooter and Thomas S. Ulen, *Law and Economics*, Addison-Wesley, New York, 6th Edition	2011

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT. /CENTRE: **Humanities and Social Sciences**

1. Subject Code: **HSN - 508** Course Title: **Macroeconomics II**

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

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

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

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

8. Pre-requisite: Basic understanding of macroeconomics

9. Objective: To provide knowledge to analyze and develop theories and models describing macroeconomic dynamics.

10. Details of Course:

S. No.	Contents	Contact hours
1	**Dynamic General Equilibrium Model:** Consumption and savings optimization-households and firms, the Ramsey model, the Diamond model, Intergenerational issues and simple neo-classical general equilibrium model	7
2	**Growth in Dynamic General Equilibrium:** Growth theories- assumptions, the dynamics of the model and impacts, Solow model, Speed of Convergence, Role of Human Capital, Empirical Issues; The golden rule of accumulation; Endogenous Growth Theory: AK model; Learning by Doing, Further Extensions	9
3	**Real Business Cycles:** Concept of economic fluctuations, Real business cycle approach-RBC model, household behavior and the special case of the model, Evaluation and accounting for Business cycle fluctuations, implications	9
4	**Micro Foundations in Macroeconomics:** Lucas critique, Stagger price adjustments - Caplin-Spulber model, Neo-Keynesian Economics, Coordination failure models, real non-Walrasian theories	8
5	**Macroeconomics and Open Economy Aspects:** Market for foreign exchange, devaluation and depreciation, real and nominal exchange rate, factors affecting exchange rate, Mundell-Fleming model, fixed versus floating exchange rate, price adjustment, role of fiscal and monetary policies under alternative exchange rate regimes, purchasing power parity concept	9
	Total	42

11. Suggested Books:

S. No.	Name of Books/Author/Publisher	Year of Publication/ Reprint
1	David Romer, *Advanced Macroeconomics*, McGraw Hill, 4th Edition	2011
2	Ragbhendra Jha, *Macroeconomics for Developing Countries*, Routledge, 2nd Edition	2003
3	Olivier Blanchard, and David R. Johnson , *Macroeconomics*, Pearson; 6th Edition	2012
4	Sala-I-Martin Xavier Barro Robert J., *Economic Growth*, The MIT Press; 2nd Edition	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT. /CENTRE: **Humanities and Social Sciences**

1. Subject Code: **HSN - 509** Course Title: **Basic Econometrics**

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: Basic knowledge of Mathematics

9. Objective: To provide knowledge of basic econometric tools and techniques useful for economic analysis.

10. Details of Course:

S. No.	Contents	Contact hours
1	**Introduction:** Nature and meaning of econometrics, structure of economic data, approaches to econometric model building	2
2	**Basic Statistical Concepts**: Sample and sample space, Random variables and Probability distributions and their properties; Tests of hypothesis; Estimation techniques	8
3	**Simple and Multiple Linear Regression Models**: Formulation, Estimation and Evaluation-Model with one and *k* Independent Variables, Assumptions of CLRM, estimation methods (OLS and ML methods), marginal effects, point and interval estimates, Gauss-Markov theorem (BLUE), Test of hypotheses - individual coefficients, testing model parameters	9
4	**Functional Forms and Model Specification**: Regression models with quadratic effects, log-transformation and non-linear equations; Test of restrictions imposed on the relationship of more parameters-Chow test, Wald test, LR test, Ramsay's RESET, Bera-Jarque test of normality of errors, Hausman specification test	7
5	**Violations in CLRM:** Heteroskedasticity, Multicollinearity and Autocorrelation-consequences, detection and remedies; specification error, omitted variables, errors in measurement; Aitken theorem and GLS method	10
6	**Dummy Variables**: Meaning and Uses of Dummy Variables; Dummy Variable Trap;	6

11. Suggested Books:

S. No.	Name of Books/Author/Publisher	Year of Publication/ Reprint
1	Paul R. Krugman and Maurice Obstfeld, *International Economics: Theory and Policy*, Pearson Education, 8th Edition	2008
2	Dominick Salvatore, *International Economics: Trade and Finance*, Wiley, 10th Edition	2012
3	Jagdish N. Bhagwati, Arvind Panagariya and T N. Srinivasan, *Lectures on International Trade*, The MIT Press	1998
4	Bo Sodersten and Geoffrey Reed, *International Economics*, Palgrave Macmillan, 3rd Edition	1994
5	Robert C. Feenstra, *Advanced International Trade: Theory and Evidence*, Princeton University Press, 2nd Edition	2015

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT. /CENTRE: **Humanities and Social Sciences**

1. Subject Code: **HSN - 510** Course Title: **International Economics**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To develop understanding of international trade theories, strategies and policies in local and global context.

10. Details of Course:

S. No.	Contents	Contact hours
1	**An Overview of the World Economy** Causes of Trade and Gains From Trade, Trade and Growth, Trade and Environment	3
2	**Theories of International Trade I:** The Ricardian Model and Comparative Advantage; Factor Endowments and Pattern of Trade and Specialization (The Heckscher-Ohlin Model), Factor Price Equalization	7
3	**Theories of International Trade II:** New Approaches to Trade Theory, The Distribution of Income and Adjustments, Empirical testing of the Inter-Industry trade and Technological progress in Inter-Industry Trade	8
4	**International Trade Policy:** The Partial Equilibrium Analysis of Trade Policy, The General Equilibrium Analysis of Trade Policy, Instruments of Trade Policy: Tariffs, Quotas, Most Favoured Nation and Other Policy Instruments	8
5	**Strategic Trade Policy:** Strategic tariff interaction, Dumping and anti-dumping measures, The theory of Custom Unions, WTO and international trade, GATT, Trade Creation and Trade Diversion	8
6	**The Balance of Payments and Determinants of Exchange Rates:** Balance of Payments, Determination of Exchange Rate: Purchasing Power Parity, Demand for and Supply of Foreign Exchange and other theories; IMF & International monetary arrangements	8
	Total	42

11. Suggested Books:

S. No.	Name of Books/Author/Publisher	Year of Publication/ Reprint
1	Paul R. Krugman and Maurice Obstfeld, *International Economics: Theory and Policy*, Pearson Education, 8th Edition	2008
2	Dominick Salvatore, *International Economics: Trade and Finance*, Wiley, 10th Edition	2012
3	Jagdish N. Bhagwati, Arvind Panagariya and T N. Srinivasan, *Lectures on International Trade*, The MIT Press	1998
4	Bo Sodersten and Geoffrey Reed, *International Economics*, Palgrave Macmillan, 3rd Edition	1994
5	Robert C. Feenstra, *Advanced International Trade: Theory and Evidence*, Princeton University Press, 2nd Edition	2015

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT. /CENTRE: **Humanities and Social Sciences**

1. Subject Code: **HSN - 511** Course Title: **Environmental Economics**

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

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

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

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

8. Pre-requisite:**Nil**

9. Objective: To enrich the understanding of various issues related to the economy and environment and basic theories of environmental economics with greater emphasis on their application.

10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Introduction:** Basic concepts and tools; scope and relevance; difference among environmental economics, ecological economics and natural resource economics; collective choices: Harden thesis of tragedy of commons, Prisoners' dilemma game and Olson concept of collective actions	5
2.	**Environment and Development** Poverty, environment, and economic growth; Environmental Kuznets Curve and its empirical evidences; Ecosystem services and development; Ecological footprints	7
3.	**Efficiency, Market and Market Failure:** Concept of efficiency, Pareto optimality, efficiency and competitive markets, efficiency in exchange of goods and bads, consumer and producer surplus; Market Failure: public and private bads, rivalry and excludability, externalities, market and optimum provision of public goods and bads, methods to correct market failure; Pigovian Fees	8
4.	**Property Rights:** The rights of polluter and the victim, The Coase theorem and its policy significance	4
5.	**Environmental Valuation and Cost Benefit Analysis:** Environmental values, Consumer demand for environmental goods, welfare effects of a price change, Methods of environmental valuation: revealed and stated preference methods (Hedonic, Household Production function, travel cost, and Contingent valuation methods); Issues in estimation of costs and benefits, pollution cost, benefits from controlling pollution, efficiency in pollution control, limitations of cost-	10

	Production function, travel cost, and Contingent valuation methods); Issues in estimation of costs and benefits, pollution cost, benefits from controlling pollution, efficiency in pollution control, limitations of cost-benefit analysis	
6.	**Environmental Regulations and Policy:** Rationale for regulations, basic regulatory instruments, issues and effects of environmental regulations; The Kyoto Protocol, CDM and Carbon Credits ; Environmental Regulatory Framework and Environmental Policy in India	8
	Total	**42**

11. Suggested Books:

Sr. No.	Name of Books/Authors	Year of Publication/ Reprint
1	Charles D. Kolstad, *Environmental Economics*, Oxford university Press, First Indian Edition, New Delhi.	2006
2	Tom Tietenberg, *Environmental and Natural Resource Economics*, Addison Wesley Longman, Inc., 7th Edition	2006
3	Steven C. Hackett, *Environmental and Natural Resources Economics: Theory, Policy, and the Sustainable Society*, Routledge, 4th Edition	2010
4	Nick Hanley, *Introduction to Environmental Economics*, Oxford University Press, 2nd Edition	2013
5	Daniel W. Bromley, *Handbook of Environmental Economics*, Blackwell Publishing, 1st Edition	1995
6	Report of Ministry of Environment and Forests, Government of India, New Delhi	Annual

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT. /CENTRE: **Humanities and Social Sciences**

1. Subject Code: **HSN - 512** Course Title: **Advanced Econometrics**

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: Knowledge of Basic Econometric Methods

9. Objective: To provide knowledge of advanced econometric techniques with statistical software applications.

10. Details of Course:

S. No.	Contents	Contact hours
1	Qualitative and Limited Dependent Models: Linear probability model(LPM)- estimation and limitations, Logit and Probit models, Censored and truncated regression, MLE estimation-Tobit model, Applications	7
2	Simultaneous Equation Systems: Structural and reduced form models, simultaneous equation bias, identification problem and estimation methods- 2SLS, 3SLS and LIML; SUR procedure; Problem of Endogeneity- causes and solution; Instrumental Variables estimation; GMM- estimation and testing for overidentification	11
3	Dynamic Econometric Models: Autoregressive and Distributed lag (ADL) relationships-specification and problems in OLS estimation, Koyck's and Almon's approach to DLM, partial adjustment and adaptive expectations method, Exogeneity tests, Wu-Hausman test	8
4	Time Series Analysis: Stationary and non-stationary time series, unit root tests; Concept of cointegration, two-variable model – Engle-Granger method and ECM; system of equations – vector autoregression (VAR), Johansen procedure, VECM, Granger causality	9
5	Analysis of Panel Data: Balanced vs. unbalanced panel, Fixed effects model, random effects model, fixed vs. random effects- Wu Hausman test, dynamic panel model	7
	Total	42

11. Suggested Books:

S.No.	Name of Books/Author/Publisher	Year of Publication/ Reprint
1	Greene, W.H., *Econometric Analysis*, Pearson, 7th Edition	2012
2	Verbeek, M., *Guide to Modern Econometrics*, Wiley, 3rd Edition	2008
3	A. Colin Cameron and Pravin K. Trivedi, *Microeconometrics using Stata*, Stata Press, 2nd Edition	2010
4	Badi H. Baltagi, *Econometric analysis of Panel Data*, Wiley, 5th Edition	2013
5	Walter Enders, *Applied Econometric Time Series*, Wiley, 3rd Edition	2013

Appendix 'B'
Item No. Senate/64.8

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
ACADEMIC CALENDAR FOR THE YEAR 2016-17
(Autumn Semester)

S.No.	Details	Autumn Semester	
		Date	Day
1.	Reporting and Registration of New Ph.D. students.	08.07.2016	Friday
2.	Institute reopens and Registration of all new PG students	14.07.2016	Thursday
3.	Registration of all existing students in the Departments/ Centres	15.07.2016	Friday
4.	Re-examination and Second examination on medical grounds (for Spring Semester 2015-16)	14.07.2016 - 16.07.2016	Thursday - Saturday
5.	Commencement of Classes for Autumn Semester (2016-17) except UG I Yr	18.07.2016	Monday
6.	Reporting and Registrations of all new UG/IMT/IMS students	21.07.2016	Thursday
7.	Orientation programme for all new students including selections of all newly admitted UG/IMT/IMS students for N.C.C./N.S.S./N.S.O. and Language Proficiency test	22.07.2016- 24.07.2016	Friday - Sunday
8.	Registration/Counselling for vacant seats of all PG programmes	22.07.2016	Friday
9.	Closing of admissions	22.07.2016	Friday
10.	Last date for sending the grades of Re-examination	22.07.2016	Friday
11.	Commencement of Classes for UG I Yr	25.07.2016	Monday
12.	Online subject registration of all new students including proficiency registration	30.07.2016- 03.08.2016	Saturday - Wednesday
13.	Last date of Academic Registration	01.08.2016	Monday
14.	Uploading of roll lists of registered students	02.08.2016	Tuesday
15.	Last date of addition/deletion of courses	03.08.2016	Wednesday
16.	Uploading of final course-wise roll lists of registered students including proficiency	06.08.2016	Saturday
17.	Assignment of Major projects to all B.Tech. final year students	12.08.2016	Friday
	Independence Day	**15.08.2016**	**Monday**
	Janmashtami	**25.08.2016**	**Thursday**
18.	Request to Departments to send list of Institute Elective/ Open Elective/ Departmental Elective (both UG and PG) courses to be offered in Spring Semester 2016-17	09.09.2016	Friday
19.	Notification to students regarding shortage of attendance by the Departments upto 08.09.2016	09.09.2016	Friday
	Id-ul-Zuha (Bakrid)*	**12.09.2016**	**Monday**
20.	Mid Term Examination (MTE) for all students	13.09.2016- 16.09.2016	Tuesday- Friday

S.No.	Details	Autumn Semester	
		Date	Day
21.	Last date to receive Institute Elective/ Open Elective / Departmental Elective (UG-PG) courses to be offered in Spring Semester from the departments	16.09.2016	Friday
22.	Notification to UG/IDD/IMT/IMS students about Institute Elective/ Open Elective/ Departmental Elective (UG-PG) courses to be offered in Spring semester 2016-17	22.09.2016	Thursday
23.	Last date for withdrawal of courses	23.09.2016	Friday
24.	Last date for requesting Second Examination	23.09.2016	Friday
25.	Intimation to parents/guardians in respect of students having short attendance & upload on website	23.09.2016	Friday
26.	**Annual Convocation 2016**	24.09.2016	Saturday
27.	Submission of remaining document(s) by all new students	30.09.2016	Friday
28.	Online subject registration for Institute Elective/ Open Elective/ Departmental Elective (UG-PG) courses by students for next semester	30.09.2016- 04.10.2016	Friday - Tuesday
	Mahatma Gandhi's Birthday	**02.10.2016**	**Sunday**
29.	Last date to display allotted list of Institute Electives/ Open Electives/ Departmental Electives to students for Spring Semester 2016-17	08.10.2016	Saturday
	Dusshera (Vijaya Dashmi)	**11.10.2016**	**Tuesday**
	Muharram*	**12.10.2016**	**Wednesday**
30.	Last date for Finalization and Display of Time Tables for Spring Semester 2016-17 by all Departments and sending to Academic Section	21.10.2016	Friday
	THOMSO 2016	21.10.2016 23.10.2016	Friday- Sunday
31.	Notification of End Term Examination schedule including seating plan (Institute Core and Elective Courses)	28.10.2016	Friday
	Diwali (Deepawali)	**30.10.2016**	**Sunday**
	Govardhan Puja	**31.10.2016**	**Monday**
	Bhai Duj	**01.11.2016**	**Tuesday**
32.	Ph.D. Interview	02.11.2016- 03.11.2016	Wednesday- Thursday
33.	Online filling of Response Forms and Subject Registration for next semester by all students	02.11.2016- 07.11.2016	Wednesday - Monday
34.	Evaluation of Final Year M.Tech./M.Arch./M.U.R.P. / M.Tech.(ES) /IDD/IMT Dissertation	02.11.2016- 21.11.2016	Wednesday- Monday
35.	Communication from Chairman, DAPC to Course Coordinators requesting to submit the final list of students having short attendance	03.11.2016	Thursday
36.	Online Application for Change of Branch during 2016-17 session by 1st year B. Tech./IMT/IMS students	03.11.2016- 10.11.2016	Thursday - Thursday

S.No.	Details	Autumn Semester	
		Date	Day
37.	Display of list of students having short attendance upto 07.11.2016 by the Departments/Centres and to send the Final list to Academic Section	08.11.2016	Tuesday
38.	Last date of Teaching	09.11.2016	Wednesday
39.	Notification of detained students due to shortage of attendance in End Term Exam by the Academic Section	09.11.2016	Wednesday
	Guru Nanak Birthday	**14.11.2016**	**Monday**
40.	End Term Examination (excluding Sunday) Practical examinations, if any, *may be held during last few laboratory days).*	11.11.2016-22.11.2016	Friday-Tuesday
41.	Notification to UG students regarding filling of Departmental Honour and Minor Specialization Courses	15.11.2016	Tuesday
42.	B.Tech. Project Evaluation Stage-1	23.11.2016 25.11.2016	Wednesday -Friday
43.	On-line filling of choices for DHC and MSC	23.11.2016-26.11.2016	Tuesday-Friday
44.	Last date of showing End Term Examination Answer Scripts to students	28.11.2015	Monday
45.	Finalization of grades by the Grade Moderation Committee	30.11.2016	Wednesday
46.	Display of grades for all courses by the Departments	30.11.2016	Wednesday
47.	Last date of sending grades to Academic Section	30.11.2016	Wednesday
48.	Last date to accept requests for Summer Internship at IITR	30.11.2016	Wednesday
49.	Last date to contact departments/centres for grade modification, if any, by students	02.12.2016	Friday
50.	Last date for sending modified grades to academic section	05.12.2016	Monday
51.	Winter vacation for students (except for M.Tech/ IDD final year and Ph.D. students)	03.12.2016-02.01.2017	Saturday - Monday
52.	Winter vacation for Teaching Faculty (Faculty members can avail total 65 days of vacation during the winter & summer breaks)	05.12.2016-02.01.2017	Monday - Monday
53.	Last date for applying for Re-Examination	09.12.2016	Friday
54.	Last date of preparation of Grade sheets	12.12.2016	Monday
	Id-e-Milad*	**13.12.2016**	**Tuesday**
55.	Notification regarding allotment DHC and MSC	17.12.2016	Friday
56.	Finalization of Change of Branch of 1st year B.Tech./ IMT/ IMS students for the session 2016-17	21.12.2016	Wednesday
	Christmas Day	**25.12.2016**	**Sunday**
57.	Reporting and Registration of new Ph.D. students	26.12.2016	Monday
58.	Last date to send the list of recommended candidates for Summer Internship at IITR	30.12.2016	Friday
59.	Institute Reopens for Spring Semester	03.01.2017	Tuesday
60.	Registration of all existing students in the Departments/ Centres	03.01.2017	Tuesday

S.No.	Details	Autumn Semester	
		Date	Day
61.	Re-examination and Second examination on medical ground (for Autumn Semester 2016-17)	04.01.2017-06.01.2017	Wednesday -Friday
62.	Commencement of Classes for all students for Spring Semester 2016-17	04.01.2017	Wednesday

*Subject to visibility of Moon.

Teaching days for Autumn Semester 2016-17 (w.e.f. 14.7.2016 to 09.11.2016)

Day	Months						
	July	August	September	October	November	Less for MTE/ THOMSO	Total days
Monday	18,25	1,8,22,29	5,19,26	3,10,17,24	7	-	14
Tuesday	19,26	2,9,16,23,30	6,**13**,20,27	4,18,25	8	**1**	14
Wednesday	20,27	3,10,17,24,31	7,**14**,21,28	5,19,26	2,9	**1**	15
Thursday	14,21,28	4,11,18	1,8,**15**,22,29	6,13,20,27	3	**1**	15
Friday	15,22,29	5,12,19,26	2,9,**16**,23,30	7,14,**21**,28	4	**2**	15
Total days	12	21	21	18	6	**5**	**78-5 =73**

Details of Saturday and Sunday used in MTE/THOMSO

MTE (September 13-16, 2016) - 13.09.2016 – Tuesday
14.09.2016 – Wednesday
15.09.2016 – Thursday
16.09.2016 – Friday

THOMSO (October 21-23, 2016) - 21.10.2016 – Friday
22.10.2016 – Saturday
23.10.2016 – Sunday

October 21, 2016 (Friday) – - **40** This will be a **Non-Teaching Working Day.**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
ACADEMIC CALENDAR FOR THE YEAR 2016-17
(Spring Semester)

S.No.	Details	Autumn Semester	
		Date	Day
1.	Reporting and Registration of New Ph.D. students.	26.12.2016	Monday
2.	Institute reopens and Registration of all new PG students	03.01.2017	Tuesday
3.	Registration of all existing students in the Departments/ Centres	03.01.2017	Tuesday
4.	Re-examination and Second examination on medical grounds (for Autumn Semester 2016-17)	04.01.2017 - 06.01.2017	Wednesday-Friday
5.	Commencement of Classes for Spring Semester	04.01.2017	Wednesday
6.	Online subject registration of all new Ph.D. students	09.01.2017-10.01.2017	Monday-Tuesday
7.	Last date for sending the grades of Re-examination	11.01.2017	Wednesday
8.	Submission of progress reports of the Ph.D. students to Academic Section by the Departments/Centres	16.01.2017	Monday
9.	Last date of Academic Registration	16.01.2017	Monday
10.	Uploading of roll lists of registered students	17.01.2017	Tuesday
11.	Last date of addition/deletion of courses	17.01.2017	Tuesday
12	Uploading of final course-wise roll lists of registered students	20.01.2017	Friday
13.	Finalization of Seminar and Dissertation topics of 1st year M.Tech./M.U.R.P./M. Arch. and IDD/IMT 4th year students	20.01.2017	Friday
	Republic Day	**26.01.2017**	**Thursday**
14.	Last date to finalize the list of candidates for Summer Internship at IITR	31.01.2017	Tuesday
15.	Notification of MTE Schedule	06.02.2017	Monday
16.	Notification to students regarding shortage of attendance by the Departments upto 16.02.2017	17.02.2017	Friday
17.	Mid Term Examination (MTE) for all students	20.02.2017-23.02.2017	Monday-Thursday
18.	Request to Departments to send list of Institute Elective/ Open Elective/ Departmental Elective (both UG and PG) courses to be offered in Autumn Semester 2017-18	27.02.2017	Monday
19.	Submission of remaining document(s) by all new students	27.02.2017	Monday
20.	**SCIENCE DAY**	**28.02.2017**	**Tuesday**
21.	Last date for withdrawal of courses	03.03.2017	Friday
22.	Last date for requesting Second Examination on medical ground	03.03.2017	Friday
23.	Intimation to parents/guardians in respect of students having short attendance & upload on website	03.03.2017	Friday
24.	Last date to receive Institute Elective/ Open Elective / Departmental Elective (UG-PG) courses to be offered in Autumn Semester from the departments	06.03.2017	Monday

S.No.	Details	Spring Semester	
		Date	Day
25.	Notification to UG/IDD/IMT/IMS students about Institute Elective/ Open Elective/ Departmental Elective (UG-PG) courses to be offered in Autumn Semester 2017-18	10.03.2017	Friday
	Holi	**13.03.2017**	**Monday**
26.	Online subject registration for Institute Elective/ Open Elective/ Departmental Elective (UG-PG) courses by students for next semester	14.03.2017-19.03.2017	Tuesday-Sunday
27.	Annual Hobbies Club Exhibition **SRISHTI - 2017**	18.03.2017-19.03.2017	Saturday – Sunday
28.	Last date to display allotted list of Institute Electives/ Open Electives/ Departmental Electives to students for Autumn Semester 2017-18	22.03.2017	Wednesday
29.	**COGNIZANCE – 2017**	24.03.2017-26.03.2017	Friday - Sunday
30.	Ph.D. Interview	30.03.2017-31.03.2017	Thursday-Friday
31.	Notification of End Term Examination Schedule including Seating Plan (Institute Core and Elective Courses)	31.03.2017	Friday
32.	Annual Sports Meet **SANGRAM - 2017**	01.04.2017-02.04.2017	Saturday-Sunday
33.	Notification to students regarding switching over from B.Tech. to IDD programme	03.04.2017	Monday
34.	Last date for Finalization of Time Tables by all Departments	04.04.2017	Tuesday
	Rama Navami	**05.04.2017**	**Wednesday**
	Mahavir Jayanti	**09.04.2017**	**Sunday**
35.	Seminar presentation of M.Tech. 1st Year	10.04.2017-13.04.2017	Monday – Thursday
36.	Online filling of Response Forms and Subject Registration for next semester by all students	10.04.2017-15.04.2017	Monday - Saturday
37.	Communication from Chairman, DAPC to Course Coordinators to submit the final list of students having short attendance	13.04.2017	Thursday
	Good Friday	**14.04.2017**	**Friday**
38.	Viva-Voce Examination for Major Project (Only for B. Tech. 4th year students)	17.04.2017-18.04.2017	Monday - Tuesday
39.	Display of list of students having short attendance upto 17.04.2017 by Departments/Centres and to send the Final list to Academic Section	18.04.2017	Tuesday
40.	Notification of detained students for shortage of attendance in End Term Examination by the Academic Section	19.04.2017	Wednesday

S.No.	Details	Spring Semester	
		Date	Day
41.	Submission of proficiency grades by all concerned Officers-in-Charges to Academic Section	21.04.2017	Friday
42.	Last date of Teaching	21.04.2017	Friday
43.	End Term Examination (excluding Sunday) Practical examinations, if any, *may be held during last few laboratory days*	22.04.2017-01.05.2017	Saturday - Monday
44.	Notification to UG students regarding filling of Departmental Honour and Minor Specialization Courses	24.04.2017	Monday
45.	Submission of Final Year M.Tech./ M. Arch./ M.U.R.P./ M.Tech. (ES)/ IDD/IMT Dissertation	01.05.2017 -05.05.2017	Monday - Friday
46.	On-line filling of choices for DHC and MSC	02.05.2017-06.05.2017	Monday-Friday
47.	Notification to PG students to switch over from M.Tech. to Ph.D. programme	02.05.2017	Monday
48.	Last date of showing of End Term Examination Answer Scripts to students	05.05.2017	Friday
49.	Finalization of grades by the Grade Moderation Committees	08.05.2017	Monday
50.	Display of Grades for all courses	08.05.2017	Monday
51.	Last date for sending Grades to Academic Section	08.05.2017	Monday
52.	Summer Vacation for Students (except for M.Tech./ IDD Final Year and Ph.D. students)	08.05.2017-13.07.2017	Monday - Thursday
53.	Evaluation of Final Year M.Tech./ M. Arch./ M.U.R.P./ M.Tech.(ES)/ IDD/IMT Dissertation and sending grades	08.05.2017-12.05.2017	Monday - Friday
54.	**Buddha Purnima**	**10.05.2017**	**Wednesday**
55.	Last date to contact Departments/Centres by students for grade modification, if any	11.05.2017	Thursday
56.	Last date for sending modified grades to Academic Section	12.05.2017	Friday
57.	Last date for applying for the re-examination of Spring Semester 2017-18	15.05.2017	Monday
58.	Summer Vacation for Teaching Faculty	15.05.2017-13.07.2017	Monday - Thursday
59.	Last date for preparation of Grade sheets (except for M.Tech./ M. Arch./ IDD Final Year students)	19.05.2017	Friday
60.	Notification regarding allotment of IDD programme and DHC and MSC	26.05.2017	Friday
61.	Declaration of result of switchover from M.Tech. to Ph.D.	31.05.2017	Thursday
62.	Last date for preparation of Grade sheets of Final Year M.Tech./ M. Arch/ IDD/IMT	05.06.2017	Monday

S.No.	Details	Spring Semester	
		Date	Day
63.	**Id-ul-Fiter***	**26.06.2017**	**Monday**
64.	Reporting and Registration of New Ph.D. students	07.07.2017	Friday
65.	Institute reopens and Registration of all New PG students	13.07.2017	Thursday
66.	Reporting and Registrations of all New UG/IMT/IMS students	13.07.2017	Thursday
67.	Registration of all existing students in the Departments/ Centres	14.07.2017	Friday
68.	Re-examination and Second examination on medical grounds (for Spring Semester 2016-17)	14.07.2017-15.07.2017	Friday - Saturday
69.	Commencement of Classes for Autumn Semester (2017-18)	17.07.2017	Monday

*Subject to change on visibility of moon.

Teaching days for Spring Semester 2016-17 (w.e.f. 04.1.2017 to 21.4.2017)

Day	Months					
	January	February	March	April	Less for MTE/Cogn.	Total days
Monday	9,16,23,30	6,13,**20**,27	6,20,27	3,10,17	1	13
Tuesday	10,17,24,31	7,14,**21**,28	7,14,21,28	4,11, 18	1	14
Wednesday	4,11,18,25	1,8,15,**22**	1,8,15,22,29	12,19	1	14
Thursday	5,12,19	2,9,16,**23**	2,9,16,23,30	6,13 ,20	1	14
Friday	6,13,20,27	3,10,17,24	3,10,17,**24**,31	7,21	1	14
Total days	19	20	22	13	4	74-5 = 69

Details of days used in MTE and COGNIZANCE

MTE (February 20- 23, 2017) - 20.02.2017 – Monday
21.02.2017 –Tuesday
22.02.2017 – Wednesday
23.02.2017 – Thursday

COGNIZANCE (March 24-26, 2017) - 24.03.2017 – Friday
25.03.2017 – Saturday
26.03.2017 – Sunday

COGNIZANCE (March 24, Friday) - This will be a **Non-Teaching working day**

NOTE:

1. The committee also discussed the various events being organized throughout the year and recommended that only the following students' events be organized in an academic session:
    1. Cultural Festival - THOMSO
    2. Technical Festival - COGNIZANCE
    3. Hobbies Club Annual Function - SRISHTI
    4. Annual Sports Meet - SANGRAM

2. It was also decided that any poster related to above activities be put/ displayed only one week prior to the start of the activity with due approval from DOSW.

बैठक अनुभाग
भारतीय प्रौद्योगिकी संस्थान रुड़की
MEETING SECTION
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Minutes of the 52nd Meeting of the Executive Committee of the Senate (ECS) held on 10.03.2016 at 12.00 Noon in the Committee Room of the Institute.

The following were present:

1.	Director	Prof. Pradipta Banerji
2.	Deputy Director	Prof. Vinod Kumar
3.	Deans	
	(a) Academics	Prof. Pramod Agarwal
	(b) Alumni Affairs & International Relations	Prof. Sandeep Singh
	(c) Faculty Affairs	Prof. Deepak Kashyap
	(d) SRIC	Prof. M. Parida
	(e) Students' Welfare	Prof. D.K. Nauriyal
	(f) Associate Dean Academic Studies	Dr. A.K. Sharma
4.	Heads of the Departments	
	(a) Architecture & Planning	Prof. Ila Gupta
	(b) Biotechnology	Dr. Partha Roy
	(c) Chemistry	Prof. M.R. Maurya
	(d) Civil Engineering	Prof. C.S.P. Ojha
	(e) Computer Science & Engg.	Prof. Manoj Misra
	(f) Earthquake Engineering	Prof. Y. Singh
	(g) Earth Sciences	Prof. Anand Joshi
	(h) Electrical Engineering	Prof. S.P. Srivastava
	(i) Electronics & Communication	Prof. Debashis Ghosh
	(j) Humanities & Social Sciences	Prof. Rashmi Gaur
	(k) Hydrology	Prof. D.S. Arya
	(l) Mathematics	Prof. V. K. Katiyar
	(m) Mechanical & Industrial Engineering	Prof. Dinesh Kumar
	(n) Metallurgical & Materials Engineering	Prof. Anjan Sil
	(o) Management	Dr. Vinay Sharma
	(p) Paper Technology	Prof. Y.S. Negi
	(q) Physics	Prof. Rajesh Srivastava
	(r) WRD&M	Prof. S.K. Mishra

5. Heads of the Academic/Service Centres/ Centres of Excellence

(a)	Alternate Hydro Energy Centre	Prof. M.P. Sharma
(b)	Continuing Education Centre	Prof. B.K. Gandhi
(c)	Nano Technology	Prof. S.K. Nath
(d)	Disaster Mitigation & Management	Prof. B.K. Maheshwari
(e)	Institute Computer Centre	Dr. R. Balasubramanian

6. Chairman, Library Advisory Committee	Prof. Praveen Kumar
7. Chairman, JEE	Dr. Rajat Rastogi
8. Coordinator, QIP	Prof. B.K. Gandhi
9. Registrar (Secretary, ECS)	Mr. Prashant Garg

The issues at hand were then taken up:

Item No. 52.1: **To consider the letter of Chairman, JAB-2016 to**

1. **Explore the possibilities of filling the vacant seat of an academic year in the next academic year**
2. **Reducing the seats from the academic programmes that are not high in demand.**

The Committee considered the letter of Chairman JAB-2016 and the recommendations of the 47th meeting of the IAPC held on 11th February 2016 and decided that the number of seats in each UG programme be modified as per table given at **Appendix 'A'**. The modified seats will be applicable with effect from 2016-17 session.

Item No. 52.2: **To consider the following options for those PG programmes where the percentage of placement offers is low:**

(i) Reducing the number of intakes
(ii) Revising the structure completely for better employability
(iii) Merger of few PG Programmes
(iv) Closer of PG Programmes

The Committee considered the options proposed for PG programmes where the percentage of placement is low and observed that some of the PG programmes are too specialized and, therefore, the employment opportunities for the graduates of these programmes some time became less. After discussion, it was decided that the departments may look into their PG programmes and propose the modifications in light of discussion.

It was also decided that the proposed modification will be considered in the Senate meeting likely to be held in July 2016. It was also emphasized that while framing the structure and syllabi of the modified courses, the level of course be kept such that the graduates are directly absorbed in industries. Departments may also indicate such industries while sending their proposal. The modified PG structure programme will be implemented from 2017-18 session.

Item No. 52.3: **To identify the key users from each of the Departments/Centres/Sections/Units etc. for the purpose of training related to ERP.**

The Director briefed the members about the ERP Project named Advaita which was launched on 21st September 2015. Its 'As-Is' and 'To-be' processes have been completed and Wave-I of the project will start in May 2016. For the purpose of imparting training, nominations be invited of 'Key Users' to look into core-issue related to ERP. The nominations should be of people who would be directly related to processes in the Departments/Centres/Units. They should be from the faculty, technical and non-technical staff who have at least 2 – 3 years remaining service.

Item No. 52.4: **To consider follow up action for preparing the structure of 2-year M.Tech. (Polymer Science) courses as decided by the Senate.**

The Director conveyed all Head of the Departments about displeasure for not following the decision of the Senate. He stated that all faculty members/ officers and employees of the Institute must deliver and fulfill the requirements of the Institute besides the routine jobs and responsibilities.

If, anyone fails or refuses the Institute's work, it will be considered violation of 'Code of Conduct' and invites disciplinary action against him/her.

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

TABLE

Code	Programme	Approved Seats for 2016-17					
		GE	OBC	SC	ST	PD	Total
1	2	3	4	5	6	7	8
R4-4104	BIOTECH	17	10	5	3	OB-1	35
R4-4107	CHEMICAL	56	30	16	8	G-1 OB-1 SC-1	110
R4-4109	CIVIL	61	32	18	9	G-2 OB-1 ST-1	120
R4-4110	CSE	38	20	11	6	G-1 SC-1	75
R4-4111	ELECTRICAL	61	32	18	9	G-2 OB-1 ST-1	120
R4-4114	E&CE	40	22	12	6	G-1 SC-1	80
R5-4117	ENG. PHYSICS	15	8	5	2	G-1	30
R4-4125	MECHANICAL	50	27	15	8	G-2 SC-1	100
R4-4127	MMED	50	27	15	8	G-2 SC-1	100
R4-4135	PSE	18	9	5	3	OB-1	35
R4-4136	P & I	20	11	6	3	OB-1	40
R5-5101	ARCH.	18	9	5	3	G-1	35
R5-5302	IMT-GT	15	8	5	2	G-1	30
R5-5303	IMT-GPT	15	8	5	2	OB-1	30
R5-5502	IMS-APM	15	8	5	2	G-1	30
	TOTAL	489	261	146	74	29	970

S.	Name	Deptt.	Topic	Supervisor	Examiner (For./Ind.)	PDC Date
1	Mr. Anurag Chauhan	AHEC	EVOLVING OPTIMAL INTEGRATED RENEWABLE ENERGY SYSTEM MODEL FOR STAND-ALONE APPLICATIONS	Dr. R. P. Saini	Prof. M.H. Nehrir / USA Dr. S. Bandyopadhyay / IIT Bombay Dr. Ashok S. / NIT Calicut	18.03.16
2	Mr. Mukesh Kumar Singhal	AHEC	OPTIMUM PLANNING OF MEDIUM HEAD HYDRO POWER PROJECTS	Dr. Arun Kumar	Prof. Robert Boes / Switzerland Dr. O. P. Rahi / NIT Hamirpur	04.04.16
3	Ms. Aanchal Sharma	AR	ENERGY EFFICIENT RETROFIT MODEL FOR ENGINEERING CAMPUSES IN INDIAN COMPOSITE CLIMATE	Dr. S. Y. Kulkarni Dr. P. S. Chani	Prof. K. Orehouning / Switzerland Prof. J. Mathur / MNIT Jaipur	22.03.16
4	Mr. Pawan Rekha	ASE	CYCLOPHOSPHAZENE BASED NANOPOROUS HYBRID MATERIALS FOR ENVIRONMENTAL APPLICATIONS	Dr. Paritosh Mohanty	Prof. Umapada Pal / Mexico Dr. Debabrata Pradhan / IITKh Dr. B. Mandal / IITG	24.02.16
5	Mr. Rajeev Kumar Arya	ASE	IMPLEMENTATION OF ROUTING PROTOCOL WITH SOFT COMPUTING METHODS IN WIRELESS SENSOR NETWORK	Dr. S. C. Sharma	Prof. Maaruf Ali / UK Dr. B. Suman / DRDO Dehradun Prof. Majid Jamil / JMI, Delhi	22.03.16
6	Ms. Akansha Tyagi - 50	BM	STRESS AND ITS EFFECT ON PSYCHOLOGICAL HEALTH MODERATING ROLE OF EMOTIONAL INTELLIGENCE	Dr. R. L. Dhar	Prof. S. Bruce Thomson / Canada Dr. P. Purang / IIT Bombay Dr. Sameer Pingle / Ahmedabad	09.02.16
7	Mr. Bhajan Lal	BM	JOB SATISAFCTION AND ORGANISATIONAL COMMITMENT AS PREDICTORS OF HUMAN CAPITAL CREATION	Dr. S. Rangnekar	Prof. Namjae Cho / Korea Prof. Geetika / MNIT Allahabad	22.02.16
8	Mr. Utkarsh Goel	BM	WORKING CAPITAL MANAGEMENT EFFICIENCY IN INDIA: AN EMPIRICAL ANALYSIS	Dr. A. K. Sharma	Prof. Birendra K. Mishra / USA Prof. A. K. Jain / IITD	17.02.16
9	Ms. Bindu Singh	BM	EFFECTS OF INTELLECTUAL CAPITAL ON PERFORMANCE: EXAMININ THE ROLE OF MEDIATORS	Dr. M. K. Rao	Dr. PDD Dominic / Malaysia Prof. Sasmita Palo / TISS Mumbai Dr. V.J.S. kumar / NIT Tiruchinapalli	23.02.16
10	Ms. Pratibha Verma	BM	PREDICTORS AND OUTCOMES OF CREATIVITY COMPONENTS: A STUDY IN INDIAN PSUs	Dr. M. K. Rao	Prof. Edyta Rudawska / Poland Dr. V.J.S. kumar / NIT Tiruchinapalli Prof. Sasmita Palo / TISS Mumbai	07.03.16
11	Ms. Pooja Kushwaha	BM	EXAMINING THE INFLUENCE OF KNOWLEDGE ELEMENTS ON INDIVIDUAL COMPETENCE	Dr. M. K. Rao	Prof. Jie Shen / China Dr. R. Baral / IIT Madras Prof. Meenakshi Gupta / IIT Bombay	31.03.16
12	Ms. Rashmi Singh	BM	COMPULSIVE BUYING & POST PURCHASE REGRET: FAMILIAL & NON-FAMILIAL STRESSORS	Dr. J. K. Nayak	Prof. Richard A. Posthuma / Texas Dr. Madhurima Deb / IIM Kashipur Dr. K. Das, XIM Bhubaneshwar	04.04.16
13	Ms. Rekha Sharma	BT	MOLECULAR AND BIOCHEMICAL STUDIES OF PROBIOTIC PROPERTIES OF *Lactobacillus fermentum* NKN51	Dr. N. K. Navani	Prof. Arun K. Bhunia / USA Dr. A. K. Mohanty / NDRI Karnal Prof. B.S. Chadha / GNDU Amritsar	09.02.16

Appendix 'D'
Item No. Senate/64.15

14	Ms. Sweta Tripathi	BT	INTERACTION OF LUTEOLIN AND MITOXANTRONE WITH G-QUADRUPLEX DNA SEQUENCES	Dr. Ritu Barthwal	Prof. M. W. Germann / Georgia Dr. G. S. Kumar / CSIR Kolkata	01.02.16
15	Ms. Priya Vashisth	BT	DESIGNING OF GELLAN BASED ELECTROSPUN NANOFIBERS FOR BIOMEDICAL APPLICATIONS	Dr. Vikas Pruthi Dr. R. P. Singh	Prof. Pietro Matricardi / Roma Dr. B. Mishra / BHU Varanasi	27.01.16
16	Ms. Manju Narwal	BT	FUNCTIONAL CHARACTERIZATION OF ALPHAVIRAL PROTEINS INVOLVED IN REPLICATION	Dr. Shailly Tomar	Prof. R. Padmanabhan / USA Prof. Savita Yadav / AIIMS Delhi	07.03.16
17	Mr. Gulab Khushalrao Pathe	CY	DESIGN, SYNTHESIS AND ESTROGEN RECEPTOR BINDING STUDY OF FLAVONE AND INDANONE BASED LIGANDS	Dr. Naseem Ahmed	Prof. Saeed R. Khan / USA Prof. M. L. N. Rao / IITK Prof. Faiz Ahmed Khan / IITH	27.01.16
18	Mr. Himanshu Gupta	CY	DETERMINATION, DEGRADATION AND REMOVAL OF POLYCYCLIC AROMATIC HYDROCARBONS	Dr. Bina Gupta	Prof. Eric Lichtfouse / France Prof. M. Muneer / AMU Aligarh Prof. Alok Mittal / MNIT Bhopal	25.01.16
19	Mr. Vinod	CY	ENANTIOSEPARATION OF CERTAIN PHARMACEUTICALS BY LIQUID CHROMATOGRAPHY	Dr. Ravi Bhushan	Prof. Danica Agbaba / Serbia Prof. Ajai Kumar Singh / IITD Prof. K. N. Singh / BHU Varanasi	19.02.16
20	Mr. Sudhir Kumar Shoora	CY	STUDIES ON SOME CHEMICAL SENSORS FOR BIOMOLECULES AND TOXIC METALS	Dr. V. K. Gupta Dr. A. K. Singh	Prof. B. J. Sanghvi / USA Prof. R.K. Mahajan /GNDU Amritsar Dr. K. P. Singh / CSIR Lucknow	08.03.16
21	Ms. Jyoti Singh Tomar	CY	UNCONVENTIONAL PROTEIN TARGETS OF MULTI DRUG RESISTANT *ACENATOBACTER*	Dr. R. K. Peddinti	Prof. David B. Neau / USA Dr. Savita Yadav / AIIMS Delhi	21.03.16
22	Mr. Sanotsh Kumar Reddy P	CY	OXIDATIVE C-C, C-S AND S-N COUPLINGS: SYNTHESIS OF ARYL SULFIDES, BIARYLS AND SULFONAMIDES	Dr. R. K. Peddinti	Prof. Janine Cossy / Farance Prof. I.N.N. Namboothiri / IIT Bombay Prof. G. Sekar / IIT Madras	31.03.16
23	Ms. Sudipti Arora	CE	PERFORMANCE EVALUATION AND MICROBIAL COMMUNITY DYNAMICS OF VERMIFILTRATION	Dr. A. A. Kazmi	Prof. Fyyaz Ali Memon / UK Prof. M. M. Ghangrekar / IITKh	11.01.16
24	Ms. Meena Kumari Sharma	CE	INTEGRATED SETTLER AND ANAEROBIC FILTER BASED ONSITE SEWAGE TREATMENT SYSTEMS	Dr. A. A. Kazmi	Prof. Masafumi Fujita / Japan Prof. A. K. Gupta / IITKh Prof. Mohammad Jawed / IITG	02.02.16
25	Ms. Satavalekar Rupali Sanjay	CE	MESHFREE MODELLING OF CONTAMINANT MIGRATION	Dr. V. A. Sawant	Prof. Krishna R. Reddy / USA Prof. G. R. Dodagoudar / IITM	29.01.16
26	Mr. V. V. Govind Kumar	CE	KNOWLEDGE BASE SYSTEM FOR CLOUDBURST DAMAGE ZONATION WITHIN A GIS ENVIRONMENT	Dr. Kamal Jain Dr. Ajay Gairola	Prof. Xuan Zhu / Australia Prof. U. C. Mohanty, IITBhu Dr. Bhoop Singh / NRDMS Delhi	11.02.16
27	Mr. Medalson Ronghang	CE	EFFICACY OF RIVERBANK FILTRATION IN HILLY AREA	Dr. Indu Mehrotra Dr. Pradeep Kumar Dr. Thomas Grischek	Prof. Chittaranjan Ray / USA Prof. M. M. Ghangrekar / IITKh Prof. Ligy Philip / IITM	14.01.16

28	Mr. John Robert Prince M.	CE	BOND BEHAVIOUR BETWEEN RECYCLED AGGREGATE CONCRETE AND DEFORMED STEEL BARS	Dr. Bhupendra Singh	Prof. B. Vijaya Rangan / Austria Prof. Ravindra Gettu / IITM	16.02.16
29	Mr. Asif Hussain Shah	CE	AN EXPERIMENTAL INVESTIGATION OF FIRE PERFORMANCE OF EARTHQUAKE DAMAGED STRUCTURES	Dr. U. K. Sharma	Prof. Faris Ali / UK Dr. S. Ghosh / IIT Bombay Prof. Sudhirkumar Barai / IITKh	15.02.16
30	Mr. Ritu Raj	CE	EFFECTS OF CROSS-SECTIONAL SHAPES ON RESPONSE OF TALL BUILDINGS UNDER WIND LOADS	Dr. A. K. Ahuja	Prof. R. Panneer Selvam / USA Dr. Rajeev Gupta / IITK Dr. Rajeev K. Garg / CRRI Delhi	29.02.16
31	Mr. Rakesh Pratap Singh	CE	CONSOLIDATION INDUCED SOLUTE TRANSPORT THROUGH CLAY DEPOSITS	Dr. Mahendra Singh Dr. C. S. P. Ojha	Prof. Ronny Berndtsson / Sweden Prof. Rajesh Srivastava / IIT Kanpur	28.03.16
32	Mr. Krishna Kishore Garg	CH	ELECTROCHEMICAL TREATMENT OF SYNTHETIC PURIFIED TEREPHTHALIC ACID WASTEWATER	Dr. B. Prasad	Prof. Rueyan Doong / Taiwan Dr. Anurag Garg / IIT Bombay Dr. S. V. Mohan / CSIR Hyderabad	11.04.16
33	Mr. Mohammad Mardani Nokandeh	CE	ESTIMATION OF CAPACITY FOR SINGLE, INTERMEDIATE AND TWO-LANE INTER-URBAN ROADS	Dr. Indrajit Ghosh	Prof. Peter T. Savolainen / USA Dr. Sudip K. Roy / IIEST Shibpur	01.04.16
34	Mr. Anurag Aeron	DMC	WEB BASED SPATIAL DECISION SUPPORT SYSTEM FOR FLOOD DISASTER MITIGATION	Dr. R. D. Garg Dr. D. S. Arya Dr. S. P. Aggarwal	Dr. K. Prasad Vadrevu / USA Dr. B. Sahoo / IIT Kharagpur Prof. R. D. Gupta / MNIT Allahabad	14.03.16
35	Ms. Niyati Baliyan	CSE	QUALITY ASSESSMENT OF SEMANTIC WEB BASED APPLICATIONS	Dr. Sandeep Kumar	Prof. Lorna Uden / UK Dr. D. Samanta / IITKh Dr. Lalit K. Singh / AED Mumbai	27.01.16
36	Mr. Shitala Prasad	CSE	MOBILE VISION SYSTEM FOR PLANT LEAF ANALYSIS	Dr. P. Sateesh K. Dr. D. Ghosh	Prof. Izzet Kale / UK Prof. I. Chakrabarti / IIT Kharagpur	02.03.16
37	Mr. Aurobinda Panda	EE	IMPROVED POWER CONVERTER FOR DISTRIBUTED PHOTOVOLTAIC GENERATION SYSTEM	Dr. M. K. Pathak Dr. S. P. Srivastava	Prof. Ned Mohan/USA Prof. D. Thukaram/ IISc Bangalore	15.01.16
38	Mr. Venkata Ramana Naik	EE	INVESTIGATIONS ON DIRECT TORQUE CONTROL OF INDUCTION MOTOR DRIVE	Dr. S. P. Singh	Prof. A.K.S. Bhat / Canada Prof. Bhim Singh / IITD	04.02.16
39	Mr. Poddar Monappa Gundappa	EE	HEART RATE VARIABILITY ANALYSIS AND CLASSIFICATION	Dr. Vinod Kumar Dr. Y. Paul Sharma	Prof. Peter Macfarlane / UK Prof. S. Dandapat / IITG	18.02.16
40	Mr. Pratul Arvind	EE	DETECTION, IDENTIFICATION AND LOCATION OF FAULTS IN DISTRIBUTION SYSTEM	Dr. R. P. Maheshwari	Prof. O.P. Malik / Canada Dr. Nilanjan Senroy / IITD	16.02.16
41	Mr. Nandkishor Wasudeorao Kinhekar	EE	DEMAND SIDE MANAGEMENT USING SMART GRID TECHNOLOGY	Dr. N. P. Padhy Dr. H. O. Gupta	Prof. J.W. Maramgon Lima / Brazil Dr. B. K. Panigrahi / IITD Dr. Sukumar Mishra / IITD	11.02.16
42	Mr. Yadav Arvindkumar Ramrekha	EE	CLASSIFICATION OF HARDWOOD SPECIES USING MULTIRESOLUTION FEATURE EXTRACTION TECHNIQUES	Dr. R. S. Anand Dr. M. L. Dewal Dr. Sangeeta Gupta	Prof. R.M. Rangayyan / Canada Prof. K. K. Biswas / IIT Delhi	04.03.16

43	Mr. Ajay Khunteta	E&CE	APPLICATION OF FUZZY LOGIC AND PSO IN SOME IMAGE PROCESSING AND ANALYSIS METHODS	Dr. D. Ghosh	Prof. Shahram Latifi / USA Prof. M. Hanmandlu / IITD	17.02.16
44	Mr. Pankaj Kumar Pal	E&CE	DUAL-k SPACER ENGINEERD DEVICES FOR HIGH PERFORMANCE DIGITAL CIRCUIT/SRAM APPLICATIONS	Dr. S. Dasgupta Dr. B. K. Kaushik	Prof. Niraj K. Jha / USA Dr. M. Gupta / DU, Delhi	29.02.16
45	Mr. Ranjay Hazra	E&CE	PERFORMANCE ANALYSIS OF NON-COHERENT IR-UWB COOPERATIVE COMMUNICATION SYSTEM	Dr. Anshul Tyagi	Prof. K. S. Kwak / Korea Dr. A. K. Chaturvedi / IIT Kharagpur Dr. S. N. Marchant / IIT Bombay	07.03.16
46	Mr. Ramesh K. Vobulapuram	E&CE	MODELING OF CROSSTALK EFFECTS IN CMOS GATE DRIVEN ON-CHIP INTERCONNECTS USING FDTD TECHNIQUE	Dr. B. K. Kaushik Dr. A. Patnik	Prof. EbyG. Friedman / New York Prof. Roy P. Paily / IIT Guwahati Prof. S. Jit / BHU Varansi	02.03.16
47	Mr. Ashwani Raju	ES	REMOTE SENSING BASED COAL FIRE STUDIES IN JHARIA COALFIELD, INDIA	Dr. Pitamber Pati	Prof. Wolfgang Wagner / Austria Dr. R. S. Chatterjee / IIRS Dehradun Dr. Arindam Guha / NRS Hyderabad	09.03.16
48	Mr. Chandra Sekhar Padhi	HY	OPTIMAL LARGE SCALE WATER TRANSFERS IN SPACE AND TIME	Dr. D. K. Srivastava	Prof. Ramesh Teegavarapu / USA Dr. Arup Kumar Sarma / IITG	15.02.16
49	Mr. Mahendra Kumar Choudhary	HY	OPTIMAL PLANNING AND OPERATION OF A WATER TRANSFER LINK	Dr. D. K. Srivastava Dr. Sunita Devi	Prof. Vijay P. Singh / USA Dr. Arup Kumar Sarma / IITG	15.02.16
50	Mr. Kamlesh Kumar	MA	MARKOVIAN QUEUEING MODELS FOR REPAIRABLE REDUNDANT SYSTEM WITH UNRELIABLE SERVERS	Dr. Madhu Jain	Prof. Kuo-Hsiung Wang / Taiwan Prof. U. C. Gupta / IITG	14.01.16
51	Ms. Renu Saini	MA	TRANSVERSE VIBRATION OF SOME NON-HOMOGENEOUS RECTANGULAR PLATES	Dr. Roshan Lal	Prof. Liew Kim Meow / Hong Kong Dr. S. C. Pradhan / IITKh	25.01.16
52	Ms. Minakshi	MA	FINITE ELEMENT STUDY OF TRANSPORT PHENOMENA IN COMPLEX FLUIDS	Dr. Rama Bhargava	Prof. Jinho Lee / South Korea Dr. Amiya Kumar Pani /IITB Prof. S. K. Tomar / PU Chandigarh	24.02.16
53	Mr. Binod Kumar Singh	MA	COMPARATIVE STUDY OF SOME ALGORITHMS FOR IMAGE RECONSTRUCTION	Dr. Tanuja Srivastava	Prof. Nipon Theera-Umpon / Thiland Dr. R. K. S. Rathore / IIT Kanpur	28.03.16
54	Mr. Subhas Khajanchi	MA	MATHEMATICAL MODELING OF MALIGNANT BRAIN TUMOR WITH T11 TARGET STRUCTURE	Dr. Sandip Banerjee	Prof. Hien Tran / Releigh Dr. Ram Rup Sarkar / NCL Pune Dr. S. P. Chakrabarty / IIT Guwahati	04.03.16
55	Mr. Divyesh Patel	MA	RECONSTRUCTION ALGORITHMS BASED ON SIMULATED ANNEALING IN DISCRETE TOMOGRAPHY	Dr. Tanuja Srivastava	Dr. Sanghyuk Lee / China Dr. C.Muralidhar /DRDL Hyderabad Dr. Prabhat Munshi / IIT Kanpur	24.02.16
56	Ms. Manisha Verma	MA	NEW FEATURE DESCRIPTORS FOR IMAGE RETRIEVAL, OBJECT TRACKING AND SHOT DETECTION	Dr. R. Balasubramanian	Prof. D. Hatzinakos / Canada Prof. S. Agarwal / MNNIT Allahabad	11.04.16

57	Mr. Temesgen Berhanu Yallew	MIE	CHARACTERIZATION AND MACHINABILITY STUDY OF NATURAL FIBER REINFORCED COMPOSITES	Dr. Pradeep Kumar Dr. Inderdeep Singh	Prof. J. Paulo Davim / Portugal Prof. Kamal K. Kar / IITK Dr. Somashekhar S. Hiremath / IITM	22.02.16
58	Mr. Bhupendra Singh	MIE	CHARACTERIZATION OF WAKE AND SUPPRESSION OF FLUID FORCES ACTING ON A ROW OF SQUARE CYLINDERS	Dr. S. Dutta Dr. B. K. Gandhi	Prof. Muammer Ozgoren / Turkey Prof. P. K. Panigrahi / IIT Kanpur Dr. Atul Sharma / IIT Bombay	16.03.16
59	Mr. Saurabh Kumar Yadav	MIE	A STUDY ON THE LUBRICATION OF HYDROSTATIC THRUST PAD BEARINGS	Dr. S. C. Sharma	Prof. Michel Fillon / France Dr. K. P. Nair / NIT Calicut Dr. R. K. Pandey / IIT Delhi	08.03.16
60	Mr. Pankaj Kumar Gupta	MIE	INVESTIGATIONS ON ECDM FOR SUBTRACTIVE MICRO-FABRICATION ON GLASS	Dr. Akshay Dvivedi Dr. Pradeep Kumar	Prof. P. Yarlagadda / Australia Dr. V. Yadava / MNNIT Allahabad	02.03.16
61	Mr. Rajesh Choudhary	MIE	STUDY OF NATURAL CONVECTION HEAT TRANSFER IN AL_2O_3/WATER NANOFLUIDS	Dr. S. Subudhi	Prof. Sushanta K. Mitra / Canada Dr. A. Dalal / IIT Guwahati Dr. K. C. Sahu / IIT Hyderabad	25.02.16
62	Mr. Ashutosh	MIE	MODELING OF RECONFIGURABLE MANUFACTURING SYSTEM WITH AVAILABILITY CONSIDERATION	Dr. Dinesh Kumar Dr. P. K. Jain	Prof. S. Nahavandi / Australia Dr. S. Sahu / IIT Bhubneshwar Dr. Ravi Shankar / IIT Delhi	21.03.16
63	Mr. Harak Sachin Sudhakar	MIE	DYNAMICS OF DRAFT GEAR FOR FREIGHT STOCK VEHICLE	Dr. S. C. Sharma Dr. S. P. Harsha	Prof. C. Nataraj / USA Dr. N. S. Vyas / IIT Kanpur	05.04.16
64	Ms. Preeti Joshi	MIE	MULTIWALLED CARBON NANOTUBE COMPOSITES AND THEIR MECHANICAL BEHAVIOR	Dr. S. H. Upadhyay	Prof. Sondipon Adhikari / UK Dr. B. B. Khatua / IIT Kharagpur Dr. Satish Chandra Jain / IIT Mandi	03.03.16
65	Mr. Gagandeep Bhardwaj	MIE	FATIGUE CRACK GROWTH SIMULATIONS USING EXTENDED ISOGEOMETRIC ANALYSIS	Dr. I. V. Singh	Prof. Timon Rabczuk / Germany Prof. B. N. Rao / IIT Madras Dr. D. K. Sehgal / IIT Delhi	11.04.16
66	Mr. Sanjay Singh Rathore	MME	PROCESSING AND PROPERTIES OF SINTER-FORGED Fe-2Cu-0.7C-xMo ALLOYS	Dr. V. V. Dabhade	Prof. Wojiech Misiolek / Bethlehem Dr. G. Appa Rao / MD Hyderabad Dr. M. Karanjal / CNM Hyderabad	21.01.16
67	Mr. Tilak Chandra Joshi	MME	PROCESSING AND PROPERTIES OF Y_2O_3 REINFORCED AL-7075 COMPOSITES BY POWDER FORGING	Dr. V. V. Dabhade Dr. Ujjwal Prakash	Prof. K. K. Shankar / Australia Dr. Rajesh Prasad / IITD	17.02.16
68	Mr. Bharat Bhushan	NT	DEVELOPMENT OF ALBUMIN BASED NANOPARTICLES FOR BIOMEDICAL APPLICATIONS	Dr. P. Gopinath	Prof. Yuzuru Takamura / Japan Dr. B. Bose / IIT Guwahati Prof. R. J. Kumar / AIMSRCC Kerla	11.03.16
69	Mr. Umesh Kumar Gaur	NT	SYNTHESIS OF PURE AND DOPED CuO NANOSTRUCTURES AND THEIR MULTIFUNCTIONAL PROPERTIES	Dr. G. D. Verma Dr. Anil Kumar	Prof. M. Willander / Sweden Prof. Hitendra K. Malik / IIT Delhi Prof. K. Sethupathi / IIT Madras	08.04.16
70	Mr. Girish Semwal	PH	DESIGN OF LONG PERIOD WAVEGUIDE GRATING DEVICES USING NATURAL OPTIMIZATION ALGORITHMS	Dr. Vipul Rastogi	Prof. Pascal Baldi / France Prof. Arun Kumar / IITD	25.02.16

71	Mr. K. Thirupathaiah	PH	MULTIBAND PHOTONIC INTEGRATED CIRCUITS USING PLASMONIC MIM WAVEGUIDE	Dr. Vipul Rastogi Dr. N. P. Pathak	Prof. Ke Wu / Canada Prof. Vishnu Priye / ISM Dhanbad Prof. R.K. Sinha / CSIR Chandigarh	29.02.16
72	Ms. Stuti Rani	PH	STURUCTURAL OPTICAL AND MAGNETIC PROPERTIES OF SPINEL OXIDE NANOPARTICLES	Dr. G. D. Verma	Prof. M. S. Seehra / USA Prof. Sujeet Chaudhary / IIT Delhi Prof. A. V. Sather / GU Goa	02.03.16
73	Mr. Harish Sharma Akkera	PH	SYNTHESIS AND CHARACTERIZATION OF NI-MN-X (X: IN, SB) FSMA THIN FILMS	Dr. Davinder Kaur Dr. Inderdeep Singh	Prof. Jean Pivin / France Prof. Chiranjib Mitra / IISER Kolkata	11.03.16
74	Ms. Lata Thakur	PH	ANISOTROPIC QUARK GLUON PLASMA: DISSOCIATION OF QUARKONIUM STATES	Dr. B. K. Patra	Prof. Sangyong Jeon / Canada Dr. H. Mishra / PRL Ahmedabad	18.03.16
75	Ms. Navjot Kaur	PH	TERNARY NiTi BASED SHAPE MEMORY ALLOY THIN FILMS	Dr. Davinder Kaur	Prof. Claus Robholz / Cyprus Prof. Sujeet Chaudhary / IIT Delhi	02.03.16
76	Ms. Dipti	PH	STUDY OF ATOMIC COLLISION PROCESSES AND PLASMA MODELING	Dr. Rajesh Srivastava	Dr. Yuri Ralchenko / USA Dr. Bobby Antony / ISM Dhanbad Dr. B.K. Sahoo / PRL Ahmedabad	17.03.16
77	Mr. Jogi Ganesh Dattatreya Tadimeti	PPE	ION TRANSPORT AND ITS FACILITATION IN ELECTRODIALYSIS	Dr. Pushplata	Prof. Tongwen Xu / China Dr. S. Sridhar / CSIR Hyderabad Dr. P. K. Bhattacharya / IITK	12.02.16
78	Ms. Shilpa Kulkarni	PT	STUDIES ON DEINKING PROCESS AND UTILIZATION OF DEINKING SLUDGE	Dr. Vivek Kumar Dr. M. C. Bansal	Prof. M. Bin Ismail / Malaysia Prof. R.Subramanian / PIA Bangalore	29.03.16
79	Mr. Kailash Bishnoi	WRDM	AN ANALYTICAL STUDY ON RIVERBED AND RIVERBANK FILTRATION	Dr. M. L. Kansal	Prof. Thomas Grischek / Germany Prof. M. Sekhar / IISc Bangalore	25.01.16
80	Mr. Surendra Kumar Chandniha	WRDM	WATERSHED SUSTAINABILITY INDEX FRAMEWORK AND ITS ESTIMATION FOR A WATERSHED	Dr. M. L. Kansal Dr. Aditya Tyagi	Prof. V. Sridhar / USA Prof. C. Chatterjee / IIT Kharagpur	11.03.16
81	Mr. Rituraj Shukla	WRDM	IMPACT OF CLIMATE AND LANDUSE CHANGES ON GROUNDWATER IN A CANAL COMMAND	Dr. Deepak Khare	Dr. Qin Xiaosheng / Singapore Prof. K. N. Tiwari / IIT Kharagpur Prof. Rohit Goyal / MNIT Jaipur	02.04.16
82	Mr. Manoj Kumar Sahani	CY	SYNTHESIS OF CHELATING IONOPHORES AND THEIR ELECTROANALYTICAL STUDIES AS CHEMICAL SENSORS	Dr. A. K. Singh Dr. A. K. Jain	Prof. J.A.O.S. Pedreno / Spain Prof. Sushil K. Singh / BHU Varansi	11.04.16
83	Mr. Navalio Daratha	EE	VOLTAGE REGULATION IN DISTRIBUTION SYSTEM WITH THE PRESENCE OF DISTRIBUTED GENERATION	Dr. B. Das	Prof. Mesut Baran / Raleigh Prof. P. R. Bijwe / IIT Delhi	11.04.16
84	Mr. Man Mohan Garg	EE	MODELING AND CONTROL OF DC-DC CONVERTERS	Dr. Y. Vijay Hote Dr. M. K. Pathak	Prof. Bimal K. Bose / USA Dr. K. R. Rajagopal / IIT Delhi	11.04.16

Appendix-A

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **EARTH SCIENCES**

1. Subject Code : **ESN- 628** Course Title: **Field Geology**
2. Contact Hours : **L: 0** **T : 0** **P : 6**
3. Examination Duration (Hrs) : **Theory : 0** **Practical : 6**
4. Relative Weightage: **CWS : 0** **PRS : 50** **MTE : 0** **ETE : 0** **PRE : 50**
5. Credits: **3** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To impart advance training on mapping analysis of geological structures in field.
10. Details of Course: Geological and Structural mapping of structures in field.

S. No.	List of field experiments
1.	Identification of mappable rock units and common structural and tectonic settings.
2.	Hands-on training on GPS, Sunto and Bruton geological compass in field. Observations on planar and linear fabric elements.
3.	Significance and methods for collection of oriented samples in field.
4.	Mapping of mesoscopic brittle structures: Fractures, joints, veins and different types of faults.
5.	Mapping of ductile structures: Folds, ductile shear zones and boudins.
6.	Geometric and kinematic analysis of observations on brittle structures.
7.	Geometric and kinematic analysis of observations on ductile structures.

11. Suggested Books:

S.No.	Name of Authors/ Books/ Publishers	Year
1.	Lisle, R. J., 2004. Geological Structures and maps: A Practical Guide, 3rd Edn, , Elsevier, Amsterdam	2004
2	Lisle, R. J., Braham, P. and Barnes, J. W. Basic geological mapping, 2011. Basic Geological mapping. 5th Edn, Wiley and Sons,, New York	2011
3.	Bennison, G. H. , Olver. P. A. and Mossley, K. 2013. An introduction to geological structures and maps. 8th Edn. Taylor and Francis, London.	2013

Note: The course is based on fieldwork that will be carried out during the weekends and/or holidays without effecting regular teaching hours.

Appendix-B

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: **EARTH SCIENCES**

1. Subject Code : **ESN- 583** Course Title: **Petrophysics and Seismic Rock Characterization**

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

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

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

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

8. Pre-requisite: **Knowledge of well-logging and seismic prospecting**

9. Objective: The main aim of the course is to give knowledge about the rocks and fluids to various frequencies of measurements and a working knowledge of how to integrate a measured property in lab or using well logs to its practical applications in Exploration Geophysics and Reservoir Engineering.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	**Scale, Units and Conversions:** Core-log-to-seismic scales, common units and conversion	2
2.	**Stress-Strain Behaviour:** Principal stresses, priciples of elastic and viscoelastic behaviour, Elastic Tensor, Anisotropy (Intrinsic and stress)	5
3.	**Dynamic Properties of Reservoir Rocks:** reservoir rock types, diagenesis, natural fractures, dissoution, porosity (dual and triple) systems, permeability, mobility, wettability, capillarity	5
4.	**Dynamic properties of Reservoir Fluids:** Hydrocarbon composition (SARA), classification of reservoir fluids, phase behaviour of single and multicomponent fluid systems, PVT properties	5
5.	**Best Practices in Core Analysis:** Routine Core Analysis, Special Core Analysis, Strength tests, GRI. Conventional versus unconventional, steady state and pseudo-steady state permeability	5
6.	**Multiscale Core Data-Overlap/Redundancy;** MICP, Adsorption, XRD, XRF, FTIR,CT SCAN, QEMSCAN	3
7.	**Core-to-Log Calibration and Seismic Property Evaluation:** impact of mineralogy.Vshale and salinity on grain density, porosity, sturation, elastic moduli. **- 57 -** Well-to-Seismic Ties: Basics of VSP, Checkshot surveys, time-depth cirve and velocity profile, Synthetic Seismograms,	5

8.	**Rock-Fluid Interaction:** matrix alteration due to dissolution/ cementation and resulting change in porosity and permeability; grain-to-grain bond weakening, surface energy reduction resulting in shear weakenning.	2
9.	**Experimental Methods in Seismic Rock Property Measurement:** Working principles of piezoelectric crystals, strain gages (semi-conductor, foil), tilt meters. LVDT, ultrasonic measurement, static load measurement, low-frequency measurements.	5
10.	**Fluid Substitution and Effective Medium Modeling:** Fluid substitution in core and log data using idealistic Gassmann, and Generalized Gass,amm & Hashin-Shtrikman, introducing secondary porosity and other heterogeneity to realize equivalent porosity medium, modeling elastic properties using effective medium models	5
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors/ Books/ Publishers	Year of Publications
1.	Petrophysics: Theory and Practice of Measuring Author: Dkennar Tiab and Eric C Donaldson Publishers: Gulf Professional Publishing	2010
2.	Petroleum Reservoir Rock and Fluid Properties Author: Abhijit Y Dandekar Publisher: CRC Press	2013
3.	Petrophysics :Fundamentals of Petrophysics of Oil and Gas Reservoirs Authors: Leonid Buryakovsky, George V. Chilingar, Herman H. Rieke, Sanghee Shin Publisher: Scrivener (Wiley) Publishing I.I.C.	2012
4.	A Geoscientist's Guide to Petrophysics Authors: Bernard Zinszner, Francois-Maric Pellerin Publisher: IFP Publication	2007
5.	Fundamentals of Borehole Seismic Technology Author: Pereira, A.M. and Jones, M. Publisher: Schlumberger	2010

Appendix-D

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT. /CENTRE: Humanities and Social Sciences

1. Subject Code: **HSN 513** Course Title: **Public Policy: Theory and Practice**

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 public policy-making and understanding of the complexity of policy problems.

10. Details of Course

S. No.	Contents	Contact hours
1	**Introduction:** Concepts, Nature, Scope and Significance of Public Policy; Types of Public Policy: Regulatory, Welfare, Distributive and Re-distributive; Evolution of Public Policy Studies; Attributes of Good Policy-Making Process	5
2	**Theories and Models of Policy Making:** Policy Paradigms; Elite Theory and Pluralism; Institutionalism and Rational Choice Theory; Systems Theory and the Process Model; Policy Networks; Public Policy Cycle; Policy Instruments	7
3	**Policy Implementation:** Actors and institutions; Policy making process; Aspects of policy implementation: State and Central Governments; Public Opinion and Interest Group Politics; Problems in Public Policy Implementation: Conceptual, Political and Administrative Problems; Conditions for Successful Implementation	7
4	**Policy Monitoring and Evaluation:** Policy Monitoring: Approaches and Techniques; Constraints in Policy Monitoring; Measures for Effective Policy Monitoring; Policy Evaluation: Role, Process and Criteria, Types of Evaluation; Evaluating Agencies; Problems in Policy Evaluation	7

5	**Domains of Public Policy, Policy Changes and Convergence:** Development Policies: Population, Education, Health, Employment; Welfare Policies: Social Security and Social Insurance; Policy changes; Cross-national policy convergence; Causes and conditions of cross-national convergence; Future challenges for policy analysis	8
6	**Policy Making in India:** Constitutional Framework for Policy Making: Legislature, Executive, Judiciary, National Development Council; Role of NITI Aayog; Other Forces in Policy-making: NGOs, Political Parties, Interest Groups, Professional Lobbyists, Media, Professional and Corporate Bodies, International organizations and Agencies; Policy Interplays and Trade-offs; Deficiencies in the Existing Policy-Making System and Process; Reforms in Policy Making Process	8
	Total	**42**

11. Suggested Books

S. No.	Name of Books/Author/Publisher	Year of Publication/ Reprint
1	William N Dunn, *Public Policy Analysis – An Introduction*, Pearson, 3rd Edition	2003
2	Thomas Dye, *Understanding Public Policy*, Prentice Hall, New Jersey, 14th Edition	2013
3	James Anderson, *Public Policy Making: An Introduction*, Houghton Mifflin, 3rd Edition	2003
4	Michael Hill and Peter Hupe, *Implementing Public Policy*, Sage	2002
5	RV Vaidyanatha Ayyar, *Public Policy Making in India*, Pearson Education India, New Delhi	2009
6	Prabir Kumar De, *Public Policy and Systems*, Pearson Education India, New Delhi	2012

Appendix-C

ANSWER BOOK NO.: No. of Supplementary Sheets_____

24 pages

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
END TERM EXAMINATION

Name of the Student.....Class/Branch.....

Subject Code .....Title.....

Date of Exam .....Enrollment No. .....Signature of Invigilator.....

INSTRUCTION

NOTE: Read the following INSTRUCTIONS carefully.

1. Write on both sides of the paper of the answer book.
2. Give the number of question and its part, if any, at the beginning of the answer. Use the same number for the answer as is given in question paper.
3. No part of this book is to be torn off. Rough work should be scored out.
4. Supplementary sheets will be provided on request.
5. No one will be allowed to borrow instrument, pen pencil, eraser, scale, ink etc. in the Examination Room.
6. No candidate, who leaves the Examination Room while dong his paper except for a short period with the permission of the invigilator, will be permitted to return to the Examination Room.
7. Supplementary sheet(s) and graph paper used, if any, must be tagged with the answer-book.
8. Please handover answer-book to the invigilator at the end to the exam.
9. **Mobile Phone, Pager, Programmable Calculator, Laptop etc. are strictly prohibited inside the Examination Room.**
10. **Use of any unfair-means will render the students liable or punishment as per institute regulations.**

I have read the above instructions.

Signature of Student.....

Question Number	MARKS AWARDED
1	
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Total	

ANSWER BOOK NO.: No. of Supplementary Sheets_____

16 pages

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
MID TERM EXAMINATION

Name of the Student.....Class/Branch.....

Subject Code .....Title.....

Date of Exam .....Enrollment No. .....Signature of Invigilator.....

INSTRUCTION

NOTE: Read the following INSTRUCTIONS carefully.

1. Write on both sides of the paper of the answer book.
2. Give the number of question and its part, if any, at the beginning of the answer. Use the same number for the answer as is given in question paper.
3. No part of this book is to be torn off. Rough work should be scored out.
4. Supplementary sheets will be provided on request.
5. No one will be allowed to borrow instrument, pen pencil, eraser, scale, ink etc. in the Examination Room.
6. No candidate, who leaves the Examination Room while dong his paper except for a short period with the permission of the invigilator, will be permitted to return to the Examination Room.
7. Supplementary sheet(s) and graph paper used, if any, must be tagged with the answer-book.
8. Please handover answer-book to the invigilator at the end to the exam.
9. **Mobile Phone, Pager, Programmable Calculator, Laptop etc. are strictly prohibited inside the Examination Room.**
10. **Use of any unfair-means will render the students liable or punishment as per institute regulations.**

I have read the above instructions.

Signature of Student.....

Question Number	MARKS AWARDED
1	
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Total	

ANSWER BOOK NO.: Supplementary Sheet No._____

4 pages

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
MID/END TERM EXAMINATION

Name of the Student.....Class/Branch.....

Subject Code .....Title.....

Date of Exam .....Enrollment No. .....Signature of Invigilator.....

DEPARTMENT OF CHEMISTRY
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Program Code: XX M.Sc. (Chemistry)
Department: CY Chemistry
Year: I

Teaching Scheme					Contact Hours/Week			Exam. Duration		Relative Weight (%)				
S.No.	Sub Code	Courses Title	Sub. Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
Semester-I (Autumn)														
1.	CYN-501	Quantum Chemistry, Symmetry and Group Theory	PCC	3	3	0	0	3	0	25	-	25	50	-
2.	CYN-503	Thermodynamics, Interfaces and Solids	PCC	3	3	0	0	3	0	25	-	25	50	-
3.	CYN-505	Basic Analytical Chemistry	PCC	3	3	0	0	3	0	25	-	25	50	-
4.	CYN-507	Structure and Reactivity of Organic Molecules	PCC	3	3	0	0	3	0	25	-	25	50	-
5.	CYN-509	Coordination Chemistry	PCC	3	3	0	0	3	0	25	-	25	50	-
6.	CYN-511	Laboratory-I	PCC	6	0	0	12	0	12	-	50	-	-	50
		Total		21	15	0	12							
Semester-II (Spring)														
1.	CYN-502	Organometallics, Inorganic Chains and Clusters	PCC	3	3	0	0	3	0	25	-	25	50	-
2.	CYN-504	Kinetics and Photochemistry	PCC	3	3	0	0	3	0	25	-	25	50	-
3.	CYN-506	Organic Reaction Mechanisms	PCC	3	3	0	0	3	0	25	-	25	50	-
4.	CYN-508	Molecular Spectroscopy	PCC	3	3	0	0	3	0	25	-	25	50	-
5.	CYN-510	Laboratory-II	PCC	6	0	0	12	0	12	-	50	-	-	50
6.	HSN-501	Technical Communication	PCC	2	2	0	0	2	0	25	-	25	50	
7.	CYN-	Program Elective-I	PEC	3	3	0	0	3	0	25	-	25	50	-
		Total		23	17	0	12							

DEPARTMENT OF CHEMISTRY
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Program Code: XX M.Sc. (Chemistry)
Department: CY Chemistry
Year: II

Teaching Scheme					Contact Hours/Week			Exam. Duration		Relative Weight (%)				
S.No.	Sub Code	Courses Title	Sub. Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
Semester-III (Autumn)														
1.	CYN-601	Laboratory-III	PCC	4	0	0	08	0	08	-	50	-	-	50
2.	CYN-	Program Elective-II	PEC	3	3	0	0	3	0	25	-	25	50	-
3.	CYN-	Program Elective-III	PEC	3	3	0	0	3	0	25	-	25	50	-
4.	CYN-	Program Elective-IV	PEC	3	3	0	0	3	0	25	-	25	50	-
5.	CYN-	Program Elective-V	PEC	3	3	0	0	3	0	25	-	25	50	-
6.	CYN-	Program Elective-VI	PEC	3	3	0	0	3	0	25	-	25	50	-
		Total		19	15	0	08							
Semester-IV (Spring)														
1.	CYN-602	Project	PR	8	0	0	0	0	0		-	-	100	-
2.	CYN- 604	Seminar	SEM	2	0	0	0	0	0		-	-	100	-
3.	CYN-	Program Elective-VII	PEC	3	3	0	0	3	0	25	-	25	50	-
		Total		13	3	0	0							

Summary				
Semester	1	2	3	4
Semester-wise Total credits	**21**	**23**	**19**	**13**
Total Credits	**76**			

Program Elective Courses in Second Semester (M.Sc. Chemistry)

Teaching Scheme					Contact Hours/Week			Exam. Duration		Relative Weight (%)				
S.No.	Sub Code	Courses Title	Sub. Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	CYN-512	Nuclear and Radiochemistry	PEC	03	3	0	0	3	0	25	-	25	50	-
2.	CYN-514	Heterocyclic Chemistry	PEC	03	3	0	0	3	0	25	-	25	50	-
3.	CYN-516	Chemistry of Main Group and Transition Elements	PEC	03	3	0	0	3	0	25	-	25	50	-
4.	CYN-518	Structure, Bonding and Properties of Solids	PEC	03	3	0	0	3	0	25	-	25	50	-

Program Elective Courses in Third Semester (M.Sc. Chemistry)

Teaching Scheme					Contact Hours/Week			Exam. Duration		Relative Weight (%)				
S. No.	Sub Code	Courses Title	Sub. Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	CYN-603	Advanced Analytical Techniques	PEC	03	3	0	0	3	0	25	-	25	50	-
2.	CYN-605	Separation Techniques and Microanalysis	PEC	03	3	0	0	3	0	25	-	25	50	-
3.	CYN-607	Electroanalytical Chemistry	PEC	03	3	0	0	3	0	25	-	25	50	-
4.	CYN-609	Inorganic Biochemistry and Reaction Mechanism	PEC	03	3	0	0	3	0	25	-	25	50	-
5.	CYN-611	Solid-State Chemistry and its Applications	PEC	03	3	0	0	3	0	25	-	25	50	-
6.	CYN-613	Frontiers in Bioinorganic Chemistry	PEC	03	3	0	0	3	0	25	-	25	50	-
7.	CYN-615	Crystal and Molecular Structure	PEC	03	2	0	2/2	2	0	20	20	20	40	-

MN/11

8.	CYN-617	Supramolecular Chemistry	PEC	03	3	0	0	3	0	25	-	25	50	-
9.	CYN-619	Modern Organic Synthetic Methods	PEC	03	3	0	0	3	0	25	-	25	50	-
10.	CYN-621	Organic Structure Determination	PEC	03	3	0	0	3	0	25	-	25	50	-
11.	CYN-623	Organic Semiconductors	PEC	03	3	0	0	3	0	25	-	25	50	-
12.	CYN-625	Proteins and Polypeptides	PEC	03	3	0	0	3	0	25	-	25	50	-
13.	CYN-627	Advanced Surface and Colloidal Chemistry	PEC	03	3	0	0	3	0	25	-	25	50	-
14.	CYN-629	Advanced Physical Chemistry	PEC	03	3	0	0	3	0	25	-	25	50	-
15.	CYN-631	Materials Chemistry	PEC	03	2	0	2/2	2	0	20	20	20	40	-
16.	CYN-633	Nanoscale Materials: Properties and Applications	PEC	03	3	0	0	3	0	25	-	25	50	-
17.	CYN-635	Advanced Magnetic Resonance Spectroscopy	PEC	03	3	0	0	3	0	25	-	25	50	-

Program Elective Courses in Fourth Semester (M.Sc. Chemistry)

Teaching Scheme					Contact Hours/Week			Exam. Duration		Relative Weight (%)				
S.No.	Sub Code	Courses Title	Sub. Area	Credits	L	T	P	T	P	CWS	PRS	MTE	ETE	PRE
1.	CYN-606	Total Synthesis	PEC	03	3	0	0	3	0	25	-	25	50	-
2.	CYN-608	Chemical Biology	PEC	03	3	0	0	3	0	25	0	25	50	-
3.	CYN-610	Molecular Modeling and Simulations	PEC	03	2	0	2/2	2	0	20	20	20	40	-
4.	CYN-612	Carbon Nanomaterials and their Applications	PEC	03	3	0	0	3	0	25	-	25	50	-
5.	CYN-614	Enantiomeric Separation	PEC	03	2	0	2/2	2	0	20	20	20	40	-

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CYN-501** Course Title: **Quantum Chemistry, Symmetry and Group Theory**
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: **PCC**
8. Pre-requisite: Nil
9. Objective: To provide basic concepts and mathematical treatment of atomic model, chemical bond, symmetry and group theory.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Quantum chemistry:** Basic postulates, eigenvalues and eigenvectors, Hermitian operators, applications including translational, vibrational and rotational degrees of freedom - particle in 1D/2D/3D box, particle in a ring, rigid rotor, harmonic oscillator. Electronic, vibrational and rotational transitions. Solution of Schrödinger equation for the hydrogen atom; radial and angular functions, atomic orbitals and electron spin. Multi-electron systems, term symbols.	14
2.	**Approximate techniques and chemical bonding:** Born-Oppenheimer approximation, variation and perturbation methods with examples. Valence bond theory including mathematical treatment of sp, sp^2 and sp^3 hybridized orbitals, molecular orbital theory with suitable examples, Hückel molecular orbital approach. Introduction to semi-empirical and *ab initio* methods.	14
3.	**Molecular symmetry and group theory:** The concept of groups, symmetry operations and symmetry elements in molecules, matrix representations of symmetry operations, point groups, representation of a group, reducible and irreducible representations, great orthogonality theorem and its consequences,	8
4.	**Applications of group theory:** Group theory and quantum mechanics, applications of group theory to atomic orbitals in ligand fields, molecular orbitals, symmetry of normal modes of vibrations, prediction of infrared, Raman active vibrational modes, and electronic transitions.	6
	Total	42

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Levine, I. N. "Quantum Chemistry", 7th Ed., PHI Learning Pvt. Ltd., Delhi.	2013
2.	McQuarrie, D. A. "Quantum Chemistry" Reprint, Viva Books.	2007
3.	Atkins, P. "Molecular Quantum Mechanics", 4th Ed., Oxford University Press.	2010
4.	Cotton, F. A., "Chemical Applications of Group Theory", Reprint, Wiley Eastern.	1994

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE: **DEPARTMENT OF CHEMISTRY**

1. Subject: **CYN-503** Course Title: **Thermodynamics, Interfaces and Solids**

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: **PCC**

8. Pre-requisite: Nil

9. Objective of Course: To familiarize the students with thermodynamics aspects of chemical phase equilibria, surface processes and ionic systems, and solids.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Classical thermodynamics:** Thermodynamic treatment of phase equilibria, thermodynamic properties of solutions, chemical potential, chemical potential of real gases and fugacity, thermodynamic function of mixing, thermodynamic treatment of ideal and non-ideal solutions, concept of activity, excess thermodynamic functions. Thermodynamic equilibria in one and two component systems.	12
2.	**Statistical thermodynamics:** Concept of microstates and ensembles, microcanonical, canonical and grand canonical ensemble, average distribution, partition functions and its relation with thermodynamics 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.	10
3.	**Thermodynamics of surfaces and interphases:** Surface and interfacial phenomenon, macromolecules, adsorption of gases by solids, BET theorem, determination of surface area of solids, adsorption from solution, electrical phenomenon of interphases.	7
4.	**Thermodynamics of ionic systems:** Thermodynamics of reversible and irreversible electrochemical systems, thermodynamic foundation of theory of ionic interaction and calculation of energy of ionic interaction, interpretation of electrical conductance of electrolytes, thermodynamic treatment of diffusion potential. Thermodynamics of different types of chemical processes accounting in living systems, metabolic and biosynthetic reaction, thermodynamics of ionic polymers.	7
5.	**Solids:** Structural classification of binary (AX, AX_2, etc.) and ternary (ABX, ABX_2, ABX_3, AB_2X_4, etc.) compositions, powder X-ray diffraction – Bragg's peak, absences, indexing of simple systems. Bonding in solids – introduction to metals, insulators and semiconductors, electronic structure of solids. Electrical conductivity, mobility, thermal conductivity, and specific heat of solids. Magnetic properties of solids, magnetization and susceptibility.	6
	Total	42

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Seddon, J. M. and Gale, J. D., "Thermodynamics and Statistical Mechanics", Royal Society of Chemistry.	2001
2.	McQuarrie, D. A. and Simon, J. D., "Physical Chemistry", Reprint, Viva Student Edition.	2013
3.	McQuarrie, D. A., "Statistical Mechanics", Reprint, Viva Books Pvt. Ltd.	2013
4.	Atkins, P.W., "Physical Chemistry", 7th Ed., ELBS, Oxford University Press.	2003
5.	Silbey, R.J. and Alberty, R.A., "Physical Chemistry", 4th Ed., John Wiley & Sons, Inc., New York.	2003
6.	West, A. R., "Solid State Chemistry and its Applications" Reprint, Wiley, India	1987
7.	Wells, A. F., "Structural Inorganic Chemistry", 5th edn., *Clarendon Press, Oxford*	1984
8.	Spaldin, N. "Magnetic Materials: Fundamentals and Device Applications", *Cambridge University Press*	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CHEMISTRY**

1. Subject code: **CYN-505** Course Title: **Basic Analytical Chemistry**
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 impart basic knowledge in different concepts of analytical chemistry.
10. Details of the Course:

S. No.	Contents	Contact Hours
1.	**Measurement basics:** Signal and noise, sensitivity and detection, hardware and software techniques for enhancing signal to noise, accuracy and instrument calibration, basic electronic components and circuits for instrumentation used in chemical analysis, optical components for instrumentation used in chemical analysis.	4
2.	**Statistical concepts for analytical chemistry:** Error analysis, regression plots, criteria for rejection of data, Q-test, t-test, F - test, ANOVA, control chart, use of spreadsheet.	6
3.	**Spectral methods:** Spectrophotometry– Beer-Lambert law, its applications and limitations, single and double beam spectrophotometer, analysis of mixtures, fluorimetry, nephelometry, turbiditmetry. Atomic absorption spectrometry–principle and applications, flame emission spectrometry (flame photometry).	7
4.	**Electroanalytical methods:** Polarography, amperometric and bio-amperometric titrations.	5
5.	**Nuclear methods:** Fundamentals of radioactivity and decay, preparation of radioisotopes for tracers, applications with radiotracers, radiometric titration, radioactivity measurements by gas filled and scintillation detectors.	6
6.	**Solvent extraction.** Partition law and its limitations, distribution ratio, separation factor, factors influencing extraction, multiple extractions. Extraction of metal chelates.	5
7.	**Basic chromatography:** Introduction and classification, theory of column chromatography, retention time, retention volume, capacity factor, concept of plate and rate theory, resolution, column performance, normal and reverse phase chromatography, paper and thin layer chromatography, ion-exchangers.	9
	Total	42

11. Suggested Books:

S. No.	Name of Authors/Books/ Publishers	Year of Publication/ Reprint
1.	Ewing, G.W., "Instrumental Methods of Chemical Analysis", 5th Ed. McGraw Hill.	2004

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.	Christian, G.D., "Analytical Chemistry" 6th Ed. Wiley	**2008**
4.	Sood, D.D., Reddy, A.V.R. and Ramamoorthy, N., "Fundamentals of Radiochemistry", IANCAS, BARC, Mumbai.	**2004**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject: **CYN-507** Course Title: **Structure and Reactivity of Organic Molecules**

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 of Course: To impart the knowledge of structure-reactivity and the reaction mechanism.

10. Details of Course

S. No.	Contents	Contact Hours
1.	**Conformational analysis of cyclic systems:** Cyclohexane and its derivatives (mono-, di- and tri-substituted), fused (decalins) and bridged bicyclic systems, dynamic stereochemistry, conformational rigidity and mobility, quantitative correlation between conformation and reactivity, effect of conformation on the reduction of cyclic ketones, nucleophilic addition to carbonyl group (Cram, Karabatsos, Felkin-Ahn models, Cieplak effect), nucleophilic substitution on cyclohexane substrates, cyclohexane epoxide formation and opening, elimination reactions of cyclohexyl halides, acetate esters and related compounds, deamination of 2-amino-cyclohexanols, elimination vs substitution competition and neighboring group participation reactions of acyclic and cyclic molecules.	12
2.	**Physical organic chemistry:** Basic concepts, thermodynamic and kinetic requirements, rate and equilibrium constants, reaction coordinate diagram, transition state (activated complex), nature of activated complex, Hammond postulate, reactivity *vs* selectivity principle, Curtin-Hammett principle, microscopic reversibility, kinetic *vs* thermodynamic control.	8
3.	**Methods for elucidating mechanism:** Kinetic analyses of simple and complex reactions, steady state and saturation kinetics, isotope effects – primary and secondary isotope effects, steric and equilibrium isotope effects, solvent isotope effects, heavy atom isotope effects, substituent effects – origin (inductive, field, resonance, steric, solvent and polarizability). Hammett linear free energy relationship, substituent parameter (sigma), reaction constant (rho), use of Hammett plot for mechanism determination, deviation from linearity, inductive *vs* resonance effects -Taft parameters, nucleophilicity and nucleofugality, factors affecting nucleophilicity (basicity/acidity, solvation, polarizability and shape), Swain-Scott parameters, Edwards and Ritchie correlations, solvent effects - bulk and specific solvent effects, Grunwald-Winstein plots, Bronsted relationships , experiments for identifying mechanism (example Cannizzaro reaction), product and intermediate identification, common intermediate detection (example Ritter reaction and Beckmann fragmentation), trapping and competition experiments, isotope labeling, crossover experiments.	16
4.	**Catalysis:** Binding in transition state *vs* ground state, electrophilic catalysis, acid and base catalysis, nucleophilic, covalent, Bronsted acid base catalysis (general and specific, Bronsted catalysis law, Leffler law), Libido rule.	6

	Total	**42**

11. Suggested books:

S. No.	Name of Authors/Books/Publishers	Year of Publication / Reprint
1.	Anslyn, E. V. and Dougherty, D. A., "Modern Physical Organic Chemistry", University Science Books.	**2006**
2.	Clayden, J., Greeves, N. and Warren, S., "Organic Chemistry", Oxford University Press.	**2012**
3.	Carey, F. A. and Sundberg, R. J., "Advanced Organic Chemistry", Part A: Structure and Mechanisms, 5th Ed., Springer.	**2007**
4.	Nasipuri, D., "Stereochemistry of Organic Compounds: Principles and Applications", New Age International.	**2014**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CYN-509** Course Title: **Coordination Chemistry**

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 impart basic and advanced concepts of coordination chemistry.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Structure, bonding and properties of transition metal complexes:** Different types of ligands and coordination geometry (symmetry considerations), coordination number, isomerism (recapitulation), HSAB concept, thermodynamic stability, successive and overall stability constants, determination of stoichiometry (Job's method) and stability constants by spectrophotometric, potentiometric and polarographic methods, Irving-William series, chelate and macrocyclic effect.	6
2.	**Stereochemical aspects of coordination complexes:** Stereoisomerism in inorganic complexes, isomerism arising out of ligand and ligand conformation, chirality and nomenclature of chiral complexes, optical rotatory dispersion (ORD) and circular dichroism (CD).	5
3.	**Metal-ligand bonding:** Overview of crystal field and ligand field theories of 4-, 5- and 6-coordinated complexes, d-orbitals splitting in linear, trigonal, octahedral, square planar, tetrahedral, square pyramidal, trigonal-bipyramidal and cubic complexes, measurement of CFSE (d^1 to d^{10}) in weak and strong ligand fields, Jahn-Teller distortion, nephelauxetic series, variation of lattice energy, ionic radii and heat of hydration across 1st row transition metal ions.	6
4.	**Molecular orbital theory (MOT) of coordination compounds:** Composition of ligand group orbitals, molecular orbital energy diagrams of octahedral, tetrahedral, square planar complexes including both σ and π bonding, angular overlap model.	7
5.	**Electronic spectra of coordination compounds:** Energy states from spectral terms of d^n configurations, selection rules for ligand-field and charge transfer transitions in metal complexes, band intensities, factors influencing band widths, splitting of various terms, Orgel and Tanabe-Sugano diagrams of octahedral and tetrahedral d^n complexes, calculation of ligand field parameters, luminescence, phosphorescent complexes.	7
6.	**Magnetic properties of coordination compounds:** Fundamental equations in molecular magnetism, magnetic susceptibility and magnetic moment, diamagnetic and paramagnetic behavior of transition metal complexes, spin-orbit coupling effects (L-S coupling and j-j coupling), orbital angular moment and its quenching in octahedral and tetrahedral complexes, temperature independent paramagnetism (TIP) of complexes, spin cross over phenomenon, spin admixed states, metal-metal direct spin interaction and super exchange spin-spin interaction through bridging	11

	ligands, ferromagnetic, anti-ferromagnetic, ferrimagnetic behaviour of transition metal compounds, effect of temperature on their magnetic properties, single molecule magnets.	
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/ Reprint
1.	Cotton, F.A., Wilkinson, G., Murillo, C.A. and Bochmann, M., "Advanced Inorganic Chemistry", 6th Ed., John Wiley & Sons.	1999
2.	Douglas, B.E., McDaniel,D.H. and Alexander, J.J., "Concepts and Models in Inorganic Chemistry", 3rd Ed., John Wiley & Sons.	2001
3.	Figgis, B.N., and Hitchman, M.A "Ligand Field Theory and Its Applications", Wiley Eastern Ltd.	1999
4.	Huheey, J.E., Keiter, E.A. and Keiter, R.L., "Inorganic Chemistry Principle of Structure and Reactivity", 4th Ed, Pearson Education, Inc.	2003
5.	Atkins, P., Overton, T., Rourke, J., Mark, W. and Armstrong, F., "Shriver and Atkins' Inorganic Chemistry", 4th Ed, Oxford university press.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CHEMISTRY**

1. Subject Code: **CYN-511** Course Title: **Laboratory-I**

2. Contact Hours: **L: 0** **T: 0** **P: 12**

3. Examination Duration (Hrs): **Theory 0** **Practical 12**

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

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

8. Pre-requisite: Nil

9. Objective: To impart practical knowledge and skills in physical, inorganic and organic chemistry laboratories.

10. Details of Course:

Contents	Contact Hours
List of Inorganic Chemistry Experiments 1. Semi-micro qualitative analysis involving 6 radicals including interfering radicals. 2. Determination of metal ions by gravimetric-cum-volumetric analysis: Ag (I) gravimetrically and Cu(II) volumetrically. 3. Determination of Cu(II) gravimetrically and Zn(II) volumetrically. 4. Determination of Fe(III) gravimetrically and Ca(II) volumetrically. 5. Gravimetric analysis of a mixture of two metal ions such as Cu and Zn. 6. Synthesis of coordination compounds and metal content determination: (i) $[Cu(NH_3)_4.H_2O]SO_4$, (ii) $[Fe(acac)_3]$, (iii) $[Mn(acac)_3]$, (iv) $[Mn(C_2O_4)_3]$. • Some experiments require two-three turns.	**4 × 14**
List of Physical Chemistry Experiments 1. Determination of pK_1 and pK_2 of an acid using pH meter. 2. Determination of cell constant and verification of Kohlrausch's law. 3. Determination of specific rotation of lactic acid/sucrose by polarimeter. 4. Determination of molar refraction equivalent to $-CH_2$, C, H, and O. 5. Determination of composition of liquid mixture by refractive index measurements. 6. Determination of dimerization constant of benzoic acid. 7. Conductometric titration of different acids against bases. 8. Verification of Ostwald's dilution law by conductometric measurements of acetic acid. 9. Verification of Freundlich's adsorption isotherms and calculation of characteristic constants. 10. Verification of Langmuir adsorption isotherms and determination of surface area. 11. Determination of surface excess concentration and thickness of interfacial adsorbed layer by surface tension measurements of water-n-butanol mixture. 12. Determination of the Parachor of binary mixture of miscible solute by surface tension measurements. 13. Verification of Hardy-Schultze rule for positive/negatively charged colloids. 14. Determination of critical micelle concentration of sodium dodecylsulphate/cetyltri-	**4 × 14**

methylammonium bromide by surface tension method.	
List of Organic Chemistry Experiments 1. Separation of organic mixtures by TLC and PTLC. 2. Synthesis of derivatives for carbonyl, amino and active methylene compounds. 3. Diels-Alder reaction between anthracene and maleic anhydride. 4. Oxidation of hydroquinone to *p*-benzoquinone. 5. Oxidation of benzoin to benzil. 6. Conversion of benzil to quinoxaline. 7. Reduction of camphor. 8. Synthesis of 2-iodobenzoic acid by Sandmeyer reaction 9. Aldol condensation (benzaldehyde + acetone or cinnamaldehyde + acetone). 10. Synthesis of binaphthol by green reaction. 11. Knoevenagel condensation between aldehyde (4-diethylaminobenzaldehyde) and malonic acid, cyanoacetic acid or malononitrile. 12. Friedel-Crafts reaction: synthesis of 1,4-di-*tert*-butyl-2,5-dimethoxybenzene. 13. Preparation and purification of *cis*- and *trans*-stilbenes by Wittig reaction. 14. Bromination of acetanilide.	**4 × 14**
Total	**168**

11. Suggested Books:

S. No.	Authors/ Title/ Publisher	Year of Publication/Reprint
1	Mendham, J., Denney, R.C., Barnes J.D. and Thomas M.J., " Vogel's Text Book of Quantitative Chemical Analysis", 6th Ed., ELBS Longman Group UK Ltd.	2004
2	Srivastava T.N. and Kamboj P.C., "Analytical Chemistry", Vishal Publications.	2000
3	Furniss B.S., Handford A.J., Smith P.W.G. and Tatchell A.R., "Vogel's Text Book of Practical Organic Chemistry", 5th Ed., Longman.	1996
4	Leonard J., Lygo B. and Procter G., "Advanced Practical Organic Chemistry", Chapman & Hall.	1995
5	Levitt, B.P., "Findlay's Practical Physical Chemistry", 9th Ed., Longman	1973
6	Garland C.W., Nifler J.W. and Schoemaber D.P., "Experiments in Physical Chemistry", 7th Ed., McGraw-Hill International.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CYN-502** Course Title: **Organometallics, Inorganic Chains and Clusters**

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 advanced concepts in organometallic chemistry and structural aspects of inorganic chains, rings, cages and clusters.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Structure and bonding in organometallics:** 18 electron rule and its application to π-acceptor ligands, limitations of 18 electron rule, description of bonding models for π-acceptor ligands including CO, alkenes (Dewar-Chatt-Duncanson model) and tertiary phosphines, physical evidences and consequences of bonding. Main group organometallics: Introduction, review of comparative aspects of synthetic methods, reactivity and bonding in ionic, covalent, electron deficient and electron rich organometallic compounds. Kinetics and mechanism of ligand substitution (associative and dissociative), oxidative addition and reductive elimination, transmetallation, migratory insertions, reactivity at metal-bound ligands.	9
2.	**Organotransition metal chemistry:** σ-Bonded transition metal-alkyls, - aryls, -alkenyls(vinyls), -alkynyls(acetylides), reactions in σ–organyls: homolytic cleavage, reductive elimination, electrophilic cleavage, insertion, β-metal hydrogen elimination, α-abstraction or α-elimination and γ- and δ-remote C-H functionlization.	5
3.	**Organotransition compounds with multiple metal-carbon bonding:** Transition metal-carbenes/-carbynes, -bridging carbenes/carbynes, reactions of carbene/carbyne complexes such as ligand substitution, nucleophilic, electrophilic attack, dismutation, and ligand coupling reactions.	4
4.	**Organotransition compounds with multicenter bonds:** Concept of hapticity, transition metal complexes of alkenes, Ziese salt, alkynes, allyls, butadienes; π-metal complexes of cyclobutadienes, cyclopentadienyls, arenes, cyclohepta-trienyls and cyclooctatetraenes, reactions and bonding in ferrocene; stereochemical non-rigidity in organometallic compounds and fluxionalty, bimetallic and cluster complexes.	6
5.	**Inorganic chains, rings, cages and clusters:** Chains– catenation and hetero-catenation, structural aspects of silicate minerals and silicones, one-dimensional conductors: $(SN)_x$ chains, chalcogenide glasses, iso- and heteropolyanions. Rings–borazines, boron nitride, phosphazenes–structural models, phosphazene polymers, and other homocylic and heterocyclic inorganic ring systems. Cages– Boron cage compounds– structural aspects (boranes-styx number and Wade's rule) of higher boranes, carboranes, metallacarboranes, phosphorous cage compounds with P–P, P–O, P–S. Clusters– metal clusters, metal carbonyl clusters, di-, tri-, tetra- and	14

	hexanuclear clusters.	
6.	**Applications of organometallics and clusters in catalysis:** Alkene metathesis, Cativa and Monsanto processes for production of acetic acid, carbonylation and decarbonylation reactions, Wacker process, cyclooligomerisation of acetylene using Ni/Cr catalysts, Mobil and Fischer-Tropsch processes, polymer-bound catalysts, metal carbonyl clusters in catalysis.	**4**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/ Reprint
1.	Huheey, J.E., Keiter, E.A. and Keiter, R.L., "Inorganic Chemistry Principle of Structure and Reactivity", 4th Ed, Pearson Education Inc.	**2003**
2.	Cotton, F.A., Wilkinson, G., Murillo, C.A. and Bochmann, M., "Advanced Inorganic Chemistry", 6th Ed., John Wiley & Sons.	**1999**
3.	Hill, A.F., "Organotransition Chemistry", The Royal Society of Chemistry, Cambridge.	**2002**
4.	Bochmann, M. (Ed.), "Oxford Premier Series on Organometallics", Vol. 1 and 2, Oxford Press.	**2002**
5.	Gupta, B.D. and Elias A.J., "Basic Organometallic Chemistry", 2nd Ed., University Press (India) Pvt. Ltd.	**2013**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CYN-504** Course Title: **Kinetics and Photochemistry**
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 of Course: To impart basic knowledge of the kinetics and photochemistry.
10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Theories:** Theoretical calculation of energy of activation using potential energy surface diagram, absolute reaction rate theory, comparison between gas phase and solution reactions.	10
2.	**Type of reactions:** Kinetics of chain reactions, detections of radical and kinetics of HBr, H_2O_2 reactions, explosion limits, elementary idea of unimolecular reactions, application of following to the reaction kinetics– solvent effect, kinetic isotope effect and salt effect, experimental technique for studying the fast reaction kinetics, kinetics of homogenous and heterogenous catalysis, kinetics of polymerization.	14
3.	**Electron transfer dynamics:** Electron transfer in homogeneous systems, theory of electron transfer processes, electron tunneling, experimental results, electron transfer in heterogeneous systems, electrode-solution interface, rate of charge transfer in electrode reactions, study of kinetics of electrode processes.	8
4.	**Photochemistry:** Quantum efficiencies of photochemical and photophysical processes, experimental techniques for continuous photolysis. Primary and secondary photochemical processes, Franck-Condon principle and its applications, rates of absorption and emission, lifetimes of electronically excited states and their fate, quenching of excited states species – dynamic and static quenching, radiationless transition and pre-dissociation, energy transfer processes, FRET analysis, mechanistic analysis and reaction dynamics. Radiation chemistry–Interaction with ionizing radiation with matter, dosimetry, generation of free radicals and intermediates, comparison between photo- and radiation chemistry.	10
	Total	42

11. Suggested books:

S.No.	Name of Authors/ Books/ Publishers	Year of Publication/Reprint
1.	Laidler, K.J., "Reaction Kinetics", Anand Sons, New Delhi.	2005
2.	Amis, E.S.,"Solvent Effect of Reaction Rates and Mechanism", Academic Press.	2005
3.	Mukherjee, K.K., "Fundamentals of Photochemistry", New Age	2004

	International Pvt. Ltd., New Delhi.	
4	Lakowicz, J.R., "Principles of Fluorescence Spectroscopy", Plenum Press, New York.	**2003**
5.	Wishart, J.F. and Nocera, D.G., "Photochemistry and Radiation Chemistry", Oxford University Press, USA.	**1998**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject: **CYN-506** Course Title: **Organic Reaction Mechanisms**

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 of Course: To familiarize the students with different types of organic reactions.

10. Details of Course

S. No.	Contents	Contact Hours
1.	**Single bond [C-X (X = C, O, N)] formations:** Nucleophilic additions to carbonyls and stereochemical aspects through various models (Cram, Cram chelation and Felkin-Anh models), chemistry of enolates (kinetic and themodynamic) and enamines, enolates, lithium and boron enolates in aldol and Michael reactions, alkylation and acylation of enolates, mechanism of aldol (Mukiyamaaldol), Knoevenagel, Claisen, Dieckmann, Perkin, Stobbe, Darzen, Acyloin condensations, organolithium, organomagnesium (Grignard), organozinc, organocopper (Gilman &Normant) reagents in synthesis, epoxidations (Prilezhaev, Sharpless, Jacobsen and Shi), Metal catalyzed C-C bond formations (Ullmann, Buchwald-Hartwig, Sonogashira, Heck, Suzuki, Stille, Nozaki-Hiyama and Kumada reactions).	14
2.	**Multiple bond [C-X (X = C, N)] formations:** Phospohorus, nitrogen and sulfur ylids, Wittig reaction, Wittig-Horner reaction, Tebbe olefination, Julia olefination, Robinson annulation, Mannich reaction, Peterson olefination, Ramberg-Backlund rearrangement, McMurry reaction, Shapiro reaction, β-eliminations (Hoffman & ester pyrolysis), Cope elimination, selenoxide elimination, dehydration of alcohols, Corey-Winter reaction, olefins from epoxides, reduction of acetylenes, olefin metathesis (Schrock's catalyst, Grubbs' catalyst), ring closing metathesis, enyne metathesis, Thorpe reaction, Corey-Fuchs reaction, Seyferth-Gilbert homologation, Ohira-Bestmann modification.	14
3.	**Pericyclic reactions:** Classification, electrocyclic, sigmatropic, cycloaddition, chelotropic and ene reactions, conservation of orbital symmetry, state correlation diagrams, frontier molecular orbital (FMO) theory, aromatic transition state (ATS) theory, generalized orbital symmetry (GOS) rule, photochemical cycloaddition reactions, Diels-Alder reaction, Dipolar cycloadditions, retrocycloadditions, electrocyclic reactions, conrotation and disrotation, orbital correlation diagrams for four-, six- and eight-electron cases, torquoselectivity, sigmatropic rearrangements, [1,3], [1,5] and [3,3] shifts, Curtius and Schmidt rearrangements, Cope and Claisen rearrangements, di-π-methane rearrangement, ene reaction, cheletropic reactions, Norrish I and II reactions.	14
	Total	42

11. Suggested books:

S. No.	Name of Authors/Books/Publishers	Year of Publication / Reprint
1.	Carey, F. A. and Sundberg, R. J., "Advanced Organic Chemistry, Part B: Reactions and Synthesis", 5th Ed., Springer.	2007
2.	Anslyn, E. V. and Dougherty, D. A., "Modern Physical Organic Chemistry", University Science Books.	2006
3.	Clayden, J., Greeves, N. and Warren, S., "Organic Chemistry", Oxford University Press.	2012
4.	Smith, M.B., "Organic Synthesis", 3rd Ed., Academic Press.	2010
5.	Bruckner, R., "Organic Mechanisms: Reactions, Stereochemistry and Synthesis", Springer.	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CHEMISTRY**

1. Subject Code: **CYN-508** Course Title: **Molecular Spectroscopy**
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: CYN-501; Elementary knowledge of symmetry and group theory.
9. Objective: To provide advance knowledge of spectroscopic techniques for identification and elucidation of structures of molecules.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Overview of molecular spectroscopy:** Different aspects of molecular spectroscopy, the Born-oppenheimer approximation, transition probability, oscillator strength, the integrated absorption coefficient. **Microwave spectroscopy:** Classification of the rotors, intensity of the rotational lines, population of energy levels, non-rigid rotation, anharmonicity and centrifugal distortion, effect of isotopic substitution. Rotation spectra of the linear, spherical top and asymmetric top polyatomic molecules, microwave technique.	6
2.	**Infrared and Raman spectroscopy:** Types of vibration bands- overtones, combination bands, Fermi resonance phenomenon, the finger print region, FTIR spectroscopy and application. Rayleigh and Raman scattering, polarizabilities, rotational and vibrational Raman spectra, selection rules, polarization of the light and Raman effect, resonance Raman and coherent anti-Raman spectroscopy.	6
3.	**UV-visible spectroscopy:** Electronic spectra, Frank-Condon Principle, predissociation spectra, Fortrat diagram, conjugated polyene and enone systems, different types of charge transfer transitions and their basis. Charge transfer spectra in organic and inorganic systems.	5
4.	**Photoelectron spectroscopy:** The photoionization processes, Auger and autoionization processes, deexcitaion by fluorescence, outlines of UPS, XPS and Auger techniques and their applications in interpretation of valence and core shell spectra of atoms and molecules.	4
5.	**Magnetic resonance spectroscopy:** Nuclear moments, nuclear spin states in a magnetic field and the resonance phenomenon, relaxation processes and their importance. Bloch equation, Larmor frequency, shielding constant and chemical shifts. Spin-spin coupling and quantum chemical description of spin systems-- spectra of two (AX cases) and three (AMX) spin systems. Dynamic NMR and line shapes. General introduction to double resonance experiments and nuclear overhauser effect, chemical shift reagents, multinuclear NMR. **ESR Spectroscopy:** Principle of ESR and interpretation of its applications for ESR spectra of $-CH_3$ and $-CH_2$ radicals.	14
6.	**Mössbauer spectroscopy:** The Mössbauer effect and chemical isomer shift. Magnetic and quadrupolar effects in the Mössbauer spectra of complexes of ^{57}Fe and other nuclei.	6
	Total	42

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/Reprint
1.	Banwell, C.N. and McCash, E.L.M.,"Fundamentals of Molecular Spectroscopy", 4th Ed. McGraw-Hill N. Y.	1999
2.	Slichter, C.P., " Principles of Magnetic Resonance", Springer Verlag.	1981
3.	Graybeal, J.D., "Molecular Spectroscopy", McGraw-Hill.	1988
4.	Atkins, P. and Paula, J.de, "Physical Chemistry", 7th Ed., Oxford Univ. Press.	2003
5.	Drago, R.S., "Physical Methods in Inorganic Chemistry", Reinhold Publishing Corp., East West Press Ltd.	1986

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CHEMISTRY**

1. Subject Code: **CYN-510** Course Title: **Laboratory-II**

2. Contact Hours: **L: 0** **T: 0** **P: 12**

3. Examination Duration (Hrs): **Theory 0** **Practical: 12**

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

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

8. Pre-requisite: CYN-511

9. Objective: To impart practical knowledge and skills in physical, inorganic and organic chemistry laboratories.

10. Details of Course:

Contents	Contact Hours
List of Inorganic Chemistry Experiments 1. Comparison of the electronic spectra of $[Ni(H_2O)_6]^{2+}$, $[Ni(NH_3)_6)^{2+}$ and $[Ni(en)_3]^{2+}$ and qualitative verification of the spectrochemical series, and quantitative estimation of nickel by spectrophotometry. 2. Synthesis and spectrophotometric study of copper complexes: (i) synthesis of bis(salicylaldimine)copper(II) and cis-bis(glycinato)copper(II), (ii) record the spectra of bis(salicylaldimine)copper(II) and cis-bis(glycinato copper(II), and (iii) record spectra of Cu^{2+} in water, NH_3, ethylene diamine and glycine, and arrange the ligands in order of increasing field strength and (iv) quantitative estimation of copper by spectrophotometry. 3. (i) Study of the complex formation between Fe(III) and thiocyanate/salicylic acid/sulphosalicylic acid or between Ni(II) and *o*-phenanthroline, and (ii) spectrophotometric determination of formation constant of the complex (Job's method and molar ratio method). 4. Preparation of (i) $[Ni(NH_3)_6]Cl_2/SO_4$, (ii) $[Ni(en)_3]Cl_2/SO_4$, (iii) bis(salicylaldimine)nickel(II), and analysis by different methods, viz. IR, UV-visible and ^1H NMR spectroscopy. 5. Synthesis of potassium tris(oxalato)aluminate, potassium tris(oxalato)chromate and potassium tris(oxalato)ferrate, and their characterization by metal determination, various spectroscopic (I.R. and U.V.-Vis) methods, magnetic moment determination, and photochemical behavior of iron complex. 6. Synthesis and characterization of $[Co(en)_3]Cl_3$. Separation of its optical isomers and determination of their optical rotation by using polarimeter. • Some experiments require two-three turns.	**4 × 14**
List of Physical Chemistry Experiments 1. To study the kinetics of H^+ catalyzed hydrolysis of an ester. 2. To study the kinetics of saponification of an ester. 3. To study the kinetics of Fe^{3+} catalyzed decomposition of hydrogen peroxide. 4. To study the kinetics of inversion of sucrose using polarimeter. 5. Determination of equilibrium constant of Kl_3 complex by distribution method. 6. Determination of compound formation between liquids by viscosity variation with composition of mixtures of liquids using Ostwald viscometer.	**4 × 14**

7. Determine the composition of KCl-KBr mixtures by potentiometric titration against silver nitrate solution. 8. Verification of Beer-Lambert's law using potassium permanganate solution. 9. To study the quenching of fluorescence of organic dye(s). 10. To study the variation in miscibility of phenol in water with temperature and to find out the critical solution temperature (CST) and also to investigate the effect of impurity on CST. 11. To determine the molecular weight of a volatile substance using Victor Meyer method. 12. To determine the cell potentials for different electrochemical cells and also to measure different thermodynamic parameters. • Some experiments require two turns.	
List of Organic Chemistry Experiments 1. Preparation of *p*-nitroaniline from acetanilide. 2. Preparation of pyridinium dichromate and its use in oxidation of benzyl alcohol. 3. Cannizzaro reaction of an aromatic aldehyde (*p*-nitrobenzaldehyde). 4. Synthesis of ω-nitrostyrene from an aromatic aldehyde and nitromethane. 5. Synthesis of chalcone from an aromatic aldehyde and acetophenone. 6. Extraction of oils from ground nuts using soxhlet apparatus. 7. Synthesis of α-bromo cinnamic acid or phenyl acetylene from benzaldehyde, (formation of cinnamic acid, bromination and elimination reactions). 8. Preparation of *meso*-stilbene dibromide and its conversion to diphenylacetylene. 9. Fisher indole synthesis. • Some experiments require two-three turns.	4 × 14
Total	**168**

11. Suggested Books:

S. No.	Authors/ Title/ Publisher	Year of Publication/Reprint
1	Mendham, J., Denney, R.C., Barnes J.D. and Thomas M.J., " Vogel's Text Book of Quantitative Chemical Analysis", 6th Ed., ELBS Longman Group UK Ltd.	2004
2	Srivastava T.N. and Kamboj P.C., "Analytical Chemistry", Vishal Publications.	2000
3	Furniss B.S., Handford A.J., Smith P.W.G. and Tatchell A.R., "Vogel's Text Book of Practical Organic Chemistry", 5th Ed., Longman.	1996
4	Leonard J., Lygo B. and Procter G., "Advanced Practical Organic Chemistry", Chapman & Hall.	1995
5	Levitt, B.P., "Findlay's Practical Physical Chemistry", 9th Ed., Longman	1973
6	Garland C.W., Nifler J.W. and Schoemaber D.P., "Experiments in Physical Chemistry", 7th Ed., McGraw-Hill International.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CHEMISTRY**

1. Subject code: **CYN-5 12** Course Title: **Nuclear and Radiochemistry**
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: **PEC**
8. Pre-requisite: Fundamental knowledge in physical chemistry.
9. Objective: To impart basic knowledge in nuclear chemistry and apply its concepts for characterization of materials and analysis.
10. Details of the Course:

S. No.	Contents	Contact Hours
1.	**Properties of nucleons and nuclei:** Nuclear stability and natural radioactivity, size and shape of a nucleus, nuclear spin, magnetic properties of a nucleus, nuclear magnetic resonance, nuclear resonance or recoil-less absorption, electric quadrupole moment, nuclear parity and nuclear statistics.	6
2.	**Nuclear models:** Shell model, liquid drop model, Fermi gas model, collective model and optical model.	4
3.	**Radioactivity**: Radioactive decay, decay kinetics, parent daughter decay growth relationship, concepts of transient and secular equilibrium, alpha, beta and gamma decay, artificial radioactivity.	6
4.	**Nuclear reaction:** Bethe's notation, types of nuclear reaction, reaction cross section, Q- value and threshold, compound nucleus theory, transuraniens, photo and thermonuclear reaction, fusion reactor, nuclear fission, fission fragments and mass distribution, fission energy, theory of nuclear fission, introduction to nuclear reactor and importance of four factor formula, reprocessing of spent fuels, nuclear waste management.	8
5.	**Interaction of radiation with matter:** Stopping power and range for charged particles, interaction with X-rays and gamma rays – photoelectric effect, Compton scattering, pair production, nuclear detectors using semiconductors, effect of radiation on polymers and inorganic compounds, concepts of positron and its use in materials science.	10
6.	**Ion beam techniques:** Activation analysis with case studies, radioisotopes for nuclear medicine, elemental mapping of trace and major elements, depth wise analysis by RBS, elastic recoil deflection analysis for hydrogen measurement, ion implantation, ion beam mixing.	8
	Total	42

11. Suggested Books:

S. No.	Name of Authors/Books/ Publishers	Year of Publication/ Reprint
1.	Loveland, W., Morrissey and D., Seaborg, G.T., "Modern Nuclear Chemistry", John Wiley and Sons, New Jersey.	2006
2.	Arnikar, H.J.,"Essentials of Nuclear Chemistry", New Age International (P) Ltd., New Delhi.	2003
3.	Friedlander, G., Kennedy J.W., Miller, E.S. and Macais, J.M., " Nuclear and Radiochemistry", John Wiley and Sons, Inc. New York.	1981

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject: **CYN-514** Course Title: **Heterocyclic Chemistry**

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: **PEC**

8. Pre-requisite: Basic organic chemistry and synthetic methods.

9. Objective of Course: To impart a broad understanding of the major classes of 5- and 6-membered ring heterocyclic compounds.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Heterocycles:** Systematic nomenclature of heterocyclic compounds (Hantzsch-Widman, replacement and fusion methods), biological importance of heterocyclic compounds.	2
2	**Five-membered heterocycles with one heteroatom:** Chemical structures of furan, pyrrole and thiophene, and degree of aromaticity. General syntheses methods for 5-member rings. Paal-Knorr, Feist-Benary, Hantzsch and Knorr syntheses. Electrophilic substitution, reactants employed and orientation of the substituent on the ring.	10
3	**Benzo derivatives of five-membered heterocycles with one heteroatom:** Preparation of indole and carbazole derivatives. Fisher, Bischler, Madelung and Reissert syntheses. Preparation and reactivity of benzofurans (coumarins), benzothiophenes, dibenzofurans and dibenzothiophenes.	8
4.	**Pyridines, quinolines and isoquinoles:** Influence of the imine group on the reactivity of the pyridine ring. Nucleophilic and electrophilic substitutions on pyridine, quinolines and isoquinolines. Comparison of reactivity with benzene and naphthalene. Preparation of pyridine salts and pyridine *N*-oxides and synthetic applications. Skraup, Friedlander, Pfintzinger Bischler-Napieralski and Pictet syntheses.	10
5.	**Heterocycles with 5 or 6 members and two or three heteroatoms:** Syntheses and reactivity of oxazoles, thiazoles, oxadiazoles, thiadiazoles, benzothiazoles, benzothiadiazoles, triazole, benzotriazole, pyrimidines, pyrazines, quinoxalines and triazines	6
6.	**New materials derived from heterocycles:** Syntheses of indigo, mauveine, cyanines, tetrathiafulvalenes and related dyes, organic sensitizers for DSSC, electron donors and acceptors for organic solar cells, optical chemosensors and organic semiconductors for thin-film transistors.	6
	Total	42

11. Suggested Books:

S.No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Gilchrist, T. L.,"Heterocyclic Chemistry", 3rd Ed., Pearson Education, India. (ISBN: 978-0582278431).	2007
2.	Sainsbury, M., "Heterocyclic Chemistry", Wiley. (ISBN: 978-0-471-28164-1)	2002
3.	Katritzky ,A. R., Ramsden, C. A., Joule, J. A. and Zhdankin, V. V., "Handbook of Heterocyclic Chemistry", 3rd Ed., Elsevier. (ISBN: 978-0-08-095843-9)	2010
4.	Gupta, R. R., Kumar, M. and Gupta, V., "Heterocyclic Chemistry, Vol. I: Principles, Three- and Four-Membered Heterocycles", Springer. (ISBN: 978-3-642-72278-3)	1998
5.	Gupta, R. R., Kumar, M. and Gupta, V., "Heterocyclic chemistry, Vol. II: Five-Membered Heterocycles", Springer. (ISBN: 978-3-642-08460-7)	1998
6.	Joule, J. A. and Mills, K., "Heterocyclic Chemistry", Wiley-Blackwell. (ISBN: 978-1-4051-3300-5)	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CYN-516** Course Title: **Chemistry of Main Group and Transition Elements**

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: **PEC**

8. Pre-requisite: Basic knowledge of inorganic chemistry.

9. Objective: To impart advance concepts in chemistry of main group and transition elements.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Chemistry of main group elements:** (i) Chemistry of Gr. 1 and 2 metals– solutions of alkali metals in liquid ammonia (reactions, electrical and magnetic properties), metal anions, complexation of Gr. I/II metals with crown ethers, cryptands and calixarenes, anomalous behavior of Li and Be. (ii) Chemistry of *p*-block elements– borides, borates and boran halides, allotropes of carbon (diamond, graphite, fullerene, carbon nanotubes), carbides, chlorofluorocarbons, silicon halides, silanes, silanols. Hydrides, oxides and oxoacids of pnictogens (N, P), chalcogens (S, Se and Te) and halogens. Pseudohalogens, inter-halogens, polyhalide anions, synthesis, structures and reactivity of compounds of xenon, bonding in xenon fluorides. Overall structural and bonding aspects (VBT) of B, Al, Si, N, P and Cl compounds.	14
2.	**Types of non-covalent interactions:** Inter- and intramolecular hydrogen bonding interactions and their effects, electrostatic interactions (ion-ion, ion-dipole, dipole-dipole, dipole-induced dipole) and other weak intermolecular forces. Principle of self-assembly, host-guest chemistry and molecular receptors, examples of supramolecular inorganic architectures, and supramolecular photochemistry. Metallic Bonding– band model, soft X-ray spectra and N(E) curves, binding energy in metals, conductors, semiconductors and insulators, effect of temperature and impurity on conductivity.	7
3.	**Concept of acid and bases**: Bronsted and Lewis acids and bases, pH, pKa, acid - base concept in non-aqueous media, buffer solution, protonic acids, proton affinities, differentiation and leveling solvents, Hammet Ho scale, acidic behavior of the binary hydrides, cosolvating agents, oxyacids. aquoacids, amphoteric oxides, nonprotonic concepts of Acid - Base reactions, Lux concept, solvent ion theory of acids and bases, non-aqueous solvents– liquid ammonia, acetic acid, BF_3. Hard and soft acids and bases, symbiosis, theoretical and electronegativity concepts of hardness and softness.	7
4.	**Lanthanides and actinides:** Separation and isolation of lanthanides, separation of Np, Pu and Am from U, electronic spectra and magnetic properties of lanthanides and actinides, general comparison of lanthanides and actinides and their applications in technology, lanthanide shift reagents.	6
5.	**Introductory bioinorganic chemistry:** Inorganic composition of cells, compartmentalization, classification of biomolecules, biological metal-coordination	8

	sites including special ligands like porphyrins and pterin. Role of metallobiomolecules in transport, transfer and transcription (preliminary ideas), selective transport and storage of iron. Chemistry of elements in medicine–chelation therapy, cancer treatment, imaging agents, anti-arthritis agents, radioisotopes and contribution of individual elements. Electron transfer proteins - active site structure and functions of ferredoxin, rubridoxin and cytochromes, and their comparisons. Mechanism of nitrogen fixation.	
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/ Reprint
1.	Huheey, J. E., Keiter, E. A. and Keiter, R. L., "Inorganic Chemistry Principle of Structure and Reactivity", 4th Ed, Pearson Education, Inc.	2003
2.	Douglas, B.E., McDaniel, D.H. and Alexander, J.J., "Concepts and Models in Inorganic Chemistry", 3rd Ed., John Wiley & Sons.	2001
3.	Cotton, F.A., Wilkinson, G., Murillo, C.A. and Bochmann, M., "Advanced Inorganic Chemistry", 6th Ed., John Wiley & Sons.	1999
4.	Atkins, P., Overton, T., Rourke, J., Mark, W. and Armstrong, F. "Shriver and Atkins' Inorganic Chemistry", 4th Ed, Oxford University Press.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CHEMISTRY**

1. Subject Code: **CYN-518** Course Title: **Structure, Bonding and Properties of Solids**

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: **PEC**

8. Pre-requisite: Nil

9. Objective: To impart fundamental understanding of crystal structure, bonding and physical properties of solids.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	**Symmetry in the crystalline state:** Crystal symmetry, elements of translation-screw axis and glide planes, symmetry in a cube, crystal classes, stereographic projection of crystal systems, space symmetry and space groups, Hermann-Mauguin and Schoenflies notations, Wyckoff positions, representation of monoclinic and orthorhombic space groups.	8
2.	**X-Ray diffraction:** Crystal planes and directions, Bragg's law in reciprocal space and Ewald sphere, structure factor, integrated intensity and systematic absences/presences, indexing and simulation of powder X-ray diffraction patterns for simple systems.	8
3.	**Crystal chemistry**: Hard sphere model, structures derived from HCP and CCP packing, crystal structures of various compositions, derived structures and polytypes, non-stoichiometry in solids, atomic order/disorder in solids, single crystals, polycrystals, quasicrystals, amorphous / glassy solids.	8
4.	**Bonding in solids:** Bonding in molecular solids – polymorphism, bonding in extended solids - ionic, covalent and metallic. Band theory of solids - classification of semiconductors, metals and insulators, free electron theory, Bloch's theorem, concept of density of state and elementary band theory, band structures of one-, two- and three- dimensional solids, selected metals and insulators.	8
5.	**Properties of solids:** Thermal, electrical, magnetic and dielectric properties of solids.	10
	Total	42

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	West, A. R., "Solid State Chemistry and its Applications", Reprint, Wiley India.	2013
2.	Rao, C.N.R. and Gopalakrishnan, J., "New Directions in Solid State Chemistry", 2nd Ed., Cambridge University Press.	1997
3.	Stout, G.H. and Jensen, L.H., "X-Ray Structure Determination: A Practical Guide", 2nd Ed., Wiley-Interscience.	1989
4.	Giacovazzo, C., Artioli, G. and Monaco, H. L., "Fundamentals of Crystallography", Oxford University Press.	2006
5.	S. Nicola, "Magnetic Materials: Fundamentals and Device Applications", Cambridge University Press.	2003
6.	Cox, P. A., "The Electronic Structure and Chemistry of Solids", Oxford University Press.	1987

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CHEMISTRY**

1. Subject Code: **CYN-601** Course Title: **Laboratory-III**
2. Contact Hours: **L: 0** **T: 0** **P: 8**
3. Examination Duration (Hrs): **Theory 0** **Practical 8**
4. Relative Weightage: **CWS: 0 PRS: 50 MTE: 0 ETE: 0 PRE: 50**
5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: CYN-511 and CYN-510
9. Objective: To impart practical knowledge and skills in handling instruments in physical, inorganic and organic chemistry laboratories.
10. Details of Course:

Contents	Contact Hours
1. Separation of binary mixture of organic compounds using column chromatography. 2. Simultaneous spectrophotometric determination of concentration of $KMnO_4$ and $K_2Cr_2O_7$ in a given mixture. 3. Determination of Na, K in a soil sample by flame photometry. 4. Determination of metal in alloy samples by AAS. 5. Radiation measurement by GM counter. 6. Determination of metal ions by polarography and voltammetry methods. 7. Extraction of Fe^{3+} using 8-hydroxyquinoline. 8. Catalytic oxidation of organic substrates and analysis by GC. 9. Structure elucidation of organic molecules using ^1H and ^{13}C NMR spectra. 10. Synthesis, characterization and applications of ZnO or CdS or CdSe nanoparticles 11. Luminol synthesis from 3-nitrophthalic acid and chemiluminescence demonstration. 12. Preparation of anthracene from phthalic anhydride. 13. Esterification and nitration of *p*-hydroxybenzoic acid. 14. Synthesis of 4-cyano-2-aminophenol from 4-hydroxybenzaldehyde.	**8 × 14**
Total	**112**

11. Suggested Books:

S. No.	Authors/ Title/ Publisher	Year of Publication/Reprint
1	Mendham, J., Denney, R.C., Barnes J.D. and Thomas M.J., " Vogel's Text Book of Quantitative Chemical Analysis", 6th Ed., ELBS Longman Group UK Ltd.	2004
2	Ewing G.W., "Instrumental Methods of Chemical Analysis", 5th Ed., McGraw Hill.	2004
3	Furniss B.S., Handford A.J., Smith P.W.G. and Tatchell A.R., "Vogel's	1996

	Text Book of Practical Organic Chemistry", 5th Ed., Longman.	
4	Garland C.W., Nifler J.W. and Schoemaber D.P., "Experiments in Physical Chemistry", 7th Ed., McGraw-Hill International.	**2002**
5	Levitt, B.P., "Findlay's Practical Physical Chemistry", 9th Ed., Longman	**1973**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CHEMISTRY**

1. Subject code: **CYN-603** Course Title: **Advanced Analytical Techniques**
2. Contact Hours: **L: 3** **T: 0** **P: 0**
3. Examination Duration (Hrs): **Theory: 3** **Practical: 0**
4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits: **3** 6. Semester: **Autumn** 7. Subject Area: **PEC**
8. Pre-requisite: Nil
9. Objective: To impart knowledge of specialized topics in analytical chemistry.
10. Details of the Course:

S. No.	Contents	Contact Hours
1.	**Electroanalytical methods:** Instrumentation, theory and applications of polarography–normal DC, pulse and differential pulse polarography, AC polarography. Linear and cyclic voltammetry, square wave voltammetry, coulometry at controlled potential, chronopotentiometry, anodic stripping voltammetry. Sensors–different types of solid and liquid sensors, nano material and chemically modified sensors, applications in environmental and biological sample analysis.	14
2.	**Nuclear and X-ray methods:** Radiotracers– choice and synthesis of radiotracers, isotope dilution methods, neutron activation analysis. Material science studies using positron emitters and Mössbauer source. Principles of X-ray spectra, X-ray absorption, emission fluorescence and diffraction methods and applications. Ion beam analysis, proton induced X-ray emission, Rutherford backscattering spectrometry, elastic recoil detection analysis for hydrogen measurement, nuclear microprobe.	14
3.	**Mass spectrometry**. Different types of ion sources, mass analyzers and detectors, resolution and resolving power, interpretation of mass spectra, hyphenated systems like LC-MS, GC-MS, MS-MS.	8
4.	**Atomic spectroscopy and hyphenation** Atomic absorption spectroscopy with electro thermal atomizers, cold vapor technique, inductively coupled plasma atomic emission methods – principle and instrumentation, hyphenation with mass spectrometry (ICP-MS), laser ablation and HPLC.	6
	Total	42

1. Suggested Books:

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

1.	Meites, L., "Polarographic Techniques", 3rd Ed., Interscience publishers, N.Y..	1990
2.	Sane, R.T. and Joshi, A.P., "Electroanalytical Chemistry: Theory and Applications", Quest Publications.	1999
3.	Loveland, W., Morrissey, D. and Seaborg, G.T., "Modern Nuclear Chemistry", John Wiley and Sons, New Jersey.	2006
4.	Sood, D.D., Reddy, A.V.R. and Ramamoorthy N., "Fundamentals of Radiochemistry", IANCAS, BARC, India.	2004
5.	Skoog, D.A., Holler, F.J. and Crouch, S.R., "Principles of Instrumental Analysis", Thomson Brooks/Cole, Canada.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CHEMISTRY**

1. Subject code: **CYN-605** Course Title: **Separation Techniques and Microanalysis**
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: **PEC**
8. Pre-requisite: Nil
9. Objective: To impart knowledge of specialized topics in analytical chemistry.
10. Details of the Course:

S. No.	Contents	Contact Hours
1.	**Chromatographic techniques:** Processes leading to non-ideal chromatography, extended form of Van Deemter equation, gas chromatography– instrumentation, types of column, stationary and mobile phases, detectors, Kovat's index, high pressure liquid chromatography– instrumentation, stationary and bonded-stationary phases, detectors, ion chromatography, size exclusion chromatography, supercritical fluid chromatography, affinity chromatography, electrophoresis.	12
2.	**Liquid – liquid extraction:** Principle, significance of various terms, batch and counter current extraction, classification of extraction systems, extraction equilibria of metal chelates, ion association extraction systems, extraction with high molecular weight amines, synergism, stripping, backwashing, salting out agents, masking agents, emulsion formation, identification of extracting species, analysis of organic phase, analysis of raffinate, environmental considerations, solid phase extraction.	12
3.	**Membrane and allied methods of separation:** Fundamentals and various terms, Liquid membranes, Cloud point extraction, Micellar enhanced separation processes, external field induced membrane separation processes.	4
4.	**Sample preparation techniques for analysis:** Extraction of semi-volatile organics from liquid, solid matrices, sample preparation for metal analysis, isoloation of nucleic acid for analysis, methods for preparing thin films for spectroscopic studies	6
5.	**Microfabrication, microanalysis and automation:** Photolithography, electron and ion beam lithography, microfluidics for analytical techniques used in micro-total analytical System (μTAS), automation in analytical methods,instrumental parameters for automated devices, principles and techniques of automation for microanalysis with emphasis on sequences of operational modes in segmented and continuous flow, non destructive autoanalysers, applications in environmental and clinical cases.	8

		Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/ Publishers	Year of Publication/ Reprint
1.	Rousseau, R.W.,"Handbook of Separation Process Technology", John Wiley & Sons.	**1989**
2.	Fifield, F.W. and Kealey, D., "Principles and Practice of Analytical Chemistry", 5th Ed., Blackwell Science.	**2000**
3.	Li, N.N., Fane, A.G., Winston, W.S. and Matsuura, H. T., (Eds.), "Advanced Membrane Technology and Applications", Wiley.	**2008**
4.	Mitra, S. (Ed.), "Sample preparation techniques in Analytical Chemistry", John Wiley and Sons, New Jersey.	**2003**
5.	Madou, M.J.," Fundamentals of Microfabrications and Nanotechnology", 3rd Ed., CRC Press.	**2011**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CHEMISTRY**

1. Subject: **CYN-607** Course Title: **Electroanalytical Chemistry**
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: **PEC**
8. Pre-requisite: Nil
9. Objective of Course: To introduce theoretical and practical knowledge of various electroanalytical systems.
10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Polarographic techniques:** Operational amplifiers concept and design of polarographic circuit using op-amps. Ilkovic equation, theory of diffusion, kinetic, adsorption and catalytic currents. Controlled potential electrolysis and coulometry. 2 and 3 electrodes systems. Polarography versus voltammetry, determination of number of electrons. Theory of reversible, quasi-reversible and irreversible electrode processes. Pulse and differential pulse polarography and their superiority over DC polarography. A.C. polarography.	14
2.	**Voltammetric techniques:** Linear and cyclic sweep voltammetry, Randles Sevcik equation, effect of sweep rate and evaluation of adsorption characteristics of reactant or product using CV. Coupled chemical reactions and their characterization. Characteristics of commonly used working electrodes such as glassy carbon, platinum, pyrolytic graphite and reference electrodes SCE and Ag/AgCl. Enzyme catalysed oxidations of biomoleules viz., uric acid, guanine, adenine and their comparison with electrochemical reactions. Anodic and cathodic stripping and determination of metal ions, pollutants and biomolecules using stripping voltammetry.	14
3.	**Sensors:** Amperometric and voltammetric sensors. Modified electrodes and their advantages over conventional electrodes in sensing variety of metals and biomolecules. Nanomaterials in electrode modification–C_{60}, single wall and multi wall carbon nanotubes. Preparation and characterization of modified surfaces. Applications of sensors in determining cases of doping.	7
4.	**Polarographic and cyclic voltametric studies of coordination compounds:** Compounds containing one or more redox centers, coupled chemical reactions — EE and EEE mechanisms, stability constant of complexes.	7
	Total	**42**

11. Suggested Books:

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

1.	Meites, L., "Polarographic Techniques", 3rd Ed., Interscience publishers, N.Y.	1990
2.	Lund and Baizer, "Organic Electrochemistry", Marcel Dekker, New York.	2000
3.	Bard, A.J. and Faulkner, L.R., "Electrochemical Methods-Fundamentals and Applications", John Wiley.	2000
4.	Sane, R.T. and Joshi, A.P., "Electroanalytical Chemistry: Theory and Applications", Quest Publications.	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject: **CYN-609** Course Title: **Inorganic Biochemistry and Reaction Mechanism**
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: **PEC**
8. Pre-requisite: Knowledge of coordination chemistry.
9. Objective of Course: To familiarize the students with mechanisms of inorganic reactions and inorganic biochemistry.
10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Inorganic reaction mechanism:** Substitution reactions in octahedral complexes–exchange reactions, acid- and base-hydrolysis, annation reaction, solvolytic and catalysed reactions. Substitution reactions in square-planar complexes–effect of non-participation of ligands on reactivity, *cis* and *trans* effects.	6
2.	**Electron transfer reactions:** Outer- and inner-sphere mechanisms, factors affecting electron transfer reaction rates, theories of electron transfer reactions, solvated electron.	5
3.	**Photochemistry of metal complexes:** Introduction to inorganic photochemistry, photochemically excited states and excited state processes for transition metal complexes, photochemical reactions of coordination compounds (Cr and Ru complexes), types of photochemical reactions in transition metal complexes–substitution, decomposition, fragmentation, rearrangement and redox reactions. Mechanism of charge transfer (CT) to mass (CTTM) photoreduction. Applications of photochemical inorganic reactions in synthesis, catalysis, biological processes and in lasers.	6
4.	**Inorganic biochemistry:** Metalloproteins and enzymes– Role of metal ions in the active sites, structure and functions of metalloproteins and enzymes containing Mg, Ca, V, Mn, Fe, Co, Ni, Cu and Zn ions. Detailed structure and mechanistic studies of the following–Mn-photosystem-II, catalase, pseudocatalase, oxygen carriers, haemoglobin, myoglobin, non-porphyrin oxygen carriers, hemerythrin, hemocyanin, Fe-ribonucleotide reductase, cytochrome c oxidases, cytochrome P-450s, Ni-urease, hydrogenase, nitrogen fixation, Cu-blue copper protein, tyrosinase, galactose oxidase, superoxide dismutases, Zn-carbonicanhydrase, carboxypeptidase, alcohol dehydrogenase. Biological importance of Vitamin B_{12} and coenzymes, and their biomimetic studies.	17
5.	**Chemical toxicity and metallotherapy:** Toxic chemicals in the environment, toxic effects of arsenic, cadmium, lead, mercury, carbon monoxide, cyanide and other carcinogens, metal containing drugs in therapy, interaction of heavy metal ions with DNA, DNA cleavage, structure-activity relationship and mode of action. Organometallic compounds as therapeutic drugs and enzyme inhibitors.	8
	Total	42

11. Suggested books:

S.No.	Name of Authors/Books/ Publishers	Year of Publication/ Reprint
1.	Huheey, J.E., Keiter, E. and Keiter, R., "Inorganic Chemistry: Principles of Structure and Reactivity", 4th Ed., Pearson Education Asia, 3rd Indian reprint.	2001
2.	Wilkins, R.G., "Kinetics and Reaction Mechanism of Transition Metal Complexes", 2nd Revised Ed., VCH, New York.	1991
3.	Mukherjee, G.N. and Das, A., "Elements of Bioinorganic Chemistry", Ist Ed., U.N. Dhur & Sons Pvt. Ltd., Calcutta.	1993
4.	Gillman, G., "Pharmacological, Basis of Therapeutic", 9th Ed., McGraw Hill.	1996
5.	Bertini, I., Gray, H.B., Lippard, S.J. and Valentine, J.S., "Bioinorganic Chemistry", University Science Books, U.S.A.	1994
6.	Lippard, S.J. and Berg, J., "Principles of Bioinorganic Chemistry", University Science Books, U.S.A.	1994

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject: **CYN-611** Course Title: **Solid-State Chemistry and its Applications**
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: **PEC**
8. Pre-requisite: Knowledge of inorganic chemistry.
9. Objective of Course: To familiarize the students with crystal structures of common inorganic compounds and their characterization methods.
10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Crystal structure of inorganic compounds:** Overview of close packing, packing efficiency, interstitial sites, limiting radius ratios, method of determination of ionic radii. Ionic crystals containing two or three different elements– FeO, ZnO, CdS, fluorite, antifluorite, nickel-arsenide, CaC_2, CdI_2 and TiO_2, $FeTiO_3$, $MgAl_2O_4$, Fe_2NiO_4, garnets, $BaTiO_3$ and $KNiF_3$. Non-ionic crystals– SiC, (BN)x, giant molecules, layer structures, crystals composed of discrete molecules.	11
2.	**Defect structures:** Thermodynamic defects and their consequences, solid electrolytes, non-stoichiometric compounds, F-centers and applications of defects in non-stoichiometric compounds.	3
3.	**Methods to synthesize solid-state materials:** Ceramic method, solid-state reaction and its kinetics, hydrothermal, sol-gel, co-precipitation (precursor), vapour phase transport methods. Different methods to grow single crystals.	6
4.	**Amorphous inorganic materials:** Glasses, refractories, materials obtained from organometallic chemical vapour deposition (MOCVD). **New materials:** Conducting polymers, carbon nanotubes, carbon nanorods and fullerenes. **Electronic materials:** Insulating, semiconducting and superconducting materials, ferroelectrics and dielectrics.	6
5.	**Intercalation chemistry:** Introduction, intercalation reactions in graphite, layered double hydroxides, layered sulfides, applications of intercalation chemistry.	3
6.	**Mesoporous materials and their catalytic applications:** Various types of mesoporous materials (oxides, sulphides), tailoring of pore size, applications of mesoporous materials in heterogeneous catalysis.	3
7.	**Structural characterization of metal complexes by physical methods:** Extended X-ray absorption spectroscopic (EXAFS), X-ray photoelectron spectroscopic (XPS), X-ray absorption near edge spectroscopic (XANES), electron spin spectrometric (ESR), electron spectroscopy for chemical analysis (ESCA) studies, soild state NMR, HMBC, HMQC, Mössbauer spectroscopic studies of metal complexes, thermal methods (TG, DTA and DSC), atomic force microscopy (AFM) and transmission electron microscopy (TEM).	10
	Total	42

11. Suggested books:

S.No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Douglas, B.E., McDaniel, D.H. and Alexander, J.J., "Concepts and Models of Inorganic Chemistry", 3rd Ed., John Wiley & Sons, Inc., New York.	2001
2.	West, A.R., "Solid State Chemistry and its Applications", Reprint, Wiley India.	2013
3.	Smart, L. and Moore, E., "Solid State Chemistry: An Introduction", Nelson Thornes Ltd.	2001
4.	Rao, C.N.R. and Gopalakrishnan, J. "New Directions in Solid State Chemistry", 2nd Ed., Cambridge University Press, Cambridge.	1997
5.	Whittingham, M.S. and Jacobson, A.J. (Ed.), "Intercalation Chemistry", Academic Press, New York.	1982

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject: **CYN-613** Course Title: **Frontiers in Bioinorganic Chemistry**
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: **PEC**
8. Pre-requisite: Nil
9. Objective of Course: To impart knowledge about metalloproteins from cellular and molecular biological point of view.
10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Homeostatic mechanism:** Cellular components and pathways in the context of metal ions, homeostatic mechanism in cell – prokaryotes to eukaryotes to human. Evolutionary pathway metals, metallocofactors and prosthetic groups.	3
2.	**Metal ion transport and assembly of metalloproteins:** Details of the metal transport in Yeast and in higher organisms, Proteins involved in uptake and efflux, metallochaperones, transcription factors (Ace1 and Mac1, copper sensor). Assembly of metals in protein, photoactivation. Heme synthesis, covalent and non-covalent interactions of heme with protein, assembly of heme in heme proteins-cytochrome c vs cytochrome b5, heme chaperoning and role of CCME. Identification of a protein as heme protein, heme oxygenase, reconstitution of hemeproteins with modified heme/other cofactors and their application in biocatalysis and electron transfer.	6
3.	**Molybdenum and tungsten in biology:** Hyperthermophilic and thermophilic bacteria. Mo and W containing enzymes, mechanism of catalytic activity– nitrogenase, sulfite oxidase, nitrate reductase, acetylene hydratase, xanthine oxidase, DMSO reductase. Structural and functional modeling of Mo and W sites and their applications as biocatalysis.	6
4.	**Iron in biosystem:** Non-Heme– iron-sulphur proteins, other non-heme iron proteins– lipoxygenase and its implication in cancer research, nitrile hydratase and its application to industry. Structural and functional modeling of heme and non-heme metal-sites and their applications as biochemistry and biocatalysis with examples such as nitrile hydratase, lipoxygenase, acetyl coenzyme synthetase (ACS), DAP1. Heme– catalytic mechanism of nitric oxide synthease and heme oxygenase.	5
5.	**Metal ions and diseases:** Role in Alzheimer's disease– Aggregation of proteins, role of copper, zinc and iron. Application of radiochemistry for the identification of metal ions. Metal binding in prion protein–binding of copper and manganese. Manganism– occupational exposure, manganese toxicity, effect on calcium channel, proteomics of manganese toxicity. Inorganic NO-donor and their applications.	8
6.	**Bioinformatics and postgenomic era:** Search of metalloprotein and metal binding	

	motif (eg Dap1). De novo design of proteins, artificial heme binding protein, target protein. Modeling with protein structure from protein data bank. DNA intercalation and electron transfer through DNA, RNA metal interactions.	5
7.	**Biomineralization:** Biomineralization in the context of bone, teeth and mollusk cells, application into materials science and biomimetic engineering. Bioorganometallic chemistry– introduction and applications.	4
8.	**NMR structural biology and structure solution of metalloproteins:** Selection of a target protein, plasmid preparation and overexpression, reparation of sample for NMR. Overexpression of heme protein–cytochrome c vs cytochrome b. Labeling of protein by ^{15}N and ^{13}C, standardization of overexpression and purification (heme as well as nonheme). Details of the NMR Experiments for spectral analysis, paramagnetic NMR, structure solution.	5
	Total	42

11. Suggested books:

S.No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Cotton, F.A. and Wilkinson, G. "Advanced Inorganic Chemistry", 4th Ed. John Wiley & Sons, New York.	1980
2.	Huheey, J.E., Keiter, E.A. and Keiter, R.L. "Inorganic Chemistry: Principles of Structures and Reactivity", 4th Ed., Low Print Edition, Pearson Education Ltd, Asia, Reprint in India.	2001
3.	Bertini, I., Gray, H.B. Lippard, S.J. and Valentine, J.S. "Bioinorganic Chemistry", University Science Book, South Asian Edition Reprint.	2004
4.	Pecoraro, V.L. "Manganese Redox Enzymes", VCH: New York.	1992
5.	Bertini, I., Sigel, A. and Sigel, H. "Handbook on Metalloproteins", Marcel Dekker.	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OD DEPTT./CENTRE: **DEPARTMENT OF CHEMISTRY**

1. Subject: **CYN-615** Course Title: **Crystal and Molecular Structure**
2. Contact Hours: **L: 2 T: 0 P: 2/2**
3. Examination Duration (Hrs): **Theory: 2 Practical: 0**
4. Relative weightage: **CWS: 20 PRS: 20 MTE: 20 ETE: 40 PRE: 0**
5. Credits: 3 6. Semester: **Autumn** 7. Subject Area: **PEC**
8. Pre-requisite: Nil
9. Objective of Course: To highlight relationship between crystal symmetry and their molecular structure determination process.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Symmetry and space group:** Concept of crystal morphology and crystal symmetry, introduction of screw axis and glide plane, crystal systems and space groups, relation between systematic absence and space group.	6
2.	**Single crystal X-ray diffraction:** X-ray source, generation of monochromatic wavelength, X-ray diffraction, Bragg equation, concept of reciprocal lattice, Bragg's law in reciprocal lattice, atomic scattering factor, structure factor equation and limiting conditions, intensity and intensity statistics, polarization and Lorentz correction, temperature factor and anisotropic effect, optical classification of crystals, phase problem. Small angle X-ray scattering/diffraction.	10
3.	**Single crystal X-ray data handling:** Fourier techniques for electron density calculation in X-ray structure, electron density map, heavy atom method, Patterson function, direct method, normalized structure factor, Σ_2 relationship, least square refinement, anomalous dispersion, twinning in crystal.	8
4.	**Neutron diffraction:** Introduction to neutron diffraction, neutron sources and detection of neutrons, scattering cross sections, application to the studies of molecular structure especially for the detection of neighbouring and light atoms.	4
	Total	**28**

List of Experiments:

1.	Introduction to the WinGX software to handling single crystal data.
2.	Determination of space group from the *hkl* data set by systematic absences.
3.	Structure solving with isotropic displacement parameter*.
4.	Structure solving with anisotropic displacement parameter and temperature effect.
5.	Treatment of hydrogen for complete structure determination.
6.	Generation of cif, ortep and checking of cif

* This experiment requires two terns.

11. Suggested books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/ Reprint
1.	Stout, G.H. and Jensen, L.H., "X-Ray Structure Determination: A Practical Guide", 2nd Ed., John Wiley and Sons, New York.	1989
2.	Clegg, W., Blake, A.J., Gould, R.O. and Main, P. "Crystal Structure Analysis: Principles and Practice", Oxford Science Publications.	2006
3.	Ladd, M. and Palmer, R. "Structure Determination by X-ray Crystallography", 4th Ed., Kluwer Academic/Plenium Publishers.	2003
4.	Massa, W. "Crystal Structure Determination" Springer-Verlag, Berlin, Heidelberg.	2004
5.	Buerjer, M.J. "Crystal Structure Analysis", John Wiley and Sons, New York.	1987

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject: **CYN-617** Course Title: **Supramolecular Chemistry**

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: **PEC**

8. Pre-requisite: Basic chemistry and spectroscopy.

9. Objective of Course: To impart in depth knowledge of non-covalent interactions in supramolecular systems and their applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Fundamentals of supramolecular chemistry:** Definitions, brief overview and examples; types of non-covalent interactions (H-bonding, electrostatic (ion-ion, ion-dipole, dipole-dipole), hydrophobic and steric, π-π, van der Waals), concepts of host-guest complexation with examples from ionophore chemistry, complexation of ions, molecular baskets, chalices and cages– podands, crown ethers, cryptands, calixarenes, macrocyclic effect, complexation of neutral molecules, self-assembly, molecular boxes and capsules, self-complementary species and self-replication.	8
2	**Supramolecular chemistry and biological processes:** Cation binding (biological relevance, affinity and selectivity, artificial ionophores, natural and artificial cation channels). Anion and neutral molecule binding –relevance factors affecting affinity and selectivity, anion and neutral molecule binding in biology, artificial hosts for anions, katapinands, guanidinium receptors, receptors based upon Lewis acid-base concepts, enantio-selective anion recognition, cyclodextrins, anion binding based upon ion-dipole interactions, simultaneous anion-cation binding, neutral molecule recognition and binding.	8
3	**Synthesis of supramolecules:** Synthesis of macrocycles, synthesis of receptors for cations anions, and neutral molecules, non-covalent synthesis, metal directed self-assembly of complex supramolecular architecture– rotaxanes, catenanes.	6
4.	**Physical methods in supramolecular chemistry:** Spectroscopy in supramolecular chemistry, determination of stoichiometry, stability constants, and geometry of complexes, binding constant determination, dynamics of supramolecular systems (solid state *vs* solution behavior).	8
5.	**Application of supramolecular chemistry:** Supramolecules in catalysis, as membrane transport, sensors, phase-transfer catalysts, supramolecular devices and switches, memories, logic gates and related systems, molecular scale machines (mechanical rotors, gears and brakes), conversion of light into fuels and light into electricity.	12
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors/ Bokks/ Publishers	Year of

		Publication/ Reprint
1.	Steed, J.W. and Aswood, J.L., "Supramolecular Chemistry", Wiley.	2000
2.	Dodziuk,,H., "Introduction to Supramolecular Chemistry", Springer, ISBN 1402002149.	2001
3.	Beer, P.D., Gale, P.A. and Smith, D.K., "Supramolecular Chemistry", Oxford Chemistry Printers, ISBN-10: 0-19-850447-0.	1999
4.	Cragg, P., "A Practical Guide to Supramolecular Chemistry", Wiley-VCH, ISBN: 0-470-86654-3.	2005
5.	Schneider, H.J. and Yatsimirsky, A., "Principles and Methods in Supramolecular Chemistry", Wiley-VCH, ISBN: 0-471-97253-3.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject: **CYN-619** Course Title: **Modern Organic Synthetic Methods**

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: **PEC**

8. Pre-requisite: Basic organic chemistry.

9. Objective of Course: To impart the knowledge of modern synthetic methods used in functional group transformations.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Oxidations:** Oxidations of hydrocarbons (alkanes, alkenes and aromatic), alkenes to epoxides (peroxides/per acids based), Sharpless asymmetric epoxidation, Jacobsen epoxidation, Shi epoxidation, alkenes to diols (Manganese, Osmium-based), Sharpless asymmetric dihydroxylation, Prevost reaction and Woodward modification, alkenes to carbonyls with bond cleavage (manganese, osmium, ruthenium and lead based-ozonolysis), alkenes to alcohols/carbonyls without bond cleavage (hydroboration-oxidation, Wacker oxidation, selenium, chromium based allylic oxidation), ketones to α-hydroxy ketones, α,β-unsaturated ketones, ester/lactones (Baeyer-Villiger), alcohols to carbonyls (chromium, manganese, aluminum, silver, ruthenium, DMSO, hypervalent iodine and TEMPO based reagents), alcohols to acids or esters, phenols (Fremy's salt, silver carbonate).	12
3.	**Named reactions:** Baylis-Hillman reaction, Henry reaction, Nef reaction, Kulinkovich reaction, Ritter reaction, Sakurai reaction, Tishchenko reaction, Ugi reaction, Brook rearrangement and Tebbe olefination.	6
4.	**Protection and deprotection of functional groups:** Protection and deprotection of hydroxy, carboxyl, carbonyl, carboxy amino groups and carbon-carbon multiple bonds, chemo- and regioselective protection and deprotection, illustration of protection and deprotection in multi-step synthesis.	6
5.	**Retrosynthetic analysis:** Basic principles and terminology of retrosynthesis, guidelines, synthesis of aromatic compounds, one group and two group C-X disconnections, one group C-C and two group C-C disconnections, amine and alkene synthesis, important strategies of retrosynthesis, functional group transposition, important functional group interconversions, reversal of polarity (umpolung).	8
	Total	42

11. Suggested books:

S. No.	Name of Authors/Books/Publishers	Year of Publication / Reprint
1.	Carey, F. A. and Sundberg, R. J., "Advanced Organic Chemistry, Part B: Reactions and Synthesis", 5th Ed., Springer.	2007
2.	Carruthers, W. and Coldham, I., "Modern Methods of Organic Synthesis", 4th Ed., Oxford University Press.	2004
3.	Smith, M.B., "Organic Synthesis", 3rd Ed., Academic Press.	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject: **CYN-621** Course Title: **Organic Structure Determination**

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: **PEC**

8. Pre-requisite: Basic organic chemistry.

9. Objective of Course: To familiarize the students with the organic structure determination methods involving spectroscopy.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Electronic spectroscopy:** Electronic transitions in organic molecules, Woodward-Fieser rules for alkenes, Woodward rules for enones, aromatic compounds.	4
2.	**Infrared and Raman spectroscopy:** For simple organic molecules, predicting number of active modes of vibrations, analysis of representative spectra of compounds with various functional groups, application of isotopic substitution.	4
3.	**Mass spectrometry:** Basic principles, hard and soft ionization techniques, mass analyzer in ESI-MS and MALDI-MS, high resolution MS, isotope abundance, molecular ion, fragmentation processes (McL) of organic molecules, deduction of structure through mass spectral fragmentation.	6
4.	**Nuclear magnetic resonance:** Effect of magnetic field strength on sensitivity and resolution, chemical shift δ, inductive and anisotropic effects on δ, chemical structure correlations of δ, chemical and magnetic equivalence of spins, spin-spin coupling, structural correlation to coupling constant *J*, first order and second order spectra, examples of AB, AX, ABX, AMX and AA'BB' systems, simplification of second order spectrum, selective decoupling, double resonance, use of chemical shift reagents for stereochemical assignments, ^{13}C NMR, T_1 relaxation, NOE effects, DEPT, determination of number of attached hydrogens, ^{1}H and ^{13}C chemical shifts to structure correlations, study of dynamic processes by VT NMR, restricted rotation (DMF, DMA, biphenyls, annulenes), cyclohexane ring inversion, degenerate rearrangements (fullvalene and related systems). Multinuclear NMR, COSY, DQF-COSY, HETCOR, HMQC, HMBC, TOCSY, ROESY, VGSE.	20
5.	**Spectroscopic application**: Structure elucidation of organic compounds using spectroscopic methods.	8
	Total	42

2. Suggested books:

S. No.	Name of Authors/Books/Publishers	Year of Publication / Reprint
1.	Silverstein, R. M., Webseter, F. X. and Kiemle, D., "Spectrometric Identification of Organic Compounds", 7th Ed., John Wiley & Sons.	2005
2.	Kemp, W. L., "Organic Spectroscopy", Palgrave.	2008
3.	Pavia, D. L., "Spectroscopy", 4th Ed., Cengage.	2012
4.	Williams, D. and Fleming, I., "Spectroscopic Methods in Organic Chemistry", 6th Ed., McGraw Hill Education (India) Private Limited.	2011

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject: **CYN-623** Course Title: **Organic Semiconductors**

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: **PEC**

8. Pre-requisite: Basic organic chemistry and spectroscopy.

9. Objective of Course: The course will deal with rapidly emerging areas in organic electronic materials.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Introduction:** General description of conjugated organic oligomers, dendrimers and polymers. Conjugated polymer structural types (polyacetylenes, polyphenylene-vinylenes, polyphenyeleneethynylenes, polyfluorenes, polythiophenes, poly-phenylenes, polyanilines, water soluble polymers, phosphorescent polymers). Carbon-rich compounds, Cross-conjugation.	6
2	**Synthesis:** Useful synthetic methods for the construction of conjugated organic oligomers and polymers. C-C and C-heteroatom coupling reactions – historical context and latest developments. Representative examples. Mechanistic consideration. All-benzenoid polycyclic aromatic hydrocarbons– synthesis, self-assembly and applications in organic electronics. Solid state strategy for the preparation of carbon-rich polymers.	10
3	**Properties:** Electronic structure of organic semiconductors – relationship between two view points: solid state physics and molecular picture of conjugated organics. Electrochemistry, electrochromism and energy level measurements. Charge transport (electronic conduction in photoactive molecular-wires). Luminescence. Energy transfer and electron transfer. Excitation dynamics in organic semiconductors. Fluorescence sensing. Non-linear optical properties.	14
4.	**Applications:** Field-effect transistors, light-emitting diodes, photovoltaics and solar cells–device architectures, materials, characterization and theory of operation. Biosensors – electrochemical detection, fluorescence optical amplification (protein, DNA and RNA sensing), solid state applications (DNA chips and micro arrays).	12
	Total	42

11. Suggested books:

S.No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Haley, M.M. and Tykwinski, R.R. (Ed.), "Carbon-Rich Compounds: From Molecules to Materials" Wiley.	2006
2.	Singh, J., "Smart Electronic Materials: Fundamentals and Applications", Cambridge University Press.	2005
3.	Fraxedas, J., "Molecular Organic Materials: From Molecules to Crystalline	2006

	Solids", Cambridge University Press.	
4.	Schubert, E.F., "Light-Emitting Diodes", 2nd Ed., Cambridge University Press.	**2006**
5.	Brabec, C., Dyakonov, V., Parisi, J. and Sariciftci, N.S. (Ed.), "Organic Photovoltaics", Springer.	**2003**
6.	Agranovich, V.M. (Ed.), "Organic Nanostructures", IOS press.	**2002**
7.	Norio, M. (Ed.), "Cross-Coupling Reactions: A Practical Guide", Springer.	**2002**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject: **CYN -625** Course Title: **Proteins and Polypeptides**
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: **PEC**
8. Pre-requisite: Basic knowledge of analytical techniques.
9. Objective of Course: To provide advanced knowledge in protein chemistry.
10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Proteins and peptides:** General nature, characteristics, introduction to primary, secondary and tertiary structures.	4
2.	**Separation and purification methods:** Electrophoresis, isoelectric focussion, gel filtration, affinity chromatography, and ion exchange – choice of gel support materials (agarose, cellulose, polyacrylamide, glass beads, DEAE-cellulose, CM-cellulose etc.) HPLC.	8
3.	**Fragmentation of polypeptides:** Chemical methods – cleavage of di-sulfide bonds, oxidation, partial acid hydrolysis, cleavages at methionine, tryptophan, tyrosine, cysteine. Enzymic methods – protein modification reactions disulphide bond cleavage, alkylaton of sulphydryl groups, modification of lysine and arginine residues. Specificity and conditions for trypsin, thrombin, chymotrypsin, thermolysin, pepsin papaine.	12
4.	**Determination of peptide sequences:** Manual sequencing, solid phase sequence analysis, automated liquid phase sequence analysis, microsequence analysis using a gas-liquid solid-phase sequenator, C-terminal sequence analysis.	6
5.	**Applications of electron impact mass spectrometry,** X-ray crystallography and electron microscopy: In the structural analysis of peptides and proteins.	6
6.	**Peptide mapping and peptide synthesis**: Prediction of peptide and protein structure. Peptide synthesis including solid-phase and automated synthesizers.	6
	Total	42

11. Suggested books:

S.No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Lehninger A.L., "Biochemistry", North Publishers.	1980
2.	Stryer L., "Biochemistry", CBS Publications and distributors.	1981

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject: **CYN- 627** Course Title: **Advanced Surface and Colloidal Chemistry**
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: **PEC**
8. Pre-requisite: Knowledge of physical chemistry.
9. Objective of Course: To impart advanced knowledge of surface and interfacial phenomenon.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Surfactants and Interfacial Phenomena:** Classification, micellization, c.m.c. and its determination. Shape and structure of micelles, effect of additives on micellization, thermodynamics of micellization, solubilization and applications, effect of electrolytes on solubilization. Macro and micro emulsions, dispersion and aggregation of solids by surfactants.	9
2.	**Membranes and their Applications:** Artificial and natural membranes, Donnan membrane equilibrium, transport of electrolytes, membrane potential and ion selective electrodes.	6
3.	**Adsorption on solids and porous materials:** Model for multilayer adsorption, BET isotherm and application to different types of adsorbents, adsorption by porous, non-porous and microporous solids. Estimation of specific surface area and pore size distribution. Special problems encountered with very narrow pore size material and adsorption from liquid phase.	7
4.	**Colloid systems and their properties:** Origin of the charges, electro-kinetic phenomena, electrophoresis, electroosmosis, sedimentation and streaming potential. The concept of electrical double layer and various models to explain its structure and properties, DLVO theory and stability of colloids. Smoluchowski theory of kinetics of coagulation and distribution of colloids aggregates. Organic and inorganic gels and clay colloids.	8
5.	**Macromolecules:** Concepts of mass and number average molecular weights, methods of determining molecular weights (osmometry, viscometry, diffusion and light scattering method), sedimentation, fractional properties of macromolecules, statistical distribution of end to end dimension, calculation of average dimension of various chain structures.	12
	Total	**42**

11. Suggested books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Hunter, R. J., "Foundation of Colloid Science", Oxford Univ. Press.	2009
2.	Lyklema, J., "Fundamentals of Interface and Colloid Science", Academic Press San Diego.	2000

3.	Adamson, A.W.,"Physical Chemistry of Surfaces", 5th Ed., John Wiley and Sons, New York.	**1990**
4.	Kruyt, H.R., "Colloid Chemistry" Vol. I & II. Elsevier Press.	**1991**
5.	Greg, S.J. and Singh, K.S.W., "Adsorption, Surface Area and Porosity", 2nd Ed., Academic Press. U K.	**1982**
6.	Flory P. J., "Principles of Polymer Chemistry", 1st Ed., Cornell University Press.	**1953**
7.	Rubinstein M. and Colby R. C., "Polymer Physics", 1st Ed., Oxford University Press.	**2003**
8.	Billmeyer, F. W., "Textbook of Polymer Science", 3rd Ed., Wiley India Private Limited	**2007**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject: **CYN-629** Course Title: **Advanced Physical Chemistry**
2. Contact Hours: **L: 3 T: 0 P: 0**
3. Examination Duration (Hrs) Theory **03** Practical **0**
4. Relative weightage: **CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0**
5. Credits: **3** 6. Semester: **Autumn** 7. Subject Area: **PEC**
8. Pre-requisite: Knowledge of physical chemistry
9. Objective of Course: To familiarize the students with advanced kinetics, thermodynamics and quantum chemistry.
10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Advanced chemical kinetics:** Theories of unimolecular reactions, kinetics-proton transfer and electron transfer reactions, fast reactions–rapid flow, stopped-flow and relaxation techniques, molecular beam method, diffusion controlled reactions, oscillatory reactions, linear free energy relationship, elucidation of mechanism from kinetic data.	14
2.	**Statistical mechanics and irreversible thermodynamics:** Phase space, Liouville's theorem, Maxwell-Boltzmann, Bose-Einstein, Fermi-Dirac statistics. Affinities and fluxes, reversible and irreversible processes, entropy production for some important irreversible processes, entropy flow due to exchange of mater and energy, entropy changes due to chemical reaction, affinity and coupling of chemical reaction, the phenomenological laws and equations and their applications in chemistry, fluctuations, response functions, time correlation function, distribution function.	14
3.	**Advanced quantum chemistry:** Dirac Bra-ket notation, addition of angular momentum, use of ladder operators– rigid rotor and harmonic oscillator, variation method– treatment of He atom, perturbation method– examples of anharmonic oscillator, He atom, Stark and Zeeman splitting, Hartree-Fock method, introduction to post Hartree-Fock methods.	14
	Total	42

11. Suggested books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Laidler, K.J., "Reaction Kinetics", Anand Sons, New Delhi.	2005
2.	Kondepudi, D. and Prigogine, I. , "Modern Thermodynamics: From Heat Engines to Dissipative Structures", John Wiley & Sons.	1998
3.	Callen, H. B., "Thermodynamics and an Introduction to Thermostatistics", John Wiley and Sons.	1985
4.	Bransden, B.H. and Joachain, C.J., "Quantum Mechanics", Addison-Wesley.	2000
5.	Sakurai, J. J., "Modern Quantum Mechanics", Pearson Education.	1994

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **CYN- 631** Course Title: **Materials Chemistry**

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

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

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

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

8. Pre-requisite: Structure, Bonding and Properties of Solids.

9. Objective: To introduce the students in the area of materials chemistry.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Reactions in the solid state and phase transitions:** General principles, kinetics of solid-state reactions-nucleation and diffusion rate, Wagner mechanism, Kirkendall effect, Vegard's law, phase transition-Ehrenfest classification and Lanbda transition, structural and magnetic phase transitions order-disorder, martensitic and atensitic, ferro-para.	4
2.	**Structure determination**: X-ray powder diffraction - lattice refinement, pattern simulation, refinement of crystal structure– Rietveld method, profile fitting, refinement of occupancy and thermal factors, isotropic and anisotropic displacements, reliability factors. Neutron scattering–elastic and inelastic, diffraction experiments with neutron, chemical and magnetic structure, magnetic scattering, elucidation of magnetically ordered structures.	8
3.	**Advanced materials and devices:** Magnetic materials, dilute magnetic semiconductors, magnetic shape-memory alloys, magnetoresistive, semiconducting, superconducting, multiferroic and spintronic materials, graphene and its nanocomposites, Li-ion batteries, solid oxide fuel cells, perovskite solar cells, magnetic tunnel junctions and spin-valves.	10
4.	**Preparation methods and processing of materials:** Revisit to general synthetic routes- gas-solid, liquid-solid and solid-solid methods. Sputtering, pulsed laser deposition (PLD), molecular beam epitaxy (MBE), liquid quenching, arc melting, induction, zone melting, chimie-douce, high-pressure, mechanochemical, ball-milling methods.	6
	Total	28

List of experiments:

1.	Drawing and visualization of crystal structures and structural parameter analysis.
2.	Indexing of powder X-ray diffraction (PXD) patterns.
3.	Lattice parameter refinement and doping analysis.
4.	Simulation of PXD patterns and occupancy modelling in doped systems.
5.	Whole pattern fitting-Le Bail method.
6.	Rietveld refinement of PXD data for crystal structure determination.

7. 8. 9.	Density functional theory softwares. Electronic structure calculation of metals/insulators. Electron localization function and Fermi surface calculation.

11. Suggested Books:

S. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	West, A. R., "Solid State Chemistry and its Applications", Reprint, Wiley India.	2013
2.	Rao, C.N.R. and Gopalakrishnan, J., "New Directions in Solid State Chemistry", 2nd edn., Cambridge University Press.	1997
3.	Stout, G.H. and Jensen, L.H., "X-Ray Structure Determination: A Practical Guide", 2nd edn., Wiley-Interscience.	1989
4.	Giacovazzo, C., Artioli, G., Monaco, H. L., "Fundamentals of Crystallography", Oxford University Press.	2006
5.	"Magnetic Materials: Fundamentals and Device Applications", Nicola Spaldin, Cambridge University Press.	2003
6.	"Electronic Structure of Materials", A. P. Sutton, A. D. Sutton, Oxford University Press.	1993

Sl. No.	Softwares and Databases		Source
1.	Diamond	(commercial)	www.crystalimpact.com
2.	XCrysden	(freeware)	http://www.xcrysden.org/
3.	ICSD	(commercial)	www.fiz-karlsruhe.com
4.	Powder Cell	(freeware)	www.ccp14.ac.uk
5.	FullProf	(freeware)	www.ill.eu
6.	Full Potential Localized Orbital (FPLO) Code	(commercial)	www.fplo.de

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CHEMISTRY**

1. Subject Code: **CYN-633** Course Title: **Nanoscale Materials: Properties and Applications**

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: **PEC**

8. Pre-requisite: Nil

9. Objective: To impart fundamental understanding on nanoscale materials, their properties and applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to nanoscale materials:** The nano-length scale, quantum confinement effect, consequences of quantum confinement of electrons, conceptual development of band theory – from molecules to clusters/quantum dots to macroscopic crystals, material dependence of nanoscale and quantum size-effect, consequences of carrier confinement in semiconductors and metals.	6
2.	**Structure of nanomaterials:** Crystalline and amorphous nanomaterials, nanocrystals, surface energy and crystal facets, equilibrium shape of nanocrystals, Wulff construction, Roughening temperature, surface energy as a function of surface curvature, chemical potential and solubility as a function of surface curvature and particle size, Ostwald ripening, nucleation and growth of nanoparticles.	6
3.	**Physical and chemical characteristics of nanomaterials:** Surface area measurement, determination of size and textural studies, composition and elemental analysis, high chemical reactivity of nanoscale materials, effect of size and shape on nanocrystal reactivity, agglomeration and sintering of nanomaterials, dispersibility and chemical stability of nanoparticles in solution, surface modification of metallic and semiconductor nanoparticles, nanofabrication and nanomanipulation	12
4.	**Synthesis and applications of nanomaterials:** Concepts of top-down and bottom-up approaches, chemical, aerogel, aerosol, spray-pyrolysis, microemulsion, solvothermal, sonochemical, and microwave methods of synthesis. Reactivity studies by adsorption–SO_2, CO_2, H_2S, CCl_4 and chemical warfare agents, destructive adsorption, detoxification by adsorption, air purification, desulphurization, biocidal applications, modification of nanocrystalline metal oxides and their applications.	14
5.	**Toxicology of nanomaterials:** Health concerns of using nanomaterials, inhalation toxicity, oral toxicity, environmental toxicity, cyto- and bio-toxicity of	4

	nanomaterials, environmental protection, precautions and case studies.	
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Klabunde, K.J. (Ed.), "Nanoscale Materials in Chemistry", Wiley-Interscience, New York.	**2001**
2.	Schmid, G. (Ed.), Nanoparticles: From Theory to Application", Wiley-VCH, Weinheim.	**2004**
3.	Cao, G. and Wang, Y., "Nanostructures and Nanomaterials: Synthesis, Properties and Applications", 2nd Revised Ed., World Scientific.	**2011**
4.	Rodriguez, J. A. And Fernandez-Garcia, M. (Ed.), "Synthesis, Properties and Applications of Oxide Nanomaterials", John Wiley, New York.	**2006**
5.	Rao, C.N.R., Müller, A. and Cheetham, A.K., "The Chemistry of Nanomaterials: Synthesis, Properties and Applications", Vol. 1 and 2, Wiley-VCH Verlag, Weinheim.	**2004**
6.	West, A. R. "Solid State Chemistry and its Applications", Reprint, Wiley India.	**2013**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CHEMISTRY**

1. Subject Code: **CYN-635** Course Title: **Advanced Magnetic Resonance Spectroscopy**

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: **PEC**

8. Pre-requisite: Basic knowledge of magnetic resonance spectroscopy.

9. Objective: To provide advance knowledge of NMR and ESR techniques for structure elucidation of molecules and radicals.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Magnetic resonance:** Nuclear spin, Zeeman effect, Larmour precession, Boltzmann distribution of spin population, magnetic field and resolution, folded signals , peak broadening and solid state effect.	3
2.	**Relaxation processes:** Longitudinal and cross sectional relaxation mechanism of magnetic vector, Bloch equation, pulse strength and magnetization vector, spin-saturation, spin-inversion and spin-echo methods for relaxation times. Effect of chemical shift anisotropy, scalar coupling, dipole-dipole coupling and electron interactions on relaxation time.	4
3.	**Chemical shift:** Shielding coefficient and chemical shift, low field and high field chemical shift, solvent effect and factors influencing the chemical shift. anisotropic effect in benzene and carbonyl compounds, chemical and magnetic equivalence.	3
4.	**Scalar and dipolar couplings:** Coupling of nuclear spins, coupled spins energy diagrams and sign of coupling constant in AX and AB systems. Geminal and vicinal coupling and Karplus relation for tetrahedral angle. Dipolar couplings in solids and bond length.	3
5.	**Double resonance:** Double resonance and Simplification spectra, pulse sequence, spin polarization transfer and Nuclear Overhauser effect, progressive and retrogressive internuclear relationship , selective decoupling, J-modulated spin-echo and attached proton test (APT), insensitive nuclei enhancement by polarization transfer (INEPT) and distortion less enhancement by polarization transfer (DEPT). Fourier transform and ^{13}C NMR spectroscopy.	6
6.	**Dynamic NMR:** Chemical and dynamic processes by NMR, temperature dependant rotamers and colescence temperature. Dynamic equilibrium, line shape and Gibb's free energy.	4
7.	**2-Dimensional NMR spectroscopy:** Basics of two dimensional NMR spectroscopy, 2D correlation (COSEY) and 2D Nuclear Overhauser enhancements Spectroscopy (NOESY) experiments and their applications in structural elucidation of organic molecules.	8
8.	**ESR spectroscopy:** Electron spin and magnetic moment, g-factor, triplet state and spin transitions, hyperfine structures, Zerofield splitting, Kramer degeneracy and	5

	double resonance.	
9.	**NQR spectroscopy:** Nuclear quadrupole moment and electrical field gradient, quardrupole coupling constants (NQCC) and asymmetry parameter (□), pure NQR and Zeeman spectra of spin 1 and spin 3/2 systems, the Towners-Dailey theory and interpretation of NQCC in terms of characteristic of the bonds and effects of other parameters.	6
	Total	**42**

11. Suggested Books:

S., No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1.	Gunther, H., "NMR Spectroscopy. Basic Principles, Concepts and Applications in Chemistry", Wiley India.	2010
2.	Banwell, C.N. and McCash, M. , "Fundamentals of Molecular Spectroscopy", McGraw Hill Education Pvt. Ltd, India.	2013
3.	Graybeal, J.D., "Molecular Spectroscopy", McGraw-Hill Book Company, India.	1988
4.	Drago, R.S., "Physical Methods in Inorganic Chemistry", Affiliated East West Press , Pvt. Ltd. India.	2010
5.	Weil, J.A., Bolton, J.R. and Wertz, J.E., "Electron Paramagnetic Resonace", Wiley-Interscience, New York.	1994

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject: **CYN-606** Course Title: **Total Synthesis**

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

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

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

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

8. Pre-requisite: **CYN-506**

9. Objective of Course: To familiarize the students with the tactics and strategies in the total synthesis of targeted compounds.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to strategies for synthesis of complex molecular architectures.	2
2.	Synthesis of antibiotics – penicillin V and tetracycline.	7
3.	Synthesis of alkaloids – reserpine and camptothecin.	7
4.	Synthesis of terpenoids – β-pinene, camphor, abietic acid and β-amirine.	8
5.	Synthesis of steroids and hormones – cholesterol, progesterone and cortisone.	8
6.	Synthesis of prostaglandins PGE_2 and $PGF_{2\alpha}$; glycosidic pigments anthocyanins and quercetin; macrocyclic lactam fluvirucin-B_1-aglycone; and vitamin biotin.	10
	Total	42

11. Suggested books:

S. No.	Name of Authors/Books/Publishers	Year of Publication / Reprint
1.	Finar, I.L., "Organic Chemistry", Vol .2, 5th Ed., ELBS.	1975
2.	Corey, E.J. and Cheng, X.-M., "The Logic of Chemical Synthesis", Wiley–VCH, Weinheim.	1995
3.	Nicolaou, K.C. and Sorensen, E.J., "Classics in Total Synthesis", Wiley–VCH, Weinheim.	1996
4.	Gewert, J.A., Gorlitzer, J., Götze, S., Looft, J, Menningen, P., Nobel, T., Schirock, H. and Wulff, C., "Organic synthesis workbook", Wiley–VCH, Weinheim.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OD DEPTT./CENTRE: **DEPARTMENT OF CHEMISTRY**

1. Subject: **CYN-608** Course Title: **Chemical Biology**
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: **PEC**
8. Pre-requisite: Knowledge of inorganic, organic synthesis and basic of fluorescence.
9. Objective of Course: To develop the knowledge of applying chemical tools in recognition process of biological systems.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Application of spectroscopy in chemical biology:** Brief introduction to chemical biology, biological structures and its constituents, spectroscopic tools to rationalize chemical reactions in biosystems, design of fluorescent and fluorogenic probes and optical biosensor molecules.	9
2.	**Chemical reactions suitable for biological applications:** Solid phase peptide synthesis, bioorthogonal reactions, functional group specific ligation techniques, strategies for attachment of synthetic molecules to biomolecules, Staudinger ligation, native chemical ligation, click chemistry, site selective protein modification.	12
3.	**Chemical interpretation of protein labeling technologies:** Green fluorescence protein (GFP), fluorescein arsenical hairpin (FlAsH), SNAP tag, CLIP tag, mutant β-lactamase (BL) tag, halo tag, and their selective significant applications.	12
4.	**Chemistry behind artificial cellular components:** Synthetic membranes, vesicles – ion transport, unnatural amino acids and their incorporation, DNA chemistry and its uses, nucleic acid templated chemistry, chemistry of morpholino and locked nucleic acid (LNA), siRNA.	9
	Total	42

10. Suggested books:

S. No.	Authors/Title/Publishers	Year of Publication/ Reprint
1.	Waldmann, H. and Janning, P. "Chemical Biology: Learning Through Case Studies", Wiley-VCH, Weinheim.	2009
2.	Dobson, C.M., Gerrard, J.A. and Pratt, A.J. "Foundations of Chemical Biology", Oxford University Press.	2002
3.	Miller, A. and Tanner, J. "Essentials Of Chemical Biology: Structure and Dynamics of Biological Macromolecules", Wiley.	2002
4.	Waldmann, H. and Janning, P. "Chemical Biology: A Practical Course", Wiley-VCH, Weinheim.	2004
5.	Hermanson, G.T. "Bioconjugate Techniques", 3rd Ed., Academic Press.	2013

6.	Lackowicz, J.R. "Principles of Fluorescence Spectroscopy", 3rd Ed., Springer.	**2006**
7.	Blackburn, G.M., Gait, M.J., Loakes, D. and Williams, D.M. "Nucleic Acids in Chemistry and Biology", 3rd Ed., RSC Publishing.	**2006**
8.	Schreiber, S.L., Kapoor, T. and Wess, G. "Chemical Biology: From Small Molecules to Systems Biology and Drug Design", Vol. 1-3, Wiley-VCH, Verlag GmbH & Co. KGaA.	**2007**

INDIAN INSTITUTE OF TECHNOLOGY ROOKEE

NAME OD DEPTT./CENTRE: **DEPARTMENT OF CHEMISTRY**

1. Subject Code: **CYN-610** Course Title: **Molecular Modeling and Simulations**
2. Contact Hours: **L: 2** **T: 0** **P: 2/2**
3. Examination Duration (Hrs.): **Theory: 2** **Practical: 0**
4. Relative Weightage: **CWS: 20** **PRS: 20** **MTE: 20** **ETE: 40** **PRE: 0**
5. Credits: **3** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisites: CYN-501 and CYN-503.
9. Objective: To provide knowledge on computational methods in chemistry
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Fundamentals of electronic structure:** Basis function–hydrogen-like, Slater-type and Gaussian type orbitals, classification of basis sets – minimal, double zeta, triple zeta, split-valence, polarization and diffuse basis sets, correlation consistent basis sets, basis set super position error, energy minimization methods–derivative and non-derivative methods-simplex method, steepest descents method, Newton-Raphson method, minima, maxima and saddle points.	8
2.	**Semi empirical and Ab intio methods:** Approximation methods, self consistent field treatment of polyatomic molecules, closed shell systems –restricted Hartree Fock calculations, open shell systems–ROHF and UHF calculations, The Roothan–Hall equations, Koopman's theorem, HF limit and electron correlation, introduction to post Hartree-Fock and density functional methods.	8
3.	**Electronic properties:** Dipole moment, electrostatic potential, frequencies, population analysis, Mulliken and Lowdin analysis, solvent effects, polarizable and nonpolarizable models.	6
4.	**Introduction to simulation methods:** Molecular mechanics, Monte carlo and molecular dynamics simulations, periodic boundary conditions, radial distribution function, calculation of thermodynamic properties.	6
	Total	28

List of practicals:

1. Potential energy curves for covalently bonded molecules and van der Waals complexes.
2. Geometry optimization of molecules at different levels of theory.
3. Frequency calculation of molecules.
4. Excited states of small molecules.
5. Determination of energy barrier for simple reactions.
6. Constructing the distribution function for liquid water using molecular dynamics method.
7. Calculation of specific heat capacities of liquid water at different conditions.

11. Suggested books:

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

		Reprint
1.	Jensen, F., "Introduction to Computational Chemistry", John Wiley & Sons Ltd.	1999
2.	Leach, A., "Molecular Modeling: Principles and Applications", Prentice Hall.	2001
3.	Cramer, C. J., "Essentials of computational chemistry: Theories and models", John Wiley & Sons.	2002
4.	Levine, I. N. "Quantum Chemistry", 7th Ed., PHI Learning Pvt. Ltd., Delhi.	2013

INDIAN INSTITUTE OF TECHNOLOGY ROOKEE

NAME OD DEPTT./CENTRE: **DEPARTMENT OF CHEMISTRY**

1. 1. Subject Code: **CYN-612** Course Title: **Carbon Nanomaterials and their Applications**
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: **PEC**
8. Pre requisite: nil
9. Objective of course: To familiarize the student with applications of carbon nanomaterials.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction and synthetic approaches:** Uncatalysed and catalyzed synthesis of carbon nanomaterials, supported nanomaterials, nanodiamonds, fullerenes, single and multi wall carbon nanotubes, carbon dots, carbon fibre.	6
2.	**Biological applications:** Biomedical application of graphene, biosensors based on carbon materials, tissue engineering, fullerenes in photodynamic therapy, interaction of fullerenes with DNA, an overview of application in cancer therapy, environmental impact of carbon materials, toxicological effect on fish, invertibrates, bacteria, soil microbes.	10
3.	**Carbon nanomaterials for sensing applications:** Carbon nanotubes and graphene for sensing applications, graphene transistor, single molecule memory devices, organic transistor odour sensor and spintronics.	8
4.	**Carbon nanomaterials for electronics, optoelectronics and photovoltaics:** Carbon nanotubes–electronic and optoelectronic applications, transistors for digital electronics, graphene–electronics and optoelectronics, digital electronics, photovoltaics– fullerenes, carbon nanotubes, graphene.	14
5.	**Space applications:** Polymer and carbon nanotube composites for space applications, meteoroids, micrometeoroids, and space-debris, conductive coatings for electrostatic discharge, thermal conductivity, space elevator, solar sails.	4
	Total	42

11. Suggested books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/ Reprint
1.	Philip, W. H.-S and Akinwande, D., "Carbon Nanotube and Graphene Device Physics", Cambridge University Press.	2011
2.	Reich, S., Thomsen, C. and Maultzsch, J., "Carbon nanotubes: Basic concepts and physical properties", Wiley-VCH.	2004
3.	Saito, R., Dresselhaus, G. and Dresselhaus, M. S., "Physical Properties of Carbon Nanotubes", Imperial College Press, London .	1998
4.	Challa, K.(Ed.), "Carbon Nanomaterials", Vol. 9., Wiley-VCH.	2011

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject : **CYN-614** Course Title: **Enantiomeric Separation**
2. Contact Hours: **L: 2** **T: 0** **P: 2/2**
3. Examination Duration (Hrs): **Theory: 2** **Practical: 0**
4. Relative weightage: **CWS: 20** **PRS: 2 0** **MTE: 20** **ETE: 40** **PRE: 0**
5. Credits: **3** 6. Semester: **Spring** 7. Subject Are: **PEC**
8. Pre-requisite: Knowledge of stereochemistry of organic compounds.
9. Objective of Course: To provide knowledge of modern chromatographic separation methods.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Modern stereochemical concepts– chirality and molecular structure, definitions and nomenclature.	2
2.	**Techniques used for studies of optically active compounds:** Methods not involving separation– polarimetry, NMR, isotope dilution, calorimetry, enzyme techniques. Determination of absolute configuration– X-ray, ORD, CD and chromatography based on comparison.	4
3.	**Modern chromatographic separation methods:** Basic chromatographic theory, instrumentation – gas and liquid chromatography.	4
4.	**Direct optical resolution:** Theory, general aspects of chiral recognition models–coordination to transition metals, charge transfer interaction, inclusion phenomena. Thermodynamic and kinetic considerations.	4
5.	**Chiral gas chromatography:** Phases based on chiral metal complexes, inclusion effects-relative merits.	4
6.	**Chiral liquid chromatography:** CSPs based on naturally occurring and synthetic polymers, bonded synthetic chiral selectors, CMPAs.	6
7.	**Analytical applications:** Amino acids, natural products, pharmaceuticals, microbial and enzymatic reactions.	4
	Total	**28**

List of Experiments:

1. Isolation of L-asparagine from *Asparagus* or Soybean, its characterization, determination of specific rotation, change of specific rotation from levo to dextro in acidic solution.
2. Isomerization of 2-aryl propionic acid or other simple less expensive optically pure compound(s).
3. Resolution of (±)-mandelic acid.
4. Separation of (-)-ephedrine and (-)-mandelate.
5. TLC enantioseparation of DL-amino acids on plates impregnated with an optically pure base.
6. Ligand exchange TLC enantioseparation of DL-amino acids (or commercial racemic pharmaceuticals) using Cu(II)-L-Pro complex.
7. Enantiomeric separation of (±)-2-butanol via its reaction with (+)-tartaric acid.
8. Racemization studies using (*R*)-3-phenyl-2-butanone or (*S*)-3-methyl cyclohexanone.
9. Synthesis of chiral variant of Sanger's reagent,

11. Suggested books:

S.No.	Name of Authors/ Books/ Publishers	Year of Publication/ Reprint
1	Kowalska,T. and Sherma, J., "Preparative Layer Chromatography", CRC-Taylor & Francis, New York.	2006
2	Ahuja, S., "Chromatography and Separation Science", Academic Press, Amsterdam.	2003
3	Snyder, L.R., Glajch, J.L., and Kirkland, J.J., "Practical HPLC Method Development", Wiley, New York.	1988

Appendix-F

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject code: **MAN-901** Course Title: **SELECTED TOPICS IN ANALYSIS**
2. Contact Hours: **L: 3 T: 0 P: 0**
3. Examination Duration (Hrs): **Theory: 3** **Practical: 0**
4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits: **3** 6. Semester: **Autumn/Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To impart the knowledge of some advanced topics in Analysis.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Abstract Integration:** The concept of measurability, simple functions, Properties of measure, Integration of positive functions and complex functions, Sets of measure zero.	7
2.	**Positive Borel Measures:** Vector spaces, Review of topological preliminaries leading to locally compact Hausdorff spaces, Riesz representation theorem, Regularity properties of Borel measures, Lebesgue measures, Continuity property of measureable functions.	7
3.	**L^p spaces:** Convex functions and inequalities, L^p spaces, Approximation by continuous functions.	5
4.	**Banach Space Techniques:** Banach spaces, Consequences of Baire's theorem, Fourier coefficients of L^1 functions, Hahn Banach theorem.	6
5.	**Integration on product spaces:** Measurability on Cartesian products, Product measure and its completion, Fubini's theorem, Convolution, Distribution functions.	6
6.	**Harmonic Functions:** Laplacian of a harmonic function, Poisson integral of L^1 functions, Mean value property, Boundary behavior of Poisson Integrals, Representation theorems.	6
7.	**Analytic Continuation:** Regular and Singular Points, Continuation along curves natural boundaries, Monodromy theorem.	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication/ Reprint
1.	W. Rudin, Real and Complex Analysis, Tata McGraw Hill, Third edition	1987
2.	H.L. Royden, Real Analysis, Collier Macmillan	1988
3.	P.R. Halmos, Measure theory, Graduate Text in Mathematics, Springer Verlag, New York	1974
4.	M. Thamban Nair, Functional Analysis, Prentice Hall, India	2003
5.	E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley and Sons	1989
6.	L.V. Ahlfors, Complex Analysis, McGraw Hill	1988
7.	J.B. Conway, Functions of one complex Variables I, Narosa Publishing House	2000
8.	S. Lang, Complex Analysis, Springer - Verlag.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject code: **MAN-902** Course Title: **ADVANCED NUMERICAL ANALYSIS**
2. Contact Hours: **L: 3 T: 0 P: 0**
3. Examination Duration (Hrs): **Theory: 3** **Practical: 0**
6. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE : 0**
7. Credits: 3 6. Semester: **Autumn/Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To impart the knowledge of some advanced topics in Numerical Analysis.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	LU and QR decomposition methods for solving a system of linear equations, Conjugate Gradient iterative method and its convergence. Norms of a matrix. Ill-conditioned system.	6
2.	Jacobi, Given and Householder method for finding eigenvalues of a symmetric matrix. LR and QR methods for finding eigenvalues of non-symmetric matrices.	8
3.	Elliptic PDE- Finite difference analysis to solve Poisson's equation in Cartesian and Cylindrical Coordinates in axial symmetry; Hockney Method or similar method for solving resulting block tri-diagonal systems.	6
4.	Parabolic PDE - Explicit and implicit finite difference schemes for heat conduction equation. Stability, consistency and convergence of finite difference schemes; ADI methods to solve tow dimension heat conduction equation.	6
5.	Hyperbolic PDE: Propagation of errors in finite difference methods for hyperbolic equations. Method of Characteristics for Hyperbolic Equation.	6
6.	Different weighted residual methods - Galerkin, Least Square and Collocation methods; Ritz method to solve a boundary value problem. Solving BVP by taking linear elements.	10
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication/ Reprint
1.	G.D. Smith, Numerical Solution of Partial Differential Equations: Finite Difference Methods 3rd Edition, Clarendon Press; 3 edition.	1985
2.	M.K. Jain, Numerical Solution of Differential Equations, Wiley Eastern Ltd.	2006
3.	L. Collatz, Numerical Treatment of Differential Equations, Springer	1962
4.	M K Jain, S. R. K. Iyengar, and R K Jain, Numerical Methods for Scientific and Engineering Computation, New Age International Publisher	2006
5.	R S Gupta, Elements of Numerical Analysis, Mcmillan Indian Ltd.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1 Subject code: **MAN-903** Course Title: **THEORY OF DIFFERENTIAL EQUATIONS**

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 impart the knowledge of some advanced topics in Differential Equations.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	System of differential equations: System of first order equations, existence and uniqueness of solution, Gronwall's inequality, continuous dependence on initial conditions and parameters.	3
2.	Linear systems: Autonomous systems, Transition matrix, Phase-space of two dimensional systems, time varying systems, fundamental matrix and its properties, linear systems with periodic coefficients.	4
3.	Stability of differential systems; Stability of linear systems, almost linear systems, stability of periodic solutions, Lyapunov stability theorems for nonlinear system, limit cycles, Poincare-Bendixon theorem, Lienard Syatems, Construction of Lyapunov function, Bifurcations (Transcritical, Saddle-node, Pitchfork, Hopf, Sotomayor theorem)	8
4.	Review of first order PDE: classification, solution method for quasi-linear and nonlinear pde, discontinuous solutions, conservation laws and shocks	3
5.	Four important linear PDE's (transport, Lapace, heat and wave equations): fundamental solution, meanvalue formulae, properties of harmonic functions, Green's function and energy method.	6
6.	Sobolev spaces: Definition, approximations, sobolev inequalities, extensions, traces, compactness, dual spaces	8
7.	Elliptic Equations: Definitions, Existence Of Weak Solutions, Regularity, Maximum principles, Eignevalues and eigen-function. Linear evolution equations: Parabolic equations, hyperbolic equations, semigroup theory	10
	Total	**42**

11. Suggested Books:

S.No.	Name of Books / Authors/ Publishers	Year of Publication/ Reprint
1.	G.F. Simmons, Differential Equations with Applications and Historical Notes, 2nd Ed., McGraw-Hill.	1991
2.	R.P. Agarwal, D.O'Regan, An Introduction to Ordinary Differential Equations, Springer.	2008
3.	K.S. Bhamra, Ordinary Differential Equations, Narosa Publications.	2015
4.	I.N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill.	1957
5.	L.C. Evans, Partial Differential Equations, 2nd Ed., American Mathematical Society.	2015
6.	M. Renardy, R.C. Rogers, An Introduction to Partial Differential Equations, 2nd Ed., Springer.	2010
7.	S. Kesavan, Topics In Functional Analysis And Its Applications, New Age International(P) Ltd.	2012

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject code: **MAN-904** Course Title: **SELECTED TOPICS IN ALGEBRA**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart the knowledge of some advanced topics in Algebra.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review of group actions and Sylow's theorems. Free groups and relations, normal series, nilpotent and solvable groups.	8
2.	Review of rings and ideals, PID, Euclidean domains, and UFD. Modules, direct sums of modules, free modules, exact sequences, finitely generated modules over a PID, structure of finitely generated abelian groups, rational and Jordan canonical forms.	10
3.	Review of algebraic extensions of fields, algebraic closure and splitting fields. Normal extensions and separable extensions, finite fields, Galois theory - The Fundamental Theorem of Galois Theory, roots of unity, cyclotomic extensions, cyclic extensions, Galois group of a polynomial, solvable and radical extensions, insolvability of the quintic.	11
4.	Artinian and Noetherian modules and rings, modules of finite lengths, simple and semisimple modules and rings. Wedderburn-Artin theorem, nil radical and Jacobson radical, radical of an Artinian ring.	10
5.	Commutative rings: Primary decompositions of ideals and modules.	3
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication/ Reprint
1.	Dummit D.S. and Foote R.M., "Abstract Algebra", John Wiley & Sons (3rd Edition)	2003
2.	Hungerford T.W., "Algebra", Springer	1980
3.	Bhattacharya P.B., Jain S.K. and Nagpaul S.R., "Basic Abstract Algebra", Cambridge University Press (2nd Edition)	1995
4.	Lang S., "Algebra", Springer (3rd Edition)	2005
5.	Jacobson N., "Basic Algebra Vol. I & Vol. II" Dover Publications (2nd Edition)	2009
6.	Musuli C., "Introduction to Rings and Modules", Narosa Publishing House (2nd Edition)	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT./CENTRE: **ELECTRONICS AND COMMUNICATION ENGINEERING**

1. Subject Code: **ECN - 578** Course Title: **Digital System Design**

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: **PCC**

8. Pre-requisite: **Digital Logic Design or Equivalent**

9. Objective: To acquaint with the hardware description languages such as VHDL/Verilog for understanding the principles for designing digital and embedded systems.

10. Details of the Course:

Sl.No.	Contents	Contact Hours
1.	**Introduction to Digital and Embedded systems design:** Digital Design Using ROMs, PLAs and PLAs, BCD Adder, 32 - bit adder, A shift and add multiplier, Array multiplier, and Binary divider. Introduction to Embedded system, Design cycle in the development phase for an embedded system, Use_ of target system or its emulator nd In-circuit emulator, Use of software tools for development of an ES.	4
2.	**Hardware Description Languages (HDL):** Digital system Design Process, Hardware Description Languages, Hardware Simulation, Hardware Synthesis, Levels of Abstraction, Characterizing Hardware Languages, Objects and Classes, Signal Assignments, Concurrent and Sequential Assignments.	6
3.	**Design Organization and Parameterization:** Definition and usage of Subprograms, Packaging Parts and Utilities, Design Parameterization, Design Configuration, Design Libraries. Type Declarations and Usage, Operators, Subprogram Parameter Types and Overloading, Other Types and Types Related Issues, Predefined Attributes, User Defined Attributes. Dataflow Description: Multiplexing and Data Selection, State Machine Description, Three State Bussing. Behavioral Description of Hardware: Process Statement, Assertion Statement, Sequential Wait Statements, Formatted ASCII I/O Operations, IC Design Flow. Practical Designs	8
4.	**EPGA Architecture:** Designing and Implementation of Finite State Machines for FPGA; Synthesis Techniques nd Timinig Analysis; Placement and Routing; Embedded Hardware and Software Design with FPGA.	8

5.	**DSP Processor Architecture:** Architecture; Functional Units; Fetch and Execute Packets; Pipelining; Registers; Linear and circular Addressing Modes; Instruction Set Assembler Directives for TMS320C6x or ADSP21xx; Linear Assembly; ASM statement within C; C-Callable Assembly Function; Timers; interrupts; Multichannel Buffered Serial Ports; Direct Memory Access; Memory Considerations; Fixed and Floating Point Format Code Improvement ; Constraints Programming Examples Using : C, Assembly, and Linear Assembly.	8
6.	**ARM Architecture and Organization:** ARM Assembly Programming; THUMB Assembly Programming; ARM-THUMB Interworking; Assembly and C Mixed Programming; Exception Handling; ARM Tool chain (Assemblers, Compilers, Linkers & Debuggers); Firmware Programming; Cache & MMU; Peripheral Programming; ARM Cortex family of Processors and architecture; Operating modes, Registers and Memory Map of Cortex-M3; Embedded OS; Porting of Embedded OS on ARM.	8

11. Suggested Books:

Sl.No.	Name of Books/Authors	Year of Publication
1.	Embedded System Design: Embedded System Foundations of Cyber-Physical Systems by Peter Marwedel, Springer	2010
2.	Embedded System Design: A Unified Hardware/Software introduction by Frank Vahid, Tony Givargis, John Wiley & Sons, Inc.	2001
3.	Fundamental of Logic Design - Charles H. Roth, and Larry L. Kinney, Brooks/Cole Inc.	2014
4.	Digital Logic and Microprocessor Design with VHDL, Enoch O. Hwang, Publisher- Thomson/Nelson	2006
5.	Digital Design and Computer Architecture, David Money Harris and Sarah L. Harris, Elsevier.	2012
6.	VHDL for Programming Logic, Kevin Skahill, Person Education	2004
7.	ARM System-on-Chip Architecture, Furber, S., 2nd ed. Pearson Education.	2000
8.	DSP Applications Using C and the TMS320C6x DSK, Rulph Chassaing, John Wiley & Sons, Inc.	2002

F. No. 24-2/2016 TS 1
Government of India
Ministry of Human Resource Development
Department of Higher Education
****

New Delhi, dated 8th April 2016

To
The Directors of all IITs

Subject: Revision of tuition fee for the undergraduate programmes

Sir,

With a view to further strengthen the IITs, Chairperson of IIT Council, after examining the report of the Committee on funding of IITs and the recommendations of the Standing Committee of the IIT Council (SCIC) for revision of tuition fee in IITs, has approved revision of tuition fee in the IITs to Rs. 2 lakh a year from the academic year 2016-17, subject to the following for protecting the interests of the socially and economically backward students:

a) The SC/ST/PH students shall get complete fee waiver.
b) The most economically backward students (whose family income is less than Rs. 1 lakh per annum) shall get full remission of the fee.
c) The other economically backward students (whose family income is between Rs. 1 lakh to Rs. 5 lakh per annum) shall get remission of 2/3rd of the fee.
d) All students shall have access to interest free loan under the Vidyalaxmi scheme for the total portion of the tuition fee payable.

2. Further, all IITs are requested to utilize funds accrued through the increased student fee for the purpose of building good quality infrastructure with the assistance of the Higher Education Funding Agency (HEFA).

3. The Directors of all IITs are requested to take action accordingly.

Yours faithfully,

(R. Subrahmanyam)
Additional Secretary (TE)