भारतीय प्रौद्योगिकी संस्थान रूड़की
रूड़की – २४७ ६६७ (भारत)

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

सीनेट की इकहत्तरवीं बैठक हेतु कार्य सूची

AGENDA FOR THE 71ˢᵗ MEETING OF THE SENATE

बैठक सं0	:	इकहत्तरवीं
MEETING NO.	:	**71ˢᵗ**
स्थान	:	सीनेट हॉल, भा0प्रौ0सं0रूड़की
VENUE	:	**Senate Hall, IIT Roorkee**
दिनांक	:	28 दिसम्बर 2017
DATE	:	**28ᵗʰ December 2017**
समय	:	3.30 बजे अपरान्ह
TIME	:	**3.30 P.M.**

भारतीय प्रौद्योगिकी संस्थान रूड़की
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
रूड़की 247 667
ROORKEE – 247 667

A G E N D A / कार्यसूची

Item No. / मुद्दा सं0	Particulars / विवरण	Page(s) / पृष्ठ
71.1	28.07.2017 और 19.09.2017 को आयोजित हुई सीनेट की 69वी बैठक एवं 70वी बैठक (विशेष बैठक) के कार्यवृत्तों की पुष्टि करना। To confirm the minutes of 69th meeting and 70th meeting (Special meeting) of the Senate held on 28.07.2017 and 19.09.2017, respectively.	1-2
71.2	28.07.2017 और 19.09.2017 को आयोजित हुई सीनेट की 69वी बैठक एवं 70वी बैठक (विशेष बैठक) में लिए गए निर्णयों के क्रियान्वयन हेतु की गई कार्रवाई को रिपोर्ट करना। To report on the actions taken to implement the decisions taken by the Senate in its 69th meeting and 70th meeting (Special meeting) held on 28.07.2017 and 19.09.2017, respectively	3-11
71.3	परास्नातक छात्रों के थीसिस जमा करने के समय शीर्षक को अंतिम रूप देने पर विचार करना। To consider finalization of title at the time of thesis submission for Masters' students.	12
71.4	निम्न प्रवीणताओं को बंद करने के प्रस्ताव पर विचार करना: 1. बागवानी 2. डाक टिकट और सिक्का To consider the proposal of closing the following proficiencies:- 1. Gardening 2. Philately and Numismatics	13-14
71.5	ब्रांच परिवर्तन के लिए नियमों/मानदंडों के प्रस्ताव पर विचार करना। To consider the proposal regarding rules/norms for change of branch.	15-16

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

The minutes of the 69th meeting and 70th meeting (Special meeting) of the Senate held on 28.07.2017 and 19.09.2017, respectively were circulated to the members vide e-mail dated 29.08.2017 and 18.10.2017, respectively. Comments received from a member on item No. 70.3 are given in **Appendix 'A'.**

The Senate may consider confirming the said minutes.

mail.iitr.ac.in/iwc_static/layout/shell.html?lang=en&2-6.01_164849

Subject: **RE: Minutes of the 70th meeting of the Senate.**   Date: 10/23/17 10:10 AM
    To: Registrar IITR <registrar@iitr.ac.in>   From: Dr.M.L Kansal <mlkfwt@iitr.ac.in>
    Cc: Director IIT Roorkee <director@iitr.ac.in>

Respected Chairman, Senate and

Registrar & Secretary, Senator,

Kindly refer to item number 70.3 about the format of degree for our institute. I as senator suggested that in the degrees, the senior most person should sign at the right most corner as the system is writing from Left to Right.

The Chairman, Senate at that time suggested that due to paucity of time, it may be dropped and will be considered next year.

I request that this mistake may please be corrected for next time and issue may be discussed in next senate (if required).

I have already mentioned that various universities (atleast I quoted Delhi University, IGNOU and Kurukshetra University) which follows the suggested system.

With regards,

M L Kansal

From: Meeting Section IIT Roorkee [mailto:meeting@iitr.ac.in]
Sent: Wednesday, October 18, 2017 6:20 PM
To: Senate-iitr
Subject: Minutes of the 70th meeting of the Senate.

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No. IITR/MS/70th Senate/086

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

The minutes of the 69th meeting and 70th meeting (Special Meeting) of the Senate held on 28.07.2017 and 19.09.2017 were circulated to the members vide e-mail dated 29.08.2017 and 18.10.2017, respectively. The status of actions taken to implement the decisions of the Senate are as under:

Item No.	Reference to the Senate minutes	Abstract of the Minutes	Status of action taken
69th meeting held on 28.07.2017			
69.3	Payment of Fellowship to M.Tech. students after submission of dissertation upto 30th June or till the period student stays in the campus for any work related to dissertation, whichever is earlier.	The Senate approved the proposal.	Notification No. Acd./5837/UG-15 dated 6th September 2017 has been issued.
69.4	Proposal received from DOSW for inclusion of Cinematic Section in the list of proficiencies.	The Senate approved the proposal.	Notification No. Acd./5838/UG-15 dated 6th September 2017 has been issued.
69.5	Renaming of some Sections of the Hobbies Club received from Chief Advisor, Hobbies Club.	The Senate approved the proposal.	Notification No. Acd/5839/UG-15 dated 6th September 2017 has been issued.

69.6	Course evaluation issues of differently abled students.	The Senate approved the proposal. Further, it was decided that a committee be constituted to consider and approve the needs of individual differently abled students for extra time in examinations (MTE & ETE), and/or services of scribes and/or for large font size question papers.	Notification No. Acd./5631/UG-15 dated 21st August 2017 has been issued.
69.7	Percentage formula for the students who have CGPA between 4.00 and 5.00 because the converted formula is available from CGPA 5.00 and onward.	The Senate decided that the Grading Committee will study the formula and submit its recommendations for consideration of the Senate. Till that time, the following extended formula, as recommended by the IAPC, be used for training and placement purposes. 	CGPA	Equivalent percentage of marks	 	4.00≤ CGPA≤9.00	10*CGPA+5.00	 	CGPA>9.00	95.00		Notification No. Acd./5840/UG-15 dated 6th September 2017 has been issued.
69.8	Delegate the power by Senate for approving the revised curricula and syllabi of courses of studies for various departments/ Centres.	The Senate accepted the proposal alongwith the following provision: Each such proposal will be circulated to faculty-iitr e-mail group by the Chairperson of the DAPC/CAPC. Comments received and the replies of the proposers will be placed before IAPC.	Notification No. Acd./5841/UG-15 dated 6th September 2017 has been issued.
69.9	Decision taken vide Senate Item No. 68.10 with respect to switch-over from M.Tech. to Ph.D. programme: To include centres running M.Tech. programme.	The Senate approved the proposal.	Notification No. Acd./5842/UG-15 dated 6th September 2017 has been issued.

69.10	Research Areas recommended by Four Departments.	The Senate approved the proposal.	Notification No. Acd./5825/UG-15 dated 6th September 2017 has been issued.
69.11	Allowing B.Tech. + M.Tech. in Computer Science programme for eligibility of Ph.D. admission in the Department of Electronics & Communication Engineering.	The Senate approved the proposal.	Notification No. Acd./5826/UG-15 dated 6th September 2017 has been issued.
69.12	Proposal of increasing the duration for candidacy in Ph.D. programme.	The Senate approved the proposal.	Notification No. Acd./5827/UG-15 dated 6th September 2017 has been issued.
69.13	Admission of Project Fellows, working in a consultancy project having R&D component as a Ph.D. research scholar.	Considered and decided that the issue be referred back to IRC to examine the issues related to NOC, quantum of fund, research component in the project, tenure of the project etc. and submit its comprehensive recommendation to the Senate for consideration.	Notification No. Acd./5828/UG-15 dated 6th September 2017 has been issued.
69.14	Re-constitution of the Evaluation Committee for CSIR and UGC fellows who enroll themselves as Ph.D. candidate for upgradation from JRF to SRF.	The Senate did not accept the proposal.	Notification No. Acd./5829/UG-15 dated 6th September 2017 has been issued.
69.15	Provision of rolling advertisemen for admitting Ph.D. candidate under national funding scheme	The Senate approved the proposal. Further, it was decided that the Academic Office will come out with a rolling advertisement for Ph.D. admissions	Notification No. Acd./5830/UG-15 dated 6th September

		other than IITR Assistantship an¦ procedure thereafter.	through research funding schemes other than IITR Assistantship. The applications shall be received in the departments and the departments will conduct the interviews on a suitable date. The list of selected candidates, who will be offered admission in the next semester, will be sent by the department to the Academic office for further processing. However, such candidates will start working as JRF in the project from their date of selection.	2017 has been issued.
69.16	New criteria for Ph.D. admission in the CSE as proposed by the Department of Computer Science & Engineering.	The Senate approved the proposal.	Notification No. Acd./5831/UG-15 dated 6th September 2017 has been issued.
69.17	Conduct of viva-voce of Ph.D. candidate through Skype under conditions that examiner is not in a position to travel to IITR.	The Senate approved the proposal for conducting viva-voce examination for Ph.D. through Skype or any other digital communication medium.	Notification No. Acd./5632/UG-15 dated 21st August 2017 has been issued.
69.18	Admission of candidate for Ph.D. working as Woman scientist under national funding scheme.	The Senate approved the procedure for selection as per the procedure for Sponsored Research Project Fellows with the mentor playing the role of the Principal Investigator (PI).	Notification No. Acd./5833/UG-15 dated 6th September 2017 has been issued.
69.19	Certificate mentioning research area with regard to Ph.D. Degree.	The Senate approved the degree format.	Action has been completed.
69.20	Changes in the provisional certificate to be issued to Undergraduates in line with the	The Senate approved the format.	Action has been completed.

	New Structure and to report the approved certificates for batch 2017.		
69.21	Revised Minimum Educational Qualification (MEQs) for JAM 2018	The Senate approved the proposal.	Notification No. Acd./5843/UG-15 dated 6th September 2017 has been issued.
69.22	Proposal of permitting III year (IV year) students to register for one course of I year (II year) as back paper.	The Senate approved the proposal. Further, it was decided that the Academic Office will review the policy on penalty.	Notification No. Acd./5845/UG-15 dated 6th September 2017 has been issued.
69.23	Dress Code for various dignitaries/faculty members/graduating students at Convocation 2017 and onwards.	The Senate in principle approved the switchover to a new dress code. Further, it was decided that a committee be constituted by the Director to examine the issue. If the changes can not be done this year, these may be done next year.	Notification No. Acd./5834/UG-15 dated 6th September 2017 has been issued.
69.24	Holding of Annual Convocation of the Institute for the award of degrees to various graduating students on two days instead of one day as presently done.	The Senate approved the proposal.	Notification No. Acd./5835/UG-15 dated 6th September 2017 has been issued.
69.25	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. 3rd March 2017 to till date.	The Senate recommended to the Board the award of Ph.D. Degrees to the students who have completed the requirements for the same in various disciplines as presented before the Senate.	The degrees were awarded to the students who have completed the retirements for the same in various

			disciplines on the Annual Convocation held on 23rd & 24th September 2017.
69.26	Proposal for Senate Standing Committee for Scholarships and Prizes for students.	The proposal was approved. However, the constitution of SCSP was modified as under: 1. Chair – to be nominated by Chairperson, Senate 2. Two faculty members to be nominated by the Chairperson, Senate. 3. Two students' representatives: (i) General Secretary, Academic Affairs (UG) or his/her nominee (ii) General Secretary, Alumni Affairs or his/her nominee	Notification No. Acd./5836/UG-15 dated 6th September 2017 has been issued.

Reported Item No. 69.27 to 29.41 were only for information of the Senate.

70th meeting dated 19.09.2017

70.1	To consider the award of Degrees to the students who have qualifed for the award of Degrees in various disciplins/courses.	The Senate considered and recommended to the Board of Governors the award of Degrees to 2153 students, as given below, who have duly qualified for the same.	Degrees were awarded.

Sl. No.	Name of the Degrees	No. of Degree
1.	B.Tech./B.Arch./IDD/Integrated Degrees	1140

			2.	M.Tech./M.Arch./M.U.R.P./M.Sc./M CA./ MBA/M.Tech.(Earth Sciences)/ M.Tech. (SSEM)/ M.Tech. (Advanced Methods of Chemical Analysis)	786	
			3.	Ph.D. Degrees (135 Nos. have already been recommended by the Senate in its earlier meetings)	92 135	
				Total	**2153**	
70.2	To consider the list of Medal/Prize recipients for Convocation 2017 and further action to be taken by SCSP.		(A) Senate noted renaming of the Institute Silver Medal as Department Gold Medal. (B) Senate noted renaming of the Institute Medal for the Best B.Tech. Project to Department Medal for securing the highest marks in Project/ thesis in Engineering & Architecture amongst the UG students in their respective disciplines. (C) (i) Senate approved the following criteria for the Director's Gold Medal: "For the best all-rounder including social service other than sports amongst the B.Tech./B.Arch./IDD/Int. M. Sc./ Int. M.Tech. passing out students entered through JEE having good character and having CGPA $\geq$ 9.0." Considering the above criteria, Senate approved Director's Gold Medal for 2017 to Sopan Khosala,				Medal/Prize were awarded to the recipients.

B.Tech. CSE.

(ii) It was noted that in Electrical Engineering Department, six students are tied having secured identical highest marks in the B.Tech. Project. Senate discussed and approved six Department Medals for securing the highest marks in Project in the Electrical Engineering Department.

(iii) It was decided that a student who gets the President Gold Medal be also given the Department Gold Medal for his/her discipline.

Considering the above criteria, Senate approved the Department Gold Medal in B.Tech. Electrical Engineering to Chetanya Rastogi.

(D) Based on (A), (B) and (C) above Senate approved the list of Medal/ Prize recipients for Convocation 2017. Following changes were noted with respect to the list mailed with the agenda.

(i) Name of recipient (Mr. Dhiraj Indana) of Sarojani Naidu Cup for work and play is added in the list.

(ii) The Indian Service of Engineers Cash Prize of Rs. 2000/- for standing first in class in "Structural Dynamics" was corrected as Indian Service of Engineers Cash Prize of Rs. 2000/- for standing first in class in "Soil Dynamics".

| | | (iii) Based on item (B) above, awardee of Department Medal for securing highest marks in Project in case of MMED is changed to Agniva Si.

(iv) Changes pursuant to item (C) above.

(E) The Senate noted the proposed roadmap. It was also noted that all the above approvals are only for Convocation 2017. SCSP will present a detailed plan for rationalizing Convocation and other awards. | |

Reported Item No. 70.3 to 70.5 were only for information of the Senate.

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

The IAPC in its meeting held on 27.10.2017 considered the change of topic of M.Tech./M.Sc./IDD programme dissertation after stage-I presentation and evaluation is over. The IAPC accepted and recommended the proposal that only broad area and supervisor be allocated by the Departments at the timeof assigning the dissertations/projects to M.Tech/M.Sc./IMS/IMT/IDD/ M.Arch./MURP students and the finalization of topic/title be carried out at the time of submission of the thesis.

The above recommendation is submitted for the consideration and approval of the Senate.

Item No. 71.4: **To consider the proposal of closing the following proficiencies (Appendix 'A'):**

1. Gardening
2. Philately and Numismatics

The IAPC in its meeting held on 27.10.2017 considered and recommended the closing of the above proficiencies.

The above recommendation is submitted for the consideration and approval of the Senate.

छात्र-मामलों की परिषद
STUDENTS' AFFAIRS COUNCIL
भारतीय प्रौद्योगिकी संस्थान रूड़की
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
रूड़की/ROORKEE-247 667

<u>**Appendix-E**</u>
IAPC/58.2.7

No.SAC/17-18/

Dated: August 23, 2(

कुलशासक, शिक्षाविदों
Dean, Academics
<u>आई. आई. टी. रूड़की/**IIT Roorkee**</u>

द्वारा/*Through* : <u>**Dean of Students' Welfare**</u>

विषय/*Subject* : <u>***Regarding the proficiencies Gardening and Philately***
Numismatics.</u>

महोदय/*Sir,*

The two proficiencies mentioned are no longer in existence. They still appear proficiency and Students' are enrolled in them. It is a request to allow such students to register for a new proficiency.

भवदीय/*Yours' Sincerely*

[मानिक वर्मा]
[Manik Verma]
संयोजक/*Convener*
छात्र-मामलों की परिषद
Students' Affairs Council

✓
ADE/ADC/ADA
FNA please.
Dean Academic Affairs

Forwarded

23/08/17

अधिष्ठाता, छात्र कल्याण
Dean of Students' Welfare
भारतीय प्रौद्योगिकी संस्थान, रुड़की
Indian Institute of Technology Roorkee

Sri DCV/Sri Budh Singh

25/8/2017

DR Academic
Please allow the students to change the proficiency if the registered proficiency is close - 14 - Also, prepare an agenda for removing these proficiencies for next IAPC meeting

24/08

-10-

E1

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

The IAPC in its meeting held on 27.10.2017 considered and recommended the proposal with the modification that the cut-off for CGPA should be 8.5. The modified proposal is given in **Appendix 'A'.**

The above proposal is submitted for the consideration and approval of the Senate.

Proposed Guidelines for Change of Branch/Programme

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

a) He/She has earned all the specified credits in the programme structure at the end of the autumn semester.
b) He/She has not failed in any course
c) He/She has not been penalized for indiscipline.
d) He/She has an SGPA of at least 8.5.

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

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

4) If a student of Branch/Programme-A with SGPA X is denied change to Branch/Programme-B because of Rule 3, change to Branch/Programme-B cannot be offered to any other student (From branches/programmes other than Branch/Programme-A also) having SGPA less than or equal to X. However, this student (From other than Branch/Programme-A) can be offered a branch/programme other than B.

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

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

The IAPC in its meeting held on 27.10.2017 considered and recommended the proposal of closing down all the proficiencies other than NCC, NSS and NSO with the modification that grading should not be carried out in NCC, NSS and NSO **(Appendix 'A')**. The students opting for these proficiencies may be given certificates with the remark excellent/very good/good/satisfactory/ unsatisfactory.

The above proposal is submitted for the consideration and approval of the Senate.

Minutes of the meeting conducted on September 25, 2017 to review the rules regarding grading of proficiencies.

Members Present

1) Dr. Vipul Rastogi, Associate Dean Academic Affairs - Curriculum
2) Dr. Mukesh Barua, Associate Dean of Students' Welfare - Student Activities
3) Dr. Manish Shrikhande, Associate Dean, SRIC
4) Dr. Inderdeep Singh, ex. Associate Dean of Students' Welfare - Discipline
5) Saksham Agrawal, General Secretary Academic Affairs (UG)

Background

On the initiative of Students' Affairs Council, the above mentioned members met to discuss possible improvements in current grading system for proficiencies.

The concerns regarding the status quo have been reproduced below:

1) It is unfair to quantify extra-curricular activities.
2) There are anomalies in the grading as the strength of students is quite large. Also, a low grade in proficiency reflects poorly during interview for placements.
3) Students should be allowed to pursue multiple proficiencies during their stay.

The recommendations of the members were:

1) To convert proficiencies from Credit based courses to open clubs or sections from second year onwards.
2) For first year students, there should be no change in existing rules i.e. it is mandatory for them to register for NSS or NCC or NSO, and they will be graded for two credits in their first year.

Implementation and Future Action

1) The request to implement the above stated recommendations should be sent to IAPC for further consideration.

The Meeting ended with a vote of thanks the convener.

Saksham Agrawal   Dr. Inderdeep Singh   Dr. Manish Shrikhande

Dr. Mukesh Barua   Dr. Vipul Rastogi

_ H1 -   Next IAPC meeting
                          Vipul Rastogi
                          05/10/17

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

The IAPC in its meeting held on 27.10.2017 considered and recommended the proposal **(Appendix 'A')** of awarding Dean's appreciation for achieving highest increase in CGPA every year to student(s) of every program and HoD's appreciation for achieving highest increase in SGPA every semester to student(s) of every program with the following modifications:

1. For Dean's Appreciation the minimum increase in CGPA ≥ 0.5

2. For HoD's appreciation the minimum increase in SGPA ≥ 1.0

3. All the students with same increase in CGPA/SGPA should be given the certificate.

The proposal is submitted for the consideration and approval of the Senate.

Request introduction of "Dean's Appreciation & HoD's Appreciation" for students

HoD's Appreciation :

This will be awarded to one student each from all batches of every department. This will be awarded every semester for achieving highest improvement in the SGPA.

Methodology: At the end of every semester, the academic section will compile the list of students who have made the highest improvement. This list will be made public and circulated through institute mail as well as notice boards (Online as well as Offline).
The selected students, if required, can get a written proof signed by the Head of their Department. The format for the proof is attached with the proposal.

Tie Break : If there is a tie between two or more students for the certificate i.e. two or more students show the similar improvement in their SGPA, then all of them should be considered.

*The above mentioned award will not be valid for students in their first semester.

Dean's Appreciation

This will be awarded to one student from each batch of every branch, every year, who secures the highest improvement in CGPA, relative to her/his last academic year's CGPA.

Methodology: At the end of every academic year, the academic section will compile the list of students who have made the highest improvement in CGPA in complete academic year. This list will be made public through institute mail as well as notice boards. (Online & Offline).
The selected students, if required, can get a written proof signed by the Dean of Academics. The format of the written proof is attached with this proposal.

Tie Break : If there is a tie between two or more students for the certificate i.e. two or more students show the similar improvement in their CGPA, then all of them should be considered.

* First year students will not be eligible for the Dean's Appreciation.

Regards,
Saksham Agrawal

J1

/ —18—

TO WHOM IT MAY CONCERN

This is to certify that Mr./Mrs./Ms ...., son/daughter of......................................, resident of.., bears an enrollment no. ...., is pursuing .... from our department and has been awarded with HoD's appreciation for *Highest improvement in Semester's Grade Point Average* in his ...... semester.

Dated. ....

Signature with Seal

J2

—19—

TO WHOM IT MAY CONCERN

This is to certify that Mr./Mrs./Ms ...., son / daughter of....................................., resident of.., bears   an   enrollment   no, ..., is   pursuing .... from Indian Institute of Technology Roorkee and has been awarded with Dean's appreciation for *Highest improvement in Cumulative Grade Point Average* during the academic year ....

Dated. ....

Signature with Seal

J3

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

The IAPC in its meeting held on 27.10.2017 considered and recommended the 2nd mercy appeals of Mr. Rakesh Kumar Meena (En. No. 10113084) and Mr. Mohit Kumar Bagdi (En.No. 10211017) on medical grounds. Mercy appeal of Miss Parul (En. No. 11116034) has also been recommended on same grounds. An extension of one year with effect from spring semester 2017-18 has been recommended for all the three students **(Appendix 'A')**. It was also suggested that an alternative mechanism such as awarding an exit degree be explored to address such issues.

The above proposal of mercy is submitted for the consideration and approval of the Senate.

To,

The Director

IIT Roorkee, Roorkee.

Sub : Regarding Registration in Autumn 2017.

Respected Sir,

I beg to say that I am a student of IDD CSI final year. My name has been struck off from the institute Roll list due to my failure to earn total required credits in given time. I was regularly suffering from medical and family problems in the duration of my degree. I met with a very serious train accident in July 2014. Also my father had a horrible car accident in October 2015.I was unable to attend classes because I was suffering from back pain, bone fractures, anemia and Stitches on my head. I was under bed rest for more than 3 months at my hometown and I was not in a position to attend classes. Due to my frail physical condition I went into depression and I was under parental supervision time to time.

After the treatment I regained my physical and mental Stability and I came back to campus with strong determination to complete my remaining courses. I earned more than 35 credits in the last semester. I also cleared GATE 2017 examination conducted by IIT Roorkee. Currently I am working on my dissertation under Dr. Rajdeep Niyogi on Robocops.

Therefore, I beg you to allow me to register for this academic year. I assure you that I have completely recovered from my ailments and I am Whole-heartedly willing to complete my degree. This is the first time I am asking for mercy.

So, kindly consider me and allow me to continue my studies. This will be my first and last time. I will be indebted to you for the rest of my life. Thank you for your time and consideration.

Yours Sincerely,

Mohit Kumar Bagdi (10211017)

Contact : 8126149250

Encl :

1.LAST SEMESTER GRADESHEET

2.GATE-2017 SCORECARD

3.MEDICALS RECEIPTS AND PHOTOGRAPHS

- 24 -

MERCY APPEAL

To   Aug 31, 2017
Director,
IIT Roorkee
Sub: Requesting for allowing me to complete my B-Tech credits

Respected Sir,

With due respect, I wish to state that I, Rakesh Kumar Meena (Enroll. No. 10113084) is pursuing B-Tech from Civil Engg. Dept. and my request for completing my program credits have been refused by Dean, Acad. Affairs on Aug 30, 2017.
I wish to do mercy appeal with my following particulars.

1. I have registered for B-Tech program in 2010 and still not able to complete my program credits due to the major accident I faced in 2015 resulting into physical illness. The doctor asked for the complete bed rest for around 12-14 months which restricts me to attend any course, resulting into incompletion of my program credits.
2. The total credits I have to complete is 189 and I have completed 151 credits, thus I have left with 38 more credits to complete my degree requirements.
3. As per the new terms and conditions, the Dean Acad. Affairs is allowing to register only those students who are left with less than 32 credits to complete.
4. I have successfully **completed my B-Tech projects** (major, minor and internship) and left with only 5th and 7th semester courses to complete as I was passing from the mental break down condition at that particular course of time.
5. I have requested Dean Acad. Affairs to kindly allow me to complete my remaining credits (i.e. **38 credits**), as **32 credits** are permissible (as per new terms), and thus, they have to only allow me for the **extra 6 credits**.
6. I am requesting for 1-year extension and I assure that I will complete my credit requirements.

Now, I am mentally disturbed and not in a state of mind to think positive after hearing this bad news from Dean Acad. Affairs.
To the best of my knowledge I have never disobey or dishonor any of my seniors or faculties. If there is knowingly, unknowingly or by any other means any mistakes are done on my part I beg pardon from you and also from my seniors.
I request you to please help me and accept my appeal to allow me to complete my program credits, so that I can continue my graduation and should be able to complete it in time. I would be highly obliged and thankful to you forever in my life.

Thanking you
Yours Truly
Rakesh Kumar Meena
B-Tech Civil
10113084
IIT Roorkee

अध्यक्ष, डी.ए.पी.सी.
Chairman, DAPC

विभागाध्यक्ष, सिविल
Head, Dept. of Civil Engg.

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N2

These are the following semesters when I was unable to appear the **CLASSES** and **EXAMS** for medical reason, I have attached medical certificates for following semesters.

SESSION 2013-14	SESSION 2014-15	SESSION 2016-17
Credit Registered 22	Credit Registered 25	Credit Registered 20
Credit Earned 0	Credit Earned 0	Credit Earned 0
Medical Attached	Medical Attached	Medical Attached

Respected Sir,

Above,I have presented my medical timeline to justify my case for an additional extension. Although,I have been given an additional year in past, but that was insufficient due to my 1.5 year of critical health condition.

<div align="center">Kindly consider my case.</div>

Thanks Regards

Rakesh Kumar Meena
B-Tech Civil
10113084
IIT Roorkee

N3

_49 _

The Director
I.I.T. Roorkee

आवक संख्या/Dy. No... 746   DOAA

Date.... 11-9-17

Sub: Mercy Appeal on the basis of medical problem 8/9/17   APP-IV

Can say re praew repre use ... meeting.

Returend 8/9/17

निदेशक/Director
भा॰ प्रौ॰ सं॰ रुड़की
I.I.T. Roorkee

Resp Sir

I am a student of B.tech, EACE. I got admitted in B.tech in 2011 and from that year itself because of home sickness I went into depression. In 2012 I was diagnosed with major depression and from that year itself my meditation and psychiatry sessions started and it took me 4 years to be normal again, now also I am undergoing through talk sessions but these are just to check if I am fine or not. I couldnot focus on my studies because of depression and from past 3 semesters I have been taking less credits so that I am depression free and it has been working too. I need a semester to complete my credits. Just because of depression I was not able to perform good. This depression has caused me a lot of things, I dnt want it to cost my degree too. Please, I request to give me last chance to complete my degree.

Yours sincerely
Parul
-11116034
Ph no - 7404979246

N4

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

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

The IAPC in its meeting held on 27.10.2017 recommended the syllabi **(Appendix 'A')**. However, the IAPC also suggested that the syllabi of courses of the entire program should be sent by the Department.

The above syllabi are submitted for the consideration and approval of the Senate.

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

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

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To develop interest and aptitude in chemistry

10. Details of the Course:

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

Q1

11.Suggested Books

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

Q2

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

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

Q3

11. Suggested Books:

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

Q4

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

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

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

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

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

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

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

Q7

Laboratory Experiments

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

11. Suggested Books:

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8.   Pre-requisite: **Nil**

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

10. Details of the Course:

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

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

11. Suggested Books:

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

Q10

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

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

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11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart basic knowledge in coordination chemistry and organometallics

10. Details of Course:

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

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11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

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

Q15

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

11. Suggested Books:

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

Q16

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Department of Chemistry

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

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

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

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- **45** -

S. No.		Topic	Hours
		compounds, hydrides, hydrazines and hydroxylamines, azides, trihalides and pentahalides, nitrogen fixation, urea, phosphate fertilizers, oxides of N,P, As and Bi, oxoacids of nitrogen and P, sulphides of P, low-valent N and P such as nitrenes and phosphinidene,phosphazenes, cyclophosphazenes and their polymers.	
6.		**Group 16 (O, S, Se, Te):**Structures and allotropes, oxides, peroxides, suboxides, neutral,basic, acidic and amphoteric oxides, oxoacids of S, Se and Te, halides,oxohalides, hydrides.	4
7.		**Group 17 (F, Cl, Br, I):**Oxidizing power, reactivity, hydrogen halides, halogen oxides, oxoacids, interhalogen compounds, polyhalides, pseudohalogens, pseudohalides.	4
8.		**Main Group Organometallics:** Preparative routes for metal carbon bond formation of main group elements, general reactivity patterns, organometallic compounds of I, II, III, IV and V group elements. Grignard reagents and their reactivity, electron deficient organometallic compounds, structure and bonding of some important main group organometallic compounds.	6
		Total	**42**

11. Suggested Books:

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

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

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

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of kinetics and photochemistry

10. Details of Course:

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

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11. Suggested Books:

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

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

The IAPC in its meeting held on 27.10.2017 considered and recommended the syllabi as given in **Appendix 'A'**.

The above syllabi are submitted for the consideration and approval of the Senate.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

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

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11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

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

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

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Vector Calculus:** Review of cartesian, cylindrical and spherical coordinate systems, constant coordinate surfaces, del operator, gradient, divergence of a vector and Gauss divergence theorem, curl of a vector and Stokes theorem, gradient, divergence, curl and Laplacian in the three coordinate systems, Laplacian of a scalar, scalar and vector fields, classification of vector fields	6
2.	**Electrostatics:** Coulomb's law, electric field intensity due to continuous charge distribution, Gauss's law and its applications, electric potential, line integral, electric dipole and flux lines, energy density in an electrostatic field, metallic conductors, conductor properties and boundary conditions, polarization in dielectrics, nature of dielectric materials and related boundary conditions, electrostatic boundary-value problems, Laplace's and Poisson's equations, uniqueness theorem, general procedure for solving Laplace's and Poisson's equation in one-dimension, resistance and capacitance	12

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3.	**Magnetostatics:**Current, current density, Biot-Savart's law, Ampere's circuital law, applications of Ampere's law, magnetic flux and magnetic flux density, scalar and vector magnetic potentials, magnetic dipole, force due to magnetic field on a differential current element, force between two differential current elements, force and torque on a closed circuit, magnetic materials, magnetization and permeability, magnetic boundary conditions, inductors, inductances, magnetic energy, magnetic circuits, potential energy and force on magnetic materials	12
4.	**Time varying electric and magnetic fields, Electromagnetic waves:** Faraday's law, displacement current, Maxwell's equations for time varying fields, electromagnetic wave equation in free space, plane waves in free space, polarization, Poynting vector and power associated with electromagnetic waves, plane waves in lossless, homogeneous, and isotropic dielectric medium, reflection and transmission of plane waves at dielectric interface, normal and oblique incidence, plane waves in good conductors, skin depth	12
	Total	42

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Semiconductor Diodes and Basic Diode Circuits:** Basic properties of Si, Ge and GaAs from diode perspective, Intrinsic and extrinsic semiconductors, Formation of *p-n* junction, Qualitative theory of the p-n junction, Current flow mechanism in forward and reverse biased diode, Volt-Ampere characteristics, Static and dynamic resistance of diode, Junction capacitance, Diode equivalent circuits, Load line analysis, p-n junction as a rectifier, Rectifier circuits (Half wave, Full wave, Bridge), Clippers and Clampers, Zener diode, Zener regulator, Loaded Zener regulator.	10
2.	**Bipolar Junction transistors:** *n-p-n* and *p-n-p* transistors, Characteristics of CB, CE and CC configurations,Current gains α, β and γ, and relations between them; Active, cutoff and saturation regions, Biasing of transistors: base bias, emitter bias, voltage divider bias, emitter follower circuit, Load line analysis	8
3.	**Field Effect Transistors:** Junction field effect transistors, Pinch-off voltage, Volt-Ampere characteristics of JFET, Insulated-gate field-effect transistor(MOSFET), Enhancement MOSFET, Depletion MOSFET, n-MOS, p-MOS, CMOS, FET biasing as covered in BJTs	8
4.	**Amplifiers:** Small signal analysis of a transistor, h parameters, h parameter equivalent circuits; CE, CB, CC amplifiers and their analysis and comparison, Frequency effects in amplifiers, Differential amplifiers: A.C. and D.C. analysis, Common mode gain and CMRR; Operational amplifiers: inverting and non-inverting amplifiers, feedback in amplifiers: effects of positive and negative	12

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

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-104**   Course Title: **Mechanics and Relativity**

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

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

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11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1.Subject Code: **PHN-207**   Course Title: **Thermal and Statistical Physics**

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

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

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7.	Isolated system and its contact with a heat reservoir, canonical ensemble, calculation of thermodynamic quantities for an ideal monatomic gas and Gibbs paradox	6
8.	Density matrix and trace, partition function and its evaluation for different ensembles, revisit of phase transition in terms of partition function	6
9.	Identical particles and symmetry requirements, M-B, B-E and F-D statistics and the corresponding distribution functions, blackbody spectrum	4
	Total	42

List of experiments:

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

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

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

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

10. Details of Course:

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

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11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Prelude to Quantum Mechanics:** Failures of classical physics; Energy quantization, Black body radiation, diffraction of matter particles, de Broglie waves and Davisson-Germer experiment, wave-particle duality, Angular momentum quantization: Stern-Gerlach experiment	08
2.	**Elements of Quantum Mechanics:** Time-dependent and time-independentSchrodinger equation, interpretation of the wave function, wave packets, stationary states; Heisenberg uncertainty principle, basic postulates and meaning of the measurement, expectation value, observables and operators, Hermitian operators, commutation relations, Dirac notation	12
3.	**Problems in one-dimension:** Particle in a box, potential step, potential barrier: reflection and transmission coefficients, tunnelingthrough multiple barriers: resonant tunneling; potential well, simple harmonic oscillator, raising and lowering operators	10
4.	**Problems in two dimension:** Two-dimensional electron gas in a perpendicular magnetic field,.Landau levels	04
5.	**Problems in three-dimension:** Symmetry and conservation laws in quantum mechanics,Central potential, hydrogen atom, angular momentum and spherical harmonics	08
	Total	42

11. Suggested Books:

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

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

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

11. Suggested Books:

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

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

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

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

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11. Suggested Books:

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-210**   Course Title: **Mathematical Physics**

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of the Course:

S. No.	Contents	Contact Hours
1.	**Vector Analysis:** Vectors in 3D spaces, coordinate transformations, rotations in R^3, differential vector operators, vector integrations, integral theorems, orthogonal curvilinear coordinate systems.	8
2.	**Matrices and Determinants:** Representing Vectors and Operators, Operations on Matrices, Orthogonal bases, Change of Basis, Determinant of a Matrix, Adjoint, Inverse and Trace, Direct products, Systems of linear equations, matrix eigen value problems, matrix diagonalization techniques.	8
3.	**Complex Analysis:** Complex variables and functions,Cauchy-Riemann Conditions, analytic and harmonic functions, Cauchy's Integral Theorem, singularities, Calculus of Residues, contour integration.	8
4.	**Integral Transforms and Gamma Functions:**Fourier series, Fourier and Laplace transforms, their properties and convolution theorems, evaluation of integral transforms and their inverses; beta and gamma functions.	8

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

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Arfken G B and Weber H J, "Mathematical Methods for Physicists", 5th Ed. Academic Press	2005
2.	Hassani, S., "Mathematical Physics: A modern Introduction to its foundations", 2nd Ed. Springer	2013
3.	Whittaker E T and Watson E W, "A Course of Modern Analysis", Cambridge University Press	2008
4.	Shankar R, "Basic Training in Mathematics: A Fitness Program for Science Students", Springer	1995
5.	Kreyszig E, "Advanced Engineering Mathematics", 9th Ed. Wiley India	2011

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code:**PHN-212**   Course Title: **Applied Optics**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To introduce students to elements of optics, i.e., interference, diffraction and polarization and their applications in engineering

10. Details of Course:

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

List of experiments:

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

11. Suggested Books:

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

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

9. Objective :To introducenumerical tools forcomputationally solving various problems of engineering physics

10. Details of Course:

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

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| | | Total | 28 |

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

11. Suggested Books:

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-315**   Course Title: **Laser and Photonics**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective:To introduce principles of different optoelectronics devices for science and
            engineering applications

10. Details of Course:

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

6.	**Lasersystems:** Mechanism and applications of argon ion-, carbon dioxide-, Nd:YAG-, Ti-sapphire-, dye-, excimer- and diode-pumped solid-state lasers	4
7.	**Modulation techniques for laser light:** Electro-optic and acousto-optic modulation, electro-optic effect, longitudinal and transverse modes, acousto-optic effect, Raman-Nath and Bragg diffraction	5
8.	**Nonlinear optics:** Nonlinear optical media, nonlinear polarization and susceptibility, second harmonic generation, optical Kerr effect, self-phase modulation, self-focusing	5
9.	**Applications:** Applications of lasers in material processing and micro machining, medicine, communication and information technology, military	4
	Total	**42**

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

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

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

10. Details of Course:

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

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	tokamak reactor	
	Total	42

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

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

10.Details of Course:

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

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

Experiments based on different types of transducers:

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

11. Suggested Books:

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code:**PHN-312**   Course Title: **Properties of Matter and Acoustics**

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Elasticity:** Hooke's Law Stress - Strain Diagram - Elastic moduli - Relation between elastic constants - Poisson's Ratio - Expressions for Poisson's ratio in terms of elastic constants - Work done in stretching and twisting a wire - Twisting couple on a cylinder- Rigidity modulus by static torsion - Torsional pendulum - Rigidity modulus and moment of inertia.-Elastic materials-Tensor of strain-Tensor of elasticity	8
2.	**Bending of beams:**Cantilever - Expression for bending moment - Expression for depression - Cantilever oscillations - Expression for time period - Experiment to find Young's modulus - Non uniform bending - Experiment to determine Young's modulus by Koenig's method - Uniform bending - Expression for elevation - Experiment to determine Young's modulus using microscope	4
3.	**Fluids:**Surface Tension: Definition and dimensions of surface tension - Excess of pressure over curved surfaces - Application to spherical and cylindrical drops and bubbles - Variation of Surface tension with temperature - Jaegar's method. Viscosity: Steady flow of Newtonian fluids – Poiseuille's equation for incompressible fluids: Statement of Stoke's law–Terminal velocity-Effect of temperature on viscosity-Reynold's number –Turbulent flow and critical velocity-Experiment to	12

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		determine co-efficient of viscosity of a liquid - Applications of viscosity. Condition of equilibrium of a fluid-Fluid dynamics-Equation of continuity-Bernoullie's theorem& conservation of energy Physics of Low Pressure. Production and Measurement of low pressure - Grades' molecular pump - Rotary pump - Knudsen absolute gauge - Detection of leakage.	
5.	**Waves and Oscillations:**Simple harmonic motion - Free, Damped, Forced vibrations and Resonance –Coupled harmonic oscillator-eigen frequencies and normal modes-Transverse vibrations in stretched strings-Wave equation for a string-Velocity of transverse wave along a string –Energy of a vibrating string-Fourier's analysis for plucked and bowed string	**10**
6.	Spherical waves, Large amplitude and Shock waves-Ultrasonics: Production of ultrasonic waves - Piezo electric crystal method - Magnetostriction method - Properties - Application to science industry and medicine.	**8**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	Feynman R P, Leighton R B and Sands M, "The Feynman Lectures on Physics", Vols. I, Narosa	2005
2.	Chakrabarthy P K, "Mechanics and General Properties of Matter", *Allied Publishers*Pvt. Ltd	2001
3.	Flowers B H and Mendoza E, "Properties of Matter", Wiley Publisher	1991
4.	Bajaj N K, "The Physics of Waves and Oscillations", Tata MC Graw Hill	1988
5.	Ingard K U, "Fundamentals of Waves and Oscillations", CambridgeUniv. Press	1988

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code:**PHN-314**   Course Title: **Microprocessors and Peripheral Devices**

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

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

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7.	**Interrupts:** Interrupt structure of 8085A microprocessor, processing of vectored and non-vectored interrupts, latency time and response time	3
8.	**Programmable Peripheral Interface:** Intel 8255, pin configuration, internal structure of a port bit, modes of operation, bit *SET/RESET* feature, programming; ADC and DAC chips and their interfacing	4
9.	**Programmable Interval Timer:** Intel 8253, pin configuration, internal block diagram of counter, modes of operation, counter read methods, programming, *READ-BACK* command of Intel 8254	4
	Total	42

11. Suggested Books:

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-324**   Course Title: **Nanotechnology**

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

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

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

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

8. Pre-requisite: Fundamental concepts of quantum mechanics

9. Objective: To introduce the emerging areas of nanotechnology

10. Details of Course:

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

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

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

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

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

10. Details of Course:

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

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

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

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

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11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication / Reprint
1.	Arfken G. B. and Weber H. J., "Mathematical Methods for Physicists" , 5th Ed. Academic Press.	2005
2.	Hassani, S., "Mathematical Physics: A modern Introduction to its foundations", 2nd Ed. Springer	2013
3.	Duffy, D. "Green's Functions with Applications", 2nd Ed. CRC Press	2015
4.	Bourne, D. E. and Kendall, P. C., "Vector Analysis and Cartesian Tensors", 3rd Ed., Springer Science	1992
5.	Cornwell, J. F., "Group Theory in Physics: An Introduction", Academic Press	1997
6.	Hammermesh M., "Group Theory and Applications to Physical Problems", Dover publications, NY.	1989
7.	Akhiezer N. I. and Glazman I. M., " Theory of Linear Operator in Hilbert Space", Dover Publications	1993

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

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

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

10. Details of Course:

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

		Total	42

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

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

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

10. Details of Course:

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

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	mechanics, Adiabatic invariants.	
	Total	42

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **PH-110**

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

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Semiconductors:** Energy bands, direct and indirect semiconductors, charge carriers, mobility, drift of carriers in field, Diamond and Zinc-Blende structure, bonds and bands in semiconductors, intrinsic and extrinsic semiconductors, law of mass action, Hall effect and cyclotron resonance in semiconductors.	12
2.	**Optical Injection:** Carrier life time, direct and indirect recombination of electron and holes, steady state carrier generation, diffusion and drift of carriers, the continuity equation, steady state carrier injection, The Haynes-Shockley experiment.	8
3.	**Junctions:** Metal-Semiconductor contact: under equilibrium, and non-equilibrium conditions, the junction diode theory, tunnel diode, photodiode, LED, solar cell, Hetro-junctions and Laser diode.	10

4.	**Bipolar Junction Transistors:** Charge transport and amplification, minority carrier distribution and terminal currents switching behaviour in bipolar transistor.	4
5.	**FET and MOSFET:** Ideal MOS capacitor, effect of work function and interface charge on threshold voltage.	6
6.	**Gunn Diode:** Transferred electron mechanism and drift of space charge domain.	2
	Total	42

List of Practical

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

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	Streetman B G and Banerjee S "Solid State Electronic Devices", 6th Ed. Prentice Hall	2005
2.	Sze S M, "Semiconductor Devices Physics and Technology" 2nd Ed. John Wiley & Sons	2003
3.	Tyagi M S, "Semiconductor Materials and Devices", John Wiley & Sons	2000
4.	Chattopadhyay D. and Rakshit P. C. , "An advanced course in Practical Physics" 7th Edition; New Central Book	2005

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

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

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

11. Suggested Books:

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

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

materials and their dynamical properties.

10. Details of Course:

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

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

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

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

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

10. Details of Course:

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

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

11.   Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

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

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

10. Details of Course:

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

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11. Suggested Books:

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **None**

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

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Atmospheric Evolution:** Solar radiation, present atmospheric constituents, evolution of the atmosphere, formation of ozone. Variation of temperature, density, ionization and pressure with altitude, Classification of atmosphere on the basis of temperature and pressure, hydrostatic equation, hypsometric equation.	8
2.	**Thermodynamics of Atmosphere:** Humidity variables, Moist air, adiabatic expansion of unsaturated air, various lapse rates, vertical mixing, vertical stability in the atmosphere, use of thermodynamic diagrams, role of convective available potential energy, Atmospheric radiation, hydrostatic equilibrium.	12
3.	**Lower Atmosphere:** Atmospheric absorption and greenhouse effect, Atmospheric aerosols and their origin, physical and chemical characteristics of aerosols, cloud formation and precipitation, cloud morphology, Growth of cloud droplets and rain droplets, physics of lightning, Radiative transfer and budget, Atmospheric equations of motion.	10
4.	**Upper Atmosphere:** Ionosphere as plasma, Concept of Plasma, Single particle motion in homogeneous and inhomogeneous E and B fields, Chapman theory of layer production, formation of ionosphere, electron, ion and neutral temperatures in the thermosphere, airglow and auroral emissions, measurements of ion and electron densities using ground based and space borne techniques.	12
	Total	42

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/ Reprint
1.	Seeds M.A., "Solar System", Brooks/Cole Thomson Learning	2007
2.	Houghton J.T. "Physics of Atmosphere", CambridgeUniv. Press	2002
3.	Rogers R R, "A Short Course in Cloud Physics", Pergamon Press	1989
4.	Anastasios A. Tsonis., "An Introduction to Atmospheric Thermodynamics", Cambridge University Press	2007
5.	Pruppacher, H.R. & J.D. Klett, "Microphysics of Cloud and Precipitation", Springer,	2010
6.	H.J. Critchfield, "General Climatology", Prentice-Hall of India.	1994
7.	Murray L. Salby , Fundamentals of Atmospheric Physics, Academic Press.	1996
8.	Ratcliffe, J.A, "An Introduction to Ionosphere and Magnetosphere", Cambridge University Press	1972
9.	Chen F F, "Introduction to Plasma Physics", Plenum Press New York	1990

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

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

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

10. Details of Course:

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

11. Suggested Books:

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code:**PHN-601**   .Course Title: **Advanced Condensed Matter Physics**
2. Contact Hours: **L: 3**   **T: 0**   **P: 3**
3. Examination Duration (Hrs.):   **Theory : 3**   **Practical: 0**

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

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

8. Pre-requisite: **PH-504**

9. Objective: To introduce the general aspects of phase transition, electronic transport phenomena, superconductivity, dielectric, optical and magnetic properties of solids.

10. Details of Course:

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

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

11. Suggested Books:

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-603**   Course Title: **Advanced Atmospheric Physics**

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

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

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

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

8. Pre-requisite: **PH-512**

9. Objective: To provide the knowledge of advances in atmospheric physics.

10. Details of Course:

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

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

11. Suggested Books:

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

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

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

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Quantum theory for the evaluation of the transition rates and Einstein's coefficients, interaction of matter with radiation having broad spectrum, interaction of near monochromatic radiation with an atom having broad frequency response.	6
2.	Line broadening mechanisms, homogeneous and inhomogeneous broadening, natural collision and Doppler broadening mechanisms and line shape functions.	4
3.	Laser rate equations, the three levels and four levels system, variation of power around threshold, optimum output coupling, quality factor, the ultimate line width of the laser.	5
4.	Optical resonators, modes of a rectangular cavity and open planar resonators, confocal resonator system, modes of a confocal resonator using Huygen's principle, planar resonators, Fox and Li theory.	6
5.	Pulsed lasers, Q-switching techniques, active and passive shutters, mode-locking, various techniques for mode-locking of a laser.	5
6.	Mechanism and applications of Ar-ion, CO_2, Nd:YAG, Ti:Sapphire, Dye, Excimer and free electron lasers.	5
7.	Semiconductor lasers, p-n junction diode lasers, hetrojunction lasers.	5
8.	Modulation techniques for laser light, electro-optic and acousto-optic modulation, electro-optic effect in KDP crystal, longitudinal and transverse modes, acousto-optic effect, Raman-Nath and Bragg diffraction, small and large angle Bragg diffraction.	6
	Total	42
S. No.	Contents	Contact Hours
1.	To determine the mode field diameter (MFD) of the fundamental mode of a given single-mode fiber using the far field technique.	

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

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

3. Examination Duration (Hrs.):   **Theory: 3**   **Practical: 0**
4. Relative Weightage: **CWS : 20   PRS:20   MTE: 20   ETE: 40 PRE: 0**

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

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

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

10. Details of Course:

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

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

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

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

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

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

10. Details of Course:

S.No	Contents	Contact Hours
1	**Crystal Structure Determination:** Brief description of Crystal Lattices; X-ray diffractometer; Determination of Crystal Structure using X-ray diffraction	12
2	**Electron Microscopes:** Brief description of different microscopes like TEM, SEM, AFM; Different modes of operation of microscopes, sample preparation, Interpretation of electron diffraction and determination of Crystal Structure; Morphology of the Crystals.	11
3	**Thermal Analysis:** Thermogravimetric analysis, Differential thermal analysis and Differential scanning calorimetry and methodology; Determination of phase transitions using these methods.	05
4	**Electrical and Magnetic Property:** Measurement of Electrical conductivity in different materials, e.g. insulators, metals and semiconductors. Using Four Probe and Hall Effect method. Vibrating Sample Magnetometer (VSM), Superconducting Quantum interference Devices (SQUID), Magnetodielectric effect	8

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

11. Suggested Books:

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-619**   Course Title: **A Primer in Quantum Field Theory**

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

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

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

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

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

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

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Basics:**Action principle; Euler-Lagrange equations of motion, second quantization; Symmetry (space-time and internal)Conserved Nöther charges.	4
2.	**Tensors:** Definitions of contravariant, covariant and mixed tensors, need to use tensors in relativistic quantum mechanics.	2
3.	**Spin-0 (Klein Gordon Field Theory):** Real scalar field theory and its canonical quantization; Normal Ordering; Charged scalar field theory and its canonical quantization, conserved Nöther current and charge, Propagator (also as vacuum expectation value of a time-ordered product), interpretation of negative-energy solutions as anti-matter; Recasting Klein-Gordon equation as a Schrödinger equation, Zitterbewegung.	7
4.	**Spin-1/2 (Dirac Field Theory):** Dirac Lagrangian for spinor fields, Feynman Gamma matrices and related identities; Covariance of the Dirac equation; Canonical quantization of the spinor fields, positive- and negative-energy spinors, positive- and negative-energy projectors, Lorentz transformations to boost from rest frame to lab frame; Propagator (also as vacuum expectation value of a time-ordered product), Discrete symmetries: Charge conjugation, Parity and Time reversal symmetries.	9
5.	**Spin-1 (Gauge Field Theory):** Covariant formulation of Maxwell's equations, (transverse) canonical quantization of the gauge field (in the Coulomb gauge),	5
6.	**Scattering:** LSZ reduction (for bosons and fermions), Wick's theorem, S-matrix, cross sections.	6
7.	**Quantum Electrodynamics:** Quantization of abelian gauge theories with fermions; Feynman Rules; Compton effect; Møller Scattering, radiative corrections; Anomalous Magnetic Moment; Infrared Divergence; Lamb shift.	9

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		Total	42

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-621**   Course Title: **Astrophysics**

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

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

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

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

8. Pre-requisite: **PH-202 and PH-303**

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

10. Details of Course:

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

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

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

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

10. Details of Course:

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

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-625**   Course Title: **Particle Physics**

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

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

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

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

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

9. Objective: To introduce the basics of elementary particle physics.

10. Details of Course:

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

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5.	**Strong Interaction:** (i) **Pre-QCD**: The structure of Hadrons, Probing a charge distribution with electrons: Inelastic electron -proton scattering, Partons and Bjorken scaling; (ii) **QCD** (quantization of non-abelian gauge theories with fermions): Yang-Mills theory, Parton model revisited, Feynman rules, Asymptotic freedom.	8
6.	**Weak Interaction:** (i) **Phenomenology**: Parity violation and the V-A form of the weak current, Muon decay, Pion decay, charged current, neutral currents, Cabibbo angle, weak mixing angle, CP Invariance, CP violation; (ii) **Electroweak Unification (Glashow-Salam-Weinberg model)**: The basic electroweak interaction, effective current-current Interaction, Spontaneous symmetry breaking, Higgs mechanism and choice of the Higgs field, masses of gauge bosons and fermions, the complete Lagrangian.	10
	Total	42

11.   Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **PH-504 and PH-508**

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

10. Details of Course:

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

11. Suggested Books:

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

NDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: DEPARTMENT OF PHYSICS

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

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To familiarize with the dynamic meteorology of earth's atmosphere

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Atmospheric Dynamics:** Equation of motion, the geostrophic approximation, cyclostrophic motion; The thermal wind equation; The equation of continuity.	8
2.	**The General Circulation:** A symmetric circulation, Inertial instability, Barotropic instability; Baroclinic instability; Sloping convection; The general circulation of the middle atmosphere.	8
3.	**Numerical Modelling of Weather:** A barotropic model; Baroclinic models; Primitive equation models; Moist processes; Radiation transfer; Forecasting models.	10
4.	**Global Observations:** Conventional observations; Remote sounding from satellites; Remote sounding of atmospheric temperature; Remote measurements of composition.	8
5.	**Atmospheric Predictability and Climate change:** Short term predictability; Variations of climate; Atmospheric feedback processes; Different kind of predictability	8
	Total	42

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Radioactive decay, Source of charged and uncharged radiation, Interaction of radiation with matter: heavy charged particle, electron, gamma-rays and neutrons, stopping power, Bragg curve, Radiation exposure, absorbed dose, equivalent dose, Counting statistics, Error analysis	9
2.	Properties of radiation detectors: operation mode, pulse height spectra, energy resolution, detection efficiency and dead time. Ionization chambers, Proportional counters, Geiger Mueller counters Scintillation detectors: Inorganic and Organic scintillators, photomultiplier tube, Response of scintillation detectors to gamma-rays and neutrons. Application of scintillation detectors	11
3.	Semiconductor diode detector and its use in alpha spectrometry, fission fragment spectroscopy, particle identification, X-ray spectroscopy. Gamma spectroscopy with Silicon(Si(Li)) and Germanium (Ge(Li), HPGe) detectors, Fast and slow neutron detection Pulse processing electronics: NIM: Amplifier, SCA, CFD, CAMAC: ADC, TDC, Timing and coincidence measurements.	12
4.	Linear and circular accelerators, Nuclear reactor: neutron source and power generator. Applications in tracing, material modification, sterilization, material modification; neutron activation analysis, medicine:	10

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

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-633**   Course Title: **Physics and Technology of Thin Films**
2. Contact Hours: **L: 3**   **T: 1**   **P: 0**
3. Examination Duration (Hrs.):   **Theory :3**   **Practical: 0**

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

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

8. Pre-requisite: **Nil**

9.   Objective: To familiarize students with basic understanding of science and technology of thin films and their potential device applications.

10.   Details of Course:

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

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11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-635**   Course Title: **Advanced Nuclear Reactions**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective:. The course is designed to provide the advance knowledge of nuclear reactions and its applications.

10. Details of Course:

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

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11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-637**   Course Title: **Semiconductor Photonics**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: The course is aimed at introducing to students the concepts of semiconductor photonic devices and various devices based on these.

10. Details of Course:

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

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

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

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

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

10. Details of Course:

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

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11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

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

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

10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Introduction :**Astronomy-Observing the universe, Astrophysics- 'Explaining' the universe; General characteristics of Thermonuclear reactions; Sources of nuclear energy; Cross sections, stellar reaction rates, mean lifetime; Maxwell-Boltzmann velocity distribution, Astrophysical S – factor,	10
2.	**Determination of reaction rates :** Neutron and charged particle induced non-resonant reactions; Reactions through narrow and broad resonances	8
3.	**Hydrogen and Helium burning :** p-p chain, CNO cycles, other cycles like NeNa, MgAl; Creation and survival of ^{12}C	9
4.	**Explosive Burning and Nucleosynthesis beyond Iron :** Silicon burning; Nucleosynthesis in massive stars, s – process, r - process	9
5.	**Indirect methods in Nuclear Astrophysics:** Coulomb dissociation, Trojan Horse and ANC methods; Neutron stars;Radioactive Ion Beams	6
	Total	42

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11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-604**   Course Title: **Physics of Nanosystems**

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

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

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

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

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

9. Objective: This course on physics of nanosystems is designed to introduce the emerging area of nanotechnology.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	*Introduction* - An overview of quantum mechanical concepts related to low-dimensional systems.	2
2.	*Hetrostructures* – Heterojunctions, Type I and Type II heterostructures, Classification of Quantum confined systems, Electrons and holes in Quantum wells, Electronic wavefunctions, energy subbands and density of electronic states in Quantum wells, Quantum wires, and Quantum dots, Effective mass mismatch in heterostructures, Coupling between Quantum wells, Superlattices	5
3.	*Electron states* - Wavefunctions and Density of States for superlattices, Excitons in bulk, in Quantum structures and in heterostructures, The unit cell for quantum well, for quantum wire and for quantum dot	6
4.	*Nanoclusters and Nanoparticles* –introduction, Metal nanoclusters-Magic numbers, Geometric structures, Electronic structure, Bulk to nanotransition, Magnetic clusters; Semiconducting nanoparticles; Rare-gas and Molecular clusters.	4
5.	*Carbon Nanostructures* –Introduction, Carbon molecules, Carbon clusters, Structure of C60 and its crystal, Small and Large Fullerenes and Other Buckyballs, Carbon nanotubes and their Electronic structure	3
6.	**Properties of Nano Materials:** Size dependence of properties, Phenomena and Properties at nanoscale, Mechanical/Frictional, Optical, Electrical Transport, Magnetic properties.	4

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7.	**Nanomaterial Characterization:** Electron Microscopy, Scanning Probe Microscopies, near field microscopy, Micro- and near field Raman spectroscopy, Surface-enhanced Raman, Spectroscopy, X-ray photoelectron spectroscopy.	7
8.	**Synthesis of nanomaterials:** Fabrication techniques: Self-Assembly, Self-Replication, Sol-Gels. Langmuir-Blodgett thin films, Nanolithograph, Bio-inspired syntheses, Microfluidic processes, Chemical Vapor Deposition, Pulse laser deposition.	8
9.	**Applications of Nanomaterials:** Nanoelectronics, Nanosensors, Environmental, Biological, Energy Storage and fuel cells.	3
	Total	42

11. Suggested Books:

S.No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	Edelstein A. A. and Cammarata R .C., "Nanomaterials- Synthesis, Properties and Applications", Institute of Physics Publishing, London	1998
2.	Shik, A, "Quantum Wells: Physics and Electronics of two-dimensional systems", World Scientific	1999
3.	Benedek et al G., "Nanostructured Carbon for advanced Applications", Kluwer Academic Publishers	2001
4.	Harrison, P, "Quantum Wells, Wires, and Dots: Theoretical and Computational Physics", John Wiley	2000
5.	Mitin, VV, Kochelap, VA and Stroscio, MA "Quantum Heterostructures: Microelectronics and Optoelectronics", CambridgeUniversity Press	1999
6.	Poole, Jr. CP and Owens, FJ,"Introduction to Nanotechnology", Wiley India.	2006

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **PH-504**

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

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Superfluidity:** Basic properties of superfluid ^{4}He and ^{3}He; Bose- Einstein condensation in an Ideal Bose Gas; Bose-Einstein Condensation in Interacting Gases, Condensate Wave Function.	8
2.	**Theory of Bose Fluids:** Landau Criterionfor Superfluidity. Excitations ina uniform Gas – Bogoliubov Transformation; Excitations in a Trapped Gas – Weak Coupling, Excitations in Non-uniform Gases.	9
3.	**Vortex States:** Quantization of Circulation, Quantized Vortices in He-II; Quantized Vortices in Superconductors; Comparison of He-II and Superconducting Vortices; Dynamics of Vortex States.	9
4.	**Ginzburg-Landau Theory:** Ginzburg Landau equations, second order critical fields; Abrikosov vortex lattice; Relation of GL theory with BCS theory; Ginzburg-Pitaevskii equations for He-II; Broken symmetry.	8
5.	**High-Tc Superconductivity:** Nature and various mechanisms of High Tc superconductivity; Equation for the critical temperature and strong electron-phonon coupling; SDW and CDW.	8
	Total	42

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11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code:**PHN-608**   Course Title: **Fiber and Nonlinear Optics**

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

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

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

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

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

9. Objective: To introduce applications of lasers in nonlinear optics, optical fiber communication and sensors.

10. Details of Course:

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

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4.	3rd order nonlinear optics: third harmonic generation, optical Kerr effect, self phase modulation, self focusing, spatial solitons, Raman gain, four wave mixing, optical phase conjugation, Raman and Brillouin scattering.	8
	Total	42

11. Suggested Books:

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-610**　　Course Title: **Quantum Optics**

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

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

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

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

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

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

10. Details of Course:

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

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11.   Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

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

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

10. Details of Course:

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

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11.   Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-614**   Course Title: **Introduction to Superstring**
                                                Theory

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

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

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

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

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

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

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Bosonic String Theory: Perturbative: free bosonic string in Minkowski space, commutation relation and mode expansion, Virasoro algebra, Light-cone gauge Quantization and no-ghost theorem, analysis of spectrum.	8
2.	Superstring Theory: World-sheet supersymmetry, boundary conditions and mode expansions, light-cone gauge quantization, [no-ghost theorem, GSO condition], extended world-sheet supersymmetry [N=2, 4], super Yang-Mills theory.	14
	Space-time supersymmetry, superparticle and superstring, type I and II superstrings, Light-cone quantization and analysis of open and closed-string spectra.	
	SO(32) and E_8 x E_8 heterotic string theories.	
3.	Basic Mathematics of String Theory: Topological Spaces, Continuous Functions, real (differentiable) manifolds, vector fields, differential forms, Riemannian Geometry, integrals of forms and Stokes theorem, Laplacian on forms, Simplicial Homology, de Rham Cohomology, Fiber Bundles, Homotopy theory, Complex Manifolds, Kählerian geometry, Dolbeault Cohomology, Calabi-Yau manifolds and their Moduli Spaces	8

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4.	Nonperturbative: dualities, basic ideas of M- and F -theories, compactifications, dualities, examples and their tests and interrelation between different duality conjectures, M-theory in 11 dimensions and its compactification, F-theory in 12 dimensions and its compactifications, nonperturbative D-branes and open strings in closed string theories.	12
	Total	42

11. Suggested Books:

S.No.	Name of Books/Authors	Year of Publication
1.	Superstring Theory: Volume 1; Introduction by Michael B. Green, John H. Schwarz, Edward Witten Cambridge University Press	1988
2.	String Theory (Cambridge Monographs on Mathematical Physics) (Volumes 1,2), J.Polchinksi	1998
3.	An Introduction to Nonperturbative String Theory, By Ashoke Sen, In *Cambridge 1997, Duality and supersymmetric theories* 297-413	1997
4.	String theory on Calabi-Yau manifolds, Brian R. Greene, (Columbia U.) : Lectures given at Theoretical Advanced Study Institute in Elementary Particle Physics (TASI 96): Fields, Strings, and Duality, Boulder, CO, 2-28 Jun 1996, Published in Boulder 1996, Fields, Strings and Duality, World Scientific Singapore	1997

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code:**PHN-616**   Course Title: **Advanced Electroceramics Technology**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: This course will introduce the students to modern day electoceramic materials and their applications and will enable the students to learn about modern applications of electroceramic materials and the underlying physical principles.

10.   Details of Course:

S. No.	Contents	Contact Hours
1.	INTRODUCTION: Oxide and non-oxide ceramics, their chemical formulae, crystal and defect structures, non-stoichiometry and typical properties.	4
2.	POWDER PREPARATION: Physical methods (different techniques of grinding), chemical routes - co-precipitation, sol-gel, hydrothermal, combustion synthesis, high temperature reaction (solid state reaction).	6
3.	BASIC PRINCIPLES AND TECHNIQUES OF CONSOLIDATION AND SHAPING OF CERAMICS: powder pressing- uniaxial, biaxial and cold isostatic and hot isostatic, injection moulding, slip casting, tape-casting, calendaring, multilayering.	5
4.	Sintering: different mechanisms and development of microstructure (including microwave sintering) Preparation of single crystal, thick and thin film ceramics Problems of sintering: Inhomogeneties and their effects on sintering, constrained sintering; rigid inclusion, thin film, solid solution additives and the sintering, sintering with chemical reaction, viscous sintering with crystallization.	5
5.	EXOTIC CERAMICS: functionally graded, smart/ Intelligent, bio-mimetic and nano- ceramics - basic principles, preparation and applications, Ceramic Sensors, Transparent ceramics, coatings and films: preparation and applications	8
6	Ceramic Capacitors: Historical Background, Ferro Electricity in Capacitors Technology, Dielectric Properties of Multi-Phase systems, Basic Dielectric Materials, Varieties of Ceramic capacitor, Capacitor performance Parameters, Typical Ceramic Dielectric Compositions, fuel cells and batteries	8
7.	Magnetic Ceramics: Spinal ferrites, Hexagonal ferrites, Rare earth-Garnet, Processing & application in various fields.	6
	Total	42

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11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Michel W. Barsoum, M. W., "Fundamental of Ceramics", McGraw Hill International edition	1997
2.	Richerson, D.W., "Modern Ceramic Engineering", Mercel Dekker NY	1992
3.	Rahman, M. N.,"Ceramic Processing and Sintering", Mercel Dekker	2003
4.	Somiya, S.,"Handbook of Advanced Ceramics", Academic Press	2003
5.	Somiya, S.,"Handbook of Advanced Ceramics, Parts 1 and 2, Academic Press	2006

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-618**   Course Title: **Atomic and Molecular Collision Physics**

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

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

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

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

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

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

10.   Details of Course:

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

11.   Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

Subject Code: **PHN-620**   Course Title: **Advanced Quantum Field Theory**

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

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

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

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

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

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

10.   Details of Course:

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

11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

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

9. Objective: **Aspects of solar interaction with Earth's upper atmosphere**

10. Details of Course:

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

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11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

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

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

10.   Details of the Course:

S. No.	Contents	Contact Hours
1.	Harmonic oscillator, wave functions, evaluation of special functions using recurrence relations and optimization, spherical harmonics, shapes of atomic orbitals, Coupling of angular momenta.	5
2.	Simulation of Rutherford scattering, Semi empirical mass formula, estimation of the constants in mass formulae using atomic mass evaluations, mapping of drip lines. Quantum tunneling: application of WKB approach to alpha and proton decays.	5
3.	Numerical evaluation of Eigen states for different potentials by solving coupled differential equations with boundary conditions, harmonic oscillator, square-well and Woods-Saxon potentials. Complex Eigen values and resonances	5
4.	Independent particle models, Eigen states, Solutions for Nilsson model. Single-j shell approximation and Cranking model. Effective interaction: Simple estimates, Evaluation of matrix elements in sd shell. Superconductivity: Solution for BCS equations at $T = 0$. Hot nuclei: Application of Fermi-Dirac distribution. Quantum Hadrodynamics: Walecka model, Equation of State for symmetric, asymmetric and neutron star matter	10
5.	Setting up large codes, parallel and distributed computing, open access codes, libraries	3
	Total	28

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11. Suggested Books:

S. No.	Name of Books/Authors	Year of Publication
1.	Greiner W and Maruhn J A, "Nuclear models", Springer-Verlag	1997
2.	Arfken G B, Weber H J and Harris F E, "Mathematical Methods for Physicists 7ed", Academic Press	2013
3.	Abramowitz M and Stegun I A, "Handbook of mathematical functions with formulas, graphs and mathematical tables", Dover Publications	1972
4.	Giordano N and Nakanishi H "Computational Physics, 2ed", Pearson/Prentice Hall	2006
5.	Pang T, "An Introduction to Computational Physics", Cambridge Univ. Press	2006

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

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

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

10. Details of Course:

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

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11. Suggested Books:

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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: Undergrad level knowledge of superconductivity

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

10. Details of Course:

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

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11. Suggested Books:

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

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

The IAPC in its meeting held on 27.10.2017 considered and recommended the syllabi of the elective courses M.Tech. (Solid State Electronic Materials) and M.Tech. (Photonics) as given in **Appendix 'A'**.

The above syllabi are submitted for the consideration and approval of the Senate.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-718**   Course Title: **Thin Film Technology**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To familiarize with different thin film deposition and characterization techniques and their advantages and limitations.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	Motivation: Thin films: Introduction, Technology as a drive and vice versa.	4
2.	Review from Material Science Perspective: Structure, defects, thermodynamics of materials, mechanical kinetics and nucleation; grain growth and thin film morphology.	7
3.	Vacuum Science and Technology Basics: Kinetic theory of gases; gas transport and pumping; vacuum pumps and systems; vacuum gauges; oil free pumping; aspects of chamber design from thin film growth perspectives.	8
4.	Different Deposition techniques of Thin Films: Spin Coating, Langmuir-Bodget, Spray Pyrolysis, Thermal Evaporation, Electron beam deposition, Metal Organic Chemical Vapor Deposition (MOCVD), Molecular Beam Epitaxy (MBE), Pulsed Laser Deposition (PLD), DC, RF and Reactive Sputtering,	8
5.	Characterization of Thin films and Surfaces: Ellipsometry; RHEED, EELS, Structural characterization; Chemical characterization; Transport; Optical and Optoelectronic properties, Internal Stress, disadvantages and advantages.	7
6.	Thin Film Processing from Devices and other Applications Perspective: Patterning, various kinds of resists; Lithography techniques; Multiple stage lithography and VLSI for devices; Large area deposition for various applications including displays and energy materials.	8
	Total	42

T 1

11.   Suggested Books:

S.No.	Name of Authors/ Books/Publishers	Year of Publication/ Reprint
1.	OhringMilton, Gall Daniel, Baker S P"Materials Science of Thin Films: Deposition and Structure", Academic Press.	2014
2.	Seshan Krishna, "Handbook of Thin Film Deposition"William Andrew	2012
3.	Chopra K L, Das S R, "Thin Film Solar Cells", Springer	2013
4.	Smith D L, "Thin Film Deposition: Principles and practice", McGraw-Hill Education	1995

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code:**PHN-719**   Course Title: **Radiation Detection and Measurements**

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

S. No.	Particulars	Contact Hours
1.	Nuclear binding energy, Nuclear stability, Radioactive decay, Interaction of radiation with matter: heavy ions, electron, gamma-rays and neutrons, stopping power, range, Bragg curve, Radiation exposure, absorbed dose, equivalent dose, Counting statistics, Error analysis.	10
2.	Properties of radiation detectors: modes of operation, pulse height spectra, energy resolution, detection efficiency. Ionization chambers, Proportional counters, Geiger Mueller counters. Scintillation detectors: Inorganic and Organic scintillators, photo sensors, gamma spectrometry with scintillation detectors.	10
3.	Semiconductor diode detectors and its use in alpha spectrometry, fission fragment spectroscopy, particle identification. Gamma spectroscopy with Silicon (Si(Li)) and Germanium (Ge(Li), HPGe) detectors, Fast and slow neutron detection. Pulse processing electronics: NIM: Amplifier, SCA, CFD, CAMAC: ADC, TDC, Timing and coincidence measurements. Accelerators: Cyclotron and Linac.	14

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4.	Industrial, analytical and medicinal applications; Power from fission, Nuclear reactors; Source of stellar energy	8
	Total	42

List of experiments:
1. To study the plateau characteristics of a G-M detector.
2. To measure the dead time of a G-M detector
3. To study the statistical nature of nuclear radiation using a G-M counter
4. To measure the energy dependent absorption coefficient of Aluminum using a G-M counter
5. To calibrate the NaI(Tl) scintillation detector and to study the complete energy spectrum of Cs-137 using a single channel analyzer
6. To calibrate the NaI (Tl) scintillation detector and to study the complete energy spectra of Cs-137, Co-60, Na-22 using a Multi channel analyzer
7. To measure the absorption coefficient of Al, Cu, Pb using a NaI(Tl) scintillation detector for 662 keV gamma rays
8. To study alpha spectrum using surface barrier detectors
9. To introduce high resolution gamma spectroscopy using HPGe detector

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Glenn F. Knoll, "**Radiation Detection and Measurement**", Wiley Publication	2010
2.	W.R. Leo, "**Techniques for Nuclear and Particle Physics experiments**", Springer-Verlag	1994
3.	S Ahmed, "**Physics and Engineering of Radiation Detection**" Academic press	2007
4.	S.S. Kapoor, V. Ramamurthy, "**Nuclear Radiation Detectors**" New Age International (P) Ltd.	2005
5.	John R. Lamarsh, Anthony J. Baratta, "**Introduction To Nuclear Engineering**", Prentice Hall.	2001
6.	Gordon R. Gilmore, "**Practical Gamma-ray Spectrometry**", John Wiley & Sons	2008

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-720**   Course Title: **Advanced Characterization Techniques**

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

Module	Contents	Contact Hours
1.	Relevance of advanced characterization techniques, Examples of different characterization techniques	2
2.	Sources of X-rays, Characteristics of X-rays, Interaction of X-rays with Matter, Neutron sources, Neutron vs X-rays	4
3.	Fundamentals of diffraction, Diffraction and convolution theorem, Laue diffraction, Powder diffraction, Surface diffraction, X-ray reflectometry, Diffraction from thin films, Neutron diffraction	12
4.	Absorption spectroscopy: X-ray absorption phenomenon, X-ray absorption spectroscopy (XAS), Extended X-ray absorption fine structure, Near-edge X-ray absorption fine structure (NEXAFS), Surface sensitive EXAFS (SEXAFS)	8
5.	Photoelectron spectroscopy: Energetics, Photoelectron escape depths, Electron energy analyzer, X-ray photoelectron spectroscopy, Ultraviolet photoelectron spectroscopy	5
6.	Microscopy: Optical microscopy, Resolution limit, Scanning electron microscope, Transmission, electron microscope, Atomic force microscopy, Scanning tunnel microscope	8

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7.	Four probe and Hall effect method. Vibrating Sample Magnetometer (VSM), Superconducting Quantum interference Devices (SQUID)	3
	Total	42

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	B. D. Culity and S. R. Stock "Elements of X-ray Diffraction", Addison-Wesley.	2001
2.	Jens Als-Nielsen and Des McMorrow, "Elements of Modern X-ray Physics" Wiley	2011
3.	Phillip Willmott "An Introduction to Synchrotron Radiation: Techniques and Applications" Wiley	2011
4.	Paul van der Heide "X-ray Photoelectron Spectroscopy: An introduction to Principles and Practices" Wiley	2011
5.	Peter J. Goodhew, J. Humphreys, R. Beanland "Electron Microscopy and Analysis" Taylor and Francis	2001
6.	S. N. Magonov, M.-H. Whangbo "Surface Analysis with STM and AFM: Experimental and Theoretical Aspects of Image Analysis" Wiley	2008
7.	A. Chtchelkanova, S. Wolf, and Y. Idzerda, "Magnetic Interactions and Spin Transport", Springer	2003

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: DEPARTMENT OF PHYSICS

1. Subject Code: **PHN-721**   Course Title: **Nanoscience and Nanotechnolo(**

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

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

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

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

8. Pre-requisite: **Nil**

9.   Objective : The course is designed to introduce the emerging area of nanotechnology that has potential to revolutionize techniques by which materials and products will be created in the future with new and superior properties and functionalities.

10.   Details of Course:

S.No.	Contents	Contact Hours
1.	**Introduction:** An over view of quantum mechanical concepts related to low dimensional systems	02
2.	**Fundamental Principles:** Size & Scale, units, Scaling Laws, Atoms, Molecules & Clusters, Nanoscale Phenomena; Tunneling, Chemical Bonds (types and strength); Intermolecular Forces, Molecular and Crystalline Structures, Hierarchical Structures and Functionality, Surfaces and Interfaces, Bulk to Surface transition, Self-Assembly and surface reconstruction.	08
3.	**Basic ideas of Hetrostructures-** Heterojunctions, Type I and Type II heterostructures, Classifications of Quantum confined systems, Electrons and holes in Quantum wells, Electronic wave functions, energy sub bands and density of electronic states in quantum wells, quantum wires and Quantum dots.	08
4.	**Properties of Nano Materials:** Phenomena and Properties at nanoscale, Mechanical/Frictional, Optical, Electrical Transport, Magnetic properties.	08

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5.	**Synthesis and characterization of nanomaterials:** Fabrication techniques: Self-Assembly, Sol-Gels. Langmuir-Blodgett thin films, Nanolithography, Bio-inspired syntheses, Microfluidic processes, high energy ball milling, Chemical Vapor Deposition, Fullerenes, Carbon Nanotubes, Nano-composites, nanoporous Materials, AFM, TEM, SAED, RHEED, LEED	08
6.	**Applications of Nanomaterials:**Functional materials, coating, nanoelectronics, membrane based application, Optoelectronic devices, Nanosensors, Energy Storage and fuel cells.	04
7	**Nanotechnology for waste reduction and improved energy efficiency:** nanotechnology based water treatment strategies. Nanoporous polymers and their applications in water purification, Nanotoxicology. Use of nanoparticles for environmental remediation and water treatment.	04
	Total	**42**

11.　Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Edelstein A. A. and Cammarata R .C., "**Nanomaterials- Synthesis, Properties and Applications**", Institute of Physics Publishing, London	1998
2.	Nalwa H.S., "**Handbook of Nanostructured Materials and Nanotechnology**", Vols. 1-5, Academic Press	2000
3.	Benedek et al G., "**Nanostructured Carbon for advanced Applications**", Kluwer Academic Publishers	2001
4.	Dresselhaus M.S., Dresselhaus G. and Eklund P., "**Science of Fullerenes and Nanotubes**", Academic Press	1996
5.	Wilson M, Kannangawa K, Smith G, Simmons M, Raguse, "**Nanotechnology: Basic Science and Emerging Technologies**", Chapman & Hall CRC	2002

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-722**   Course Title: **Functional Properties of Material**

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

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

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

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

8. Pre-requisite: **NIL**

9.   Objective: The aim is to provide comprehensive knowledge on functional materials a and devices

10.   Details of Course:

S. No.	Contents	Contact Hours
1.	Functional Materials: Scope, Present status and Future trend, Classification according to their different functions. Electrical and electronic conduction in ceramics, defect chemistry, ionic conductivity, ceramic electrolytes and fast ion conductors, ceramic insulators; Ceramic Capacitors, piezoelectric, ferroelectric and electro optic Material Fabrication systems, processing and Application, Ionic Conductors: diffusivity, transference number, Dielectrics, Polarization, Ferro electricity, Magnetic Materials, Overview of semiconductor materials and physics	12
2.	Thin film technology, materials and deposition methods, microelectronics and micro systems; Multilayer ceramic technology, Sequential, laminated MLC processes, processing of multi layer ceramics, sintering of multilayer structure. Low temperature co-fired glass ceramics. Chemical methods for preparing functional materials. Characterizations	08
3.	Smart functional roles of the materials in devices which depends on their electrical, optical and thermal properties, e.g. active semi conducting devices and associated passive electrical components, smart transducers, optical fibers, optical coatings, liquid crystal displays, optical storage devices, energy storage devices, solar cell, ceramic insulator,	08

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4.	Sensors and resistors- classification, Operating principles of different sensors, Preparation and applications; Positive temperature coefficient and negative temperature coefficient ceramics thermistor, gas sensor, humidity sensor, pressure sensors, ZnO-varistors technology, varistor microstructure and fabrication, mechanism, equivalent circuit. varistor application.	08
5.	Ceramic membranes: classifications, material requirements, preparation and applications; Special glass and glass ceramics for defense application.	06
	Total	**42**

11. Suggested Books:

S.N o.	Names of Books/Authors	Year of Publication
1.	C. S. Sunandana, "**Introduction to Solid State Ionics: Phenomenology and Applications**" CRC Press	2015
2	Buchanan R. C., "**Ceramic Materials for Electronics**", Marcel Dekker, NY	2004
3.	Moulson A. J. and Herbert J. M., " **Electroceramics: Materials, Properties and Applications**", Wiley	2003
4.	Bachs H. and Krause D., "**Low Thermal Expansion Glass Ceramics**", Springer	2005
5.	Setter N., "**Electro-ceramic-based MEMS: Fabrication Technology and Applications**", Springer	2005
6.	Nenov T. G., Yordanov S. P. and Nenov N., "**Ceramic Sensors: Technology and Applications**", CRC Press	1996
7.	Z. Lin Wang, W. Z-Lin-Wang, Z C Kang, "**Functional and Smart Material**", Springer	1998
8.	Jaffe B., Cook W. R., Jaffe H. and Jaffe H. L. C., Piezoelectric Ceramics, R.A.N Publishers	1990

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-723**   Course Title: **Engineered Materials for Device Applications**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To introduce students to the recent developments in the area of engineered materials for device applications

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Introduction: Broad Overview of Materials with Novel Quantum Properties	2
2.	2 D Materials (I): Structural, Electronic and Transport Properties of Graphene, Synthesis and Device Applications, RF Applications of Graphene, Thermal Transport in Graphene, Graphene-Semiconductor Hybrids, Graphene in Sensor Design, Graphene Oxides	10
3.	2 D Materials (II): Physical properties of Transition Metal Dichalcogenides (TMD), MoS_2/Metal, MoS_2/Oxide interfaces, TMD Schottky junctions, TMD photodetectors, light emitters, Photovoltaics, Flexible TMD	10

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4.	Spintronics: Overview and recent progress in the field, Spin dependent Transport in Ferromagnetic Metals, Giant Magnetoresistance (GMR), Colossal Magnetoresistance (CMR), Tunnel Magnetoresistance (TMR), Anisotropic Magnetoresistance (AMR), Spin Orbit Interaction, Spin Hall Effect, Rashba Interfaces, Spin Transfer Torque and Spin pumping	10
5.	Oxide Heterostructures : Synthesis of epitaxial oxide Heterostructures, Boundary conditions in Oxide Hetrerostructures, Mott Insulator and Band Insulator Heterostructures, Thermoelectric oxide films and Heterostructures, Ferroelectric Random Access Memories, $LaAlO_3/SrTiO_3$ based device concepts,	10
	Total	**42**

11. Suggested books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	M. Houssa, A. Dimoulas, and A. Molle, "2D Materials for Nanoelectronics" CRC Press	2016
2.	A. Tiwari, M. Syväjärvi, "Advanced 2D Materials" Wiley	2016
3.	T. Shinjo "Nanomagnetism and Spintronics" Elsevier	2014
4.	E. Y. Tsymba, Elbio R. A. Dagotto, Chang-BeomEom, R. Ramesh "Multifunctional Oxide Heterostructures" Oxford University Press	2012

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-724**   Course Title: **Semiconductor Micro-Electronic Technology**

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

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

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

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

8. Pre-requisite: **Nil**

9.   Objective: To impart knowledge of physics of semiconductor devices and their fabricatior technologies

10.   Details of course:

S. No.	Contents	Contact Hours
1.	**Crystal Growth and Epitaxy:** Single crystal growth techniques of Silicon and GaAs, epitaxial growth techniques, structures and defects in epitaxial layers, thermal oxidation of silicon including the Deal-Grove model	10
2.	**Film Formation:** Vacuum science, vacuum technology and basic physics of a plasma, thermal oxidation of Si, deposition of SiO_2 film by CVD technique	7
3.	**Lithography:** Optical and non-optical lithography, electron beam lithography, X-ray lithography, etching techniques- wet and dry etch processes including reactive ion and high density plasma etching	8
4.	**Impurity Doping:** Impurity diffusion in semiconductors, diffusion mechanisms, and rapid thermal processes, diffusion process, diffusion equation, diffusion profiles, evaluation of diffused layers, ion implantation- range of implanted ions, ion distribution, ion stopping, ion channeling, implant damage and annealing	9
5.	**Integrated devices:** Fabrication of active and passive components in an integrated circuit, bipolar, MOSFET and MESFET technologies	8
	Total	42

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11. Suggested books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/Reprnt
1.	Sze S.M., "Semiconductor Devices: Physics and Technology", John Wiley and Sons	2012
2.	Streetman B.G. and Banerjee S., "Solid State Electronic Devices", Prentice Hall	2006
3.	Gandhi S.K., "VLSI Fabrication Principles", John Wiley and Sons	1994
4.	Nagchoudhuri D.,"Microelectronic Devices", Pearson	2001
5.	Jaeger R. C.,"Introduction to Microelectronic Fabrication", Prentice Hall	2001

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-725**   Course Title: **Nano-electronics and Photonics**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To familiarize students with the Advanced Electronics and photonics Devices.

10. Details of course:

S. No.	Contents	Contact Hours
1.	**Introduction:** CMOS Scaling, The nanoscale MOSFET, Limits to scaling, Short channel effects, FinFETs, Vertical MOSFETs. Basic effects in Nano-dimensional structures, Energy quantization in Nano-dimension and density of states.	6
2.	**Tunnel Devices:** Tunnel diode, Band diagram, the tunneling current, MIS Tunnel Devices, MIS Switch Diode, MIM Tunnel Diode, Resonant tunneling diode (RTD), Tunnel FET	5
3.	**Single Electron and Spintronic Devices:** Single Electron transistors (SET); Single Electron Box, Quantum Resistance, Quantum Conductance, Coulomb Blockade, Stability Diagram, Quantum Coulomb Blockade, Stability Diagram, Superconductor based devices and Spintronic Devices.	9
4.	**Molecular Electronics:** Molecular electronics involving single molecules as electronic devices, transport in molecular structures, molecular systems as alternatives to conventional electronics.	4
5.	**Fundamentals of Semiconductor Lasers:** Key elements of a semiconductor laser, Threshold gain, I-V characteristic, Modes, Noises	4
6.	**Quantum Well Laser Diodes:** Configuration of Quantum Wells, Characteristic of Quantum Well Laser Diodes, Multiple Quantum Well Lasers, Strained Quantum Well Laser Diodes, Requirement for Fabrication	3
7.	**Quantum Dot Lasers:** Structural and electronic properties of self-organized quantum dots, Optical gain and threshold characteristics of a self-organized quantum dot diode lasers, Fabrication techniques and methods for semiconductor quantum dots, Surface Emitting Quantum Dot Lasers	4
8.	**Quantum Cascade Lasers:** Inter-subband and Inter-band transitions in Semiconductor, Mid Infrared Quantum Cascade Lasers, Properties and Characterization,	7

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11. Suggested Books:

S.No.	Name of Authors/ Books/Publishers	Year of Publication/ Reprint
1.	Sze S.M., "Semiconductor Devices: Physics and Technology", John Wiley and Sons	2012
2.	V. V. Mitin, V. A. Kochelap. M. A. Stroscio, "Introduction to Nanoelectronics: Science, Nanotechnology, Engineering and Applications", Cambridge University Press	2011
3.	H. Grabert, M. H. Dwvoret, "Single Charge Tunneling in Coulomb Blockade Phenomenon in Nanostructure, Springer	1992
4.	V. M. Ustinov, A. E. Zhukov, A. EuEgorov and N. A. Maleev, "Quantum Dot Lasers", Oxford University press	2003
5.	Jerome Faist, "Quantum Cascade Lasers", OUP Oxford	2013

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-726**   Course Title: **Solar Photovoltaics and Energy Storage**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To learn the fundamentals, design and application of solar photovoltaics and energy storage systems.

10.   Details of Course:

S. No.	Contents	Contact Hours
1.	**Device Physics of Solar Cells:** Photovoltaic effect - Principle of direct solar energy conversion into electricity in a solar cell. Semiconductor properties, energy levels, basic equations. Solar cell, p-n junction, structure. Solar radiation, conversion efficiency, p-n junction model, Effect of Parasitic resistance, irradiation and temperature on I-V characteristics,Schockley-Queisser Limit, Numerical solar cell modeling	8
3.	**First Generation Photovoltaics:** Silicon feedstock, Basic design of a c-Si solar cell, Factors that limit efficiency, c-Si device designs, Multi junction III-V solar cells	4
4.	**Second Generation Photovoltaics:** Single junction a-Si: carrier collection vs. light absorption. a-Si tandems and triple junction cells, CdTe and CIGS solar cells, organic solar cells, plasmonics solar cells	4
5.	**Third Generation Photovoltaics:** Dye Sensitized Solar Cells, Perovskite Solar Cells-fabrication, morphology optimization, photophysics study,Perovskite-Si Tandem Solar Cells	6
5.	**Physics of Ionic Conduction:** Ionic Diffusion vis a vis Electron Diffusion, Conductivity Basics: Ionic, Electronic, and Mixed Conductivity, Structure-Defect-Ion Dynamics Nexus. Measurement of Ionic conduction, Electrochemical Impedance spectroscopy: Introduction, Fundamental of impedance Spectroscopy	8

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6.	Energy Storage Devices:	12
	Solis State Batteries:	
	Basic physical concepts of thermodynamics and kinetics involved in electrochemical reactions, e.g. Charge transfer at the electrode interfaces; cell resistance; ion diffusion and migration; electron diffusion into the electrode; concentration gradients within the electrolyte; capacity fade, Introduction to Battery technologies, Battery components: The Cathode, The Electrolyte, The Anode, Advanced Lithium Ion Battery Technologies, Systems Architecture and Integration, The Electric Vehicle Challenge, Hybrid Battery Devices	
	Supercapacitors: Introduction, working principle and Storage mechanism, Type of supercapacitors: Electric double layer capacitor, Pseudocapacitance, symmetric/asymmetric capacitors and hybrid capacitors: Special Applications: Space, Medical, Emergency, and Backup	
	Fuel Cells : Basics of Energy Conversion Process, Fuel Cell Elements	
	Physics of the Solid Oxide, Design and Evaluation of Solid Oxide Fuel Cell	
	SOFC vis a vis MCFC and Other Types	
6.	**Total**	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Jasprit Singh, **"Semiconductor Devices, Basic Principles"**, Wiley	2001
2.	Jenny Nelson, **"The Physics of Solar Cells"**, Imperial College Press	2003
3.	Stephen J. Fonash , **"Solar Cell Device Physics"**, 2nd edition, Academic Press	2010
4.	A. Luque and S. Hegedus, **"Handbook of Photovoltaic Science & Engineering"**, Wiley	2003
5.	Tsakalakos.L., **"Nanotechnology for Photovoltaic's"**, CRC	2010

6.	C. S. Sunandana, **"Introduction to Solid State Ionics: Phenomenology and Applications"** CRC Press	2015
7.	Serguei N. Lvov, **"Introduction to Electrochemical Science and Engineering"**, CRC Press	2014
8.	Orazem Mark E., Tribollet Bernard, **"Electrochemical Impedance Spectroscopy"**, Willey-Interscience.	2008
9.	YU Aiping, Chabot Victor, Zhang Jiujun, **"Electrochemical Supercapacitors for Energy Storage and Delivery: Fundamentals and Applications (Electrochemical Energy Storage and Conversion)"**, CRC Press	2013
10.	RevankarShripad T. , MajumdarPradip, **"Fuel Cells: Principles, Design, and Analysis"**, CRC Press	2014

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-727**   Course Title: **Advanced Fuel Cell and Battery Technology**

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

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

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

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

8. Pre-requisite: **NIL**

9.   Objective: The aim is to provide comprehensive knowledge on advanced Fuel cell and battery technologies

10. Details of course:

S. No.	Contents	Contact Hours
1.	Introduction to Fuel cell, Battery, Types of battery, Market value, research trends and challenges associated with fuel cell and battery technology.	4
2.	**Physics of Ionic Conduction:** Crystal structure, Defects in ionic crystal: Schottkey and Frankel, Kröger-Vink notations, and Thermodynamics of point defects, Role of defects and imperfection in conduction in energy storage and conversion materials.Ionic Diffusion vis a vis Electron Diffusion, Conductivity Basics: Ionic, Electronic, and Mixed Conductivity, Structure-Defect-Ion Dynamics Nexus.	8
3.	**Transport Properties of Solids:** Phenomenology, Mobility, Diffusivity, Chemical Diffusion, Solid Electrolytes, and Conduction Mechanism Determination of Partial Ionic and Electronic Conductivities (EMF, Polarization methods) Case studies of Solid oxide ion electrolytes and Li ion conductors. Electrochemical Impedance spectroscopy: Introduction, Fundamental of impedance Spectroscopy, Elementary analysis of Impedance spectra, Theory, Electrical Models, Measuring Techniques and Data analysis: introduction, frequencyTime Domain analysis, Data presentation and data analysis methods. Impedance spectra fitting and analysis	9

T 20

3	**Battery and Fuel cell Technology:** Understand the basic physical concepts of thermodynamics and kinetics involved in electrochemical reactions, e.g. Charge transfer at the electrode interfaces; cell resistance; ion diffusion and migration; electron diffusion into the electrode; concentration gradients within the electrolyte; capacity fade, Battery components: The Cathode, The Electrolyte, The Anode, Advanced Lithium Ion Battery Technologies, Systems Architecture and Integration, The Electric Vehicle Challenge, Hybrid Battery Devices. Fuel Cells, Fuel cell thermodynamics, Fuel cell kinetics, Fuel Cell Performance Curve, Types of Fuel Cells, and Applications of Fuel Cells	10
4.	**Theory, design and performance evaluation techniques for battery and fuel cell:** working principle, storage mechanism, various components, energy storage device's selection criteria, Case study of various batteries and fuel cell' electrode material. Charge and Discharge Curves of Cells, Cycle Life of Batteries, Battery Capacity, Discharge Characteristics by Discharge Rate, Temperature Characteristics, Energy and Power Density (Gravimetric/Volumetric). Galvanostatic/potentiostatic measurement techniques.	8
5.	Industrial production, applications, recycling and environmental issues. Challenges and Future direction for Energy storage, Battery and fuel cell technology.	3
	TOTAL	**42**

11. Suggested books

Sl. No.	Name of the Books/Authors/Publisher	Year of Publication
1.	C. S. Sunandana, Introduction to Solid State Ionics: Phenomenology and Applications, CRC Press	2015
2.	Introduction to Electrochemical Science and Engineering, Serguei N. Lvov, CRC Press	2014
3.	T. Minami Ed., Solid State Ionics for Batteries, Springer	2013
4.	Electrochemical Impedance Spectroscopy: The Electrochemical Society, USA Series Willey-Interscience	2008
5.	E. Baesukov and J.R. Macdonald, Ed., Impedance Spectroscopy: Theory, Experiment and Application, Second Edition, Willey-Interscience.	2005
6.	Thomas, P. J. Crompton, Battery Reference Book, Newnes, Oxford	2000
7.	Aiping Yu, Victor Chabot, Jiujun Zhang, Electrochemical Supercapacitors for Energy Storage and Delivery: Fundamentals and Applications (Electrochemical Energy Storage and Conversion), CRC Press	2013
8.	Shripad T. Revankar, PradipMajumdar, Fuel Cells: Principles, Design, and Analysis, CRC Press	2014

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-728**   Course Title: **MEMS and NEMS**

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

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

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

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

8. Pre-requisite: **NIL**

9. Objective: To impart knowledge in the areas of micro-/nano-systems design and analysis as well as manufacture.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Multidisciplinary nature of MEMS/NEMS** – working principles: as micro sensors - acoustic wave sensor, biomedical and biosensor, chemical sensor, optical sensor, capacitive sensor, pressure sensor and thermal sensor. Applications in automotive industry – health care – aerospace – industrial product consumer products – lab on chip – molecular machines – data storage devices – micro reactor – telecommunications, Servo systems.	10
2.	**Material Properties in Nano-scale**: Grain size effect on materials properties (mechanical, electrical, magnetic, etc.), Multilayered structures, Nanocluster Composites; Nanocrystals and nanoparticles; Nanotubes, Nanowires, Quantum Dots	08
3.	**Manufacturing Techniques and Processes**: Fabrication of cantilever beam arrays; Cleanroom and Fabrication Procedures; Photolithography: E-Beam Lithography, Dry and Wet Etching, Sputtering Deposition, Bonding and Embossing	08
4.	**Material properties**: Important material properties and physical effects, Piezoresistivity, Piezoelectricity and thermoelectricity, Inter atomic bonds, Material structures.	08
5.	**Materials for MEMS/NEMS**: Silicon – Compatible material systems, Silicon, Silicon oxide and nitride, Thin metal films, Polymers, Other materials and substrates, Glass and fused quartz substrates, Silicon carbide and diamond, Gallium Arsenide and other group III-V compound semiconductors, Shape - memory alloys transduction.	08
	Total	42

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11. Suggested Books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/Reprint
1.	Sergey Edward Lyshevski, "MEMS and NEMS: Systems, Devices, and Structures"; CRC Press	2002
2.	NadimMalut and Kirt Williams, "An Introduction to Microelectromechanical Systems Engineering", Artech House	2004
3.	James J Allen, "Micro electro mechanical systems Design," CRC Press	2005
4.	Sergey Edward Lysherski, Mircea Dragoman, Daniela Dragoman, "Nano- and Micro-Electromechanical Systems: Fundamentals of Nano- and Microengineering", CRC Press	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: DEPARTMENT OF PHYSICS

1. Subject Code: **PHN-729**   Course Title: **Advanced Ceramics & Composites**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart basic understanding about ceramics, fibersand composites with their properties, manufacturing routes and applications.

10.   Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** oxide and non-oxide ceramics, their chemical formulae, crystal and defect structures, non-stoichiometry and typical properties.	4
2.	**Powder preparation:** Physical methods (different techniques of grinding), chemical routes - co-precipitation, sol-gel, hydrothermal, combustion synthesis, high temperature reaction (solid state reaction).	5
3.	**BASIC PRINCIPLES AND TECHNIQUES OF CONSOLIDATION AND SHAPING OF CERAMICS:** powder pressing- uniaxial, biaxial and cold isostatic and hot isostatic, injection moulding, slip casting, tape-casting, calendaring, multilayering. Sintering: different mechanisms and development of microstructure (including microwave sintering) Preparation of single crystal, thick and thin film ceramics	5
4.	**EXOTIC CERAMICS:** functionally graded, smart/ Intelligent, bio-mimetic and nano- ceramics - basic principles, preparation and applications	5
5.	**COMPOSITES:** Introduction to composite materials – definition, characteristics, classification; Matrix Materials – polymers, metals and ceramics; Fabrication of thermosetting resin matrix composites, thermoplastic resin matrix composites, metal matrix composites, ceramic matrix composites, carbon – carbon composites, their preparation and properties (including nano-composites)	5
6	**Transparent ceramics, coatings and films:** Preparation and applications	3

T 24

7.	**SPACE CERAMICS:** Materials aspects of missile and satellite reentry, auxiliary space powder devices- rocket nozzle technology- the space environment and its effects. Quantitative analysis of texture, nature of grain boundaries, development of microstructure, grain growth, microstructure in glass ceramics, effect of particle size, pressure and sintering, dependence of mechanical and thermal properties on microstructure.	7
8.	**CERAMIC FIBRES** Introduction – difference between material in bulk form and fiber form, types of fibers, fiber flexibility, fiber manufacturing technology, glass fibers: manufacture & applications, carbon and graphite fibers, grades of carbon fibers.	4
9	**Engineering applications:** at room and high temperatures (including armour application), Bio-medical applications of ceramic materials	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Michel W. Barsoum, M. W., "Fundamental of Ceramics", McGraw Hill International edition	1997
2.	Richerson, D.W., " Modern Ceramic Engineering", Mercel Dekker NY	1992
3.	Rahman, M. N., "Ceramic Processing and Sintering", Mercel Dekker	2003
4.	Somiya, S., "Handbook of Advanced Ceramics", Academic Press	2003
5.	Somiya, S., "Handbook of Advanced Ceramics, Parts 1 and 2, Academic Press	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-730**   Course Title: **Guided Wave Optical Components and Devices**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To familiarize the students with optical wave guided based technology.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	Integrated optics, asymmetric planar waveguides and their modal analysis, single-polarization single-mode waveguides, 2-D waveguides and their analysis, effective index method, perturbation method.	8
2.	Guided wave devices, directional couplers, modulators, Mach-Zhenderinteferrometer, waveguide gratings, arrayed waveguide gratings.	6
3.	Step-index and graded-index optical fibers, attenuation, pulse dispersion, dispersion shifted fiber, dispersion compensating fiber.	7
4.	Fused fiber coupler, beam splitter/combiner, WDM coupler, wavelength interleaver, side-polished optical fiber and its applications, polarization controller, isolator, circulator.	6
5.	Optical fiber amplifiers, erbium doped fiber amplifiers (EDFAs), mechanism of optical amplification in EDFA, noise figure, Raman amplifiers, gain spectrum	6
6.	Fiber gratings, fiber Bragg gratings, coupled mode analysis, reflection spectrum, add/drop multiplexer, dispersion compensation, strain and temperature sensing, fabrication techniques, long-period gratings, WDM filter, gain flattening of EDFA, mode converters	9
	Total	42

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	List of Experiments	14 x 3 hrs
	1. Characterization and analysis of wavelength division multiplexers and Demultiplexers. 2. Characterization of fiber Bragg gratings and their sensing properties. 3. Characterization of optical isolator and circulator. 4. Gain and noise study of erbium doped fiber amplifiers. 5. Study of time division multiplexing of digital optical signals. 6. Study of wavelength division multiplexed optical fiber communication link. 7. Study of adding and dropping of optical channels in a fiber link. 8. Qualitative and quantitative study of optical signals using eye diagrams and bit-error rate. 9. Rise and fall time study for bandwidth estimation of optical devices. 10. Study of RZ and NRZ signal generation anddetection; and comparative study of the two for non-linearity mitigation in optical fibers.	

11. Suggested Books:

S.No.	Name of Authors/ Books/Publishers	Year of Publication/ Reprint
1.	Pal B. P., "Guided Wave Optical Components and Devices	2006
2.	Ghatak A. and Thyagarajan K., "Introduction to Fiber Optics," Cambridge University Press	1998
3.	Agrawal G. P., "Optical Fiber Communication System," Wiley Interscience	2003
4.	Keiser, G., "Optical Fiber Communication," McGraw Hill Education	2014
5.	Shenoy, M. R., Khijwania, S. K., Ghatak, A. K., and Pal, B. P., "Fiber optics through experiments," Viva Books	2014

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code:**PHN- 731**   Course Title: **Optical Communication Systems**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart the knowledge of basic communication and optical communication devices and sub-systems as needed modern communication networks.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to Communication Systems:** Overview, Analog Vs Digital messages, Signal to Noise ratio and channel capacity, Elements of digital communication systems, Communication Channels(Wireline, Fiber-optic, Wireless, Underwater acoustic and storage channels) and their characteristics, Mathematical models for communication channels, Need of optical communication, Various generations of Optical Communication, Components needed for Optical communication.	5
2.	**Digital Modulation and demodulation Schemes:** Representation of digitally modulated signals, Modulation methods(With memory and memoryless), ASK, PSK, PAM, QAM, etc., and corresponding demodulation methods, Power spectrum of digitally modulated signals,	9
3.	**Multichannel and Multicarrier Systems :** Multichannel digital communication in AWGN channels (Binary and M-ary orthogonal signals), Multicarrier communications: Single carrier vs multicarrier modulation, capacity of a non-ideal linear filter channel, OFDM, Modulation and demodulation in an OFDM system, Algorithm implementation of an OFDM systems, Spectral characteristics of multicarrier signals, Bit and power allocation in multicarrier modulation, Peak to average ratio in multicarrier modulation	6

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4.	**Optical Transmitters:** Semiconductor laser Physics, Single mode semiconductor lasers-various types, Laser Characteristics, Optical signal generation through direct and external modulation, LEDs and their characteristics , Transmitter design	6
5.	**Optical Amplifiers:** Semiconductor optical amplifiers: Basic theory, performance characteristics, Gain clamping, quantum dots;Fiber and waveguide amplifiers: Rare earth doped fiber amplifiers, Raman and Brillouin fiber amplifiers, waveguide amplifiers, Optical parametric amplifiers, Wideband fiber amplifiers; Optical regeneration.	6
6	**Optical Receivers:** Basic concepts:Absorption, Quantum efficiency, responsivity; Common Photodetectors(with and without internal gain), Receiver design, Receiver noise, Coherent detection, Receiver sensitivity(through minimum received power, BER, Eye diagram analysis), Sensitivity degradation	10
	TOTAL	42

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	J.G. Proakis, and M. Salehi, "Digital Communications", McGraw Hill	2008
2.	Agrawal GP, "Fiber-Optic Communication Systems", Wiley	2010
3.	Senior JM, "Optical Fiber Communications", Pearson Education	2011
4.	Keiser G "Optical fiber Communications", McGraw Hill	1993
5.	Gowar J, "Optical Communication Systems", Prentice Hall.	1999
6	Powers John, "Introduction to Fiber Optic Systems", Tata McGraw Hill	2010
7	B.P. Lathi, and Z. Ding, "Modern Digital and Analog Communication Systems", Oxford University Press	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-732**   Course Title: **Optical Networks**

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

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

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

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

8. Pre-requisite: Basic Knowledge of Communication Systems

9. Objective: The course is designed to provide an in-depth study of optical communication networks and the challenges in modern(optical) networks.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to Communication Networks:** Telecommunications network architectures, Network topologies, Circuit switching and packet switching, Layered architecture and protocols, Functions of various layers, Overview of TCP/IP, ISDN and SS-7 protocol architectures.	3
2.	**Optical Signal Processing Components in Networks:**Bistable devices: All-optical flip-flops, Coupled Semiconductor lasers and SOAs; Wavelength convertors: XPM, FWM, SOA and resonator based; Data format convertors; Optical regenerators: 2R and 3R, regeneration of phase encoded signals.	5
3.	**Light wave network systems:** System architectures: Point-to-point links, distribution networks, LAN; Long-Haul network systems: performance limiting factors, Terrestrial and undersea light wave systems	5
4.	**Client layers of Optical Layer:** SONET/SDH, Optical Transport Network, Generic Framing procedure, Ethernet, IP, Multiprotocol label switching, Resilient packet ring, Storage area network	8
5.	**WDM Network Elements, and Control and Management:** Optical line terminals, line amplifiers, OADMs, ROADMs, Optical X-connects; Network management functions, optical layer services layer and interfacing, layers within optical layer, multi-vendor interoperability, performance and fault management, Optical layer overhead, Client layers, Configuration management, Optical Safety	6

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6	**Network Survivability:** Basic concepts, Protection in SONET/SDH, Protection in Client layer, Need of optical layer protection, Optical layer protection schemes, Interworking between layers	6
7	**WDM Network Design and Access Networks:** Cost trade-offs, LTD and RWA problems, Dimensioning wavelength-routing networks, Statistical dimensioning models, Maximum load dimensioning models; Overview of access network architecture, Enhanced hybrid fiber coax, Fiber to the curb-PON evolution	6
8	**Photonic Packet switching:** Optical time division multiplexing , Synchronization, Header processing, Buffering, Burst switching, Testbeds	5

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	R. Ramaswami, K. N. Sivrajan, and G. H. Sasaki, "Optical Networks-A Practical perspective", Elsevier	2010
2.	Agrawal GP, "Fiber-Optic Communication Systems", Wiley	2010
3	Walrand, J., "Communication Networks", McGraw-Hill.	2009
4.	Senior JM, "Optical Fiber Communications", Pearson Education	2011
5.	Keiser G "Optical fiber Communications", McGraw Hill	1993

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPAT./CENTRE: DEPARTMENT OF PHYSICS

1. Subject code: **PHN-733**   Course Title: **Solid State Lighting**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To familiarize students with the basics of Solid state lighting

10. Details of Course:

SI No.	Content	Contact Hours
1	**INTRODUCTION:** Properties of light, Chronological History of Lighting, Nature and Quality of Lighting, Conventional Light Sources.	6
2	**LED BASED SOLID STATE LIGHTING:** Principles of Inorganic LEDs, Homojunction LEDs, Heterojunction LEDs, Surface- and Edge-Emitting LEDs, Light Extraction from LEDs, Semiconductor Materials for Inorganic LEDs, Fabrication of Inorganic LEDs, LED Performance and characterization, Materials for white LEDs, Packaging of LEDs.	10
3	**ORGANIC LEDS:** Concept of organic semiconductors, polymers/small molecules for LEDs, device fabrication and characterization. White organic LEDs, large area organic LEDs for lighting, challenges in large area manufacturing, emerging new materials for LEDs.	10
4	**LED DRIVING CIRCUIT:** DC and AC driving circuit for LEDs, LED dimming, series and parallel strings of LEDs, linear transistor regulators, switch mode power supply, lifetime of the driving circuits and LEDs.	6
5	**SMART LIGHTING AND DISPLAY:** Infusing Intelligence or Smartness in Lighting Buildings, Aims and scope of smart lighting, Design for occupancy sensing and daylight-sensing devices, Inorganic and OLED display, passive and active matrix display.	6
6	**FUTURE OF LIGHTING** Miscellaneous Applications of Solid-State Lighting, Opportunities and Challenges of Solid-State Lighting.	4
	Total	**42**

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11. Suggested Books:

Sl No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1	Fundamentals of Solid-State Lighting: LEDs, OLEDs, and Their Applications in Illumination and Displays: Volume Editor: Vinod Kumar Khanna, CRC press,	2014
2.	ArtūrasŽukauskas and Michael S. Shur"Introduction to Solid State Lighting," Wiley-Blackwell	2002
3.	"Handbook of Visual Display technology", Edited Janglin Chen, Wayne Cranton, Mark Fihn, Springer Link	2012
4.	"Handbook of Flexible Organic Electronics", Edited by S. Logothetidis, Woodhead Publishing	2014
5.	"Organic Electronics: Materials, Manufacturing, and Applications", Edited by Hagen Klauk, Wiley,	2006
6.	YuriiPleskov , "Semiconductor Photoelectrochemistry", , Springer US	1986

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN-734**　　　Course Title: **Display Technology**

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

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

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

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

8. Pre-requisite:　　**Nil**

9. Objective: To familiarize the students with the recent developments in Display Technology

10.　Details of Course:

Sl. No.	Contents	Contact Hours
1.	Brief review of geometric optics, wave optics, formation of point images and lasers, basics of visual perception, human visual system, colorimetry, depth perception, motion pictures, holographical principles, holographic optical elements.	6
2.	Display basics, fundamental measures, color and intensity production, signal and image processing, associated electronics	4
3.	Spatial light modulation, transmissive, reflective, transflective and emissive displays, high dynamic range displays, bi-directional displays, projection displays, three-dimensional displays, near-eye displays	8
4.	Inorganic LED displays, alphanumeric and color video displays, resolution of LED video image, virtual pixel to enhance image quality, building larger LED screens by assembly of elementary modules, single-, double- and full-color LED display modules, LED TV, LED backlit LCD TV, flexible inorganic displays	12
5.	Organic LED displays, passive matrix organic displays, active matrix organic displays, TFT backplane technologies, OLED mobile phone, TV and computer displays.	8
6.	Image processing for displays, fixed function graphics pipeline, programmable graphics pipeline, GPU programming languages	4
	Total	**42**

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11. Suggested Books:

S.No.	Name of Authors/ Books/Publishers	Year of Publication/ Reprint
1.	Hainich R R and Bimber O, "Displays : Fundamental & Applications," CRC press	2011
2.	Khanna V K "Fundamentals of solid state lighting," CRC press	2014
3.	Ono Y A, " Electroluminescent Display" World Scientific	2000

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code:**PHN- 735**   Course Title: **Photonic Sensors**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To develop the concepts and design methodology of photonic sensors and their applications in various fields.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review of light propagation in optical waveguides and fibers, single and multi-mode fibers, photonic crystal fiber, surface plasmon modes at the interface of a metal and dielectric and in metal clad optical waveguides.	6
2.	Fiber and Integrated Optic Sensors: Intensity, phase, polarization and wavelength modulation schemes, intensity modulation based sensors, displacement sensor, micro-bend based sensors, pressure sensor, evanescent wave sensors, phase modulation based sensors, Mach-Zehnder interferometer sensors, polarization modulation based sensors, fiber optic current sensor, fiber optic gyroscope, photonic crystal fiber based sensors, gas sensors	12
3.	Wavelength interrogation based sensors: review of basics of fiber Bragg gratings (FBG) and long-period fiber gratings (LPFG), FBG based sensors, strain sensor, pressure sensor, structural health monitoring and smart structures, LPFG based sensors, refractive index sensors, temperature sensor	10
4.	Distributed sensors: stimulated Raman scattering (SRS) and stimulated Brillouin scattering (SBS), temperature sensors, gas pipe-line monitoring	5
5.	Surface plasmon based sensors: bio-sensors based on Krechman and Otto configurations in metal coated prism, metallic grating based sensors, coupling with optical fiber modes, localized surface plasmon mode resonance, plasmonic nanoparticles	6
6	Signal processing aspects in sensors, noise factors, lock-in detection	3
	Total	**42**

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11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Gupta, B. D., "Fiber Optic Sensors : Principles and Applications," New India Publishing	2006
2.	Udd, E. and Spillman, W. B., "Fiber Optic Sensors, An introduction for Engineers and Scientists," Wiley	2012
3.	Fang, Z., Chin, K. K., Qu, R., and Cai, H., "Fundamentals of Optical Fiber Sensors," Wiley	2012
4.	Ghatak A. and Thyagarajan K., "Introduction to Fiber Optics," Cambridge University Press	1998
5.	Pal, B. P., "Fundamentals of Fiber Optics and Telecommunication and Sensor Systems," New Age International	2015

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PHN- 736**   Course Title: **Photonics Analysis and Design**

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

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

4. Relative Weight: **CWS: 15   PRS: 15   MTE: 20   ETE: 20   PRE: 30**

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

8. Pre-requisite: Basic knowledge of optical electronics and simulations

9. Objective: To introduce the various numerical methods for optoelectronic devices and link level design using Simulink

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Need of simulations and design for optical fiber communication, On-chip communication basics, Basic facts about Optics: Geometrical Optics, Wave Optics, Analysis of Fabry Perot Etalon, Phase velocity and group Velocity	7
2.	**Analysis of Modes:** Hybrid, TE and TM Modes, Bragg Mirrors, Plots of B-V for fibers, planar waveguides, Analysis of three layer planar waveguides, Determination of propagation constants and field profile, Transcendental equation for TE field,	5
3.	**Fiber modes and propagation of linear pulses :** Mode characterization and Analysis through Bessel function, Refractive index using Sellemeier equation, Waveguide and material dispersion; Basic pulses: Rectangular and Gaussian, Analysis of chirped pulses, pulse train, Split step method and evolution of pulses by FT split step method	6
4.	**Optical Source, Amplifiers and Receivers:** Parameters for active region in rate equations, Small signal analysis with and without gain compression, Large signal analysis and rate equations for large signal analysis, Gain Saturation in SOA and EDFA, Gain vs fiber length, Gain vs power, Gain ripples vs reflectivity, Unsaturated gain and pulse shapes; Circuit model of PIN photodetector, BER and Gaussian noise, RC constants modeling and calculation, Minimum signal power, BER vs Q.	9

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5.	FDTD and BPM Formulation: Two dimensional formulation, One dimensional model, One dimensional implementation without dispersion, Stability Criterion, One dimensional model with losses, Boundary conditions in 1 D, 2D Yee implementation without dispersion, Absorbing boundary conditions (ABC) in 2D, Propagation of a Gaussian Pulse in free space using FDTD, Propagation of Gaussian pulse in 2D; Paraxial formulation, Comparison of pulses before and after propagation using BPM, Slowly varying envelope approximation (SVEA), 1+1 FD-BPM formulation, 3D profiles of pulses before after propagation, Applications of BPM for pulse propagation in tapered waveguides,	8
6	Design of Optical Links: Introduction to Simulink: Blocks and Libraries;, Review of advanced modulation formats, Multiwavelength Simulink models, Simulink models of optically amplified digital transmission systems,	7

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Wartak M.S., "Computational Photonics : An Introduction with Matlab", Cambridge University Press	2013
2.	Agrawal GP, "Fiber-Optic Communication Systems", 4thEd. Wiley	2010
3.	Binh N.L., "Optical Fiber Communications Systems-Theory and Practice with MATLAB And Simulink Models", CRC Press	2010
4.	Binh N.L., "Guided Wave Photonics-Fundamentals and Applications with MATLAB ", CRC Press	2012
5.	Obayya S., "Computational Photonics", Wiley	2010

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code:**PHN- 737**   Course Title: **Silicon Photonics**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To impart the knowledge about the silicon photonic devices and its integration possibilities and challenges silicon for co- integration with CMOS technology.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Metal Oxide Semiconductor(MOS) Transistors:** Structure of MOSFET, Operation of MOSFET: Qualitative analysis, I-V characteristics derivation, Channel length modulation, MOS transconductance, Velocity saturation; MOS device models: Small and large signals, PMOS and NMOS transistors, comparison of BJTs and MOSFETs	6
2.	**CMOS Processing Technology:** CMOS Technologies, Layout design rules, CMOS process enhancements, Technology related CAD issues: DRC and circuit extraction, Manufacturing issues	8
3.	**Silicon Photonic waveguides :** SOI platform suitable for wire waveguides, Channel waveguides and rib waveguides, modes of two dimensional waveguides, Effective index method for waveguide analysis, Waveguide loss mechanisms: absorption , scattering, plasma dispersion effect, thermo-optic effect; Loss characterization Slot waveguides , Waveguides for MIR photonics, Fabrication of silicon photonic waveguides	8
4.	**Coupling to Photonic waveguides:** End fire coupling, Grating couplers, Mode transformers, Inverted tapers, Derivations for coupling efficiencies in mentioned schemes, Comparison of coupling schemes in light of manufacturing and alignment issues.	5
5.	**Resonant and Non-resonant Passive Devices:** Coupled waveguides and directional Couplers, Y branch splitters, Arrayed waveguides, filters, Multiplexers, De-multiplexers, performance, MMI splitters, MxN star couplers, Delay lines	6

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6	**Active Silicon Photonic Devices:** Electro-optic switches and modulators, Hybrid-Silicon lasers, Ge-on-Si photodetectors, Coherent detectors Silicon Raman lasers, Silicon OPAs, Variable optical attenuators	9
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Razavi B., "Fundamentals of Microelectronics", Wiley	2007
2.	Weste N.H.E and Harris D.M., "CMOS VLSI Design", 4thEd., Pearson	2015
3.	Reeds G.T. and Knights A.P., "Silicon Photonics-an Introduction", John Wiley & Sons	2004
4.	Pavesi L., and Lockwood D.J.(Eds.)"Silicon Photonics", Springer	2003
5.	Pavesi L., and Lockwood D.J.(Eds.)"Silicon Photonics", Springer	2010
6	Chremos I., Otto S., and Uzunoglu N.(Eds.), "Photonic Microresonators Research and Applications ", Springer	2010
7	Pollock C.R. , and Lipson M. : Integrated photonics, Kluwer	2003

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1 Subject code: **PHN-738**   Course title: **Quantum Photonics**

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

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

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

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

8. Pre-requisite: Nil

9. Objective: The course provides an understanding of the physical principles of the light matter interaction, achieving of ultra-cold atoms, quantum computation and making integrated quantum circuits on chip.

10. Detail of course:

Sl. No.	Contents	Contact Hours
1.	**Review of Classical Optics:** Review of Quantum Mechanics (Brief history, the postulates of quantum theory, Dirac notation).Radiative transitions in Atoms & Molecules.	8
2.	**Basic laser physics:** properties of Gaussian beam, CW, pulsed, frequency comb, Xasers. Photon Statistics, Photon Correlation. Coherent, Squeezed & Number states.	5
3.	**Atom-Light interaction:**Two level atom density matrices, Rabi oscillation, Laser cooling of atoms, Cold atoms & atom optics, atom lasers, EIT, slow light & coherent control, coherent population trapping (CPT)-dark states, Optical pumping, Atom in cavities, Jaynes-Cumming model, Cavity QED.	12
4.	**Fundamental concepts:**Density operator, Reduced density operator, Quantum entanglement, the quantum circuit model, Super-dense coding, Quantum teleportation and the no-cloning theorem. Quantum Computing using photon, ions, and Rydberg atoms	8
5.	**Quantum computing:**Quantum qubits, quantum logic gates,Quantum Circuits, Universal quantum gates, application ofquantum computer; Deutsche's algorithm, Deutsch-Jozsaalgorithm, Simons Algorithm, Simulation of quantum system, Integrated quantum circuits.	9
	Total	42

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11. Suggested Books:

S.No.	Name of books	Year of publication
1.	H.J. Metcalf and P.Van der Stratten, Laser cooling and trapping, Springer	1999
2.	M. Fox, Introduction to quantum optics, Oxford University Press	2007
3.	OrazioSvelto, Principles of Lasers, Springer	2010
4.	Michael A Nielsen and Isaac Chuang, QuantumComputation and quantum information, Cambridge University Press.	2010

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

The IAPC in its meeting held on 27.10.2017 considered the above request of Mr. R. Gokul Krishnan (En.No. 1211034) and recommended for registering in 2 self study courses as the student is in extended year and his program would be complete with these courses. Further, the credits after including these courses would be 22 which are within the permissible limit.

On the recommendations of IAPC, the student was allowed to provisionally register for the courses and the registration was subject to the approval of the Senate.

The above request is submitted for the consideration and approval of the Senate.

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

The IAPC in its meeting held on 27.10.2017 considered the above request for modifications in the program structure of M.Tech. (Electric Drives & Power Electronics) and recommended for consideration and approval of the Senate as given in **Appendix 'A'**.

The modified structure is submitted for the consideration and approval of the Senate.

DEPARTMENT OF ELECTRICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Program Code: 25 M.Tech. (Electric Drives & Power Electronics)
Department: EE Department of Electrical Engineering
Year: I

S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
		Teaching Scheme			Contact Hours/Week			Exam Duration		Relative Weight (%)				
Semester- I (Autumn)														
1.	EEN-580	Advanced Linear Control Systems	DCC	4	3	1	2/2	3	-	20	20	20	40	-
2.	EEN-540	Advanced Power Electronics	PCC	4	3	1	2/2	3	-	20	20	20	40	-
3.	EEN-541	Analysis of Electrical Machines	PCC	4	3	0	2	3	-	15	25	20	40	-
4.	EEN-542	Power Electronic Controlled Electric Drives	PCC	4	3	1	2/2	3	-	15	25	20	40	-
5.	EEN-xxx	Program Elective Course-I	PEC	4	-	-	-	-	-	-	-	-	-	-
		Total		20	12	2	6	-	-	-	-	-	-	-
Semester-II (Spring)														
1.	EEN-543	FACTS Devices	PCC	4	3	1	0	3	-	25	-	25	50	-
2.	EEN-xxx	Program Elective Course-II	PEC	4	-	-	-	-	-	-	-	-	-	-
3.	EEN-xxx	Program Elective Course-III	PEC	4	-	-	-	-	-	-	-	-	-	-
4	EEN-xxx	Program Elective Course-IV	PEC	4	-	-	-	-	-	-	-	-	-	-
3.	EEN-700	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
		Total		18	6	1	2	-	-	-	-	-	-	-

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DEPARTMENT OF ELECTRICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Program Code: 25 M.Tech. (Electric Drives & Power Electronics)
Department: EE Department of Electrical Engineering
Year: II

S. No.	Subject Code	Course Title	Subject Area	Credits	Contact Hours/Week			Exam Duration		Relative Weight (%)				
					L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
Semester- I (Autumn)														
1.	EEN-701A	Dissertation Stage–I (to be continued next semester)	DIS	12	-	-	-	-	-	-	-	-	100	-
		Total		12										
Note: Students can take 1 or 2 audit courses as advised by the supervisor, if required.														
Semester-II (Spring)														
1.	EEN-701B	Dissertation Stage–II (contd. From III semester)	DIS	18	-	-	-	-	-	-	-	-	100	-
		Total		18										

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

(2/4)

Program Elective Courses (EDPE)

S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE
		Teaching Scheme						Contact Hours/Week		Exam Duration	Relative Weight (%		
1.	EEN-640	Advanced Electric Drives	PEC	4	3	0	2	3	-	20	20	20	40
2.	EEN-641	Microcontroller and Its Applications to Power Converters	PEC	4	3	0	2	3	-	15	25	20	40
3.	EEN-642	DSP Controlled Electric Drives	PEC	4	3	0	2	3	-	15	25	20	40
4.	EEN-643	Electric Drives for Hybrid Vehicles	PEC	4	3	1	0	3	-	25	-	25	50
5.	EEN-644	Design of Electric Drives	PEC	4	3	1	0	3	-	25	-	25	50
6.	EEN-645	Instrumentation in Electric Drives	PEC	4	3	1	0	3	-	25	-	25	50
7.	EEN-646	Drive System in Electric Traction	PEC	4	3	1	0	3	-	25	-	25	50
8.	EEN-647	Control Techniques in Power Electronics for AC Drives	PEC	4	3	0	2	3	-	15	25	20	40
9.	EEN-648	Pulse Width Modulation for Power Converters	PEC	4	3	1	0	3	-	25	-	25	50
10.	EEN-649	Enhanced Power Quality AC-DC Converters	PEC	4	3	0	2	3	-	15	25	20	40
11.	EEN-650	Switch Mode Power Supply	PEC	4	3	1	0	3	-	25	-	25	50
12.	EEN-651	Power Quality Improvement Techniques	PEC	4	3	0	2	3	-	15	25	20	40
13.	EEN-652	CAD of Power Apparatus	PEC	4	3	1	0	3	-	25	-	25	50
14.	EEN-653	Selected Topics in Machines and Transformers	PEC	4	3	0	2	3	-	15	25	20	40
15.	EEN-654	Synchronous Machines and System Stability	PEC	4	3	1	0	3	-	25	-	25	50
16.	EEN-655	Special Machines	PEC	4	3	1	0	3	-	25	-	25	50
17.	EEN-656	Testing and Commissioning of Electrical Equipment	PEC	4	3	1	0	3	-	25	-	25	50

(3/4)

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

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

The IRC in its 18th meeting held on 29.11.2017 recommended that:

(i) SRC should examine the courses representing extra credits as claimed by the student with respect to the contact hours, contents and level of course before recommending the case. Courses should be from PG level. Full justification shall be provided for approval.

(ii) Based on equivalence, extra credits can be adjusted upto maximum of 20 credits.

(iii) Minimum theory courses to be taken up by a student shall be as specified for students with M.Tech degree admitted in Ph.D. programme.

The above recommendation is submitted for the consideration and approval of the Senate.

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

The IRC in its 18th meeting held on 29.11.2017 recommended the following:

1. Minimum requirement for the submission of thesis shall be governed by the regulations and ordinances in force at the time of admission to Ph.D. programme.

2. Evaluation of the thesis shall be governed by the regulations and ordinances in force at the time of submission of the thesis.

The recommendations are submitted for the consideration and approval of the Senate.

Eligibility Criteria for Submission of Thesis

Description	October 2010	August 2015		

Minimum time of submission
 	
  a. B.Tech/M.Sc./M.A. degree holder
 	
  b. M. Tech degree
	Not Less than **3 years** from **date of initial registration** Can be reduced to 2 years with the permission of Senate
	
	2 years registration
		For all students – Minimum 2 years from the date of candidacy		

Maximum time of submission	Five years from the date of initial registration Extendable to 6 years / 7 years for Full time / Part time candidate **by Dean**	Five years from the date of initial registration Extendable to 6 years / 7 years for Full time / Part time candidate **by competent authority**		
Paper publication	At least **1 paper** published / accepted in refereed journal of repute (preferably SCI) or at least 1 patent filed **Another paper** published / accepted in referred journal of repute /in proceedings of a referred International Conference If no such publication then SRC will give justification and supervisor will make efforts for publication	At least **2 paper** published / accepted in refereed journal of repute (preferably SCI) or at least 1 patent filed		

Thesis Evaluation Procedure

Description	October 2010	August 2015	March 2016	Sept 2016
Panel of examiners	At least 50% from outside India	At least 50% from outside India		
Examiners	Internal Examiners – Supervisor Two External examiners – **one from India** and one from abroad	Internal Examiners – Supervisor Three External examiners – **Two from India** and one from abroad		Dropped Supervisor as an examiner
Minimum time of Recommendation	6 week from the date of receiving the thesis	6 week from the date of receiving the thesis		
Appointment of another examiner	If report not received with 8 week	----		
Examiners Recommendations	One out of **FOUR** as A, B, C and D Combinations of recommendations and procedure to be adopted by Dean	One out of **FIVE** as A, B, C, D and E Combinations of recommendations and procedure to be adopted by Dean	Report of two external examiners (**one Indian and One foreign**) required	
Oral Defence Committee (ODC)	HOD – Chairman Chairman – SRC Indian Expert Supervisor(s) Viva-voce to be arranged **by supervisor** ODC recommends – **3 options** If there is difference in opinion in ODC then recommendations be put to Director who may ask for fresh viva held with new ODC or recommend acceptance or send to Senate	HOD/nominee – Chairman Chairman – SRC Indian Expert Supervisor(s) Viva-voce to be arranged **by Chairman SRC and supervisor** ODC recommends – **2 options** If there is difference in opinion in ODC then recommendations be put to Director who may ask for fresh viva held with new ODC or recommend acceptance or send to Senate		

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

The IRC in its 18th meeting held on 29.11.2017 recommended:

(a) Government organisation or research laboratory as a whole shall be considered while awarding the Part Time status to a Full Time research scholar. It should not be based on the location of a unit of that organisation.

(b) Regarding appointing a local supervisor, if the organisation where student is placed after appointment is more than 100 km from Roorkee, any working professional in that organisation at place of work having a Ph.D. degree or working at level Scientist-G or above can become the local supervisor.

The recommendations are submitted for the consideration and approval of the Senate.

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

The IRC in its 18th meeting held on 29.11.2017 deliberated and subsequently recommended the report of the committee constituted to look into above-mentioned subject **(Appendix 'A')**.

The recommended report is submitted for the consideration and approval of the Senate.

Report of the Committee for recommending guidelines for admission of candidates with professional experience to Ph.D. degree

It has been observed that candidates having extensive professional experience, sometimes at the level of Director/AGM/MD or equivalent, in government laboratories / PSUs and renowned private companies apply for admission to PhD program at IIT Roorkee as Part-Time/Sponsored/Self-sponsored candidates. Such candidates already have a record of research / professional activities through publications/patents. These candidates, due to having high positions in their organizations and job responsibilities, find it difficult to stay in the campus and do regular course work. These candidates, however, through vast professional experience, have the capability of doing research. To facilitate the induction of such candidates in the PhD Program, the following guidelines are proposed.

1. Candidates working only in government organizations/laboratories, PSUs, and reputed companies should be considered.

2. Eligibility criteria should be as follows:

   Candidates having M. Tech./M.Arch./MURP or equivalent degree with at least 18 years of professional experience.
                              OR
   Candidates having B.Tech./M.Sc. or equivalent degree with at least 20 years of professional experience

   (This eligibility criteria is a guideline for identifying the candidate holding high positions such as Director / AGM /GM etc. in their organizations and alone should not be considered as the satisfying criteria)

3. Candidates should have research papers in reputed refereed SCI journals / patents / technology transfer/copy right, in total at least 5 in numbers.

4. The Pre Ph.D. course credit requirement would be as per the current practice for Part-Time candidates.

5. The course work as recommended by the SRC, can be carried out in the form of project/dissertation/seminar. NPTEL online courses by IIT Professors.

6. There would be no residency requirements for such candidates.

7. Applications in this category can be made throughout the year to the office of Dean Academic Affairs (DAA). The application should clearly mention the preferred area of work and choice of supervisor (if any). The DAA office will send the application to the concerned Head of the Department seeking the inputs on the application from the faculty members working in the concerned area. The name of the proposed supervisor may be sent along with the recommendations of extended DRC (with faculty members of the same specialization as special invitees) to the office of DAA. The final selection will be made by a 3-member committee chaired by the Director.

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

The IRC in its 18th meeting held on 29.11.2017 recommended that a contractual employee may be allowed to apply for Ph.D. Programme of the institute after taking NOC from appropriate authority. The applicant's department may screen the application after examining the service conditions, work experience and qualification attained by the applicant. The admission procedure adopted will remain the same as for any Part Time admission.

The recommendation is submitted for the consideration and approval of the Senate.

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

The list is presented in **Appendix 'A'.**

S.No.	Name	Deptt.	Topic	Supervisor	Examiner (For./Ind.)	PDC Date
1	Mr. Anuj Kumar	AHEC	INVESTIGATIONS ON PERFORMANCE OF A SAVONIUS HYDROKINETIC TURBINE	Dr. R. P. Saini	Prof. A. Akbarzadeh, Australia Dr. Dhiman Chatterjee, IIT Madras Prof. Ujjwal K. Saha, IIT Guwahati	23.11.17
2	Ms. Khushboo Gulati	BT	DELINEATING THE MOLECULAR INTERACTIONS OF GRO CHEMOKINES	Dr. K. Mohan Poluri	Prof. Daniel Huster, Germany Dr. Ashutosh Kumar, IIT Bombay Dr. Neel Sarovar Bhavesh, ICGEB Delhi	20.11.17
3	Mr. Dharmender Yadav	CE	ENHANCED BIOLOGICAL PHOSPHORUS REMOVAL IN CONVENTIONAL ACTIVATED SLUDGE PROCESS	Dr. Pramod Kumar Dr. Vikas Pruthi	Prof. Devendra P. Saroj, UK Prof. Ashok K. Gupta, IIT Kharagpur	04.10.17
4	Mr. Ganesh R.	CE	KINEMATIC LIMIT ANALYSIS SOLUTIONS FOR SOME GEOTECHNICAL STABILITY PROBLEMS	Dr. J. P. Sahoo	Prof. Braja M. Das, USA Prof. D. M. Dewaikar, IIT Bombay Prof. Jyant Kumar, IISc Bangalour	09.11.17
5	Mr. Nitin Kumar Singh	CE	INTEGRATED FIXED FILM ACTIVATED SLUDGE PROCESS FOR SEWAGE TREATMENT	Dr. A. A. Kazmi	Prof. Fayyaz Ali Memon, UE, UK Prof. Ligy Philip, IIT Madras Prof. A. K. Gupta, IIT Kharagpur	13.11.17
6	Mr. Amardeep	CE	OPERATIONAL PERFORMANCE MEASURES FOR INTERCITY ROADS	Dr. Indrajit Ghosh	Prof. Srinivas Peeta, USA Dr. S. Velmurugan, CRRI Delhi	28.11.17
7	Mr. Saurav Rukhaiyar	CE	BEHAVIOUR OF SANDSTONE UNDER CYCLIC AND POLYAXIAL STATES OF STRESS	Dr. N. K. Samadhiya	Prof. Jaak Deaemen, USA Prof. T. N. Singh, IIT Bombay Prof. T. G. Sitharam, IISc Bangalore	05.12.17
8	Mr. Amit Kumar Verma	CE	SUGARCANE CROP CLASSIFICATION AND YIELD ESTIMATION USING GEOSPATIAL TECHNIQUES	Dr. P. K. Garg Dr. K. S. Hari Prasad Dr. V. K. Dadhwal	Dr. C. Arrowsmith, Australia Prof. Onkar Dikshit, IIT Kanpur Dr. Anil Kumar, ISRO Dehradun	06.12.17
9	Mr. Vinay Kumar	CE	TARGET DETECTION USING HYPER-SPECTRAL IMAGES IN THERMAL INFRA-RED BAND	Dr. J. K. Ghosh	Prof. Jocelyn Chanussot, France Prof. K. Mohan Buddhiraju, IIT Bombay	12.12.17
10	Mr. Atul Kant Piyoosh	CE	IMPACT OF LAND USE LAND COVER ON LOCAL CLIMATIC VARIABLES: A GIS BASED ANALYSIS	Dr. S. K. Ghosh	Prof. Qihao Weng, USA Dr. Raaj Ramsankaran, IIT Bombay Dr. Sameer Saran, ISRO Dehradun	12.12.17
11	Mr. Tej Pratap Singh	CH	REMOVAL OF FLUORIDE FROM INDUSTRIAL WASTE WATER	Dr. C. B. Majumder	Prof. K. Reddy, USA Prof. K. K. Pant, IIT Delhi Prof. A. K. Srivastava, IIT Delhi	27.09.17
12	Ms. Shruti Gupta	CSE	IMAGE ANALYSIS BASED ADAPTIVE LAND COVER CLASSIFICATION ALGORITHMS AND ROLE OF ONTOLOGY	Dr. Sandeep Kumar Dr. Dharmendra Singh	Prof. V. Lakshmi, USA Dr. A. K. Verma, ISRO Ahmedabad Prof. T. N. Singh, IIT Bombay	26.10.17

13	Ms. Nisha Jarwal	CY	COMPUTATIONAL STUDIES ON WITTIG AND ANALOGOUS ORGANIC REACTIONS	Dr. P. P. Thankachan Dr. R. K. Peddinti	Prof. Hsin-Yi Liao, Taiwan Prof. G. Nareh Patwari, IIT Bombay	05.12.17
14	Ms. Pallavi Singh	CY	SUSTAINABLE APPROACHES FOR CONSTRUCTING C–C AND C–S BONDS IN ORGANIC SYNTHESIS	Dr. R. K. Peddinti Dr. U. P. Singh	Prof. Roberto Sanz, Spain Prof. K. N. Singh, IIT (BHU) Varanasi	05.12.1
15	Ms. Priyanka Singh	ES	Sr. ISOTOPE, MAJOR AND TRACE ELEMENTAL MOBILITY OF CENTRAL GANGA ALLUVIAL PLAIN	Dr. Sandeep Singh	Prof. Mery Leech, USA Prof. N. J. Raju, JNU Delhi ProfMunendra Singh, UL Lucknow	31.10.17
16	Mr. Suman Sourav Baral	ES	GEOINFORMATICS FOR TERRAIN CHANGE STUDIES IN TECTONICALLY ACTIVE KUTCH REGION, INDIA	Dr. A. K. Saraf Dr. Josodhir Das	Prof. Saied Pirasteh, Canada Dr. S. Maiti, IIT Kharagpur Prof. J. K. Pati, UA Allahabad	09.11.17
17	Mr. Javed Raoof	ES	GEODYNAMIC MODEL OF THE HIMALAYAS ON THE BASIS OF EARTHQUAKE TOMOGRAPHY	Dr. S. Mukhopadhyay	Dr. A. Replumaz, France Dr. N. Kumar, WIHG Dehradun Dr. Vineet K. Gahalaut, New Delhi	01.12.17
18	Mr. Sukanta Halder	EE	INVESTIGATIONS ON MULTI-LEVEL INVERTER FED PERMANENT MAGNET SYNCHRONOUS MOTOR DRIVE	Dr. Pramod Agarwal Dr. S. P. Srivastava	Prof. Bimal K. Bose, USA Prof. Ranjit Mahanty, IIT (BHU) Varanasi	11.12.17
19	M. Rachna Arora	HSS	ECRITURE FEMININE: A STUDY OF SELECTED NOVELS OF MARGARET ATWOOD	Dr. Smita Jha	Dr. Kanika Batra, USA Dr. R. K. Dhawan, New Delhi Dr. Smriti Singh, IIT Patna	20.11.17
20	Mr. Suraj Gunwant	HSS	UNMASKING THE MASCULINE IN SELECT INDIAN ENGLISH NOVELS	Dr. Rashmi Gaur	Dr. Robin Field, USA Prof. M. R. Paranjape, JNU Delhi Prof. G. Neelakantan, IIT Kanpur	13.10.17
21	Ms. Riya Mukherjee	HSS	REREADING DENIED CITIZENSHIP: A COMPARISON OF DALIT AND AUSTRALIAN ABORIGINAL LITERATURES	Dr. Smita Jha	Dr. Kanika Batra, USA Prof. Raj Kumar, DU Delhi Prof. Rumina Sethi, Chandigarh	28.11.17
22	Mr. Bharat Arora	MS	INVESTIGATING THE INFLUENCE OF IT CAPABILITY ON SUSTAINABLE COMPETITIVE ADVANTAGE	Dr. Z. Rahman	Prof. Kannan Govindan, Denmark Dr. R. K. Amit, IIT Madras Prof. O. P. Wali, Delhi	27.09.17
23	Mr. Prince Doliya	MS	ANALYZING FAIR VALUE AUDITING IN CONTEMPORARY FINANCIAL REPORTING SCENARIO	Dr. J. P. Singh	Dr. Periklis Gogas, Greece Dr. Sandeep Goel, Delhi Prof. J. K. Pattanayak, ISM Dhanbad	05.12.17
24	Mr. Srinivasan V.	MA	CONTROLLABILITY AND STABILITY OF FRACTIONALORDER DYNAMICAL SYSTEMS	Dr. N. Sukavanam	Dr. Chee Peng Lim, Australia Prof. D. Bahuguna, IIT Kanpur Prof. S. Das, IIT (BHU) Varanasi	13.11.17
25	Mr. Assif Assad	MA	DESIGN AND APPLICATIONS OF NEW HARMONY SEARCH ALGORITHMS	Dr. Kusum Deep	Prof. Lipo Wang, Singapore Dr. Aruna Tiwari, IIT Indore Prof. Punam Bedi, U Delhi	23.11.17

26	Ms. Renu Chaudhary	MA	EXISTENCE AND APPROXIMATION OF SOLUTIONS TO SOME FUNCTIONAL EVOLUTION EQUATIONS	Dr. D. N. Pandey	Prof. G. S. Ladde, USA Prof. D. Bahuguna, IIT Kanpur Prof. M. Imdad, AMU Aligarh	05.12.17
27	Mr. Deepak Khurana	MIE	STUDY OF THERMAL PROPERTIES, FORCED CONVECTION & PRESSURE DROP IN Al2O3 & TiO2 NANOFLUIDS	Dr. Sudhakar Subudhi	Prof. Mihir Sen, USA Prof. P. K. Das, IIT Kharagpur Dr. R. Repaka, IIT Ropar	26.10.17
28	Mr. Ambrish Maurya	MIE	INVESTIGATION OF IN-MOLD ELECTROMAGNETIC STIRRING PROCESS IN CONTINUOUS CASTING MOLD	Dr. P. K. Jha	Prof. A. H. Castillejos Escobar, Mexcio Prof. Prabal Talukdar, IIT Delhi Prof. S. K. Das, IIT Kharagpur	30.11.17
29	Mr. Vikas Verma	MME	TiCN BASED CERMET SYSTEMS FOR THE IMPROVED WEAR AND MACHINING PERFORMANCE	Dr. B. V. Manojkumar	Prof. Kevin Plucknett, Canada Dr. A. Mukhopadhyay, IIT Bombay Prof. Bikramjit Basu, IISc Bangalore	26.10.17
30	Mr. Sandan K. Sharma	MME	TRIBOLOGICAL BEHAVIOUR OF SiC-WC COMPOSITES	Dr. B. V. Manojkumar	Prof. Oscar Borrero-Lopez, Spain Dr. Kantesh Balani, IIT Kanpur Prof. Bikramjit Basu, IISc Bangalore	30.10.17
	Mr. Amit Joshi	MME	FATIGUE & FRACTURE STUDIES ON ULTRAFINE GRAINED 2014 AL ALLOY	Dr. R. Jayaganthan	Prof. Gbadebo Owolabi, USA Prof. R. Velmurugan, IIT Madras Prof. S. Aravindan, IIT Delhi	25.11.17
31	Mr. Deepak Kumar	MME	DEVELOPMENT OF 18%Cr OXIDE DISPERSION STRENGTHENED STEEL CONTAINING YTTRIA BY POWDER FORGING	Dr. Ujjwal Prakash	Prof. S. Challapalli, USA Prof. G. Sundararajan, IIT Madras Dr. Samantaray, IGCAR Kalpakkam	08.12.17
32	Mr. K. K. Yogesh	MME	MECHANICAL BEHAVIOUR OF ULTRAFINE GRAINED 5052 AL ALLOY PROCESSED BY SPD	Dr. R. Jayaganthan	Prof. Gbadebo Owolabi, USA Prof. M. M. Kamaraj, IIT Madras Dr. K. Venkateswarlu, CSIR Bangalore	08.12.17
33	Ms. Neelam	PH	ASPECTS IN BREAK-UP REACTIONS	Dr. Rajdeep Chatterjee	Prof. Andrea Vitturi, Italy Dr. Prabir Banerjee, ABNSC, W.B.	04.10.17
34	Mr. Gagandeep Singh	PH	THEORETICAL INVESTIGATIONS IN THE BREAKUP OF EXOTIC NUCLEI	Dr. Rajdeep Chatterjee	Prof. Carlos A. Bertulani, USA Dr. Rudrajyoti Palit, TIFR Mumbai Dr. Radhey Shyam, Kolkata	01.12.17
35	Mr. Raja Singh R.	WRDM	DESIGN AND DEVELOPMENT OF ENERGY CONSERVATION STRATEGIES FOR ASYNCHRONOUS MACHINE DRIVES	Dr. T. Raj Chelliah	Prof. Hamid A. Toliyat, USa Prof. Bhim Singh, IIT Delhi Dr. Z. V. Lakaparampil, AJCE Kottayam	11.10.17

S.No.	Name	Deptt.	Topic	Supervisor	Examiner (For./Ind.)	PDC Date
36	Mr. Mukesh Kumar	AHEC	PRODUCTION OF BIODIESEL FROM CHLORELLA PROTOTHECOIDES MICROALGAL OIL	Dr. M. P. Sharma	Prof. Xiaolei Zhang, UK Prof. Hifjur Raheman, IIT Kharagpur Prof. Virendra K. Vijay, IIT Delhi	21.12.17
37	Mr. Kushal Manoharrao Jagtap	AHEC	LOSS ALLOCATION IN RADIAL DISTRIBUTION NETWORK WITH DISTRIBUTED GENERATION	Dr. D. K. Khatod	Prof. Nick Jenkins, UK Prof. S. N. Singh, IIT Kanpur	21.12.17
38	Mr. Pawar Aniruddha Subarao	AR	CLIMATOGRAPHY MODEL FOR SUSTAINABLE URBAN BUILT ENVIRONMENT	Dr. Mahua Mukheerjee	Prof. Roberto Lamberts, Brazil Prof. N. K. Bansal, New Delhi Prof. Arvind Krishan, Gurgaon	19.12.17
39	Mr. Sidharth Arora	BT	PHYTASE PRODUCTION BY SOLID-STATE FERMENTATION AND BIOREACTOR DESIGN	Dr. Sanjay Ghosh	Prof. Cristobal Noe Aguilar, Mexico Dr. Jamesh Gomes, IIT Delhi Dr. KSMS Raghavarao, CSIR Mysore	26.12.17
40	Mr. Harish Chandra Arora	CE	EVALUATION OF DURABILITY OF FRP STRENGTHENED CONCRETE STRUCTURAL ELEMENTS	Dr. Umesh K. Sharma Dr. B. Kameswara, Dr. A.Chakrabarti	Prof. Shamim A Sheikh, Canada Prof. Yogesh M. Desai, IIT Bombay	14.12.17
41	Mr. Anil Kumar Verma	CH	PYROLYSIS KINETICS OF BIOMASS FEEDSTOCKS AND BIO-OIL PRODUCTION	Dr. Prasenjit Mondal	Prof. Ajay K. Dalai, Canada Prof. B. C. Meikap, IIT Kharagpur Prof. Kaustubha Mohanty, IIT Guwahati	26.12.17
42	Ms. Soumita Talukdar	CY	STUDIES ON MODIFIED ZINC SULPHIDE AND CADMIUM SULPHIDE NANOPARTICLES	Dr. R. K. Dutta	Prof. Detlef Bahnemann, Germany Prof. R. Nagarajan, Univ. of Delhi	26.12.17
43	Mr. Balram Rao	HSS	LABOUR RELATIONS IN CONSTRUCTION INDUSTRY: A STUDY OF DELHI NCR	Dr. S. P. Singh	Prof. Elizabeth Jillian Wells, UK Prof. Malathy Duraisamy, IIT Madras Prof. R. S. Ghuman, Chandigarh	21.12.17
44	Mr. Nitin Simha Vihari	DOMS	ANTECEDENTS AND CONSEQUENCES OF SUSTAINABLE HRM: EMPIRICAL EVIDENCE	Dr. M. K. Rao	Prof. Edyta Rudawska, Poland Dr. Susmita Mukhopadhyay, IIT Kharagpur	21.12.17
45	Mr. Vinay Panwar	MIED	USE OF DIFFERENT GRAPHENE-DERIVATIVES TO PREPARE HIGH-PERFORMANCE POLYMERIC COMPOSITES	Dr. Kaushik Pal	Prof. Joong H. Lee, Korea Prof. G. C. Nayak, IIT (ISM) Dhanbad Dr. Bhanu B. Khatua, IIT Kharagpur	19.12.17
46	Mr. Tesfa Worku Meshesha	WRDM	WATERSHED HYDROLOGICAL MODELLING CONSIDERING LANDUSE AND CLIMATE CHANGES	Dr. Deepak Khare Dr. S. K. Tripathi	Dr. Qin Xiaoseng, Singapore Dr. Kishor Anil Dhore, Bangalore Dr. D. K. Swain, IIT Kharagpur	21.12.17

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

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

On the recommendation of the IRC, the Chairman Senate approved the minimum education qualification for admission to Ph.D. programme in the Department of Applied Science & Engineering, Department of Pulp & Paper Technology, Department of Polymer & Process Engineering, Saharanpur Campus and Centre for Nanotechnology, Roorkee Campus for the session 2017-18.

- **Roorkee Campus**

Centre for Nanotechnology

B.E./B.Tech or M.E./M.Tech. in Metallurgy / Chemical / Polymer / Mechanical / Biotechnology / Physics / Chemistry / Electronics /Electrical./Civil or equivalent ; M.Sc./M.S. (Science/Engineering)

B. Pharm /M. Pharm.

- **Saharanpur Campus**

Department of Applied Science & Engineering:

(i) M.Sc. /M.S./M.A. (Science/Engineering/ Humanities)

(ii) BE/B.Tech/M.E./M.Tech. in any branch of engineering or equivalent

Department of Pulp & Paper Engineering:

(i) M.Sc. /M.S. (Science/Engineering)

(ii) BE/B.Tech/B.Pharm/M.E./M.Tech./M.Pharm. in any branch of engineering or equivalent

Polymer and Process Engineering:

(i)   M.Sc. /M.S./MBA
(Science/Engineering/Management)

(ii)   BE/B.Tech/B.Pharm/M.E./M.Tech./M.Pharm in any branch of engineering or equivalent

These recommendations were approved by the Chairman, Senate for the session 2017-18 and are submitted to the senate for ratification.

Further, the Senate is requested to approve these recommendations for subsequent years.

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

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

Eligibility Criteria:

Candidates with postgraduate degree in professional courses can be admitted with institute assistantship. The condition of GATE/NET qualification is not mandatory.

The Chairman, Senate on recommendations of IRC approved the same for including in information brochure for the session 2017-18.

These recommendations are submitted to the senate for ratification for the session 2017-18 and approval for subsequent years.

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

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

Eligibility Criteria:

• Candidates should be recipient of any one fellowship namely UGC/CSIR/DBT/DST/Inspire/ICMR etc.

• The result of fellowship should have been declared after the deadline of advertisement of Ph.D. admissions with institute assistantship in Autumn / Spring semester (i.e. last week of March / September respectively).

Candidates can apply only once through the rolling advertisement. If he/she wants to apply more than once, he/she may apply through the regular advertisement.

Note: 1. Institute will not provide any financial assistance at any point of time

2. *GATE/GPAT qualified candidates are required to apply through regular advertisement released during September and February every year through online portal* ***http://pgadm.iitr.ernet.in/*** .

APPLICATION PROCESS

For admission to Ph.D. programmes through rolling advertisement, candidates need to fill the application form and send it to the Head of the concerned department. The department will send a call for the interview on an appropriate date. The selected candidates will be registered for Ph.D. as per institute rule. Selected candidates will start working as JRF under the assigned faculty member (Ph.D. Thesis supervisor) from the date of selection in the admitting Department.

If the candidate is applying for more than one department/centre, separate applications should be submitted for each department / Centre.

The selection procedure will remain the same as adopted for admission with institute assistantship. The selection board will consist of all faculty members.

The maximum limit of Ph.D. candidates for individual faculty will remain the same as in force as per Ph.D. ordinances and regulations.

The Chairman, Senate on recommendations of IRC approved the same for including in information brochure for the session 2017-18.

These recommendations are submitted to the senate for ratification for the session 2017-18 and approval for subsequent years.

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

The IAPC in its meeting held on 27.10.2017 considered and accepted the change. The modified structure of P. G. Diploma and M. Tech. (I.W.M.) programmes as given in **Appendix 'A'.**

The Chairman, Senate on recommendations of IAPC approved the same.

The Senate is requested to ratify the above modification.

संलग्नक — l

(Revised)

Academic Curriculum for PG Diploma / Master of Technology in
IRRIGATION WATER MANAGEMENT (IWM)

S.No	SUBJECT CODE	COURSE TITLE	SUBJECT AREA	CREDITS	Contact Hours per Week			Exam. Duration (Hrs.)		Relative Weightage (%)				
					L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1st YEAR		**I SEMESTER (AUTUMN)**												
1.	WR-501	System Design Techniques	PCC	4	3	1	0	3	-	25	-	25	50	-
2.	WR-571	Design of Irrigation Structures and Drainage Works	PCC	4	3	1	-	3	-	25	-	25	50	-
3.	WR-573	Principles and Practices of Irrigation	PCC	4	3	1	-	3	-	25	-	25	50	-
4.	WR-575	On Farm Development	PCC	4	3	1	-	3	-	25	-	25	50	-
5.		Program Elective Course	PEC	4	3	1	-	3	-	25	-	25	50	-
		Sub Total		20										
		II SEMESTER (SPRING)												
1.	WR-574	Diagnostic Analysis	PCC	2	-	-	4	-	-	-	50	-	-	50
2.		Program Elective Course	PEC	4	3	1	-	3	-	25	-	25	50	-
3.		Program Elective Course	PEC	4	3	1	-	3	-	25	-	25	50	-
4.		Program Elective Course	PEC	4	3	1	-	3	-	25	-	25	50	-
5.		Program Elective Course	PEC	4	3	1	-	3	-	25	-	25	50	-
6.	WR-700	Seminar	SEM	2	-	-	-	-	-	-	-	100	-	-
		Sub Total		20										

Note: P.G. Diploma course in IWM shall be of ONE YEAR duration comprising of semesters I and II only, with a minimum credits of 40

2nd YEAR		**III SEMESTER (AUTUMN)**												
1.	WR-701A	Dissertation Stage I	DIS	12	-	-	-	-	-	-	-	-	100	-
		Sub Total		12										

* to be continued and grade to be awarded in the next semester

		IV SEMESTER (SPRING)												
1.	WR-701B	Dissertation Stage II (contd. From 3rd Semester)	DIS	18	-	-	-	-	-	-	-	-	100	-
		Sub Total		18										
		Total		70										

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PROGRAMME ELECTIVES COURSES (IWM)

1.	WR-503	Water Resources Planning and Management	PEC	4	3	1		3	-	25	-	25	50	-
2.	WR-504	Applied Hydrology	PEC	4	3	1	-	3	-	25	-	25	50	-
3.	WR-513	Earth and Rockfill Dams	PEC	4	3	1	-	3	-	25	-	25	50	-
4.	WR-516	Rural and Urban Water Supply	PEC	4	3	1	-	3	-	25	-	25	50	-
5.	WR-520	Environmental Impact Assessment of Water Resource Projects	PEC	4	3	1	-	3	-	25	-	25	50	-
6.	WR-522	Climate Change and Water Resources	PEC	4	3	1	-	3	-	25	-	25	50	-
7.	WR-572	Soil and Agronomy	PEC	4	3	1	-	3	-	25	-	25	50	-
8.	WR-576	Operation Maintenance and Management of Irrigation Systems	PEC	4	3	1	-	3	-	25	-	25	50	-
9.	WR-577	Water and Land Laws	PEC	4	3	1	-	3	-	25	-	25	50	-
10.	WR-578	Rural Sociology and Irrigation Economics	PEC	4	3	1	-	3	-	25	-	25	50	-
11.	WR-579	Evaluation of Irrigation Project	PEC	4	3	1	-	3	-	25	-	25	50	-
12.	WR-580	Renewable Energy System Technology	PEC	4	3	1	-	3	-	25	-	25	50	-
13.	WR-581	Water Quality Monitoring and Modeling	PEC	4	3	1	-	3	-	25	-	25	50	-
14.	WR-582	Theory of Seepage	PEC	4	3	1	-	3	-	25	-	25	50	-
15.	WR-583	Remote Sensing and GIS Applications in Agriculture	PEC	4	3	1	-	3	-	25	-	25	50	-
16.	WR-584	Cropping System Modeling	PEC	4	3	1	-	3	-	25	-	25	50	-
17.	WR-585	Environmental Impact of Irrigated Agriculture	PEC	4	3	1	-	3	-	25	-	25	50	-
18.	WR-586	Groundwater Development and Management	PEC	4	3	1	-	3	-	25	-	25	50	-
19.	WR-587	Watershed Development and Management	PEC	4	3	1	-	3	-	25	-	25	50	-

अध्यक्ष, के. ख. के. / Chairman DAC
के. ख. इंजी. एवं जल संसाधन विकास एवं
प्र. भौ. संस्थान रुड़की / IITR

प्रोफेसर एवं विभागाध्यक्ष / Prof. & Head
जल एवं जल संसाधन वि0 / WRD&M Deptt.
भा. प्रौ. सं. रुड़की / IIT Roorkee

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

The Chairman Senate on recommendations of emergent IAPC held on 11.8.2017 has approved the following:

1. Continuation of study for one more year to complete the degree requirements of the following UG/IDD students:-

1. Mrinal Barla (Enrl. No. 10110039)
2. Karan Kumar (Enrl. No. 11114021)
3. Gurkirat Singh (Enrl. No. 10213006)
4. N. Shashank (Enrl. No. 11115055)
5. Vemireddy Sai Sudheep (Enrl. No. 11115113)
6. Shubham Bansal (Enrl. No. 10214025)
7. R. Indra Kumar (Enrl. No. 10211021)

2. Striking off names of the following students of UG/IDD which have not completed their programmes during maximum period allowable as per Ordinances & Regulations of UG programme:-

1. RAKESH KUMAR MEENA (Enrl. No.10113084)
2. MOHIT KUMAR BAGDI (Enrl. No.10211017)
3. PARUL (Enrl. No.11116034)
4. YELTHURI GOUTHAM (Enrl. No.11116055)
5. RAJ KUMAR BHARTI (Enrl. No.10115083)
6. GAJENDRA SINGH (Enrl. No.10117019)

3. Striking off names of the following 1st year students who have earned less credits than the required to continue their studies:-

1. THEJAVATH RAVI TEJA (Enrl. No. 16111035)
2. BADAVATH VILAS NAYAK (Enrl. No. 16115036)
3. KHUSHWANT (Enrol. No. 16112034)
4. RAJADITYA (Enrl. No. 16115090)

The above is submitted to the Senate for ratification.