

FYUGP
PHYSICS HONOURS/ RESEARCH
&
ASSOCIATED CORE COURSE
&
ELECTIVE COURSE
&
MDC (MULTIDISCIPLINARY COURSE)

FOR UNDER GRADUATE COURSES UNDER
BINOD BIHARI MAHTO KOYALANCHAL UNIVERSITY, DHANBAD



Implemented from
Academic Session 2025-2029

Sayantan Sili
18/08/2026

18/08/26

18/08/26

Savita Srivastava
18/08/2026

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Members of Board of Studies of FYUGP Syllabus as per Guidelines of the Binod Bihari Mahto Koyalanchal University, Dhanbad

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Head, University Dept. of Physics
BBMKU, Dhanbad | Chairman |
| 2. Dr. Dilip Kumar Giri
Assistant Prof. University Dept. of Physics
BBMKU, Dhanbad | Member |
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Session 2025-2029 onwards

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Table 1 A: Credit Framework for the first three years of FYUGP:

Academic Level	Level of Courses	Semester	MJJ: Discipline Specific Courses - Core or Major (60)	AC: Associated core courses from discipline/ Interdisciplinary/ vocational (8)	ELC: Elective courses may be opted from four paths [Follow table 4, 5 & 6] (16)	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) & (ii) Social awareness (2)	RC: Research Courses (12)	AMJ: Advanced Courses instead of Research (12)	Total Credits	IAP: Internship/Apprenticeship/ Project/ Vocational course/ Dissertation (4)	
	1	2	3 (80)	4 (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	4
		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	4	
		VI	4+4+4+4	-	4	-	-	-	-	-	-	-	20		
		Exit Point: Bachelor's Degree with Summer Internship/ Project/ Vocational course/ Dissertation (4 credits)													
													120	+4	

Session 2025-2029 onwards

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Table 1 B: Credit Framework for various pathways in the fourth year of FYUGP:

Table 1 B: Credit Framework for various pathways in the fourth year of B.Tech.															
Academic Level	Level of Courses	Semester	MJ: Discipline Specific Courses – Core or Major (20)	AC: Associated core courses from discipline/ Interdisciplinary/ vocational (8)	ELC: Elective courses opted in Semester III from four paths of Table 4, 5 & 6 (8)	MDC: Multidisciplinary Courses (From a pool of Courses) (0)	AEC: Ability Enhancement Courses (Modern Indian Language and English) (0)	SEC: Skill Enhancement Courses (0)	VAC: Value Added Courses (0)	IKS: (i) Indian Knowledge System (0) & (ii) Social awareness (0)	RC: Research Courses (12)	AMJ: Advanced Courses in place of Research (12)	Total Credits	IAP: Internship/Apprenticeship/ Project/ Vocational course/ Dissertation (4)	
	1	2	3 (80)		4(32)	5	6	7	8	9	10	11	12	13	
	Honours with Research														
Level 6	Level 400-499: Advanced courses	VII	4+4+4	-	4	-	-	-	-	-	4	-	20	---	
		VIII	4+4	-	4	-	-	-	-	-	8	-	20		
		Exit Point: Bachelor's Degree with Hons. with Research												OR	
OR	Honours														
Level 6	Level 400-499: Advanced courses	VII	4+4+4	-	4	-	-	-	-	-	-	4	20	---	
		VIII	4+4	-	4	-	-	-	-	-	-	4+4	20		
		Exit Point: Bachelor's Degree with Hons.													

Session 2025-2029 onwards

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SEMESTER WISE COURSES OF STUDY FOR FOUR YEAR UNDERGRADUATE PROGRAMME

2025 onwards**Table 2: 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	20
	VAC-1	Value Added Course- 1	2	
	IKS-1	Indian Knowledge System	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	20
	VAC-2	Value Added Course-2	2	
	IKS-2	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	20
	SEC-3	Skill Enhancement Course-3	3	
	MDC-3	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	20
	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	20
	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 10 (Disciplinary/ Interdisciplinary Major)	4	
VI	ELC-4	Elective courses from discipline/ Interdisciplinary/ vocational	4	20
	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

Session 2025-2029 onwards

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Table 3A: 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
VIIA	ELC-5	Elective courses from Discipline/Interdisciplinary/vocational	4	20
	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	
	RC-1	Research proposal - Planning & Techniques (Disciplinary/Interdisciplinary Major)	4	
VIII A	ELC-6	Elective courses from Discipline/Interdisciplinary/vocational	4	20
	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 (IAP) of 4 Credits			160	160

Table 3B: 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
VIIB	ELC-5	Elective courses from Discipline/Interdisciplinary/vocational	4	20
	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 Paper-1 (Disciplinary/Interdisciplinary Major)	4	
VIII B	ELC-6	Elective courses from Discipline/Interdisciplinary/vocational	4	20
	MJ-19	Major paper 19 (Disciplinary/Interdisciplinary Major)	4	
	MJ-20	Major paper 20 (Disciplinary/Interdisciplinary Major)	4	
	AMJ-2	Advanced Major Paper-2 (Disciplinary/Interdisciplinary Major)	4	
	AMJ-3	Advanced Major Paper-3 (Disciplinary/Interdisciplinary Major)	4	
Total Credits excluding one internship (IAP) of 4 Credits			160	160

Session 2025-2029 onwards

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Abbreviations:

AEC	Ability Enhancement Courses
SEC	Skill Enhancement Courses
IAP	Internship/Apprenticeship/ Project
IKS	Indian Knowledge System
MDC	Multidisciplinary Courses
ELC	Elective Courses
MJ	Major Disciplinary/interdisciplinary Courses
AC	Associated core courses from discipline/ Interdisciplinary/ vocational
AMJ	Advanced Major Disciplinary/interdisciplinary Courses
RC	Research Courses
JOC	Skill based Job Oriented Courses

AEC (Ability enhancements courses)- 2 Credits

- Full marks – 50, Pass Marks – 20
- In AEC the students of all faculties will have to select either Hindi or English in Semester -1, and those students who have opted Hindi will have to select English as AEC in Semester -2, and vice versa.
- In the 3rd and 4th Semesters, AEC-3 and AEC-4 shall be offered respectively. Students may opt for Sanskrit, Urdu, Bengali, English, Hindi, or TRL in the 3rd Semester, and the same subject shall be continued in the 4th Semester.
- No internal examination will be conducted.

VAC (Value added Courses)- 2 Credits

- Full marks – 50, Pass Marks – 20
- Understanding India
- Health, Wellness & Yoga
- Environmental Studies

The above three subjects may be taken in Semester I, II, or, IV in any order, as per the option exercised by the students)

- No internal examination will be conducted.

SEC (Skill Enhancement Courses) – 3 Credits

- Full Marks – 75, Pass Marks – 30
- For 1st semester – SEC-I "Computer Fundamentals & Computer Proficiency"
- For 2nd semester- SEC-II "Cyber-Crime & Cybersecurity"
- For 3rd Semester – SEC-III "Digital Learning & AI Tools"
- No internal examination will be conducted.

MDC (Multidisciplinary Courses) – 3 credits

- Full Marks – 75, Pass Marks – 30
- A student will study three different subjects in the multidisciplinary courses during first three semesters.
- No internal examination will be conducted.

Indian Knowledge System (IKS) & Awareness Module

The National Education Policy 2020 (NEP 2020) integrates the Indian Knowledge System (IKS) into education at all levels. A 2-credit IKS course introduces students to India's cultural, scientific, and philosophical heritage.

A 2-credit Awareness Module covers social ethics and common rules, balancing broad and in-depth topics.

Part 1 (10 hours) includes road safety, diversity, cleanliness, financial management, and basic first aid.

Session 2025-2029 onwards

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Part 2 (20 hours) focuses on a single topic like civic education, drug abuse, gender norms, or sustainable development.

Universities are encouraged to experiment and revise course content, with credits awarded through alternative activities like quizzes, workshops, group presentations, and community projects.

UGC mandates that at least 5% of UG programme credits be dedicated to IKS, with 50% integrated into the student's major. The **FYUGP curriculum** includes 9 credits for IKS, comprising a 2-credit common course, a 3-credit multidisciplinary course, and 4 credits of IKS content within a major paper.

Common Course

- Full marks – 50, Pass Marks – 20
- For 1st Semester (IKS-1)– “Indian Knowledge System.”
- For 2nd Semester (IKS-2) – “Social Awareness Activities.”
- There shall be two modules in 2nd Semester, SA-1 and SA-2, a student can choose any one of the two modules.

Major Paper having IKS

- In the 4th Semester, Major Paper 5 shall be IKS.
- Full marks – 100: Internal-15 (Written-10+ Class Performance and Attendance-5), End Semester Examination Theory-60, Practical-25
Pass Marks Theory– 30: (Internal-6+ End Semester Examination-24), Pass Marks Practical-10.
- No internal examination will be conducted for the practical paper.

AC (Associated Core Courses) – 4 credits

- Full Marks Theory (Internal + End Semester)– (15+60), Pass Marks –30; Full Marks Practical-25, Pass Marks-10.
- A student will study two different subjects in the Associated Core courses during the first and second semesters.
- No internal examination will be conducted for the practical paper.

ELC (Elective Courses) – 4 credits

- Full Marks Theory (Internal + End Semester)– (15+60), Pass Marks –30; Full Marks Practical-25, Pass Marks-10.
- A student will study two different subjects in the Elective courses from the third to the eighth semesters.
- No internal examination will be conducted for the practical paper.

Session 2025-2029 onwards

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Table 4: Suggested list of Associated Core (AC) for SCIENCE Discipline

S.N.	Major (MJ)	Associated Core (AC)
1	Botany	Chemistry
		Zoology
2	Zoology	Chemistry
		Botany
3	Chemistry	Physics /Botany
		Mathematics/Zoology
4	Physics	Mathematics/Statistics
		Chemistry
		Geology
5	Mathematics	Chemistry/Computer Science
		Physics/ Statistics/Economics
6	Statistics	Mathematics
		Computer Science/Physics
7	Geology	Chemistry /Physics
		Geography

SEMESTER WISE COURSES OF STUDY FOR FOUR YEAR UNDERGRADUATE PROGRAMME 2025 onwards**Table 5: Semester-wise Course Code and Credit Points and Marks distribution of Associated core courses**

S.N.	Semester	Paper	Credits	Full Marks		Pass Marks	
				Theory (Internal+ End Sem)	Practical End Sem.	Theory (Internal+ End Sem)	Practical
1.	I/II	AC-1/AC-2	3+1	15+60	25	30	10

- **For internal examinations, the written examination will carry 10 marks, and class performance and attendance will carry 5 marks.*
- *No internal or mid-semester examination will be conducted for practical papers.*

Table 6: Semester wise Course Code and Credit Points and Marks distribution of Elective courses

S.N.	Semester	Paper	Credits	Full Marks		Pass Marks	
				Theory (Internal+ End Sem)	Practical End Sem.	Theory (Internal+ End Sem)	Practical
1.	III/IV	ELC-1/ELC-2	3+1	15+60	25	30	10
2.	V/VI	ELC-3/ELC-4	3+1	15+60	25	30	10
3.	VII/VIII	ELC-5/ELC-6	3+1	15+60	25	30	10

- **For internal examinations, the written examination will carry 10 marks, and class performance and attendance will carry 5 marks.*

Session 2025-2029 onwards

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- No internal or mid-semester examination will be conducted for practical papers.

SEMESTER WISE COURSES IN PHYSICS FOR FYUGP 2025 onwards

Table 7: Semester wise Papers and Examination Structure for Physics Major during the First Three Years of FYUGP :

Year	Semester	Physics Major		Examination Structure				Pass Marks	
		Code	Papers	Credits	Internal (Mid Semester) Theory (F.M.)	End Semester Theory (F.M.)	End Semester Practical (F.M.)	Internal Theory +(Mid Sem.) End Sem. Theory	End sem. Practical
1st	I	MJ-1: Theory	Mathematical Physics-I	3	15 (10+5)*	60	-	30	-
		MJ-1: Practical	Practical	1	-	-	25	-	10
	II	MJ-2: Theory	Mechanics & Waves	3	15 (10+5)*	60	-	30	-
		MJ-2: Practical	Practical	1	-	-	25	-	10
EXIT POINT: UNDERGRADUATE CERTIFICATE									
2nd	III	MJ-3: Theory	Electricity & Magnetism	3	15 (10+5)*	60	-	30	-
		MJ-3: Practical	Practical	1	-	-	25	-	10
		MJ-4: Theory	Optics	3	15 (10+5)*	60	-	30	-
		MJ-4: Practical	Practical	1	-	-	25	-	10
	IV	MJ-5: Theory	Indian Knowledge System	3	15 (10+5)*	60	-	30	-
		MJ-5: Practical	Practical	1	-	-	25	-	10
		MJ-6: Theory	Electromagnetic Theory	3	15 (10+5)*	60	-	30	-
		MJ-6: Practical	Practical	1	-	-	25	-	10
		MJ-7: Theory	Mathematical Physics-II	3	15 (10+5)*	60	-	30	-
		MJ-7: Practical	Practical	1	-	-	25	-	10
EXIT POINT: UNDERGRADUATE DIPLOMA									
3rd	V	MJ-8: Theory	Mathematical Physics-III	3	15 (10+5)*	60	-	30	-
		MJ-8: Practical	Practical	1	-	-	25	-	10

Session 2025-2029 onwards

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VI	MJ-9: Theory	Thermal Physics	3	15 (10+5)*	60	-	30	-
	MJ-9: Practical	Practical	1	-	-	25	-	10
	MJ-10: Theory	Statistical Mechanics	3	15 (10+5)*	60	-	30	-
	MJ-10: Practical	Practical	1	-	-	25	-	10
	MJ-11: Theory	Analog Electronics	3	15 (10+5)*	60	-	30	-
	MJ-11: Practical	Practical	1	-	-	25	-	10
	MJ-12: Theory	Digital Electronics	3	15 (10+5)*	60	-	30	-
	MJ-12: Practical	Practical	1	-	-	25	-	10
	MJ-13: Theory	Elements of Modern Physics	3	15 (10+5)*	60	-	30	-
	MJ-13: Practical	Practical	1	-	-	25	-	10
	MJ-14: Theory	Quantum Mechanics and Applications	3	15 (10+5)*	60	-	30	-
	MJ-14: Practical	Practical	1	-	-	25	-	10
	MJ-15: Theory	Classical Dynamics	3	15 (10+5)*	60	-	30	-
	MJ-15: Practical	Practical	1	-	-	25	-	10
EXIT POINT: BACHELOR'S DEGREE								

- *For internal examinations, the written examination will carry 10 marks, and class performance and attendance will carry 5 marks.
- No internal or mid-semester examination will be conducted for practical papers.

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Table 8 A: Fourth Year Papers and Examination Structure for Physics Major with Bachelor's Degree (Honours with Research):

Year	Semester	Physics Major		Examination Structure				Pass Marks	
		Code	Papers	Credits	Internal (Mid Semester) Theory (F.M.)	End Semester Theory (F.M.)	End Semester Practical (F.M.)	Internal Theory + (Mid Sem.) End Sem. Theory	End sem. Practical
4th	VII	MJ-16: Theory	Research Methodology	4	25 (20+5)*	75	-	40	-
		MJ-17: Theory	Solid State Physics	3	15 (10+5)*	60	-	30	-
		MJ-17: Practical	Practical	1	-	-	25	-	10
		MJ-18: Theory	Nuclear and Particle Physics	3	15 (10+5)*	60	-	30	-
		MJ-18: Practical	Practical	1	-	-	25	-	10
		RC-1	Research Proposal- Planning & Techniques (Disciplinary/ Interdisciplinary Major)	4	25	75	-	40	-
	VIII	MJ-19: Theory	Atomic and Molecular Physics (Quantum Approach) and Laser Physics	3	15 (10+5)*	60	-	30	-
		MJ-19: Practical	Practical	1	-	-	25	-	10
		MJ-20: Theory	Advanced Mathematical Physics	3	15 (10+5)*	60	-	30	-
		MJ-20: Practical	Practical	1	-	-	25	-	10
		RC-2	Research Internship & Dissertation/Thesis	8	-	200	-	80 (End Sem.)	-
EXIT POINT: BACHELOR'S DEGREE (HONOURS with RESEARCH)									

- *For internal examinations, the written examination will carry 10 marks, and class performance and attendance will carry 5 marks.
- No internal or mid-semester examination will be conducted for practical papers.

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Table 8 B: Fourth Year Papers and Examination Structure for Physics Major with Bachelor's Degree (Honours):

Year	Semester	Physics Major		Examination Structure				Pass Marks		
		Code	Papers	Credits	Internal (Mid Semester) Theory (F.M.)	End Semester Theory (F.M.)	End Semester Practical (F.M.)	Internal Theory (Mid Sem.)	End Sem. Theory	End sem. Practical
4th	VII	MJ-16: Theory	Advanced Mathematical Physics-I	3	15 (10+5)*	60	-	30	-	-
		MJ-16: Practical	Practical	1	-	-	25	-	-	10
		MJ-17: Theory	Solid State Physics	3	15 (10+5)*	60	-	30	-	-
		MJ-17: Practical	Practical	1	-	-	25	-	-	10
		MJ-18: Theory	Nuclear and Particle Physics	3	15 (10+5)*	60	-	30	-	-
		MJ-18: Practical	Practical	1	-	-	25	-	-	10
		AMJ-1: Theory	Advanced Quantum Mechanics	3	15 (10+5)*	60	-	30	-	-
		AMJ-1: Practical	Practical	1	-	-	25	-	-	10
	VIII	MJ-19: Theory	Atomic and Molecular Physics (Quantum Approach) and Laser Physics	3	15 (10+5)*	60	-	30	-	-
		MJ-19: Practical	Practical	1	-	-	25	-	-	10
		MJ-20: Theory	Advanced Mathematical Physics-II	3	15 (10+5)*	60	-	30	-	-
		MJ-20: Practical	Practical	1	-	-	25	-	-	10
		AMJ-2: Theory	Advanced Theoretical Physics-I (Electrodynamics & Statistical Mechanics)	3	15 (10+5)*	60	-	30	-	-
		AMJ-2: Practical	Practical	1	-	-	25	-	-	10
		AMJ-3: Theory	Advanced Theoretical Physics-II (Condensed Matter Physics & Nuclear and Particle Physics)	3	15 (10+5)*	60	-	30	-	-
		AMJ-3: Practical	Practical	1	-	-	25	-	-	10
EXIT POINT: BACHELOR'S DEGREE (HONOURS)										

- *For internal examinations, the written examination will carry 10 marks, and class performance and attendance will carry 5 marks.
- No internal or mid-semester examination will be conducted for practical papers.

Session 2025-2029 onwards

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Table 9: Semester wise Papers and Examination Structure for Associated Core Course in Physics

Semester	Code	Minor Papers	Credits	Full Marks		Pass Marks	
				Theory (Internal+ End Sem)	Practical End Sem.	Theory (Internal+ End Sem)	Practical End Sem
I/II	AC Theory	Mechanics	3	15(10+5) +60	-	30	
	AC Practical	Mechanics	1	-	25	-	10

- For internal examination, the written examination will carry 10 marks, and class performance and attendance will carry 5 marks.
- No internal or mid-semester examination will be conducted for practical papers.

Table 10: Semester wise Papers and Examination Structure for Elective Course in Physics

Semester	Code	Minor Papers	Credits	Full Marks		Pass Marks	
				Theory (Internal+ End Sem)	Practical End Sem.	Theory (Internal+ End Sem)	Practical End Sem
III/IV	ELC -1 Theory	Electricity & Magnetism	3	15(10+5) +60	-	30	-
	ELC -1 Practical	Electricity & Magnetism	1	-	25	-	10
V/VI	ELC -2 Theory	Thermal Physics and Statistical Mechanics	3	15(10+5) +60	-	30	-
	ELC -2 Practical	Thermal Physics and Statistical Mechanics	1	-	25	-	10
VII/VIII	ELC -3 Theory	Waves & Optics	3	15(10+5)+60	-	30	-
	ELC -3 Practical	Waves & Optics	1	-	25	-	10

- For internal examinations, the written examination will carry 10 marks, and class performance and attendance will carry 5 marks.
- No internal or mid-semester examination will be conducted for practical papers.

Sayantan Saha
18/08/2026

18/08/26

18/08/2026

18/08/26

18/08/26

18/08/26

General Instructions

1. The **Semester Internal Theory Examination** will be of **1-hour duration**.
2. There shall be **only one Practical Examination of 3-hour duration in each semester for each paper** separately.
3. **One external and one internal examiner** will conduct the Practical Examinations.
4. There will be **only one Semester Internal Examination** in Major, Minor, and Research Courses, which will be organized at the college/institution level.
5. Out of **100 marks**, the **Semester Internal Theory Examination** (each of 1 hour) will carry **15 marks** for practical subjects and **25 marks** for non-practical subjects.
6. The **15 marks** in the Theory Examination of practical subjects may include **10 marks** from the **Written Examination/Assignment/Project/Tutorial**, wherever applicable, and **5 marks** based on **attendance/overall class performance** during the semester.
7. The **25 marks** in the Theory Examination of non-practical subjects may include **20 marks** from the **Written Examination/Assignment/Project/Tutorial**, wherever applicable, and **5 marks** based on **attendance/overall class performance** during the semester.
8. To convert **attendance into marks**, a **suggestive range** is provided below:
 - Attendance up to 45%: 1 mark
 - $45\% < \text{Attendance} \leq 55\%$: 2 marks
 - $55\% < \text{Attendance} \leq 65\%$: 3 marks
 - $65\% < \text{Attendance} \leq 75\%$: 4 marks
 - Attendance above 75%: 5 marks

Sayantra Sil
18/08/2026

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18/08/2026

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18/08/26

Kunal
18/8/26

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18/8/26

SEMESTER-WISE PAPERS FOR PHYSICS MAJOR DURING THE FIRST THREE YEARS OF FYUGP

MAJOR PAPERS

SEMESTER I

PHYSICS MJ-1 THEORY: MATHEMATICAL PHYSICS-I

Credits: 03 Lectures: 45

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance =05) Pass Marks (Internal + End Semester) = 30

Instructions to Question Setters

Semester Internal Examination (SIE) – 10 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

- ✦ The emphasis of course is to equip students with the mathematical tools required in solving problem of interest to physicists.
- ✦ To expose students to fundamental computational physics skills and hence enable them to solve a wide range of physics problems.
- ✦ To help students develop critical skills and knowledge that will prepare them not only for doing fundamental and applied research but also prepare them for a wide variety of careers.

COURSE LEARNING OUTCOMES

- ✦ Revise the knowledge of calculus, vectors and vector calculus. These basic mathematical structures are essential in solving problems in various branches of Physics as well as in engineering.
- ✦ Draw and interpret graphs of various functions.
- ✦ Solve first order differential equations and apply it to physics problems solve linear second order homogeneous and non-homogeneous differential equations with constant coefficients.
- ✦ Calculate partial derivatives of function of several variables Understand the concept of gradient of scalar field and divergence and curl of vector fields.
- ✦ Perform line, surface and volume integration and apply Green's, Stokes' and Gauss's Theorems to compute these integrals.
- ✦ Apply curvilinear coordinates to problems with spherical and cylindrical symmetries.
- ✦ Understand Dirac-delta function and its properties.

Session 2025-2029 onwards

Sayantanil
18/08/2026

18/08/2026

18/08/2026

18/08/2026

18/08/2026

18/08/2026

- ✦ Revise the knowledge of calculus, vectors, vector calculus, probability and probability distributions. These basic mathematical structures are essential in solving problems in various branches of Physics as well as in engineering.

SKILLS TO BE LEARNED

- ✦ Training in calculus will prepare the student to solve various mathematical problems.
- ✦ He/she shall develop an understanding of how to formulate a physics problem and solve the given mathematical equation arising out of it.

COURSE CONTENT

Differential Equations: First Order and Second Order Differential Equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with Constant Coefficients. Wronskian and general solution. (7 Lectures)

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. (4 Lectures)

Vector Calculus: Scalar and Vector Fields. 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. (10 Lectures)

Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface, and volume elements. Line, surface, and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems, and their applications. (10 Lectures)

Orthogonal Curvilinear Coordinates: Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl, and Laplacian in Cartesian, Spherical, and Cylindrical Coordinate Systems. (5 Lectures)

Dirac Delta function and its properties: Definition of Dirac delta function. Representation as a limit of a Gaussian function and rectangular function. Properties of the Dirac delta function. (5 Lectures)

Introduction to probability: Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson, with examples. Mean and variance. Dependent events: Conditional Probability. Bayes' Theorem and the idea of hypothesis testing. (4 Lectures)

Reference Books:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn. Elsevier.
2. An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning.
3. Differential Equations, George F. Simmons, 2007, McGraw Hill.
4. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
5. Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book.
6. Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
7. Mathematical Physics, Goswami, 1st edition, Cengage Learning.
8. Engineering Mathematics, S. Pal and S.C. Bhunia, 2015, Oxford University Press.
9. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
10. Essential Mathematical Methods, K.F. Riley & M.P. Hobson, 2011, Cambridge Univ. Press.
11. Mathematical Physics, H.K. Dass and R. Verma, S. Chand & Company.
12. Mathematical Physics, B.S. Rajput, Pragati Prakashan, 21st Edition, 2009.
13. Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
14. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.

Sayantan Sil
18/08/2026

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MJ-1: Practical**Credit: 01 Lectures: 30(15X2)*****Instructions to Question Setters******End Semester Examination (ESE): 25 Marks***

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:

Experiment = 15 marks

Practical record notebook = 05 marks

Viva-voce = 05 marks

Note: No internal or mid-semester examination will be conducted for the practical paper

The aim of this Lab is not just to teach computer programming and numerical analysis, but to emphasize its role in solving problems in Physics.

- ✦ Highlights the use of 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
- ✦ Aim at teaching students to construct the computational problem to be solved
- ✦ Students can use any one of the operating systems, Linux or Microsoft Windows

Topics	Description with Applications
Introduction and Overview	Computer architecture and organization, memory and Input/output devices
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow-emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Errors and error Analysis	Truncation and round off errors, Absolute and relative errors, Floating point computations.
Review of C & C++ Programming fundamentals	Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (If-statement. If-else Statement. Nested if Structure. Else-if Statement. Ternary Operator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops), Arrays (1D & 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects
Programs:	Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search
Random number generation	Area of circle, area of square, volume of sphere, value of π

Sayantra 51
18/08/2026

Kunt
18/8/26

18/08/26

18/08/2026

18/08/26

18/8/26

Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equations, solving $\alpha = \tan \alpha; I = I_0 \left(\frac{\sin \alpha}{\alpha} \right)^2$ in optics.
Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation	Evaluation of trigonometric functions e.g. $\sin \theta$, $\cos \theta$, $\tan \theta$, etc.
Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method	Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop
Solution of Ordinary Differential Equations (ODE) First order Differential equation Euler, modified Euler and Runge-Kutta (RK) second and fourth order methods	First order differential equation - Radioactive decay - Current in RC, LC circuits with DC source - Newton's law of cooling - Classical equations of motion Attempt the following problems using the RK 4 order method: - Solve the coupled differential equations $\frac{dx}{dt} = y + x - \frac{x^3}{3}; \frac{dy}{dx} = -x$ or four initial conditions $x(0) = 0, y(0) = -1, -2, -3, -4$. Plot x vs y for each of the four initial conditions on the same screen for $0 \leq t \leq 15$ The differential equation describing the motion of a pendulum is $\frac{d^2\theta}{dt^2} = -\sin(\theta)$. The pendulum is released from rest at an angular displacement α, i.e. $\theta(0) = \alpha$ and $\dot{\theta}(0) = 0$. Solve the equation for $\alpha = 0.1, 0.5$ and 1.0 and plot θ as a function of time in the range $0 \leq t \leq 8\pi$. Also plot the analytic solution valid for small θ, $(\sin(\theta)) = \theta$.

Reference Books:

1. Introduction to Numerical Analysis, S. S. Sastry, PHI Learning Pvt. Ltd., 5th ed., 2012.
2. Schaum's Outline of Programming with C++, J. Hubbard, McGraw-Hill, 2000.
3. Numerical Recipes in C: The Art of Scientific Computing, W. H. Press, S. A. Teukolsky, W. T. Vetterling, and B. P. Flannery, Cambridge University Press, 3rd ed., 2007.
4. A First Course in Numerical Methods, U. M. Ascher and C. Greif, PHI Learning, 2012.
5. Elementary Numerical Analysis, K. E. Atkinson, Wiley India Edition, 3rd ed., 2007.
6. Numerical Methods for Scientists and Engineers, R. W. Hamming, Courier Dover Publications, 1973.
7. An Introduction to Computational Physics, T. Pang, Cambridge University Press, 2nd ed., 2006.
8. Computational Physics, D. Walker, Scientific International Pvt. Ltd., 1st ed., 2015.

Sayantra Sil
18/08/2026

26/2
18/08/26

18/08/2026

18/08/26

18/08/26

18/08/26

SEMESTER II**PHYSICS-MJ-2 THEORY: MECHANICS & WAVES****Credits: 03 Lectures: 45**

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance=05) Pass Marks (Internal + End Semester) = 30

Instructions to Question Setters**Semester Internal Examination (SIE) – 10 Marks:**

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

- ✦ The emphasis of this course is to enhance the understanding of the basics of mechanics.
- ✦ This course also includes the ideas of superposition of harmonic oscillations, leading to physics of travelling and standing waves and also acoustics of buildings, growth and decay of sound.
- ✦ By the end of this course, students should be able to solve the seen or unseen problems/numerical in mechanics and waves and also have an in depth understanding of mechanics, wave phenomena and acoustics.

COURSE LEARNING OUTCOME

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

- ✦ Understand the phenomena of collisions and idea about centre of mass and laboratory frames and their correlation.
- ✦ Understand the principles of elasticity through the study of Young Modulus and modulus of rigidity.
- ✦ Understand simple principles of fluid flow and the equations governing fluid dynamics.
- ✦ Apply Kepler's law to describe the motion of planets and satellite in circular orbit, through the study of law of Gravitation.
- ✦ Explain the phenomena of simple harmonic motion and the properties of systems executing such motions.
- ✦ 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.
- ✦ Recognize and use a mathematical oscillator equation and wave equation, and derive these equations for certain systems.

Session 2025-2029 onwards

Sayantan Si
18/08/2026

18/08/26

18/08/2026

18/08/26

18/08/2026

18/08/26

- ✦ Understand the principle of superposition of waves, so thus describe the formation of standing waves.
- ✦ Explain several phenomena we can observe in everyday life that can be explained as wave phenomena.
- ✦ Use the principles of wave motion and superposition of waves.
- ✦ Recapitulate and learn the special theory of relativity- postulates of the special theory of relativity, Lorentz transformations on space-time and other four vectors, four-vector notations, space-time invariant length, length contraction, time dilation, mass-energy relation, Doppler effect, light cone and its significance, problems involving energy- momentum conservations.

SKILLS TO BE LEARNED

- ✦ Learn the concepts of elasticity of solids and viscosity of fluids.
- ✦ Develop skills to understand and solve the equations of Newtonian gravity and central force problem.
- ✦ Learn about inertial and non-inertial systems.
- ✦ Acquire basic knowledge of oscillation.
- ✦ Learn about superposition of two Collinear Harmonic Oscillations.
- ✦ Superposition of two Perpendicular Harmonic Oscillations.
- ✦ Learn about Wave Motion in general.
- ✦ Learn about Velocity of Waves.
- ✦ Learn about acoustics of buildings, growth and decay of sound.
- ✦ Acquire knowledge of Superposition of Two Harmonics Waves.
- ✦ Develop the basic concepts of special theory of relativity and its applications to dynamical systems of particles.

COURSE CONTENT

Collisions: Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames.

Elasticity: Relation between Elastic constants. Twisting torque on a Cylinder or Wire. (2 Lectures)

Flexure of Beam: Bending of beam, Cantilever-loaded at one end and loaded at middle. (2 Lectures)

Surface Tension: Ripples and Gravity waves, Determination of surface tension by Jaeger's and Quincke's methods. Temperature dependence of surface tension. (3 Lectures)

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

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

Oscillations: SHM: 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. (5 Lectures)

Non-Inertial Systems: Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Coriolis force and centrifugal force. Effect of centrifugal force due to rotation of the earth. Coriolis force on a freely falling body. Geographical effects of Coriolis force (qualitative). (3 Lectures)

Session 2025-2029 onwards

Sayantan Sil
18/08/2026

18/08/26

18/08/2026

18/08/26

18/08/26

18/08/26

Superposition of Collinear 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. **(3 Lectures)**

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

Wave Motion: Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves. **(3 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. **(2 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. **(5 Lectures)**

Special Theory of Relativity: Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events, Length contraction, Time dilation. Relativistic transformation of velocity, acceleration, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Mass-less Particles. Mass-energy Equivalence. Relativistic Doppler effect, Relativistic Kinematics (inelastic collisions and Compton effect). Transformation of Energy and Momentum. **(7 Lectures)**

Reference Books:

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
2. Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
3. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
4. Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning
5. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
6. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
7. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
8. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
9. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
10. Relativistic Mechanics, Satya Prakash & K. P. Gupta, Pragati Prakashan, 2019.

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.

Suryanil
18/08/2026

26/08
18/08/26

18/08/2026

18/08/26

PHYSICS-MI-2: PRACTICAL**Credit: 01 Lectures: 30(15X2)****Instructions to Question Setters****End Semester Examination (ESE): 25 Marks**

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:

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

Note: No internal or mid-semester examination will be conducted for the practical paper

1. To measure the volume of a sphere/cylinder using vernier caliper.
2. To measure the diameter of a thick wire using screw gauge.
3. To determine the Height of a Building using a Sextant.
4. To study the random error in observations.
5. To study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
6. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
7. To determine the Young's Modulus of a Wire by suitable method.
8. To determine the Modulus of Rigidity of a Wire by suitable method.
9. To determine the elastic Constants of a wire by Searle's method.
10. To determine the value of g using Bar Pendulum.
11. To determine the value of g using Kater's Pendulum.
12. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2-T law.
13. To study Lissajous Figures.

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, I. Prakash & Ramakrishna, 11th Edn., 2011, Kitab Mahal.
4. Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
5. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.
6. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
7. B.Sc. Practical Physics, C. L. Arora, S. Chand & Company, 19th Edition, 1995, Reprint 2014.

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18/08/2026

18/08/26

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SEMESTER III**PHYSICS-MJ-3 THEORY: ELECTRICITY & MAGNETISM****Credits: 03 Lectures: 45**

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance=05) Pass Marks (Internal + End Semester) = 30

Instructions to Question Setters**Semester Internal Examination (SIE) – 10 Marks:**

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

- ✦ The course covers static and dynamic electric and magnetic field,
- ✦ It also includes analysis of electrical circuits and introduction of network theorems.
- ✦ By the end of the course student should be able to have an in depth understanding of electric field and electric potential, dielectric properties of matter, growth and decay of current, magnetic properties of matter analyse electrical circuits using network theorems.
- ✦ Also, students should learn about the basics of Ballistic galvanometer.

COURSE LEARNING OUTCOME

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

- ✦ 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.
- ✦ Explain and differentiate the vector (electric fields, Coulomb's law) and scalar (electric potential, electric potential energy) formalisms of electrostatics.
- ✦ Apply Gauss's law of electrostatics to solve a variety of problems.
- ✦ Articulate knowledge of electric current, resistance and capacitance in terms of electric field and electric potential.
- ✦ Demonstrate a working understanding of capacitors.
- ✦ Describe the magnetic field produced by magnetic dipoles and electric currents.
- ✦ Explain Faraday-Lenz and Maxwell laws to articulate the relationship between electric and magnetic fields.
- ✦ Understand the dielectric properties, magnetic properties of materials and the phenomena of electromagnetic induction.
- ✦ Describe how magnetism is produced and list examples where its effects are observed.
- ✦ Apply Kirchhoff's rules to analyse AC circuits consisting of parallel and/or series

Session 2025-2029 onwards

Sayan Saha
18/08/2026

18/08/26

18/08/2026

18/08/26

18/08/26

combinations of voltage sources and resistors and to describe the graphical relationship of resistance, capacitor and inductor.

- ✦ 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.
- ✦ In the laboratory course the student will get an opportunity to verify various laws in electricity and magnetism.
- ✦ Should be able to verify of various circuit laws, network theorems elaborated above, using simple electric circuits.

SKILLS TO BE LEARNED

- ✦ This course will help in understanding basic concepts of electricity and magnetism and their applications.
- ✦ Basic course in electrostatics will equips the student with required prerequisites to understand electrodynamic phenomena.

COURSE CONTENT

Electric Field and Electric Potential: Conservative nature of Electrostatic Field. Electrostatic Potential. Gauss' law in integral and differential form. Laplace's and Poisson equations & its solution in Cartesian coordinates, The Uniqueness Theorem. Multipole expansion (monopole, dipole & quadrupole), energy density in an electric field. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere. **(10 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. **(7 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. **(7 Lectures)**

Transients: Growth and Decay of currents in LR, CR, LC and LCR circuits. **(5 Lectures)**

Electrical 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. Anderson's bridge, De Sauty's Bridge and Owen's bridge & their vector diagram representation. Three phase electrical power supply, delta and star connections. **(8 Lectures)**

Network theorems: Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Reciprocity theorem, Maximum Power Transfer theorem and Superposition Theorem. **(5 Lectures)**

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

Reference Books:

1. Classical Electromagnetism, H.C. Verma, Bharati Bhawan (Publishers & Distributors); First Edition, 2022.
2. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, TMH

Session 2025-2029 onwards

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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. Electricity and Magnetism, D. C. Tayal, 1988, Himalaya Publishing House.
9. Electricity and Magnetism K. K. Tewari S. Chand and Company.

PHYSICS-MJ-3: PRACTICAL

Credit: 01 Lectures: 30(15X2)

Instructions to Question Setters

End Semester Examination (ESE): 25 Marks

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:

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

Note: No internal or mid-semester examination will be conducted for the practical paper

1. To find the value of a resistor and its tolerance by colour coding.
2. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
1. To study the characteristics of a series RC Circuit.
2. To verify the laws of combination (series and parallel) of resistances using a metre bridge
3. To determine an unknown Low Resistance using Potentiometer.
4. To verify Ohm's law for the given unknown resistance.
5. To determine an unknown Low Resistance using Carey Foster's Bridge.
6. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
7. To verify the Thevenin theorem.
8. To verify the Norton theorem.
9. To verify the Superposition theorem.
10. To verify Maximum power transfer theorem.
11. To determine self-inductance of a coil by Anderson's bridge.
12. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
13. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
14. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing 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. Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning.
5. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.
6. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
7. B.Sc. Practical Physics, C. L. Arora, S. Chand & Company, 19th Edition, 1995, Reprint 2014.

Session 2025-2029 onwards

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PHYSICS-MJ-4 THEORY: OPTICS**Credits: 03 Lectures: 45**

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance =05) Pass Marks (Internal + End Semester) = 30

Instructions to Question Setters**Semester Internal Examination (SIE) – 10 Marks:**

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

- ✦ The physics and mathematics of wave motion underlie many important phenomena. Light too, often displays properties that are wave-like. There are a number of phenomena in which light behaves as waves and displays wave properties such as interference, diffraction, and polarization, with emphasis on examples as seen in daily life.
- ✦ The course provides an in-depth understanding of wave phenomena of light, namely, interference and diffraction, with emphasis on practical applications of the same.

COURSE LEARNING OUTCOME

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

- ✦ Understand Interference as the superposition of waves from coherent sources derived from same parent source.
- ✦ Demonstrate understanding of Interference experiments: Young's Double Slit, Fresnel's biprism, Newton's Rings.
- ✦ Demonstrate basic concepts of Diffraction: Superposition of wavelets diffracted from apertures.
- ✦ Understand Fraunhofer Diffraction from a slit.

SKILLS TO BE LEARNED

- ✦ This course in the basics of optics will enable the student to understand various optical phenomena, principles, workings, and applications of optical instruments.
- ✦ He/she shall develop an understanding of Wave Motion and its properties.

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COURSE CONTENT

Wave Optics: Electromagnetic nature of light. Definition and properties of the wave front. Huygens Principle. Temporal and Spatial Coherence. **(7 Lectures)**

Interference: Division of amplitude and wavefront. Interference in Thin Films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index. **(10 Lectures)**

Interferometer: Michelson Interferometer-(1) Idea of form of fringes (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer and measurement of wavelength. **(10 Lectures)**

Fraunhofer diffraction: Single slit. Double slit. Plane transmission grating. Circular aperture and airy pattern, Resolving Power of a telescope. Resolving power of grating. **(10 Lectures)**

Fresnel Diffraction: 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 Zone Plate. **(8 Lectures)**

Reference Books:

1. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
2. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
3. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill.
4. Introduction to Geometrical and Physical Optics, B. K. Mathur, Gopal Printing.
5. A Text Book on Light, B. Ghosh and K. G. Mazumdar, 5thEdn., Reprint 2015, Sreedhar Publishers.
6. Geometrical and Physical Optics, P. K. Chakraborty, New Central Book Agency (P) Ltd.
7. A Text Book of Optics, Dr. N. Subrahmanyam, Brijlal, Dr. M. N. Avadhanulu, S. Chand Publishers.
8. Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.

PHYSICS-MJ-4: Practical

Credit: 01 Lectures: 30(15X2)

Instructions to Question Setters***End Semester Examination (ESE): 25 Marks***

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:

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

Note: No internal or mid-semester examination will be conducted for the practical paper

1. To find the focal length of a convex lens by plotting graphs between u and v or between $1/u$ and $1/v$.
2. To determine refractive index (μ) of the material of given prism by plotting a graph between angle of incidence (i) and angle of deviation (δ).
3. Familiarization with: Schuster's focusing; determination of angle of prism.
4. To determine refractive index of the Material of a prism using sodium source.
5. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
6. To determine wavelength of sodium light using Fresnel Biprism.
7. To determine wavelength of sodium light using Newton's Rings.
8. Determination of wavelength of Sodium light using Michelson Interferometer.

Session 2025-2029 onwards

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9. Determination of wavelength of Sodium light using Fabry – Perot interferometer.
10. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
11. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
12. To determine dispersive power and resolving power of a plane diffraction grating.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing 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. Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning.
5. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.
6. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
7. B.Sc. Practical Physics, C. L. Arora, S. Chand & Company, 19th Edition, 1995, Reprint 2014.

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SEMESTER IV**PHYSICS-MJ-5 THEORY: INDIAN KNOWLEDGE SYSTEM IN PHYSICS****Credits: 03 Lectures: 45**

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance =05) Pass Marks (Internal + End Semester) = 30
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Instructions to Question Setters**Semester Internal Examination (SIE) – 10 Marks:**

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

The course aims to explore the rich contributions of Indian knowledge systems (IKS) to the field of physics, including classical mechanics, optics, acoustics, and materials science, while integrating traditional Indian scientific principles with modern physics.

Also, this course intends to explore the historical contributions of Indian scholars to physics by analyzing scientific principles found in ancient Indian texts and examining their relevance to modern physics. Investigate traditional Indian perspectives on motion, optics, acoustics, materials science, and cosmology to understand how early thinkers conceptualized physical phenomena. Apply experimental methods to validate and interpret ancient Indian scientific theories, bridging historical knowledge with empirical investigation. Encourage interdisciplinary research that integrates Indian scientific heritage with contemporary advancements, fostering a holistic understanding of physics across different eras and knowledge systems.

COURSE LEARNING OUTCOME

By the end of the course, students will be able to:

- ✦ Identify key Indian physicists and their contributions to fundamental physics concepts.
- ✦ Compare classical Indian scientific theories with modern physics principles.
- ✦ Demonstrate the application of traditional Indian knowledge in practical experiments.
- ✦ Analyze ancient Indian technological achievements in optics, acoustics, and metallurgy.
- ✦ Critically evaluate Indian cosmological models and their scientific interpretations.
- ✦ Develop interdisciplinary insights bridging ancient wisdom and modern technology.

SKILLS TO BE LEARNED

Students will gain skills in:

Session 2025-2029 onwards

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- ✦ Analytical Thinking – Evaluating historical and scientific perspectives critically.
 - ✦ Experimental Application – Performing hands-on experiments inspired by ancient Indian discoveries.
 - ✦ Interdisciplinary Research – Integrating traditional Indian knowledge into modern scientific frameworks.
 - ✦ Scientific Writing & Communication – Presenting findings from comparative studies effectively.
 - ✦ Problem-Solving – Applying ancient techniques to innovative modern solutions in physics.
- Certainly! Here's a structured syllabus for an Indian Knowledge System in Physics course, designed with 3 theory credits (45 lectures) and 1 practical credit.

COURSE CONTENT

Foundations of Indian Knowledge System in Physics: Introduction to Indian Knowledge Systems in Science. Contributions of ancient Indian scholars such as Aryabhata, Bhaskara, Kanada, Nagarjuna, and others. Understanding the concept of physical laws in Vedic and Sutra literature. Ancient classification of matter and energy. Philosophical perspectives on space-time and causality. **(7 Lectures)**

Classical Mechanics and Motion: Concepts of motion in the Vaisheshika Sutra. Kanada's atomic theory and classification of substances. Ancient Indian texts on gravity and planetary motion. Kinetics and dynamics discussed in Sanskrit literature. Parallels between traditional and modern physics concepts. **(10 Lectures)**

Optics and Light: Optical theories found in Indian scriptures. Principles of reflection and refraction in ancient Indian writings. Concepts of light and vision in Nyaya and Vaisheshika philosophy. Study of spherical mirrors in the Surya Siddhanta. Applications of optics in ancient Indian architecture and astronomy. **(8 Lectures)**

Acoustics and Wave Theory: Sound propagation as described in ancient Indian texts. Nada Yoga: Understanding resonance, harmonics, and wave motion. Cymatics and frequency patterns in Vedic chants. Applications of acoustics in Indian musical instruments. The role of sound waves in spiritual and healing practices. **(8 Lectures)**

Materials Science and Metallurgy: Principles of metallurgy described in ancient Indian texts. Scientific explanation of rust-free iron, exemplified by the Delhi Iron Pillar. Processing and properties of alloys within India's rich metallurgical tradition. Influence of traditional materials science on modern engineering. Biophysics in Ayurveda and Indian medical practices. **(7 Lectures)**

Astronomy and Cosmology: Siddhantic astronomy and Indian cosmological models. Space-time concepts in Hindu philosophy. Earth's motion and celestial mechanics as presented in ancient Indian texts. Contributions of Indian astronomy to global knowledge. **(5 Lectures)**

Reference Books:

1. Ancient Indian Knowledge System of Physics, Dr. Anil Tiwari, Yajur Publishing House, 2024, ISBN: 978-8196931742
2. Indian Knowledge Systems – A Comprehensive Resource on Traditional Indian Sciences and Their Applications, Kapil Kapoor, Awadhesh Kumar Singh, D.K. Printworld, Volume 2, 2005, ISBN: 8124603367
3. Textbook on The Knowledge System of Bhārata, Bhag Chand Chauhan
4. History of Science in India, Volumes 1 (Parts I & II), Volume VIII, Sibaji Raha et al., National Academy of Sciences, India and The Ramakrishna Mission Institute of Culture, Kolkata, 2014
5. Indian Physics: Outline of Early History, David Pingree
6. Ayurvedic Physics: Theory and Practice of Ayurveda, Vasant D. Lad
7. Quantum Yoga: The Science of Inner Transformation, Amit Goswami

Session 2025-2029 onwards

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Reference Research Papers:

1. "Physics in Ancient Indian Knowledge System – A Research Paper Exploring Indian Contributions to Physics, Including Vedic Interpretations and Scientific Investigations," Ravi Sharma, Kamlesh Thakkar, K.K. Dubey, *Journal of Technology*, Volume 12, Issue 12, 2024
2. "Unearthing Some Scientific Aspects of Indian Knowledge Systems – A Study on the Scientific Aspects of Indian Knowledge, Including Astronomy, Acoustics, and Metallurgy," Dr. Rajeshwar Mukherjee, Academy of Research for Cultivation of Indian Sciences (ARCIS)
3. "Science in Ancient India: Physics of Ancient Indian Technologies – A Lecture-Based Document Covering Contributions of Indian Physicists Like Kanada, Aryabhata, and Varahamihira," *Vijnana Bharati*, 4th Edition, 2019.

PHYSICS-MJ-5: PRACTICAL**Credit: 01 Lectures: 30(15X2)*****Instructions to Question Setters******End Semester Examination (ESE): 25 Marks***

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:

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

Note: No internal or mid-semester examination will be conducted for the practical paper

1. Determine the focal length and magnification of traditional convex and concave lenses used in ancient Indian optics.
2. Analyze the reflection and refraction properties of metal mirrors used in old temples and manuscripts.
3. Study the dispersion of light through gemstones, as referenced in ancient Indian texts.
4. Measure the frequency and wavelength of sounds produced by different Indian musical instruments (sitar, tabla, veena) using modern techniques.
5. Determine the corrosion resistance of traditional metal artifacts, such as iron pillars, through environmental exposure experiments.
6. Analyze the thermal conductivity and electrical properties of alloys mentioned in Rasashastra texts.
7. Calculate planetary positions using formulas from Surya Siddhanta and compare them with modern astronomical data.
8. Determine the accuracy of Panchang calendar predictions by observing eclipses and planetary alignments.
9. Conduct star-position mapping using indigenous techniques and traditional instruments like the gnomon.
10. Experimentally validate the concept of projectile motion described in ancient Indian texts by measuring velocity and trajectory.
11. Determine the relationship between force, acceleration, and mass using traditional weighing and balancing methods.
12. Study rotational dynamics using spinning objects inspired by ancient Indian toys and devices.

Session 2025-2029 onwards

31

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Reference books:

1. Physics Practical Manual for UG & PG, Dr. Dinesh V Kala, Paperback, InSc International Publisher, 2020, ISBN-10: 8194831768, ISBN-13: 978-8194831761, <https://www.amazon.in/Physics-Practical-Manual-UG-PG/dp/8194831768>.
2. AICTE Recommended Books for Undergraduate Courses, Includes Classical Mechanics, Optics, Materials Science, and other engineering subjects, AICTE, 2018, <https://www.aicte-india.org/sites/default/files/list-suggested-books-indian-authors-publishers.pdf>.
3. Guidelines for Training of Faculty on Indian Knowledge Systems, University Grants Commission (UGC), 2022, https://www.ugc.gov.in/pdfnews/5855891_Guidelines-for-Indian-Knowledge-System.pdf.
4. Ancient Indian Knowledge System of Physics, Covers practical applications of Indian scientific principles, <https://ijcrt.org/papers/IJCRT2405418.pdf>.
5. Indian Knowledge Systems, Ministry of Education, Government of India, 2020, <https://iksindia.org/>.
6. Educational eBooks and Textbook Publishers in India, Pragati Prakashan, Established in 1955, Offers academic books for undergraduate and postgraduate courses, <https://www.pragatiprakashan.co.in/>.

PHYSICS-MJ-6 THEORY: ELECTROMAGNETIC THEORY**Credits: 03 Lectures: 45**

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance=05) Pass Marks (Internal + End Semester) = 30

Instructions to Question Setters**Semester Internal Examination (SIE) – 10 Marks:**

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

- ✦ The course deals with electromagnetic theory covering Maxwell's equations, propagation of electromagnetic waves in different homogeneous-isotropic as well as anisotropic unbounded and bounded media, production and detection of different types of polarized E. M. waves.

COURSE LEARNING OUTCOME

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

- ✦ Achieve an understanding of Maxwell's equations, the role of displacement current, gauge transformations, scalar and vector potentials, Coulomb and Lorentz gauge, boundary conditions at the interface between different media.

Session 2025-2029 onwards

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- ✦ Apply Maxwell's equations to deduce the wave equation, electromagnetic field energy, momentum, and angular momentum density.
- ✦ Analyse the phenomena of wave propagation in the unbounded and bounded media.
- ✦ Understand the laws of reflection and refraction and to calculate the reflection and transmission coefficients at the plane interface in bounded media.
- ✦ Understand the linear, circular, and elliptical polarisations of e m waves. Production as well as detection of waves in the laboratory.
- ✦ Understand propagation of e m waves in uniaxial and biaxial crystals phase retardation plates and their uses.
- ✦ Understand the concept of optical rotation, theories of optical rotation, and their experimental rotation, calculation of angle rotation, and specific rotation.
- ✦ Verify the laws of Polarisation for plane polarised light.
- ✦ Determine the Polarisation of light by Reflection and determine the polarization angle off or air-glass surface.
- ✦ Study the specific rotation of sugar using a Polarimeter.
- ✦ Analyse experimentally the Elliptically Polarised light using Babinet's Compensator

SKILLS TO BE LEARNED

- ✦ This course in electromagnetic theory will enable the student to understand the propagation of electromagnetic waves through different bound and unbound media.
- ✦ He/she shall develop an understanding of Wave Motion and its properties. Comprehend the role of Maxwell's equations in unifying electricity and magnetism.
- ✦ Derive the expression for Energy density.
- ✦ Derive and understand the properties associated with EM waves passing through the interface between two media, like reflection, refraction, and transmission.
- ✦ Learn the basic physics associated with the polarization of electromagnetic waves by doing various experiments for plane polarized light, circularly polarized light, and elliptically polarized light.

COURSE CONTENT

Maxwell Equations: Derivation of Maxwell's field equations. Displacement Current. Boundary Conditions at the Interface between Different Media. **(4 Lectures)**

EM Wave Propagation in Unbounded Media: Propagation of 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, and skin depth. Poynting Theorem and Poynting Vector. **(10 Lectures)**

EM Wave in Bounded Media: Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. **(10 Lectures)**

Polarization of Electromagnetic Waves: Description of Linear, Circular and Elliptical Polarization. Uniaxial and Biaxial Crystals. Double Refraction. Polarization by Double Refraction. Huygen's principle of double refraction. Ordinary & extraordinary refractive indices. Nicol Prism. 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. **(15 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. **(6 Lectures)**

Session 2025-2029 onwards

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Reference Books:

1. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
2. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
3. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill.
4. Introduction to Geometrical and Physical Optics, B. K. Mathur, Gopal Printing.
5. A Text Book on Light, B. Ghosh and K. G. Mazumdar, 5th Edn., Reprint 2015, Sreedhar Publishers.
6. Geometrical and Physical Optics, P. K. Chakraborty, New Central Book Agency (P) Ltd.
7. A Text Book of Optics, Dr. N. Subrahmanyam, Brijlal, Dr. M. N. Avadhanulu, S. Chand Publishers.
8. Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.
9. Classical Electromagnetism, H.C. Verma, Bharati Bhawan (Publishers & Distributors); First Edition, 2022.
10. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
11. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
12. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
13. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill.
14. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning.
15. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer.
16. Electromagnetic Fields & Waves, P. Lorrain & D. Corson, 1970, W. H. Freeman & Co.
17. Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
18. Electromagnetic Theory, Chopra and Agarwal, K. Nath & Co., Meerut.
19. Electromagnetic Theory and electrodynamics Satyaprakash, KedarNath Ram Nath Publishers
20. Electricity and Magnetism, K.K. Tewari, S Chand Publishers.
21. Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004, Cambridge University Press.

PHYSICS-MJ-6: Practical**Credit: 01 Lectures: 30(15X2)***Instructions to Question Setters***End Semester Examination (ESE): 25 Marks***There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:*

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

Note: No internal or mid-semester examination will be conducted for the practical paper

1. To verify the law of Malus for plane-polarized light.
2. To determine the specific rotation of the sugar solution using a Polarimeter.
3. Verification of Brewster's Law using a spectrometer.
4. To analyze elliptically polarized Light by using a Babinet's compensator.
5. To study the dependence of radiation on angle for a simple Dipole antenna.
6. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through the ultrasonic grating.
7. To study the reflection, refraction of microwaves
8. To study Polarization and double slit interference in microwaves.
9. To determine the refractive index of a liquid by total internal reflection using Wollaston's air-film.

Session 2025-2029 onwards

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10. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
11. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.

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, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
4. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
5. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
6. B.Sc. Practical Physics, C. L. Arora, S. Chand & Company, 19th Edition, 1995, Reprint 2014.

PHYSICS-MJ-7 THEORY: MATHEMATICAL PHYSICS-II

Credits: 03 Lectures: 45

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance =05) Pass Marks (Internal + End Semester) = 30

Instructions to Question Setters

Semester Internal Examination (SIE) – 10 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

- ✦ The emphasis of the course is to equip students with the mathematical tools required in solving problems of interest to physicists.
- ✦ To expose students to fundamental computational physics skills and hence enable them to solve a wide range of physics problems.
- ✦ To help students develop critical skills and knowledge that will prepare them not only for doing fundamental and applied research but also prepare them for a wide variety of careers.
- ✦ This course will aim at introducing the concepts of Fourier series, special functions, and solving linear partial differential equations by the separation of variables method.

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COURSE LEARNING OUTCOMES

On successfully completing this course, the students will be able to

- ✦ Represent a periodic function by a sum of harmonics using Fourier series and their applications in physical problems such as vibrating strings etc.
- ✦ Expand an odd or even function as half range sine and cosine Fourier series.
- ✦ Understand properties and applications of special functions like Legendre polynomials, Bessel functions and their differential equations and their applications in various physical problems such as in quantum mechanics.
- ✦ Learn about gamma and beta functions and their applications.
- ✦ Solve linear partial differential equations of second order with separation of variable method.
- ✦ Generate and plot Legendre polynomials and Bessel functions and verify their recurrence relations.

SKILLS TO BE LEARNED

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

COURSE CONTENT

Fourier series: Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Fourier series of square, saw-tooth and triangular waves. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series.

(14 Lectures)

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions.

(4 Lectures)

Frobenius Method and Special Functions: Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations: Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions ($J_0(x)$ and $J_1(x)$) and Orthogonality.

(15 Lectures)

Theory of Errors: Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error.

(4 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, rectangular and circular membranes. Diffusion Equation.

(8 Lectures)

Session 2025-2029 onwards

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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. Mathematical Physics with Classical Mechanics, Satya Prakash, Sultan Chand & Sons, 2014, 6th edition.
4. Mathematical Physics, P. K. Chattopadhyay, New Age International Publishers, 2004.
5. Mathematical Physics, B.D. Gupta, Vikash Publishing House, 2010, 4th edition.
6. Fundamental of Mathematical Physics, A. B. Gupta, Books & Allied Ltd, 2012, 5th edition.
7. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
8. Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
9. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
10. Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
11. Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
12. Engineering Mathematics, S. Pal and S.C. Bhunia, 2015, Oxford University Press.
13. Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books.
14. Mathematical Physics, Goswami, 1st edition, Cengage Learning.
15. Engineering Mathematics, S. Pal and S.C. Bhunia, 2015, Oxford University Press.
16. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
17. Mathematical Physics, B.S. Rajput, Pragati Prakashan, 21st Edition, 2009.
18. Mathematical Physics, H.K. Dass and R. Verma, S. Chand & Company.
19. Linear Algebra, W. Cheney, E. W. Cheney & D.R. Kincaid, 2012, Jones & Bartlett Learning.

Session 2025-2029 onwards

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PHYSICS-MJ-7: Practical**Credit: 01 Lectures: 30(15X2)****Instructions to Question Setters****End Semester Examination (ESE): 25 Marks**

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:

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

Note: No internal or mid-semester examination will be conducted for the practical paper

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 in Scilab, 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
Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen values problems	Solution of mesh equations of electric circuits (3 meshes) Solution of coupled spring mass systems (3 masses)
Generation of Special functions using User defined functions in Scilab	Generating and plotting Legendre Polynomials Generating and plotting Bessel function

Session 2025-2029 onwards

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Solution of ODE First order Differential equation Euler, modified Euler and Runge-Kutta second order methods Second order differential equation Fixed difference method Partial differential equations	First order differential equation - Radioactive decay - Current in RC, LC circuits with DC source - Newton's law of cooling - Classical equations of motion Second order Differential Equation - Harmonic oscillator (no friction) - Damped Harmonic oscillator - Over damped - Critical damped - Oscillatory - Forced Harmonic oscillator - Transient and - Steady state solution
	Apply above to LCR circuits also Solve $x^2 \frac{d^2 y}{dx^2} - 4x(1-x) \frac{dy}{dx} - 2(1-x)y = x^3$ boundary conditions at $x=1, y = \frac{1}{2}e^2, \frac{dy}{dx} = -\frac{3}{2}e^2 - 0.5$ in the range $1 \leq x \leq 3$. Plot y and $\frac{dy}{dx}$ against x in the given range on the same graph. Partial Differential Equation: - Wave equation - Heat equation - Poisson equation - Laplace equation
Using Scicos / xcos	- Generating square wave, sine wave, saw tooth wave - Solution to harmonic oscillator - Study of beat phenomenon - Phase space plots

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SEMESTER V**PHYSICS-MI-8 THEORY: MATHEMATICAL PHYSICS-III****Credits: 03 Lectures: 45**

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance=05) Pass Marks (Internal + End Semester) = 30

Instructions to Question Setters**Semester Internal Examination (SIE) – 10 Marks:**

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

- ✦ This course focuses on providing students with essential mathematical tools to tackle problems relevant to physicists.
- ✦ To make students determine continuity, differentiability, and analyticity of a complex function and find the derivative of a function.
- ✦ To help students understand properties of elementary complex functions (polynomials, reciprocals, exponential, trigonometric, hyperbolic, etc) of a single complex variable.
- ✦ To enable students to work with multi-valued functions (logarithmic, complex power, inverse trigonometric function) and determine branches of these functions
- ✦ To evaluate a contour integral using parametrization, the fundamental theorem of calculus, and Cauchy's integral formula.
- ✦ To find the Taylor series of a function and determine its radius of convergence;
- ✦ To determine the Laurent series expansion of a function in different regions and find the residues, use the residue theory to evaluate a contour integral and a real integral.
- ✦ To find the Fourier transform and the inverse Fourier transform of a function and understand their properties
- ✦ To enable students, understand the properties of the Laplace transform and inverse Laplace transform and use it to solve boundary value problems.

COURSE LEARNING OUTCOMES

On completing this course, the students will be able to

- ✦ learn about complex numbers and their properties, functions of complex numbers, and their properties such as analyticity, poles, and residues. The students are expected to learn the residue theorem and its applications in evaluating definite integrals.

Session 2025-2029 onwards

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- 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 transform, their properties, and their applications in solving physical problems.

SKILLS TO BE LEARNED

- These skills will aid in comprehending how the modelled system behaves.
- Ability to learn mathematics of complex variables and solve simple problems with relative functions, complex integrals, and their applications to physical problems.
- Ability to use the Fourier transform, the inverse Fourier transform, and apply in physical problems. Also, the ability to apply the Laplace transform, the inverse Laplace transform in solving physical problems.

COURSE CONTENT

Complex Analysis: Brief Revision of Complex Numbers and their Graphical Representation. 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 and branch points, order of singularity, branch cuts. 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.

(15 Lectures)

Integrals Transforms: Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three-dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One-dimensional Wave and Diffusion/Heat Flow Equations.

(15 Lectures)

Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along an infinite bar using the Laplace transform.

(15 Lectures)

Reference Books:

- Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
- Mathematical Physics with Classical Mechanics, Satya Prakash, Sultan Chand & Sons, 2014, 6th edition.
- Mathematical Physics, P. K. Chattopadhyay, New Age International Publishers, 2004.
- Mathematical Physics, B.D. Gupta, Vikash Publishing House, 2010, 4th edition.
- Fundamental of Mathematical Physics, A. B. Gupta, Books & Allied Ltd, 2012, 5th edition.
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- Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
- Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
- Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
- Engineering Mathematics, S. Pal and S.C. Bhunia, 2015, Oxford University Press.
- Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books.

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13. Mathematical Physics, Goswami, 1st edition, Cengage Learning.
14. Engineering Mathematics, S. Pal and S.C. Bhunia, 2015, Oxford University Press.
15. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
16. Mathematical Physics, B.S. Rajput, Pragati Prakashan, 21st Edition, 2009.
17. Mathematical Physics, H.K. Dass and R. Verma, S. Chand & Company.
18. Schaum's Outline of Complex Variables, Murray R. Spiegel, Seymour Lipschutz, John J. Schiller, Dennis Spellman, Second Edition.
19. Complex Variables, A.S. Fokas & M. J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press.
20. Complex Variables and Applications, J.W. Brown & R.V. Churchill, 7th Ed. 2003, Tata McGraw-Hill.
8. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett.
21. Linear Algebra, W. Cheney, E. W. Cheney & D.R. Kincaid, 2012, Jones & Bartlett Learning.
22. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press.

PHYSICS-MJ-8: Practical

Credit: 01 Lectures: 30(15X2)

Instructions to Question Setters

End Semester Examination (ESE): 25 Marks

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:

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

Note: No internal or mid-semester examination will be conducted for the practical paper

Scilab/C++ based simulation experiments based on Mathematical Physics problems like

1. Solve differential equations:

$$\frac{dy}{dx} = e^{-x} \quad y = 0 \text{ for } x = 0$$

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

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

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

2. Dirac Delta Functions:

Evaluate $\frac{1}{\sqrt{2\pi\sigma^2}} \int e^{-\frac{(x-2)^2}{2\sigma^2}} (x+3) dx$ for $\sigma = 1, 0.1, 0.01$ and show tends to 5.

3. Fourier Series:

Program to sum $\sum_{n=1}^{\infty} 0.2^n$

Evaluate the Fourier coefficients of a given periodic function (square wave).

4. Frobenius method and Special functions:

$$\int_{-1}^1 P_n(\mu) P_m(\mu) d\mu = \delta_{n,m}$$

Session 2025-2029 onwards

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Plot $P_n(x), j_n(x)$

Show the recursion relation.

5. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).
6. Calculation of least square fitting manually without giving weightage to error. Confirmation of the least square fitting of data through a computer program.
7. Evaluation of trigonometric functions e.g., $\sin \theta$, Given Bessel's function at N points, find its value at an intermediate point. Complex analysis: Integrate $1/(x^2+2)$ numerically and check with computer integration.
8. Compute the n^{th} roots of unity for $n = 2, 3$, and 4.
9. Find the two square roots of $-5+12j$.
10. Solve Kirchhoff's Current law for any node of an arbitrary circuit using Laplace's transform.
11. Solve Kirchhoff's Voltage law for any loop of an arbitrary circuit using Laplace's transform.
12. Perform circuit analysis of a general LCR circuit using Laplace's transform.

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

PHYSICS-MJ-9 THEORY: THERMAL PHYSICS

Credits: 03 Lectures: 45

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance =05) Pass Marks (Internal + End Semester) = 30

Instructions to Question Setters

Semester Internal Examination (SIE) – 10 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

Session 2025-2029 onwards

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COURSE OBJECTIVE

- ✦ This course will introduce Thermodynamics and Kinetic theory of gases to the students.
- ✦ The primary goal is to understand the fundamental laws of thermodynamics and their applications to various thermodynamic systems and processes.

COURSE LEARNING OUTCOMES

At the end of this course, students will

- ✦ Learn 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. They are also expected to learn Maxwell's thermodynamic relations.
- ✦ Know the fundamentals of the kinetic theory of gases, equipartition of energies, mean free path of molecular collisions, viscosity, thermal conductivity, diffusion, and Brownian motion.
- ✦ Learn the quantum statistical distributions, viz., the Bose-Einstein statistics and the Fermi-Dirac statistics.
- ✦ In the laboratory course, the students are expected to: Measure of Planck's constant using black body radiation, determine Stefan's Constant, coefficient of thermal conductivity of a bad conductor and a good conductor, determine the temperature co-efficient of resistance, study variation of thermo emf across two junctions of a thermocouple with temperature etc.

SKILLS TO BE LEARNED

- ✦ In this course, the students should be skilled in doing calculations in thermodynamics. They should also be proficient in doing calculations with the kinetic theory of ideal and real gases.
- ✦ In the laboratory course, the students should acquire the skills of doing basic experiments in thermal physics with the right theoretical explanations of results therefrom.

COURSE CONTENT**THERMAL PHYSICS**

Introduction to Thermodynamics: Zeroth Law and First Law of Thermodynamics and its differential form. Internal energy. Reversible and Irreversible Processes with examples. Interconversion of Work and Heat. Carnot's Theorem. Heat Engines. Carnot's Cycle, Carnot engine & efficiency, Refrigerator & coefficient of performance.

(6 Lectures)

Entropy: 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.

(8 Lectures)

Thermodynamic Potentials: Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibbs Free Energy. Their Definitions, Properties and Applications. Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples.

(8 Lectures)

Maxwell's Thermodynamic Relations: Derivations and Applications of Maxwell's Relations (1) Clausius-Clapeyron equation, (2) Values of $C_p - C_v$, (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases.

(8 Lectures)

Session 2025-2029 onwards

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KINETIC THEORY OF GASES

Molecular Collisions: Mean Free Path. Collision Probability. Estimation of Mean Free Path. Transport Phenomena in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity, and (3) Diffusion. Brownian Motion and its Significance. **(5 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. **(10 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, Oxford University Press
8. Advanced Text Book on Heat, P. K. Chakrabarti, 10th Edn., Reprint 2015, Sreedhar Prakashan.
9. Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.
10. Thermal Physics, B.K. Agrawal, Lok Bharti Publications.
11. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
12. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
13. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
14. An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press.

PHYSICS-MJ-9: Practical

Credit: 01 Lectures: 30(15X2)

Instructions to Question Setters***End Semester Examination (ESE): 25 Marks***

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:

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

Note: No internal or mid-semester examination will be conducted for the practical paper.

1. To determine the mechanical equivalent of heat (J) by Callendar and Barnes' constant flow method.
2. To measure Planck's constant using blackbody radiation.
3. To determine Stefan's constant.
4. To determine the coefficient of thermal conductivity of copper using Searle's apparatus.
5. To determine the coefficient of thermal conductivity of copper by Angstrom's method.
6. To study the variation of thermo-emf across two junctions of a thermocouple with temperature.
7. To determine the coefficient of thermal conductivity of a bad conductor using Lee and Charlton's disc method.

Session 2025-2029 onwards

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8. To determine the temperature coefficient of resistance using a platinum resistance thermometer.
9. To record and analyse the cooling temperature of a hot object as a function of time using a thermocouple and a suitable data acquisition system.
10. To calibrate a Resistance Temperature Detector (RTD) using the null method or off-balance method.
11. Study of the photoelectric effect and plotting graphs for:
 - Kinetic energy of photoelectrons vs. frequency of incident radiation.
 - Photocurrent vs. applied potential and determination of Planck's constant.
 - Kinetic energy vs. frequency and determination of stopping potential.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practical, 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. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
5. B.Sc. Practical Physics, C.L. Arora, S. Chand Publishing, Revised Edition, 2022.
6. Advanced Practical Physics (Vol. I & II), C.L. Arora, S. Chand Publishing, Latest Reprint, 2021.
7. Practical Physics, S.L. Gupta & V. Kumar, Pragati Prakashan, Reprint Edition, 2022.
8. Advanced Level Practical Physics, M.P. Poonia & S.C. Sharma, Hitech Publishing House, 1st Edition, 2020.
9. Practical Physics, S.P. Singh & M.K. Bagde, S. Chand Publishing, 4th Edition, 2021.
10. Advanced Practical Physics for Students, B.L. Worsnop & H.T. Flint, S. Chand Publishing (Indian Reprint), Reprint Edition, 2021.
11. Experimental Physics, R.K. Shukla & Anchal Srivastava, New Age International Publishers, 2nd Edition, 2019.
12. Laboratory Manual of Physics for UG & PG, K.K. Tiwari, Atmaram & Sons, 3rd Edition, 2021.
13. Mathematica and Computer-Based Physics Experiments, Arvind Kumar & K.C. Gupta, Narosa Publishing House, 1st Edition, 2018.

PHYSICS-MJ-10 THEORY: STATISTICAL MECHANICS**Credits: 03 Lectures: 45**

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance =05) Pass Marks (Internal + End Semester) = 30

Instructions to Question Setters**Semester Internal Examination (SIE) – 10 Marks:**

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

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COURSE OBJECTIVE

- ✦ This course provides students with an introduction to the principles of Statistical Mechanics.
- ✦ This coursework will help students grasp the relationship between macroscopic observations of physical systems and the microscopic behaviour of atoms and molecules, as explained through statistical mechanics.

COURSE LEARNING OUTCOMES

At the end of this course, students will

- ✦ Learn 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. They are also expected to learn Maxwell's thermodynamic relations.
- ✦ Gain an understanding of the Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, and Sackur-Tetrode equation, along with the Law of Equipartition of Energy. Explore black body radiation and the significance of Stefan-Boltzmann's law, Rayleigh-Jean's law, and Planck's law.
- ✦ Learn the quantum statistical distributions, viz., the Bose-Einstein statistics and the Fermi-Dirac statistics.

In the laboratory course, the students shall

- ✦ Analyze the computational behaviour of a system of particles governed by Newtonian mechanics and interacting via the Lennard-Jones potential.
- ✦ Investigate equilibrium properties such as local number density, fluctuations, and transient behaviour leading to equilibrium.
- ✦ Understand the relationship between large system size (N) and the arrow of time.
- ✦ Compute and compare velocity distributions with Maxwell velocity distribution.
- ✦ Study the dependence of mean molecular speed on particle mass and determine the fraction of molecules near the most probable speed in an ideal gas.
- ✦ Evaluate the partition function for finite-level systems under Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein statistics.
- ✦ Examine how statistical parameters such as energy, fluctuations, and heat capacity depend on temperature and system characteristics.
- ✦ Compare different statistical distributions at varying temperatures and analyze occupation number ratios.
- ✦ Plot and compare Planck's law and Rayleigh-Jeans law for black-body radiation at different temperatures.
- ✦ Assess specific heat models for solids, including the Dulong-Petit law, Einstein distribution function, and Debye distribution function.
- ✦ Graph key statistical distributions (Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein) as functions of energy at different temperatures.

SKILLS TO BE LEARNED

- ✦ In this course the students should be skilled in doing calculations in thermodynamics and in statistical mechanics.
- ✦ They should also be proficient in doing calculations with the kinetic theory of ideal and real gases.

In the laboratory course, the students will develop

- ✦ Computational modeling and numerical analysis skills for studying particle behaviour.
- ✦ Data visualization and interpretation techniques for equilibrium and transient dynamics.
- ✦ Critical thinking in understanding physical laws governing macroscopic and microscopic systems.
- ✦ Proficiency in statistical mechanics concepts, partition functions, and probability distributions.

Session 2025-2029 onwards

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- ↓ Ability to compare and evaluate different statistical approaches to thermodynamic properties.
- ↓ Mathematical and computational skills for plotting and analyzing physical phenomena.
- ↓ Practical understanding of black-body radiation and thermodynamic principles in solids.

COURSE CONTENT

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, Gibbs Paradox, 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. **(15 Lectures)**

Quantum Theory of Radiation: Spectral Distribution of Black Body Radiation. Inadequacy of classical radiation theory. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law. **(12 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. **(10 Lectures)**

Fermi-Dirac Statistics: Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals. **(8 Lectures)**

Reference Books:

1. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
2. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
3. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
4. Statistical Mechanics, K. Huang, 2Ed., 1987, Wiley.
5. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill.
6. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall.
7. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
8. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
9. An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press.

PHYSICS-MJ-10: Practical**Credit: 01 Lectures: 30(15X2)****Instructions to Question Setters****End Semester Examination (ESE): 25 Marks**

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:

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

Note: No internal or mid-semester examination will be conducted for the practical paper

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Use C/C++/Scilab/other numerical simulations for solving the problems based on Statistical Mechanics like

1. Computational analysis of the behaviour of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:
 - a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations
 - b) Study of transient behaviour of the system (approach to equilibrium)
 - c) Relationship of large N and the arrow of time
 - d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution
 - e) Computation and study of mean molecular speed and its dependence on particle mass
 - f) Computation of fraction of molecules in an ideal gas having speed near the most probable speed
2. Computation of the partition function $Z(\beta)$ for examples of systems with a finite number of single particle levels (e.g., 2 level, 3 level, etc.) and a finite number of non-interacting particles N under Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics:
 - a) Study of how $Z(\beta)$, average energy $\langle E \rangle$, energy fluctuation ΔE , specific heat at constant volume C_v , depend upon the temperature, total number of particles N and the spectrum of single particle states.
 - b) Ratios of occupation numbers of various states for the systems considered above
 - c) Computation of physical quantities at large and small temperature T and comparison of various statistics at large and small temperature T .
3. Plot Planck's law for Black Body radiation and compare it with Rayleigh-Jeans Law at high temperature and low temperature.
4. 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 two cases.
5. Plot the following functions with energy at different temperatures
 - a) Maxwell-Boltzmann distribution
 - b) Fermi-Dirac distribution
 - c) Bose-Einstein distribution

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practical, 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. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
5. B.Sc. Practical Physics, C.L. Arora, S. Chand Publishing, Revised Edition, 2022.
6. Advanced Practical Physics (Vol. I & II), C.L. Arora, S. Chand Publishing, Latest Reprint, 2021.
7. Practical Physics, S.L. Gupta & V. Kumar, Pragati Prakashan, Reprint Edition, 2022.
8. Advanced Level Practical Physics, M.P. Poonia & S.C. Sharma, Hitech Publishing House, 1st Edition, 2020.
9. Practical Physics, S.P. Singh & M.K. Bagde, S. Chand Publishing, 4th Edition, 2021.
10. Advanced Practical Physics for Students, B.L. Worsnop & H.T. Flint, S. Chand Publishing (Indian Reprint), Reprint Edition, 2021.
11. Experimental Physics, R.K. Shukla & Anchal Srivastava, New Age International Publishers, 2nd Edition, 2019.
12. Laboratory Manual of Physics for UG & PG, K.K. Tiwari, Atmaram & Sons, 3rd Edition, 2021.

Session 2025-2029 onwards

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13. Mathematica and Computer-Based Physics Experiments, Arvind Kumar & K.C. Gupta, Narosa Publishing House, 1st Edition, 2018.
14. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014Springer ISBN: 978-3319067896 Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444.
15. Scilab Image Processing, L. M. Surhone. 2010, Betascript Pub., ISBN: 978-6133459274.

PHYSICS-MJ-11 THEORY: ANALOG ELECTRONICS

Credits: 03 Lectures: 45

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance=05) Pass Marks (Internal + End Semester) = 30

Instructions to Question Setters

Semester Internal Examination (SIE) – 10 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

- ✦ In this paper students will get to learn both about Analog Electronics.
- ✦ They will learn about the physics of semiconductor p-n junction and devices such as rectifier diodes, Zener diode, photodiode etc. and bipolar junction transistors.
- ✦ Transistor biasing and stabilization circuits are explained. The concept of feedback is discussed in amplifiers and the oscillator circuits are also studied.

COURSE LEARNING OUTCOMES

At the end of this course, students will be able to develop the following learning outcomes:

- ✦ To have knowledge about characteristics of semiconductor materials in terms of band structure, movement of charge carriers, and to explain properties of n and p-type semiconductors.
- ✦ To know the basic concepts of p-n junction diode, its fabrication, conduction mechanism, and determine its barrier potential and width.
- ✦ To learn the structure and operation of simple p-n junction devices such as LED, photo diodes, Solar cells, Zener diodes, etc.
- ✦ To apply the basics of diodes to describe the working of rectifier circuits and quantitatively explain the effect of the capacitance filter, line, and load regulation
- ✦ n-p-n and p-n-p transistors and basic configurations, namely common base, common emitter, and common collector, and also about current and voltage gain.

Session 2025-2029 onwards

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- ✦ To understand the structure and operation of Bipolar Junction transistors. Also, be able to explain various current components and characteristics of different configurations. And also have a general idea about FET.
- ✦ To describe the application of transistors for current and voltage applications, the need for biasing and stabilization in transistor amplifiers.
- ✦ To analyse single-stage CE and two-stage RC coupled transistor amplifier using h- h-parameter model of the transistor.
- ✦ To understand the effect of feedback in amplifiers and apply it to design different types of oscillators.
- ✦ Operational amplifiers and knowledge about different configurations, namely inverting and noninverting.
- ✦ In the laboratory course students will gain an understanding of semiconductor devices, their characteristics, and applications in electronic circuits. They will analyze transistor configurations, amplifier designs, oscillators, and diode-based voltage regulators, applying theoretical concepts to practical scenarios.

SKILLS TO BE LEARNED

- ✦ In this course, students should be able to learn basic concepts of semiconductor diodes and their applications to rectifiers.
- ✦ Students should also learn about junction transistor and their applications.
- ✦ They should also learn about different types of amplifiers.
- ✦ Students also learn about sinusoidal oscillators.
- ✦ Learn about different types of amplifiers, including operational amplifiers. (Op-Amp) and their applications.
- ✦ In the laboratory course the students will develop hands-on proficiency in circuit analysis, electronic component characterization, and designing amplifiers and oscillators. They will also enhance their problem-solving abilities in semiconductor electronics and electrical measurements.

COURSE CONTENT

Semiconductor Diodes: P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. **(6 Lectures)**

Two-terminal Devices and their Applications: 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. **(6 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 and Saturation Regions. **(6 Lectures)**

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. **(6 Lectures)**

Coupled Amplifier: Two stage RC-coupled amplifier and its freq. response. **(3 Lectures)**

Session 2025-2029 onwards

FET: JFET- Construction, working and characteristics.

(2 Lectures)

Feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.

(3 Lecture)

Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts's 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 concept of Virtual ground. Inverting and non-inverting amplifiers, Adder, Subtractor, Differentiator, Integrator, Log amplifier.

(8 Lectures)

Reference Books:

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. A first Course in Electronics, Khan & Dey, PHI, 1/e, 2006.
3. Basic Electronics, Arun Kumar, Bharati Bhawan, 1/e, 2007.
4. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
5. Solid State Electronic Devices, B. G. Streetman & S. K. Banerjee, 6th Edn., 2009, PHI Learning.
6. Electronic Devices & circuits, S. Salivahanan & N. S. Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill.
7. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
8. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University 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.

PHYSICS-MJ-11: Practical

Credit: 01 Lectures: 30(15X2)

Instructions to Question Setters

End Semester Examination (ESE): 25 Marks

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:

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

Note: No internal or mid-semester examination will be conducted for the practical paper

1. To study V-I characteristics of PN junction diode, and verification of diode equation.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
6. Study of Output and Transfer Characteristics of JFET
7. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
8. To design a Wien bridge oscillator for given frequency using an op-amp.
9. To design a phase shift oscillator of given specifications using BJT.
10. To study the Colpitts oscillator.
11. To study the Hartley oscillator.

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12. Study of Half-wave Rectifier with and without C-Filter: Measurement of Ripple Factor and Efficiency
13. Study of Full-wave Rectifier (Centre-tapped and Bridge) with and without C-Filter
14. Study of Inverting and Non-inverting Amplifier using Op-Amp
15. Design and Study of an Op-Amp based Adder and Subtractor
16. Design and Study of Integrator and Differentiator using Op-Amp
17. Design of a Log Amplifier using Op-Amp

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, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
4. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
5. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
6. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
7. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
8. B.Sc. Practical Physics, C.L. Arora, S. Chand Publishing, Revised Edition, 2022.
9. Advanced Practical Physics (Vol. I & II), C.L. Arora, S. Chand Publishing, Latest Reprint, 2021.
10. Practical Physics, S.L. Gupta & V. Kumar, Pragati Prakashan, Reprint Edition, 2022.
11. Advanced Level Practical Physics, M.P. Poonia & S.C. Sharma, Hitech Publishing House, 1st Edition, 2020.
12. Practical Physics, S.P. Singh & M.K. Bagde, S. Chand Publishing, 4th Edition, 2021.
13. Advanced Practical Physics for Students, B.L. Worsnop & H.T. Flint, S. Chand Publishing (Indian Reprint), Reprint Edition, 2021.
14. Experimental Physics, R.K. Shukla & Anchal Srivastava, New Age International Publishers, 2nd Edition, 2019.
15. Laboratory Manual of Physics for UG & PG, K.K. Tiwari, Atmaram & Sons, 3rd Edition, 2021.
16. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
17. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
18. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
19. Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson.

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SEMESTER VI**PHYSICS-MJ-12 THEORY: DIGITAL ELECTRONICS****Credits: 03 Lectures: 45**

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance =05) Pass Marks (Internal + End Semester) = 30

Instructions to Question Setters**Semester Internal Examination (SIE) – 10 Marks:**

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

- ✚ In this paper, students will explore the fundamentals of Digital Electronics and gain a comprehensive understanding of its principles.
- ✚ This paper introduces the concept of Boolean algebra and basic digital electronics.
- ✚ In this course, students will be able to understand Arithmetic Circuits.

COURSE LEARNING OUTCOMES

At the end of this course, students will be able to develop following learning outcomes:

- ✚ Gaining a fundamental understanding of the principles of a Cathode Ray Oscilloscope (CRO).
- ✚ Differentiating between Analog and Digital circuits, the concepts of number systems like Binary, BCD, Octal, and hexadecimal are developed to elaborate on and focus on digital systems.
- ✚ Explains the concepts of logic states and logic gates AND, OR, NOT, NAND, NOR, XOR and XNOR as fundamental, universal, and derived gates with their utility.
- ✚ Covers the realisation of NOT, OR and AND gates using diodes and transistors.
- ✚ Students learn how to write logical Boolean statements using the truth table, its simplification using Boolean Algebra, De-Morgan's Theorem and Karnaugh Maps, specially the Sum of Products method, and realise the corresponding logic circuit.
- ✚ Understanding the Arithmetic circuits.
- ✚ Principles of Flip-Flops, timers, shift registers, and counters.
- ✚ In the laboratory course, the students will design a combinational logic system for a given equation, minimizing the logic circuit, Adder and Subtractor.

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SKILLS TO BE LEARNED

- ✦ In this course, students should be able to learn the basics of IC and digital circuits, and the difference between analog and digital circuits. Various logic GATES and their realization using diodes and transistors.
- ✦ Learn the fundamental of Boolean algebra and their role in constructing digital circuits.
- ✦ Understand basic Arithmetic circuits.

COURSE CONTENT

Introduction to CRO: Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference. **(4 Lectures)**

Digital Circuits: 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. **(6 Lectures)**

Boolean algebra: 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. **(6 Lectures)**

Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor. **(6 Lectures)**

Sequential Circuits: 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. **(8 Lectures)**

Timers: IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator. **(4 Lectures)**

Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits). **(4 Lectures)**

Counters (4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter. **(4 Lectures)**

Conversion: Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation). **(3 Lectures)**

Reference Books:

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. A first Course in Electronics, Khan & Dey, PHI, 1/e, 2006.
3. Basic Electronics, Arun Kumar, Bharati Bhawan, 1/e, 2007.
4. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
5. Solid State Electronic Devices, B. G. Streetman & S. K. Banerjee, 6th Edn., 2009, PHI Learning.
6. Electronic Devices & circuits, S. Salivahanan & N. S. Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill.
7. Electronic circuits: Handbook of design & applications, U. Tietze, C. Schenk, 2008, Springer.
8. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India.
9. Digital Computer Electronics, Malvino and Brown, 3/e, McGraw Hill Education.
10. Digital Electronics G K Kharate, 2010, Oxford University Press.
11. Digital Systems: Principles & Applications, R. J. Tocci, N. S. Widmer, 2001, PHI Learning.
12. Logic circuit design, Shimon P. Vingron, 2012, Springer.

Session 2025-2029 onwards

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13. Digital Systems and Applications, Nutan Lata, Pragati Prakashan, 1/e, 2019.
14. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
15. Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill.
16. Digital Electronics, Floyd.
17. Digital systems & Applications, Dr Umamageswari and Dr. M. Sivakumar, Vishal Publishing Co., 2022-23.

PHYSICS-MJ-12: Practical

Credit: 01 Lectures: 30(15X2)

Instructions to Question Setters

End Semester Examination (ESE): 20 Marks

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:

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

Note: No internal or mid-semester examination will be conducted for the practical paper

1. To measure (a) Voltage, and (b) Time period of a periodic waveform using a CRO.
2. To verify and design AND, OR, NOT, and XOR gates using NAND gates.
3. To design a digital-to-analog converter (DAC) of given specifications.
4. To study the analog-to-digital converter (ADC) IC.
5. To design a NOT gate switch using a transistor.
6. Study of Half Adder and Full Adder, and 4-bit binary Adder.
7. Study of Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
8. To build Flip-Flop (RS, Clocked RS, D-type, and JK) circuits using NAND gates.
9. To build JK Master-slave flip-flop using Flip-Flop ICs
10. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study the timing diagram.
11. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
12. To design an astable multivibrator of given specifications using a 555 Timer.
13. To design a monostable multivibrator of given specifications using a 555 Timer.

Reference Books:

1. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
2. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
3. Practical Physics, S.L. Gupta & V. Kumar, Pragati Prakashan, Reprint Edition, 2022.
4. Advanced Level Practical Physics, M.P. Poonia & S.C. Sharma, Hitech Publishing House, 1st Edition, 2020.
5. Practical Physics, S.P. Singh & M.K. Bagde, S. Chand Publishing, 4th Edition, 2021.
6. Advanced Practical Physics for Students, B.L. Worsnop & H.T. Flint, S. Chand Publishing (Indian Reprint), Reprint Edition, 2021.
7. Classical Mechanics and Fluid Dynamics (Lab Manual), J.C. Upadhyaya, Ram Prasad & Sons, Latest Edition, 2020.
8. Experimental Physics, R.K. Shukla & Anchal Srivastava, New Age International Publishers, 2nd Edition, 2019.
9. Laboratory Manual of Physics for UG & PG, K.K. Tiwari, Atmaram & Sons, 3rd Edition, 2021.

Session 2025-2029 onwards

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10. Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.
11. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
12. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
13. B.Sc. Practical Physics, C. L. Arora, S. Chand & Company, 19th Edition, 1995, Reprint 2014.
14. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
15. Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson.

PHYSICS-MJ-13 THEORY: ELEMENTS OF MODERN PHYSICS

Credits: 03 Lectures: 45

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance =05) Pass Marks (Internal + End Semester) = 30

Instructions to Question Setters

Semester Internal Examination (SIE) – 10 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

This course introduces modern development in Physics that ushered in relativity and quantum physics which not only revolutionized mankind's understanding of time, space, atomic and sub-atomic structures that make up the matter around us, but also led to fascinating developments in technology that are being witnessed all around us. Beginning with technological marvels like electronics, spectroscopy, semiconductor-based devices, IC chips, lasers, harnessing of nuclear energy, satellite communication, atomic clocks, GPS, space travel, scanning tunnelling microscope, nano-materials, nano-technology, CCDs, etc. modern physics brought forth useful tools in our daily lives like laptop computers, mobile phones, laser pointers, LEDs, LCD screens, so on and so forth. Therefore, the objective of this course is to teach the physical and mathematical foundations necessary for learning various topics in modern physics. Starting from Planck's law, this course introduces experimental observation of photo-ejection of electrons, idea of wave- particle duality as well as Bohr model of atoms and, then it develops the formulation of Schrodinger equation and the idea of probability interpretation associated with wave-

COURSE LEARNING OUTCOMES

The students will be able to learn the following from this course:

- ✦ Quantum measurements and the theory of wave packets and uncertainty principle.
- ✦ The central concepts of quantum mechanics: wave functions, momentum and energy operator, the Schrodinger equation, time dependent and time independent cases, probability

Session 2025-2029 onwards

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- density and the normalization techniques, skill development on problem solving e.g. one-dimensional rigid box, tunnelling through potential barrier, step potential, rectangular barrier.
- ✦ 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.
 - ✦ Decay rates and lifetime of radioactive decays like alpha, beta, gamma decay. Neutrino, its properties and its role in theory of beta decay.
 - ✦ Fission and fusion well as nuclear processes to produce nuclear energy in nuclear reactor and stellar energy in stars.
 - ✦ Various interactions of electromagnetic radiation with matter. Electron positron pair creation.
 - ✦ 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 details. Basic lasing.
 - ✦ In the laboratory course, the students will get opportunity to measure Planck's constant by more than one method, verify photoelectric effect and determination of the work Function of a metal, determine e/m of electron.
 - ✦ Ionization potential of atoms, wavelength of the emission lines in the spectrum of Hydrogen atom, absorption lines in the rotational spectrum of molecules.
 - ✦ The wavelength of Laser sources by single and Double slit experiment and the wavelength and angular spread of He-Ne Laser using plane diffraction grating.

SKILLS TO BE LEARNED

- ✦ Comprehend the failure of classical physics and need for quantum physics.
- ✦ Grasp the basic foundation of various experiments establishing the quantum physics by doing the experiments in laboratory and interpreting them.
- ✦ Formulate the basic theoretical problems in one-, two- and three-dimensional physics and solve them.
- ✦ Learning to apply the basic skills developed in quantum physics to various problems in
 - Nuclear Physics
 - Atomic Physics
 - Laser Physics
- ✦ Learn to apply basic quantum physics to Ruby Laser, He-Ne Laser
- ✦ This course shall develop an understanding of how to model a given problem, such as a particle in a box, hydrogen atom, hydrogen atom in electric fields.
- ✦ These skills will help in understanding the different Quantum Systems in atomic and nuclear physics.
- ✦ In the laboratory course Students will gain proficiency in designing and conducting physics experiments, analyzing data, and interpreting results in the context of quantum mechanics and modern physics. They will enhance their problem-solving abilities and practical laboratory skills in precision measurement and optical spectroscopy.

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 relation between them. Probability. Wave amplitude and wave functions. Davisson-Germer experiment. Discreteness of energy. Frank-Hertz Experiment.

(8 Lectures)

Quantum Uncertainty: Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables), gamma ray microscope thought experiment; Derivation from Wave Packets

Session 2025-2029 onwards

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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: Postulates of Quantum mechanics, 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.

(8 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.

(6 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 and its significance. Shell model and magic numbers.

(5 Lectures)

Radioactivity: Stability of the nucleus; Law of radioactive decay; Mean life and half-life; Successive disintegration; Elementary idea: 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.

(6 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)

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

(4 Lectures)

Reference Books:

1. A Text book of Quantum Mechanics, P. M. Mathews and K. Venkatesan, 2nd Ed., 2010, McGraw Hill.
2. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
3. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
4. Quantum Mechanics, G. Aruldas, 2nd Edn. 2002, PHI Learning of India.
5. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
6. Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer.
7. Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press.
8. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
9. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
10. Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer.
11. Quantum Physics, H. C. Verma, 2018, Surya Publications.
12. Quantum Mechanics, S. N. Biswas, Books & Allied (P) Ltd.
13. Advanced Quantum Mechanics, Satya Prakash, KedarNath Ram Nath Publisher.
14. Schaum's Outline of Modern Physics, McGraw-Hill, 1999.
15. Schaum's Outline of College Physics, by E. Hecht, 11th edition, McGraw Hill, 2009.
16. Modern Physics by K Sivaprasath and R Murugesan, S Chand Publication, 2010.
17. Quantum Mechanics: 500 problems and solutions by G. Aruldas. PHI Learning Pvt.Ltd., 2016.
18. Introduction to Quantum Mechanics, Nikhil Ranjan Roy, 2015, Vikas Publishing.
19. Elements of Nuclear Physics, Nikhil Ranjan Roy and Rakesh Kumar Pandey, Atlantic publishers & Distributors (P) Ltd., 2024.

Session 2025-2029 onwards

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20. An introduction to Lasers Theory and Applications, M. N. Avadhanulu and P. S. Hemne, S. Chand Publishing; First edition, 2012.
21. Lasers And Non-Linear Optics, B. B. Laud, New Age International Private Limited, 2011.
22. Lasers and Non-linear optics, G. D. Baruah, Pragati Prakashan, 2021.

PHYSICS-MJ-13: Practical

Credit: 01 Lectures: 30(15X2)

Instructions to Question Setters

End Semester Examination (ESE): 25 Marks

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:

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

Note: No internal or mid-semester examination will be conducted for the practical paper

1. Measurement of Planck's constant using black body radiation and a photo-detector
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
3. To determine the work function of the material of the filament of the directly heated vacuum diode.
4. To determine Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of the H-alpha emission line of the Hydrogen atom.
6. To determine the ionization potential of mercury.
7. To determine the absorption lines in the rotational spectrum of Iodine vapour.
8. To determine the value of e/m by (a) Magnetic focusing or (b) a Bar magnet
9. To set up the Millikan oil drop apparatus and determine the charge of an electron.
10. To show the tunnelling effect in a tunnel diode using I-V characteristics.
11. To determine the wavelength of laser source using diffraction of single slit.
12. To determine the wavelength of laser source using diffraction of double slits.
13. To determine (1) the wavelength and (2) the angular spread of the He-Ne laser using a plane diffraction grating.

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, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
4. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
5. B.Sc. Practical Physics, C.L. Arora, S. Chand Publishing, Revised Edition, 2022.
6. Advanced Practical Physics (Vol. I & II), C.L. Arora, S. Chand Publishing, Latest Reprint, 2021.
7. Practical Physics, S.L. Gupta & V. Kumar, Pragati Prakashan, Reprint Edition, 2022.
8. Advanced Level Practical Physics, M.P. Poonia & S.C. Sharma, Hitech Publishing House, 1st Edition, 2020.
9. Practical Physics, S.P. Singh & M.K. Bagde, S. Chand Publishing, 4th Edition, 2021.

Session 2025-2029 onwards

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10. Advanced Practical Physics for Students, B.L. Worsnop & H.T. Flint, S. Chand Publishing (Indian Reprint), Reprint Edition, 2021.
11. Experimental Physics, R.K. Shukla & Anchal Srivastava, New Age International Publishers, 2nd Edition, 2019.
12. Laboratory Manual of Physics for UG & PG, K.K. Tiwari, Atmaram & Sons, 3rd Edition, 2021.
13. Mathematica and Computer-Based Physics Experiments, Arvind Kumar & K.C. Gupta, Narosa Publishing House, 1st Edition, 2018.

PHYSICS-MJ-14 THEORY: QUANTUM MECHANICS AND APPLICATIONS

Credits: 03 Lectures: 45

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance=05) Pass Marks (Internal + End Semester) = 30

Instructions to Question Setters

Semester Internal Examination (SIE) – 10 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

After learning the elements of modern physics, students would be poised to learn more advanced topics like how to solve the Schrodinger equation for spherically symmetric potentials. Then, in this course, eigenvalues and eigen functions of the Hamiltonian as well as the orbital angular momentum would be studied. Furthermore, application of Schrodinger equation to various quantum mechanical problems would be taken up. The spin angular momentum of electrons would also be introduced in the course.

COURSE LEARNING OUTCOMES

The students will be able to learn the following from this course:

- ✦ Familiarization with quantum mechanics formulation.
- ✦ After an exposition of inadequacies of classical mechanics in explaining microscopic phenomena, quantum theory formulation is introduced through Schrodinger equation.
- ✦ The interpretation of wave function of quantum particle and probabilistic nature of its location and subtler points of quantum phenomena are exposed to the student.
- ✦ Methods to solve time-dependent and time-independent Schrodinger equation
- ✦ Through understanding the behavior of quantum particle encountering a barrier potential, the student gets exposed to solving non-relativistic hydrogen atom, for its spectrum and eigenfunctions.

Session 2025-2029 onwards

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- ✚ Study of influence of electric and magnetic fields on atoms will help in understanding Stark effect and Zeeman Effect respectively.
- ✚ Angular momentum: Orbital angular momentum and spin angular momentum.
- ✚ Bosons and fermions - symmetric and anti-symmetric wave functions.
- ✚ Application to atomic systems

SKILLS TO BE LEARNED

- ✚ This course shall develop an understanding of how to model a given problem such as hydrogen, particle in a box etc. atom etc using wave function, operators and solve them.
- ✚ These skills will help in understanding the different Quantum Systems.

COURSE CONTENT

Time dependent Schrodinger equation: 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 independent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Position-momentum uncertainty principle. **(8 Lectures)**

General discussion of bound states in an arbitrary potential: 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. **(8 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; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m ; s , p , d ,.... **(8 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 Magnetron. Normal and Anomalous Zeeman Effect. Paschen Back effect. **(8 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. **(7 Lectures)**

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Reference Books:

1. A Text book of Quantum Mechanics, P. M. Mathews and K. Venkatesan, 2nd Ed., 2010, McGraw Hill.
2. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
3. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
4. Quantum Mechanics, G. Aruldas, 2nd Edn. 2002, PHI Learning of India.
5. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
6. Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer.
7. Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press.
8. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
9. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
10. Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer.
11. Quantum Physics, H. C. Verma, 2018, Surya Publications.
12. Quantum Mechanics, S. N. Biswas, Books & Allied (P) Ltd.
13. Advanced Quantum Mechanics, Satya Prakash, KedarNath Ram Nath Publisher.
14. Introduction to Quantum Mechanics, Nikhil Ranjan Roy, 2015, Vikas Publishing.

PHYSICS-MJ-14: Practical**Credit: 01 Lectures: 30(15X2)****Instructions to Question Setters****End Semester Examination (ESE): 25 Marks**

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:

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

Note: No internal or mid-semester examination will be conducted for the practical paper.

Use C/C++/Scilab/Python 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 the hydrogen atom:

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

where 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) $^{1/2}$, $\hbar c = 1973$ (eVÅ) and $m = 0.511 \times 10^6$ eV/c 2 .

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

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

$$V(r) = \frac{-e^2}{r} e^{-r/a}$$

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

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3. 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 $e = 3.795 \text{ (eV\AA)}^{1/2}$, $m = 0.511 \times 10^6 \text{ eV/c}^2$, and $a = 3 \text{ \AA}, 5 \text{ \AA}, 7 \text{ \AA}$. In these units $\hbar c = 1973 \text{ (eV\AA)}$. The ground state energy is expected to be above -12 eV in all three cases.

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

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

5. For an harmonic 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 $m = 940 \text{ MeV/c}^2$, $k = 100 \text{ MeV fm}^{-2}$, $b = 0, 10, 30 \text{ MeV fm}^{-3}$. In these units, $\hbar c = 197.3 \text{ MeV fm}$. The ground state energy is expected to lie between 90 and 110 MeV for all three cases.

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

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

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

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

Laboratory-based experiments:

8. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
9. Study of Zeeman effect: with external magnetic field; Hyperfine splitting.
10. To show the tunneling effect in tunnel diode using V-I characteristics.
11. Quantum efficiency of CCDs.

Reference Books:

1. Hubbard, J. (2000). Schaum's Outline of Programming with C++. McGraw-Hill.
2. Press, W. H., Teukolsky, S. A., Vetterling, W. T., & Flannery, B. P. (2007). Numerical Recipes in C: The Art of Scientific Computing (3rd ed.). Cambridge University Press.
3. Pang, T. (2006). An Introduction to Computational Physics (2nd ed.). Cambridge University Press.
4. Vande Wouwer, A., Saucez, P., & Fernández, C. V. (2014). Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications. Springer.
5. Ramchandran, H., & Nair, A. S. (2011). Scilab: A Free Software to MATLAB. S. Chand & Company.
6. Hunt, B. R., Lipsman, R. L., & Rosenberg, J. M. (2014). A Guide to MATLAB (3rd ed.). Cambridge University Press.
7. Surhone, L. M. (Ed.). (2010). Scilab Image Processing. Betascript Publishing. ISBN: 978-6133459274.
8. Kumar, A., & Gupta, K. C. (2018). Mathematica and Computer-Based Physics Experiments (1st ed.). Narosa Publishing House.

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PHYSICS-MJ-15 THEORY: CLASSICAL DYNAMICS**Credits: 03 Lectures: 45**

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance =05) Pass Marks (Internal + End Semester) = 30

Instructions to Question Setters**Semester Internal Examination (SIE) – 10 Marks:**

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

This course on classical dynamics trains the student in problem solving ability and develops understanding of physical problems. The course begins with the review of Newton's Laws of Motion and ends with the Special Theory of Relativity by 4-vector approach and fluids. Students will also learn the Lagrangian and Hamiltonian Mechanics. The emphasis of this course is to enhance the understanding of Classical Mechanics (Lagrangian and Hamiltonian Approach). By the end of this course, students should be able to solve the seen or unseen problems/numericals in classical mechanics.

COURSE LEARNING OUTCOMES

- ✦ Understand the physical principle behind the derivation of Lagrange and Hamilton equations, and the advantages of these formulations.
- ✦ Translate physical problems into appropriate mathematical language and apply appropriate mathematical tools – particularly, calculus, differential equations, linear algebra, and the calculus of variations – to analyse and solve the resulting equations.
- ✦ Apply Lagrangian & Hamiltonian methods to complex motion problems.
- ✦ One will be able to relate symmetries to conservation laws in physical systems, and apply these concepts to practical situations.
- ✦ Understand the intricacies of motion of particle in central force field. Critical thinking and problem-solving skills
- ✦ Review the retarded potentials, potentials due to a moving charge, Lienard Wiechert potentials, electric and magnetic fields due to a moving charge, power radiated, Larmor's formula and its relativistic generalization.
- ✦ Recapitulate and learn the special theory of relativity- postulates of the special theory of relativity, Lorentz transformations on space-time and other four vectors, four-vector notations, space-time invariant, length contraction, time dilation, mass-energy relation, Doppler effect, light cone and its significance, problems involving energy- momentum conservations.
- ✦ Learn the basics of fluid dynamics, streamline and turbulent flow, Reynolds's number, coefficient of viscosity and Poiseuille's equation.
- ✦ Upon taking the classical dynamics course students will be able to integrate competently

Session 2025-2029 onwards

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the knowledge and skills acquired in post-undergraduate studies.

- ✦ The laboratory course will enhance the understanding of fundamental physical principles by exploring charged particle dynamics, oscillatory motion, fluid mechanics, and space-time concepts through experiments and simulations.

SKILLS TO BE LEARNED

- ✦ Learn to define generalised coordinates, generalised velocities, generalised force, and write Lagrangian for mechanical system in terms of generalised coordinates.
- ✦ Learn to derive the Euler-Lagrange equation of motion and solve them for simple mechanical systems.
- ✦ Learn to write Hamiltonian for mechanical systems and derive and solve Hamilton's equation of motion for simple mechanical systems.
- ✦ Formulate the problem of small amplitude oscillation and solve it to obtain normal modes of oscillation and their frequencies in simple mechanical systems.
- ✦ Develop the basic concepts of the special theory of relativity and its applications to dynamical systems of particles.
- ✦ Develop the methods of relativistic kinematics of one and two-particle system and their application to two-particle decay and scattering.
- ✦ Develop and understand the basic concepts of fluid dynamics and its applications to simple problems in liquid flow.
- ✦ The laboratory course will develop skills in mathematical modelling, data analysis, experimental techniques, and critical thinking, which are essential for tackling complex physics problems and applications in engineering and research.

COURSE CONTENT

Classical Mechanics of Point Particles: Review of Newtonian Mechanics; Application to the motion of a charge particle in external electric and magnetic fields- motion in uniform electric field, magnetic field- gyroradius and gyrofrequency, motion in crossed electric and magnetic fields. Generalized coordinates and velocities, Hamilton's principle, Lagrangian and the Euler-Lagrange equations, one-dimensional examples of the Euler-Lagrange equations- one-dimensional Simple Harmonic Oscillations and falling body in uniform gravity; applications to simple systems such as coupled oscillators, Canonical momenta & Hamiltonian. Hamilton's equations of motion.

Applications: Hamiltonian for a harmonic oscillator, solution of Hamilton's equation for Simple Harmonic Oscillations; particle in a central force field- conservation of angular momentum and energy.

(15 Lectures)

Small Amplitude Oscillations: Minima of potential energy and points of stable equilibrium, expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations, example of N identical masses connected linearly to $(N-1)$ - identical springs.

(8 Lectures)

Special Theory of Relativity: Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone, and world lines. Space-time diagrams. Time-dilation, length contraction, and twin paradox. Four-vectors: space-like, time-like, and light-like. Four-velocity and acceleration. Metric and alternating tensors. Four-momentum and energy-momentum relation. Doppler effect from a four-vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to the two-body decay of an unstable particle.

(15 Lectures)

Session 2025-2029 onwards

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Fluid Dynamics: Density and pressure P in a fluid, an element of fluid and its velocity, continuity equation and mass conservation, streamlined motion, laminar flow, Poiseuille's equation for flow of a liquid through a pipe, Navier-Stokes equation, qualitative description of turbulence, Reynolds number

(7 Lectures)

Reference Books:

1. Classical Mechanics, H. Goldstein, C.P. Poole, J.L. Safko, 3rd Edn., Pearson Education 2002.
2. Mechanics, L. D. Landau and E. M. Lifshitz, Pergamon, 1976.
3. Classical Mechanics, P.S. Joag, N.C. Rana, 1st Edn., McGraw Hall.
4. Classical Mechanics, R. Douglas Gregory, Cambridge University Press, 2015.
5. Solved Problems in Classical Mechanics, O.L. Delange and J. Pierrus, Oxford Press, 2010.
6. Classical Mechanics, Tai L. Chow, CRC Press.
7. Introduction to Classical Mechanics, Nikhil Ranjan Roy, Vikash Publishing.
8. Classical Mechanics, J. C. Upadhyaya, Himalaya Publishing House, 1 January, 2019.
9. Classical Mechanics, Gupta, Kumar, Sharma, Pragati Prakashan, 2012.
10. Classical Mechanics, B. D. Gupta, Satya Prakash, Kedar Nath Ram Nath Publication, 2020
11. Classical Mechanics, John R. Taylor, University Science Books, 2005.
12. Analytical Mechanics, Louis N. Hand and Janet D. Finch, Cambridge University Press, 1998.
13. Classical Dynamics of Particles and Systems, Stephen T. Thornton and Jerry B. Marion, Cengage Learning.
14. Classical Mechanics, Walter Greiner, Springer.
15. Introduction to Classical Mechanics, David Morin, Cambridge University Press, 2008.

PHYSICS-MJ-15: Practical

Credit: 01 Lectures: 30(15X2)

Instructions to Question Setters

End Semester Examination (ESE): 25 Marks

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:

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

Note: No internal or mid-semester examination will be conducted for the practical paper

1. To determine the coupling coefficient of coupled pendulums.
2. To determine the coupling coefficient of coupled oscillators.
3. To determine the coupling and damping coefficient of a damped coupled oscillator.
4. To observe the trajectory of a charged particle in a uniform electric field.
5. To verify the gyroradius and gyrofrequency of charged particles moving in a uniform magnetic field.
6. Investigate the drift velocity of a charged particle in perpendicular E and B fields.
7. Study oscillations using a mass-spring system or pendulum.
8. Investigate normal modes of two pendulums connected by a spring.
9. Examine potential energy minima and stable equilibrium points.
10. Visualize space-time contraction and dilation effects using software simulations.
11. Study fluid flow characteristics using the Reynolds number.
12. Measure the pressure drop across a pipe to validate Poiseuille's equation.
13. Verify the principle of the continuity equation using narrowing pipe setups.

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Reference Books:

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
 2. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
 3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
 4. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
 5. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
 6. B.Sc. Practical Physics, C.L. Arora, S. Chand Publishing, Revised Edition, 2022.
 7. Advanced Practical Physics (Vol. I & II), C.L. Arora, S. Chand Publishing, Latest Reprint, 2021.
 8. Practical Physics, S.L. Gupta & V. Kumar, Pragati Prakashan, Reprint Edition, 2022.
 9. Advanced Level Practical Physics, M.P. Poonia & S.C. Sharma, Hitech Publishing House, 1st Edition, 2020.
 10. Practical Physics, S.P. Singh & M.K. Bagde, S. Chand Publishing, 4th Edition, 2021.
 11. Advanced Practical Physics for Students, B.L. Worsnop & H.T. Flint, S. Chand Publishing (Indian Reprint), Reprint Edition, 2021.
 12. Classical Mechanics and Fluid Dynamics (Lab Manual), J.C. Upadhyaya, Ram Prasad & Sons, Latest Edition, 2020.
 13. Experimental Physics, R.K. Shukla & Anchal Srivastava, New Age International Publishers, 2nd Edition, 2019.
 14. Laboratory Manual of Physics for UG & PG, K.K. Tiwari, Atmaram & Sons, 3rd Edition, 2021.
 15. Mathematica and Computer-Based Physics Experiments, Arvind Kumar & K.C. Gupta, Narosa Publishing House, 1st Edition, 2018.
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FOURTH YEAR PAPERS FOR PHYSICS MAJOR WITH BACHELOR'S DEGREE (HONOURS WITH RESEARCH)

The Bachelor's degree (Honours with Research) includes the following essential research elements to strengthen students' analytical and investigative abilities:

✦ Research Methodology [1x4 = 4 Credits]

Students shall undertake a compulsory 4-credit course in Research Methodology. This course will focus on subject-specific research methods, aiming to develop essential skills required for conducting academic and applied research.

✦ Research Proposal - Planning and Techniques [1x4 = 4 Credits]

Students shall also undertake a 4-credit, activity-based course on research proposal development. This course will guide them through the processes of project formulation, literature review, data collection, and the application of techniques relevant to laboratory experiments, field studies, surveys, and internships.

✦ Research Internship & Dissertation/Thesis [1x8 = 8 Credits]

In Semester VIII, students shall complete an 8-credit research internship and dissertation/thesis. This component will involve hands-on research through laboratory work, field projects, surveys, or internships. Students are required to submit a comprehensive research report and defend their dissertation/thesis before an evaluation committee.

The evaluation shall consider the following aspects:

- Project dissertation design
- Methodology and content depth
- Participation in an internship programme with a reputed organization
- Application of research techniques in data collection
- Data Analysis
- Report presentation
- Presentation style
- Results and discussion
- Future scope
- References

Marks distribution may be as follows or adjusted as appropriate:

- Assessment of Project Synopsis: 50 marks
- Assessment of Project Thesis: 100 marks
- Viva-voce: 50 marks

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SEMESTER VII**PHYSICS-MJ-16 THEORY: RESEARCH METHODOLOGY****Credits: 04 Lectures: 60**

Marks: 100 (End Semester Examination=75 Semester Internal Examination= 20 (Theory), Class Performance & Attendance =05) **Pass Marks (Internal + End Semester) = 40**

Instructions to Question Setters**Semester Internal Examination (SIE) – 20 Marks:**

The question paper will be divided into two groups: Group A and Group B.

Group A: Group A is compulsory, which will contain two questions.

Question No.1 will consist of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Question No.2 will be the short-answer type of 5 marks. This question is also compulsory.

Group B: Contains two descriptive-type questions, each carrying 10 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 75 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains six descriptive-type questions, each carrying 15 marks. Candidates are required to answer any four questions from this group.

Note: Questions in the theory papers may have subdivisions.

In Semester VII, students shall be required to undertake a compulsory 4-credit course in Research Methodology, which will cover subject-specific research methods aimed at developing essential research skills.

COURSE OBJECTIVES

- To introduce students to the basic concepts of research and research methodology.
- To develop an understanding of research design, data collection methods, and data analysis techniques.
- To equip students with skills for formulating research problems, hypotheses, and conducting literature reviews.
- To enable students to write research proposals and reports ethically and systematically.

COURSE OUTCOMES

After completion of the course, students will be able to:

1. Understand the fundamentals of research and its types.
2. Formulate research problems and hypotheses.
3. Conduct literature surveys using digital tools and databases.
4. Apply qualitative and quantitative research techniques.
5. Prepare research proposals, reports, and theses.
6. Understand ethical issues in research and plagiarism.

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COURSE CONTENT**Unit I: Introduction to Research****(12 Lectures)**

- Meaning, Objectives, and Characteristics of Research
- Types of Research: Basic, Applied, Descriptive, Analytical, Quantitative, Qualitative, Experimental
- Research in Interdisciplinary and Multidisciplinary Contexts
- Scientific Method and Research Process
- Identification and Formulation of Research Problem

Unit II: Literature Review and Research Design**(12 Lectures)**

- Sources of Literature: Journals, Books, Databases (INFLIBNET, JSTOR, Google Scholar, Scopus)
- Techniques of Review Writing and Referencing Styles (AIP/APA/MLA/Chicago)
- Plagiarism and Academic Integrity: Use of Plagiarism Detection Tools (Turnitin, URKUND)
- Research Design: Concept, Components, and Types (Exploratory, Descriptive, Experimental)

Unit III: Data Collection and Sampling Techniques**(12 Lectures)**

- Primary and Secondary Data
- Methods of Data Collection: Observation, Interview, Questionnaire, Survey, Case Study
- Sampling Techniques: Probability and Non-probability Sampling
- Tools and Techniques for Data Collection (e.g., Google Forms, Surveys)

Unit IV: Data Analysis and Interpretation**(12 Lectures)**

- Classification, Tabulation, and Presentation of Data (Charts, Graphs, Tables)
- Measures of Central Tendency and Dispersion
- Correlation and Regression Basics
- Introduction to Statistical Software (SPSS, Excel, R, Python – basic commands)
- Interpretation and Drawing Inferences

Unit V: Research Reporting and Ethics**(12 Lectures)**

- Structure of Research Report/Thesis
- Referencing and Citation Management Tools (Zotero, Mendeley)
- Ethics in Research: Fabrication, Falsification, Plagiarism, Authorship Issues
- IPR, Patents, Copyright, and Open Access Publishing

Suggested Readings and Tools

1. Research Methodology: Methods and Techniques, C. R. Kothari and Gaurav Garg, New Age International Publishers, 4th ed., 2019.
2. Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar, Pearson Education, 5th ed., 2021.
3. Research Methodology, R. Panneerselvam, PHI Learning Pvt. Ltd., 2nd ed., 2014.
4. Research Methodology: Concepts and Cases, Deepak Chawla and Neena Sondhi, Vikas Publishing, 2nd ed., 2016.
5. Data Reduction and Error Analysis for the Physical Sciences, Philip R. Bevington and D. Keith Robinson, McGraw-Hill Education, 3rd ed., 2003.
6. How to Write and Publish a Scientific Paper, Robert A. Day and Barbara Gastel, Cambridge University Press, 8th ed., 2016.
7. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, John W. Creswell and J. David Creswell, SAGE Publications, 5th ed., 2018.
8. Technical Report Writing, Aditham Bhujanga Rao, PHI Learning Pvt. Ltd., 1st ed., 2012.

Session 2025-2029 onwards

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PHYSICS-MJ-17 THEORY: SOLID STATE PHYSICS**Credits: 03 Lectures: 45**

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance =05) Pass Marks (Internal + End Semester) = 30

Instructions to Question Setters**Semester Internal Examination (SIE) – 10 Marks:**

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

The introduction to this course caters to the basic concepts and principles to understand the various properties exhibited by condensed matter, especially solids. These properties depend on the chemical constituents making the particular solid and their arrangement in the crystal. A semi-classical approach is used to introduce various models, from a toy model to a higher level, suitable to explain the particular property exhibited by the solid. Towards the end of this course, some basic nuclear physics and radioactivity have been introduced.

COURSE LEARNING OUTCOMES

On completion of the course, students will be able to:

- ✚ Learn the concept of lattices, crystals, and symmetry operations.
- ✚ Explain the concepts such as the reciprocal lattice and the Brillouin zone, and the dynamics of atoms and electrons in solids.
- ✚ Explain the diffraction of X-rays by solids to determine the crystal structure.
- ✚ Understand the elementary lattice dynamics and its influence on the properties of materials.
- ✚ Understand lattice vibrations, phonons and in-depth Einstein and Debye theory of specific heat of solids.
- ✚ Describe the main features of the physics of electrons in solids.
- ✚ Understand the origin of energy bands, and how they influence electronic behavior.
- ✚ Explain the origin of dia-, para-, and ferro-magnetic properties of solids.
- ✚ Explain the origin of the dielectric properties exhibited by solids and the concept of polarizability.
- ✚ Understand the basics of phase transitions and the preliminary concept and experiments related to superconductivity in solid.
- ✚ Apply the gained knowledge to solve problems in solid state physics using relevant mathematical tools.
- ✚ To appreciate how matter exhibits such interesting and wonderful properties and communicate the importance of solid-state physics in the modern society.

Session 2025-2029 onwards

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- ✦ The understand properties of nuclei like density, size, binding energy, nuclear forces and structure of atomic nucleus, liquid drop model and mass formula.
- ✦ To calculate the decay rates and lifetime of radioactive decays like alpha and beta
- ✦ Fission and fusion well as nuclear processes to produce nuclear energy in nuclear reactor and stellar energy in stars.
- ✦ 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 determine the hall coefficient of a semiconductor.

SKILLS TO BE LEARNED

- ✦ Learn basics of crystal structure and physics of lattice dynamics
- ✦ Learn the physics of different types of material like magnetic materials, dielectric materials, metals and their properties.
- ✦ Understand the physics of insulators, semiconductor and conductors with special emphasis on the elementary band theory of semiconductors.
- ✦ Comprehend the basic theory of superconductors. Type I and II superconductors, their properties and physical concept of BCS theory.

COURSE CONTENT

Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Bravais lattice, 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, Laue theory of X-ray diffraction, Atomic and Geometrical Factor. **(10 Lectures)**

Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear Monoatomic 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. **(8 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. **(6 Lectures)**

Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mossotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeier relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons. **(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. **(4 lectures)**

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Elementary band theory: Bloch Theorem, Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (four-probe method) & Hall coefficient. **(6 Lectures)**

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. BCS theory (elementary idea). **(3 Lectures)**

Reference Books:

1. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
2. Elements of Solid State Physics, J.P. Srivastava, 2nd Edition, 2006, Prentice-Hall of India.
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning.
5. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer.
6. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India.
7. Solid State Physics, M.A. Wahab, 2011, Narosa Publications.
8. Solid State Physics, Puri and Babbar, S. Chand Publications, 1st Edition 1997, Reprint 2016.
9. Solid State Physics, M.K. Mahan and P. Mahto, 2008, Bharti Bhawan.
10. Introduction to Solid State Physics, Arun Kumar, PHI Learning.
11. Solid State Physics, Gerald Burns, Academic Press, 1999.
12. The Physics of Solids, Richard Turton, Oxford University Press, 2000.
13. Solid State Physics: Essential Concepts, David W. Snoke, Addison-Wesley, 2009.
14. Fundamentals of Solid State Physics, J. Richard Christman, John Wiley & Sons, 1988.
15. Solid State Physics, S.O. Pillai, New Age International, 2004.

PHYSICS-MJ-17: Practical

Credit: 01 Lectures: 30(15X2)

Instructions to Question Setters

End Semester Examination (ESE): 25 Marks

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:

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

Note: No internal or mid-semester examination will be conducted for the practical paper

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 complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
6. To determine the refractive index of a dielectric layer using SPR
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To study the BH curve of iron using a Solenoid and determine the energy loss.
9. To measure the resistivity of a semiconductor (Ge) crystal with temperature by four-probe method (room temperature to 150 °C) and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.

Session 2025-2029 onwards

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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, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
4. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
5. B.Sc. Practical Physics, C.L. Arora, S. Chand Publishing, Revised Edition, 2022.
6. Advanced Practical Physics (Vol. I & II), C.L. Arora, S. Chand Publishing, Latest Reprint, 2021.
7. Practical Physics, S.L. Gupta & V. Kumar, Pragati Prakashan, Reprint Edition, 2022.
8. Advanced Level Practical Physics, M.P. Poonia & S.C. Sharma, Hitech Publishing House, 1st Edition, 2020.
9. Practical Physics, S.P. Singh & M.K. Bagde, S. Chand Publishing, 4th Edition, 2021.
10. Advanced Practical Physics for Students, B.L. Worsnop & H.T. Flint, S. Chand Publishing (Indian Reprint), Reprint Edition, 2021.
11. Classical Mechanics and Fluid Dynamics (Lab Manual), J.C. Upadhyaya, Ram Prasad & Sons, Latest Edition, 2020.
12. Experimental Physics, R.K. Shukla & Anchal Srivastava, New Age International Publishers, 2nd Edition, 2019.
13. Laboratory Manual of Physics for UG & PG, K.K. Tiwari, Atmaram & Sons, 3rd Edition, 2021.
14. Mathematica and Computer-Based Physics Experiments, Arvind Kumar & K.C. Gupta, Narosa Publishing House, 1st Edition, 2018.

PHYSICS-MJ-18 THEORY: NUCLEAR AND PARTICLE PHYSICS**Credits: 03 Lectures: 45**

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance =05) Pass Marks (Internal + End Semester) = 30

Instructions to Question Setters**Semester Internal Examination (SIE) – 10 Marks:**

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

The objective of the course is to impart an understanding of subatomic particles and their properties. It will emphasize gaining knowledge about the different nuclear techniques and their applications in different branches of Physics and their application to society. The phenomenology and experimental foundations of nuclear and particle physics are explored in this course. Emphasis is on the fundamental

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forces and particles, as well as composites. The students will learn how cutting-edge research is trying to answer the big questions about our universe. In addition, they will learn how new ideas find their way from fundamental research to specific applications that have practical value. They will understand the relevance of everything from the development and construction of nuclear physics experimental equipment, including accelerators and detectors, and eventually their use in order to study the structure of the nucleus. By the end of the course, the students would be able to explain the basic properties of nuclei, classify elementary particles into hadrons and leptons, and understand how hadrons are constructed from quarks. They will also learn about flavour quantum numbers such as isospin, strangeness, etc. The course will focus on the development of problem-based skills.

COURSE LEARNING OUTCOMES

- ✦ To be able to understand the basic properties of nuclei as well as knowledge of experimental determination of the same, the concept of binding energy, its various dependent parameters, N-Z curves, and their significance
- ✦ To appreciate the formulations and contrasts between different nuclear models, such as the Liquid drop model, the Fermi gas model, and the Shell Model, and the evidence in support
- ✦ Knowledge of radioactivity and decay laws. A detailed analysis, comparison, and energy kinematics of alpha, beta, and gamma decays.
- ✦ Familiarization with different types of nuclear reactions, Q- Q-values, compound and direct reactions.
- ✦ To know about energy losses due to ionizing radiations, energy losses of electrons, gamma ray interactions through matter, and neutron interactions with matter. Through the section on accelerators, students will acquire knowledge about Accelerator facilities in India, along with a comparative study of a range of detectors and accelerators, which are building blocks of modern-day science.
- ✦ It will acquaint students with the nature and magnitude of different forces, particle interactions, families of sub-atomic particles with the different conservation laws, concept of the quark model.
- ✦ The acquired knowledge can be applied in the areas of nuclear medicine, medical physics, archaeology, geology, and other interdisciplinary fields of Physics and Chemistry. It will enhance the special skills required for these fields.
- ✦ The lab course provides hands-on experience in nuclear physics, allowing students to explore fundamental principles such as nuclear binding energy, charge distribution, spin-parity, radioactive decay, nuclear reactions, and radiation interactions. Through various experiments, students will gain a deeper understanding of conservation laws, particle interactions, and detection techniques, reinforcing theoretical concepts with practical applications.

SKILLS TO BE LEARNED

- ✦ Skills to describe and explain the properties of nuclei and derive them from various models of nuclear structure.
- ✦ To understand, explain, and derive the various theoretical formulations of nuclear disintegration, like α decay, β decay, and γ decay.
- ✦ Develop a basic understanding of nuclear reactions and decays with the help of theoretical formulation and laboratory experiments.
- ✦ Skills to develop a basic understanding of the interaction of various nuclear radiation with matter in low and high energy.
- ✦ Ability to understand, construct, and operate simple detector systems for nuclear radiation and training to work with various types of nuclear accelerators.

Session 2025-2029 onwards

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- ✦ Develop basic knowledge of elementary particles as fundamental constituents of matter, their properties, and conservation laws during their interactions with matter.
- ✦ In the lab course, students will develop proficiency in conducting nuclear physics experiments, analyzing radiation spectra, applying computational models for nuclear reactions, and working with various detectors like scintillation and semiconductor devices. Additionally, they will enhance their ability to interpret data, solve physics problems using empirical and theoretical approaches, and gain familiarity with essential experimental techniques in radiation detection and nuclear interactions.

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, Spin parity, magnetic moment, electric moments, nuclear excited states.

(6 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.

(6 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.

(6 Lectures)

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

(4 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.

(5 Lectures)

Nuclear Radiation Detectors: Behaviour of ion pairs in 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 detector.

(7 Lectures)

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

(4 Lectures)

Particle Physics: Particle interactions; types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, Parity, Baryon number, Lepton number, Isospin, Strangeness and Charm, Concept of quark model, Colour quantum number and gluons. Baryon octet and Meson octet.

(7 Lectures)

Reference Books:

1. Introductory nuclear Physics by Kenneth S. Krane Wiley India Pvt. Ltd., 2008.
2. Concepts of Nuclear Physics by Bernard L. Cohen. Tata McGraw Hill, 1998.

Session 2025-2029 onwards

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3. Theoretical Nuclear Physics, J.M. Blatt & V. F. Weisskopf, Dover Pub.Inc., 1991.
4. Nuclear Physics, S. N. Ghosal, S. Chand Publisher, 1994.
5. Nuclear Physics, D. C. Tayal, 2011, Himalaya Publishing House.
6. Basic ideas and concepts in Nuclear Physics, K. Heyde, 3rd Edition., Institute of Physics Pub.
7. Concepts of Modern Physics, Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury 2017, McGraw-Hill.
8. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
9. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
10. Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
11. Theory and Problems of Modern Physics, Schaum's outline, R. Gautreau and W. Savin, 2nd Edn., Tata McGraw-Hill Publishing Co. Ltd.
12. Elements of Nuclear Physics, Nikhil Ranjan Roy and Rakesh Kumar Pandey, Atlantic publishers & Distributors (P) Ltd., 2024.

PHYSICS-MJ-18: Practical

Credit: 01 Lectures: 30(15X2)

Instructions to Question Setters

End Semester Examination (ESE): 25 Marks

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:



Note: No internal or mid-semester examination will be conducted for the practical paper.

1. Calculate binding energy using mass defect data and analyze its variation with mass number.
2. Study charge distribution within a nucleus using empirical relations.
3. Examine experimental data to understand nuclear spin and parity assignments.
4. Use the semi-empirical mass formula and interpret nuclear stability conditions.
5. Examine nuclear magic numbers based on isotope stability trends and energy gaps.
6. Measure the energy spectrum of emitted alpha particles using radiation detectors.
7. Observe beta radiation and verify energy distribution using computational data analysis tools.
8. Use a scintillation detector to analyze gamma-ray emission spectra.
9. Compute reaction Q-values and verify conservation laws.
10. Study Coulomb scattering using computational models and simulation techniques.
11. Apply the Bethe-Bloch formula to study charged particle energy loss in matter.
12. Conduct experiments on the photoelectric effect, Compton scattering, and pair production.
13. Measure ionization levels and study detector behaviour in different radiation environments.
14. Examine light emission from scintillators for radiation detection applications.
15. Study photon detection principles using semiconductor detectors.

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, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.

Session 2025-2029 onwards

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4. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
5. B.Sc. Practical Physics, C.L. Arora, S. Chand Publishing, Revised Edition, 2022.
6. Advanced Practical Physics (Vol. I & II), C.L. Arora, S. Chand Publishing, Latest Reprint, 2021.
7. Practical Physics, S.L. Gupta & V. Kumar, Pragati Prakashan, Reprint Edition, 2022.
8. Advanced Level Practical Physics, M.P. Poonia & S.C. Sharma, Hitech Publishing House, 1st Edition, 2020.
9. Practical Physics, S.P. Singh & M.K. Bagde, S. Chand Publishing, 4th Edition, 2021.
10. Advanced Practical Physics for Students, B.L. Worsnop & H.T. Flint, S. Chand Publishing (Indian Reprint), Reprint Edition, 2021.
11. Experimental Physics, R.K. Shukla & Anchal Srivastava, New Age International Publishers, 2nd Edition, 2019.
12. Laboratory Manual of Physics for UG & PG, K.K. Tiwari, Atmaram & Sons, 3rd Edition, 2021.
13. Techniques for Nuclear and Particle Physics Experiments: A How-to Approach, William R. Leo, 2nd Revised Edition, Springer-Verlag, 1994.
14. Nuclear Physics, S. N. Ghosal, S. Chand Publisher, 1994.
15. Nuclear Physics, D. C. Tayal, 2011, Himalaya Publishing House.
16. Basic ideas and concepts in Nuclear Physics, K. Heyde, 3rd Edition., Institute of Physics Pub. Introductory nuclear Physics by Kenneth S. Krane Wiley India Pvt. Ltd., 2008.
17. Concepts of Nuclear Physics by Bernard L. Cohen. Tata McGraw Hill, 1998.
18. Elements of Nuclear Physics, Nikhil Ranjan Roy and Rakesh Kumar Pandey, Atlantic publishers & Distributors (P) Ltd., 2024.

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RC-1: RESEARCH PROPOSAL – PLANNING AND TECHNIQUES**Credits: 04 Lectures: 60**

Marks: 100 (End Semester Examination=75 Semester Internal Examination= 20 (Theory), Class Performance & Attendance =05) Pass Marks (Internal + End Semester) = 40

Instructions to Question Setters**Semester Internal Examination (SIE) – 20 Marks:**

The question paper will be divided into two groups: Group A and Group B.

Group A: Group A is compulsory, which will contain two questions.

Question No.1 will consist of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Question No.2 will be the short-answer type of 5 marks. This question is also compulsory.

Group B: Contains two descriptive-type questions, each carrying 10 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 75 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains six descriptive-type questions, each carrying 15 marks. Candidates are required to answer any four questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVES

- ✚ To introduce students to the structure and components of a research proposal.
- ✚ To train them in developing research objectives, questions, and methodologies.
- ✚ To provide skills in time and resource planning, budgeting, and ethical compliance.
- ✚ To prepare students to write and present professional research proposals.

COURSE OUTCOMES

After completing the course, students will be able to:

- ✚ Understand the purpose and structure of a research proposal.
- ✚ Frame a feasible research problem and formulate objectives.
- ✚ Choose an appropriate research design and methodology.
- ✚ Plan research resources, time, and budgets effectively.
- ✚ Write and present a research proposal suitable for academic or funding submission.

COURSE CONTENT**Unit I: Introduction to Research Proposal****(10 Lectures)**

- Definition, Purpose, and Types of Research Proposals (Academic, Funding, Institutional)
- Features of a Good Proposal: Clarity, Feasibility, Innovation, Relevance
- Stages of Proposal Development

Unit II: Research Problem, Objectives, and Questions**(10 Lectures)**

- Identifying a Research Problem
- Formulating Research Objectives

Session 2025-2029 onwards

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- Hypothesis and Research Questions
- Defining Scope and Limitations

Unit III: Proposal Structure and Methodology**(10 Lectures)**

- Standard Components of a Proposal: Title, Abstract, Introduction, Literature Review, Objectives, Methodology, Expected Outcomes, Timeline, Budget, References
- Research Design and Methods: Qualitative, Quantitative, Mixed Methods
- Tools and Techniques of Data Collection

Unit IV: Planning, Budgeting, and Timeline**(10 Lectures)**

- Time and Resource Planning: Gantt Chart, Activity Scheduling
- Budgeting: Estimating Cost for Equipment, Travel, Contingency, Human Resources
- Proposal Submission Process (UGC/MHRD/DBT/ICSSR formats)

Unit V: Ethics and Writing Techniques**(10 Lectures)**

- Research Ethics: Consent, Privacy, Confidentiality, Integrity
- Plagiarism and Referencing (APA, MLA, Chicago)
- Language, Style, and Formatting
- Using Reference Managers: Zotero/Mendeley
- Peer Review and Revisions

Unit VI: Proposal Presentation and Evaluation**(10 Lectures)**

- Presentation Skills: Oral and Poster Formats
- Evaluating Research Proposals: Rubrics and Criteria
- Simulated Proposal Presentation and Peer Feedback

Suggested Readings & Resources

1. Research Methodology: Methods and Techniques, C. R. Kothari and Gaurav Garg, New Age International Publishers, 4th ed., 2019.
2. Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar, Pearson Education, 5th ed., 2021.
3. Research Methodology, R. Panneerselvam, PHI Learning Pvt. Ltd., 2nd ed., 2014.
4. Research Methodology: Concepts and Cases, Deepak Chawla and Neena Sondhi, Vikas Publishing, 2nd ed., 2016.
5. Data Reduction and Error Analysis for the Physical Sciences, Philip R. Bevington and D. Keith Robinson, McGraw-Hill Education, 3rd ed., 2003.
6. How to Write and Publish a Scientific Paper, Robert A. Day and Barbara Gastel, Cambridge University Press, 8th ed., 2016.
7. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, John W. Creswell and J. David Creswell, SAGE Publications, 5th ed., 2018.
8. Technical Report Writing, Aditham Bhujanga Rao, PHI Learning Pvt. Ltd., 1st ed., 2012.
9. UGC Research Handbook, ICSSR/ICMR Guidelines.

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SEMESTER VIII**PHYSICS-MJ-19 THEORY: ATOMIC AND MOLECULAR PHYSICS (QUANTUM APPROACH) AND LASER PHYSICS****Credits: 03 Lectures: 45**

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance=05) Pass Marks (Internal + End Semester) = 30

Instructions to Question Setters**Semester Internal Examination (SIE) – 10 Marks:**

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

The main objective is to teach students the basic atomic structures with quantum mechanical approach leading to their fundamental spectroscopies. The effect of magnetic and electric field on the atomic spectra is also highlighted. To teach the students the nature of molecular spectra (rotational, vibrational, electronic and Raman), polyatomic molecules (including diatomic) are classified on the basis of their topological symmetry. The fundamentals of electronic states will also be taught. Also, the LASER part of this course will enable the students to understand the two-, three- and four- level laser systems also the non-linear interaction of light with matter.

COURSE LEARNING OUTCOMES

- ✦ Details of atomic and diatomic molecular (diatomic) structures in terms of quantum mechanical treatment elaborately beyond the basic models. It will give the descriptions of fine and hyperfine structure of atoms and molecular. Space quantization, commutator algebra, theory of orbital and spin angular momenta. Clebsch-Gordon coefficients for unitary transformation.
- ✦ The various coupling schemes and interactions of fields with spectra will enrich the student's knowledge about transitions. The details of these spectroscopies would serve as the fundamentals for various concerned experimental studies.
- ✦ Analyzing the polyatomic molecules (including diatomic) and to predict the nature of their vibrational spectra depending on their symmetry using IR Raman Spectroscopy.
- ✦ The complete picture of rotational, vibrational and electronic spectra of polyatomic molecules will be comprehended. This kind of specialization is expected to provide a larger scope for research in the various related and interdisciplinary areas.
- ✦ Understanding fundamental physical processes of the laser.
- ✦ Understanding Einstein's postulates and laser field with unique properties not found in ordinary light.

Session 2025-2029 onwards

82

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SKILLS TO BE LEARNED

- ✦ Learn about the spectrum of 1 electron and many electron atoms; various important quantum-mechanical models to study the electronic structure of many electron systems; Spectroscopic terms which represent the states.
- ✦ Have an intuitive understanding about the outcomes of the interactions of the electromagnetic radiation with the various atoms and the molecules and the rules governing this process. They will learn about the rotational, vibrational, electronic Raman and infrared spectrums arising due to this interaction.
- ✦ Gain in-depth knowledge about the molecular structure using various concepts.
- ✦ Learn the fundamentals and the principles of lasers. Also, they will learn about various types of lasers developed with time. Also, the principle of Holography.

COURSE CONTENT

One electron system: Quantum states of an electron in an atom, Electron Probability density, Space Quantization, Electron Spin, Stern-Gerlach experiment, Spectroscopic terms and selection rules, Spin – orbit interaction energy, Relativistic corrections for energy levels of Hydrogen atom, Hydrogen fine structure, Hyperfine structure, Isotopic shift, Width of spectral lines, Pauli exclusion principle, Exchange symmetry of wave function. **(7 Lectures)**

Two-electron system: Hartree-Fock theory, L-S and J-J couplings, equivalent and non-equivalent electrons, Spectrum of Helium atom and alkali atom, Ortho and para modification, Normal and Anomalous Zeeman effect, Paschen-Back effect, Characteristics X-ray Spectra: Kossel's Explanation and Moseley Law, Augur effect. **(7 Lectures)**

Vibration-rotational spectra of diatomic molecules: Types of molecules, Diatomic linear symmetric-top, Asymmetric-top and Spherical-top, Pure rotational spectra-The diatomic molecule as rigid rotator, Non-rigid rotator, Selection rules, Vibrational spectra of Harmonic oscillator, Anharmonic oscillator and vibrational-rotational spectra, Isotopic effect on vibrational-rotational spectra, Intensity of rotation-vibration spectra, Raman spectra of diatomic molecules. **(8 Lectures)**

Electronic spectra: Classification of electronic states, Electronic and total energy: Born-Oppenheimer approximation, Vibrational structure of electronic transitions, Rotational fine structure, P, Q, R branches of a band, The Fortrat parabola, Intensity of electronic bands, Franck Condon principle: Absorption & emission, Isotopic effect on electronic states, Nuclear Magnetic Resonance, Electron Spin Resonance, Chemical shift. **(8 Lectures)**

LASER PHYSICS

Laser rate equations and types of lasers: Three-level and Four- level laser rate equations. The Nd³⁺ YAG laser, The Neodymium Glass laser, The CO₂ Laser, Semiconductor Laser, Dye lasers, Liquid Laser. **(5 Lectures)**

Laser Resonators, Coherence, and Advanced Systems: Cavity resonators and shaping of beams, condition for steady state laser oscillation, Cavity modes, qualitative description of longitudinal and transverse electromagnetic modes, Quality factor Q, Theory of Q-Switching, Methods of Q-switching, Mode locking theory, Techniques of mode locking. **(7 Lectures)**

Holography: Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms, Characteristics and its applications. **(3 Lectures)**

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Reference Books:

1. H. E. White, Introduction to Atomic Spectra, McGraw-Hill Inc., US, 1934.
2. G. Herzberg, Atomic Spectra and Structure, Vol. I & II, 1944.
3. G. Herzberg, Molecular Spectra and Structure, 1950.
4. C. N. Banwell, Fundamentals of Molecular Spectroscopy, McGraw-Hill Higher Ed., 1994.
5. Raj Kumar, Atomic and Molecular Spectra and Laser, Kedar Nath Ram Nath, Merrut, India, 2012.
6. K. P. R. Nair, Atom, Molecules and Laser, Alpha Science International Ltd., USA, 2006.
7. B. H. Bransden and C. J. Joachain, Physics of Atoms & Molecules, Prentice Hall, 1982.
8. H. Huber and G. Herzberg, Molecular Spectra and Molecular Structure, Springer, 1950.
9. S. N. Ghoshal, Atomic Physics, S. Chand, 1991.
10. G. Aruldas, Molecular Structure and Spectroscopy, PHI Learning Pvt. Ltd., 2014.
11. M. N. Avadhanulu and P. S. Hemne, An Introduction to Lasers: Theory and Applications, S. Chand Publishing, First Edition, 2012.
12. Leonard I. Schiff, Quantum Mechanics, 3rd Edition, McGraw-Hill, 1968.
13. R. Shankar, Principles of Quantum Mechanics, 2nd Edition, Springer, 2010.
14. David J. Griffiths, Introduction to Quantum Mechanics, 2nd Edition, Pearson, 2015.
15. Nouredine Zettili, Quantum Mechanics: Concepts and Applications, 2nd Edition, Wiley, 2009.
16. John R. Taylor, Scattering Theory: The Quantum Theory of Nonrelativistic Collisions, Revised Edition, Dover Publications, 2006.
17. B. H. Bransden and C. J. Joachain, Quantum Mechanics, 2nd Edition, Pearson, 2000.
18. V. K. Thankappan, Quantum Mechanics, 2nd Edition, New Age International Publishers, 1996.

PHYSICS-MJ-19: Practical**Credit: 01 Lectures: 30(15X2)*****Instructions to Question Setters******End Semester Examination (ESE): 25 Marks***

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:

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

Note: No internal or mid-semester examination will be conducted for the practical paper

1. Study space quantization and electron spin by analyzing the magnetic deflection of silver atoms.
2. Observe spectral splitting due to spin-orbit interaction using a spectrometer.
3. Study normal and anomalous Zeeman splitting of spectral lines in a magnetic field.
4. Record and analyze emission spectra of helium and alkali atoms, identifying ortho and para modifications.
5. Verify Rayleigh's criterion for the limit of resolution of spectral lines using (a) telescope, (b) prism, and (c) grating spectrum.
6. Study rotational transitions in diatomic molecules using infrared spectroscopy.
7. Analyze absorption spectra of CO and HCl to observe vibrational and rotational transitions.
8. Perform Raman spectral analysis to study molecular vibrations and isotopic shifts.
9. Measure absorption and emission bands to analyze electronic transition intensities.
10. Study chemical shifts and molecular environments using NMR techniques.
11. Determine the value of Boltzmann constant by studying the forward characteristics of a diode.
12. Determine the value of Planck's constant using four different LEDs.

Session 2025-2029 onwards

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13. Determine the value of e/m by (a) magnetic focusing or (b) bar magnet method.
14. Determine the wavelengths of hydrogen spectral lines and calculate the Rydberg constant.
15. Determine the wavelength of the H-alpha line of hydrogen.
16. Estimate the temperature of a sodium flame by studying the reversal of D-lines.
17. Determine the wavelength and velocity of ultrasonic waves in a liquid using an ultrasonic grating.
18. Determine the resolving power of (a) a telescope and (b) a prism.
19. Determine the wavelength of He-Ne laser light using (a) transmission grating, (b) vernier calipers, and (c) metallic ruler.
20. Determine the thickness of a thin wire using laser light.
21. Determine the refractive index of a given sample or glass plate using (a) He-Ne/diode laser and (b) Michelson interferometer.
22. Determine the wavelength of laser light using a Michelson interferometer.
23. Calculate the beam divergence and spot size of a given laser beam.
24. Study the output characteristics and wavelength of Nd:YAG and semiconductor lasers.
25. Study mode characteristics of near-infrared diode laser and measure atmospheric oxygen absorption.
26. Generate and reconstruct holograms using interference methods.
27. Investigate harmonic generation using laser beams through a nonlinear crystal.

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, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
4. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
5. B.Sc. Practical Physics, C.L. Arora, S. Chand Publishing, Revised Edition, 2022.
6. Advanced Practical Physics (Vol. I & II), C.L. Arora, S. Chand Publishing, Latest Reprint, 2021.
7. Practical Physics, S.L. Gupta & V. Kumar, Pragati Prakashan, Reprint Edition, 2022.
8. Advanced Level Practical Physics, M.P. Poonia & S.C. Sharma, Hitech Publishing House, 1st Edition, 2020.
9. Practical Physics, S.P. Singh & M.K. Bagde, S. Chand Publishing, 4th Edition, 2021.
10. Advanced Practical Physics for Students, B.L. Worsnop & H.T. Flint, S. Chand Publishing (Indian Reprint), Reprint Edition, 2021.
11. Experimental Physics, R.K. Shukla & Anchal Srivastava, New Age International Publishers, 2nd Edition, 2019.
12. Laboratory Manual of Physics for UG & PG, K.K. Tiwari, Atmaram & Sons, 3rd Edition, 2021.
13. S. N. Ghoshal, Atomic Physics, S. Chand, 1991.
14. Physics of Atoms and Molecules, B.H. Bransden & C.J. Joachain, 2nd Edition, Pearson Education, 2003.
15. Atomic Physics, J.C. Foot, 1st Edition, Oxford University Press, 2005
16. Molecular Quantum Mechanics, P.W. Atkins & R.S. Friedman, 5th Edition, Oxford University Press, 2010.
17. Laser Physics, Simon Hooker & Colin Webb, 1st Edition, Oxford University Press, 2010.
18. Atomic and Molecular Spectroscopy, S.L. Gupta & V. Kumar, 1st Edition, New Age International Publishers, 2015
19. Principles of Laser Spectroscopy and Quantum Optics, P.R. Berman & V.S. Malinovsky, 1st Edition,

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Princeton University Press, 2011.

20. G. Aruldas, Molecular Structure and Spectroscopy, PHI Learning Pvt. Ltd., 2014.

21. M. N. Avadhanulu and P. S. Hemne, An Introduction to Lasers: Theory and Applications, S. Chand Publishing, First Edition, 2012.

PHYSICS-MJ-20 THEORY: ADVANCED MATHEMATICAL PHYSICS

Credits: 03 Lectures: 45

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance =05) **Pass Marks (Internal + End Semester) = 30**

Instructions to Question Setters

Semester Internal Examination (SIE) – 10 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE LEARNING OUTCOMES

The students will be able to learn the following from this course:

- ✦ Demonstration of Algebraic Structures in n-dimension. Application of Vector Spaces & Matrices in the quantum world.
- ✦ Learn the basic properties of the linear vector space such as linear dependence and independence of vectors, change of basis, isomorphism and homomorphism, linear transformations and their representation by matrices.
- ✦ Learn the basic properties of matrices, different types of matrices viz., Hermitian, skew Hermitian, orthogonal and unitary matrices and their correspondence to physical quantities, e.g. operators in quantum mechanics. They should also learn how to find the eigenvalues and eigenvectors of matrices.
- ✦ Learn some basic properties of tensors, their symmetric and antisymmetric nature, the Cartesian tensors, the general tensors, contravariant, covariant, and mixed tensors, and their transformation properties under coordinate transformations, physical examples of tensors such as moment of inertia tensor, energy momentum tensor, stress tensor, strain tensor etc.
- ✦ Learn how to express the mathematical equations for the Laws of Physics in their co- covariant forms.
- ✦ Learn how to express a mathematical equation concerned with an event compatible with the physical system.
- ✦ In the laboratory course, the students are expected to solve the following problems using the Scilab/C++ computer language:

- ❖ Multiplication of two 3×3 matrices,

Session 2025-2029 onwards

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- ❖ Diagonalization of a matrix,
- ❖ Inverse of a matrix,
- ❖ Solutions of differential equations satisfied by different orthogonal polynomials and special function,
- ❖ Determination of wave functions for stationary states as eigenfunctions of Hermitian differential operators and also the energy eigenvalues,

SKILLS TO BE LEARNED

- ✦ This course equips students with essential computational skills in linear vector spaces, matrices, eigenvalues and eigenvectors, tensors, and transformations across real and complex fields. They will gain proficiency in linear and multilinear transformations, including applications in physics, such as Lorentz transformations. Additionally, students will develop expertise in the calculus of variations, a powerful mathematical tool for solving optimization problems.
- ✦ Through laboratory exercises, they will enhance their ability to apply computational tools—C++, Scilab, MATLAB, and Mathematica—to solve standard physics problems, reinforcing both theoretical understanding and practical problem-solving techniques.

COURSE CONTENT

Linear Vector Spaces: Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Inner product and Norm. Inner product of functions: the weight function. Triangle and Cauchy Schwartz Inequalities. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices. **(10 Lectures)**

Matrices: Addition and Multiplication of Matrices. Null Matrices. Diagonal, Scalar and Unit Matrices. Upper-Triangular and Lower-Triangular Matrices. Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew-Hermitian Matrices. Singular and Non-Singular Matrices. Orthogonal and Unitary Matrix. Trace of a Matrix. Inner Product. **(7 Lectures)**

Eigen-values and Eigenvectors. Cayley-Hamilton Theorem. Diagonalization of Matrices. Solution of Coupled Linear Ordinary Differential Equations. Functions of a Matrix **(5 Lectures)**

Cartesian Tensors: Transformation of Co-ordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Invariant Tensors: Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors: Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Tensorial Formulation of Analytical Solid Geometry: Equation of a Line. Angle Between Lines. Projection of a Line on another Line. Condition for Two Lines to be Coplanar. Foot of the Perpendicular from a Point on a Line. Rotation Tensor. Isotropic Tensors. Tensorial Character of Physical Quantities. Moment of inertia Tensor. Stress and Strain Tensors: Symmetric Nature. Elasticity Tensor. Generalized Hooke's Law. **(16 lectures)**

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General Tensors: Transformation of Co-ordinates. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant, and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor. **(7 Lectures)**

Reference Books:

1. Matrices and Tensors in Physics, A. W. Joshi, 4th Edition, New Age International (P) Limited.
2. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
3. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, and F.E. Harris, 1970, Elsevier.
4. Mathematical Methods for Physicists and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press.
5. Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications.
6. Mathematical Physics, B.S. Rajput, Pragati Prakashan, Edition: XXXI, 2019.
7. Mathematical Physics H K Dass, Rama Verma, Revised Edition 2018, S. Chand and Company Limited.
8. Linear Algebra, W. Cheney, E. W. Cheney & D. R. Kincaid, 2012, Jones & Bartlett Learning.
9. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.

PHYSICS-MJ-20: Practical

Credit: 01 Lectures: 30(15X2)

Instructions to Question Setters

End Semester Examination (ESE): 25 Marks

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:

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

Note: No internal or mid-semester examination will be conducted for the practical paper

Scilab/ C++ based simulations experiments based on Mathematical Physics problems like

1. Linear algebra:
 - Multiplication of two 3 x 3 matrices.
 - Eigenvalue and eigenvectors of

$$\begin{pmatrix} 2 & 1 & 1 \\ 1 & 3 & 2 \\ 3 & 1 & 4 \end{pmatrix}; \begin{pmatrix} 1 & -i & 3+4i \\ +i & 2 & 4 \\ 3-4i & 4 & 3 \end{pmatrix}; \begin{pmatrix} 2 & -i & 2i \\ +i & 4 & 3 \\ -2i & 3 & 5 \end{pmatrix}$$

2. Orthogonal polynomials as eigenfunctions of Hermitian differential operators.
3. Determination of the principal axes of moment of inertia through diagonalization.
4. Vector space of wave functions in Quantum Mechanics: Position and momentum differential operators and their commutator, wave functions for stationary states as eigenfunctions of a Hermitian differential operator.
5. Lagrangian formulation in Classical Mechanics with constraints.

Session 2025-2029 onwards

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6. Study of geodesics in Euclidean and other spaces (surface of a sphere, etc).
7. Estimation of ground state energy and wave function of a quantum system.
8. Determination of the principal axes of moment of inertia through diagonalization (Matrix can be generated for a given distribution of discrete masses).
9. Application to solve differential equations for a bound system – Eigenvalue problem.
10. Application to computer graphics:
Write operators for shear, strain, two-dimensional rotational problems, Reflection, Translation etc.
Plot old and new coordinates.
11. Vector space of wave functions in Quantum Mechanics: Position and Momentum differential operators and their commutator, wave functions for stationary states as eigenfunction.

Reference Books

1. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications, A. Vande Wouwer, P. Saucez, and C. V. Fernández, Springer, 2014, ISBN: 978-3319067896.
2. Scilab by Example, M. Affouf, 2012, ISBN: 978-1479203444.
3. Scilab Image Processing, L. M. Surhone, Betascript Publishing, 2010, ISBN: 978-6133459274.
4. Mathematica and Computer-Based Physics Experiments, Arvind Kumar and K. C. Gupta, Narosa Publishing House, 1st ed., 2018.

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RC-2: RESEARCH INTERNSHIP & DISSERTATION/THESIS

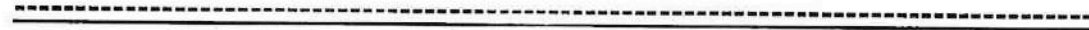
This course will include laboratory work, practicums, field projects, survey analyses, or internship-based projects. Students must submit a comprehensive research report and defend their dissertation/thesis.

The evaluation will consider the following:

- Project dissertation design
- Methodology and content depth
- Participation in an internship programme with a reputed organization
- Application of research techniques in data collection
- Data Analysis
- Report presentation
- Presentation style
- Results and discussion
- Future scope
- References

Marks distribution may be as follows or adjusted as appropriate:

- ↓ Assessment of Project Synopsis: 50 marks
- ↓ Assessment of Project Thesis: 100 marks
- ↓ Viva-voce: 50 marks



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FOURTH YEAR PAPERS FOR PHYSICS MAJOR WITH BACHELOR'S DEGREE (HONOURS)

SEMESTER VII

PHYSICS-MJ-16 THEORY: ADVANCED MATHEMATICAL PHYSICS-I

Credits: 03 Lectures: 45

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance=05) Pass Marks (Internal + End Semester) = 30

Instructions to Question Setters

Semester Internal Examination (SIE) – 10 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

The course is intended to impart the concept of generalized mathematical constructs in terms of Algebraic Structures (mainly Vector Spaces) and Tensors to have an in-depth analysis of our physical system.

COURSE LEARNING OUTCOMES

The students will be able to learn the following from this course:

- ✦ Demonstration of Algebraic Structures in n-dimension. Application of Vector Spaces & Matrices in the quantum world.
- ✦ Learn the basic properties of the linear vector space such as linear dependence and independence of vectors, change of basis, isomorphism and homomorphism, linear transformations and their representation by matrices.
- ✦ Learn the basic properties of matrices, different types of matrices viz., Hermitian, skew Hermitian, orthogonal and unitary matrices and their correspondence to physical quantities, e.g. operators in quantum mechanics. They should also learn how to find the eigenvalues and eigenvectors of matrices.
- ✦ Learn some basic properties of tensors, their symmetric and antisymmetric nature, the Cartesian tensors, the general tensors, contravariant, covariant, and mixed tensors, and their transformation properties under coordinate transformations, physical examples of tensors such as moment of inertia tensor, energy momentum tensor, stress tensor, strain tensor etc.

Session 2025-2029 onwards

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- ✦ Learn how to express the mathematical equations for the Laws of Physics in their co- covariant forms.
- ✦ Learn how to express a mathematical equation concerned with an event compatible with the physical system.
- ✦ In the laboratory course, the students are expected to solve the following problems using the Scilab/C++ computer language:

- ❖ Multiplication of two 3×3 matrices,
- ❖ Diagonalization of a matrix,
- ❖ Inverse of a matrix,
- ❖ Solutions of differential equations satisfied by different orthogonal polynomials and special function,
- ❖ Determination of wave functions for stationary states as eigenfunctions of Hermitian differential operators and also the energy eigenvalues,

SKILLS TO BE LEARNED

- ✦ This course equips students with essential computational skills in linear vector spaces, matrices, eigenvalues and eigenvectors, tensors, and transformations across real and complex fields. They will gain proficiency in linear and multilinear transformations, including applications in physics, such as Lorentz transformations. Additionally, students will develop expertise in the calculus of variations, a powerful mathematical tool for solving optimization problems.
- ✦ Through laboratory exercises, they will enhance their ability to apply computational tools—C++, Scilab, MATLAB, and Mathematica—to solve standard physics problems, reinforcing both theoretical understanding and practical problem-solving techniques.

COURSE CONTENT

Linear Vector Spaces: Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Inner product and Norm. Inner product of functions: the weight function. Triangle and Cauchy Schwartz Inequalities. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices. (10 Lectures)

Matrices: Addition and Multiplication of Matrices. Null Matrices. Diagonal, Scalar and Unit Matrices. Upper-Triangular and Lower-Triangular Matrices. Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew-Hermitian Matrices. Singular and Non-Singular Matrices. Orthogonal and Unitary Matrix. Trace of a Matrix. Inner Product. (7 Lectures)

Eigen-values and Eigenvectors. Cayley-Hamilton Theorem. Diagonalization of Matrices. Solution of Coupled Linear Ordinary Differential Equations. Functions of a Matrix (5 Lectures)

Cartesian Tensors: Transformation of Co-ordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Invariant Tensors: Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors: Scalar and Vector Products, Scalar and Vector

Session 2025-2029 onwards

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Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Tensorial Formulation of Analytical Solid Geometry: Equation of a Line. Angle Between Lines. Projection of a Line on another Line. Condition for Two Lines to be Coplanar. Foot of the Perpendicular from a Point on a Line. Rotation Tensor. Isotropic Tensors. Tensorial Character of Physical Quantities. Moment of inertia Tensor. Stress and Strain Tensors: Symmetric Nature. Elasticity Tensor. Generalized Hooke's Law. **(16 lectures)**

General Tensors: Transformation of Co-ordinates. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant, and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor. **(7 Lectures)**

Reference Books:

1. Matrices and Tensors in Physics, A. W. Joshi, 4th Edition, New Age International (P) Limited.
2. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
3. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, and F.E. Harris, 1970, Elsevier.
4. Mathematical Methods for Physicists and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press.
5. Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications.
6. Mathematical Physics, B.S. Rajput, Pragati Prakashan, Edition: XXXI, 2019.
7. Mathematical Physics H K Dass, Rama Verma, Revised Edition 2018, S. Chand and Company Limited.
8. Linear Algebra, W. Cheney, E. W. Cheney & D. R. Kincaid, 2012, Jones & Bartlett Learning.
9. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.

PHYSICS-MJ-16: Practical

Credit: 01 Lectures: 30(15X2)

Instructions to Question Setters

End Semester Examination (ESE): 25 Marks

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:

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

Note: No internal or mid-semester examination will be conducted for the practical paper

Scilab/ C++ based simulations experiments based on Mathematical Physics problems like

1. Linear algebra:
 - Multiplication of two 3 x 3 matrices.
 - Eigenvalue and eigenvectors of

$$\begin{pmatrix} 2 & 1 & 1 \\ 1 & 3 & 2 \\ 3 & 1 & 4 \end{pmatrix}; \begin{pmatrix} 1 & -i & 3+4i \\ +i & 2 & 4 \\ 3-4i & 4 & 3 \end{pmatrix}; \begin{pmatrix} 2 & -i & 2i \\ +i & 4 & 3 \\ -2i & 3 & 5 \end{pmatrix}$$

Session 2025-2029 onwards

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2. Orthogonal polynomials as eigenfunctions of Hermitian differential operators.
3. Determination of the principal axes of moment of inertia through diagonalization.
4. Vector space of wave functions in Quantum Mechanics: Position and momentum differential operators and their commutator, wave functions for stationary states as eigenfunctions of a Hermitian differential operator.
5. Lagrangian formulation in Classical Mechanics with constraints.
6. Study of geodesics in Euclidean and other spaces (surface of a sphere, etc).
7. Estimation of ground state energy and wave function of a quantum system.
8. Determination of the principal axes of moment of inertia through diagonalization (Matrix can be generated for a given distribution of discrete masses).
9. Application to solve differential equations for a bound system – Eigenvalue problem.
10. Application to computer graphics:
Write operators for shear, strain, two-dimensional rotational problems, Reflection, Translation etc.
Plot old and new coordinates.
11. Vector space of wave functions in Quantum Mechanics: Position and Momentum differential operators and their commutator, wave functions for stationary states as eigenfunction.

Reference Books

1. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications, A. Vande Wouwer, P. Saucez, and C. V. Fernández, Springer, 2014, ISBN: 978-3319067896.
2. Scilab by Example, M. Affouf, 2012, ISBN: 978-1479203444.
3. Scilab Image Processing, L. M. Surhone, Betascript Publishing, 2010, ISBN: 978-6133459274.
4. Mathematica and Computer-Based Physics Experiments, Arvind Kumar and K. C. Gupta, Narosa Publishing House, 1st ed., 2018.

PHYSICS-MJ-17 THEORY: SOLID STATE PHYSICS

Credits: 03 Lectures: 45

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance=05) Pass Marks (Internal + End Semester) = 30

Instructions to Question Setters

Semester Internal Examination (SIE) – 10 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

The introduction to this course caters to the basic concepts and principles to understand the various properties exhibited by condensed matter, especially solids. These properties depend on the chemical constituents making the particular solid and their arrangement in the crystal. A semi-classical

Session 2025-2029 onwards

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approach is used to introduce various models, from a toy model to a higher level, suitable to explain the particular property exhibited by the solid. Towards the end of this course, some basic nuclear physics and radioactivity have been introduced.

COURSE LEARNING OUTCOMES

On completion of the course, students will be able to:

- ✦ Learn the concept of lattices, crystals, and symmetry operations.
- ✦ Explain the concepts such as the reciprocal lattice and the Brillouin zone, and the dynamics of atoms and electrons in solids.
- ✦ Explain the diffraction of X-rays by solids to determine the crystal structure.
- ✦ Understand the elementary lattice dynamics and its influence on the properties of materials.
- ✦ Understand lattice vibrations, phonons and in-depth Einstein and Debye theory of specific heat of solids.
- ✦ Describe the main features of the physics of electrons in solids.
- ✦ Understand the origin of energy bands, and how they influence electronic behavior.
- ✦ Explain the origin of dia-, para-, and ferro-magnetic properties of solids.
- ✦ Explain the origin of the dielectric properties exhibited by solids and the concept of polarizability.
- ✦ Understand the basics of phase transitions and the preliminary concept and experiments related to superconductivity in solid.
- ✦ Apply the gained knowledge to solve problems in solid state physics using relevant mathematical tools.
- ✦ To appreciate how matter exhibits such interesting and wonderful properties and communicate the importance of solid-state physics in the modern society.
- ✦ To understand properties of nuclei like density, size, binding energy, nuclear forces and structure of atomic nucleus, liquid drop model and mass formula.
- ✦ To calculate the decay rates and lifetime of radioactive decays like alpha and beta
- ✦ Fission and fusion as well as nuclear processes to produce nuclear energy in nuclear reactor and stellar energy in stars.
- ✦ 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 determine the hall coefficient of a semiconductor.

SKILLS TO BE LEARNED

- ✦ Learn basics of crystal structure and physics of lattice dynamics
- ✦ Learn the physics of different types of material like magnetic materials, dielectric materials, metals and their properties.
- ✦ Understand the physics of insulators, semiconductor and conductors with special emphasis on the elementary band theory of semiconductors.
- ✦ Comprehend the basic theory of superconductors. Type I and II superconductors, their properties and physical concept of BCS theory.

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COURSE CONTENT

Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Bravais lattice, 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, Laue theory of X-ray diffraction, Atomic and Geometrical Factor. (10 Lectures)

Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear Monoatomic 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 (8 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. (6 Lectures)

Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mossotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeier relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons. (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. (4 lectures)

Elementary band theory: Bloch Theorem, Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (four-probe method) & Hall coefficient. (6 Lectures)

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. BCS theory (elementary idea). (3 Lectures)

Reference Books:

1. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
2. Elements of Solid State Physics, J.P. Srivastava, 2nd Edition, 2006, Prentice-Hall of India.
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning.
5. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer.
6. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India.
7. Solid State Physics, M.A. Wahab, 2011, Narosa Publications.
8. Solid State Physics, Puri and Babbar, S. Chand Publications, 1st Edition 1997, Reprint 2016.
9. Solid State Physics, M.K. Mahan and P. Mahto, 2008, Bharti Bhawan.
10. Introduction to Solid State Physics, Arun Kumar, PHI Learning.
11. Solid State Physics, Gerald Burns, Academic Press, 1999.
12. The Physics of Solids, Richard Turton, Oxford University Press, 2000.
13. Solid State Physics: Essential Concepts, David W. Snoke, Addison-Wesley, 2009.
14. Fundamentals of Solid State Physics, J. Richard Christman, John Wiley & Sons, 1988.
15. Solid State Physics, S.O. Pillai, New Age International, 2004.

Session 2025-2029 onwards

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PHYSICS-MJ-17: Practical**Credit: 01 Lectures: 30(15X2)****Instructions to Question Setters****End Semester Examination (ESE): 25 Marks**

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:

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

Note: No internal or mid-semester examination will be conducted for the practical paper

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 complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
6. To determine the refractive index of a dielectric layer using SPR
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To study the BH curve of iron using a Solenoid and determine the energy loss.
9. To measure the resistivity of a semiconductor (Ge) crystal with temperature by four-probe method (room temperature to 150 °C) and to determine its band gap.
10. To Determine Energy Band Gap of PN junction diode.
11. 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, 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. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
5. B.Sc. Practical Physics, C.L. Arora, S. Chand Publishing, Revised Edition, 2022.
6. Advanced Practical Physics (Vol. I & II), C.L. Arora, S. Chand Publishing, Latest Reprint, 2021.
7. Practical Physics, S.L. Gupta & V. Kumar, Pragati Prakashan, Reprint Edition, 2022.
8. Advanced Level Practical Physics, M.P. Poonia & S.C. Sharma, Hitech Publishing House, 1st Edition, 2020.
9. Practical Physics, S.P. Singh & M.K. Bagde, S. Chand Publishing, 4th Edition, 2021.
10. Advanced Practical Physics for Students, B.L. Worsnop & H.T. Flint, S. Chand Publishing (Indian Reprint), Reprint Edition, 2021.
11. Classical Mechanics and Fluid Dynamics (Lab Manual), J.C. Upadhyaya, Ram Prasad & Sons, Latest Edition, 2020.
12. Experimental Physics, R.K. Shukla & Anchal Srivastava, New Age International Publishers, 2nd Edition, 2019.
13. Laboratory Manual of Physics for UG & PG, K.K. Tiwari, Atmaram & Sons, 3rd Edition, 2021.
14. Mathematica and Computer-Based Physics Experiments, Arvind Kumar & K.C. Gupta, Narosa Publishing House, 1st Edition, 2018.

Session 2025-2029 onwards

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PHYSICS-MJ-18 THEORY: NUCLEAR AND PARTICLE PHYSICS**Credits: 03 Lectures: 45**

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance=05) Pass Marks (Internal + End Semester) = 30

Instructions to Question Setters**Semester Internal Examination (SIE) – 10 Marks:**

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

The objective of the course is to impart an understanding of subatomic particles and their properties. It will emphasize gaining knowledge about the different nuclear techniques and their applications in different branches of Physics and their application to society. The phenomenology and experimental foundations of nuclear and particle physics are explored in this course. Emphasis is on the fundamental forces and particles, as well as composites. The students will learn how cutting-edge research is trying to answer the big questions about our universe. In addition, they will learn how new ideas find their way from fundamental research to specific applications that have practical value. They will understand the relevance of everything from the development and construction of nuclear physics experimental equipment, including accelerators and detectors, and eventually their use in order to study the structure of the nucleus. By the end of the course, the students would be able to explain the basic properties of nuclei, classify elementary particles into hadrons and leptons, and understand how hadrons are constructed from quarks. They will also learn about flavor quantum numbers such as isospin, strangeness, etc. The course will focus on the development of problem-based skills.

COURSE LEARNING OUTCOMES

- ✦ To be able to understand the basic properties of nuclei as well as knowledge of experimental determination of the same, the concept of binding energy, its various dependent parameters, N-Z curves, and their significance
- ✦ To appreciate the formulations and contrasts between different nuclear models, such as the Liquid drop model, the Fermi gas model, and the Shell Model, and the evidence in support.
- ✦ Knowledge of radioactivity and decay laws. A detailed analysis, comparison, and energy kinematics of alpha, beta, and gamma decays.
- ✦ Familiarization with different types of nuclear reactions, Q- Q-values, compound and direct reactions.
- ✦ To know about energy losses due to ionizing radiations, energy losses of electrons, gamma ray interactions through matter, and neutron interactions with matter. Through the section on accelerators, students will acquire knowledge about Accelerator facilities in India, along with a comparative study of a range of detectors and accelerators, which are building blocks of

Session 2025-2029 onwards

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modern-day science.

- ✦ It will acquaint students with the nature and magnitude of different forces, particle interactions, families of sub-atomic particles with the different conservation laws, concept of the quark model.
- ✦ The acquired knowledge can be applied in the areas of nuclear medicine, medical physics, archaeology, geology, and other interdisciplinary fields of Physics and Chemistry. It will enhance the special skills required for these fields.
- ✦ The lab course provides hands-on experience in nuclear physics, allowing students to explore fundamental principles such as nuclear binding energy, charge distribution, spin-parity, radioactive decay, nuclear reactions, and radiation interactions. Through various experiments, students will gain a deeper understanding of conservation laws, particle interactions, and detection techniques, reinforcing theoretical concepts with practical applications.

SKILLS TO BE LEARNED

- ✦ Skills to describe and explain the properties of nuclei and derive them from various models of nuclear structure.
- ✦ To understand, explain, and derive the various theoretical formulations of nuclear disintegration, like α decay, β decay, and γ decay.
- ✦ Develop a basic understanding of nuclear reactions and decays with the help of theoretical formulation and laboratory experiments.
- ✦ Skills to develop a basic understanding of the interaction of various nuclear radiation with matter in low and high energy.
- ✦ Ability to understand, construct, and operate simple detector systems for nuclear radiation and training to work with various types of nuclear accelerators.
- ✦ Develop basic knowledge of elementary particles as fundamental constituents of matter, their properties, and conservation laws during their interactions with matter.
- ✦ In the lab course, students will develop proficiency in conducting nuclear physics experiments, analyzing radiation spectra, applying computational models for nuclear reactions, and working with various detectors like scintillation and semiconductor devices. Additionally, they will enhance their ability to interpret data, solve physics problems using empirical and theoretical approaches, and gain familiarity with essential experimental techniques in radiation detection and nuclear interactions.

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, Spin parity, magnetic moment, electric moments, nuclear excited states.

(6 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.

(6 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.

(6 Lectures)

Session 2025-2029 onwards

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Nuclear Reactions: Types of Reactions, Conservation Laws, kinematics of reactions, Q-value equation, reaction rate, reaction cross section, Concept of compound and direct reaction, resonance reaction, Coulomb scattering (Rutherford scattering). **(4 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. **(5 Lectures)**

Nuclear Radiation Detectors: Behaviour of ion pairs in 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 detector. **(7 Lectures)**

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

Particle Physics: Particle interactions; types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, Parity, Baryon number, Lepton number, Isospin, Strangeness and Charm, Concept of quark model, Colour quantum number and gluons. Baryon octet and Meson octet. **(7 Lectures)**

Reference Books:

1. Introductory Nuclear Physics, Kenneth S. Krane, Wiley India Pvt. Ltd., 1st Edition, 2008.
2. Concepts of Nuclear Physics, Bernard L. Cohen, Tata McGraw Hill, 1998.
3. Theoretical Nuclear Physics, J.M. Blatt & V.F. Weisskopf, Dover Publications Inc., 1991.
4. Nuclear Physics, S.N. Ghoshal, S. Chand Publisher, Latest Edition.
5. Nuclear Physics, D.C. Tayal, Himalaya Publishing House, 2011.
6. Basic Ideas and Concepts in Nuclear Physics, K. Heyde, Institute of Physics Publishing, 3rd Edition, 2004.
7. Concepts of Modern Physics, Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury, McGraw-Hill, 7th Edition, 2017.
8. Introduction to Modern Physics, R. Meyer, E. Kennard, E. Coop, Tata McGraw Hill, 2002.
9. Physics for Scientists and Engineers with Modern Physics, Jewett & Serway, Cengage Learning, 9th Edition, 2010.
10. Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, PHI Learning, 2nd Edition, 2004.
11. Theory and Problems of Modern Physics (Schaum's Outline), Ronald Gautreau & William Savin, Tata McGraw-Hill, 2nd Edition, 1996.
12. Elements of Nuclear Physics, Nikhil Ranjan Roy & Rakesh Kumar Pandey, Atlantic Publishers & Distributors (P) Ltd., 1st Edition, 2024.
13. Introduction to High Energy Physics, Donald H. Perkins, Cambridge University Press, 4th Edition, 2000.
14. Quarks and Leptons: An Introductory Course in Modern Particle Physics, Francis Halzen & Alan D. Martin, Wiley India, 1st Edition, 2008.
15. Introduction to Elementary Particles, David Griffiths, Wiley-VCH, 2nd Edition, 2008.
16. Particles and Nuclei: An Introduction to the Physical Concepts, B. Povh, K. Rith, C. Scholz, F. Zetsche, Springer, 6th Edition, 2008.
17. Fundamentals of Nuclear Physics, Jean-Louis Basdevant, James Rich, Michel Spiro, Springer, 2005.

Session 2025-2029 onwards

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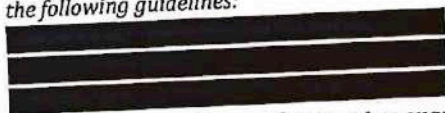
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PHYSICS-MJ-18: Practical**Credit: 01 Lectures: 30(15X2)****Instructions to Question Setters****End Semester Examination (ESE): 25 Marks**

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:



Note: No internal or mid-semester examination will be conducted for the practical paper

1. Calculate binding energy using mass defect data and analyze its variation with mass number.
2. Study charge distribution within a nucleus using empirical relations.
3. Examine experimental data to understand nuclear spin and parity assignments.
4. Use the semi-empirical mass formula and interpret nuclear stability conditions.
5. Examine nuclear magic numbers based on isotope stability trends and energy gaps.
6. Measure the energy spectrum of emitted alpha particles using radiation detectors.
7. Observe beta radiation and verify energy distribution using computational data analysis tools.
8. Use a scintillation detector to analyze gamma-ray emission spectra.
9. Compute reaction Q-values and verify conservation laws.
10. Study Coulomb scattering using computational models and simulation techniques.
11. Apply the Bethe-Bloch formula to study charged particle energy loss in matter.
12. Conduct experiments on the photoelectric effect, Compton scattering, and pair production.
13. Measure ionization levels and study detector behaviour in different radiation environments.
14. Examine light emission from scintillators for radiation detection applications.
15. Study photon detection principles using semiconductor detectors.

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, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
4. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
5. B.Sc. Practical Physics, C.L. Arora, S. Chand Publishing, Revised Edition, 2022.
6. Advanced Practical Physics (Vol. I & II), C.L. Arora, S. Chand Publishing, Latest Reprint, 2021.
7. Practical Physics, S.L. Gupta & V. Kumar, Pragati Prakashan, Reprint Edition, 2022.
8. Advanced Level Practical Physics, M.P. Poonia & S.C. Sharma, Hitech Publishing House, 1st Edition, 2020.
9. Practical Physics, S.P. Singh & M.K. Bagde, S. Chand Publishing, 4th Edition, 2021.
10. Advanced Practical Physics for Students, B.L. Worsnop & H.T. Flint, S. Chand Publishing (Indian Reprint), Reprint Edition, 2021.
11. Experimental Physics, R.K. Shukla & Anchal Srivastava, New Age International Publishers, 2nd Edition, 2019.
12. Laboratory Manual of Physics for UG & PG, K.K. Tiwari, Atmaram & Sons, 3rd Edition, 2021.
13. Techniques for Nuclear and Particle Physics Experiments: A How-to Approach, William R. Leo, 2nd Revised Edition, Springer-Verlag, 1994.

Session 2025-2029 onwards

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PHYSICS-AMI-1 THEORY: ADVANCED QUANTUM MECHANICS**Credits: 03 Lectures: 45****Instructions to Question Setters****Semester Internal Examination (SIE) – 10 Marks:**

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

After completing this course on Advanced Quantum Mechanics, students will gain an essential understanding necessary for theoretical formulation of physical phenomena at the quantum level in matter and radiation fields. This foundation will support further study in various advanced topics in quantum physics.

COURSE LEARNING OUTCOMES

- Develop a foundational understanding of Quantum Mechanics needed for various quantum mechanical approaches.
- Understand the significance of quantum numbers in explaining atomic structures, including the hydrogen atom and multi-electron systems.
- Grasp the matrix formulation of quantum mechanics and the significance of the Schrödinger, Heisenberg, and interaction pictures.
- Comprehend space quantization, commutator algebra, and the theory of orbital and spin angular momenta.
- Use Clebsch-Gordon coefficients for unitary transformations.
- Apply stationary perturbation theory for approximate solutions to quantum mechanical problems.
- Understand the Klein-Gordon and Dirac equations, including their applications and limitations.
- Learn the principles of quantizing the electromagnetic field.

Session 2025-2029 onwards

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- Grasp basic concepts and principles of quantum mechanics and their applications to systems like the simple harmonic oscillator.
- Master the matrix formulation of quantum mechanics.
- Apply the Schrödinger, Heisenberg, and interaction pictures, particularly to the linear harmonic oscillator.
- Understand and use commutation relations for angular momentum operators.
- Solve angular momentum problems using Clebsch-Gordon coefficients.
- Employ various approximation techniques to solve quantum systems.
- Distinguish between particles with half-integer and integer spin; understand the implications of symmetric and antisymmetric wavefunctions.
- Calculate energy levels and wave functions for quantum systems with conserved quantities.
- Explore the semi-classical theory of radiation, including the derivation and significance of Einstein's A and B coefficients.

COURSE CONTENT

Matrix formulation of Quantum Mechanics: Harmonic Oscillator by Schrödinger equation and by matrix method, Matrix formulation of Quantum Mechanics, Schrödinger, Heisenberg and interaction pictures and their applications to linear harmonic oscillator. **(5 Lectures)**

Angular Momentum: Commutation relations for angular operators, Eigenvalues and Eigenvectors, Pauli spin matrices and spin eigenvectors, addition theorem, Clebsch-Gordon coefficients, angular momentum and rotation, motion in centrally symmetric field, Schrödinger's theory of Hydrogen atom. **(8 Lectures)**

Approximation method in Quantum Mechanics: Time independent perturbation theory, non-degenerate and degenerate cases, Stark effect, Variational methods - Application to ground state of Hydrogen atom and first excited state of harmonic oscillator, WKB approximation. Time dependent perturbation theory and Fermi's golden rule, selection rules. Identical particles, Pauli exclusion principle, spin-statistics connection, Semi-classical theory of radiation-Einstein A and B coefficients. **(12 Lectures)**

Elementary theory of scattering: Laboratory and Centre of mass reference frames, scattering amplitude, differential scattering cross section and total scattering cross section. Scattering by spherically symmetric potentials, partial wave analysis and phase shifts, Born approximation, S-matrix scattering and T-matrix scattering theories. **(8 lectures)**

Relativistic Quantum Mechanics: Klein-Gordon equation and its merit and demerit, Dirac equation, probabilities and current densities, Magnetic moment and spin of electron, free particle solution of Dirac equation and interpretation of negative energy states. **(8 Lectures)**

Second Quantization: Canonical Quantization of fields, Second Quantization of K G fields, Dirac fields and EM fields. **(4 Lectures)**

Reference Books:

1. Leonard I. Schiff, Quantum Mechanics, 3rd Edition, McGraw-Hill, 1968.
2. R. Shankar, Principles of Quantum Mechanics, 2nd Edition, Springer, 2010.
3. David J. Griffiths, Introduction to Quantum Mechanics, 2nd Edition, Pearson, 2015.
4. Nouredine Zettili, Quantum Mechanics: Concepts and Applications, 2nd Edition, Wiley, 2009.
5. John R. Taylor, Scattering Theory: The Quantum Theory of Nonrelativistic Collisions, Revised Edition, Dover Publications, 2006.
6. B. H. Bransden and C. J. Joachain, Quantum Mechanics, 2nd Edition, Pearson, 2000.
7. V. K. Thankappan, Quantum Mechanics, 2nd Edition, New Age International Publishers, 1996.
8. J. J. Sakurai and Jim Napolitano, Modern Quantum Mechanics, 2nd Edition, Addison-

Session 2025-2029 onwards

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Wesley, 2010.

9. Claude Cohen-Tannoudji, Bernard Diu, and Franck Laloë, Quantum Mechanics, 2 Volumes, Wiley, 2005.
10. Franz Schwabl, Advanced Quantum Mechanics, 4th Edition, Springer, 2008.
11. Hans A. Bethe and Edwin E. Salpeter, Quantum Mechanics of One- and Two-Electron Atoms, Springer, 2008.
12. Paul Dirac, The Principles of Quantum Mechanics, 4th Edition, Oxford University Press, 1981.
13. L. D. Landau and E. M. Lifshitz, Quantum Mechanics: Non-Relativistic Theory, 3rd Edition, Pergamon Press, 1981.
14. Albert Messiah, Quantum Mechanics, 2 Volumes, Dover Publications, 2014.
15. E. Merzbacher, Quantum Mechanics, 3rd Edition, Wiley, 1998.
16. Walter Greiner, Quantum Mechanics: An Introduction, 4th Edition, Springer, 2001.
17. Julian Schwinger, Quantum Mechanics: Symbolism of Atomic Measurements, Springer, 2001.
18. P. M. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, 2nd Edition, Tata McGraw-Hill, 2010.
19. Ajoy Ghatak and S. Lokanathan, Quantum Mechanics: Theory and Applications, 5th Edition, Macmillan India, 2004.
20. B. K. Agarwal and Hari Prakash, Quantum Mechanics, 1st Edition, PHI Learning Pvt. Ltd., 1997.
21. Aruldas G., Quantum Mechanics, 2nd Edition, PHI Learning Pvt. Ltd., 2022.
22. Ashok Das and A. C. Melissinos, Quantum Mechanics: A Modern Introduction, Gordon and Breach Science Publishers, 1986.

PHYSICS-AMJ-1: Practical

Credit: 01 Lectures: 30(15X2)

Instructions to Question Setters

End Semester Examination (ESE): 25 Marks

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:



Note: No internal or mid-semester examination will be conducted for the practical paper

1. Demonstrate quantization of angular momentum using the Stern-Gerlach experiment.
2. Observe the Zeeman effect through spectral line splitting in a magnetic field.
3. Verify discrete energy levels in atoms using the Franck-Hertz experiment.
4. Determine Planck's constant via the photoelectric effect.
5. Analyze hydrogen spectral lines using spectroscopy.
6. Explore wave-particle duality with the electron diffraction experiment.
7. Measure the fundamental charge of an electron using Millikan's oil drop experiment.
8. Investigate quantum tunnelling through a potential barrier (e.g., tunnel diode).
9. Study vibrational transitions in molecules using Raman spectroscopy.
10. Explore atomic transitions and spin polarization using optical pumping.
11. Study atomic absorption spectra using spectroscopy techniques.
12. Verify Planck's law through blackbody radiation measurements.
13. Observe quantum revivals and wave packet evolution via simulations.
14. Simulate bound and scattering states using computational tools.
15. Verify the Heisenberg uncertainty principle experimentally.

Session 2025-2029 onwards

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16. Solve time-independent Schrödinger equation models computationally.
17. Analyze fine and hyperfine splitting in atomic spectra.

Reference Books:

1. Advanced Practical Physics for Students – B.L. Flint & H.T. Worsnop; Asia Publishing House; 1971
2. Advanced Practical Physics for Students – B.L. Worsnop & H.T. Flint; S. Chand Publishing (Indian Reprint); Reprint Edition; 2021
3. Advanced Level Physics Practicals – Michael Nelson & Jon M. Ogborn; Heinemann Educational Publishers; 4th Edition, reprinted 1985
4. A Textbook of Practical Physics – I. Prakash & Ramakrishna; Kitab Mahal; 11th Edition; 2011
5. B.Sc. Practical Physics – N.N. Ghosh; Bharati Bhawan Publishers; (Edition/year not specified)
6. B.Sc. Practical Physics – C.L. Arora; S. Chand Publishing; Revised Edition; 2022
7. Advanced Practical Physics (Vol. I & II) – C.L. Arora; S. Chand Publishing; Latest Reprint; 2021
8. Practical Physics – S.L. Gupta & V. Kumar; Pragati Prakashan; Reprint Edition; 2022
9. Advanced Level Practical Physics – M.P. Poonia & S.C. Sharma; Hitech Publishing House; 1st Edition; 2020
10. Practical Physics – S.P. Singh & M.K. Bagde; S. Chand Publishing; 4th Edition; 2021
11. Experimental Physics – R.K. Shukla & Anchal Srivastava; New Age International Publishers; 2nd Edition; 2019
12. Laboratory Manual of Physics for UG & PG – K.K. Tiwari; Atmaram & Sons; 3rd Edition; 2021
13. Quantum Mechanics: Theory and Applications – Ajoy Ghatak & S. Lokanathan; Macmillan India; 5th Edition; 2004
14. Quantum Mechanics – B.K. Agarwal & Hari Prakash; PHI Learning Pvt. Ltd.; 1st Edition; 1997
15. Quantum Mechanics – Aruldas G.; PHI Learning Pvt. Ltd.; 2nd Edition; 2022
16. Quantum Mechanics: A Modern Introduction – Ashok Das & A.C. Melissinos; Gordon and Breach Science Publishers; 1986
17. Quantum Mechanics – Leonard I. Schiff; McGraw-Hill; 3rd Edition; 1968
18. Principles of Quantum Mechanics – R. Shankar; Springer; 2nd Edition; 2010
19. Introduction to Quantum Mechanics – David J. Griffiths; Pearson; 2nd Edition; 2015
20. Quantum Mechanics: Symbolism of Atomic Measurements – Julian Schwinger; Springer; 2001
21. A Textbook of Quantum Mechanics – P.M. Mathews & K. Venkatesan; Tata McGraw-Hill; 2nd Edition; 2010

Session 2025-2029 onwards

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SEMESTER VIII**PHYSICS-MJ-19 THEORY: ATOMIC AND MOLECULAR PHYSICS (QUANTUM APPROACH) AND LASER PHYSICS****Credits: 03 Lectures: 45****Instructions to Question Setters****Semester Internal Examination (SIE) – 10 Marks:**

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

The main objective is to teach students the basic atomic structures with quantum mechanical approach leading to their fundamental spectroscopies. The effect of magnetic and electric field on the atomic spectra is also highlighted. To teach the students the nature of molecular spectra (rotational, vibrational, electronic and Raman), polyatomic molecules (including diatomic) are classified on the basis of their topological symmetry. The fundamentals of electronic states will also be taught. Also, the LASER part of this course will enable the students to understand the two-, three- and four- level laser systems also the non-linear interaction of light with matter.

COURSE LEARNING OUTCOMES

- Details of atomic and diatomic molecular (diatomic) structures in terms of quantum mechanical treatment elaborately beyond the basic models. It will give the descriptions of fine and hyperfine structure of atoms and molecular. Space quantization, commutator algebra, theory of orbital and spin angular momenta. Clebsch-Gordon coefficients for unitary transformation.
- The various coupling schemes and interactions of fields with spectra will enrich the student's knowledge about transitions. The details of these spectroscopies would serve as the fundamentals for various concerned experimental studies.
- Analyzing the polyatomic molecules (including diatomic) and to predict the nature of their vibrational spectra depending on their symmetry using IR Raman Spectroscopy.
- The complete picture of rotational, vibrational and electronic spectra of polyatomic molecules will be comprehended. This kind of specialization is expected to provide a larger scope for research in the various related and interdisciplinary areas.
- Understanding fundamental physical processes of the laser.
- Understanding Einstein's postulates and laser field with unique properties not found in ordinary light.

Session 2025-2029 onwards

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SKILLS TO BE LEARNED

- Learn about the spectrum of 1 electron and many electron atoms; various important quantum-mechanical models to study the electronic structure of many electron systems; Spectroscopic terms which represent the states.
- Have an intuitive understanding about the outcomes of the interactions of the electromagnetic radiation with the various atoms and the molecules and the rules governing this process. They will learn about the rotational, vibrational, electronic Raman and infrared spectrums arising due to this interaction.
- Gain in-depth knowledge about the molecular structure using various concepts.
- Learn the fundamentals and the principles of lasers. Also, they will learn about various types of lasers developed with time. Also, the principle of Holography.

COURSE CONTENT

COURSE CONTENT
One electron system: Quantum states of an electron in an atom, Electron Probability density, Space Quantization, Electron Spin, Stern-Gerlach experiment, Spectroscopic terms and selection rules, Spin-orbit interaction energy, Relativistic corrections for energy levels of Hydrogen atom, Fine structure, Hyperfine structure, Isotopic shift, Width of spectral lines, Pauli exclusion principle, Exchange symmetry of wave function. **(7 Lectures)**

Two-electron system: Hartree-Fock theory, L-S and J-J couplings, equivalent and non-equivalent electrons, Spectrum of Helium atom and alkali atom, Ortho and para modification, Normal and Anomalous Zeeman effect, Paschen-Back effect, Characteristics X-ray Spectra: Kossel's Explanation and Moseley Law, Augur effect. **(7 Lectures)**

Vibration-rotational spectra of diatomic molecules: Types of molecules, Diatomic linear symmetric-top, Asymmetric-top and Spherical-top, Pure rotational spectra-The diatomic molecule as rigid rotator, Non-rigid rotator, Selection rules, Vibrational spectra of Harmonic oscillator, Anharmonic oscillator and vibrational-rotational spectra, Isotopic effect on vibrational-rotational spectra, Intensity of rotation-vibration spectra, Raman spectra of diatomic molecules. **(8 Lectures)**

Electronic spectra: Classification of electronic states, Electronic and total energy: Born-Oppenheimer approximation, Vibrational structure of electronic transitions, Rotational fine structure, P, Q, R branches of a band, The Fortrat parabola, Intensity of electronic bands, Franck Condon principle: Absorption & emission, Isotopic effect on electronic states, Nuclear Magnetic Resonance, Electron Spin Resonance, Chemical shift. **(8 Lectures)**

LASER PHYSICS

Laser rate equations and types of lasers: Three-level and Four-level laser rate equations. The Nd³⁺ YAG laser, The Neodymium Glass laser, The CO₂ Laser, Semiconductor Laser, Dye lasers, Liquid Laser. **(5 Lectures)**

Laser Resonators, Coherence, and Advanced Systems: Cavity resonators and shaping of beams, condition for steady state laser oscillation, Cavity modes, qualitative description of longitudinal and transverse electromagnetic modes, Quality factor Q, Theory of Q-Switching, Methods of Q-switching, Mode locking theory, Techniques of mode locking. **(7 Lectures)**

Holography: Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms, Characteristics and its applications. (3 Lectures)

Reference Books:

1. Quantum Mechanics: Theory and Applications – Ajoy Ghatak & S. Lokanathan; Macmillan India; 5th Ed.; 2004
2. Atomic and Molecular Spectra – Raj Kumar; Kedar Nath Ram Nath Publishers; Latest Ed.
3. Fundamentals of Molecular Spectroscopy – K. K. Rohatgi-Mukherjee; New Age International; 3rd Ed.; 2004
4. Atomic and Nuclear Physics (Vol I & II) – S. N. Ghoshal; S. Chand & Co.; Latest Ed.
5. Laser Physics and Spectroscopy – P. K. Chakrabarti; Books & Allied; 1st Ed.; 2012
6. Physics of Atoms and Molecules – B. H. Bransden & C. J. Joachain; Pearson Edu.; 2nd Ed.; 2003
7. Fundamentals of Molecular Spectroscopy – C. N. Banwell & E. M. McCash; McGraw; 4th Ed.; 1994
8. Introduction to Atomic Spectra – H. E. White; McGraw-Hill; 1st Ed.; 1934
9. Quantum Optics: An Introduction – Mark Fox; Oxford University Press; 2nd Ed.; 2006
10. Laser Fundamentals – William T. Silfvast; Cambridge University Press; 2nd Ed.; 2004
11. Lasers – Anthony E. Siegman; University Science Books; 1st Ed.; 1986
12. Principles of Lasers – Orazio Svelto; Springer; 5th Ed.; 2010
13. Molecular Quantum Mechanics – P. W. Atkins & R. S. Friedman; Oxford Univ. Press; 4th Ed.; 2005
14. Atomic Spectra and Structure (Vol I & II) – G. Herzberg; Prentice Hall; 1944
15. Molecular Spectra and Structure – G. Herzberg; Van Nostrand Reinhold; 1950
16. Atoms, Molecules and Lasers – K. P. R. Nair; Alpha Science International; 2006
17. Molecular Spectra and Molecular Structure – H. Huber & G. Herzberg; Van Nostrand
18. Atomic Physics – S. N. Ghoshal; S. Chand Publishing; 5th Ed.; 2004
19. Atomic Physics – J. C. Foot; Oxford University Press; 1st Ed.; 2005
20. Molecular Quantum Mechanics – P. W. Atkins & R. S. Friedman; Oxford Univ. Press; 5th Ed.; 2010
21. Laser Physics – Simon Hooker & Colin Webb; Oxford University Press; 1st Ed.; 2010
22. Atomic and Molecular Spectroscopy – S. L. Gupta & V. Kumar; New Age Int.; 1st Ed.; 2015
23. Principles of Laser Spectroscopy and Quantum Optics – P. R. Berman & V. S. Malinovsky; Princeton University Press; 1st Ed.; 2011
24. Molecular Structure and Spectroscopy – G. Aruldas; PHI Learning; 2014
25. An Introduction to Lasers: Theory and Applications – M. N. Avadhanulu & P. S. Hemne; S. Chand Publishing; 1st Ed.; 2012

PHYSICS-MJ-19: Practical**Credit: 01 Lectures: 30(15X2)*****Instructions to Question Setters******End Semester Examination (ESE): 25 Marks***

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:

Note: No internal or mid-semester examination will be conducted for the practical paper.

1. Study space quantization and electron spin by analyzing the magnetic deflection of silver atoms.
2. Observe spectral splitting due to spin-orbit interaction using a spectrometer.
3. Study normal and anomalous Zeeman splitting of spectral lines in a magnetic field.
4. Record and analyze emission spectra of helium and alkali atoms, identifying ortho and para modifications.

Session 2025-2029 onwards

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5. Verify Rayleigh's criterion for the limit of resolution of spectral lines using (a) telescope, (b) prism, and (c) grating spectrum.
6. Study rotational transitions in diatomic molecules using infrared spectroscopy.
7. Analyze absorption spectra of CO and HCl to observe vibrational and rotational transitions.
8. Perform Raman spectral analysis to study molecular vibrations and isotopic shifts.
9. Measure absorption and emission bands to analyze electronic transition intensities.
10. Study chemical shifts and molecular environments using NMR techniques.
11. Determine the value of Boltzmann constant by studying the forward characteristics of a diode.
12. Determine the value of Planck's constant using four different LEDs.
13. Determine the value of e/m by (a) magnetic focusing or (b) bar magnet method.
14. Determine the wavelengths of hydrogen spectral lines and calculate the Rydberg constant.
15. Determine the wavelength of the H-alpha line of hydrogen.
16. Estimate the temperature of a sodium flame by studying the reversal of D-lines.
17. Determine the wavelength and velocity of ultrasonic waves in a liquid using an ultrasonic grating.
18. Determine the resolving power of (a) a telescope and (b) a prism.
19. Determine the wavelength of He-Ne laser light using (a) transmission grating, (b) vernier calipers, and (c) metallic ruler.
20. Determine the thickness of a thin wire using laser light.
21. Determine the refractive index of a given sample or glass plate using (a) He-Ne/diode laser and (b) Michelson interferometer.
22. Determine the wavelength of laser light using a Michelson interferometer.
23. Calculate the beam divergence and spot size of a given laser beam.
24. Study the output characteristics and wavelength of Nd:YAG and semiconductor lasers.
25. Study mode characteristics of near-infrared diode laser and measure atmospheric oxygen absorption.
26. Generate and reconstruct holograms using interference methods.
27. Investigate harmonic generation using laser beams through a nonlinear crystal.

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, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
4. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
5. B.Sc. Practical Physics, C.L. Arora, S. Chand Publishing, Revised Edition, 2022.
6. Advanced Practical Physics (Vol. I & II), C.L. Arora, S. Chand Publishing, Latest Reprint, 2021.
7. Practical Physics, S.L. Gupta & V. Kumar, Pragati Prakashan, Reprint Edition, 2022.
8. Advanced Level Practical Physics, M.P. Poonia & S.C. Sharma, Hitech Publishing House, 1st Edition, 2020.
9. Practical Physics, S.P. Singh & M.K. Bagde, S. Chand Publishing, 4th Edition, 2021.
10. Advanced Practical Physics for Students, B.L. Worsnop & H.T. Flint, S. Chand Publishing (Indian Reprint), Reprint Edition, 2021.
11. Experimental Physics, R.K. Shukla & Anchal Srivastava, New Age International Publishers, 2nd Edition, 2019.
12. Laboratory Manual of Physics for UG & PG, K.K. Tiwari, Atmaram & Sons, 3rd Edition, 2021.

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PHYSICS-MI-20 THEORY: ADVANCED MATHEMATICAL PHYSICS-II**Credits: 03 Lectures: 45****Instructions to Question Setters****Semester Internal Examination (SIE) – 10 Marks:**

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

This course provides an understanding of the variational principle and its application in calculating geodesics in both two and three dimensions. It covers the Euler-Lagrange equation and its application to basic problems in one and two dimensions. Additionally, the course introduces fundamental concepts of Hamiltonian mechanics, including Hamilton's principle, Hamiltonian equations of motion, and Poisson and Lagrange brackets.

Students will also explore elementary group theory, covering definitions and properties of groups, subgroups, homomorphism, isomorphism, normal and conjugate groups, as well as representations of groups. The course includes a study of reducible and irreducible groups, supplemented by relevant examples and exercises for practical understanding.

COURSE LEARNING OUTCOMES

The students will be able to learn the following from this course:

- By the end of this course, students will gain a comprehensive understanding of key mathematical and physical concepts. Beginning with Calculus of Variations, students will explore the variational principle and its application in physics, learning how to derive solutions using Euler's equation and analyze geodesics in different coordinate systems. They will develop familiarity with Lagrangian mechanics, generalized coordinates, and Euler-Lagrange equations, applying these tools to systems such as the simple pendulum and harmonic oscillator. The course then advances to canonical momenta, Hamilton's principle, Hamiltonian equations of motion, and Poisson brackets, equipping students with essential techniques in classical mechanics.
- In the Group Theory section, students will build foundational knowledge in set theory, mappings, and binary operations before diving into the structure and properties of groups. They will explore subgroups, cyclic groups, and permutation transformations, along with homomorphism and isomorphism for understanding group relationships. Further study will introduce matrix representations of groups, distinguishing between reducible and irreducible representations. The course culminates with an introduction to Lie groups and Lie algebras, featuring

Session 2025-2029 onwards

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examples like $SU(2)$, $O(3)$, and $SU(3)$, which are essential in modern mathematical physics.

- The final section, Advanced Probability Theory, equips students with probabilistic reasoning and statistical tools. Beginning with fundamental probability theorems, conditional probability, and Bayes' theorem, students will apply these concepts to real-world scenarios. They will analyze repeated trials using binomial and multinomial expansions and work with random variables and probability distributions. Expectation and variance will be studied in depth, along with special distributions such as binomial, Poisson, and Gaussian. Finally, students will explore the principle of least squares, applying statistical inference techniques for data analysis and optimization.
- Through this structured learning progression, students will develop the analytical skills necessary for tackling advanced problems in physics, mathematics, and engineering. express the mathematical equations for the Laws of Physics in their covariant forms.

SKILLS TO BE LEARNED

- They also become efficient in doing calculations with the "calculus of variations".
- Applying the variational principle, Euler-Lagrange equations, and Hamiltonian mechanics to optimize physical systems.
Ability to derive Euler equations of motion and apply it to the simple pendulum and harmonic oscillator.
- Gaining familiarity with advanced mathematical concepts like Lie groups, Poisson brackets, and canonical transformations.
- Understanding group structures, transformations, and representations to analyze symmetry in physics and mathematics.
- Working with probability distributions, statistical inference, and least squares methods for data analysis.
- Using mathematical tools to solve real-world physics problems, from classical mechanics to group theory applications.
- Learning fundamental theorems, probability principles, and algebraic structures to develop rigorous mathematical reasoning.

COURSE CONTENT

Calculus of Variations: Variable Calculus: Variational Principle, Euler's Equation and its Application to Simple Problems. Geodesics. Concept of Lagrangian. Generalized co-ordinates. Definition of canonical moment, Euler-Lagrange's Equations of Motion and its Applications to Simple Problems (e.g., Simple Pendulum and One-dimensional harmonic oscillator). Definition of Canonical Momenta. Canonical Pair of Variables. Definition of Generalized Force: Definition of Hamiltonian. Hamilton's Principle. Poisson Brackets and their properties. Lagrange Brackets and their properties. (16 Lectures)

Group Theory: Review of sets, Mapping and Binary Operations, Relation, Types of Relations. Groups: Elementary properties of groups, uniqueness of solution, Subgroup, Centre of a group, Co-sets of a subgroup, cyclic group, Permutation/Transformation. Homomorphism and Isomorphism of Groups. Normal and conjugate subgroups, Completeness and Kernel. Some special groups with operators. Matrix Representations: Reducible and Irreducible. Lie groups and Lie algebra with $SU(2)$, $O(3)$, and $SU(3)$ as example. (16 Lectures)

Advanced Probability Theory: Fundamental Probability Theorems. Conditional Probability, Bayes' Theorem, Repeated Trials, Binomial and Multinomial expansions. Random Variables and Probability

Session 2025-2029 onwards

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Distributions, Expectation and Variance, Special Probability Distributions: The binomial distribution, The Poisson distribution, Continuous distribution: The Gaussian (or normal) distribution, The principle of least squares. (13 Lectures)

Reference Books:

1. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
2. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, and F.E. Harris, 1970, Elsevier.
3. Mathematical Methods for Physicists and Engineers, K.F. Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press.
4. Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications.
5. Mathematical Physics, B.S. Rajput, Pragati Prakashan, Edition: XXXI, 2019.
6. Mathematical Physics H K Dass, Rama Verma, Revised Edition 2018, S. Chand and Company Limited.
7. Linear Algebra, W. Cheney, E. W. Cheney & D. R. Kincaid, 2012, Jones & Bartlett Learning.
8. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
9. Mathematical Methods for Physicists: A Concise Introduction: Tai L. Chow, 2000, Cambridge Univ. Press.
10. Elements of Group Theory for Physicists by A. W. Joshi, 1997, John Wiley & Sons.
11. Group Theory and its Applications to Physical Problems by Morton Hamermesh, 1989, Dover
12. Introduction to Mathematical Physics: Methods & Concepts: Chun Wa Wong, 2012, Oxford University Press
13. Introduction to Mathematical Probability, J. V. Uspensky, 1937, Mc Graw-Hill.

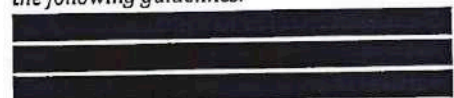
PHYSICS-MJ-20: Practical

Credit: 01 Lectures: 30(15X2)

Instructions to Question Setters

End Semester Examination (ESE): 25 Marks

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:



Note: No internal or mid-semester examination will be conducted for the practical paper

1. Implement the Euler-Lagrange equation in C++ to solve simple problems like the simple pendulum and one-dimensional harmonic oscillator.
2. Use Scilab to simulate geodesics on various surfaces (e.g., spheres, paraboloids) and visualize the shortest paths.
3. Develop a C++ program to compute the Hamiltonian for a given system and analyze its behaviour over time.
4. Implement Poisson brackets in Scilab to study their properties and applications in classical mechanics.
5. Write a C++ program to perform basic group operations, including subgroup identification, cosets, and cyclic groups.
6. Use Scilab to visualize matrix representations of Lie groups such as SU(2), O(3), and SU(3).
7. Implement a C++ program to generate and analyze permutation groups and their

Session 2025-2029 onwards

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transformations.

8. Develop a C++ program to simulate conditional probability scenarios using Bayes' theorem.
9. Use Scilab to generate and visualize probability distributions such as binomial, Poisson, and Gaussian distributions.
10. Implement a Monte Carlo method in C++ to approximate probabilities and expectations in complex systems.
11. Lagrangian Mechanics Simulation: Implement a C++ program to solve equations of motion using the Lagrangian formulation for different physical systems.
12. Use Scilab to simulate Markov processes, demonstrating state transitions and probability distributions over time.

Reference Books

1. A. Vande Wouwer, P. Saucez, C. V. Fernández, Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications, Springer, 2014. ISBN: 978-3319067896.
2. M. Affouf, Scilab by Example, 2012. ISBN: 978-1479203444.
3. L. M. Surhone (Ed.), Scilab Image Processing, Betascript Publishing, 2010. ISBN: 978-6133459274. (Note: Betascript books are often compilations from Wikipedia and may not be academically rigorous.)
4. Yashavant Kanetkar, Let Us C: Authentic Guide to C Programming Language, 20th Edition, BPB Publications, 2023. ISBN: 978-9355515513.
5. Arvind Kumar & K.C. Gupta, Mathematica and Computer-Based Physics Experiments, 1st Edition, Narosa Publishing House, 2018.

PHYSICS-AMJ-2 THEORY: ADVANCED THEORETICAL PHYSICS-I (ELECTRODYNAMICS & STATISTICAL MECHANICS)

Credits: 03 Lectures: 45

Instructions to Question Setters

Semester Internal Examination (SIE) – 10 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

This course on Advanced Theoretical Physics-I aims to deepen understanding by integrating topics that have not been thoroughly covered previously in the syllabus in Electrodynamics and Statistical Mechanics. The Electrodynamics section focuses on electromagnetic potentials, the dynamics of moving

Session 2025-2029 onwards

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charges, radiating systems, and relativistic electrodynamics. In Statistical Mechanics, topics include Quantum Statistics, Phase Transitions, High-Density Gases, and Non-Equilibrium Statistical Mechanics.

COURSE LEARNING OUTCOMES

Electrodynamics:

- Review concepts of Electromagnetic Vector and Scalar Potentials, and the Wave Equation, including the Lorentz condition.
- Understand the Retarded potential, Lienard-Wiechert potentials, and the electromagnetic fields produced by moving and accelerated charges.
- Develop a solid grasp of Minkowski space, Lorentz transformations, Four Vectors, and the transformation of charge and current densities.
- Learn the transformation equations for electromagnetic potentials and the invariance of Maxwell's field equations using four-vectors and tensors.

Statistical Mechanics:

- Understand Liouville's Theorem and the Density Matrix.
- Explore the properties of degenerate Bose gases, Bose-Einstein condensation, and the thermal properties of Bose-Einstein gas and liquid helium.
- Comprehend the Ising model, Bragg-Williams Approximation, Landau theory of phase transitions, and mean field theories.
- Learn about high-density astrophysical objects such as white dwarfs and neutron stars (Chandrasekhar mass limit).
- Understand Brownian motion through Langevin's equation and solve the Fokker-Planck equation.
- The laboratory course aims to provide students with hands-on experience in fundamental concepts of electromagnetism, relativistic electrodynamics, quantum statistics, phase transitions, and electronics.

SKILLS TO BE LEARNED

- Develop problem-solving skills related to electromagnetic potentials and relativistic electrodynamics.
- Understand the behaviour of Fermi and Bose gases and analyse phase transitions using theoretical models.
- Apply the Fokker-Planck equation to phenomena such as Brownian motion.
- Will acquire practical laboratory skills, including the ability to set up and perform measurements using Helmholtz coils, cryostats, and diffusion chambers. Additionally, students will develop data analysis and problem-solving abilities, enabling them to interpret complex physical phenomena, apply theoretical concepts to experimental results, and utilize modern simulation techniques for investigating advanced physics problems. Also, this course equips learners with the ability to analyze, design, and evaluate electronic components such as MOSFETs, SCRs, UJT's, and operational amplifiers, fostering skills in circuit characterization, signal processing, waveform generation, and digital-analog conversion for real-world applications in electronic systems.

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COURSE CONTENT**ELECTRODYNAMICS**

Electromagnetic potentials: Electromagnetic Vector and Scalar Potentials, Wave equation. Lorentz condition. Non-Uniqueness of electromagnetic potentials and the concept of gauge. (5 lectures)

Electrodynamics of a moving charge and radiating systems: Retarded potential, Lienard-Wiechert potentials and derivation of LW potential of a moving point charge. Electric and Magnetic fields due to a uniformly moving point charge and an accelerated charge. Angular Distribution of Radiation emitted by an accelerated charge. Radiation Damping: Abraham Lorentz formula. (10 lectures)

Relativistic Electrodynamics: Minkowski space, Geometrical interpretation of Lorentz transformations of space and time, Four Vectors, Transformation for charge and current density, Covariance of Continuity equation and Lorentz condition. Transformation equations for the electromagnetic potentials. Invariance of the Maxwell field equation in terms of four vectors. Electromagnetic field tensor, Maxwell's equation in covariance Four Tensor Form. (10 lectures)

STATISTICAL MECHANICS (QUANTUM APPROACH):

Quantum Ensemble Theory: Liouville's Theorem and Density Matrix. (2 lecture)

Quantum Statistics: Equation of state of ideal Fermi and Bose gases, Degenerate electron gas and specific heat, Degenerate Bose gas, Bose-Einstein condensation, Thermal properties of Bose-Einstein gas and liquid He, The Lambda transition, Liquid Helium I and II. (6 lectures)

Phase Transitions: Ising model, Bragg-Williams Approximation, Mean field theories of the Ising model in one-dimension, Exact solutions in one dimension, Landau theory of first and second-order phase transitions. (5 lectures)

High-Density Gases: Equation of state at very high density, Equilibrium of bodies of large mass, Chandrasekhar mass limit, White dwarf and neutron stars. (3 lectures)

Non-Equilibrium (fluctuation) Statistical Mechanics: Langevin's equation and Brownian motion, The Fokker-Planck Equation, Solution of the Fokker-Planck Equation- application to Brownian motion. (4 lectures)

Reference Books:

1. S. P. Chopra and G. C. Agarwal, Electromagnetic Theory, K. Nath & Co., 1990.
2. S. L. Gupta, V. Kumar, and H. V. Singh, Electrodynamics, Pragati Prakashan, 2001.
3. Satyaprakash, Electromagnetic Theory and Electrodynamics, Kedar Nath Ram Nath, 2006.
4. John D. Jackson, Classical Electrodynamics, 3rd Edition, Wiley, 1999.
5. B. B. Laud, Electromagnetics, New Age International Publishers, 1987.
6. P. Sengupta, Classical Electrodynamics, New Age International Publishers, 2010.
7. David J. Griffiths, Introduction to Electrodynamics, 4th Edition, Pearson, 2013.
8. Edward C. Jordan and Keith G. Balmain, Electromagnetic Waves and Radiating Systems, 2nd Edition, Prentice Hall, 1968.
9. Matthew N. O. Sadiku, Elements of Electromagnetics, 6th Edition, Oxford University Press, 2014.
10. Ashutosh Pramanik, Electromagnetism: Theory and Applications, 2nd Edition, PHI Learning Pvt. Ltd., 2014.
11. Frank S. Crawford Jr., Waves, Berkeley Physics Course, Vol. 3, McGraw-Hill, 1968.

Session 2025-2029 onwards

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12. S.K. Sinha, Statistical Mechanics, 1st Edition, 1984, S. Chand & Co.
18. Kerson Huang, Statistical Mechanics, 2nd Edition, 1987, Wiley
19. L.D. Landau and E.M. Lifshitz, Statistical Physics, 1st Edition, 1980, Pergamon Press
20. R.K. Patharia, Statistical Mechanics, 2nd Edition, 2011, Butterworth-Heinemann
21. B.B. Laud, Fundamentals of Statistical Mechanics, 1st Edition, 1981, New Age International
22. R.K. Srivastava and J. Ashok, Statistical Mechanics, 1st Edition, 1995, Prentice Hall of India
23. Gupta and Kumar, Statistical Mechanics, 1st Edition, 2009, Tata McGraw-Hill
24. B.K. Agrawal, Statistical Mechanics, 1st Edition, 2005, McGraw-Hill
25. Satyaprakash and J.P. Agrawal, Statistical Mechanics, 1st Edition, 1987, Wiley Eastern
26. B.K. Agrawal and M. Eisner, Statistical Mechanics, 1st Edition, 1996, Springer
27. F. Reif, Fundamentals of Statistical and Thermal Physics, 1st Edition, 1965, McGraw-Hill

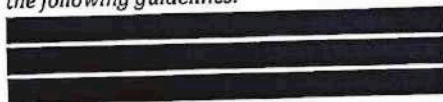
PHYSICS-AMI-2: Practical

Credit: 01 Lectures: 30(15X2)

Instructions to Question Setters

End Semester Examination (ESE): 25 Marks

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:



Note: No internal or mid-semester examination will be conducted for the practical paper

Electrodynamics

1. Mapping of Electric Field and Equipotential Lines using Conducting Paper.
2. Verification of Biot-Savart Law using Helmholtz Coil.
3. Study of Faraday's Law of Electromagnetic Induction using Rotating Coil Setup.
4. Demonstration of Poynting Vector and Energy Flow in Electromagnetic Waves.
5. Measurement of Magnetic Field along the Axis of a Circular Coil.
6. Measurement of the Speed of Light in Coaxial Cable using Time Delay Technique.
7. Measurement of the Electromagnetic Vector and Scalar Potentials Using a Helmholtz Coil Setup.
8. Demonstration of the Non-Uniqueness of Electromagnetic Potentials Using a Variable Gauge Setup.

Statistical Mechanics (Quantum Approach)

9. Study of Specific Heat of Solids at Low Temperatures (Debye and Einstein Models).
10. Measurement of Magnetic Susceptibility of Paramagnetic Salts (Curie's Law).
11. Study of Phase Transition in Liquid Crystals using Polarized Light.
12. Measurement of Thermal Conductivity vs. Temperature (Phonon Transport).
13. Blackbody Radiation Experiment – Planck's Law Verification.
14. Investigation of the Bose-Einstein Condensation Using Liquid Helium.
15. Study of the Lambda Transition in Liquid Helium Using a Cryostat.
16. Analyzing the Equation of State for a Degenerate Electron Gas Using a Metal Sample.
17. Brownian Motion Experiment Using Microscopic Particles in a Liquid.
18. Verification of the Fokker-Planck Equation Using a Particle Diffusion Experiment.

Electronics

19. Analysis of the output characteristics of an n-channel MOSFET by plotting ID vs. VDS for various VGS.
20. Study of the performance characteristics of a Silicon-Controlled Rectifier (SCR).

Session 2025-2029 onwards

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21. Study of the performance characteristics of a Metal-Oxide-Semiconductor Field-Effect Transistor (MOSFET).
22. To study the characteristics of a Uni-Junction Transistor (UJT).
23. Study of basic properties and voltage gain of inverting and non-inverting operational amplifiers.
24. Performance of an op-amp as a differentiator.
25. Performance of an op-amp as an integrator.
26. Design and analysis of a function generator using an op-amp (sine, triangular, square waveforms).
27. Design of a Digital-to-Analog Converter (DAC) with given specifications.
28. Study of an Analog-to-Digital Converter (ADC) IC.

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, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
4. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
5. B.Sc. Practical Physics, C.L. Arora, S. Chand Publishing, Revised Edition, 2022.
6. Advanced Practical Physics (Vol. I & II), C.L. Arora, S. Chand Publishing, Latest Reprint, 2021.
7. Practical Physics, S.L. Gupta & V. Kumar, Pragati Prakashan, Reprint Edition, 2022.
8. Advanced Level Practical Physics, M.P. Poonia & S.C. Sharma, Hitech Publishing House, 1st Edition, 2020.
9. Practical Physics, S.P. Singh & M.K. Bagde, S. Chand Publishing, 4th Edition, 2021.
10. Advanced Practical Physics for Students, B.L. Worsnop & H.T. Flint, S. Chand Publishing (Indian Reprint), Reprint Edition, 2021.
11. Experimental Physics, R.K. Shukla & Anchal Srivastava, New Age International Publishers, 2nd Edition, 2019.
12. Laboratory Manual of Physics for UG & PG, K.K. Tiwari, Atmaram & Sons, 3rd Edition, 2021.
13. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
14. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
15. Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson.
16. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.

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PHYSICS-AMJ 3 THEORY: ADVANCED THEORETICAL PHYSICS-II**(CONDENSED MATTER PHYSICS & NUCLEAR AND PARTICLE PHYSICS)****Credits: 03 Lectures: 45****Instructions to Question Setters****Semester Internal Examination (SIE) – 10 Marks:***The question paper will be divided into two groups: Group A and Group B.**Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.**Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.***End Semester Examination (ESE) – 60 Marks:***The question paper will be divided into two groups: Group A and Group B.**Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.**Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.**Note: Questions in the theory papers may have subdivisions.***COURSE OBJECTIVE**

This course on Advanced Theoretical Physics-II aims to deepen understanding by integrating topics that have not been thoroughly covered in Condensed Matter Physics, Nuclear and Particle Physics. The Condensed Matter Physics section explores Transport Phenomena, Electronic Properties, Magnetism, Superconductivity, and Defects. The Nuclear and Particle Physics section addresses two-body problems, Nuclear β -Decay, Nuclear Reactions, and provides a basic understanding of Particle Physics.

COURSE LEARNING OUTCOMES**Condensed Matter Physics:**

- Grasp the fundamentals of Boltzmann transport equation, relaxation time approximation, and Sommerfeld theory of electrical conductivity.
- Develop concepts related to electrons in a periodic lattice, free electron approximation, tight binding approximation, and Fermi surface topology.
- Learn about magnetic phenomena, including the Heisenberg model, spin waves, magnons, and ferromagnetic domains.
- Understand superconductivity basics, including the BCS theory and Josephson effects.
- Gain knowledge about defects in crystals, liquid crystalline order, and quasi-crystals.

Nuclear & Particle Physics:

- Analyse two-body problems, including the deuteron structure and low-energy neutron-proton scattering.
- Understand Fermi's theory of beta decay and its associated phenomena, such as Kurie plots and parity violation.
- Develop a framework for nuclear reactions, including compound nucleus theory and the Breit-Wigner formula.
- Learn about fundamental symmetries and violations (CP and CPT invariance), classification of hadrons, Lie algebra, SU (2)-SU (3) multiplets, and the quark model.

Session 2025-2029 onwards

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- The laboratory course is designed to provide students with practical experience in Condensed matter physics, nuclear physics, and particle physics through experimental and computational methods. Students will learn how to measure physical properties, analyze quantum and relativistic effects, and apply simulation techniques to model transport phenomena, magnetism, superconductivity, nuclear interactions, and fundamental particle behaviors.

SKILLS TO BE LEARNED

- Gain insight into advanced topics like the de Haas van Alphen Effect, superconductivity, and magnetic domains.
- Solve the deuteron problem and understand the principles behind Nuclear β -Decay and other nuclear reactions.
- Obtain foundational knowledge of particle physics, including the classification of particles and the quark model.
- Will develop proficiency in experimental techniques such as four-probe conductivity measurements, X-ray diffraction, neutron-proton scattering, and superconductivity testing using a cryostat. Additionally, they will gain expertise in computational physics, implementing numerical simulations in Scilab and C++ to analyze quantum transport, phase transitions, spin dynamics, and high-energy physics phenomena. These skills will enhance their ability to interpret experimental results, perform advanced simulations, and apply theoretical concepts to real-world systems in modern physics research.

COURSE CONTENT

CONDENSED MATTER PHYSICS

Transport phenomena: Boltzmann transport equation - relaxation time approximation, Sommerfeld theory of electrical conductivity. (3 Lectures)

Electronic Properties: Electron in a Periodic lattice, Free electron approximation, Tight binding approximation- application to a simple cubic lattice, Cellular and Pseudopotential method, Topology of Fermi surface, de Haas van Alphen Effect. (7 Lectures)

Magnetism: Exchange interaction, Heisenberg model and molecular field theory, spin waves and magnons, Ferromagnetic domains and Bloch Wall energy. (5 Lectures)

Superconductivity: Basic properties of superconductors, a.c. and d.c. Josephson effect, BCS theory, superfluidity. (4 Lectures)

Defects and dislocations: Qualitative description of defects in crystals- point, line and plane defects, translational and orientational order, kinds of liquid crystalline order. Quasi-crystals. (4 Lectures)

NUCLEAR & PARTICLE PHYSICS

Two-body problems: ground state of the deuteron, excited state of the deuteron. Two-body scattering: Kinematics, cross-sections, low energy neutron-proton scattering and proton-proton scattering, effective range theory, coherent scattering of neutrons by Ortho- and Para-hydrogen, charge independence and charge symmetry of nuclear forces, Isospin formalism, Yukawa interaction. (8 lectures)

Nuclear β -Decay: Fermi's theory of beta decay, Kurie plots, Comparative half-life, allowed and forbidden transitions, selection rules in beta decay, Non-conservation of parity in beta decay. (3 lectures)

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Nuclear reactions: Statistical theory of the compound nucleus, Ghosal experiment, Breit-Wigner formula, direct reactions, optical model. **(5 lectures)**

Particle Physics: Parity, Charge conjugation and Time reversal, CP violation, CPT invariance and its consequences, classification of hadrons, Lie algebra, SU (2) -SU (3) multiplets, Quark model, Gellmann-Okubo mass formula for octet and decuplet hadrons, Gellman-Nishijima formula, Unification of forces (qualitative description of electro-weak, GUT and SUSY models). **(6 lectures)**

Reference Books:

1. John R. Christman, Fundamentals of Solid-State Physics, 1st Edition, 1988, Wiley
2. Adrian J. Dekker, Solid State Physics, 1st Edition, 1957, Macmillan
3. Charles Kittel, Introduction to Solid State Physics, 8th Edition, 2004, Wiley
4. J.P. Srivastava, Elements of Solid-State Physics, 4th Edition, 2017, Prentice Hall of India
5. James P. McKelvey, Solid State and Semiconductor Physics, 2nd Edition, 1982, Harper & Row
6. Neil W. Ashcroft and N. David Mermin, Solid State Physics Problems and Solutions, Companion to the 1st Edition, 1976
7. S.O. Pillai, Solid State Physics, 8th Edition, 2015, New Age International Publishers
8. M. Ali Omar, Elementary Solid-State Physics, Revised Edition, 1999, Pearson
9. Charles Kittel, Quantum Theory of Solids, 2nd Edition, 1987, Wiley
10. Nikhil Ranjan Roy and Rakesh Kumar Pandey, Elements of Nuclear Physics, Atlantic publishers & Distributors (P) Ltd., 2024.
11. R.R. Roy and B.P. Nigam, Nuclear Physics, Revised Edition, 2001, New Age International
12. Kenneth S. Krane, Introductory Nuclear Physics, 1st Edition, 1987, Wiley
13. S.N. Ghoshal, Atomic and Nuclear Physics (Vol. 2), 1st Edition, 1997, S. Chand Group
14. Irving Kaplan, Nuclear Physics, 2nd Edition, 1987, Narosa Publications
15. H.A. Bethe and P. Morrison, Elementary Nuclear Theory, 2nd Edition, 1956, Dover Publications
16. Enrico Fermi, Nuclear Physics, 1st Edition, 1950, University of Chicago Press
17. J.P. Srivastava, Elements of Nuclear Physics, 1st Edition, 2015, Prentice Hall of India
18. A.K. Sinha and K. Chattopadhyay, Fundamentals of Nuclear Physics, 1st Edition, 2012, Prentice Hall of India

PHYSICS-AMJ 3: Practical

Credit: 01 Lectures: 30(15X2)

Instructions to Question Setters

End Semester Examination (ESE): 25 Marks

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:



Note: No internal or mid-semester examination will be conducted for the practical paper

Electrical & Magnetic Properties

1. Measurement of electrical properties of thin film samples.
2. Determine the electrical conductivity of a semiconductor using the Four-Probe Method.
3. Determine carrier concentration and mobility using Hall Effect measurements in semiconductors.
4. Study of temperature dependence of the Hall coefficient.
5. Study of impedance spectrometry of a given sample using an LCR meter.

Session 2025-2029 onwards

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6. Determination of magnetic susceptibility using Gouy's method.
7. Determination of magnetic parameters of selected minerals using a hysteresis loop tracer.
8. Determination of Curie temperature using dielectric constant apparatus.
9. Measurement of dielectric constants of solid and liquid samples.
10. Determine the modulus of rigidity and internal friction using a modulus of rigidity apparatus.
11. Determine the optical constants of a metal in thin film form.
12. Determining optical constants of a metal by reflection of light.

Crystallography & Materials Analysis

13. Crystal structure analysis using 3D X-ray diffraction data:
 - (a) Use of heavy atom technique
 - (b) Use of direct methods
 - (c) Computation of 3D Fourier map and interpretation
 - (d) Computation of bond lengths, angles, H-bonds, etc.
 - (e) ORTEP plot of the molecule
14. Synthesis of materials under different stoichiometric ratios.
15. Study of the absorption pattern of a given sample using an FTIR spectrometer.
16. Examine crystal defects using X-ray diffraction and determine dislocation types.
17. Investigate liquid crystalline order using Polarized Light Microscopy and determine phase transitions.

Nuclear Physics & Radiation Detection

18. Determination of operating voltage of a GM counter.
19. Study of the plateau characteristics of a GM (Geiger-Müller) counter.
20. Determination of the dead time of a GM counter using the two-source method.
21. Study of the statistical nature of radioactive decay using counting techniques.
22. Determination of the energy resolution of a NaI(Tl) scintillation detector.
23. Determination of magnetic field strength and resonance frequency using ESR.
24. Determine the half-life of a radioactive isotope using a Geiger Counter.
25. Analyze beta decay spectra using Kurie plots and determine allowed and forbidden transitions.
26. Measure neutron-proton scattering cross-sections and determine effective range theory parameters.
27. Analyze CP violation in particle physics using Kaon decay data.

Advanced & Specialized Techniques

28. Analyze quantum oscillations in magnetization via de Haas-van Alphen Effect.
29. Visualize ferromagnetic domain structures using Magnetic Force Microscopy (MFM); determine Bloch wall energy.
30. Demonstrate the Josephson Effect by measuring tunnelling currents in a superconducting junction.
31. Determine the transition temperature of a superconductor using resistance vs. temperature measurements with a cryostat.

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, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
4. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
5. B.Sc. Practical Physics, C.L. Arora, S. Chand Publishing, Revised Edition, 2022.

Session 2025-2029 onwards

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6. Advanced Practical Physics (Vol. I & II), C.L. Arora, S. Chand Publishing, Latest Reprint, 2021.
 7. Practical Physics, S.L. Gupta & V. Kumar, Pragati Prakashan, Reprint Edition, 2022.
 8. Advanced Level Practical Physics, M.P. Poonia & S.C. Sharma, Hitech Publishing House, 1st Edition, 2020.
 9. Practical Physics, S.P. Singh & M.K. Bagde, S. Chand Publishing, 4th Edition, 2021.
 10. Advanced Practical Physics for Students, B.L. Worsnop & H.T. Flint, S. Chand Publishing (Indian Reprint), Reprint Edition, 2021.
 11. Classical Mechanics and Fluid Dynamics (Lab Manual), J.C. Upadhyaya, Ram Prasad & Sons, Latest Edition, 2020.
 12. Experimental Physics, R.K. Shukla & Anchal Srivastava, New Age International Publishers, 2nd Edition, 2019.
 13. Laboratory Manual of Physics for UG & PG, K.K. Tiwari, Atmaram & Sons, 3rd Edition, 2021.
 14. Mathematica and Computer-Based Physics Experiments, Arvind Kumar & K.C. Gupta, Narosa Publishing House, 1st Edition, 2018.
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ASSOCIATED CORE COURSE**ASSOCIATED CORE COURSE IN PHYSICS****SEMESTER I/SEMESTER II****PHYSICS-AC-1 THEORY: MECHANICS****Credits: 03 Lectures: 45****Instructions to Question Setters****Semester Internal Examination (SIE) – 10 Marks:***The question paper will be divided into two groups: Group A and Group B.**Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.**Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.***End Semester Examination (ESE) – 60 Marks:***The question paper will be divided into two groups: Group A and Group B.**Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.**Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.**Note: Questions in the theory papers may have subdivisions.***COURSE OBJECTIVE**

- This course begins with the review of Vectors and Differential equations and ends with the Special Theory of Relativity. Students will also appreciate the Gravitation, Elasticity, Surface tension, Viscosity and Oscillations.
- The emphasis of this course is to enhance the basics of mechanics. By the end of this course, students should be able to solve the seen or unseen problems/numericals in vectors, differential equations and mechanics and some properties of matter.

COURSE LEARNING OUTCOMES

Upon completion of this course, students are expected to understand the following concepts which would help them to appreciate the application of the fundamental concepts to the analysis of simple, practical situations related to the real world:

- Understand the role of vectors and coordinate systems in Physics.
- Learn to solve Ordinary Differential Equations: First order, Second order Differential Equations with constant coefficients.
- Understand laws of motion and their application to various dynamical situations.
- Apply Kepler's law to describe the motion of planets and satellite in circular orbit through the study of law of Gravitation.
- Explain the phenomenon of simple harmonic motion.
- Understand special theory of relativity - special relativistic effects and their effects on the mass and energy of a moving object.

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- In the laboratory course, after acquiring knowledge of how to handle measuring instruments (like screw gauge, vernier callipers, travelling microscope) student shall embark on verifying various principles learnt in theory. Measuring 'g' using Bar Pendulum, Kater's pendulum and measuring elastic constants of materials, viscous properties of liquids etc.

SKILLS TO BE LEARNED

- Learn the concepts of vector calculus.
- Learn the concepts of elasticity of solids and viscosity of fluids.
- Develop skills to understand and solve the equations of Newtonian gravity and central force problem.
- Acquire basic knowledge of oscillation.
- Have an understanding of basic concepts of Special Theory of Relativity.

COURSE CONTENT

Vector Analysis: Triple Scalar product, Triple Vector product, gradient, divergence, Curl and their physical significance, scalar and vector fields, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem. **(10 Lectures)**

Ordinary Differential Equations: 1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients. **(4 Lectures)**

Central force field: Motion of a particle in a central force field –two body problem. Kepler's Laws and their deduction. **(4 Lectures)**

Oscillations: Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. **(4 Lectures)**

Elasticity: Elastic constants and their interrelations, 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 - Determination of Rigidity modulus by static torsion, Torsional pendulum. **(8 Lectures)**

Fluids: Surface Tension: Excess of pressure - Application to spherical and cylindrical drops and bubbles - variation of surface tension with temperature. Viscosity - Rate flow of liquid in a capillary tube - Poiseuille's formula - Determination of coefficient of viscosity of a liquid - Variations of viscosity of liquid with temperature. **(8 Lectures)**

Special Theory of Relativity: Galilean transformations. Postulates of Special Theory of Relativity. Lorentz transformation, Length contraction. Time dilation. Relativistic addition of velocities. **(7 Lectures)**

Reference Books:

1. Mathematical Physics, H K Das and Dr. Rama Verma, S. Chand and Company Limited.
2. Mathematical Physics, B D Gupta, Vikash Publishing House, 4th edition.
3. Mathematical Physics, B.S. Rajput, Pragati Prakashan, 21st Edition, 2009.
4. Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning.
5. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
6. University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addison-Wesley.
7. Mechanics Berkeley Physics, v.1: Charles Kittel, et. al. 2007, Tata McGraw-Hill.

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8. Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley.
9. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
10. Elements of Properties of Matter, D. S. Mathur, S. Chand Publication.
11. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
12. Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al. 2007, Tata McGraw-Hill.
13. Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning
14. Feynman Lectures, Vol. I, R.P. Feynman, R.B. Leighton, M.Sands, 2008, Pearson Education
15. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
16. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
17. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
18. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.

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.

PHYSICS AC-1: Practical

Credit: 01 Lectures: 30(15X2)

Instructions to Question Setters

End Semester Examination (ESE): 25 Marks

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:



Note: No internal or mid-semester examination will be conducted for the practical paper

1. To measure the diameter of a thick wire using a vernier caliper.
2. To measure the diameter of a thick wire using screw gauge.
3. To measure the diameter of a thick wire using a travelling microscope.
4. To study the random error in observations.
5. To study the Motion of a Spring and calculate (a) the Spring constant, (b) g.
6. To determine the Coefficient of Viscosity of water by the Capillary Flow Method (Poiseuille's method).
7. To determine the Young's Modulus of a Wire by a suitable method.
8. To determine the Modulus of Rigidity of a Wire by a suitable method.
9. To determine the elastic Constants of a wire by Searle's method.
10. To determine the value of g using the Bar Pendulum.
11. To determine the value of g using Kater's Pendulum.

Session 2025-2029 onwards

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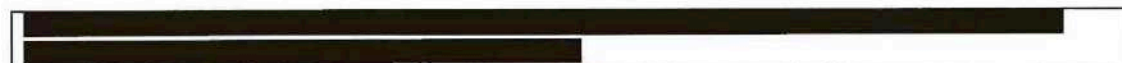
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Reference Books:

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, I. Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal
 4. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
 5. B.Sc. Practical Physics, C. L. Arora, S. Chand & Company, 19th Edition, 1995, Reprint 2014.
 6. Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
 7. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.
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ELECTIVE COURSES**ELECTIVE COURSES IN PHYSICS****SEMESTER-III/SEMESTER IV****PHYSICS- ELC-1 THEORY: ELECTRICITY & MAGNETISM****Credits: 03 Lectures: 45****Instructions to Question Setters****Semester Internal Examination (SIE) – 10 Marks:**

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

This course begins with static electric field and magnetic field. By the end of the course student should have in depth knowledge of electrostatics and magnetostatics, learn about Faraday's and Len's laws of electromagnetic induction and also appreciate Maxwell's equations.

COURSE LEARNING OUTCOMES

At the end of this course, students will be able to

- 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.
- Explain and differentiate the vector (electric fields, Coulomb's law) and scalar (electric potential, electric potential energy) formalisms of electrostatics.
- Apply Gauss's law of electrostatics to solve a variety of problems.
- Articulate knowledge of electric current, resistance and capacitance in terms of electric field and electric potential.
- Demonstrate a working understanding of capacitors
- Calculate the magnetic forces that act on moving charges and the magnetic fields due to currents (Biot- Savart and Ampere laws)
- Have brief idea of dia-, para- and ferro-magnetic materials
- Understand the concepts of induction and self-induction, to solve problems using Faraday's and Lenz's laws

Session 2025-2029 onwards

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- Have an introduction to Maxwell's equations
- In the laboratory course the student will get an opportunity to verify various laws in electricity and magnetism.
- Should be able to verify of various circuit laws, network theorems elaborated above, using simple electric circuits.

SKILLS TO BE LEARNED

- This course will help in understanding basic concepts of electricity and magnetism and their applications.
- He / she shall comprehend the role of Maxwell's equation in unifying electricity and magnetism.
- Enable the student to understand propagation of electromagnetic waves through different bound and unbound media.

COURSE CONTENT

Electrostatics: Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.

(20 Lectures)

Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of 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 ferro- magnetic materials.

(10 Lectures)

Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in 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 and isotropic dielectric medium, transverse nature of EM waves.

(10 Lectures)

Reference Books:

1. Classical Electromagnetism, H.C. Verma, Bharati Bhawan (Publishers & Distributors); First Edition (1 February 2022).
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. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn, 1998, Benjamin Cummings.
7. Electromagnetic Theory and electrodynamics Satyaprakash, Kedar Nath Ram Nath Publishers
8. Electricity and Magnetism, K.K. Tiwari, S Chand Publishers.
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.

Session 2025-2029 onwards

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13. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer.
14. Electromagnetic Fields & Waves, P. Lorrain & D. Corson, 1970, W.H. Freeman & Co.
15. Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
16. Electromagnetic Theory, Chopra and Agarwal, K. Nath & Co., Meerut.
17. Electromagnetic Theory and electrodynamics, Satyaprakash, KedarNath Ram Nath Publishers
18. Electricity and Magnetism, K.K. Tiwari, S Chand Publishers.
19. Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004, Cambridge University Press.

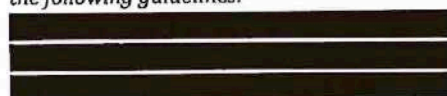
PHYSICS- ELC-1: Practical

Credit: 01 Lectures: 30(15X2)

Instructions to Question Setters

End Semester Examination (ESE): 25 Marks

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:



Note: No internal or mid-semester examination will be conducted for the practical paper.

1. To find the value of a resistor and its tolerance by colour coding.
2. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
3. To study the characteristics of a series RC Circuit.
4. To verify the laws of combination (series and parallel) of resistances using a metre bridge.
5. To determine an unknown Low Resistance using Potentiometer.
6. To verify Ohm's law for the given unknown resistance.
7. To verify the Thevenin theorem.
8. To verify the Norton theorem.
9. To verify the Superposition theorem.
10. To verify Maximum power transfer theorem.

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, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
4. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
5. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
6. B.Sc. Practical Physics, C. L. Arora, S. Chand & Company.

Session 2025-2029 onwards

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SEMESTER-V/SEMESTER VI

PHYSICS- ELC-2 THEORY: THERMAL PHYSICS AND STATISTICAL MECHANICS

Credits: 03 Lectures: 45

Instructions to Question Setters

Semester Internal Examination (SIE) – 10 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

This course will introduce Thermodynamics, Kinetic theory of gases and Statistical Mechanics to the students. The primary goal is to understand the fundamental laws of thermodynamics and its applications to various thermodynamical systems and processes. This coursework will also enable the students to understand the connection between the macroscopic observations of physical systems and microscopic behaviour of atoms and molecule through statistical mechanics.

COURSE LEARNING OUTCOMES

At the end of this course, students will

- ❖ Learn 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. They are also expected to learn Maxwell's thermodynamic relations.
- ❖ Know the fundamentals of the kinetic theory of gases, Maxwell-Boltzmann distribution law, equipartition of energies, mean free path of molecular collisions, viscosity, thermal conductivity, diffusion and Brownian motion.
- ❖ Learn about the black body radiations, Stefan- Boltzmann's law, Rayleigh-Jean's law and Planck's law and their significances.
- ❖ Learn the quantum statistical distributions, viz., the Bose-Einstein statistics and the Fermi-Dirac statistics.
- ❖ In the laboratory course, the students are expected to: Measure of Planck's constant using black body radiation, determine Stefan's Constant, coefficient of thermal conductivity of a bad conductor and a good conductor, determine the temperature co-efficient of resistance, study variation of thermo emf across two junctions of a thermocouple with temperature etc.

Session 2025-2029 onwards

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SKILLS TO BE LEARNED

- ✦ In this course the students should be skilled in doing calculations in thermodynamics and statistical mechanics.
- ✦ They should also be proficient in doing calculations with the kinetic theory of ideal and real gases.
- ✦ In the laboratory course, the students should acquire the skills of doing basic experiments in thermal physics with the right theoretical explanations of results therefrom.

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 CP and CV, 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 (statement only), Unattainability of absolute zero.

(15 Lectures)

Thermodynamical Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications - Joule-Thompson Effect, Clausius- Clapeyron Equation, Expression for (CP – CV), CP/CV, TdS equations.

(8 Lectures)

Kinetic Theory of Gases: Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path, Transport Phenomena: Viscosity, Conduction and Diffusion, Law of equipartition of energy and its applications to specific heat of gases; mono-atomic and diatomic gases.

(8 Lectures)

Theory of Radiation: Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction from Planck's law-Rayleigh- Jeans Law, Stefan Boltzmann Law and Wien's displacement 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. Advanced Text Book on Heat, P. K. Chakrabarti, 10th Edition, Reprint 2015, Sreedhar Publishers.
7. Heat Thermodynamics and Statistical Physics, Brijlal, Dr. N. Subrahmanyam and P. S. Hemne, S. Chand Publishers.

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PHYSICS ELC-2: Practical**Credit: 01 Lectures: 30(15X2)****Instructions to Question Setters****End Semester Examination (ESE): 25 Marks**

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:



Note: No internal or mid-semester examination will be conducted for the practical paper

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. Measurement of Planck's constant using black body radiation.
3. To determine Stefan's Constant.
4. To determine the coefficient of thermal conductivity of Cu by Searle's Apparatus.
5. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
6. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.
7. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.

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 Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985, Vani Publication.
4. A text book on Practical Physics, K. G. Mazumdar and B. Ghosh, Sreedhar Publishers, Reprint 2016.
5. Advanced Text Book on Heat, P. K. Chakrabarti, 10th Edition, Reprint 2015, Sreedhar Publishers.
6. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
7. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
8. B.Sc. Practical Physics, C. L. Arora, S. Chand & Company.

Session 2025-2029 onwards

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SEMESTER-VII/SEMESTER VIII

PHYSICS- ELC-3 THEORY: WAVES & OPTICS

Credits: 03 Lectures: 45

Marks: 75 (End Semester Examination=60, Semester Internal Examination= 10 (Theory), Class Performance & Attendance =05) Pass Marks (Internal + End Semester) = 30

Instructions to Question Setters

Semester Internal Examination (SIE) – 10 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A: Consists of five very short answer-type questions, each carrying 1 mark. All five questions are compulsory.

Group B: Contains two descriptive-type questions, each carrying 5 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) – 60 Marks:

The question paper will be divided into two groups: Group A and Group B.

Group A (Compulsory): Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.

Group B: Contains five descriptive-type questions, each carrying 15 marks. Candidates are required to answer any three questions from this group.

Note: Questions in the theory papers may have subdivisions.

COURSE OBJECTIVE

This is one of the core courses in Physics curriculum that begins with explaining ideas of superposition of harmonic oscillations leading to physics of travelling and standing waves. This course helps in understanding forced vibrations, resonance, acoustics of buildings, Reverberation and time of reverberation - absorption coefficient. The course also provides an in depth understanding of wave phenomena of light, namely, interference, diffraction and polarization with emphasis on practical applications of the same.

COURSE LEARNING OUTCOMES

At the end of this course, students will

- ✦ Understand Simple harmonic oscillation and superposition principle.
- ✦ Understand superposition of a range of collinear and mutually perpendicular simple harmonic motions and their applications.
- ✦ Understand the importance of classical wave equation in transverse and longitudinal waves and solving a range of physical systems on its basis.
- ✦ Understand different types of waves and their velocities: Plane, Spherical, Transverse, Longitudinal.
- ✦ Understand Concept of normal modes in transverse and longitudinal waves: their frequencies and configurations.
- ✦ Understand Forced vibrations and resonance, Fourier's Theorem. Acoustics of buildings, Reverberation and time of reverberation - Absorption coefficient - Sabine's formula.
- ✦ Understand Interference as superposition of waves from coherent sources derived from same parent source.

Session 2025-2029 onwards

Sayantra S
18/08/2026

18/08/26

18/08/2026

18/08/26

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- Demonstrate understanding of Interference experiments: Young's Double Slit, Fresnel's biprism, Lloyd's Mirror, Newton's Rings, Michelson Interferometer and Fabry-Perot Interferometer
- Demonstrate basic concepts of Diffraction: Superposition of wavelets diffracted from apertures
- Understand Fraunhofer Diffraction from apertures: Rectangular, Slit, Double Slit, Grating, Circular apertures.
- Demonstrate fundamental understanding of Fresnel Diffraction: Half period zones, Zone Plate, Fresnel's Integrals, Cornu's Spiral and its applications.
- Understand the phenomenon of polarization of light, production and analysis of plane, circular and elliptical polarized light.
- 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 Rings experiment, Fresnel Biprism etc. Resolving power of optical equipment can be learnt first-hand.
- The motion of coupled oscillators, study of Lissajous figures and behaviour of transverse and longitudinal waves can be learnt in this laboratory course.

SKILLS TO BE LEARNED

- In this course the students should understand waves motion and its properties.
- The students shall develop the skills to understand about Acoustics of buildings, Reverberation and time of reverberation
- The students shall develop an understanding on various optical phenomena, principles, workings and applications optical instruments

COURSE CONTENT

Superposition of Two Collinear Harmonic oscillations: Linearity & Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats).

(4 Lectures)

Waves Motion: Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity.

(6 Lectures)

Sound: Forced vibrations and resonance, Fourier's Theorem - Application to saw tooth wave and square wave. Acoustics of buildings, Reverberation and time of reverberation - Absorption coefficient - Sabine's formula.

(8 Lectures)

Interference: Interference: Division of amplitude and division of wavefront. 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.

(8 Lectures)

Michelson's Interferometer: (1) Idea of form of fringes (no theory needed), (2) Determination of wavelength, (3) Wavelength difference, (4) Refractive index, and (5) Visibility of fringes.

(5 Lectures)

Diffraction: Fraunhofer diffraction- Single slit; Double Slit. Plane Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis.

(9 Lectures)

Polarization: Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization.

(5 Lectures)

Session 2025-2029 onwards

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18/08/2024

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18/08/2024

18/08/2024

18/08/2024

134

Reference Books:

1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
2. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
3. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
4. Oscillations & Waves, Satya Prakash, Pragati Prakashan, Meerut, Edition XI, 2019.
5. Sound, K. Bhattacharyya, Shreedhar Prakashani, Reprint-2015.
6. A text book of Sound, M. Ghosh, S. Chand & Company, 1998.
7. A text book of Oscillations, Waves and Acoustics, M Ghosh & D Bhattacharya, S. Chand, 2016.
8. A textbook of Sound, N Subrahmanyam, Brij Lal, S, Chand, Second Edition, 2018.
9. Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-Hill
10. Principles of Optics, B.K. Mathur, 1995, Gopal Printing.
11. Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publications.
12. University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley.
13. Introduction to Geometrical and Physical Optics, B. K. Mathur, Gopal Printing.
14. Geometrical and Physical Optics, P. K. Chakraborty, New Central Book Agency (P) Ltd.
15. Introduction to Geometrical and Physical Optics, B. K. Mathur, Gopal Printing.
16. A Text Book on Light, B. Ghosh and K. G. Mazumdar, 5th Edn., Reprint 2015, Sreedhar Publishers.
17. A Text Book of Optics, Dr. N. Subrahmanyam, Brijlal, Dr. M. N. Avadhanulu, S. Chand Publishers.

PHYSICS ELC-3: Practical**Credit: 01 Lectures: 30(15X2)*****Instructions to Question Setters******End Semester Examination (ESE): 25 Marks***

There will be one Practical Examination of 3 hours duration. Evaluation of the Practical Examination will be as per the following guidelines:

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

Note: No internal or mid-semester examination will be conducted for the practical paper

1. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify $\lambda^2 - T$ Law.
2. To investigate the motion of coupled oscillators.
3. To study Lissajous Figures.
4. Familiarization with: Schuster's focusing; determination of angle of prism.
5. To determine the Refractive Index of the Material of a Prism using Sodium Light.
6. To determine Dispersive Power of the Material of a Prism using Mercury Light
7. To determine the value of Cauchy Constants.
8. To determine the Resolving Power of a Prism.
9. To determine wavelength of sodium light using Fresnel Biprism.
10. To determine wavelength of sodium light using Newton's Rings.
11. To determine the wavelength of Laser light using Diffraction of Single Slit.
12. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating
13. To determine the Resolving Power of a Plane Diffraction Grating.

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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 Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985, Vani Publication.
 4. A text book on Practical Physics, K. G. Mazumdar and B. Ghosh, Sreedhar Publishers, Reprint 2016.
 5. Principles of Optics, B.K. Mathur, 1995, Gopal Printing.
 6. A Text Book on Light, B. Ghosh and K. G. Mazumdar, 5th Edn., Reprint 2015, Sreedhar Publishers.
 7. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
 8. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
 9. B.Sc. Practical Physics, C. L. Arora, S. Chand & Company
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Session 2025-2029 onwards

136

Sayantra Sil
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MDC (Multidisciplinary Course): PHYSICS**SEMESTER I/SEMESTER II/SEMESTER III****MDC-1/2/3: PHYSICS****(Credits: Theory-03 Lectures-45)****Marks: 75 (End Semester Examination=75, No Semester Internal Examination)****Pass Marks: = 30****Instructions to Question Setter for****End Semester Examination (ESE) – 75 Marks:***The question paper will be divided into two groups: Group A and Group B.****Group A (Compulsory):** Question 1: Five very short answer-type questions of 1 mark each. Questions 2 and 3: Short answer-type questions, each carrying 5 marks.****Group B:** Contains six descriptive-type questions, each carrying 15 marks. Candidates are required to answer any four questions from this group.****Note:** Questions in the theory papers may have subdivisions.***Unit I Motion**

Velocity, acceleration, momentum, inertia, force, laws of motion. Newton's law of gravitation, acceleration due to gravity, mass and weight, weightlessness.

(6 lectures)**Unit II Properties of Matter**

Different phases of matter, surface tension, capillary rise, viscosity-Poiseuille's formula, Heat, temperature, different temperature scales: degree Celsius, Fahrenheit and Kelvin, idea of transverse and longitudinal waves.

(9 Lectures)**Unit III Light & lenses**

Reflection, refraction, total internal reflection, dispersion, diffraction, interference, scattering (elementary ideas only), blue colour of sky, twinkling of stars. Mirage, rainbow, concave and convex lenses, focal length, power of a lens, refractive index, defects of the eye– myopia, hypermetropia, presbyopia and astigmatism and their correction by lens.

(11 Lectures)**Unit IV Electricity & Magnetism**

Electricity: Voltage and current, Ohm's law, idea of combination of resistance in series and parallel, Electric power (E Bill), calculation of energy requirement of electric appliances, transformer, generator.

Magnetism: Electromagnetic induction-super conductivity-Meissner effect (qualitative idea), Maglev train.

(10 Lectures)**Unit V Our Universe**

Galaxies- Stars, Planets & satellites – solar system, lunar and solar eclipses, evolution of stars, black holes (basic concept). Artificial satellites: Geo stationary and Polar satellites.

(9 Lectures)

Sayan Kumar
18/08/2026

Session 2025-2029 onwards

18/08/26

18/08/2026

18/8/20

137

18/08/26

Reference Books:

1. Physics text books for class 11th and 12th NCERT, New Delhi, revised editions 2022.
2. Concepts of Physics, Part-I and Part-II, H. C. Verma, 2020, Bharati Bhawan.
3. Elements of Properties of Matter, D. S Mathur, 2010, S. Chand & Co.
4. Fundamentals of Physics with Applications, Arthur Beiser, 2010, Tata McGraw-Hill publishing Co. Ltd.
5. Optics by Ajay Ghatak, New Delhi, 1998 Tata McGraw-Hill publishing Co. Ltd.
6. Electricity and Magnetism, A S Mahajan, A. A. Rangwala, 2017 McGraw Hill, New Delhi.
7. An Introduction to Astrophysics, Baidyanath Basu, Tanuka Chattopadhyay, Sudhindra Nath Biswas, Second Edition, 2010, PHI Learning Private Limited.

Additional Books for reference:

1. Mechanics (in SI units) - (Berkley Physics course-volume 1), Charles Kittel, Walter Dknight etc, Tata McGraw Hill publication, 2017, second edition
2. Fundamental of General Properties of Matter, H.R Gulati, R Chand and Co, Fifth edition (1977).
3. A Text book of Optics by Subrahmanyam N., BrijLal and M. N. Avadhanulu,

Sayantra Sil
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FORMAT OF QUESTION PAPER FOR SEMESTER INTERNAL EXAMINATIONSQuestion format for 10 Marks:

F.M. =10	Subject/ Code Time=1Hr.	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 sub parts of a question at one place. v. Numbers in right indicate full marks of the question.		
<u>Group A</u>		
1.	i. ii. iii. iv. v.	[5x1=5]
<u>Group B</u>		
2.		[5]
3.		[5]
Note: There may be subdivisions in each question asked in Theory Examination.		

Question format for 20 Marks:

F.M. =20	Subject/ Code Time=1Hr.	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 sub parts of a question at one place. v. Numbers in right indicate full marks of the question.		
<u>Group A</u>		
1.	i. ii. iii. iv. v.	[5x1=5]
2.		[5]
<u>Group B</u>		
3.		[10]
4.		[10]
Note: There may be subdivisions in each question asked in Theory Examination.		

Sujantan Sii
18/08/2026
Session 2025-2029 onwards

26/08/26
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FORMAT OF QUESTION PAPER FOR END-SEMESTER UNIVERSITY EXAMINATIONS
Question Format for 50 Marks AEC Paper

F.M. =50	Subject/ Code Time=2Hrs.	Exam Year
General Instructions:		
i. Group A carries very short answer type compulsory questions. ii. Answer 3 out of 6 subjective/ descriptive questions given in Group B. iii. Answer in your own words as far as practicable. iv. Answer all sub parts of a question at one place. v. Numbers in right indicate full marks of the question.		
Group A		
1.		[5x1=5]
i.		
ii.		
iii.		
iv.		
v.		
Group B		
2.		[15]
3.		[15]
4.		[15]
5.		[15]
6.		[15]
7.		[15]
Note: There may be subdivisions in each question asked in Theory Examination.		

Question format for 60 Marks:

F.M. =60	Subject/ Code Time=3Hrs.	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 sub parts of a question at one place. v. Numbers in right indicate full marks of 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]
Note: There may be subdivisions in each question asked in Theory Examination.		

Session 2025-2029 onwards

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Question format for 75 Marks:

F.M. = 75		Subject/ Code	Exam Year
		Time=3Hrs.	
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 sub parts of a question at one place.			
v. Numbers in right indicate full marks of the question.			
<u>Group A</u>			
1.			[5x1=5]
	i.		
	ii.		
	iii.		
	iv.		
	v.		
2.			[5]
3.			[5]
<u>Group B</u>			
4.			[15]
5.			[15]
6.			[15]
7.			[15]
8.			[15]
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Note: There may be subdivisions in each question asked in Theory Examination.			

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Session 2025-2029 onwards

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Question Format for 50 Marks AEC (Ability Enhancement Courses) Paper

Semester	Credit	Subject/Paper name	Exam Duration	Pattern of Question Paper	Full Marks	Pass Marks
I	2	Hindi/English	2 Hrs	Group A • 5 Very Short Answer Type Questions • 1 Mark each $5 \times 1 = 5$ Marks Group B — Long Answer Questions • Questions to be set • Students will attempt any 3 • Each question may contain sub-parts • 15 Marks each $3 \times 15 = 45$ Marks Grand Total = 50 Marks	50	20
II	2	English/Hindi				
III	2	Hindi/English/MIL/TRL				
IV	2	Same as Semester III				

Session 2025-2029 onwards

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Question Format for 50 Marks VAC (Value Aded Courses) Paper

Semester	Credit	Subject/Paper name	Exam Duration	Pattern of Question Paper	Full Marks	Pas Marks
I	2	1. Understanding India 2. Health, Wellness & Yoga 3. Environmental Studies (The above three subjects may be taken in Semester I, II, or, IV in any order, as per the option exercised by the students)	2 Hrs	- Question Type: Multiple Choice Questions (MCQs) - Number of Questions: 50 - Marks per Question: 1 Mark each - Total Marks: 50	50	20
II	2					
IV	2					

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Session 2025-2029 onwards

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Question Format for 50 Marks SEC (Skill Enhancement Courses) Paper

Semester	Credit	Subject/Paper Name	Exam Duration	Pattern of Question Paper	Full Marks	Pass Marks
I	3	There shall be three Skill Enhancement Course (SEC) papers focusing on Computer Awareness and Skills. The courses shall be of a progressive and sequential nature, wherein the curriculum of the subsequent semester shall build upon the knowledge and skills acquired in the preceding semester. - Semester I: SEC-I "Computer Fundamentals & Computer Proficiency" - Semester II: SEC-II "Cyber-Crime & Cybersecurity" - Semester III: SEC-III "Digital Learning & AI Tools"	2 Hrs	- Question Type: Multiple Choice Questions (MCQs) - Number of Questions: 50 - Marks per Question: 1.5 Mark each - Total Marks: 75	50	30
II	3					
III	3					

Session 2025-2029 onwards

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144

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Question Format for 75 Marks MDC (Multidisciplinary Courses) Paper

Semester	Credit	Subject/Paper Name	Exam Duration	Pattern of Question Paper	Full Marks	Pass Marks
I	3	This course must be distinct from their core courses and cannot be repeated from higher secondary education.	2 Hrs	Group A — (15 Marks) This group shall contain three questions: - Q 1: Very Short Answer Type 5 Questions 1 Mark each $5 \times 1 = 5$ Marks - Q2 & Q3 Short Answer Type 2 Questions 5 Marks each $2 \times 5 = 10$ Marks	75	30
II	3			Group B — Long Answer Questions (60 Marks) 6 Questions shall be set. - Students shall attempt any four questions. - Each question may contain sub-parts. - Each question shall carry 15 Marks. $4 \times 15 = 60$ Marks		
III	3			Grand Total = 75 Marks		

Session 2025-2029 onwards

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Question Format for 50 Marks IKS (Indian knowledge System-I/Social Awareness Activities) Paper

Semester	Credit	Subject/Paper Name	Exam Duration	Pattern of Question Paper	Full Marks	Pass Marks
I	2	There shall be two Indian knowledge System (IKS) paper. This course aims to familiarize students with India's rich culture, philosophical, scientific, and technical heritage promoting an appreciation for traditional knowledge systems and their application in modern contexts. Semester I: Indian Knowledge System	2 Hrs	- Question Type: Multiple Choice Questions (MCQs) - Number of Questions: 50 - Marks per Question: 1 Mark each - Total Marks: 50	50	20
II	2	Semester II: Social Awareness Activities - There shall be two modules: - SA-1 - SA-2 - Students can choose any one of the two modules.	1.5 Hrs (ESE)	Internal Assessment (IA) (Total Marks: 20) - Class test: 05 Marks — MCQs or short Answer (2-3 sentence) question - Out-of-class Activities: 10 Marks, (01 mark per activities) - Attendance: 05 marks End Semester University Examinations (ESE) (Total Marks: 30) - Question Type: Multiple Choice Questions (MCQs) - Number of Questions: 30 - Marks per Question: 1 Mark each - Total marks: 50 (IA+ESE)	20+30=50 (IA+ESE)	20

Session 2025-2029 onwards

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