NEP FYUGP CURRICULUM

PHYSICS HONOURS/

PHYSICS HONOURS WITH RESEARCH PROGRAMME

SUBJECT CODE = 55

FOR UNDERGRADUATE COURSES UNDER RANCHI UNIVERSITY, RANCHI

Implemented w.e.f.
Academic Session 2025-26 & onwards

UNIVERSITY DEPARTMENT OF PHYSICS
RANCHI UNIVERSITY, RANCHI

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Ref. No. : Phy P.G. ....

Date : ....

Board of Studies
FYUGP 2025 Curriculum & 1-Year/2-Year PG Curriculum 2025

Chairman : Dr. Sunil Kumar Singh
Associate Professor & Head
University Department of Physics
Ranchi University, Ranchi
11/07/2025

External Members:

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2. Prof. N. N. Ojha. (Retd.) Head. Deptt. of Physics, DSPMU, Ranchi 11.07.2025.

Alumnus:

1. Dr. Satish Chandra Gupta
   Retd. Associate Prof, Department of Physics,
   Ranchi College, Ranchi.
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   Marwari College, Ranchi
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Student Representative:

1. Miss. Palak Priya Kumari, Sem-IV (2023-25) Palak Priya Kumari 11/07/25
2. Miss. Roqayah Saman, Sem-I (2024-26) Roqaiyah Saman 11/07/25

Approval by the Members of the NEP Implementation and Monitoring Committee of Ranchi University, Ranchi

The Curriculum of Bachelor's Degree (Honours)/ (Honours with Research) has been approved by the NEP Implementation and Monitoring Committee of R.U., duly forwarded by the Head of the Department; it will be offered to the students of the 4-year Undergraduate Programme (FYUGP). It is implemented from the 1st Semester of the Academic Session 2025-26 and onwards.

Member Secretory

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HIGHLIGHTS OF FYUGP CURRICULUM

PROGRAMME DURATION

- The Full-time, Regular UG programme for a regular student shall be for a period of four years with multiple entry and multiple exit options.
- The session shall commence from the **1st of July**.

ELIGIBILITY

- The selection for admission will be primarily based on the availability of seats in the Major subject and marks imposed by the institution. Merit point for selection will be based on marks obtained in the Major subject at Class 12 (or equivalent level) or the aggregate marks of Class 12 (or equivalent level) if the Marks of the Major subject is not available. Reservation norms of the Government of Jharkhand must be followed as amended in times.
- UG Degree Programmes with Double Major shall be provided only to those students who secure a minimum of 75% overall marks or 7.5 CGPA or higher.
- Other eligibility criteria, including those for multiple entry, will be in light of the UGC Guidelines for Multiple Entry and Exit in Academic Programmes offered in Higher Education Institutions.

ADMISSION PROCEDURE

- The reservation policy of the Government of Jharkhand shall apply in admission and the benefit of the same shall be given to the candidates belonging to the State of Jharkhand only. The candidates of other states in the reserved category shall be treated as General category candidates. Other relaxations or reservations shall be applicable as per the prevailing guidelines of the University for FYUGP.

VALIDITY OF REGISTRATION

- Validity of a registration for FYUGP will be for a maximum of **Seven years** from the date of registration.

ACADEMIC CALENDAR

- An Academic Calendar will be prepared by the University to maintain uniformity in the UG Honours/ Honours with Research Programmes and PG Diploma Programmes, running in the colleges under the university (Constituent/Affiliated).
- **Academic Year:** Two consecutive (one odd + one even) semesters constitute one academic year.
- **Semester:** The Odd Semester is scheduled from **July to December,** and the Even Semester is from **January to June**. Each week has a minimum of 40 working hours spread over 6 days.
- Each semester will include Admission, coursework, conduct of examination and declaration of results, including semester break.
- To undergo an 8-week summer internship/ apprenticeship during the summer camp, the Academic Calendar may be scheduled for academic activities as below:
  a) Odd Semester: **From the first Monday of August to the third Saturday of December**
  b) Even Semester: **From the first Monday of January to the third Saturday of May**
- An academic year comprising 180 working days in the least is divided into two semesters, each semester having at least 90 working days. With six working days in a week, this would mean that each semester will have 90/ 6 = 15 teaching/ working weeks. Each working week will have 40 hours of instructional time.
- Each year, the University shall draw out a calendar of academic and associated activities, which shall be strictly adhered to. The same is non-negotiable. Further, the Department will make all reasonable endeavours to deliver the programmes of study and other educational services as mentioned in its Information Brochure and website. However, circumstances may change, prompting the Department to reserve the right to change the content and delivery of courses, discontinue or combine courses and introduce or withdraw areas of specialization.

PROGRAMME OVERVIEW/ SCHEME OF THE PROGRAMME

- Undergraduate degree programmes of either 3 or 4-year duration, with multiple entries and exit points and re-entry options within this period, with appropriate certifications such as:

- UG Certificate after completing 1 year (2 semesters) of study in the chosen fields of study, provided they complete one vocational course of 4 credits during the summer vacation of the first year or internship/ Apprenticeship in addition to 6 credits from skill-based courses earned during the first and second semesters.,
- UG Diploma after 2 years (4 semesters) of study diploma provided they complete one vocational course of 4 credits or internship/ Apprenticeship/ skill based vocational courses offered during the first year or second year summer term, in addition to 9 credits from skill-based courses earned during the first, second, and third semester.
- Bachelor's Degree after a 3-year (6 semesters) programme of study,
- Bachelor's Degree (Honours) after a 4-year (8 semesters) programme of study.
- Bachelor's Degree (Honours with Research) after a 4-year (8 semesters) programme of study to the students undertaking a 12-credit Research component in the fourth year of FYUGP.

CREDIT OF COURSES

The term 'credit' refers to the weightage given to a course, usually in terms of the number of instructional hours per week assigned to it. The workload relating to a course is measured in terms of credit hours. It determines the number of hours of instruction required per week over a semester (minimum 15 weeks).

a) One hour of teaching/ lecture or two hours of laboratory /practical work will be assigned per class/interaction.
One credit for Theory = 15 Hours of Teaching
One credit for Practicum = 30 Hours of Practical work
One credit for Internship = 02 Weeks of Practical experience

b) For credit determination, instruction is divided into three major components:
Hours (L) – Classroom Hours of one hour duration.
Tutorials (T) – Special, elaborate instructions on specific topics of one hour duration
Practical (P) – Laboratory or field exercises in which the student has to do experiments or other practical work of a two-hour duration.
Internship – For the Exit option after any academic year of a Four-year U.G. Programme for the award of U.G. Certificate, U.G. Diploma, U.G. Degree (Level 4.5, 5 or 5.5 respectively), Students can either complete two 4-week internships worth 2 credits each or one 8-week internship for all 4 credits. This practical experience connects academic learning with real-world applications, offering valuable exposure to professional environments in their fields of study

CHANGE OF MAJOR OR MINOR COURSES

- The change of Major or Minor courses may be allowed only once after the Second Semester and before the third Semester in the FYUG Programme, depending on the provisions laid by the FYUGP and the conditions laid by the Institution. **However, the student must clear the papers (Mid Sem & End Sem both) from the previous semesters of the new subject opted in the next Examination of the coming session.**

CALCULATION OF MARKS FOR THE PURPOSE OF THE RESULT

- Students' final marks and the result will be based on the marks obtained in the Semester Internal Examination and End Semester Examination organized taken together.
- Passing in a subject will depend on the collective marks obtained in the Semester internal and End Semester University Examination. However, students must pass in Theory and Practical Examinations separately.

PROMOTION CRITERIA

First degree programme with a single major (160+4=164 credits):

i. The Requisite Marks obtained by a student in a particular subject will be the criteria for promotion to the next Semester.
ii. No student will be detained in odd Semesters (I, III, V & VII).
iii. To get promotion from Semester-II to Semester-III a student will be required to pass in at least 75% of the Courses in an academic year, a student has to pass in minimum 11 papers out of the total 14 papers. It is further necessary

to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 4 papers out of 7 papers in Semester-II.

iv. To get promotion from Semester-IV to Semester-V (taken together of Semester I, II, III & IV) a student has to pass in minimum of 20 papers out of the total 26 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 3 papers out of 6 papers in Semester-IV.

v. To get promotion from Semester-VI to Semester-VII (taken all together of Semester I, II, III, IV, V & VI) a student has to pass in minimum of 27 papers out of the total 36 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 3 papers out of 5 papers in Semester VI.

vi. However, it will be necessary to procure pass marks in each of the papers before completion of the programme.

First degree programme with dual major (192+4=196 credits):

i. Please refer to the FYUGP Regulations for the detailed provisions of Double Major and Dual Degrees.

ii. No student will be detained in odd Semesters (I, III, V & VII).

iii. To get promotion from Semester-II to Semester-III a student will be required to pass in at least 75% of the Courses in an academic year, a student has to pass in minimum 11 papers out of the total 15 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 4 papers out of 8 papers in Semester-II.

iv. To get promotion from Semester-IV to Semester-V (taken together of Semester I, II, III & IV) a student has to pass in minimum 20 papers out of the total 27 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 4 papers out of 7 papers in Semester-IV.

v. To get promotion from Semester-VI to Semester-VII (taken all together of Semester I, II, III, IV, V & VI) a student has to pass in minimum 28 papers out of the total 37 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 3 papers out of 6 papers in Semester VI.

vi. However, it will be necessary to procure pass marks in each of the papers before completion of the programme.

PUBLICATION OF RESULTS

- The examination result shall be notified by the Controller of Examinations of the University in different newspapers and the same is to be posted also on the University website.
- If a student is found indulging in any malpractice/ unfair means during an examination, the examination taken by the student for the semester will be cancelled. The candidate has to reappear in all the papers of the session with the students of the next session, and his one year will be detained. However, marks secured by the candidate in all previous semesters will remain unaffected.
- There shall be no Supplementary or Re-examination for any subject. Students who have failed in any subject in an even semester may appear in the subsequent even semester examination to clear the backlog. Similarly, the students who have failed in any subject in an odd semester may appear in the subsequent odd semester examination to clear the backlog.

Regulations related to any concern not mentioned above shall be guided by the Regulations of the Ranchi University for FYUGP.

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COURSE STRUCTURE FOR FYUGP '**HONOURS/ RESEARCH/ PG DIPLOMA**'

Table 1: Credit Framework for Four-Year Undergraduate Programme (FYUGP) under State Universities of Jharkhand [Total Credits = 164]

Academic Level	**Level of Courses**	**Semester**	**MJ**: Discipline Specific Courses – Core or Major (80)	**AC**: Associated core courses from discipline/ Interdisciplinary/ vocational (8)		**ELC**: Elective courses may be opted from four paths [Follow table 2] (24)	**MDC**: Multidisciplinary Courses (From a pool of Courses) (9)	**AEC**: Ability Enhancement Courses (Modern Indian Language and English) (8)	**SEC**: Skill Enhancement Courses (9)	**VAC**: Value Added Courses (6)	**IKS**: (i) Indian Knowledge System (2) & **SA**: (ii) Social awareness (2)	**RC**: Research Courses (4+8)/	**AMJ**: Advanced Courses instead of Research (4+4+4)/ **PGD:** PG Diploma Level 6 (4+4+4)	**Total Credits**	**IAP**: Internship/Apprenticeship/ Project/ Vocational course/ Dissertation (4) **In between Sem I to Sem-VI**
	1	2	3 (Major- 80)	4 (Minor-32)			5	6	7	8	9	10	11	12	13
Level 4.5	Level 100-199: **Foundation or Introductory courses**	**I**	4	4	---	---	3	2	3	2	2	---	---	**20**	
		II	4	---	4	---	3	2	3	2	2	---	---	**20**	
		Exit Point: Undergraduate Certificate provided with Summer Internship/ Project/ Vocational course/ Dissertation (4 credits)													
Level 5	Level 200-299: **Intermediate-level courses**	**III**	4+4	---		4	3	2	3	---	---	---	---	**20**	4
		IV	4+4+4	---		4	---	2	---	2	---	---	---	**20**	
		Exit Point: Undergraduate Diploma provided with Summer Internship/ Project/ Vocational course/ Dissertation (4 credits)													
Level 5.5	Level 300-399: **Higher-level courses**	**V**	4+4+4+4	---		4	---	---	---	---	---	---	---	**20**	
		VI	4+4+4+4	---		4	---	---	---	---	---	---	---	**20**	
		Exit Point: Bachelor's Degree with Summer Internship/ Project/ Vocational course/ Dissertation (4 credits)												**124**	
Level 6	Level 400-499: **Advanced courses** Hons with Research (>7.5 CGPA)/ Honours/ PG Diploma	**VII**	4+4+4	---		4	---	---	---	---	---	4	4	**20**	**---**
		VIII	4+4	---		4	---	---	---	---	---	8	4+4	**20**	
		Exit Point: Bachelor's Degree with Honours/ Honours with Research/ PG Diploma Level 6												**164**	

Note: Honours students not undertaking research will do 3 courses for 12 credits in lieu of a Research project.

Table 2: Options for Elective Minor Courses

Path A	Path B	Path C	Path D
ELC-A; Elective courses from Interdisciplinary Subjects 1 & 2 (24)	**ELC-B**; Elective courses from discipline (24)	**ELC-C**; Elective courses from vocational (24)	**ELC-D**; Elective courses from discipline for Double Major (48)
This pathway may be recommended for students who wish to develop core competency in multiple disciplines of study. In this case, the credits for the minor pathway shall be distributed among the constituent disciplines/subjects. If students pursuing FYUGP are awarded a UG Degree in a Major discipline, they are eligible to mention their core competencies in other disciplines of their choice if they have earned 12 credits each from pathway courses of two particular disciplines. In the first three years of FYUGP, this pathway is composed of one Major discipline with 60 credits from 15 courses, and two other disciplines, with 12 credits from 3 courses in each discipline. In this pathway, if the students choose one of the two disciplines for 12 credits in one discipline then they should choose a different discipline for the other 12 credits. If the students continue to the fourth year of FYUGP, the students need to earn an additional 4 credits in both disciplines.	This pathway may be recommended to those students who wish for an in-depth study in more than one discipline with a focus on one discipline (Major) and relatively less focus on the other (Minor). If students exit at the end of the third year of FYUGP, they are awarded a Major Degree in a particular discipline and a Minor in another discipline of their choice, if they earn a minimum of 24 credits from the courses in the Minor discipline. If the students continue to the fourth year of FYUGP, they should earn a minimum of 32 credits in the Minor discipline, to be eligible for a UG Degree (Honours) with a Major and a Minor. For this, in the fourth year, they should earn an additional minimum of 8 credits through 2 courses in the Minor discipline.	This pathway may be recommended to those students who wish for exposure to a vocational discipline in addition to the in-depth study in the Major discipline. The credit requirements for Major and Vocational Minor disciplines in this pathway are the same as those for Major with Minor pathway, except that the Minor courses are in a vocational discipline. If students exit at the end of the third year of FYUGP, they are awarded a Major Degree in a particular discipline and a Minor in vocational discipline of their choice, if they earn a minimum of 24 credits from the Vocational courses. If the students continue to the fourth year of FYUGP, they should earn a minimum of 32 credits in the vocational discipline. For this, in the fourth year, they should earn an additional minimum of 8 credits through 2 courses in the Vocational discipline.	To secure the required minimum credits in each discipline, students who wish to opt for a Double Major should include the credits earned by them from the Multi-Disciplinary Courses, Skill Enhancement Courses, and Value-Added Courses offered by the respective Major disciplines. The Double Major pathway is extended to the fourth year. Shifting to a double major from a minor in the third semester will be allowed subject to clearance of the courses of double major (not studied earlier) in succeeding sessions. In the fourth year, the student can continue to earn the required credits in either Major A or Major B to qualify for a UG Degree (Honours)/ UG Degree (Honours with Research) in A or B. If he/she opts to continue with Major B in the fourth year, he/she should earn an additional 16 credits of 300-399 level in Major B through mandatory online courses. The institution will not provide the courses in physical mode in the fourth year of this segment.

Table 3: Credit Distribution in Elective Minor Courses during the Four Years of FYUGP

Academic Level	Level of Courses	Semester	**Path A** **ELC**; Elective courses from Interdisciplinary Subjects 1 & 2 (24)		**Path B** **ELC**; Elective courses from the discipline (24)	**Path C** **ELC**; Elective courses from vocational (24)	**Path D** **ELC**; Elective courses from the discipline for Double Major (64)
	1	2	3A. Subject 1	3B. Subject 2	4	5	6
Level 4.5	Level 100-199: **Foundation or Introductory courses**	**I**	---	---	---	---	4+4
		II	---	---	---	---	4+4
		Exit Point: Bachelor's Degree with Hons. with Research					
Level 5	Level 200-299: **Intermediate-level courses**	**III**	4	---	4	4	4+4
		IV	---	4	4	4	4+4
		Exit Point: Bachelor's Degree with Hons.					
Level 5.5	Level 300-399: **Higher-level courses**	**V**	4	---	4	4	4+4
		VI	---	4	4	4	4+4
		Exit Point: P.G. Diploma Degree					
Level 6	Level 400-499: **Advanced courses** Hons with Research (>7.5 CGPA)/ Honours/ PG Diploma	**VII**	4	---	4	4	4+4
		VIII	---	4	4	4	4+4
		Exit Point: (A) Bachelor's Degree with Hons. with Research/ (B) Bachelor's Degree with Hons./ (C) P.G. Diploma Degree					

COURSES OF STUDY FOR FOUR-YEAR UNDERGRADUATE PROGRAMME 2025 onwards

Table 4: Semester-wise Course Code and Credit Points for Single Major during the First Three Years of FYUGP

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Credits	
	Code	Papers	Paper	Semester
I	AEC-1	Language and Communication Skills (MIL-1; Modern Indian language Hindi/ English)	2	**7 Papers** (20 credits)
	VAC-1	Value Added Course-1	2	
	IKS-1	Indian Knowledge System-I (Foundation Course)	2	
	SEC-1	Skill Enhancement Course-1	3	
	MDC-1	Multi-disciplinary Course-1	3	
	AC-1	Associated core courses from discipline/ Interdisciplinary/ vocational	4	
	MJ-1	Major paper 1 (Disciplinary/ Interdisciplinary Major)	4	
II	AEC-2	Language and Communication Skills (MIL-1; Modern Indian language English/ Hindi)	2	**7 Papers** (20 credits)
	VAC-2	Value Added Course-2	2	
	SA	Social Awareness Activities	2	
	SEC-2	Skill Enhancement Course-2	3	
	MDC-2	Multi-disciplinary Course-2	3	
	AC-2	Associated core courses from discipline/ Interdisciplinary/ vocational	4	
	MJ-2	Major paper 2 (Disciplinary/ Interdisciplinary Major)	4	
III	AEC-3	Language and Communication Skills (MIL-2; MIL including TRL)	2	**6 Papers** (20 credits)
	SEC-3	Skill Enhancement Course-3	3	
	MDC-3	IKS as a Multi-disciplinary Course-3	3	
	ELC-1	Elective courses from discipline/ Interdisciplinary/ vocational	4	
	MJ-3	Major paper 3 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-4	Major paper 4 (Disciplinary/ Interdisciplinary Major)	4	
IV	AEC-4	Language and Communication Skills (MIL-2; MIL including TRL)	2	**6 Papers** (20 credits)
	VAC-3	Value Added Course-3	2	
	ELC-2	Elective courses from discipline/ Interdisciplinary/ vocational	4	
	MJ-5	Major paper 5 (Disciplinary/ Interdisciplinary Major having IKS)	4	
	MJ-6	Major paper 6 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-7	Major paper 7 (Disciplinary/ Interdisciplinary Major)	4	
V	ELC-3	Elective courses from discipline/ Interdisciplinary/ vocational	4	**5 Papers** (20 credits)
	MJ-8	Major paper 8 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-9	Major paper 9 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-10	Major paper 10 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-11	Major paper 11 (Disciplinary/ Interdisciplinary Major)	4	
VI	ELC-4	Elective courses from discipline/ Interdisciplinary/ vocational	4	**5 Papers** (20 credits)
	MJ-12	Major paper 12 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-13	Major paper 13 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-14	Major paper 14 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-15	Major paper 15 (Disciplinary/ Interdisciplinary Major)	4	
Total Credits, excluding one Internship (IAP) of 4 credits =			**120**	**120**

Note: It is mandatory to take One Internship of 4 credits in any one of the semesters during the first three years in FYUGP or before exit at any of the exit points if a student wishes to opt for the same.

Table 5A: Semester-wise Course Code and Credit Points for Single Major during the Fourth Year of FYUGP for Bachelor's Degree (Honours with Research)

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Credits	
	Code	Papers	Paper	Semester
VII A	ELC-5	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-16	Major paper 16 (Research Methodology)	4	
	MJ-17	Major paper 17 (Disciplinary/Interdisciplinary Major)	4	
	MJ-18	Major paper 18 (Disciplinary/Interdisciplinary Major)	4	
	RC-1	Research proposal – Planning & Techniques (Disciplinary/Interdisciplinary Major)	4	
VIII A	ELC-6	Elective courses from discipline/ Interdisciplinary/ vocational	4	4 Papers (20 credits)
	MJ-19	Major paper 19 (Disciplinary/Interdisciplinary Major)	4	
	MJ-20	Major paper 20 (Disciplinary/Interdisciplinary Major)	4	
	RC-2	Research Internship/Field Work/Project/Dissertation/Thesis	8	
		Total Credits, excluding one Internship of 4 credits =	**160**	**160**

Table 5B: Semester-wise Course Code and Credit Points for Single Major during the Fourth Year of FYUGP for Bachelor's Degree (Honours)

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Credits	
	Code	Papers	Paper	Semester
VII B	ELC-5	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-16	Major paper 16 (Disciplinary/Interdisciplinary Major)	4	
	MJ-17	Major paper 17 (Disciplinary/Interdisciplinary Major)	4	
	MJ-18	Major paper 18 (Disciplinary/Interdisciplinary Major)	4	
	AMJ-1	Advanced Major pape-1 (Disciplinary/Interdisciplinary Major)	4	
VIII B	ELC-6	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-19	Major paper 19 (Disciplinary/Interdisciplinary Major)	4	
	MJ-20	Major paper 20 (Disciplinary/Interdisciplinary Major)	4	
	AMJ-2 AMJ-3	Advanced Major paper-2 (Disciplinary/Interdisciplinary Major) Advanced Major paper-3 (Disciplinary/Interdisciplinary Major)	4 4	
		Total Credits, excluding one Internship of 4 credits =	**160**	**160**

Table 5C: Semester-wise Course Code and Credit Points for Single Major during the Fourth Year of FYUGP for Bachelor's Degree (with Postgraduate Diploma)

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Credits	
	Code	Papers	Paper	Semester
VII C	ELC-5	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-16	Major paper 16 (Disciplinary/Interdisciplinary Major)	4	
	MJ-17	Major paper 17 (Disciplinary/Interdisciplinary Major)	4	
	MJ-18	Major paper 18 (Disciplinary/Interdisciplinary Major)	4	
	JOC-1	Skill based Job Oriented paper (Disciplinary/Interdisciplinary Major)	4	
VIII C	ELC-6	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-19	Major paper 19 (Disciplinary/Interdisciplinary Major)	4	
	MJ-20	Major paper 20 (Disciplinary/Interdisciplinary Major)	4	
	JOC-2	Skill based Job Oriented paper (Disciplinary/Interdisciplinary Major)	4	
	JOC-3	Skill based Job Oriented paper (Disciplinary/Interdisciplinary Major)	4	
		Total Credits, excluding one Internship of 4 credits =	**160**	**160**

AIMS OF BACHELOR'S DEGREE PROGRAMME IN PHYSICS

The aim of bachelor's degree programme in Physics is intended to provide:

i. The aim of bachelor's degree programme in Physics is intended to provide:
ii. Broad and balance knowledge in Physics in addition to understanding of key Physical concepts, principles, and theories.
iii. To develop students' ability and skill to acquire expertise over solving both theoretical and applied Physics problems.
iv. To provide knowledge and skill to the students' thus enabling them to undertake further studies in Physics in related areas or multidisciplinary areas that can be helpful for self- employment/entrepreneurship.
v. To provide an environment that ensures cognitive development of students in a holistic manner. A complete dialogue about Physics and its significance is fostered in this framework, rather than mere theoretical aspects
vi. To provide the latest subject matter, both theoretical as well as practical, such a way to foster their core competency and discovery learning. A Physics graduate as envisioned in this framework would be sufficiently competent in the field to undertake further discipline-specific studies, as well as to begin domain-related employment.
vii. To mold a responsible citizen who is aware of most basic domain-independent knowledge, including critical thinking and communication.
viii. To enable the graduate, prepare for national as well as international competitive examinations, especially UGC-CSIR NET, GATE, JAM, JEST, and UPSC Civil Services Examination.
ix. To enable student, seek their career in the field of Research, Applied Physics, Energy, Technology, Geophysics and meteorology, Space and Astronomy, Radiation Physics, Instrumentation, Oceanography and such many fields with a further specialization in the same.

PROGRAMME LEARNING OUTCOMES

The programme learning outcomes relating to Honours/Research Degree in Physics:

i. The student graduating with the Degree Honours/Research in Physics would be able to:
ii. Core competency: Students will acquire core competency in the subject Physics, and in allied subject areas.
iii. Systematic and coherent understanding of the fundamental concepts in Physics and other related allied Physics subjects.
iv. Students will be able to use the evidence based comparative Physics approach to explain the scientific and technological problems.
v. The students will be able to understand the laws of nature.
vi. Students will be able to understand the basic principle of equipment; instruments used in the Physics laboratory.
vii. Students will be able to demonstrate the experimental techniques and methods of their area of specialization in Physics.
viii. Disciplinary knowledge and skill: A graduate student are expected to be capable of demonstrating comprehensive knowledge and understanding of both theoretical and experimental/applied Physics knowledge in various fields of interest like Mathematical Physics, Thermal and Statistical Physics, Electromagnetism, Waves and Optics, Analog and Digital Electronics, Modern Physics, Quantum Mechanics, Solid State Physics, Nuclear and Particle Physics, Classical Dynamics, Experimental Techniques, Devices and Instruments, etc.
ix. Skilled communicator: The course curriculum incorporates basics and advanced training in order to make a graduate student capable of expressing the subject through technical writing as well as through oral presentation.
x. Critical thinker and problem solver: The course curriculum also includes components that can be helpful to graduate students to develop critical thinking ability by way of solving problems/numerical using basic Physics knowledge and concepts.
xi. Sense of inquiry: It is expected that the course curriculum will develop an inquisitive characteristic among the students through appropriate questions, planning and reporting experimental investigation.
xii. Team player: The course curriculum has been designed to provide opportunity to act as team player by contributing in laboratory, field-based situation and industry.
xiii. Skilled project manager: The course curriculum has been designed in such a manner as to enable a graduate student to become a skilled project manager by acquiring knowledge about Physics project management, writing, planning, study of ethical standards and rules and regulations pertaining to scientific project operation.
xiv. Digitally literate: The course curriculum has been so designed to impart a good working knowledge in understanding and carrying out data analysis, use of library search tools, and use of simulation software and related computational work.
xv. Ethical awareness/reasoning: A graduate student requires to understand and develop ethical awareness/reasoning which the course curriculum adequately provide.
xvi. Lifelong learner: The course curriculum is designed to inculcate a habit of learning continuously through use of advanced ICT technique and other available techniques/books/journals for personal academic growth as well as for increasing employability opportunity..

SEMESTER WISE COURSES IN PHYSICS HONOURS **2025 onwards**

Table 6: Semester-wise Course Code and Credit Points of Major Courses in Physics

Semester	Courses		Examination Structure			
	Code	Courses in NEP FYUGP Syllabus of Physics Session 2025-26 & onwards	Credits	Mid Semester Theory (F.M.)	End Semester Theory (F.M.)	End Semester Practical/ Viva (F.M.)
I	MJ-1	Basic Mathematical Physics & Mechanics	4	25	75	---
	SEC-1	Electrical Circuits and Network Skills	3	---	75	---
II	MJ-2	Electromagnetism	4	25	75	---
	SEC-2	Basic Instrumentation Skills	3	---	75	---
III	MJ-3	Waves and Optics	4	25	75	---
	MJ-4	Practical-I	4	---	---	100
	SEC-3	Elementary Computer Application Softwares	3	---	75	---
IV	MJ-5	Ancient Indian Physics & Astronomy (IKS)	4	25	75	---
	MJ-6	Thermal and Statistical Physics	4	25	75	---
	MJ-7	Practical-II	4	---	---	100
V	MJ-8	Analog and Digital Electronics	4	25	75	---
	MJ-9	Elements of Modern Physics	4	25	75	---
	MJ-10	Advanced Mathematical Physics	4	25	75	---
	MJ-11	Practical-III	4	---	---	100
VI	MJ-12	Quantum Mechanics and Applications	4	25	75	---
	MJ-13	Solid State Physics	4	25	75	---
	MJ-14	Nuclear and Particle Physics	4	25	75	---
	MJ-15	Practical-IV	4	---	---	100
VII	MJ-16	Research Methodology	4	25	75	---
	MJ-17	Advanced Mathematical Methods in Physics	4	25	75	---
	MJ-18	Advanced Quantum Mechanics-I	4	25	75	---
	AMJ-1/	Advanced Quantum Mechanics-II/	4	25	75	---
	RC-1	Research Planning & Techniques	4	25	75	---
VIII	MJ-19	Spectroscopy	4	25	75	---
	MJ-20	Practical-V	4	---	---	100
	AMJ-2	Advanced Nuclear Physics	4	25	75	---
	AMJ-3/	Practical-VI	4	---	---	100
	RC-2	Project Dissertation/ Research Internship/ Field Work	8	50	---	150

* It is mandatory to take Either One Internship of 4 credits or Two Internships of 2 credits each in any one of the semesters during the first three years in FYUGP or before exit at any of the exit points if a student wishes to opt for the same.

Table 7: Semester-wise Course Code and Credit Points of Minor Courses in Physics

Courses		Examination Structure			
Code	**Minor Courses in NEP FYUGP Syllabus of Economics** Session 2025-26 & onwards	**Credits**	**Mid Semester Theory (F.M.)**	**End Semester Theory (F.M.)**	**End Semester Practical/ Viva (F.M.)**
MN-A	Introductory Physics	4	15	60	25
MN-B	Mechanics	4	15	60	25
MN-C	Electricity and Magnetism	4	15	60	25
MN-D	Thermal Physics and Statistical Mechanics	4	15	60	25
MN-E	Waves and Optics	4	15	60	25
MN-F	Digital, Analog Circuits and Instrumentation	4	15	60	25
MN-G	Solid State Physics	4	15	60	25

INSTRUCTION TO QUESTION SETTER

SEMESTER INTERNAL EXAMINATION (SIE):

There will be Only One Semester Internal Examination in Major, Minor and Research Courses, which will be organized at college/institution level. However, Only One End semester evaluation in other courses will be done either at College/ Institution or University level depending upon the nature of course in the curriculum.

A. (SIE 10+5=15 marks):

There will be two group of questions. **Question No.1 will be very short answer type in Group A** consisting of five questions of 1 mark each. **Group B will contain descriptive type** two questions of five marks each, out of which any one to answer.

The Semester Internal Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks, (b) Class Attendance Score (CAS) of 5 marks.

B. (SIE 20+5=25 marks):

There will be two group of questions. **Group A is compulsory** which will contain two questions. **Question No.1 will be very short answer type** consisting of five questions of 1 mark each. **Question No.2 will be short answer type** of 5 marks. **Group B will contain descriptive type** two questions of ten marks each, out of which any one to answer.

The Semester Internal Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 20 Marks, (b) Class Attendance Score (CAS) of 5 marks.

Conversion of Attendance into score may be as follows:

Attendance Upto 45%, 1mark; 45<Attd.<55, 2 marks; 55<Attd.<65, 3 marks; 65<Attd.<75, 4 marks; 75<Attd, 5 marks.

END SEMESTER UNIVERSITY EXAMINATION (ESE):

A. (ESE 50 marks):

There will be two group of questions. **Group A is compulsory** which will contain one question. **Question No.1 will be very short answer type** consisting of five questions of 1 mark each. Group B will contain descriptive type five questions of fifteen marks each, out of which any three are to answer.

B. (ESE 60 marks):

There will be two group of questions. **Group A is compulsory** which will contain three questions. **Question No.1 will be very short answer type** consisting of five questions of 1 mark each. **Question No.2 & 3 will be short answer type** of 5 marks. Group B will contain descriptive type five questions of fifteen marks each, out of which any three are to answer.

C. (ESE 75 marks):

There will be two group of questions. **Group A is compulsory** which will contain three questions. **Question No.1 will be very short answer type** consisting of five questions of 1 mark each. **Question No. 2 & 3 will be short answer type** of 5 marks. Group B will contain descriptive type six questions of fifteen marks each, out of which any four are to answer.

D. (ESE 100 marks):

There will be two group of questions. **Group A is compulsory** which will contain three questions. **Question No.1 will be very short answer type** consisting of ten questions of 1 mark each. **Question No. 2 & 3 will be short answer type** of 5 marks. Group B will contain descriptive type six questions of twenty marks each, out of which any four are to answer.

FORMAT OF QUESTION PAPER FOR MID/ END SEMESTER EXAMINATIONS

Question format for **15 Marks**:

Subject/ Code

F.M. =15 **Time** = 1 Hr. Exam Year

General Instructions:

i. **Group A** carries very short answer-type compulsory questions.
ii. **Answer 1 out of 2** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all subparts of a question in one place.
v. Numbers in the right indicate full marks for the question.

Group A

1. [5x1=5]
   i. ....
   ii. ....
   iii. ....
   iv. ....
   v. ....

Group B

2. .... [10]
3. .... [10]

Note: There may be subdivisions in each question asked in Theory Examination.

Question format for **20 Marks**:

Subject/ Code

F.M. =20 **Time** = 1 Hr. Exam Year

General Instructions:

i. **Group A** carries very short answer-type compulsory questions.
ii. **Answer 1 out of 2** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all subparts of a question in one place.
v. Numbers in the right indicate full marks for the question.

Group A

1. [5x1=5]
   i. ....
   ii. ....
   iii. ....
   iv. ....
   v. ....
2. .... [5]

Group B

3. .... [10]
4. .... [10]

Note: There may be subdivisions in each question asked in the Theory Examination.

Question format for **50 Marks**:

Subject/ Code

F.M. =50 **Time** = 1.5 Hrs. Exam Year

General Instructions:

i. **Group A** carries very short answer-type compulsory questions.
ii. **Answer 3 out of 5** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all subparts of a question in one place.
v. Numbers in the right indicate full marks for the question.

Group A

1. [5x1=5]
   i. ....
   ii. ....
   iii. ....
   iv. ....
   v. ....

Group B

2. .... [15]
3. .... [15]
4. .... [15]
5. .... [15]
6. .... [15]

Note: There may be subdivisions in each question asked in the Theory Examination.

Question format for **60 Marks**:

Subject/ Code

F.M. =60 **Time** = 3 Hrs. Exam Year

General Instructions:

i. **Group A** carries very short answer-type compulsory questions.
ii. **Answer 3 out of 5** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all subparts of a question in one place.
v. Numbers in the right indicate full marks for the question.

Group A

1. [5x1=5]
   vi. ....
   vii. ....
   viii. ....
   ix. ....
   x. ....
2. .... [5]
3. .... [5]

Group B

4. .... [15]
5. .... [15]
6. .... [15]
7. .... [15]
8. .... [15]

Note: There may be subdivisions in each question asked in the Theory Examination.

Question format for **75 Marks**:

Subject/ Code

F.M. =75 **Time** = 3 Hrs. Exam Year

General Instructions:

i. **Group A** carries very short answer-type compulsory questions.
ii. **Answer 4 out of 6** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all subparts of a question in one place.
v. Numbers in the right indicate full marks for the question.

Group A

1. [5x1=5]
    i. ....
    ii. ....
    iii. ....
    iv. ....
    v. ....
2. .... [5]
3. .... [5]

Group B

4. .... [15]
5. .... [15]
6. .... [15]
7. .... [15]
8. .... [15]
9. .... [15]

Note: There may be subdivisions in each question asked in the Theory Examination.

Question format for **100 Marks**:

Subject/ Code

F.M. =100 **Time** = 3 Hrs. Exam Year

General Instructions:

i. **Group A** carries very short answer-type compulsory questions.
ii. **Answer 4 out of 6** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all subparts of a question in one place.
v. Numbers in the right indicate full marks for the question.

Group A

1. [10x1=10]
    i. .... vi. ....
    ii. .... vii. ....
    iii. .... viii. ....
    iv. .... ix. ....
    v. .... x. ....
2. .... [5]
3. .... [5]

Group B

4. .... [20]
5. .... [20]
6. .... [20]
7. .... [20]
8. .... [20]
9. .... [20]

Note: There may be subdivisions in each question asked in the Theory Examination.

SEMESTER I

I. MAJOR COURSE –MJ 1:
BASIC MATHEMATICAL PHYSICS & MECHANICS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:
On successful completion of this course the student should know:
1. Revise the knowledge of calculus. These basic mathematical structures are essential in solving problems in various branches of Physics as well as in engineering.
2. Learn the curvilinear coordinates which have applications in problems with spherical and cylindrical symmetries.
3. In the laboratory course, learn the fundamentals of the C and C++ programminglanguages and their applications in solving simple physical problems involving differentiations, integrations, differential equations as well as finding theroots of equations.
4. Understand laws of motion and their application to various dynamical situations, the notion of inertial frames and the concept of Galilean invariance. He/she will learn the concept of conservation of energy, momentum, angular momentum and apply them to basic problems.
5. Understand the principles of elasticity through the study of Young's Modulus and modulus of rigidity.
6. Understand simple principles of fluid flow and the equations governing fluid dynamics.
7. Apply Kepler's law to describe the motion of planets and satellites in circular orbit,through the study of law of Gravitation.
8. Explain the phenomena of simple harmonic motion and the properties of systemsexecuting such motions.
9. Describe how fictitious forces arise in a non-inertial frame, e.g., why a person sitting ina merry-go-round experiences an outward pull.
10. Describe special relativistic effects and their effects on the mass and energy of amoving object.
11. appreciate the nuances of the Special Theory of Relativity (STR)
12. In the laboratory course, the student shall perform experiments related to mechanics (compound pendulum), rotational dynamics (Flywheel), elastic properties (YoungModulus and Modulus of Rigidity) and fluid dynamics (verification of Stokes law, Searle method) etc.

Skills to be learned:
1. Training in calculus will prepare the student to solve various mathematical problems.
2. He/she shall develop an understanding of how to formulate a physics problem and solve the given mathematical equation risen out of it.
3. Learn the concepts of elasticity in constant of solids and viscosity of fluids.
4. Develop skills to understand and solve the equations central force problem.
5. Acquire basic knowledge of oscillation.
6. About inertial and non-inertial systems and the special theory of relativity

Course Content:

The emphasis of the course is on applications in solving problems of interest to physicists.The students are to be examined entirely on the basis of problems, seen and unseen.

Calculus:
Taylor and binomial series, First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Particular Integral. **(8 Lectures)**

Vector Calculus:
Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities.
Vector Integration: Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and theirapplications (no rigorous proofs). **(15 Lectures)**

Orthogonal Curvilinear Coordinates:
Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. **(7 Lectures)**

Elasticity: Elastic constants and the interrelation between Elastic constants Twisting torque on a Cylinder or Wire and Twisting couple. **(3 Lectures)**

Flexure of Beam: Bending of the beam, Cantilever. **(3 Lectures)**

Surface Tension: Ripples and Gravity waves, Determination of surface tension by Jaeger's and Quinke's methods. Temperature dependence of surface tension. **(6 Lectures)**

Fluid Motion: Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube and corrections. **(2 Lectures)**

Central Force Motion: Motion of a particle under a central force field. Two-body problem and its reduction to the one-body problem and its solution. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of the global positioning system (GPS). (**3 Lectures)**

Oscillations: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor. **(4 Lectures)**

Special Theory of Relativity: Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass- energy Equivalence. Relativistic Doppler effect. (**9 Lectures)**

Reference Books:

1. Concepts of Electromagnetic Theory, K. Mamta, Raj Kumar Singh and J. N. Prasad, 1/e, 2021, Wiley/I. K. International Publishing House, New Delhi
2. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn.,Elsevier.
3. Mathematical Physics, P. K. Chattopadhyaya, 2/e, New Age International Publisher
4. An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
5. Differential Equations, George F. Simmons, 2007, McGraw Hill.
6. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
7. Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
8. Advanced Engg. Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones andBartlett Learning
9. Mathematical Physics, Goswami, 1st edition, Cengage Learning
10. Engineering Mathematics, S. Pal and S.C. Bhunia, 2015, Oxford University Press
11. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
12. Essential Mathematical Methods, K. F. Riley & M. P. Hobson, 2011, Cambridge Univ. Press.
13. Mathematical Physics, H.K. Dass and R. Verma, S. Chand & Company.
14. An introduction to Mechanics, D. Kleppner, R. J. Kolenkow, 1973, McGraw-Hill.
15. Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al. 2007, Tata McGraw-Hill.
16. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
17. Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning
18. Feynman Lectures, Vol. I, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education
19. Undergraduate Mechanics, Arun Kumar, J. P. Agarwal and Nutan Lata, Pragati Prakashan
20. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.

Additional Books for Reference

1. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
2. University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
3. Physics for scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010,Cengage Learning.
4. Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

II. SKILL ENHANCEMENT COURSE- SEC 1: **ELECTRICAL CIRCUITS AND NETWORK SKILLS**

Marks: 75 (ESE: 3Hrs) = 75	Pass Marks: Th (ESE) = 30

(Credits: Theory-03) **45 Hours**

Course Objectives:

The aim of this course is to enable the students to design and trouble shoots the electrical circuits, networks and appliances through hands-on mode

Course Contents:

Basic Electricity Principles: Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC Electricity and DC Electricity. Familiarization with multimeter, voltmeter and ammeter. **(5 Lectures)**

Understanding Electrical Circuits: Main electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money. **(5 Lectures)**

Electrical Drawing and Symbols:
Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop. **(5 Lectures)**

Generators and Transformers: **(5 Lectures)**
DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.

Electric Motors: Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters & motors. Speed & power of ac motor. **(6 Lectures)**

Solid-State Devices: Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources **(5 Lectures)**

Electrical Protection: Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device) **(6 Lectures)**

Electrical Wiring: Different types of conductors and cables. Basics of Wiring-Star and delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and stranded cable. Conduit. Cable trays. Splices: wirenuts, crimps, terminal blocks, split bolts, and solder. Preparation of the extension board. **(8 Lectures)**

Laboratory Exercises:
1. Use of multimeter, voltmeter and ammeter
2. To observe current and voltage drop across the DC circuit elements.
3. To track the connections of elements and identify current flow and voltage drop.
4. To observe the working of transformer under no load and full load condition
5. Use of diode as half wave, full wave and bridge rectifier
6. To observe the response of inductor and capacitor with DC or AC sources
7. To understand the importance of interfacing DC or AC sources to relay protection device
8. To prepare an extension board with more than one input terminal (3 pin socket) and check its working

Reference Books:

1. A text book in Electrical Technology - B L Theraja - S Chand & Co.
2. A text book of Electrical Technology - A K Theraja
3. Performance and design of AC machines - M G Say ELBS Edn.
4. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
5. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
6. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
7. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
8. Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
9. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

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SEMESTER II

I. MAJOR COURSE- MJ 2: **ELECTROMAGNETISM**

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:

After going through the course, the student should be able to

1. Explain and differentiate the vector (electric fields, Coulomb's law) and scalar (electricpotential, electric potential energy) formalisms of electrostatics.
2. Apply Gauss's law of electrostatics to solve a variety of problems.
3. Articulate knowledge of electric current, resistance and capacitance in terms of electricfield and electric potential.
4. Describe the magnetic field produced by magnetic dipoles and electric currents.
5. Explain Faraday-Lenz and Maxwell laws to articulate the relationship between electricand magnetic fields.
6. Understand the dielectric properties, magnetic properties of materials and thephenomena of electromagnetic induction.
7. Describe how magnetism is produced and list examples where its effects are observed.
8. Apply Kirchhoff's rules to analyze AC circuits consisting of parallel and/or series combinations of voltage sources and resistors and to describe the graphical relationship of resistance, capacitor and inductor.
9. Apply various network theorems such as Superposition, Thevenin, Norton, Reciprocity,Maximum Power Transfer, etc. and their applications in electronics, electrical circuit analysis, and electrical machines.
10. In the laboratory course the student will get an opportunity to verify various laws in electricity and magnetism such as Lenz's law, Faraday's law and learn about theconstruction, working of various measuring instruments.
11. Should be able to verify of various circuit laws, network theorems elaborated above, using simple electric circuits.
12. Achieve an understanding of Maxwell's equations, role of displacement current, gauge transformations, scalar and vector potentials, Coulomb and Lorentz gauge, boundary conditions at the interface between different media.
13. Apply Maxwell's equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density.
14. Analyse the phenomena of wave propagation in the unbounded, bounded, vacuum, dielectric, guided and unguided media.
15. Understand the laws of reflection and refraction and to calculate the reflection and transmission coefficients at plane interface in bounded media.
16. Plan and Execute 2-3 group projects for designing new experiments based on the Syllabi.

Skills to be learned:

1. This course will help in understanding basic concepts of electricity and magnetism andtheir applications.
2. Basic course in electrostatics will equips the student with required prerequisites tounderstand electrodynamics phenomena.
3. Comprehend the role of Maxwell's equation in unifying electricity and magnetism.
4. Derive expression for
    a. Energy density
    b. Momentum density
    c. Angular momentum density of the electromagnetic field
5. Learn the implications of Gauge invariance in EM theory in solving the wave equationsand develop the skills to actually solve the wave equation in various media like
    a. Vacuum
    b. Dielectric medium
    c. Conducting medium
6. Derive and understand associated with the properties, EM wave passing through theinterface between two media like
    a. Reflection
    b. Refraction
    c. Transmission

Course Content:

Electric Field and Electric Potential

Conservative nature of the Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole. Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductorsin an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. **(6 Lectures)**

Dielectric Properties of Matter: Electric Field in Matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector **D**. Relations between **E**, **P** and **D**. Gauss' Law in dielectrics. **(5 Lectures)**

Magnetic Field: Magnetic force between current elements and definition of Magnetic Field **B**. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of **B**: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current-carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field. **(10 Lectures)**

Magnetic Properties of Matter: Magnetization vector (**M**). Magnetic Intensity (**H**). Magnetic Susceptibility and Permeability. Relation between **B, H, M**. Ferromagnetism. B-H curve and hysteresis. **(4 Lectures)**

Electrical Circuits: AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor,and (4) Band Width. Parallel LCR Circuit. **(5 Lectures)**

Ballistic Galvanometer: Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR. **(3 Lectures)**

Maxwell Equations: Review of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Vector and Poynting Theorem. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density. **(10 Lectures)**

EM Wave Propagation in Unbounded Media: Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant,wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth. **(8 Lectures)**

EM Wave in Bounded Media: Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at a plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection. **(9 Lectures)**

Reference Books:

1. Concepts of Electromagnetic Theory, K. Mamta, Raj Kumar Singh and J. N. Prasad, 1st Edn 2021, Wiley/I. K. International Publishing House, New Delhi
2. Electricity and Magnetism, P. K. Chakraborty, New Age International Pvt. Ltd.
3. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
4. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
5. Feynman Lectures Vol.2, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education
6. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
7. Electricity and Magnetism, J.H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press.
8. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
9. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
10. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
11. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
12. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
13. Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
14. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

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II. SKILL ENHANCEMENT COURSE- SEC 2: **BASIC INSTRUMENTATION SKILLS**

Marks: 75 (ESE: 3Hrs) = 75	**Pass Marks: Th (ESE) = 30**

(Credits: Theory-03) **45 Hours**

Course Objectives:

1. This course is to get exposure with various aspects of instruments and their usage through hands-on mode.
2. Experiments listed below are to be done in continuation of the topics.

Course Contents:

Basic of Measurement: Instrument accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects.

Multimeter: Principles of measurement of DC voltage and DC, AC voltage, current and resistance. Specifications of a multimeter and their significance. **(5 Lectures)**

Electronic Voltmeter: Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage measurement (block diagram only). Specifications of an electronic Voltmeter/ Multimeter and their significance. AC millivoltmeter: Types of AC millivoltmeters: Amplifier-rectifier, and rectifier-amplifier. Block diagram of an AC millivoltmeter**,** specifications and their significance. **(7 Lectures)**

Cathode Ray Oscilloscope: Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time-based operation, synchronization. Front panel controls. Specifications of a CRO and their significance. Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working. **(12 Lectures)**

Signal Generators and Analysis Instruments: Block diagram, explanation and specifications of low-frequency signal generators. pulse generator, and a function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis. **(6 Lectures)**

Impedance Bridges & Q-Meters: Block diagram of bridge. working principles of basic (balancing type) RLC bridge. Specifications of the RLC bridge. Block diagram & working principles of a Q-Meter. Digital LCR bridges. **(5 Lectures)**

Digital Instruments: Principle and working of digital meters. Comparison of Analog & digital instruments. Characteristics of a digital meter. Working principles of a digital voltmeter. **(5 Lectures)**

Digital Multimeter:

Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/ frequency counter, time-base stability, accuracy and resolution. **(5 Lectures)**

The test of lab skills will include the following test items:

1. Use of an oscilloscope.
2. CRO as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipment,
4. Use of a Digital multimeter/VTVM for measuring voltages
5. Circuit tracing of Laboratory electronic equipment,
6. Winding a coil/transformer.
7. Study the layout of the receiver circuit.
8. Troubleshooting a circuit
9. Balancing of bridges

LABORATORY EXERCISES:

1. To observe the loading effect of a multimeter while measuring voltage across a
2. low resistance and high resistance.
3. To observe the limitations of a multimeter for measuring high-frequency voltage
4. and currents.
5. To measure Q of a coil and its dependence on frequency, using a Q-meter.
6. Measurement of voltage, frequency, time period and phase angle using CRO.
7. Measurement of time period, frequency, and average period using a universal counter/ frequency counter.
8. Measurement of rise, fall and delay times using a CRO.
9. Measurement of the distortion of an RF signal generator using a distortion factor meter.
10. Measurement of R, L and C using an LCR bridge/ universal bridge.

Open Ended Experiments:

1. Using a Dual Trace Oscilloscope
2. Converting the range of a given measuring instrument (voltmeter, ammeter)

Reference Books:

1. A text book in Electrical Technology - B L Theraja - S Chand and Co.
2. Performance and design of AC machines - M G Say ELBS Edn.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Logic circuit design, Shimon P. Vingron, 2012, Springer.
5. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
6. Electronic Devices and circuits, S. Salivahanan & N. S. Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
7. Electronic circuits: Handbook of design and applications, U. Tietze, Ch. Schenk, 2008, Springer
8. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

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SEMESTER III

I. MAJOR COURSE- MJ 3: WAVES AND OPTICS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:

This course will enable the student to

1. Recognize and use a mathematical oscillator equation and wave equation, and derivethese equations for certain systems.
2. Apply basic knowledge of principles and theories about the behaviour of light and thephysical environment to conduct experiments.
3. Understand the principle of superposition of waves, so thus describe the formation ofstanding waves.
4. Explain several phenomena we can observe in everyday life that can be explained aswave phenomena.
5. Use the principles of wave motion and superposition to explain the Physics of polarisation, interference and diffraction.
6. Understand the working of selected optical instruments like a biprism, an interferometer, a diffraction grating, and holograms.
7. In the laboratory course, students will gain hands-on experience of using various optical instruments and making finer measurements of the wavelength of light using Newton Ringsexperiment, Fresnel Biprism etc. The resolving power of optical equipment can be learnt firsthand.
8. The motion of coupled oscillators, the study of Lissajous figures and the behaviour of transverse, longitudinal waves can be learnt in this laboratory course.

Skills to be learned:

1. He/she shall develop an understanding of various aspects of harmonic oscillations andwaves specially.
   a. Superposition of collinear and perpendicular harmonic oscillations
   b. Various types of mechanical waves and their superposition.
2. This course in basics of optics will enable the student to understand various opticalphenomena, principles, workings and applications optical instruments.

Course Content:

Wave Motion: Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. DifferentialEquation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves. **(4 Lectures)**

Velocity of Waves: Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction. **(6 Lectures)**

Superposition of Collinear and two perpendicular Harmonic oscillations: Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences. Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. **(5 Lectures)**

Superposition of Two Harmonic Waves: Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves. **(7 Lectures)**

Interference and Interferometer: Temporal and Spatial Coherence. Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index. Michelson Interferometer- (1) Idea of form of fringes (No theory required), Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5)Visibility of Fringes. Fabry-Perot interferometer. **(13 Lectures)**

Diffraction: Single slit, Double slit. Multiple slits, Diffraction grating. Circular aperture. Resolving Power of telescope and grating. Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a ZonePlate. Fresnel diffraction pattern of a straight edge. **(15 Lectures)**

Polarization of Electromagnetic Waves: Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses Analysis of Polarized Light. **(7 Lectures)**

Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter. **(3 Lectures)**

Reference Books:

1. Concepts of Electromagnetic Theory, K. Mamta, Raj Kumar Singh and J. N. Prasad, 1/e, 2021, Wiley/I. K. International Publishing House, New Delhi
2. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
3. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
4. Optics, Ajoy Ghatak, 2008, Tata McGraw-Hill
5. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
6. Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. ChandPublications.
7. Electromagnetic Theory, Chopra & Agarwal, Kedarnath Ramnath & Co.

II. MAJOR COURSE- MJ 4: **PRACTICALS-I**

Marks: Pr (ESE: 6Hrs) =100	Pass Marks: Pr (ESE) = 40

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for
End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:
Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals (Mechanics, Optics & Electromagnetism):

1. To determine the Coefficient of Viscosity of water by the Capillary Flow Method (Poiseuille'smethod).
2. To determine the elastic Constants of a wire by Searle's method.
3. To determine the value of g using Kater's Pendulum.
4. Familiarization with: Schuster`s focusing; determination of the angle of the prism.
5. To determine the refractive index of the Material of a prism using sodium source.
6. To determine the wavelength of sodium light using Newton's Rings.
7. To determine the wavelength of (1) sodium source and (2) spectral lines of the mercury source using plane diffraction grating.
8. To determine the specific rotation of a sugar solution using a Polarimeter.
9. To study diffraction due to a straight edge.
10. To study the response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Bandwidth.
11. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonantfrequency and (b) Quality factor Q.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, AsiaPublishing House
2. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition,reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal, 1985, VaniPub.

III. SKILL ENHANCEMENT COURSE- SEC 3: **ELEMENTARY COMPUTER APPLICATION SOFTWARES**

Marks: 75 (ESE: 3Hrs) = 75	**Pass Marks: Th (ESE) = 30**

A Common Syllabus for FYUGP (Credits: Theory-03) **45 Hours**

Instruction to Question Setter
*There will be **objective type test** consisting of **Seventy-five questions of 1 mark each**. Students are required to mark their answer on **OMR Sheet** provided by the University.*

Course Objectives:
The objective of the course is to generate qualified manpower in the area of Information Technology (IT) and Graphic designing which will enable such person to work seamlessly at any Offices.

1. Basic Concept of Computer: What is a Computer, Applications of a Computer, Types of Computers, Components of Computer System, Central Processing Unit (CPU) **(3 Hours)**

2. Concepts of Hardware: Input Devices, Output Devices, Computer Memory, Types of Memory, Processing Concept of Computer **(4 Hours)**

3. Operating system: Operating System, Functions of Operating System (Basic), Introduction to Windows 11, Working on Windows 11 environment, Installation of Application Software, My Computer, Control Panel, searching techniques in Windows environment, Basic of setting **(6 Hours)**

4. Concept of Software: What is Software, Types of Software, Computer Software- Relationship between Hardware and Software, System Software, Application Software, some high-level languages **(4 Hours)**

5. Internet & its uses: Basic of Computer networks; LAN, WAN, MAN, Concept of Internet, Applications of Internet; connecting to internet, what is ISP, World Wide Web, Web Browsing software's, Search Engines, URL, Domain name, IP Address, using e-governance website, Basics of electronic mail, getting an email account, Sending and receiving emails. **(6 Hours)**

6. Microsoft Word: Word processing concepts, Creation of Documents, Formatting of Documents, Formatting of Text, Different tabs of word 2016 environment, Formatting Page, Navigation of Page, Table handling, Header and footer, Page Numbering, Page Setup, Find and Replace, Printing the documents **(7 Hours)**

7. Microsoft Excel (Spreadsheet): Spreadsheet Concepts, Creating, Saving and Editing a Workbook, Inserting, Deleting Work Sheets, Formatting a worksheet, Excel Formula, Concept of charts and Applications, Pivot table, Goal Seek, Data filter, data sorting and scenario manager, printing the spreadsheet **(6 Hours)**

8. Microsoft PowerPoint (Presentation Package): Concept and Uses of presentation package, Creating, Opening and Saving Presentations, working in different views in PowerPoint, Animation, slide show, Master Slides, Creating photo album, Rehearse timing and record narration **(5 Hours)**

9. Digital Education: Introduction & Advantages of digital Education, Concept of e-learning, Technologies used in e learning **(4 Hours)**

Reference Books

1. Nishit Mathur, *Fundamentals of Computer*, APH Publishing Corporation (2010)
2. Neeraj Singh, *Computer Fundamentals (Basic Computer),* T Balaji, (2021)
3. Joan Preppernau, *Microsoft PowerPoint 2016 step by step*, Microsoft Press (2015)
4. Douglas E Corner, *The Internet Book* 4th Edition, prentice –Hall (2009)
5. Wallace Wang, *Microsoft Office 2019*, Wiley (January 2018)
6. Noble Powell, *Windows 11 User Guide For Beginners and Seniors*, ASIN, (October 2021)

SEMESTER IV

I. MAJOR COURSE- MJ 5:
ANCIENT INDIAN PHYSICS & ASTRONOMY (IKS)

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:
1. Learn the basic elements of Ancient Indian Physics.
2. Learn the astronomical knowledge in Samhitas, Brahmanas, and Sutras.
3. Learn the contribution of ancient Indian Astronomers.

Skills to be learned:
1. The Doctrine of five elements, atomism and attributes of matter in Ancient Indian Knowledge.
2. Astronomical knowledge in Samhitas, Brahmanas and Sutras
3. Contributions of Ancient Indian Astronomers in the theory and technology of astronomy.

Course Content:

ANCIENT INDIAN PHYSICS AND ASTRONOMY

The Physical World
Main literary sources, Outline of Indian Physical concepts in ancient and medieval periods **(6 Lectures)**

The Doctrine of Five Elements
Samkhya, Prthvi (earth), Ap (water), Tejas (fire), Vayu (air), Akasa **(4 Lectures)**

Atomism
Nyaya-Vaisesika Atomism, The Nyaya-Vaisesika and Greek Atomic views, The Jaina Atomism, The Buddha Atomism **(10 Lectures)**

Attributes of Matter
Gurutva (gravity), Dravatva (fluidity), Snigdha (viscidity), Sthitisthapaka (elasticity), Samyoga and Viyoga or Vibhaga (conjunction and disjunction), Motion, Akasa Space and Time, Heat, Light, Sound. **(12 Lectures)**

Astronomical Knowledge in Samhitas, Brahmanas, and Sutras
The Sun, The Sun's path, the Ecliptic, The Moon, The Solar Eclipse, The planets, Rahu and Ketu, The stars, the nakshatra system and the lunar zodiac, the nakshatras and constellations, Division of time, day, month, season, vedic luni-solar calendar, solstices and **(12 Lectures)**

Astronomical Siddhantas
The Five Siddhantas: The Paitamaha Siddhanta, The Vasistha Siddhanta, The Paulisa Siddhanta, The Romaka Siddhanta, The Surya Siddhanta; The modern Surya Siddhanta **(10 Lectures)**

Ancient Indian Astronomers. Aryabhatta I, Varahmihira, Bhaskara I, Brahmagupta, Vateswara, Manjulacarya, Aryabhatta II, Sripati, Satananda, Bhaskara II, Sawai Jai Singh II, Jagannatha. **(6 Lectures)**

Reference Books:
1. A Concise History of Science in India- D. M. Bose, S.N. Sen & B.V. Subbarayappa, Indian National Science Academy, New Delhi

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II. MAJOR COURSE- MJ 6:
THERMAL AND STATISTICAL PHYSICS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:

1. Comprehend the basic concepts of thermodynamics, the first and the second law of thermodynamics, the concept of entropy and the associated theorems, the thermodynamic potentials and their physical interpretations.
2. Learn about Maxwell's thermodynamic relations.
3. Learn the basic aspects of kinetic theory of gases, Maxwell-Boltzmann distribution law, equitation of energies, mean free path of molecular collisions, viscosity, thermal conductivity, diffusion and Brownian motion.
4. Learn about the real gas equations, Van der Waal equation of state, the Joule-Thomson effect.
5. Understand the concepts of microstate, macrostate, ensemble, phase space, thermodynamic probability and partition function.
6. Understand the combinatoric studies of particles with their distinguishably orindistinguishably nature and conditions which lead to the three different distribution laws e.g. Maxwell-Boltzmann distribution, Bose-Einstein distribution and Fermi-Dirac distribution laws of particles and their derivation.
7. To apply classical statistical mechanics to derive the law of equipartition of energy and specific heat.
8. Understand Gibbs paradox, equipartition of energy & concept of negative temp. in two level system.
9. Learn to derive classical radiation laws of black body radiation. Wiens law, Rayleigh Jeans law, ultraviolet catastrophe. Saha ionization formula.
10. Learn to calculate the macroscopic properties of a degenerate photon gas using BE distribution law, understand the Bose-Einstein condensation law and liquid Helium. Bose derivation of Plank's law
11. Understand the concept of Fermi energy and Fermi level, calculate the macroscopic properties of a completely and strongly degenerate Fermi gas, electronic contribution to specific heat of metals.
12. Understand the application of F-D statistical distribution law to derive thermodynamic functions of a degenerate Fermi gas, electron gas in metals and their properties.
13. Calculate electron degeneracy pressure and ability to understand the Chandrasekhar mass limit, stability of white dwarfs against gravitational collapse.
14. Use Computer simulations to study:
    a. Planck's Black Body Radiation Law and compare with the Wien's Law and Raleigh-Jeans Law in the appropriate temperature region.
    b. Specific Heat of Solids by comparing Dulong-Petit, Einstein's and Debye's Lawsand study their temperature dependence
15. Compare the following distributions as a function of temperature for various energiesand the parameters of the distribution functions:
    a. Maxwell-Boltzmann distribution b. Bose-Einstein distribution c. Fermi-Dirac distribution
16. Do 3-5 assignments given by the course instructor to apply the methods of Statisticalmechanics to simple problems in Solid solid-state physics and Astrophysics

Skills to be learned:

1. Thermodynamical concepts, principles.
2. Learn the basic concepts & definition of physical quantities in classical statistics andclassical distribution law.
3. Learn the application of classical statistics to the theory of radiation.
4. Comprehend the failure of classical statistics and the need for quantum statistics.
5. Learn the application of quantum statistics to derive and understand.
    a. Bose Einstein statistics and its radiation applications.
    b. Fermi-Dirac statistics and its applications to quantum systems.

Course Content:

THERMAL PHYSICS

Thermodynamics laws and Related Concepts: Zeroth Law and First Law of thermodynamics and its differential form. Internal energy. Reversible and Irreversible process with examples. Interconversion of Work and Heat. Carnot's Theorem. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Concept of entropy, Clausius theorem, Clausius inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Entropy Changes in Reversible and Irreversible processes with examples. Principle of Increase of Entropy. Entropy of the Universe. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero. **(9 Lectures)**

Thermodynamic Potentials and Maxwell's Relations: Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples. Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Values of Cp-Cv, TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases. **(10 Lectures)**

Real Gases: Behaviour of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Critical Constants. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. P-V diagrams. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule-Thomson Cooling. **(6 Lectures)**

Molecular Collisions: Free path, Mean Free Path. Collision Probability. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance. **(4 Lectures)**

STATISTICAL PHYSICS

Classical Statistics: Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, GibbsParadox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature **(9 Lectures)**

Quantum Theory of Radiation: Spectral Distribution of Black Body Radiation. Inadequacy of classical radiation theory. Planck's Quantum Postulates. Planck's Law of Black body Radiation: Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law. **(8 Lectures)**

Bose-Einstein Statistics: B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose-Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law. **(7 Lectures)**

Fermi-Dirac Statistics: Fermi-Dirac Distribution Law, Thermodynamic functions of aCompletely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit. **(7 Lectures)**

Reference Books:

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2. Heat and Thermodynamics, P. K. Chakraborty, New Age International Pvt.
3. A Treatise on Heat, Meghnad Saha, and B. N. Srivastava, 1958, Indian Press
4. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
5. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
6. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
7. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, OxfordUniversity Press
8. Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.
9. Thermal Physics, B.K. Agrawal, Lok Bharti Publications.
10. Statistical Mechanics, R. K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, OxfordUniversity Press.
11. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
12. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
13. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears andGerhard L. Salinger, 1986, Narosa.
14. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
15. An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, OxfordUniv. Press

III. MAJOR COURSE- MJ 7: **PRACTICALS-II**

Marks: Pr (ESE: 6Hrs) =100	**Pass Marks: Pr (ESE) = 40**

(Credits: Practicals-04) **120 Hours**

Instructions to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:
Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals (Thermal and Statistical Physics):

This Lab aims to use computational methods to solve physical problems. The course will consist of lectures (both theory and practical) in the Lab. Evaluation not done on the programming but based on formulating the problem

Topics	**Description with Applications**
Introduction to Numerical Computation Software Scilab	Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables inScilab, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2D and 3D plotting (2), Branching Statements and program design, Relational & logical operators, the while loop, for loop, details of loop operations, break & continue statements, nested loops, logical arrays and vectorization (2) User defined functions, Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays (2) an introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program (2).
Curve fitting, Least square fit, Goodness of fit, standard deviation	Ohms law to calculate R, Hooke's law to calculate spring Constant
Inverse of a matrix, Eigen vectors, eigen values problems	System of algebraic equation
Generation of Special functions usingUser defined functions in Scilab	Generating and plotting Legendre Polynomials Generating and plotting Bessel function

Use C/C^{++}/Scilab/Matlab/other numerical simulations for solving the problems based on StatisticalMechanics like

- Solve the differential equations: $dy/dx = e^{-x}$ with y = 0 for x = 0

$$\frac{dy}{dx} + e^{-x}y = x^2$$

$$\frac{d^2y}{dt^2} + 2\frac{dy}{dt} = -y$$

$$\frac{d^2y}{dt^2} + e^{-t}\frac{dy}{dt} = -y$$

- Fourier series: Program to sum $\sum_{n=1}^{\infty} 0.2^n$
  Evaluate the Fourier coefficients of a given periodic function (square wave)

- Frobenius method and Special functions: $\int_{-1}^{1} \mathrm{Pn}(\mu)\mathrm{Pm}(\mu)\, d\mu = \delta n, m$
  Plot *Pn(x), jv(x)* Show recursion relation

- Evaluation of trigonometric functions e.g. sin θ, Given Bessel's function at N points find its value at an intermediate point. Complex analysis: Integrate 1/(x2+2) numerically and check with computer integration.
- Compute the nth roots of unity for n = 2, 3, and 4.
- Plot Planck's law for Black Body radiation and compare it with Raleigh-Jeans Law at high temperature and low temperature.
- Plot Specific Heat of Solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them for these cases.
- Plot the following functions with energy at different temperatures - Maxwell-Boltzmann distribution, Fermi-Dirac distribution, Bose-Einstein distribution
- To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
- To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee's disc method.
- To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
- To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.

Reference Books:

1. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J.Bence, 3rd ed., 2006, Cambridge University Press
2. Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
3. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
4. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn.,Cambridge University Press
5. Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444
6. Scilab (A free software to Matlab): H. Ramchandran, A. S. Nair. 2011 S. Chand & Company
7. Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing
8. https://web.stanford.edu/~boyd/ee102/laplace_ckts.pdf
9. ocw.nthu.edu.tw/ocw/upload/12/244/12handout.pdf
10. A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal,1985, Vani Pub.
11. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia PublishingHouse
12. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
13. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted1985, Heinemann Educational Publishers
14. Elementary Numerical Analysis, K. E. Atkinson, 3rd Edn. 2007, Wiley India Edition
15. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed.,1996, Oxford University Press.
16. Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University Press, 1987
17. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears andGerhard L. Salinger, 1986, Narosa.
18. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
19. Statistical and Thermal Physics with computer applications, Harvey Gould and JanTobochnik, Princeton University Press, 2010.

SEMESTER V

I. MAJOR COURSE- MJ 8: **ANALOG AND DIGITAL ELECTRONICS**

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:

As the successful completion of the course the student is expected to be conversant with thefollowing.

1. Secure a first-hand idea of different components including both active and passive components to gain an insight into circuits using discrete components and also to learn about integrated circuits.
2. About analog systems and digital systems and their differences, fundamental logic gates, combinational as well as sequential and number systems.
3. Synthesis of Boolean functions, simplification and construction of digital circuits by employing Boolean algebra.
4. Sequential systems by choosing Flip-Flop as a building bock- construct multivibrators, counters to provide a basic idea about memory including RAM, ROM and also about memory organization.
5. In the laboratory he is expected to construct both combinational circuits and sequential circuits by employing NAND as building blocks and demonstrate Adders, Subtractors, Shift Registers, and multivibrators using 555 ICs. He is also expected to use µP 8085 todemonstrate the same simple programme using assembly language and execute the programme using a µP kit.
   At the end of the course the student is expected to assimilate the following and possess basic knowledge of the following.
6. N- and P- type semiconductors, mobility, drift velocity, fabrication of P-N junctions; forward and reverse biased junctions. Application of PN junction for different types of rectifiers and voltage regulators.
7. NPN and PNP transistors and basic configurations, namely common base, common emitter and common collector, and also about current and voltage gain.
8. Biasing and equivalent circuits, coupled amplifiers and feedback in amplifiers and oscillators.
9. To characterize various devices, namely PN junction diodes, LEDs, Zener diodes, solar cells, PNP and NPN transistors. Also construct amplifiers and oscillators using discrete components. Demonstrate inverting and non-inverting amplifiers using op-amps.

Skills to be learned:

1. Learn the basics of IC and digital circuits, and the difference between analog and digitalcircuits. Various logic GATES and their realization using diodes and transmitters.
2. Learn the fundamental of Boolean algebra and their role in constructing digital circuits.
3. Learn about combinatorial and sequential systems by building block circuits toconstruct multivibrators and counters.
4. Learn basic concepts of semiconductor diodes and their applications to rectifiers.
5. Learn about junction transistor and their applications. Learn about different types of amplifiers including operational amplifiers. (Op-Amp) and their applications. Learn about sinusoidal oscillators of various types and A/D conversion.

Course Content:

ANALOG ELECTRONICS:

Two-terminal Devices and their Applications: Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter, Zener Diode and Voltage Regulation. Principle and structure of LEDs, Photodiode and Solar Cell. **(5 Lectures)**

Bipolar Junction Transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β, Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical mechanism of current flow, Active, Cutoff andSaturation Regions. **(5 Lectures)**

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as a 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using the Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. Two-stage RC-coupled amplifier and its frequency response. **(8 Lectures)**

Feedback: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators. **(5 Lectures)**

Operational Amplifiers and Applications: Characteristics of an Ideal and Practical Op- Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and the concept of Virtual ground. Inverting and non-inverting amplifiers, Adder, Subtractor, Differentiator, Integrator, Log amplifier. **(7 Lectures)**

DIGITAL ELECTRONICS:

Digital Circuits and Boolean Algebra: Difference between analog and digital circuits, Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates, NAND and NOR Gates as Universal Gates. XOR and XNOR Gates. de Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map. **(10 Lectures)**

Arithmetic and Sequential Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop. **(9 Lectures)**

Timers, Registers and Counters: Classification of ICs. Examples of Linear and Digital ICs, IC 555: Block diagram and applications: Astable multivibrator and Monostable multivibrator, Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits). Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter. **(11 Lectures)**

Reference Books:

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata McGraw-Hill.
2. A First Course in Electronics, Khan & Dey, PHI, 1/e, 2006
3. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
4. Solid State Electronic Devices, B. G. Streetman & S. K. Banerjee, 6th Edn.,2009, PHI Learning
5. Electronic Devices & circuits, S. Salivahanan & N. S. Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
6. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
7. Basic Electronics, Arun Kumar, Bharati Bhawan, 1/e, 2007
8. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford Univ. Press.
9. Analog Systems and Applications, Nutan Lata, Pragati Prakashan
10. Electronic circuits: Handbook of design & applications, U. Tietze, C. Schenk,2008, Springer
11. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
12. Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning
13. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India
14. Digital Computer Electronics, Malvino and Brown, 3/e, McGraw Hill Education
15. Digital Electronics G K Kharate ,2010, Oxford University Press
16. Digital Systems: Principles & Applications, R. J. Tocci, N. S. Widmer, 2001, PHI Learning
17. Logic circuit design, Shimon P. Vingron, 2012, Springer.
18. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
19. Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill
20. Digital Systems and Applications, Nutan Lata, Pragati Prakashan, 1/e, 2019

II. MAJOR COURSE- MJ 9: **ELEMENTS OF MODERN PHYSICS**

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:
1. Understand the theory of quantum measurements, wave packets and uncertainty principle.
2. Understand the central concepts of quantum mechanics: wave functions, momentum andenergy operator, the Schrodinger equation, time dependent and time independent cases, probability density and the normalization techniques, skill development on problem solving e.g. one-dimensional rigid box, tunneling through potential barrier, step potential, rectangular barrier.
3. Understanding the properties of nuclei like density, size, binding energy, nuclear forces and structure of atomic nucleus, liquid drop model and nuclear shell model and mass formula.
4. Ability to calculate the decay rates and lifetime of radioactive decays like alpha, beta, gamma decay. Neutrinos and its properties and role in the theory of beta decay.
5. Understand fission and fusion well as nuclear processes to produce nuclear energy in nuclear reactor and stellar energy in stars.
6. Understand various interactions of electromagnetic radiation with matter. Electron positron pair creation.
7. Understand the spontaneous and stimulated emission of radiation, optical pumping and population inversion. Three-level and four-level lasers. Ruby laser and He-Ne laser in detail. Basic lasing.
8. In the laboratory course, the students will get the opportunity to perform the following experiments
9. Measurement of Planck's constant by more than one method.
10. Verification of the photoelectric effect and determination of the work Function of a metal.
11. Determination of the charge of an electron and e/m of electron.
12. Determination of the ionization potential of atoms.
13. Determine the wavelength of the emission lines in the spectrum of Hydrogen atom.
14. Determine the absorption lines in the rotational spectrum of molecules.
15. Determine the wavelength of Laser sources by single and Double slit experiments
16. Determine the wavelength and angular spread of He-Ne Laser using plane diffraction grating.
17. Verification of the law of Radioactive decay and determine the mean lifetime of a Radioactive Source, study the absorption of the electrons from Beta decay. Study of the electron spectrum in Radioactive Beta decays of nuclei.
18. Plan and Execute 2-3 group projects in the field of Atomic, Molecular and Nuclear Physics in collaboration with other institutions, if, possible, where advanced facilities areavailable.

Skills to be learned:
1. Comprehend the failure of classical Physics and need for quantum Physics.
2. Grasp the basic foundation of various experiments establishing quantum Physics bydoing the experiments in the laboratory and interpreting them.
3. Formulate the basic theoretical problems in one-, two- and three-dimensional Physics and solve them.
4. Learning to apply the basic skills developed in quantum physics to various problems in
    a. Nuclear Physics b. Atomic Physics c. Laser Physics
5. Learn to apply basic quantum physics to Ruby Laser, He-Ne Laser

Course Content:

Quantum theory of Light: Planck's concept of light as a collection of photons; Photo-electric effect and Compton scattering. Wave-particle duality, de Broglie wavelength and matter waves; Two-Slit experiment with electrons. Wave description of particles by wave packets. Group and Phase velocities and the relation between them. Probability. Wave amplitude and wave functions. Davisson-Germer experiment. Discreteness of energy. Frank-Hertz Experiment.
(14 Lectures)

Quantum Uncertainty- Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables), gamma ray microscope thought experiment; Derivation from Wave Packets impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle- application to various physical problems. **(5 Lectures)**

Matter waves and wave amplitude: Schrodinger equation for non-relativistic particles; Physical observables as operators, Position, Momentum and Energy operators; stationary states; Physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension.
(10 Lectures)

One-dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum mechanical scattering and tunnelling in one dimension- across a step potential & rectangular potential barrier.
(10 Lectures)

Atomic nucleus: General properties of nuclei. Nature of nuclear force, nuclear radius and its relation with atomic weight. Nucleus as a Liquid drop, Semi-empirical mass formula of Weiszaker and its significance.

(6 Lectures)

Radioactivity: Stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay- energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. **(8 Lectures)**

Fission and Fusion- Mass deficit and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions). **(3 Lectures)**

Laser: Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. **(4 Lectures)**

Reference Books:

1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
2. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw-Hill
3. Introduction to Quantum Mechanics, Nikhil Ranjan Roy, 2016, Vikash Publishing House Pvt. Ltd.
4. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
5. Physics for Scientists and Engineers with Modern Physics, Jewett and Serway, 2010, CengageLearning.
6. Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGraw-Hill
7. Quantum Mechanics: Theory & Applications, A. K. Ghatak & S. Lokanathan, 2004, Macmillan

Additional Books for Reference

1. Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
2. Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
3. Quantum Physics, Berkeley Physics, Vol 4. E. H. Wichman, 1971, Tata McGraw-Hill Co.
4. Basic ideas and concepts in Nuclear Physics, K. Heyde, 3rd Edn., Institute of Physics Pub.
5. Six Ideas that Shaped Physics: Particle Behave like Waves, T. A. Moore, 2003, McGraw-Hill

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III. MAJOR COURSE- MJ 10: **ADVANCED MATHEMATICAL PHYSICS**

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:

1. Learn the Fourier analysis of periodic functions and their applications in physical problems such as vibrating strings etc.
2. Learn about the special functions, such as the Hermite polynomial, the Legendre polynomial, the Laguerre polynomial and Bessel functions and their differential equations, applications in various physical problems such as in quantum mechanics which they will learn in future courses in detail.
3. Learn the beta, gamma and the error functions and their applications in doing integrations.
4. Acquire knowledge of methods to solve partial differential equations with the examples of important partial differential equations in Physics.
5. Apply the Scilab software in curve fittings, in solving system of linear equations, generating and plotting special functions such as Legendre polynomial and Bessel functions, solving first and second order ordinary and partial differential equations.
6. Learn about the Fourier transform, the inverse Fourier transform, their properties and their applications in physical problems. They are also expected to learn the Laplace transform, the inverse Laplace transforms, their properties and their applications in solving physical problems.
7. In the laboratory course, the students should apply their C++/Scilab programming language to solve the following problems:
   a. Solution 1st and 2nd order ordinary differential equations with appropriate boundary conditions,
   b. Evaluation of the Fourier coefficients of a given periodic function,
   c. Plotting the Legendre polynomials and the Bessel functions of different orders and interpretations of the results, Least square fit of a given data to a graph

Skills to be learned:

1. Training in mathematical tools like calculus, integration, series solution approach, special functions will prepare
2. The student to solve ODE, PDE's which model physical phenomena.
3. He/she shall develop an understanding of how to model a given physical phenomenon such as pendulum motion,
4. rocket motion, stretched string, etc., into a set of ODE's, PDE's and solve them.
5. These skills will help in understanding the behaviour of the modelled system/s.

Course Content:

Fourier Series: Periodic functions, Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. **(8 Lectures)**

Frobenius Method and Special Functions: Frobenius method and its applications to differential equations. Legendre, Bessel, and Hermite Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Bessel Functions of the First Kind: Generating Function. Zeros of Bessel Functions (Jo(x) and J1(x)) and Orthogonality. Beta and Gamma Functions and the Relation between them. Expression of Integrals in terms of Gamma Functions. **(16 Lectures)**

Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string. **(4 Lectures)**

Complex Analysis: Euler's formula, de Moivre's theorem, Roots of Complex Numbers. Functions of Complex variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles, order of singularity. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals. **(14 Lectures)**

Integrals Transforms: Fourier Transforms: Fourier Integral Theorem. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of the Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Properties of Fourier transforms. Three-dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One-dimensional Wave and Diffusion/Heat Flow Equations. **(9 Lectures)**

Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs, LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits. **(9 Lectures)**

Reference Books:

1. A Concise History of Science in India- D. M. Bose, S.N. Sen & B.V. Subbarayappa, Indian National Science Academy, New Delhi
2. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
3. Complex Variables, A.S. Fokas & M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
4. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan,1940, Jones & Bartlett
5. Computational Physics, D. Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.
6. Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
7. Complex Variables, A. S. Fokas & M. J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
8. Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press
9. Complex Variables and Applications, J. W. Brown & R. V. Churchill, 7th Ed. 2003, TataMcGraw-Hill
10. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones& Bartlett

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IV. MAJOR COURSE- MJ 11: **PRACTICALS-III**

Marks: Pr (ESE: 6Hrs) =100	Pass Marks: Pr (ESE) = 40

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practical:

1. To study V-I characteristics of the PN junction diode, and the verification of the diode equation.
2. To study the V-I characteristics of a Zener diode and its use as a voltage regulator.
3. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
4. To design an inverting amplifier using Op-amp (741,351) for a given DC voltage of given gain
5. To design a non-inverting amplifier using Op-amp (741,351) and study its frequency response
6. Use of OP-Amp (741, 351) as an integrator and as a differentiator.
7. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.
8. To design a NOT gate switch using a transistor.
9. To verify and design AND, OR, NOT and XOR gates using NAND gates.
10. Half Adder, Full Adder and 4-bit binary Adder.
11. To design an astable multivibrator of given specifications using a 555 Timer.
12. Measurement of Planck's constant using black body radiation and a photo-detector
13. Photoelectric effect: photo current versus intensity and wavelength of light; maximumenergy of photo-electrons versus frequency of light
14. To determine Planck's constant using LEDs of at least 4 different colours.
15. To determine the wavelength of the laser source using the diffraction of a single slit.
16. To determine the wavelength of the He-Ne laser using a plane diffractiongrating

Reference Books

1. Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.
2. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
3. Microprocessor Architecture Programming and appls. with 8085, R.S. Goankar, 2002, Prentice Hall.
4. Microprocessor 8085: Architecture, Programming and interfacing, A. Wadhwa, 2010, PHI Learning.
5. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
6. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
7. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
8. Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson
9. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
10. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
11. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Edn, 2011, Kitab

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SEMESTER VI

I. MAJOR COURSE- MJ 12**:**
QUANTUM MECHANICS AND APPLICATIONS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:

This course will enable the student to get familiar with the quantum mechanics formulation.

1. After an exposition of inadequacies of classical mechanics in explaining microscopic phenomena, quantum theory formulation is introduced through the Schrodinger equation.
2. The interpretation of wave function of a quantum particle and the probabilistic nature of its location and subtler points of quantum phenomena are exposed to the student.
3. Through understanding the behaviour of a quantum particle encountering a i) barrier, ii) potential, the student gets exposed to solving the non-relativistic hydrogen atom, for its spectrum and eigenfunctions.
4. Study of the influence of electric and magnetic fields on atoms will help in understanding Stark effect and Zeeman Effect respectively.
5. The experiments using Sci-lab will enable the student to appreciate the nuances involved in the theory.
6. This basic course will form a firm basis to understand quantum many-body problems.
7. In the laboratory course, with the exposure in computational programming in the computer lab, the student will be in a position to solve the Schrodinger equation for ground state energy and wave functions of various simple quantum mechanical one-dimensional and three-dimensional potentials.

Skills to be learned:

1. This course shall develop an understanding of how to model a given problem such as a particle in a box, a hydrogen atom, hydrogen atom in electric fields.
2. Many-electron atoms, L-S and J-J couplings.
3. These skills will help in understanding the different Quantum Systems in atomic and nuclear physics.

Course Content:

Time-dependent Schrodinger equation: Postulates, Time-dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function. Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle. **(6 Lectures)**

Time independent Schrodinger Equation-Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Position-momentum uncertainty principle. **(10 Lectures)**

Bound States- Continuity of wavefunction, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero-point energy & uncertainty principle. **(12 Lectures)**

Quantum theory of hydrogen-like atoms: Angular momentum operator and commutation relation between them. time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; Orbital angular momentum quantum numbers l and m; s, p, d... shells. **(10 Lectures)**

Atoms in Electric & Magnetic Fields: Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern- Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton. Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only). **(12 Lectures)**

Single and Many electron atoms: Pauli's Exclusion Principle. Symmetric & Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector Model. Spin-orbit coupling in atoms-L-S and J-J couplings. Hund's Rule. **(10 Lectures)**

Reference Books:

1. A Text book of Quantum Mechanics, P. M. Mathews and K. Venkatesan, 2nd Ed., 2010,McGraw Hill
2. Introduction to Quantum Mechanics, Nikhil Ranjan Roy, 2016, Vikash Publishing House Pvt. Ltd.
3. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
4. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
5. Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
6. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
7. Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer
8. Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press

Additional Books for Reference

1. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
2. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
3. Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer

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II. MAJOR COURSE- MJ 13: **SOLID STATE PHYSICS**

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:

At the end of the course the student is expected to learn and assimilate the following.

1. A brief idea about crystalline and amorphous substances, about lattice, unit cell, Miller indices, reciprocal lattice, concept of Brillouin zones and diffraction of X-rays bycrystalline materials.
2. Knowledge of lattice vibrations, phonons and in-depth knowledge of Einstein and Debye theory of specific heat of solids.
3. Knowledge of different types of magnetism from diamagnetism to ferromagnetism and hysteresis loops and energy loss.
4. Secured an understanding of the dielectric and ferroelectric properties of materials.
5. Understanding above the band theory of solids and must be able to differentiate insulators, conductors and semiconductors.
6. Understand the basic idea about superconductors and their classifications.
7. To carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop. They will also employ to four probe methods to measure electrical conductivity and the Hall set-up to determinethe Hall coefficient of a semiconductor.

Skills to be learned:

1. Learn basics of crystal structure and physics of lattice dynamics
2. Learn the physics of different types of material like magnetic materials, dielectricmaterials, metals and their properties.
3. Understand the physics of insulators, semiconductors and conductors with specialemphasis on the elementary band theory of semiconductors.
4. Comprehend the basic theory of superconductors. Type I and II superconductors, theirproperties and the physical concept of BCS theory.

Course Content:

Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor. **(12 Lectures)**

Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear Mono-atomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law **(10 Lectures)**

Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of Dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss. **(8 Lectures)**

Dielectric Properties of Materials: Polarization. Electric Susceptibility. Polarizability. Clausius-Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. **(8 Lectures)**

Ferroelectric Properties of Materials: Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop **(6 lectures)**

Elementary band theory: Periodic potential and Bloch theorem. Kronig-Penney model. Band Gap. Conductor, Semiconductor (P and Ntype) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (04 probe method) & Hall coefficient. **(10 Lectures)**

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, Isotope effect. Idea of BCS theory (No derivation) **(6 Lectures)**

Reference Books:

1. Concepts of Electromagnetic Theory, K. Mamta, Raj Kumar Singh and J. N. Prasad, 1/e, 2021, Wiley/I. K. I.Pub. House, N Delhi
2. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
3. Introduction to Solid State Physics, Arun Kumar, PHI
4. Elements of Solid-State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India
5. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
6. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
7. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
8. Solid State Physics, Rita John, 2014, McGraw Hill
9. Elementary Solid-State Physics, 1/e M. Ali Omar, 1999, Pearson India
10. Solid State Physics, M.A. Wahab, 2011, Narosa Publications

III. MAJOR COURSE- MJ 14: **NUCLEAR AND PARTICLE PHYSICS**

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:

1. Learn the ground state properties of a nucleus – the constituents and their properties, mass number and atomic number, relation between the mass number and the radius and the mass number, average density, range of force, saturation property, stability curve,the concepts of packing fraction and binding energy, binding energy per nucleon vs. mass number graph, explanation of fusion and fission from the nature of the binding energy graph.
2. Know about the nuclear models and their roles in explaining the ground state properties of the nucleus –(i) the liquid drop model, its justification so far as the nuclear properties are concerned, the semi-empirical mass formula, (ii) the shell model, evidence of shell structure, magic numbers, predictions of ground state spin and parity, theoretical deduction of the shell structure, consistency of the shell structure with the Pauli exclusion principles.
3. Learn the basic aspects of nuclear reactions, the Q-value of such reactions and itsderivation from conservation laws, the reaction cross-sections, the types of nuclear reactions, direct and compound nuclear reactions, Rutherford scattering by Coulomb potential.
4. Learn some basic aspects of the interaction of nuclear radiation with matter- interaction of gamma ray by photoelectric effect, Compton scattering and pair production, energy loss due to ionization, Cerenkov radiation.
5. The students are expected to learn about the principles and basic constructions ofparticle accelerators such as the Van-de-Graff generator, cyclotron, synchrotron. They should know about the accelerator facilities in India.
6. Gain knowledge on the basic aspects of particle Physics – the fundamental interactions, elementary and composite particles, the classifications of particles: leptons, hadrons (baryons and mesons), quarks, gauge bosons. The students should know about the quantum numbers of particles: energy, linear momentum, angular momentum, isospin, electric charge, colour charge, strangeness, lepton numbers, baryon number and the conservation laws associated with them.

Skills to be learned:

1. Skills to describe and explain the properties of nuclei and derive them from variousmodels of nuclear structure.
2. To understand, explain and derive the various theoretical formulation of nucleardisintegration like α decay, β decay and γ decays.
3. Develop a basic understanding of nuclear reactions and decays with the help of theoretical formulate and laboratory experiments.
4. Ability to understand, construct and operate simple detector systems for nuclearradiation and training to work with various types of nuclear accelerators.
5. Develop basic knowledge of elementary particles as fundamental constituents of matter,their properties, conservation laws during their interactions with matter.

Course Content:

General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excited states. **(8 Lectures)**

Nuclear Models: Liquid drop model approach, semi-empirical mass formula and significance of its various terms, condition of nuclear stability, two-nucleon separation energies, evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force. **(8 Lectures)**

Radioactive Decay: (a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) β-decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. **(8 Lectures)**

Nuclear Reactions: Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering). **(8 Lectures)**

Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe-Bloch formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter **(8 Lectures)**

Nuclear Radiation Detectors: Behaviour of ion pairs in an electric field, Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detectors. **(8 Lectures)**

Particle Accelerators: Accelerator facility available in India: Van-de Graaff Generator, Linear accelerator, Cyclotron, Synchrotrons. **(4 Lectures)**

Particle Physics: Particle interactions; basic features, types of particles and itsfamilies. Symmetries and Conservation Laws: energy and momentum, angular momentum, Parity, Baryon number, Lepton number, Isospin, Strangeness and Charm, Concept of quark model, Color quantum number and gluons. **(8 Lectures)**

Reference Books:

1. Elements of Nuclear Physics, Nikhil Ranjan Roy & Rakesh Kumar Pandey, Atlantic P & D, 1/e, 2024
2. Nuclear Physics-An introduction, W. E. Burcham, 2/e, Longman Group Limited 1973
3. Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
4. Concepts of nuclear Physics by Bernard L. Cohen. (Tata McGraw Hill, 1998).
5. Introduction to the Physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
6. Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
7. Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
8. Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
9. Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP-Institute of Physics Publishing, 2004).
10. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
11. Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press,Elsevier, 2007).
12. Theoretical Nuclear Physics, J.M. Blatt & V. F. Weisskopf (Dover Pub. Inc., 1991)

IV. MAJOR COURSE- MJ 15:
PRACTICALS-IV:

Marks: Pr (ESE: 6Hrs) =100	Pass Marks: Pr (ESE) = 40

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment	*= 60 marks*
Practical record notebook	*= 15 marks*
Viva-voce	*= 25 marks*

Practicals (Quantum and Solid-State Physics):

Use C/C^{++}/Scilab/Matlab for solving the following problems based on Quantum Mechanics, like

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of thehydrogen atom:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E]\ where\ V(r) = -\frac{e^2}{r}$$

Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is ≈ -13.6 eV. Take e = 3.795 (eVÅ)$^{1/2}$, ħc = 1973 (eVÅ) and m = 0.511x10^6 eV/c^2.

2. Solve the s-wave radial Schrodinger equation for an atom:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E]$$

where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential $V(r) = -\frac{e^2}{r}e^{\frac{-r}{a}}$. Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 (eVÅ)$^{1/2}$, m = 0.511x10^6 eV/c^2, and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

3. Solve the s-wave radial Schrodinger equation for a particle of mass m:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E]$$

For the anharmonic oscillator potential $V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$
for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose m= 940 MeV/c^2, k= 100MeV fm^{-2}, b= 0, 10, 30 MeV fm^{-3} In these units, cħ= 197.3 MeV fm. The ground state energy I expected to lie between 90 and 110 MeV for all three cases.

4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2\mu}{\hbar^2}[V(r) - E]$$

Where μ is the reduced mass of the two-atom system. For the Morse potential

$$V(r) = D\left(e^{-2\alpha r'} - e^{-\alpha r'}\right), r' = \frac{r-r_0}{r}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of threesignificant digits. Also plot the corresponding wave function. Take: m = 940x10^6 eV/C^2, D = 0.755501 eV, α = 1.44, r_0 = 0.131349 Å

5. Estimate the energy gap of a semiconductor using a PN junction.
6. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)
7. To measure the Magnetic susceptibility of Solids.
8. To determine the Coupling Coefficient of a Piezoelectric crystal.
9. To measure the Dielectric Constant of a dielectric Materials with frequency
10. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
11. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 ^{o}C) and to determine its band gap.
12. To determine the Hall coefficient of a semiconductor sample.

Reference Books:

1. Schaum's outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Publication
2. Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3rd Edn., 2007,Cambridge University Press.
3. An introduction to computational Physics, T. Pang, 2nd Edn.,2006, Cambridge Univ. Press
4. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific &Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández.2014 Springer.
5. Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
6. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., CambridgeUniversity Press
7. Scilab Image Processing: L. M. Surhone.2010 Betascript Publishing ISBN:978-6133459274
8. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia PublishingHouse.
9. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted1985, Heinemann Educational Publishers.
10. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
11. Elements of Solid-State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.

SEMESTER VII

I. MAJOR COURSE- MJ 16:
RESEARCH METHODOLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:
1. To introduce students to the basics of research and scientific inquiry
2. To enable students to identify and define research problems
3. To familiarize students with various research methods, tools, and ethical practices
4. To develop basic skills in data collection, analysis, and reporting

Course Learning Outcomes:
Students would be able to understand:
1. Characteristics of good research viz; a comprehensive study of research reviews, gaps, objective, methodology, results, discussion and conclusion with future scope.
2. How to keep ethical considerations and stay away from plagiarism.

Course Content:
Foundations of Research: *Introduction to Research:* meaning, objectives, and significance of research.
Nature of Scientific Knowledge: theory, empiricism, deductive and inductive reasoning. *Types of Research:* basic, applied, and translational research. Research Methods vs Methodology: distinction and scope. *Criteria of Good Research:* clarity, objectivity, reliability, and generalizability. *Research Theory and Practice:* foundations of research theory, linking theory with methodology, importance of structuring the research project. **(12 Lectures)**

Research Planning and Design: *Research Problem:* identification, selection, and precise definition of a research problem; necessity of defining the problem; techniques involved in defining a problem with illustrations. *Literature Review:* purpose, types of sources (books, journals, patents), use of databases (Scopus, Web of Science, Google Scholar), identifying gaps. *Hypothesis Formulation:* meaning, types (null and alternative), role in research, and features of a good hypothesis. *Research Design:* concept, meaning, and need for research design; features of a good design; important concepts relating to research design; types including exploratory, descriptive, diagnostic, and experimental; basic principles of experimental designs such as randomization, replication, and control. **(12 Lectures)**

Data Collection and Measurement: Data collection methods and tools, *Sampling Techniques:* concepts of population, sample, sampling frame, sampling errors, and non-response. *Measurement and Scaling:* levels of measurement – nominal, ordinal, interval, and ratio; common issues in measurement; reliability and validity. **(12 Lectures)**

Data Analysis, Interpretation, and Research Tools: *Data Preparation:* editing, coding, classification, and tabulation of data. *Data Presentation:* use of tables, bar diagrams, pie charts, and other visual formats. *Descriptive Statistics:* mean, median, mode, standard deviation. *Inferential Statistics:* hypothesis testing, correlation, regression analysis. *Interpretation of Results:* drawing conclusions and generalizations from data. *Use of Technology:* MS Excel/SPSS for data analysis. *Reference Management:* use of Zotero and Mendeley for citation and bibliography. *Formatting Tools:* MS Word/ LaTeX for research writing. **(12 Lectures)**

Research Reporting, Ethics, and Publication: *Research Reporting:* structure and format of research papers and thesis. *Citation Styles:* APA, MLA, Chicago, and others. *Research Ethics:* integrity and honesty in research; types of misconduct including fabrication, falsification, plagiarism, and self-plagiarism; authorship issues. predatory journals, role of COPE, use of plagiarism detection software/tool. *Publication and Research Metrics:* journal impact measures such as Impact Factor, CiteScore, SNIP; author-level metrics including h-index, i10-index, altmetrics. **(12 Lectures)**

Books Suggested:
1. Kothari, C. R. – Research Methodology: Methods and Techniques.
2. Online resources: SWAYAM, NPTEL, and Google Scholar.
3. Kothari, C.R. and Garg, Gaurav, Research methodology: Methods and techniques, New Age International.
4. Breakwell, Glynis M. Hammond, S. Fifeschaw, C., Smith, J.A. Research Methods in Psychology, Sage Publication.
5. Kerlinger, Fred N., Foundation of Behavioural Research, Hort, Rinehart and Winston publishing.
6. Ahuja, Ram., Research Methods, Rawat Publications.
7. Business Research Methods – Donald Cooper & Pamela Schindler, TMGH, 9th edition
8. Business Research Methods – Alan Bryman & Emma Bell, Oxford University Press.

II. MAJOR COURSE- MJ 17: ADVANCED MATHEMATICAL METHODS IN PHYSICS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:

On successful completion of this course the student should know:

1. Revise the knowledge of Mathematical Physics. These basic mathematical structures are essential in solving problems in various branches of Physics as well as in Engineering.
2. Learn Green's function and its application to one, two, and three-dimensional problems.
3. Understand Electrodynamics and Relativity and apply them to basic problems.

Skills to be learned:

1. Training in Mathematical Physics will prepare the student to solve various mathematical problems.
2. He/she shall develop an understanding of how to formulate a physics problem and solve a given mathematical equation arising out of it.
3. Learn the concepts of Electrodynamics and Relativity.
4. Develop skills to solve the equations of central electrodynamics and Relativity force problem.
5. Acquire basic knowledge of Advanced Mathematical Physics.

Course Content:

Matrices and Tensors: Introduction of matrices through rotation of co-ordinate systems, Orthogonal,Hermitian, Unitary, Null and Unit matrices, Singular and Non-singular matrices, Inverse of a matrix, Trace of a matrix, Eigenvalues and Eigenvectors, Diagonalization. Tensorial character of physical entities, Covariant, Contravariant and Mixed tensors, Contraction, Quotient rule, Differentiation, Kronecker tensor, Pseudo-tensor, Symmetric and Anti symmetric tensors.

(**20 Lectures)**

Green's Function: Introduction Construction of the Green's function for 1d, 2d and 3d problems.Solution of some standard problems using Green's function technique. **(8 Lectures)**

Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs, LTs of 1st and 2nd order Derivatives and Integralsof Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations.

(7 Lectures)

Electrodynamics and Relativity: Lorentz transformation as orthogonal transformation in 4- dimensions, 4-vectors and light cone, energy-momentum 4-vectors, Relativistic force equation, Covariance of Maxwell's equation. Transformation of electromagnetic fields, Solution of wave equation in covariant form, Field due to a charge moving with constant velocity, Radiation from oscillating dipole, Total power radiated from an accelerated charge, Larmor formula, Principle of equivalence, Principle of covariance, Covariant differentiation, Curvature tensor, field equation, Reduction to Newton's laws of gravitation. **(25 Lectures)**

Books Suggested:

1. Mathematical Methods for Physicists, G. B. Arfken, H. J. Waber, E.E. Harris, 2013, 7thEdn., Elsevier.
2. Boas, M.L., Mathematical Methods in Physical Sciences, Wiley International Editions.
3. Group Theory and Quantum Mechanics, M. Timkham.
4. Mathematical Physics: Das and Sharma.
5. Mathematical Methods for Physicist & Engineers: Pipes & Harvel.
6. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
7. Mathematical Methods for Scientists and Engineers: D. A. McQuarrie, 2003, Viva Book.
8. Advanced Engineering Mathematics: D. G. Zill and W. S. Wright, 5-Ed, 2012, Jones and Bartlett Learning.
9. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
10. Essential Mathematical Methods, K. F. Riley & M. P. Hobson, 2011, Cambridge Univ. Press.
11. Classical Electrodynamics, J. D. Jackson, 3rd Edn, 1988, Wiley.
12. The Classical Theory of Fields, L. D. Landau, E. M. Lifshitz, 4th Edn. 2003, Elsevier.
13. Electromagnetic Field Theory for Engineers & Physicists, P. Lorrain & D. Corson, 1970.

III. MAJOR COURSE- MJ 18: ADVANCED QUANTUM MECHANICS-I

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:
On successful completion of this course the student should know:
1. Revise the knowledge of advanced Quantum Mechanics.
2. Learn different Quantum Dynamics and apply them to solve standard Quantum mechanical problems.
3. Understand Invariance Principle and Conservation laws for linear momentum, angular momentum, energy and parity.

Skills to be learned:
1. Training in advanced Quantum Mechanics will prepare the student to solve various mathematical problems.
2. He/she shall develop an understanding of how to formulate a physics problem and solve a given mathematical equation arising out of it.
3. Learn the concepts of advanced Quantum Mechanics.
4. Develop skills to understand and solve the equations of central advanced Quantum Mechanics problems.
5. Acquire basic knowledge of Advanced Quantum Mechanics.

Course Content:

Mathematical Foundation of Quantum Mechanics: Vectors and Linear vector space, Closure property, Linear independence of vectors, Bases and dimensions. Some examples of linear vector spaces, Dirac's notations, Bra and Ket vectors, Combining bras with kets, Inner product and inner product space, Orthonormality of vectors, Completeness condition,Outer product, Hilbert spaces, Operator on a linear vector space, Algebra of linear operators. **(20 Lectures)**

Hilbert Space Formalism of Quantum Mechanics: Postulates, Expectation values and probabilities, Explicit representation of operators, The general uncertainty relationship. **(8 Lectures)**

Quantum Dynamics: The equation of motion- The Schrodinger; Applications to the linear harmonic oscillator and the hydrogen atom. Linear harmonic oscillatorusing Creation and annihilation operators. **(12 Lectures)**

Heisenberg Matrix Mechanics: Matrix representation of states and operators, Matrix transformation, Diagonalizability of matrix, Application to linear harmonic oscillator problem. **(8 Lectures)**

Angular Momentum: Commutation relations for angular momentum operators, Eigenvalues andeigenvectors, Pauli spin matrices and spin eigenvectors, Motion in a centrally symmetric field. **(8 Lectures)**

Invariance Principle and Conservation Laws: Space-time symmetries and conservation Laws forlinear momentum, Angular momentum, Energy and Parity. **(4 Lectures)**

Books Suggested:

1. Mathews, P.M., &Venkatesan, K., "A Text Book of Quantum Mechanics", TMH.
2. Merzbacker, E., "Quantum Mechanics", John Wiley
3. Messiah, A., "Quantum Mechanics", North-Holland Publishing Co.
4. Schiff, L.I., "Quantum Mechanics", Tata McGraw-Hill, 3rd Edition 2010
5. Ghatak, A., Quantum Mechanics", Narosa Publishing House, New Delhi.
6. Agarwal, B. K., "Quantum Mechanics', PHI
7. Landau, L.D. & Lifshitz, E.M., "Quantum Mechanics", Pergman Press
8. Quantum Mechanics for Scientists and Engineers, D. A. B. Miller 2008, Cambridge UniversityPress
9. Introductory Quantum Mechanics, Richard L. Liboff, Pearson Education, New Delhi.
10. Quantum Mechanics, B.H. Bransden and C. J. Joachin, Pearson Education, New Delhi.

IV. ADVANCED MAJOR COURSE- AMJ 1: **ADVANCED QUANTUM MECHANICS-II**

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

(Only for Hons Degree)

Course Learning Outcomes:

On successful completion of this course the student should know:

1. Revise the knowledge of advanced Quantum Mechanics-II.
2. Learn different Quantum Approximation methods and apply them to solve standard Quantum mechanical problems.
3. Understand the theory of scattering and relativistic quantum mechanics.

Skills to be learned:

1. Training in advanced Quantum Mechanics-II will prepare the student to solve various quantum problems.
2. He/she shall develop an understanding of how to formulate a physics problem and solve the given mathematical equation arising out of it.
3. Learn the concepts of advanced Quantum Mechanics-II.
4. Develop skills to understand and solve the equations of central advanced Quantum Mechanics-II.

Course Content:

Approximation Methods: The WKB approximation and its applications to one-dimensional bound systems, The vibrational method (Ritz method) and its application to linear harmonic oscillators, Stationary perturbation theory, non-degenerate and degenerate cases and applications to anharmonic oscillators. Time-dependent perturbation theory, constant perturbation and the Fermi Golden rule, harmonic perturbation (Einstein's A and B coefficients). (**26 Lectures)**

Theory of Scattering: Scattering amplitude and cross-section, Partial wave analysis, Born approximation. (**8 Lectures)**

Identical Particles: Many particles Schrodinger equation, The Indistinguishability principle, Symmetric and anti-symmetric wave functions, Pauli exclusion principle. (**13 Lectures)**

Relativistic Quantum Mechanics: Klein-Gordon equation for free particle, Dirac equation, Properties of Dirac matrices, Probability and current densities, Covariance of Dirac equation, Free particle solution and negative energy states, magnetic moment and spin of electron. (**13 Lectures)**

Books Suggested:

1. Thankappan, V.K., "Quantum Mechanics", Wiley Eastern
2. Mathews, P.M., &Venkatesan, K., "A Text Book of Quantum Mechanics", TMH.
3. Merzbacker, E., "Quantum Mechanics", John Wiley
4. Messiah, A., "Quantum Mechanics", North-Holland Publishing Co.
5. Schiff, L.I., "Quantum Mechanics", McGraw-Hill
6. Ghatak, A., Quantum Mechanics", Narosa Publishing House, New Delhi.
7. Agarwal, B. K., "Quantum Mechanics', PHI
8. Landau, L.D. & Lifshitz, E.M., "Quantum Mechanics", Pergman Press
9. Introduction to Quantum Mechanics by D. J. Griffiths. II Edn., Pearson Education

……..also the books recommended earlier in Quantum Mechanics Course – I

OR RESEARCH COURSES- RC 1: (In lieu of AMJ 1)
RESEARCH PLANNING & TECHNIQUES

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

(Only for Hons with Research Degree)

Course Objectives:
1. To develop a comprehensive understanding of research methodology and planning in the context of physical sciences.
2. To enable students to identify gaps in current physics research and formulate meaningful research problems.
3. To train students in applying advanced tools, instruments, and data analysis techniques used in modern physics research.
4. To build competencies in scientific writing, proposal development, and presentation of research outcomes.

Course Learning Outcomes:
1. Identify and define relevant research problems in theoretical, experimental, or computational physics.
2. Conduct systematic literature reviews using domain-specific databases.
3. Design and structure research investigations aligned with specific physics subfields.
4. Select and apply appropriate experimental or simulation-based techniques.
5. Interpret and validate research data with scientific rigor.
6. Present research proposals and reports adhering to academic standards.

Course Content:

Components of research

Foundations of scientific research in physics
Formulating research problems and hypotheses in theoretical and experimental physics,
Research proposal or Synopsis preparation, Review of literature: Sources (arXiv, INSPIRE-HEP, NASA ADS, Scopus) and citation styles (APA, MLA, IEEE, etc) and tools (Zotero, Mendeley, etc), Motivation and significance of the study, State of the art and gap identification, Objective of the investigation, Hypothesis to be tested or explored, Relevance to present-day problems and societal needs, Expected contribution to existing knowledge, Future scope and potential extensions, References and bibliography. **(18 Lectures)**

Research Methods and Data Collection Techniques

Experimental, theoretical, and computational research methods in physics
Data acquisition in laboratory and remote sensing environments, Introduction to sampling strategies and observational methods, Basics of statistical tools in physics as a data framework. **(10 Lectures)**

Instrumentation and Experimental Tools in Physics

Principles and working of key instruments: oscilloscopes, spectrometers, interferometers, vector network analyzer (VNA), SEM, TEM, cryostats, superconducting magnets, Data logging, interfacing, and real-time acquisition (LabVIEW, DAQ systems), Sensor selection and calibration techniques **(12 Lectures)**

Data Analysis and Interpretation

Statistical analysis: error analysis, uncertainty propagation, curve fitting, significance testing. Data visualization tools: Origin/ Excel/ SPSS/ Simulation tools for theoretical modeling: Python/ Pspice/ LTSpice/ SciLab/ MATLAB/ COMSOL/ LAMMPS/ HFSS/ CST, Structuring a research report and scientific writing. **(12 Lectures)**

Research reporting-Thesis writing

Thesis structure, Report writing in LaTeX/MS Word, Oral and poster presentation techniques
Peer review and critique, Plagiarism, Ethics in research publication and avoiding plagiarism, Plagiarism detection tools. **(8 Lectures)**

Reference Books:

1. C.R. Kothari, Gaurav Garg – Research Methodology: Methods and Techniques – New Age International
2. Angelika Hofmann – Scientific Writing and Communication – Oxford University Press
3. Wayne C. Booth et al. – The Craft of Research – University of Chicago Press
4. Douglas Montgomery – Design and Analysis of Experiments – Wiley
5. Paul D. Leedy & Jeanne Ellis Ormrod – Practical Research: Planning and Design – Pearson

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SEMESTER VIII

I. MAJOR COURSE- MJ 19: SPECTROSCOPY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:

On successful completion of this course the student should know:

1. Revise the knowledge of Spectroscopy.
2. Learn different spectroscopy Physics and apply them to solve standard spectroscopy problems.
3. Understand the Rotation of molecules, the Born Oppenheimer approximation, Techniques and Instrumentation applications.

Skills to be learned:

1. Training in Spectroscopy will prepare the student to solve various spectral problems.
2. He/she shall develop an understanding of how to formulate a physics problem and solve the given mathematical equation arising out of it.
3. Learn the concepts of Spectroscopy, including the concept of molecular spectra, resonance spectroscopy.
4. Develop skills to understand and solve the equations of Lasers and Holography.
5. Acquire basic knowledge of Spectroscopy.

Course Content:

Atomic Spectra: Quantum theory of Zeeman effect (normal and anomalous), Paschen-Back effect, Stark effect (linear and non-linear). Hyperfine structure of spectral lines, X-ray spectra characteristicsand absorption. **(8 Lectures)**

The Rotation of the Molecule: Rotational spectra-Rigid diatomic molecule, intensities of spectral lines, Effect of isotopic substitution, the non-rigid rotator, Simple harmonic oscillator, The anharmonic oscillator, Diatomic vibrating rotator, Born Oppenheimer approximation. **(15 Lectures)**

Molecular Spectra: Infrared and Raman spectra of diatomic molecules using anharmonic oscillator,non-rigid rotator and vibrating rotator as models. Electronic states and electronic transitions in diatomic molecules, Frank Frank-Condon principle. **(15 Lectures)**

Resonance Spectroscopy: Nature of spinning particle, Interaction between spin and a magnetic field,Larmor Precession, Theory of NMR, Chemical shift-relaxation Mechanism, experimental study of NMR, Theory and experimental study of NQR, Theory of ESR, Hyperfine structure and fine structureof ESR, Mossbauer spectroscopy, Principle-Isomer shift, Quadrupole effect, effect of magnetic field. **(15 Lectures)**

Laser and Holography: Modes of resonator and coherence length, The Nd, YAG laser, The Neodymium Glass laser, The CO_2 Laser, Organic Dye lasers, Semi-conductor Laser, Liquid Laser. Principle of Holography, Theory-practical applications including data storage. **(7 Lectures)**

Books Suggested:

1. Kuhn, "Atomic Spectra".
2. Ghatak & Loknathan, "Quantum Mechanics".
3. Herzberg, Spectra of diatomic molecules
4. Elements of Spectroscopy: Gupta, Kumar and Sharma, Pragati Prakashan.
5. Fundamentals of Molecular Spectroscopy: Colin and Elaine, TMH.
6. Laser and Non-linear Optics: B. B. Laud, New Age Publications

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II. MAJOR COURSE- MJ 20:
PRACTICALS-V:

Marks: Pr (ESE: 6Hrs) =100	**Pass Marks: Pr (ESE) = 40**

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:
Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals (Optics and Laser):

1. Studies with Michelson's Interferometer.
    a. Determination of wavelength separation of sodium D-lines.
    b. Determination of the thickness of mica sheet.
2. Studies with Fabre-Perot Etalon.
3. Studies with Edser-Butler Plate.
4. Studies of phenomena with polarized light:
    a. Verification of Brewster's law.
    b. Verification of Fresnel's law of reflection of plane polarized light.
    c. Analysis of elliptically polarized light using $\lambda/4$ plate and Babinet's compensator.
5. Verification of Rayleigh's criterion for the limit of resolution of spectral lines using
    a. prism spectrum and (b) grating spectrum.
6. Studies on the Zeeman effect.
7. Experiments using He-Ne laser source:
    a. Determination of grating pitch using phenomena of self-imaging.
    b. Determination of wavelength with a vernier caliper.

III. ADVANCED MAJOR COURSE- AMJ 2: **ADVANCED NUCLEAR PHYSICS**

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

(Only for Hons Degree)

Course Learning Outcomes:

On successful completion of this course the student should:

1. Revise the knowledge of advanced Nuclear Physics-1.
2. Learn different aspects of advanced nuclear physics, viz. nuclear radiation detectors, nuclear reactor theory etc.
3. Understand the theory of nuclear reactor right from the fundamentals of nuclear fission and upto criticality of an infinite homogeneous reactor.

Skills to be learned:

1. Training in advanced nuclear physics-I will prepare the student to solve various nuclear reactor and detector problems.
2. He/she shall develop an understanding of how to formulate a physics problem and solve the given mathematical equation arising out of it.
3. Learn the concepts of advanced nuclear physics-I.
4. Develop skills to understand and solve the problems of advanced nuclear physics-I.

Course Content:

Nuclear Radiation Detectors: A Simple model of a detector, energy measurement, position and time measurement. Surface barrier detectors, Scintillation counters:Organic and inorganic scintillators, Gamma Ray Scintillation Spectrometer. General principles of high energy detectors, Nuclear emulsions, Cloud chambers, Bubble chambers. **(15 Lectures)**

Fundamentals of Nuclear Fission: Fission fuels, Prompt and delayed neutrons, Chain reaction,Multiplication factor, Condition for criticality, Breading phenomena. Diffusion of neutrons, Neutron current density, The equation of continuity, Fick's law, Thediffusion equation, Measurement of diffusion parameters. **(15 Lectures)**

Neutron Moderation: Moderation without absorption, Energy loss in elastic collisions, Average logarithmic energy decrement, Slowing down power and moderating ratio of a medium. Slowing downdensities, Moderation- Space dependent slowing down, Fermi's age theory, Moderation with absorption. **(15 Lectures)**

Criticality of an Infinite Homogenous Reactor: The critical equation, Optimum reactor shapes,Material and geometrical bucklings, Neutron balance in a thermal reactor, four factor formula, Calculation of critical size and composition in simple cases **(15 Lectures)**

Books Suggested:

1. Elements of Nuclear Physics, Nikhil Ranjan Roy & Rakesh Kumar Pandey, Atlantic P & D, 1/e, 2024
2. Segre, E., "Experimental Nuclear Physics", John Wiley
3. Singru, R.M., "Introduction to Experimental Nuclear Physics", John Wiley & Sons, 1974.
4. W.R. Leo, "Techniques for Nuclear and Particle Physics Experiments"
5. Kapoor S.S and Ramamurthy V.S., "Nuclear Radiation Detectors", New Age International Publishers 1986.
6. Syed Naeem Ahmed, "Physics and Engineering of Radiation Detection", Academic Press, Elsevier, 2007.
7. Glasstone, S. and Edlund, M. C., "The Elements of Nuclear Reactor Theory", Van Nostrand Co., 1953.
8. Stacey, W. M., "Nuclear Reactor Physics"
9. Lamarsh, J. R., "Introduction to Nuclear Reactor Theory', Addison Wesley, 1966
10. Murray, L., "Introductions of Nuclear Engineering".
11. Varma, J. "NUCLEAR Physics Experiments", New Age International Publishers 2001.
12. Singru, R.M., "Introduction to Experimental Nuclear Physics" Wiley Eastern Pvt. Ltd.

IV. ADVANCED MAJOR COURSE- AMJ 3:
PRACTICALS-VI:

Marks: Pr (ESE: 6Hrs) =100	Pass Marks: Pr (ESE) = 40

(Credits: Practicals-04) **120 Hours**

(Only for Hons Degree)

Instruction to Question Setter for

End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:
Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals (General Electronics, Atomic and Nuclear Physics):

1. 'e/m' measurement by Braun's tube and by the Magnetron valve method.
2. 'e' measurement by the Millikan oil drop apparatus.
3. Design and characteristics of passive attenuators (T- and π-types)
4. BJT-based voltage amplifier: design and performance study with and without negative feedback.
5. JFET-based voltage amplifier: design and performance study.
6. Half- and Full-wave rectifier with and without filters
7. Series and shunt voltage regulators using a Zener diode.
8. Characterization of Photo–resister.
9. Determine the plateau characteristics of the given GM counter.
10. Verification of Inverse Square Law for Gamma-rays.
11. To measure the absorption coefficient of gamma rays in Aluminum or Copper.
12. To plot the Gaussian or normal distribution curve for background radiation.
13. Determination of dead time of the GM Counter.

OR RESEARCH COURSES- RC 2: (In lieu of AMJ 2 & AMJ 3)

RESEARCH/ PROJECT DISSERTATION/ RESEARCH INTERNSHIP/ FIELD WORK

Marks: 50 (SIE: 25 Synopsis + 25 Viva on Synopsis: 1Hr) + 100 (ESE Pr: 6Hrs) + 50 (Viva) = 200	**Pass Marks = 80**

(Only for Hons with Research Degree)

Guidelines to Examiners for <u>Semester Internal Examination (SIE):</u>

Evaluation of project dissertation work may be as per the following guidelines:
Project Synopsis = 25 marks
Project Synopsis presentation and viva-voce = 25 marks

Guidelines to Examiners for <u>End Semester Examination (ESE):</u>

Evaluation of project dissertation work may be as per the following guidelines:
Project model (if any) and the Project record notebook = 100 marks
Project presentation and viva-voce = 50 marks

The overall project dissertation may be evaluated under the following heads:

- *Motivation for the choice of topic*
- *Project dissertation design*
- *Methodology and Content depth*
- *Results and Discussion*
- *Future Scope & References*
- *Participation in an Internship programme with a reputed organization*
- *Application of the Research technique in Data collection*
- *Report Presentation*
- *Presentation style*
- *Viva-voce*

Research Project

Research project under a Supervisor of the Department/Institution may be allocated to the eligible and qualifying candidate.

Project Dissertation/ Research Internship/ Field Work

The students of Post-Graduation must work Thirty-Six (36) days as Interns under Any Organisation having an MoU with the Ranchi University, which may include Government Organizations/judiciary/ Health Care Sectors/ Educational Institutions/ NGOs etc.

- The nature and the place of working must be informed in writing, seeking permission from the head of the department or the institution before undertaking the Project dissertation.

Submission of the Project Work

Each student has to submit two copies of the dissertation work duly forwarded by the HOD of the Department concerned. The forwarded copies will be submitted to the Department/Institution for evaluation at least seven days before the seminar.

The Project Report will consist of:

a. Field work/Lab work related to the project.
b. Preparation of the dissertation based on the work undertaken.
c. Presentation of project work in the seminar on the assigned topic & open viva there on.
d. At least one Research paper must be presented at a conference or may be published in a reputed journal.

Topics

Project work related to the Industrial/socially relevant topics may be given.

NB: Students will select topics for the project work in consultation with a teacher of the department.

The seminar will be held in the respective University Department at Ranchi University, Ranchi.

COURSES OF STUDY FOR FYUGP IN **"PHYSICS" MINOR**

ASSOCIATED CORE COURSE- MN A **Either may be opted in Sem-I or Sem-II**

I. ASSOCIATED CORE COURSE- MN A: INTRODUCTORY PHYSICS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:

At the end of the course the student is expected to learn and assimilate the following.

1. A brief idea about different branches of Physics in higher education.
2. Basic knowledge of the key principles of Physics
3. Overall understanding of the key units such as vector calculus, mechanics, electricity and magnetism, waves and optics, thermal physics, modern physics, electronics and special theory of relativity.
4. Understanding the inter-relation and applicability of different topics in physics

Skills to be learned:

1. Learn basics of different topics in physics
2. Learn the physics of vector calculus, mechanics, electricity and magnetism, waves and optics, thermal physics, electronics, and relativity
3. Learn the inter-relation between different topics and their applications in physics.

Vector Calculus

Scalar and Vector fields. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities.

Vector Integration: Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs). Dirac Delta function and its properties:

(8 lectures)

Mechanics

Review of Newton's Laws of Motion. Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse. Angular momentum of a particle and a system of particles. Torque. Principle of conservation of angular momentum. Moment of Inertia. Kinetic energy of rotation. Motion involving both translation and rotation. Elastic constants and the interrelation between them. Twisting torque on a Cylinder or Wire and twisting couple. Surface tension, Surface energy, Ripples and Gravity waves. Temperature dependence of Surface Tension. Viscosity, Kinematics of Moving Fluids, velocity profile: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube and the corrections.

(10 lectures)

Electricity and Magnetism

Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. Electrostatic Potential. Laplace's and Poisson Equations. Solution of Laplace's equation. Potential and Electric Field due to a dipole. Force and Torque on a dipole. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Displacement vector **D**. Relations between **E**, **P** and **D**. Gauss' Law in dielectrics. Magnetic force between current elements and definition of Magnetic Field **B**. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of **B**: curl and divergence. Vector Potential. Magnetic Force on (1) on a point charge (2) on current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field. Magnetization vector (**M).** Magnetic Intensity **(H).** Magnetic Susceptibility and permeability. Relation between **B, H, M**. Ferromagnetism. B-H curve and hysteresis.

(12 lectures)

Waves and Optics

Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Velocity of Transverse Vibrations of Stretched Strings. Newton's Formula for Velocity of Sound. Laplace's Correction. Interference of light, Division of amplitude and wavefront. Young's double slit experiment. Diffraction of light, Fresnel and Fraunhoffer diffraction. **(6 lectures)**

Thermal Physics

Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes. Work done during Isothermal and Adiabatic Processes. Reversible and Irreversible process with examples. Heat Engines. Carnot's

Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements. Concept of Entropy, Entropy Changes in Reversible and Irreversible processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics (Nearst's Heat Theorem). Unattainability of Absolute Zero. **(8 lectures)**

Elements of Modern Physics

Wave-particle duality, the Photoelectric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle. Schrodinger equation; Position, Momentum and Energy operators; physical interpretation of a wave function, probabilities and normalization; Law of radioactive decay; Mean life and half-life; fission and fusion. **(6 lectures)**

Basic Electronics

P and N-type semiconductors. Energy Level Diagram. Barrier Formation in PN Junction Diode. Current Flow Mechanism in Forward and Reverse Biased Diode. Half-wave Rectifier. Centre-tapped Full-wave Rectifiers, Ripple Factor and Rectification Efficiency, Zener Diode and Voltage Regulation. n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β. DC Load line and Q-point. Active, Cut off and Saturation Regions. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. Octal and Hexadecimal numbers. AND, OR and NOT Gates. NAND and NOR Gates as Universal Gates. XOR and XNOR Gates. De Morgan's Theorems. Boolean Laws. Binary Addition. 1's and 2's complement. **(7 lectures)**

Special Theory of Relativity

Galilean transformation, Postulates of Special Theory of Relativity. Lorentz Transformations. Length contraction, time dilation, and relativistic variation of mass. **(3 lectures)**

Reference Books;

1. Concepts of Electromagnetic Theory, K. Mamta, Raj Kumar Singh and J. N. Prasad, 1st Edn 2021, I. K. International Publishing House, New Delhi
2. Mathematical Physics, B. D. Gupta.
3. Mathematical Physics, B. S. Rajput.
4. Mathematical Physics, H. K. Dass.
5. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
6. Waves and Acoustics, P. K. Chakraborty and Satyabrata Chowdhury.
7. Optics, Ajoy Ghatak, 2008, Tata McGraw-Hill
8. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
9. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
10. A Treatise on Heat, Meghnad Saha, and B. N. Srivastava, 1958, Indian Press
11. Digital Electronics, Floyd.
12. Digital Computer Electronics, Malvino
13. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
14. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India
15. A first course in Electronics, Khan and Dey, PHI
16. Basic Electronics, Arun Kumar
17. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.

MINOR COURSE-B

I. MINOR COURSE- MN B:
MECHANICS

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40

(Credits: Theory-03) **45 Hours**

Course Learning Outcomes:
On successful completion of this course the student should be able to:
Understand laws of motion and their application to various dynamical situations, notion of inertial frames and concept of Galilean invariance. He / she will learn the concept of conservation of energy, momentum, angular momentum and apply them to basic problems.

1. Understand the principles of elasticity through the study of Young Modulus and modulus of rigidity.
2. Understand simple principles of fluid flow and the equations governing fluid dynamics.
3. Apply Kepler's law to describe the motion of planets and satellite in circular orbit, through the study of law of Gravitation.
4. Explain the phenomena of simple harmonic motion and the properties of systems executing such motions.
5. Describe how fictitious forces arise in a non-inertial frame, e.g., why a person sitting in a merry-go-round experiences an outward pull. Describe special relativistic effects and their effects on the mass and energy of a moving object.
6. Appreciate the nuances of the Special Theory of Relativity (STR)
7. In the laboratory course, the student shall perform experiments related to mechanics (compound pendulum), rotational dynamics (Flywheel), elastic properties (Young Modulus and Modulus of Rigidity) and fluid dynamics (verification of Stokes law, Searle method) etc.

Skills to be learned:

1. Understand the analogy between translational and rotational dynamics, and the application of both motions simultaneously in analyzing rolling with slipping.

Course Content:
Linear and Rotational Motion: Frames of reference. Newton's Laws of Motion. Dynamics of a system of particles. Centre of Mass. Conservation of momentum. Work and energy. Conservation of energy. Angular velocity and angular momentum. Torque. Conservation of angular momentum. **(18 Lectures)**

Gravitation: Newton's Law of Gravitation. Motion of a particle in a central force field (motion in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. **(6 Lectures)**

Oscillations: Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations. **(6 Lectures)**

Elasticity: Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire – Twisting couple on a cylinder. **(5 Lectures)**

Fluids: Surface Tension, Excess of pressure -Application to spherical and cylindrical drops and bubbles - variation of surface tension with temperature - Jaegar's method. Viscosity - Rate flow of liquid in a capillary tube - Poiseuille's formula. **(4 Lectures)**

Speed Theory of Relativity: Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities. **(6 Lectures)**

Note: *Students may not be familiar with vector calculus. Hence all examples must involve, as far as possible, differentiation either in one dimension or with respect to the radial coordinate.*

Reference Books:

1. University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addison-Wesley
2. Mechanics Berkeley Physics, v.1: Charles Kittel, et. al. 2007, Tata McGraw-Hill.
3. Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley
4. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
5. A textbook of General Physics, Edser
6. Undergraduate Mechanics, Arun Kumar, J. P. Agarwal and Nutan Lata, Pragati Prakashan
7. Oscillations and waves, Satya Prakash.
8. A textbook of oscillation, waves and Acoustics, M. Ghosh and D. Bhattacharya

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II. MINOR COURSE- MN B PR:
PHYSICS MINOR-B PRACTICALS

Marks: Pr (ESE: 6Hrs) = 25	Pass Marks: Pr (ESE) = 10

(Credits: Practicals-01) **30 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:
Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

Practicals:
1. To determine the Young's Modulus of a bar by the method of bending.
2. To determine the Elastic Constants of a Wire by Searle's method.
3. To determine g by the Bar Pendulum.
4. To determine g by Kater's Pendulum.
5. To study the Motion of a Spring and calculate (a) Spring Constant, (b) acceleration due to gravity (g).
6. To determine the modulus of rigidity of the material of the given wire by the dynamical method.
7. To determine the surface tension of water by rise in a capillary tube.

Reference Books

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

MINOR COURSE-C

I. MINOR COURSE- MN C:
ELECTRICITY AND MAGNETISM

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40

(Credits: Theory-03) **45 Hours**

Course Learning Outcomes:
On successful completion of this course the student should be able to:
1. Demonstrate Gauss' law, Coulomb's law for the electric field, and apply it to systems of point charges as well as line, surface, and volume distributions of charges.
2. Explain and differentiate the vector (electric fields, Coulomb's law) and scalar (electric potential, electric potential energy) formalisms of electrostatics.
3. Apply Gauss's law of electrostatics to solve a variety of problems.
4. Describe the magnetic field produced by magnetic dipoles and electric currents.
5. Explain Faraday-Lenz and Maxwell laws to articulate the relationship between electric and magnetic fields.
6. Understand the dielectric properties, magnetic properties of materials and the phenomena of electromagnetic induction.
7. Describe how magnetism is produced and list examples where its effects are observed.
8. Apply Kirchhoff's rules to analyze AC circuits consisting of parallel and/or series combinations of voltage sources and resistors and to describe the graphical relationship of resistance, capacitor and inductor.
9. Apply various network theorems such as Superposition, Thevenin, Norton, Reciprocity, Maximum Power Transfer, etc. and their applications in electronics, electrical circuit analysis, and electrical machines.
10. Should be able to verify of various circuit laws, network theorems elaborated above, using simple electric circuits.

Skills to be learned:
1. This course will help in understanding basic concepts of electricity and magnetism and their applications.
2. Basic course in electrostatics will equips the student with the required prerequisites to understand electrodynamics phenomena.

Course Content:
Vector Analysis: Scalar and Vector product, gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Statement of Gauss-divergence theorem and Stoke's theorem of vectors.
(10 Lectures)
Electrostatics: Electric potential as a line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of the electric field from the potential. Capacitance of Parallel plate. Energy per unit volume in an electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. A parallel plate capacitor completely filled with a dielectric. **(15 Lectures)**

Magnetism: Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of the magnetic field. Magnetic vector potential. Ampere's circuital law. Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of Dia-, para- and ferromagnetic materials. **(10 Lectures)**

Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of a single coil, M of two coils. Energy stored in a magnetic field. **(5 Lectures)**

Maxwell`s equations and Electromagnetic wave propagation: Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum. **(5 Lectures)**

Reference Books:
1. Concepts of Electromagnetic Theory, K. Mamta, Raj Kumar Singh and J. N. Prasad, 1/e, 2021, Wiley/I. K. International Publishing House, New Delhi
2. Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
3. Electricity & Magnetism, J.H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press
4. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
5. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
6. D. J. Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings.
7. Electricity and Magnetism, Chattopadhyaya and Rakshit
8. Electricity and Magnetism, Mahajan and Rangwala
9. Electricity and Magnetism, K. K. Tewary.

II. MINOR COURSE- MN C PR:
PHYSICS MINOR-C PRACTICALS

Marks: Pr (ESE: 6Hrs) = 25	**Pass Marks: Pr (ESE) = 10**

(Credits: Practicals-01) **30 Hours**

Instructions to Question Setter for
End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

Practicals:
1. To compare capacitances using De' Sauty's bridge.
2. To study the Characteristics of a Series RC Circuit.
3. To study a series LCR circuit and determine its
   a. Resonant frequency, b. Quality factor
4. To study a parallel LCR circuit and determine its
   a. Anti-resonant frequency and b. Quality factor Q
5. To verify the Thevenin theorem.
6. To verify the Superposition and Maximum Power Transfer Theorems
7. To determine the resistance of given moving coil galvanometer by the half deflection method
8. To determine the figure of merit of a moving coil galvanometer.

Reference Books

1. Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed 2011, Kitab Mahal
4. Engineering Practical Physics, S. Panigrahi & B. Mallick,2015, Cengage Learning India Pvt. Ltd.

MINOR COURSE-D

I. MINOR COURSE- MN D:

THERMAL PHYSICS AND STATISTICAL MECHANICS

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	**Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40**

(Credits: Theory-03) **45 Hours**

Course Learning Outcomes:

On successful completion of this course the student should be able to:

1. Demonstrate laws of thermodynamics, thermodynamic potentials, kinetic theory of gases etc.
2. Explain and differentiate between various laws of thermodynamics and their applications.
3. Understand different thermodynamic processes.
4. Articulate knowledge of entropy and related theorems.
5. Demonstrate a working understanding of capacitors.
6. Describe the blackbody and blackbody radiations.
7. Explain the Displacement law.
8. Understand the statistical behaviour of a thermodynamic system.
9. Should be able to verify various thermodynamic statistical laws and be able to identify the systems following them.

Skills to be learned:

3. This course will help in understanding basic concepts of Thermal and Statistical Physics
4. Basic course in Thermal Physics and Statistical Physics will equip the student with the required prerequisites to understand thermodynamic and statistical phenomena.

Course Content:

Laws of Thermodynamics: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law and Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero. **(15 Lectures)**

Thermodynamical Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications, Joule-Thomson Effect, Clausius-Clapeyron Equation, Expression for ($C_P - C_V$), C_P/C_V, TdS equations. **(8 Lectures)**

Kinetic Theory of Gases: Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) & its applications to specific heat of gases; monoatomic and diatomic gases. **(8 Lectures)**

Theory of Radiation: Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh-Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law. **(5 Lectures)**

Statistical Mechanics: Maxwell-Boltzmann law - distribution of velocity – Quantum statistics - Phase space - Fermi-Dirac distribution law - electron gas - Bose-Einstein distribution law - photon gas - comparison of three statistics. **(9 Lectures)**

Reference Books:

1. Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.
3. Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.
4. Thermodynamics, Kinetic theory & Statistical thermodynamics, F. W. Sears and G. L. Salinger. 1988, Narosa
5. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
6. Heat and Thermodynamics, A. B. Gupta and H. P. Roy.
7. Heat and Thermodynamics, P. K. Chakraborty.
8. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
9. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
10. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
11. Statistical Mechanics, K. Huang.

II. MINOR COURSE- MN D PR: **PHYSICS MINOR-D PRACTICALS**

Marks: Pr (ESE: 6Hrs) = 25	**Pass Marks: Pr (ESE) = 10**

(Credits: Practicals-01) **30 Hours**

Instructions to Question Setter for

End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:
Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

Practicals:

1. Measurement of Planck's constant using black body radiation.
2. To determine Stefan's Constant.
3. To determine the coefficient of thermal conductivity of Cu by Searle's Apparatus.
4. To determine the coefficient of thermal conductivity of a bad conductor by the Lee disc method.
5. To determine the temperature coefficient of resistance a Platinum resistance thermometer.
6. To study the variation of thermo emf across two junctions of a thermocouple with temperature.
7. To record and analyze the cooling temperature of a hot object as a function of time using a thermocouple

Reference Books:

1. Advanced Practical Physics for students, B. L. Flint & H. T. Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
3. A Laboratory Manual of Physics for Undergraduate Classes, D. P. Khandelwal, 1985, Vani Publication.

MINOR COURSE-E

I. MINOR COURSE- MN E:
WAVES AND OPTICS

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	**Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40**

(Credits: Theory-03) **45 Hours**

Course Learning Outcomes:
This course will enable the student to

1. Apply basic knowledge of principles and theories about the behaviour of light and the physical environment to conduct experiments. Understand the principle of superposition of waves, so thus describe the formation ofstanding waves.
2. Explain several phenomena we can observe in everyday life that can be explained as wave phenomena.
3. Use the principles of wave motion and superposition to explain the Physics of polarization, interference and diffraction
4. Understand the working of selected optical instruments like interferometer,diffraction grating, and holograms.
5. In the laboratory course, student will gain hands-on experience of using various optical instruments and making finer measurements of wavelength of light using Newton Ringsexperiment, Fresnel Biprism etc. Resolving power of optical equipment can be learnt firsthand.
6. The motion of coupled oscillators, study of Lissajous figures and behaviour of transverse, longitudinal waves can be learnt in this laboratory course.

Skills to be learned:

1. He / she shall develop an understanding of various aspects of harmonic oscillations andwaves specially.
   a. Superposition of collinear and perpendicular harmonic oscillations
   b. Various types of mechanical waves and their superposition.
2. This course in basics of optics will enable the student to understand various opticalphenomena, principles, workings and applications optical instruments.

Course Content:

Wave Motion- General: Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity. **(5 Lectures)**

Superposition of Two Collinear Harmonic oscillations: Linearity & Superposition Principle. Oscillations having equal frequencies and (2) Oscillations having different frequencies(Beats). **(5 Lectures)**

Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. **(2 Lectures)**

Sound: Simple harmonic motion - forced vibrations and resonance - Fourier's Theorem -Application to saw tooth wave and square wave - Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient - Sabine's formula - measurement of reverberation time, Acoustic aspects of halls and auditoria. **(9 Lectures)**

Wave Optics: Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle. **(3 Lectures)**

Interference and Interferometer: Young's Double Slit experiment. Interference in Thin Films: parallel and wedge-shaped films. Newton's Rings: measurement of wavelength and refractive index, Michelson's Interferometer, Idea of form of fringes (no theory needed), Determination of wavelength, Wavelength difference, Refractive index, and Visibility of fringes. **(9 Lectures)**

Diffraction: Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge. Resolving power of telescope and grating. **(7 Lectures)**

Polarization: Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization **(5 Lectures)**

Reference Books:

1. Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-Hill
2. Principles of Optics, B.K. Mathur, 1995, Gopal Printing
3. Concepts of Electromagnetic Theory, K. Mamta, Raj Kumar Singh and J. N. Prasad, 1/e 2021, Wiley/I. K. International Publishing House, New Delhi
4. Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publications
5. University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley

II. MINOR COURSE- MN E PR: **PHYSICS MINOR-E PRACTICALS**

Marks: Pr (ESE: 6Hrs) = 25	**Pass Marks: Pr (ESE) = 10**

(Credits: Practicals-01) **30 Hours**

Instructions to Question Setter for
End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:
Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

Practicals:
1. Familiarization with Schuster`s focusing; determination of angle of prism.
2. To determine the Refractive Index of the Material of a Prism using Sodium Light.
3. To determine Dispersive Power of the Material of a Prism using Mercury Light
4. To determine the value of Cauchy Constants.
5. To determine the Resolving Power of a Prism.
6. To determine wavelength of sodium light using Newton's Rings.
7. To determine the wavelength of Laser light using Diffraction of Single Slit.
8. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light usingplane diffraction Gratin
9. To determine the Resolving Power of a Plane Diffraction Grating.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, AsiaPublishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition,reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, KitabMahal, New Delhi.

MINOR COURSE-F

I. MINOR COURSE- MN F: DIGITAL, ANALOG CIRCUITS AND INSTRUMENTATION

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40

(Credits: Theory-03) **45 Hours**

Course Learning Outcomes:

As the successful completion of the course the student is expected to be conversant with thefollowing.

1. Secure first-hand idea of different components including both active and passive components to gain an insight into circuits using discrete components and also to learn about integrated circuits.
2. About analog systems and digital systems and their differences, fundamental logic gates, combinational as well as sequential and number systems.
3. Synthesis of Boolean functions, simplification and construction of digital circuits by employing Boolean algebra.
4. N- and P- type semiconductors, forward and reverse biased junctions. Application of PN junction for different type of rectifiers and voltage regulators.
5. NPN and PNP transistors and basic configurations namely common base, common emitter and common collector, and also about current and voltage gain.
6. To characterize various devices namely PN junction diodes, LEDs, Zener diode, solar cells, PNP and NPN transistors.

Skills to be learned

1. Learn the basics of IC and digital circuits, and difference between analog and digitalcircuits. Various logic GATES and their realization using diodes and transmitters.
2. Learn fundamental of Boolean algebra and their role in constructing digital circuits.
3. Learn basic concepts of semiconductor diodes and their applications to rectifiers.
4. Learn about junction transistor and their applications.

Course Content:

Digital Circuits:

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binaryto Decimal Conversion, AND, OR and NOT Gates (Realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates. **(6 Lectures)**

De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Minterms and Maxterms. Conversion of a Truth Table into an EquivalentLogic Circuit by (1) Sum of Products Method and (2) Karnaugh Map. **(6 Lectures)**

Binary Addition. 1's and 2's complement, Binary Subtraction using 2's Complement Method). Half Adders and Full Adders. **(4 Lectures)**

Analog Circuits:

Semiconductor Diodes: P and N type semiconductors. Barrier Formation in PN Junction Diode. Qualitative Idea of Current Flow Mechanism in Forward and Reverse Biased Diode. PN junctionand its characteristics. Static and Dynamic Resistance. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell. **(8 Lectures)**

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB and CE Configurations. Active, Cutoff & Saturation regions Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line & Q-point. Voltage Divider Bias Circuit for CE Amplifier. **(14 Lectures)**

Instrumentations

Power Supply: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers Calculation of Ripple Factor and Rectification Efficiency, Basic idea about capacitor filter, Zener Diode and Voltage Regulation. **(7 Lectures)**

Reference Books:

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. Electronic devices & circuits, S. Salivahanan & N.S. Kumar, 2012, Tata Mc-Graw Hill
3. Microelectronic Circuits, M.H. Rashid, 2nd Edn., 2011, Cengage Learning.
4. Modern Electronic Instrumentation and Measurement Tech., Helfrick and Cooper, 1990, PHI Learning
5. Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw Hill
6. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.
7. Fundamentals of Digital Circuits, A. Anand Kumar, 2nd Edition, 2009, PHI Learning Pvt. Ltd.
8. OP-AMP & Linear Digital Circuits, R.A. Gayakwad, 2000, PHI Learning Pvt. Ltd.

II. MINOR COURSE- MN F PR:
PHYSICS MINOR-F PRACTICALS

Marks: Pr (ESE: 6Hrs) = 25	Pass Marks: Pr (ESE) = 10

(Credits: Practicals-01) **30 Hours**

Instruction to Question Setter for
End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of the Practical Examination may be as per the following guidelines:

Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

Practicals:
1. To measure (a) Voltage, and (b) Frequency of a periodic waveform using CRO
2. To verify and design AND, OR, NOT and XOR gates using NAND gates.
3. To minimize a given logic circuit.
4. Half adder and Full adder circuit.
5. To study IV characteristics of PN junction diode, Zener diode and Light emitting diode
6. Zener diode as voltage regulator
7. To study the characteristics of a Transistor in CE configuration.
8. To design a CE amplifier of given gain (mid-gain) using voltage divider bias.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, AsiaPublishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition,reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, KitabMahal, New Delhi.

MINOR COURSE-G

I. MINOR COURSE- MN G:
SOLID STATE PHYSICS

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40

(Credits: Theory-03) **45 Hours**

Course Learning Outcomes:

At the end of the course the student is expected to learn and assimilate the following.

1. A brief idea about crystalline and amorphous substances, about lattice, unit cell, miller indices, reciprocal lattice, concept of Brillouin zones and diffraction of X-rays bycrystalline materials.
2. Knowledge of lattice vibrations, phonons and in depth of knowledge of Einstein and Debye theory of specific heat of solids.
3. At knowledge of different types of magnetism from diamagnetism to ferromagnetism and hysteresis loops and energy loss.
4. Understanding above the band theory of solids and must be able to differentiate insulators, conductors and semiconductors.
5. Understand the basic idea about superconductors and their classifications.

Skills to be learned:

1. Learn basics of crystal structure and physics of lattice dynamics
2. Learn the physics of different types of material like magnetic materials, dielectricmaterials, metals and their properties.
3. Understand the physics of insulators, semiconductor and conductors with specialemphasis on the elementary band theory of semiconductors.
4. Comprehend the basic theory of superconductors. Type I and II superconductors, theirproperties and physical concept of BCS theory.

Course Content:

Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell. Miller Indices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor. **(12 Lectures)**

Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law. **(10 Lectures)**

Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of Dia – and Paramagnetic Domains. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. **(12 Lectures)**

Dielectric Properties of Materials: Polarization. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Langevin-Debye equation. **(10 Lectures)**

Elementary Band theory: Kronig Penny model. Band Gaps. Conductors, Semiconductors and insulators. Conductivity of Semiconductors, mobility, Hall Effect, Hall coefficient. **(10 Lectures)**

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors. **(6 Lectures)**

Reference Books:

1. Concepts of Electromagnetic Theory, K. Mamta, Raj Kumar Singh and J. N. Prasad, 1st Edn 2021, I. K. International Publishing House, New Delhi
2. Introduction to Solid State Physics, Charles Kittel, 8th Ed., 2004, Wiley India Pvt. Ltd.
3. Elements of Solid-State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India
4. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
5. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
6. Solid State Physics, Rita John, 2014, McGraw Hill
7. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
8. Elementary Solid-State Physics, 1/e M. Ali Omar, 1999, Pearson India
9. Solid State Physics, M.A. Wahab, 2011, Narosa Publications

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II. MINOR COURSE- MN G PR:
PHYSICS MINOR-G PRACTICALS

Marks: Pr (ESE: 6Hrs) = 25	Pass Marks: Pr (ESE) = 10

(Credits: Practicals-01) **30 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:
Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

Practicals:
1. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency
5. To determine the refractive index of a dielectric layer using SPR
6. To study the BH curve of iron using a Solenoid and determine the energy loss.
7. To measure the resistivity of a semiconductor (Ge) crystal with temperature by four-probemethod (room temperature to 150 ^{o}C) and to determine its band gap.
8. To determine the Hall coefficient of a semiconductor sample.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, AsiaPublishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Edn., 2011, Kitab Mahal
4. Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India

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