Pt. Ravishankar Shukla University,
Raipur (C.G.), India 492010
Center for Basic Sciences

CURRICULUM & Syllabus
(Based on CBCS & LOCF)

Five Year Integrated M.Sc. (Physics Stream)
(Semester System)

Semester: I – X
Session: 2025-30

टीपः– सत्र **2024–25** के पाठ्यक्रम को सत्र. **2025–26** के लिए यथावत प्रभावशील किया जाता है।

Approved by	:	
Board of Studies	:	**Physics**
Dates	:	19/05/2025
Name of Chairman	:	Dr Nameeta Brahme
Name of Member's	:	1. Kishor Chelak 19.05.25
		2. Umashankar Bhardwaj
		3. Prof. D. P. Bisen 19/05/2025
		4. Prof. A. S. Gour
		5. Mr. Chitrakant Belodhiya
		6. Dr. Laxmi Kant
		7. Dr. G. Nag Bhargavi (online)
		8. Dr. Rajiv Manohar (online)
		9. Dr. Vikas Gulhare (online)

Center for Basic Sciences
PT. RAVISHANKAR SHUKLA UNIVERSITY RAIPUR, CHHATTISGARH

OBJECTIVES :

The CBS model of education is concept-based and inquiry-driven, as opposed to the more traditional content-based models. There is a strong emphasis on the interdisciplinary nature of today's science, and recognition of the importance of research experience in undergraduate education. Courses offered in the Int. M. Sc. program at CBS form part of a comprehensive program that will enable the students:

- To understand the basic laws of nature and develop necessary skills to apply them to any desired area or discipline.
- To undertake projects to solve field base problems.
- To provide student centric learning facilities for the development of overall personality of learner. The program is planned as student-centric collaborative learning.
- Students get trained for a career in basic sciences or any related applied science or technology.

General Pattern of the Integrated M. Sc. Program in Physics:

The course structure of five year Integrated-M.Sc. Physics is designed to start the journey so as to help the student to perform a journey from introduction of the subject in the first semester to an advanced level of understanding in the final semester and also give him/her glimpses of contemporary research in the stream of specialization and/or other interdisciplinary areas.

- The curriculum for the first two semesters (first year) is common to all students (10+2 PCM and PCB group) and consist of (i) Introductory theory courses in biology, chemistry, mathematics and physics, (ii) Laboratory courses, and (iii) courses in communication skills, computer basics as well as electronics.
- At the beginning of the second year (third semester), a student will opt for specialization in one of the streams (Biology, Chemistry, Mathematics or Physics) according to their choice.
- In the second and third years of study, the students are taught courses not only in the specialised discipline, but often courses from other science disciplines as well, as recommended for an integrated understanding of the subject matter.
- The courses in fourth and fifth years of the integrated M.Sc. Programmer are more advanced in nature and are mainly from the respective disciplines, although there are some interdisciplinary courses.
- The Center focuses on imparting a complete education and prescribes some compulsory courses which belong to humanities, social sciences, technical communication, history of science, environmental and energy sciences, etc.
- In order to expose the young minds to research early in their career, the students are offered projects from 4th year onward. Thus, in 7th semester they are exposed to supervised learning of a research topic, followed by a mini research project in 8th semester. The 9th semester entails a dissertation, where the students need to go outside of the CBS to carry out a full semester external project.

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- The students are thus encouraged to take up summer projects and visit reputed national, international laboratories and universities, so as to broaden their vision and widen their horizon.
- Students also get an opportunity to learn from and interact with eminent scientists from India and abroad who are invited to the Center at regular intervals to deliver colloquia and seminars.

Program Outcomes:

The Integrated M.Sc. in Physics is a comprehensive 5-year, 10-semester program. Its objectives are achieved through engagement with a diverse and carefully structured curriculum. Each component is meticulously designed to develop specific competencies and outcomes, equipping students with the skills and knowledge expected upon successful completion of the program.

PO-1	**Knowledge:** Demonstrate a solid understanding of core and advanced concepts in physics, applying theoretical and experimental methods to solve complex problems.
PO-2	**Critical Thinking and Reasoning:** Exhibit advanced critical thinking by analyzing physical phenomena, constructing logical arguments, and assessing the validity of physical theories.
PO-3	**Problem Solving:** Solve abstract and applied problems using advanced mathematical and computational techniques, demonstrating proficiency in model development and experimental design.
PO-4	**Advanced Analytical and Computational Skills:** Utilize a range of computational tools and software for simulation and data analysis to support theoretical and experimental physics.
PO-5	**Effective Communication:** Communicate complex physical ideas and research findings effectively to both technical and non-technical audiences, through written, oral, and digital media.
PO-6	**Social/Interdisciplinary Interaction:** Work collaboratively across disciplinary boundaries to address multi-faceted problems, integrating physics with other scientific and engineering disciplines.
PO-7	**Self-directed and Life-long Learning:** Engage in self-directed learning to stay abreast of advancements in physics and related fields, adapting to continuous changes in the landscape of scientific research.
PO-8	**Effective Citizenship: Leadership and Innovation:** Lead initiatives and innovative projects in scientific research and community engagement, demonstrating responsibility and ethical leadership.
PO-9	**Ethics:** Uphold high ethical standards in research and professional activities, showing integrity and respect for scientific rigor and societal needs.
PO-10	**Further Education or Employment:** Pursue further academic studies or professional careers in physics, contributing to academia, industry, or government sectors with high competence.
PO-11	**Global Perspective:** Understand and incorporate global and cultural perspectives in physics research and practice, enhancing international collaborations and solutions.

Programme Specific Outcomes:

At the end of the program, the student will be able to:

PSO1	**Scientific Reasoning:** Develop the ability to comprehend, analyze, and evaluate physical processes using scientific reasoning, starting from fundamental principles to make informed predictions and hypotheses.
PSO2	**Knowledge Integration:** Apply a broad base of physics knowledge to solve interdisciplinary problems, linking different physics concepts and integrating them with other scientific fields such as biophysics and computational physics.
PSO3	**Experimental Skills:** Demonstrate proficiency in laboratory techniques and experimental setups; design experiments to test hypotheses or solve problems using advanced tools and methodologies.
PSO4	**Computational Proficiency:** Utilize modern computational tools and techniques to model, simulate, and solve complex physical problems, effectively employing both numerical and analytical methods.
PSO5	Student should acquire knowledge and problem-solving skills to pass National level CSIR/UGC NET, State level SET/SLET and Ph. D. entrace examinations in Physical Sciences.

Integrated M.Sc. in Physics Program: Course and Credit Summary

Specification of Course	Semester	No. of Courses	Credits
Core	I-IX	**62**	220
Elective	X	**04**	20
Total		68	240
Additional Courses (Qualifying in nature, for Student admitted in CBS only)			
Additional Paper (EVS)	I	**01**	**02**
	II	**01**	**02**
Skill Enhancement /Value Added Courses	V	**01**	**02**
	VI	**01**	**02**
	VII	**01**	**02**
Skill Enhancement Course (only for Physics students)	VIII	**01**	**02**

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Course structure of
Five Year M. Sc. Integrated (Physics Stream)
Session 2024-25 & Onwards

- Minimum total credits for integrated M.Sc. degree is 240.
- Semesters I to VIII will carry 25 credits each.
- Semesters IX and X will carry 20 credits each.

Abbreviation: **B**: Biology, **C**: Chemistry, **M**: Mathematics, **P**: Physics, **G**: General, **H**: Humanities, **BL**: Biology Laboratory, **CL**: Chemistry Laboratory, **PL**: Physics Laboratory, **GL**: General Laboratory, **PE**: Physics Elective, **PPr**: Physics Project, **SEL**: Skill Enhancement Laboratory, **CIA**: Continuous Internal Assessment, **ESE**: End Semester Examination

FIRST YEAR

SEMESTER -I

Course Nature	Course Code	Course Title	Course Type	Contact Hours / Week [Theory + Tutorials]	Credits	Marks		
						CIA	ESE	Total
Core	B101	Biology - I	T	[2+1]	3	60	40	100
Core	C101	Chemistry - I	T	[2+1]	3	60	40	100
Core	M101/MB101	Mathematics - I	T	[2+1]	3	60	40	100
Core	P101	Physics - I	T	[2+1]	3	60	40	100
Core	G101	Computer Basics	T	[2+1]	3	60	40	100
Core	H101	Communication Skills	T	[2]	2	60	40	100
Core	PL101	Physics Laboratory - I	P	[4]	2	60	40	100
Core	CL101	Chemistry Laboratory - I	P	[4]	2	60	40	100
Core	BL101	Biology Laboratory - I	P	[4]	2	60	40	100
Core	GL101	Computer Laboratory	P	[4]	2	60	40	100
Total (25 of 240 credits)					**25**			
Additional Papers								
Qualifying	ES101	Environmental Studies	T	[2]	2	60	40	100

SEMESTER -II

Course Nature	Course Code	Course Title	Course Type	Contact Hours / Week [Theory + Tutorials]	Credits	Marks		
						CIA	ESE	Total
Core	B201	Biology - II	T	[2+1]	3	60	40	100
Core	C201	Chemistry - II	T	[2+1]	3	60	40	100
Core	M201/MB201	Mathematics - II	T	[2+1]	3	60	40	100
Core	P201	Introductory Physics - II	T	[2+1]	3	60	40	100
Core	G201	Electronics and Instrumentation	T	[2+1]	3	60	40	100
Core	BL201	Biology Laboratory - II	P	[4]	2	60	40	100
Core	CL201	Chemistry Laboratory - II	P	[4]	2	60	40	100
Core	PL201	Physics Laboratory - II	P	[4]	2	60	40	100
Core	GL201	Electronics Laboratory	P	[2]	2	60	40	100
Core	H201	Communication Skills Lab	P	[4]	2	60	40	100
Total (50 of 240 credits)					**25**			
Additional Papers								
Qualifying	ES201	Environmental Studies II	T	[2]	2	60	40	100

SECOND YEAR

SEMESTER - III

Course Nature	Course Code	Course Title	Course Type	Contact Hours / Week [Theory + Tutorials]	Credits	Marks		
						CIA	ESE	Total
Core	P301	Mathematical Physics - I	T	[3+1]	4	60	40	100
Core	P302	Classical Mechanics - I	T	[3+1]	4	60	40	100
Core	P303	Electromagnetism	T	[3+1]	4	60	40	100
Core	P304	Waves and Oscillations	T	[3+1]	4	60	40	100
Core	H301	Creative Hindi	T	[2+0]	2	60	40	100
Core	H302	History and Philosophy of Science	T	[2+0]	2	60	40	100
Core	PL301	Physics Laboratory - III	P	[6]	3	60	40	100
Core	GL301	Applied Electronics Laboratory	P	[4]	2	60	40	100
Total (75 of 240 credits)					**25**			

***H302 is Indian Knowledge System (IKS) Course.**

SEMESTER -IV

Course Nature	Course Code	Course Title	Course Type	Contact Hours / Week [Theory + Tutorials]	Credits	Marks		
						CIA	ESE	Total
Core	P401	Mathematical Physics - II	T	[4+1]	5	60	40	100
Core	P402	Quantum Mechanics - I	T	[4+1]	5	60	40	100
Core	PCB401	Physical and Chemical Kinetics	T	[3+1]	4	60	40	100
Core	G401	Statistical Techniques and Applications	T	[3+1]	4	60	40	100
Core	PL401	Physics Laboratory-IV	P	[6]	3	60	40	100
Core	GL401	Computational Laboratory and Numerical Methods	P	[4]	2	60	40	100
Core	H401	Communication Skills Lab-II	P	[4]	2	60	40	100
Total (100 of 240 credits)					**25**			

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THIRD YEAR

SEMESTER - V

Course Nature	Course Code	Course Title	Course Type	Contact Hours / Week [Theory + Tutorials]	Credits	Marks		
						CIA	ESE	Total
Core	P501	Quantum Mechanics - II	T	[4+1]	5	60	40	100
Core	P502	Classical Mechanics - II	T	[4+1]	5	60	40	100
Core	P503	Atomic and Molecular Physics	T	[3+1]	4	60	40	100
Core	PM501	Numerical Analysis	T	[3+1]	4	60	40	100
Core	H501	Scientific Writing in Hindi	T	[2]	2	60	40	100
Core	PL501	Physics Laboratory - V	P	[6]	3	60	40	100
Core	PML501	Numerical Methods Laboratory	P	[4]	2	60	40	100
Total (125 of 240 credits)					**25**			
Value Added Course								
Qualifying	SEL501	English Language for Competence Skills	P	[4]	2	60	40	100

SEMESTER - VI

Course Nature	Course Code	Course Title	Course Type	Contact Hours / Week [Theory + Tutorials]	Credits	Marks		
						CIA	ESE	Total
Core	P601	Electrodynamics	T	[4+1]	5	60	40	100
Core	P602	Statistical Mechanics - I	T	[4+1]	5	60	40	100
Core	P603	Condensed Matter Physics - I	T	[3+1]	4	60	40	100
Core	P604	Lasers	T	[3+1]	4	60	40	100
Core	H601	Ethics of Science and IPR	T	[2]	2	60	40	100
Core	H602	Scientific Writing in English	T	[2]	2	60	40	100
Core	PL601	Physics Laboratory - VI	P	[6]	3	60	40	100
Total (150 of 240 credits)					**25**			
Value Added Course								
Qualifying	SEL601	Pratiyogi Prikshaon ke liye Hindi Bhasha	P	[4]	2	60	40	100

FOURTH YEAR

SEMESTER - VII

Course Nature	Course Code	Course Title	Course Type	Contact Hours / Week [Theory + Tutorials]	Credits	Marks		
						CIA	ESE	Total
Core	P701	Astronomy and Astrophysics - I	T	[3+1]	4	60	40	100
Core	P702	Quantum Mechanics - III	T	[3+1]	4	60	40	100
Core	P703	Statistical Mechanics - II	T	[3+1]	4	60	40	100
Core	P704	Computational Physics	T	[3+1]	4	60	40	100
Core	PL701	Advanced Physics Laboratory - I	P	[10]	5	60	40	100
Core	PPr701	Reading Project	P	[8]	4	60	40	100
Total (175 of 240 credits)					**25**			
Value Added Course								
Qualifying	SEL701	Linux Operating System	T	[4]	2	60	40	100

SEMESTER - VIII

Course Nature	Course Code	Course Title	Course Type	Contact Hours / Week [Theory + Tutorials]	Credits	Marks		
						CIA	ESE	Total
Core	P801	Astronomy and Astrophysics-II	T	[3+1]	4	60	40	100
Core	P802	Fluid Mechanics	T	[3+1]	4	60	40	100
Core	P803	Nuclear and Particle Physics	T	[3+1]	4	60	40	100
Core	P804	Condensed Matter Physics - II	T	[3+1]	4	60	40	100
Core	PL801	Advanced Physics Laboratory - II	P	[10]	5	60	40	100
Core	PPr801	Project	P	[8]	4	60	40	100
Total (200 of 240 credits)					**25**			
Value Added Course								
Qualifying	SEPML801	LaTeX & XFig - typesetting software	T	[4]	2	60	40	100

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FIFTH YEAR

SEMESTER - IX

Course Nature	Course Code	Course Title	Course Type	Contact Hours / Week [Theory + Tutorials]	Credits	Marks		
						CIA	ESE	Total
Core	PPr901	Project	P	-	20	-	400	400
Total (220 of 240 credits)					**20**			

SEMESTER - X

Course Nature	Course Code	Course Title	Course Type	Contact Hours / Week [Theory + Tutorials]	Credits	Marks		
						CIA	ESE	Total
Elective	PE - 1	Quantum Field Theory	T	[4+1]	5	60	40	100
Elective	PE - 2	General Relativity and Cosmology	T	[4+1]	5	60	40	100
Elective	PE - 3	Experimental Techniques	T	[4+1]	5	60	40	100
Elective	PE - 4	CCD Imaging and Spectroscopy	T	[4+1]	5	60	40	100
Elective	PE - 5	Biophysics	T	[4+1]	5	60	40	100
Elective	PE - 6	Particle Physics	T	[4+1]	5	60	40	100
Elective	PE - 7	Nonlinear Dynamics and Chaos	T	[4+1]	5	60	40	100
Elective	PE - 8	Reactor Physics and Radiation Science	T	[4+1]	5	60	40	100
Elective	PE - 9	Accelerator Physics and Applications	T	[4+1]	5	60	40	100
Elective	PE - 10	Glimpses of Contemporary Sciences	T	[4+1]	5	60	40	100
Elective	PE - 11	Earth Science and Energy & Environmental Sciences	T	[4+1]	5	60	40	100
Elective	PE - 12	Circuits and Electronics	T	[4+1]	5	60	40	100
Total (240 of 240 credits)					**20**			

***Four Subjects will be offered according to the availability of instructors and minimum number of interested students taking a course.The chosen four subject will have codes PE1001, PE1002, PE1003 and PE1004.**

Skill Enhancement/ Value Added Courses:

Candidates enrolled in the 5-Year Integrated M.Sc. in Physics program at the Center for Basic Sciences must complete Skill Enhancement/Value Added Courses, which are qualifying in nature.

Semester	Course Code	Course Title	Course Type (T/P)	Hrs/ Week	Credits	Marks		
						CIA	ESE	Total
V	SEL501	**English Language for Competence Skills**	P	4	2	60	40	100
VI	SEL601	**Pratiyogi Parikshao ke liye Hindi Bhasha**	P	4	2	60	40	100
VII	SEL701	**Linux Operating System**	P	4	2	60	40	100
VIII	SEPML801	**LaTeX & XFig - typesetting software**	P	4	2	60	40	100

Indian Knowledge System Course:

Candidates enrolled in the 5-Year Integrated M.Sc. Program at the Center for Basic Sciences are required to complete the Indian Knowledge System course, a core component of the curriculum.

Semester	Course Code	Course Title	Course Type (T/P)	Hrs/ Week	Credits	Marks		
						CIA	ESE	Total
III	**H302**	**History and Philosophy of Science**	**T**	[2 + 0]	**2**	**60**	**40**	**100**

Programme Articulation Matrix

Following matrix depicts the correlation between all the courses of the programme and Programme Outcomes

Course Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4	PSO5
B101	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
C101	✓	✓	✓	×	×	×	×	×	✓	✓	✓	✓	×	✓	×	×
M101/MB101	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
P101	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
G101	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
H101	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
BL101	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
CL101	✓	✓	✓	×	×	×	×	×	✓	✓	✓	✓	✓	✓	✓	×
PL101	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
GL101	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
ES101	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
B201	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
C201	✓	✓	✓	×	×	×	×	×	✓	✓	✓	✓	×	✓	×	×
M201/MB201	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
P201	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
G201	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
H201	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
BL201	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
CL201	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
PL201	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
GL201	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
ES201	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×

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Course Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4	PSO5
P301	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
P302	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
P303	✓	✓	✓	×	×	×	✓	×	×	✓	✓	✓	×	✓	✓	✓
P304	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
H301	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
H302	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
PL301	✓	✓	✓	×	×	×	✓	×	✓	✓	✓	✓	×	✓	×	×
GL301	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
PCB401	✓	✓	✓	×	×	×	✓	×	×	✓	✓	✓	✓	×	✓	×
P401	✓	✓	✓	×	×	×	✓	×	×	✓	✓	✓	✓	×	✓	✓
P402	✓	✓	✓	×	×	×	✓	×	×	✓	✓	✓	✓	×	✓	✓
G401	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
PL401	✓	✓	✓	✓	×	×	✓	×	✓	✓	✓	✓	✓	✓	✓	×
GL401	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
H401	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
PM501	✓	✓	✓	✓	×	✓	×	×	✓	✓	✓	✓	✓	✓	✓	×
P501	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓	✓	×	✓	✓
P502	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓	✓	×	✓	✓
P503	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓	✓	×	✓	✓
H501	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PL501	✓	✓	✓	✓	×	×	×	×	×	✓	✓	✓	✓	✓	✓	✓
PML501	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
P601	✓	✓	✓	×	×	×	×	×	✓	✓	✓	✓	✓	×	✓	✓
P602	✓	✓	✓	×	×	×	×	×	✓	✓	✓	✓	✓	×	✓	✓
P603	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓	✓	×	✓	✓
P604	✓	✓	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	✓	✓	✓
H601	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
H602	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
PL601	✓	✓	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	✓	✓	×
P701	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
P702	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
P703	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
P704	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PPr701	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
PL701	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
P801	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
P802	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
P803	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
P804	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PL801	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
PPr801	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
PPr901	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
PE1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
PE2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
PE3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
PE4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
PE5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
PE6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PE7	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
PE8	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
PE9	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
PE10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
PE11	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
PE12	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	76	76	76	62	56	63	63	57	66	76	76	76	76	63	76	27
SEL501	✓	×	×	×	✓	✓	×	×	×	×	×	×	✓	×	×	×
SEL601	✓	×	×	×	✓	✓	×	×	×	×	×	×	✓	×	×	×
SEL701	✓	✓	✓	✓	✓	×	×	×	×	✓	×	×	✓	✓	✓	×
SEPML801	✓	✓	✓	✓	✓	×	×	×	×	✓	×	×	✓	✓	✓	×

Semester-wise Syllabus

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SEMESTER - I

1.1 P101: Introductory Physics – I

Program	Subject	Year	Semester
Int. M.Sc	Physics	1	I
Course Code	**Course Title**		**Course Type**
P101	**Introductory Physics – I**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
3	2	1	-
Maximum Marks		**CIA**	**ESE**
100		60	40

1.1.1 Learning Objective (LO):

The course aims to develop the students' thought process, consolidating knowledge acquired at the +2 level, and creating a deep interest in understanding the laws of nature by fostering a comprehensive understanding of physics.

1.1.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand the relation of physics to other sciences, focusing on the conservation of energy and the characteristics of fundamental forces.	U
2	Analyze oscillatory motion, particularly simple harmonic motion, and understand its role in natural phenomena.	An
3	Understand the concepts of heat, temperature, and mechanisms of heat transfer, including the absolute temperature scale.	U
4	Review thermodynamics, emphasizing the macroscopic study of ideal gases and related processes.	U
5	Apply kinetic theory to understand the microscopic behavior of ideal gases and derive implications.	U

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CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

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1.1.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	2	1	-	3	3	3	1	1	2	1	3	3	1	1	1
CO2	3	3	3	-	3	2	3	2	1	2	1	3	2	2	1	1
CO3	3	3	3	-	2	2	3	2	1	2	1	3	2	2	1	3
CO4	3	3	3	-	3	2	3	1	1	2	1	3	2	1	1	3
CO5	3	3	3	-	3	2	3	1	1	2	1	3	2	1	1	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

1.1.4 Detailed Syllabus: P101 : Introductory Physics – I

Unit No.	Topics	No. of Lect.	CO No.
I	The Relation of Physics to Other Sciences: Chemistry, Biology, Astronomy, Geology, Psychology Conservation of Energy: What is energy?, Gravitational potential energy, Kinetic energy, Other forms of energy, Characteristics of Force: What is a force?, Friction, Molecular forces, Fundamental forces, Fields, Pseudo forces, Nuclear forces.	10	1
II	The Harmonic Oscillator: harmonic oscillator, Harmonic motion and circular motion, Initial conditions, Forced oscillations, Resonance: Complex numbers and harmonic motion, The forced oscillator with damping, Electrical resonance, Resonance in nature.	10	2
III	Heat: Equilibrium and the zeroth law: temperature, Calibrating temperature, Absolute zero and the Kelvin scale, Heat and specific heat, Phase change, Radiation, convection, and conduction, Heat as molecular kinetic energy, Boltzmann's constant and Avogadro's number, microscopic definition of absolute temperature.	10	3
IV	Thermodynamics: Statistical properties of matter and radiation, Thermodynamic processes, Quasi-static processes, the first law of thermodynamics, Specific heats: cv and cp, Cycles and state variables, Adiabatic processes, the second law of thermodynamics, The Carnot engine, Defining T using Carnot engines.	8	4

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Unit No.	Topics (Continued)	No. of Lect.	CO No.
V	Entropy and Irreversibility: Entropy, The second law: law of increasing entropy, Statistical mechanics and entropy, Entropy of an ideal gas: full microscopic analysis, illustration of maximum entropy principle, Gibbs formalism, third law of thermodynamics.	7	5

1.1.5 Suggested Texts and References:

1. Text Book for UNIT-I and II: *The Feynman Lectures in Physics, Volume 1*, by R. P. Feynman, R. B. Leighton, M. Sands.
2. Text Book for UNIT-III, IV and V: *Fundamentals of Physics I – Mechanics, Relativity, and Thermodynamics (Open Yale Courses)*, by R. Shankar.
3. References:
   - *An Introduction to Mechanics*, by D. Kleppner and R. Kolenkow.
   - *Mechanics*, by Charles Kittel, Walter D. Knight, and Malvin A. Ruderman, Berkeley Physics Course Volume 1.
   - *Waves*, by F. S. Crawford, Berkeley Physics Course Volume 3.
   - *Thermodynamics, Kinetic Theory and Statistical Thermodynamics*, 3rd Edition, by F. W. Sears and G. L. Salinger, Narosa Publishing House, 1998.
   - *Heat and Thermodynamics*, 8th Edition, by M. W. Zemansky and R. H. Dittman, Tata McGraw–Hill Education, 2011.
   - *University Physics*, 7th Edition, by Francis W. Sears, Mark Zemansky, and Hugh D. Young, Addison-Wesley, 1987.

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1.2 PL101: Physics Laboratory - I

Program	Subject	Year	Semester
Int. M.Sc	Physics	1	I
Course Code	**Course Title**		**Course Type**
PL101	**Physics Laboratory – I**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
2	-	-	4
Maximum Marks		**CIA**	**ESE**
100		60	40

1.2.1 Learning Objective (LO):

The learning objective is to perform a series of physics experiments to enhance the understanding of laboratory skills. Students should gain hands-on experience in conducting fundamental physics experiments.

1.2.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Have knowledge of plots (normal, semi-log, log-log), understand uncertainty/error in measurements and uncertainty/error analysis, and understand the concepts of standards and calibration.	An
2	Learn about the motion of a simple pendulum and coupled strip oscillations.	E
3	Understand the surface tension of water and other liquids, gain knowledge of Young's modulus of metal, and use the traveling microscope.	E
4	Learn about lenses, the combination of lenses, nodal points, and the thermal expansion of metals.	An
5	Understand the resistance of a wire, charging and discharging of a capacitor, and application of a multimeter.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

1.2.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5

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CO1	3	3	3	1	2	3	3	3	1	3	2	3	3	2	1	1
CO2	3	3	3	1	2	1	3	3	1	3	2	3	3	2	1	1
CO3	3	3	3	1	2	1	3	3	1	3	2	3	2	2	1	1
CO4	3	3	3	1	2	1	3	3	1	3	2	3	2	2	1	1
CO5	3	3	3	1	2	1	3	3	1	3	2	3	2	2	1	1

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

1.2.4 Detailed Syllabus: PL101 : Physics Laboratory - I

Unit No.	Topics	No. of Lect.	CO No.
I	Introduction to experimental physics – conceptual and procedural understanding, planning of experiments; Plots (normal, semi-log, log-log); uncertainty/error in measurements and uncertainty/error analysis. Introduction to measuring instruments – concepts of standards and calibration.	12	1
II	Determination of time periods in simple pendulum and coupled strip oscillator system with emphasis on uncertainty in the measurements and accuracy requirements; study of projectile motion – understand the timing requirements.	10	2
III	Determination of surface tension of a liquid from the study of liquid drops formed under the surface of a glass surface; determination of Young's modulus of a strip of metal by double cantilever method (use of traveling microscope).	12	3
IV	Study of combination of lenses and nodal points and correspondence to a thick lens; study of thermal expansion of metal – use of thermistor as a thermometer.	12	4
V	Measurement of small resistance of a wire using Carey-Foster bridge and determine electrical resistivity of the wire; study of time dependence of charging and discharging of capacitor using digital multimeter – use of semi-log plot.	14	5

1.2.5 Suggested Texts and References:

1. *Advanced Practical Physics for Students*, by B. L. Worsnop and H. T. Flint, Methuen and Co. Ltd., London.

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SEMESTER - II

2.1 P201: Introductory Physics – II

Program	Subject	Year	Semester
Int. M.Sc	Physics	1	II
Course Code	**Course Title**		**Course Type**
P201	**Introductory Physics – II**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
3	2	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

2.1.1 Learning Objective (LO):

The course aims to equip students with an understanding of electric field, electric dipole, Gauss's Law and its applications, Magnetism, Biot-Savart's Law and its applications, Wave theory of light, interference, diffraction, reflection, and optics.

2.1.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand the basics of electric field, field due to electric dipole, and Gauss's Law.	U
2	Understand and learn various applications of Gauss's Law.	An
3	Understand and learn the basics of magnetism, Lorentz force, Biot-Savart Law, and its applications.	An
4	Understand and learn about wave theory of light, including interference, diffraction, and reflection phenomena.	U
5	Understand and learn about geometrical optics, color vision of the human eye, and mechanisms of color vision.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

2.1.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	2	-	1	3	2	3	2	2	3	2	3	2	1	1	3
CO2	3	3	-	1	3	2	3	3	2	3	2	3	2	1	1	3
CO3	3	3	-	1	3	2	3	3	2	3	2	3	2	1	1	3
CO4	3	3	-	1	3	2	3	3	2	2	2	3	2	1	1	-
CO5	3	3	-	1	3	3	3	2	1	2	2	3	2	2	1	-

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

2.1.4 Detailed Syllabus: P201 : Introductory Physics – II

Unit No.	Topics	No. of Lect.	CO No.
I	The Electric Field: Review of key ideas, Digression on nuclear forces, The electric field E, Visualizing the field, Field of a dipole, Far field of dipole: general case, Response to a field, Dipole in a uniform field, Gauss's Law: Field of an infinite line charge, Field of an infinite sheet of charge, Spherical charge distribution: Gauss's law, Digression on the area vector dA, Composition of areas, An application of the area vector, Gauss's law through pictures, Continuous charge density	10	1
II	Application of Gauss's Law: Applications of Gauss's law, Field inside a shell, Field of an infinite charged wire, Field of an infinite plane, Conductors, Field inside a perfect conductor, The net charge on a conductor, A conductor with a hole inside, Field on the surface of a conductor	8	2
III	Magnetism: Experiments pointing to magnetism, Examples of the Lorentz force, the cyclotron, Lorentz force on current-carrying wires, The magnetic dipole, The DC motor, Biot-Savart Law, field of a loop, Microscopic description of a bar magnet, Magnetic field of an infinite wire, Ampere's law, Maxwell's equations (static case)	8	3
IV	Wave Theory of Light: Interference of waves, Adding waves using real numbers, Adding waves with complex numbers, Analysis of interference, Diffraction grating, Single-slit diffraction, Understanding reflection and crystal diffraction, Light incident on an oil slick, Normal incidence, Oblique incidence	7	4

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Unit No.	Topics (Continued)	No. of Lect.	CO No.
V	Optics: The Principle of Least Time Light, Reflection and refraction, Fermat's principle of least time, Applications of Fermat's principle, Geometrical Optics: The focal length of a spherical surface, The focal length of a lens, Magnification, Compound lenses, Aberrations, Resolving power, Color Vision: The human eye, dependence of Color intensity, Measuring the color sensation, The chromaticity diagram, The mechanism of color vision, Physiochemistry of color vision, Mechanisms of Seeing: The sensation of color, The physiology of the eye, The rod cells, The compound (insect) eye, Other eyes, Neurology of vision	12	5

2.1.5 Suggested Texts and References:

1. Text Book for UNIT-I to IV: *Fundamentals of Physics II – Electromagnetism, Optics, and Quantum Mechanics: 2 (The Open Yale Courses Series)*, by R. Shankar.

2. Text Book for UNIT-V: *The Feynman Lectures in Physics, Volume 1*, by R. P. Feynman, R. B. Leighton, M. Sands.

3. References:

   - *Electricity and Magnetism, Berkeley Physics Course Vol. 2*, 2nd Edition, Edward M. Purcell, Tata McGraw Hill, 2011.
   - *The Feynman Lectures on Physics Vol. 2*, by R. P. Feynman, R. B. Leighton, and M. Sands, Narosa Publications, 2010.
   - *Fundamentals of Optics*, 4th Edition, by F. A. Jenkins and H. E. White, Tata McGraw Hill, 2011.
   - *University Physics*, 7th Edition, by Francis W. Sears, Mark Zemansky, and Hugh D. Young, Massachusetts: Addison Wesley, 1987.
   - *Optics*, 4th Edition by Eugene Hecht, Massachusetts: Addison Wesley.
   - *Foundations of Electromagnetic Theory*, 4th edition, by John R. Reitz, Fredrick Milford & Robert Christ, Massachusetts: Addison Wesley, 1993.
   - *Fundamentals of Optics*, 4th Edition by Francis A. Jenkins and Harvey E. White, New York Mc Graw Hill Book Company Inc. 2001.
   - *Optical Physics*, 3rd Edition by Stephen G. Lipson, Henry Lipson & D. S. Tannhauser, New York Cambridge University Press, 1995.

2.2 G201: Electronics and Instrumentation

Program	Subject	Year	Semester
Int. M.Sc	Physics	1	II
Course Code	**Course Title**		**Course Type**
G201	**Electronics and Instrumentation**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
3	2	1	3
Maximum Marks		**CIA**	**ESE**
100		60	40

2.2.1 Learning Objective (LO):

This course covers a theoretical understanding of the functionality of electronic components in circuitry and also develops the thought process for instrumentation.

2.2.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand the basic electronics principles and abstractions on which the design of electronic systems is based, including lumped circuit models, digital circuits, and operational amplifiers.	U
2	Use abstractions to analyze and design simple electronic circuits.	An
3	Employ Boolean algebra to describe the function of logic circuits.	Ap
4	Design circuits that represent digital logic expressions, specifically design a gate-level digital circuit to implement a given Boolean function.	Ap
5	Understand the basic principles behind measuring instruments.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

2.2.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	1	1	2	3	3	2	1	3	2	3	1	2	1	1
CO2	3	3	1	1	2	3	3	2	1	3	2	3	2	2	1	1
CO3	3	3	3	1	2	3	3	2	2	3	2	3	2	3	1	3

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CO4	3	3	1	1	2	3	3	2	1	3	2	3	1	2	1	-
CO5	3	3	1	1	2	3	3	2	1	3	2	3	1	2	1	-

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

2.2.4 Detailed Syllabus: G201 : Electronics and Instrumentation

Unit No.	Topics	No. of Lect.	CO No.
I	The Circuit Abstraction: The Power of Abstraction, The Lumped Circuit Abstraction, The Lumped Matter Discipline, Limitations of the Lumped Circuit Abstraction, Practical Two-Terminal Elements, Batteries, Linear Resistors, Associated Variables Convention, Ideal Two-Terminal Elements, Ideal Voltage Sources, Wires, and Resistors, Element Laws, The Current Source, Another Ideal Two-Terminal Element, Modeling Physical Elements, Signal Representation, Analog Signals, Digital Signals, Value Discretization	8	1
II	Resistive Networks: Terminology, Kirchhoff's Laws, KCL, KVL, Circuit Analysis: Basic Method, Single-Resistor Circuits, Quick Intuitive Analysis of Single-Resistor Circuits, Energy Conservation, Voltage and Current Dividers, Intuitive Method of Circuit Analysis: Series and Parallel Simplification, Circuit Examples, Dependent Sources and the Control Concept Circuits with Dependent Sources, A Formulation Suitable for a Computer Solution Network Theorems: The Node Voltage, The Node Method, Floating Independent Voltage Sources, Dependent Sources and the Node Method, The Conductance and Source Matrices, Loop Method, Superposition, Superposition Rules for Dependent Sources, Thevenin's Theorem and Norton's Theorem, The Thevenin Equivalent Network, The Norton Equivalent Network	9	2
III	Number Systems and Codes: Decimal Odometer, Binary Odometer, Number codes, Binary-to-Decimal conversion, Decimal-to-Binary conversion, Hexadecimal Numbers, Hexadecimal-to-Binary conversion, Binary-to-Hexadecimal conversion, Decimal-to-Hexadecimal conversion, BCD Numbers, ASCII code Digital electronics: Review of basic logic gates; DeMorgan's theorem, Use of NAND / NOR as universal building blocks; arithmetic circuits; binary addition, half adder, full adder, binary subtraction - 1s and 2s complement, controlled inverter, adder / subtracter, parity checker	7	3

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Unit No.	Topics (Continued)	No. of Lect.	CO No.
IV	Introduction to measurements: Measurement units, Measurement system applications, Elements of a measurement system, Choosing appropriate measuring instruments, Instrument types and Performance Characteristics: Review of instrument types, Active and passive instruments, Null-type and deflection-type instruments, Analogue and digital instruments, Indicating instruments and instruments with a signal output, Smart and non-smart instruments, Static characteristics of instruments: Accuracy and inaccuracy (measurement uncertainty), Precision/repeatability/reproducibility, Tolerance, Range or span, Linearity, Sensitivity of measurement, Threshold, Resolution, Sensitivity to disturbance, Hysteresis effects, Dead space, Dynamic characteristics of instruments: Zero order instrument, First order instrument, Second order instrument, Necessity for calibration	9	4
V	Errors during the Measurement Process: Sources of systematic error, System disturbance due to measurement, Errors due to environmental inputs, Wear in instrument components, Connecting leads, Reduction of systematic errors, Careful instrument design, Method of opposing inputs, High-gain feedback, Calibration, Manual correction of output reading, Intelligent instruments, Quantification of systematic errors, Random errors, Statistical analysis of measurements subject to random errors, Graphical data analysis techniques – frequency distributions, Aggregation of measurement system errors, Combined effect of systematic and random errors, Aggregation of errors from separate measurement system components, Total error when combining multiple measurements, Calibration of Measuring Sensors and Instruments: Principles of calibration, Control of calibration environment, Calibration chain and traceability, Calibration records	12	5

2.2.5 Suggested Texts and References:

1. Text Book for UNIT-I and II: *Foundations of Analog and Digital Electronic Circuits*, by Anant Agarwal and Jeffrey H. Lang, Morgan Kaufmann Publishers, Elsevier.

2. Text Book for UNIT-III: *Digital Computer Electronics*, Tata McGraw-Hill (Third Edition) by Albert P. Malvino, Jerald A. Brown.

3. *Electronics Principles and Applications*, Tata McGraw-Hill, (Ninth Edition), by Charles A. Schuler.

4. Text Book for UNIT-IV and V: *Measurements and Instrumentation Principles*, Third Edition, by Alan S. Morris.

5. *Electronic Devices and Circuit Theory*, by R. L. Boylestad, L. Nashelsky, K. L. Kishore, Pearson.

6. *Electronic Principles*, by Malvino and Bates.

7. *Electronic Circuit Analysis and Design*, by Donald A. Neamen, Tata McGraw Hill.

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8. *Electronic Devices and Circuits*, by David A. Bell.

9. *Digital Principles and Applications*, by Leach, Malvino, and Saha.

10. *Modern Digital Electronics*, Tata McGraw-Hill (2003), by R.P. Jain.

11. *Digital Design*, Pearson Education Asia, (2007), by M. Morris Mano, Michael D. Ciletti.

12. *Digital Fundamentals*, Pearson Education Asia (1994), by Thomas L. Floyd.

13. *Measurement & Instrumentation*, by DVS Murthy.

14. *Electrical Measurements & Electronic Measurements*, by A.K. Sawhney.

2.3 PL201: Physics Laboratory - II

Program	Subject	Year	Semester
Int. M.Sc	Physics	1	II
Course Code	**Course Title**		**Course Type**
PL201	**Physics Laboratory – II**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
2	-	-	4
Maximum Marks		**CIA**	**ESE**
100		60	40

2.3.1 Learning Objective (LO):

The course introduces the students to how mathematical and graphical tools can be used to simplify problems and visualize physical phenomena for better understanding.

2.3.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand uncertainty/error in measurements and perform uncertainty/error analysis, including the least squares fit method. Gain an introductory understanding of instrumentation concepts like sensing and transduction.	E
2	Gain practical exposure to calculating 'g' (acceleration due to gravity) by the free fall method, using a physical pendulum, and understanding variations in 'g' with changes in oscillation plane angle.	E
3	Learn Newton's law of motion, conservation of linear and angular momentum, using a PC-interfaced apparatus and Maxwell's needle apparatus.	E
4	Study the phenomenon of refraction in prisms, and double refraction in calcite and quartz.	An
5	Visualize equipotential surfaces and study electrical inductance with varying current and ferromagnetic cores.	E

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

2.3.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5

CO1	3	3	3	1	2	1	3	2	1	3	2	3	2	1	1	1
CO2	3	3	3	1	2	1	3	2	1	3	2	3	2	2	1	2
CO3	3	3	3	1	2	1	3	2	1	3	2	3	2	2	1	2
CO4	3	3	3	1	2	1	3	2	1	3	2	3	2	2	1	-
CO5	3	3	3	1	2	1	3	2	1	3	2	3	2	2	1	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

2.3.4 Detailed Syllabus: PL201 : Physics Laboratory - II

Unit No.	Topics	No. of Lectures	CO No.
I	Review of uncertainty/error analysis; least squares fit method; introduction to sensors/transducers.	8	1
II	Determination of 'g' (acceleration due to gravity) by free fall method; study of physical pendulum using a PC interfaced apparatus; study of variation of effective 'g' with change of angle of plane of oscillation; investigation of effect of large angle of oscillation on the motion.	16	2
III	Study of Newton's laws of motion using a PC interfaced apparatus; study of conservation of linear and angular momentum using Maxwell's needle apparatus; study of vibrations of a soft massive spring; study of torsional oscillatory system.	16	3
IV	Study of refraction in a prism; double refraction in calcite and quartz.	8	4
V	Study of equipotential surface using different electrode shapes in a minimal conducting liquid medium; determination of electrical inductance by vector method and study effect of ferromagnetic core; study of non-linearity of inductance with current.	12	5

2.3.5 Suggested Texts and References:

1. *Advanced Practical Physics for Students*, by B. L. Worsnop and H. T. Flint, Methuen and Co. Ltd., London.

2.4 GL201: Electronics Laboratory

Program	Subject	Year	Semester
Int. M.Sc	Physics	1	II
Course Code	**Course Title**		**Course Type**
GL201	**Electronics Laboratory**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
2	-	-	4
Maximum Marks		**CIA**	**ESE**
100		60	40

2.4.1 Learning Objective (LO):

Students will perform experiments to learn basic network theorems, design single stage amplifiers, operational amplifiers, gate design, flip-flop circuits, and other fundamental electronics concepts.

2.4.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Learn about half-wave and full-wave rectifiers, and understand the effect of filters on their circuit performance.	U
2	Design single stage CE amplifiers and calculate their specific gain.	E
3	Understand operational amplifiers and their different modes of operation.	U
4	Understand types of logic gates, their outputs, and use NAND gates to design AND, OR, NOT, and XOR gates.	Ap
5	Learn about flip-flop circuits and power regulator circuits.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

2.4.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	1	2	2	3	2	1	3	2	3	2	2	1	3
CO2	3	3	3	1	2	2	3	2	1	3	2	3	2	2	1	3
CO3	3	3	3	1	2	2	3	2	1	3	2	3	2	2	1	3
CO4	3	3	3	1	2	2	3	2	1	3	2	3	2	2	1	3

CO5	3	3	3	1	2	2	3	2	1	3	2	3	2	2	1	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

2.4.4 Detailed Syllabus: GL201 : Electronics Laboratory

Unit No.	Topics	No. of Lectures	CO No.
I	To study the Half wave and Full wave rectifier and study the effect of C filter.	12	1
II	To design a Single Stage CE amplifier for a specific gain and bandwidth.	16	2
III	Study of Operational amplifier in inverting and non-inverting mode.	16	3
IV	To verify and design AND, OR, NOT and XOR gates using NAND gates.	16	4
V	To study flip-flop circuits and to study power regulator circuits.	8	5

2.4.5 Suggested Texts and References:

1. *Advanced Practical Physics for Students*, by B. L. Worsnop and H. T. Flint, Methuen and Co. Ltd., London.

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SEMESTER - III

3.1 P301: Mathematical Physics – I

Program	Subject	Year	Semester
Int. M.Sc	Physics	2	III
Course Code	**Course Title**		**Course Type**
P301	**Mathematical Physics – I**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
4	3	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

3.1.1 Learning Objective (LO):

The course aims to acquire knowledge and problem-solving skills to pass National level CSIR/UGC NET and State level SET/SLET examination in Physical Science Subject during the final year of the course. Students should have competence to get selected for Ph.D. programs in reputed national and international research institutes/universities.

3.1.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand and apply the mathematical skills to solve quantitative problems in the study of physics.	E
2	Understand different types of differential equations like Legendre, Hermite, Bessel, etc., and their application in solving physical problems.	An
3	Learn about complex variables.	E
4	Apply integral transform to solve mathematical problems of interest in physics.	E
5	Use Fourier transforms as an aid for analyzing experimental data.	E

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

3.1.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	-	2	2	3	1	1	3	2	3	2	-	2	3
CO2	3	3	3	-	2	2	3	1	1	3	2	3	2	-	2	3
CO3	3	3	3	-	2	2	3	1	1	3	2	3	2	-	2	3
CO4	3	3	3	-	2	2	3	1	1	3	2	3	2	-	2	3
CO5	3	3	3	-	2	2	3	1	1	3	2	3	2	-	2	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

3.1.4 Detailed Syllabus: P301 : Mathematical Physics – I

Unit No.	Topics	No. of Lectures	CO No.
I	Review of first order differential equations, the notion of Wronskian and its properties, Series solutions of second order differential equations, Frobenius method. Rodrigues formula and classical orthogonal polynomials, recurrence relations, symmetry properties, special values, orthogonality, normalization.	13	1
II	Generating functions. Legendre, Hermite, Laguerre, Bessel, and Hypergeometric differential equations. Integral representations of special functions. Expansion of functions in orthonormal basis.	11	2
III	Complex variables: Notion of analyticity, Cauchy–Riemann conditions, Harmonic functions; Contour integrals, Cauchy theorem, simply and multiply connected domains, Cauchy integral formula, derivatives of analytic functions.	12	3
IV	Laurent series, uniform convergence; Notion of residues, residue theorem, notion of principal values, applications of residues to evaluation of improper integrals, definite integrals, indentation, branch points, and branch cuts.	12	4
V	Fourier series and simple applications. Fourier transforms, Parseval's theorem, convolution, and their simple applications. Laplace transforms, initial value problems, simple applications, transients in circuits, convolution.	12	5

3.1.5 Suggested Texts and References:

1. *Complex Variables and Applications*, R. V. Churchill and J. W. Brown, McGraw-Hill, 2009.
2. *Complex Variables: Introduction and Applications*, 2nd Edition, M. J. Ablowitz and A. S. Fokas, Cambridge, 2003.

3. *Differential Equations*, G. F. Simmons, McGraw-Hill, 2006.
4. *Ordinary Differential Equations*, V. I. Arnold, MIT Press, 2009.
5. *Mathematical Methods for Physicists*, 7th Edition, G. Arfken and Hans J. Weber, Elsevier, 2012.

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3.2 P302: Classical Mechanics – I

Program	Subject	Year	Semester
Int. M.Sc	Physics	2	III
Course Code	**Course Title**		**Course Type**
P302	Classical Mechanics – I		Core
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
4	3	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

3.2.1 Learning Objective (LO):

This course serves as a foundation to ensure an appropriate level of understanding of the statics and dynamics necessary for other advanced subjects in physics. The course aims to acquire knowledge and problem-solving skills to pass National level CSIR/UGC NET and State level SET/SLET examinations in Physical Science Subject during the final year of the course. Students should have the competence to get selected for Ph.D. programs in reputed national and international research institutes/universities.

3.2.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Learn about fundamental concepts of forces, energy, potentials, linear and angular momentum.	U
2	Learn about central force, trajectories, orbits, center of mass, and relative motion.	U
3	Perform a rigorous exercise in Newtonian Mechanics, including applications to rigid bodies.	U
4	Learn about the statics and dynamics of Einstein's special relativity.	U
5	Understand the introduction to four vectors and the concept of spacetime.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

3.2.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5

CO1	3	3	3	-	2	1	3	1	-	3	2	3	1	2	1	3
CO2	3	3	3	-	2	1	3	1	-	3	2	3	1	2	1	3
CO3	3	3	3	-	2	1	3	1	-	3	2	3	1	-	1	3
CO4	3	3	3	-	2	1	3	1	-	3	2	3	1	-	1	3
CO5	3	3	3	-	2	1	3	1	-	3	2	3	1	-	1	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

3.2.4 Detailed Syllabus: P302 : Classical Mechanics – I

Unit No.	Topics	No. of Lectures	CO No.
I	Recap: Newton's laws, vector algebra, gradient; momentum, energy, constraints, conservative forces, potential energy, angular momentum. Inertial and non-inertial frames, fictitious forces.	8	1
II	Foucault pendulum, effects of Coriolis force. Central forces, conservation of energy and angular momentum, trajectories, orbits, $1/r$ potential (quadrature), classical scattering, two-body problem, center of mass and relative motions.	12	2
III	Rigid body motion, moment of inertia tensor, energy and angular momentum, Euler's theorem, motion of tops, gyroscope, motion of the Earth. Introduction to Lagrangian through variational principle, applications of variational principle.	15	3
IV	Relativity: Historical background, inconsistency of electrodynamics with Galilean relativity. Einstein's hypothesis and Lorentz transformation.	15	4
V	Doppler shift, energy, momentum and mass, mass-energy equivalence. Four-vector notation, consistency of electrodynamics with relativity.	10	5

3.2.5 Suggested Texts and References:

1. *An Introduction to Mechanics*, 1st Edition, D. Kleppner and R. J. Kolenkow, Tata McGraw-Hill Education, 2007.

2. *Classical Mechanics*, 5th Edition, T. W. B. Kibble, F. Berkshire, World Scientific, 2004.

3. *Introduction to Special Relativity*, R. Resnick, Wiley (India), 2012.

4. *Spacetime Physics*, 2nd Edition, E. F. Taylor, J. A. Wheeler, W. H. Freeman and Co., 1992.

5. *Classical Mechanics*, N. C. Rana, P. S. Joag, Tata McGraw-Hill Education, 2001.

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3.3 P303: Electromagnetism

Program	Subject	Year	Semester
Int. M.Sc	Physics	2	III
Course Code	**Course Title**		**Course Type**
P303	**Electromagnetism**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
4	3	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

3.3.1 Learning Objective (LO):

Topics covered in this syllabus form the foundation of electrostatics and magnetostatics in physics, preparing students for more advanced studies in electromagnetism.

3.3.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Learn about integral and differential form of Gauss's law, scalar potential, understand how complex charge distributions can be simplified into multipole expansion, method of images, and understand the relationship between work and energy in electrostatic systems.	U
2	Learn about key principles of electric fields in different materials and the behavior of dielectrics.	U
3	Gain a comprehensive understanding of magnetic fields, their generation, and how materials interact with them in magnetostatics.	U
4	Explain and solve advanced problems based on classical electrodynamics using Maxwell's equations.	E
5	Learn about the interaction of electromagnetic waves with various media, including energy transfer and wave behavior in different environments.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

3.3.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5

CO1	3	3	3	2	2	2	3	2	2	3	2	3	2	3	2	3
CO2	3	3	3	2	2	2	3	2	2	3	2	3	2	3	2	3
CO3	3	3	3	2	2	2	3	2	2	3	2	3	2	3	2	3
CO4	3	3	3	2	2	2	3	2	2	3	2	3	2	3	2	3
CO5	3	3	3	2	2	2	3	2	2	3	2	3	2	2	2	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

3.3.4 Detailed Syllabus: P303 : Electromagnetism

Unit No.	Topics	No. of Lectures	CO No.
I	Electrostatics: Coulomb's law, Electric field, Gauss' law in differential and integral forms, Scalar potential, Poisson and Laplace equations, Discontinuities in Electric field and potential: electrostatic boundary conditions, Uniqueness theorem, conductors and second uniqueness theorem, method of images, multipole expansion, work and energy in electrostatics.	12	1
II	Electric Fields in matter: dielectrics, polarization, bound charges, notion of electric displacement, Gauss' law in presence of dielectrics, boundary conditions, linear dielectrics: susceptibility, permittivity, dielectric constant, boundary value problems, energy in dielectric system.	10	2
III	Magnetostatics: Lorentz force law, steady currents, Biot–Savart law, Ampere's law, vector potential, magnetostatic boundary conditions, multipole expansion for vector potential, magnetic scalar potential. Diamagnets, paramagnets, and ferromagnets, magnetization, bound currents, the H field, boundary conditions, magnetic susceptibility, and permeability.	12	3
IV	Electrodynamics: Electromotive force, electromagnetic induction and Faraday's law, induced electric fields and inductance, energy in magnetic fields. Maxwell's equations: equation of continuity and Modification in Ampere's law, Gauge transformations, Lorentz and Coulomb gauge. Maxwell's equations in matter, integral and differential forms, boundary conditions.	12	4
V	Poynting's theorem, conservation of momentum, angular momentum. Lossy media, Poynting's theorem for lossy media. Wave equation, electromagnetic waves in vacuum, plane waves, propagation in lossless and lossy linear media, absorption and dispersion, reflection at the interface of two lossy media, guided waves.	14	5

3.3.5 Suggested Texts and References:

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1. *Introduction to Electrodynamics*, 4th Edition, D. J. Griffiths, Addison-Wesley, 2012.

2. *Classical Electricity and Magnetism*, 2nd Edition, W. K. H. Panofsky and M. Phillips, Dover, 2005.

3. *Engineering Electromagnetics*, 2nd Edition, Nathan Eda, Springer, 2007.

3.5 H302: History and Philosophy of Science

Program	Subject	Year	Semester
Int. M.Sc	Physics	2	III
Course Code	**Course Title**		**Course Type**
H302	**History and Philosophy of Science**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
2	2	0	0
Maximum Marks		**CIA**	**ESE**
100		60	40

3.5.1 Learning Objective (LO):

The aim of this course is to provide students with an understanding of the historical development of science with a focus on ancient Indian contributions, and to introduce key concepts in the philosophy of science. It seeks to foster an appreciation of the interplay between science, culture, and philosophy, and to develop critical thinking skills regarding scientific inquiry and methodology.

3.5.2 Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand the foundational aspects of ancient Indian science and civilization, and their contributions to various fields.	U
2	Analyze the works of key figures in ancient Indian science and assess their impact on modern science.	An
3	Comprehend scientific concepts and innovations in ancient India, including mathematics, astronomy, and technology.	U
4	Evaluate philosophical perspectives on science, including scientific methodology and the nature of scientific revolutions.	E
5	Distinguish between science and pseudoscience, and apply critical thinking to assess scientific claims.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

3.5.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	2	1	-	3	3	3	1	1	2	1	3	3	1	1	1

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3.4.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	3	2	3	2	2	3	2	3	2	3	1	-
CO2	3	3	2	2	3	2	3	2	2	3	2	3	2	1	1	-
CO3	3	3	3	2	3	2	3	2	2	3	2	3	2	3	1	-
CO4	3	3	3	2	3	2	3	2	2	3	2	3	2	3	1	-
CO5	3	3	3	2	3	2	3	2	2	3	2	3	2	2	1	-

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

3.4.4 Detailed Syllabus: P304 : Waves and Oscillations

Unit No.	Topics	No. of Lectures	CO No.
I	Free oscillations, Simple harmonic motion, damped and forced oscillations; Coupled oscillators, normal modes, beats, infinite coupled oscillators and dispersion relation of sound; vibrating string; travelling and stationary waves; Amplitude, phase and energy. Derivation of wave equation for a string; Longitudinal and transverse waves.	15	1
II	Waves in two and three dimensions, the wave vector, wave equation, linearity, superposition, Fourier decomposition of a wave, notion of wave packets, phase and group velocity. Example of mechanical waves (sound waves), speed of sound in air, effect of bubbles, natural observations and qualitative explanations.	15	2
III	String and wind instruments. Chladni plates. Propagation in changing media, continuity condition, characteristic impedance. Snell's laws and translation invariant boundary, prism, total internal reflection, evanescent waves. Water waves, ocean waves, Tsunami.	15	3
IV	Electromagnetic waves, polarization, interference.	6	4
V	Fraunhofer diffraction. Shock waves, boat wakes, linear analysis of the Kelvin wake. Alfven waves (qualitative).	9	5

3.4.5 Suggested Texts and References:

1. *Waves, Berkeley Physics Course Vol. 3*, Frank S. Crawford, Tata McGraw–Hill Education, 2011.
2. *Introduction to the Physics of Waves*, Tim Freegarde, Cambridge Univ. Press, 2012.
3. *The Physics of Waves*, Howard Georgi (http://www.people.fas.harvard.edu/ hgeorgi/new.htm).

3.4 P304: Waves and Oscillations

Program	Subject	Year	Semester
Int. M.Sc	Physics	2	III
Course Code	**Course Title**		**Course Type**
P304	**Waves and Oscillations**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
4	3	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

3.4.1 Learning Objective (LO):

This course covers essential topics in wave mechanics, oscillations, and sound theory. Students use both analytical mathematics and numerical methods to explore the subject. In particular, they should be able to analyze experimental oscillator or wave phenomena, such as sound, using suitable methods. Students should have competence to get selected for Ph.D. programs in reputed national and international research institutes/universities.

3.4.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Students should be able to understand physical characteristics of SHM and obtain solutions of the oscillator using differential equations.	U
2	Students should be able to describe and calculate what happens when waves move from one medium to another, and be able to explain dispersion and group and phase velocity.	U
3	Students should learn how to use geometric optics to describe and explain optical instruments, and by simple measurements estimate what strength glasses a person needs.	An
4	Students should be able to explain how several waves or parts of waves interact, and be able to calculate and analyze diffraction and interference phenomena, and explain the conditions required for such phenomena to appear.	An
5	Students should learn a comprehensive understanding of wave mechanics, optics, and plasma physics.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

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CO2	3	3	3	-	3	2	3	2	1	2	1	3	2	2	1	1
CO3	3	3	3	-	2	2	3	2	1	2	1	3	2	2	1	3
CO4	3	3	3	-	3	2	3	1	1	2	1	3	2	1	1	3
CO5	3	3	3	-	3	2	3	1	1	2	1	3	2	1	1	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

3.5.4 Detailed Syllabus: H302: History and Philosophy of Science

Unit No.	Topics	No. of Lect.	CO No.
I	**Foundations of Ancient Indian Science and Civilization** Indian civilization from pre-historic times to the Indus Valley Civilization; Traditional Knowledge Systems; The Vedas and their influence on science; Main Schools of Philosophy; Ancient Education Systems: Takshashila University, Nalanda University; Knowledge export from Bharata; Strengths and potentialities of ancient Indian science.	6	1
II	**Pioneers of Ancient Indian Science** Mathematics and Astronomy: Key Figures - Aryabhata, Varahamihira, Bhaskaracharya, Madhavacharya; Kerala School of Mathematics and Astronomy. Medicine and Biology: Key Figures - Charaka, Sushruta, Jivaka; Ancient Indian medicine and biology. Philosophy and Logic: Key Figures - Kanada, Patanjali, Panini, Kautilya. Women in Science: Lopamudra, Ghosha, Gargi, Maitreyi.	6	2
III	**Scientific Concepts and Innovations in Ancient India** Mathematical Concepts: Concepts of Zero and Pi, Number System, Pythagoras Theorem in Vedic Mathematics. Astronomy and Cosmology: Units of Time (Kala), Sun, Earth, Moon, and Eclipses; Earth's sphericity and rotation; Vedic Cosmology and modern concepts; Archaeoastronomy. Physics and Technology: Concept of Matter, Life, and Universe; Gravity in ancient Indian texts; Vimana: Aeronautics; Sage Agastya's Model of Battery; Velocity of Light in Vedic literature.	8	3
IV	**Introduction to Philosophy of Science** What is Science?; Scientific Methodology; Falsificationism; Scientific Reasoning; Scientific Temperament; Explanation in Science; Realism and Instrumentalism; Scientific Change and Scientific Revolutions.	5	4

Continued on next page

Unit No.	Topics (Continued)	No. of Lect.	CO No.
V	**Rationality, Objectivity, and Scientific Inquiry** Values in Science: Rationality and Objectivity; Values in scientific practice. Science vs. Pseudoscience: Demarcation criteria; Case studies of pseudoscience; Group presentations by students on pseudoscience examples. Great Scientific Experiments: Eratosthenes' Experiment; Historical experiments in science; Group presentations by students on significant experiments.	5	5

3.5.5 Suggested Texts and References:

1. Stephen F. Mason, *A History of the Sciences*, Macmillan Pub. Co. (1962).
2. D. M. Bose, S. N. Sen, B. V. Subbarayappa, *A Concise History of Science in India*, INSA (1971).
3. Samir Okasha, *Philosophy of Science – A Very Short Introduction*, Oxford University Press (2002).
4. Thomas Crump, *A Brief History of Science: As Seen Through the Development of Scientific Instruments*, Running Press; Carroll & Graf edition (2001).
5. Ron Harre, *Great Scientific Experiments*, Oxford University Press (1983).
6. Lloyd Motz and Jefferson Hane Weaver, *The Story of Physics*, Avon Books (1992).
7. Colin A. Ronan, *The Cambridge Illustrated History of World Science*, Cambridge-Newnes (1982).
8. Helaine Selin and Roddam Narasimha (Eds.), *Encyclopaedia of Classical Indian Sciences.*
9. Bhag Chand Chauhan, *Textbook on The Knowledge System of Bharata.*
10. Sibaji Raha et al., *History of Science in India Volume-1, Part-I, Part-II, Volume VIII*, National Academy of Sciences, India and The Ramakrishna Mission Institute of Culture, Kolkata (2014).
11. Pradeep Kohle et al. (Eds.), *Pride of India- A Glimpse of India's Scientific Heritage*, Samskrit Bharati (2006).
12. Keshav Dev Verma, *Vedic Physics*, Motilal Banarsidass Publishers (2012).
13. Suresh Soni, *India's Glorious Scientific Tradition*, Ocean Books Pvt. Ltd. (2010).

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3.6 PL301: Physics Laboratory - III

Program	Subject	Year	Semester
Int. M.Sc	Physics	2	III
Course Code	**Course Title**		**Course Type**
PL301	**Physics Laboratory - III**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
3	-	-	6
Maximum Marks		**CIA**	**ESE**
100		60	40

3.6.1 Learning Objective (LO):

Students will conduct experiments to build a practical understanding of key physics concepts related to circuits, optics, thermodynamics, and classical physics experiments. This laboratory course aims to develop experimental skills and deepen conceptual knowledge through hands-on experiences, reinforcing theoretical learning.

3.6.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand the frequency response of R-C circuits, LC circuits, and R-L-C circuits, including the phase difference between voltage and current.	U
2	Apply concepts to observe and analyze interference patterns, Newton's rings, polarization, and refraction of light.	Ap
3	Understand heat capacity of air and use thermocouples or platinum resistance thermometers for temperature measurements.	U
4	Apply the principles of gyroscopes to determine their laws and understand their applications.	Ap
5	Apply the technique of Millikan's oil drop experiment to measure the charge of an electron.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

3.6.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5

CO1	3	3	3	1	2	2	3	2	1	3	2	3	2	2	1	3
CO2	3	3	3	1	2	2	3	2	1	3	2	3	2	2	1	3
CO3	3	3	3	1	2	2	3	2	1	3	2	3	2	2	1	-
CO4	3	3	3	1	2	2	3	2	1	3	2	3	2	2	1	1
CO5	3	3	3	1	2	2	3	2	1	3	2	3	2	2	1	1

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

3.6.4 Detailed Syllabus: PL301 : Physics Laboratory - III

Unit No.	Topics	No. of Lectures	CO No.
I	Frequency response of R-C circuit (concept of cut-off frequency and filter) and frequency response of LC circuit; concepts of phase difference between voltage and current in these circuits, phase factor for appliances using AC mains supply; R-L-C (series/parallel) resonance; transient response in RLC series circuit.	18	1
II	Study of Newton's rings and interference in wedge-shaped films; study of double refraction in calcite/quartz prisms, polarization of the refracted light rays, optical activity in dextrose and fructose.	18	2
III	Soldering experience – make a gated timer with an indicator; measurement of heat capacity of air.	18	3
IV	Use of thermocouple/platinum resistance thermometer, use of instrumentation amplifier in amplifying signal from thermocouple.	18	4
V	Study of the laws of a gyroscope; determination of the charge of an electron by Millikan's oil drop experiment.	18	5

3.6.5 Suggested Texts and References:

1. *Advanced Practical Physics for Students*, B. L. Worsnop and H. T. Flint, Methuen and Co. Ltd., London.

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3.7 GL301: Applied Electronics Laboratory

Program	Subject	Year	Semester
Int. M.Sc	Physics	2	III
Course Code	**Course Title**		**Course Type**
GL301	**Applied Electronics Laboratory**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
2	-	-	4
Maximum Marks		**CIA**	**ESE**
100		60	40

3.7.1 Learning Objective (LO):

This course provides hands-on experience with microcontroller system EXPEYES, Python programming, and sensor-based data collection. Students will gain practical knowledge of microcontroller operations, programming languages, and interfacing techniques, which are essential for embedded systems and practical electronics.

3.7.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Learn about microcontroller systems, focusing on expEYES and ATmega32, including the use of the expEYES kit for monitoring pendulum motion and capacitor charging/discharging.	U
2	Understand binary numbers, microprocessor and microcontroller concepts, including CPU, memory, data buses, and instruction sets.	U
3	Gain knowledge of programming concepts, assembly language, and I/O programming.	U
4	Apply C language for writing larger programs, including data acquisition and signal conversion, as well as understanding Python integration with expEYES.	Ap
5	Perform automated measurements using expEYES, including experiments such as temperature monitoring and pH measurement, utilizing a variety of sensors.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

3.7.3 CO-PO/PSO mapping for the course:

PO/CO	POs	PSO

	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	1	2	3	3	2	1	3	2	3	2	2	3	-
CO2	3	3	3	1	2	3	3	2	1	3	2	3	2	2	3	-
CO3	3	3	3	1	2	3	3	2	1	3	2	3	2	2	3	-
CO4	3	3	3	1	2	3	3	2	1	3	2	3	2	2	3	-
CO5	3	3	3	1	2	3	3	2	1	3	2	3	2	2	3	-

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

3.7.4 Detailed Syllabus: GL301 : Applied Electronics Laboratory

Unit No.	Topics	No. of Lectures	CO No.
I	The course is based on the microcontroller system expEYES and 'Microhope' based on ATmega32 microcontroller, developed at IUAC under a UGC program. Use of expEYES kit for monitoring pendulum motion, charge, and discharge of a capacitor.	12	1
II	Revision of concepts of binary numbers: 'Bit', 'Byte', 'Word', hexadecimal numbers; Concepts of microprocessor and microcontrollers - CPU, registers, memory (RAM, ROM, different kinds of ROM), data and address bus, decoder, encoder, instruction set, etc.	12	2
III	Review of concepts of Digital to Analogue Conversion (DAC) and Analogue to Digital Conversion (ADC), Introduction to microcontroller ATmega32 (used in expEYES). Concepts of programming, flowchart, assembly language, and simulator. Simple I/O programming for ATmega32.	12	3
IV	C language for writing larger programs, such as monitoring temperature, which uses ADC of ATmega32. Concept of interrupt and its use in real-time data acquisition. Introduction to elements of Python language and integration with expEYES.	12	4
V	Automated measurement of simple experiments under expEYES, including applications such as temperature monitor, pH meter, calorimeter, and protein measurement. Introduction to sensors like temperature, pressure, humidity, pH sensors, photodetectors, etc.	12	5

3.7.5 Suggested Texts and References:

1. *Phoenix: Computer Interfaced Science Experiments*, B.P. Ajith Kumar, available at `http://www.iuac.res.in/elab/phoenix/`
2. *expEYES microcontroller system*, B.P. Ajith Kumar, available at `http://www.iuac.res.in/elab/phoenix/`

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3. *The AVR Microcontroller and Embedded Systems Using Assembly and C*, A.A. Mazidi, S. Naimi, S. Mnaimi, Pearson Publications, Delhi, 2013.

SEMESTER - IV

4.1 P401: Mathematical Physics - II

Program	Subject	Year	Semester
Int. M.Sc	Physics	2	IV
Course Code	**Course Title**		**Course Type**
P401	**Mathematical Physics - II**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
4	3	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

4.1.1 Learning Objective (LO):

Students should gain a deep understanding of mathematical methods used in physics, especially in differential equations, tensors, and group theory. This course aims to build a strong mathematical foundation that is essential for advanced topics in theoretical and applied physics.

4.1.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Apply knowledge of partial differential equations in curvilinear co-ordinates to solve physical problems.	Ap
2	Understand inhomogeneous equations and utilize Green's functions in 1, 2, and 3 dimensions.	Ap
3	Comprehend and apply tensor calculus, including contravariant and covariant notation, and utilize Levi-Civita symbols and pseudo tensors.	Ap
4	Understand and solve integral equations, including Fredholm and Volterra equations, and explore their applications.	Ap
5	Analyze group theory concepts, including subgroups, normal subgroups, classes, cosets, and their applications to physical problems.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

4.1.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	1	2	3	3	2	-	3	2	3	3	-	1	3
CO2	3	3	3	1	2	3	3	2	-	3	2	3	3	-	1	-
CO3	3	3	3	1	2	3	3	2	-	3	2	3	3	-	1	-
CO4	3	3	3	1	2	3	3	2	-	3	2	3	3	-	1	-
CO5	3	3	3	1	2	3	3	2	-	3	2	3	3	-	1	-

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

4.1.4 Detailed Syllabus: P401 : Mathematical Physics - II

Unit No.	Topics	No. of Lectures	CO No.
I	Review of curvilinear coordinates, scale factors, Jacobian. Partial differential equations in curvilinear coordinates, classification. Laplace equation, separation of variables, boundary conditions, initial conditions, examples.	12	1
II	Inhomogeneous equations, Green's functions in 1, 2, and 3 dimensions.	12	2
III	Tensor calculus: contravariant and covariant notation, Levi-Civita symbol, pseudo tensors, quotient rule, dual tensors.	12	3
IV	Integral equations: Fredholm and Volterra equations, separable kernel, applications. Elementary group theory and group representations, cyclic, permutation groups; isomorphism, homomorphism.	12	4
V	Subgroups, normal subgroups, classes and cosets; orthogonal, rotation group, Lie group; equivalent, reducible, irreducible; Schur's lemma.	12	5

4.1.5 Suggested Texts and References:

1. *Mathematical Methods for Physicists*, 7th Edition, G. Arfken and Hans J. Weber, Elsevier 2012.
2. *Mathematics for Physicists*, P. Dennery and A. Krzywicki, Dover 1996.
3. *Mathematics for Quantum Mechanics*, 4th Edition, J. D. Jackson, Dover 2009.
4. *Elements of Group Theory for Physicists*, A. W. Joshi.
5. *Lectures on Groups and Vector Spaces for Physicists*, C. J. Isham, World Scientific 1989.
6. *Group Theory and Its Application to Physical Problems*, M. Hemmermesh, Dover 1989.
7. *Elements of Green's Functions and Propagation*, G. Barton, Oxford 1989.

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4.2 P402: Quantum Mechanics - I

Program	**Subject**	**Year**	**Semester**
Int. M.Sc	Physics	2	IV
Course Code	**Course Title**		**Course Type**
P402	**Quantum Mechanics - I**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
4	3	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

4.2.1 Learning Objective (LO):

The primary objective of this course is to provide students with foundational knowledge in quantum mechanics, focusing on key concepts such as wave-particle duality, uncertainty principles, quantum measurement, and quantum dynamics. Students will develop an understanding of the core principles that underpin quantum systems and learn how these principles differ from classical mechanics.

4.2.2 Course Outcomes (CO):-

CO No.	**Expected Course Outcomes At the end of the course, the students will be able to:**	**CL**
1	Understand the inadequacy of classical mechanics and the need for quantum mechanics to describe physical phenomena at microscopic scales.	U
2	Explain the differences between classical and quantum mechanics, understand quantization of physical variables, wave function, and its interpretation.	U
3	Understand the postulates of quantum mechanics and apply them to solve problems involving wave functions for simple quantum systems.	U
4	Understand and analyze 1-D scattering phenomena in quantum mechanics, including tunneling effects.	U
5	Acquire the essential background knowledge to advance to Quantum Mechanics II (P501).	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

4.2.3 CO-PO/PSO mapping for the course:

PO/CO	**POs**	**PSO**

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	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	2	1	2	3	2	3	2	3	3	1	1	3
CO2	3	3	3	3	2	1	2	3	2	3	2	3	3	1	1	3
CO3	3	3	3	3	2	1	2	3	2	3	2	3	3	1	1	3
CO4	3	3	3	3	2	1	2	3	2	3	2	3	3	1	1	3
CO5	3	3	3	3	2	1	2	3	2	3	2	3	3	1	1	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

4.2.4 Detailed Syllabus: P402 : Quantum Mechanics - I

Unit No.	Topics	No. of Lectures	CO No.
I	Quantum Mechanics: The Main Experiment, Double-slit experiment with light, Trouble with Maxwell, Digression on photons, Photoelectric effect, Compton effect, Matter waves, Photons versus electrons, The Heisenberg uncertainty principle, states of position and momentum in QM, Heisenberg microscope, The wave function Ψ, Collapse of the wave function.	10	1
II	The Wave Function and Its Interpretation, Probability in classical and quantum mechanics, Statistical concepts: mean and uncertainty, Quantization and Measurement, more on momentum states, Single-valuedness and quantization of momentum, Quantization, the integral of $\Psi_p(x)$, Measurement postulate: momentum an example solvable by inspection, using a normalized Ψ, Finding $A(p)$ by computation, Fourier's theorems.	14	2
III	Measurement postulate: general, more than one variable, States of Definite Energy, Free particle on a ring, Analysis of energy levels: degeneracy, Particle in a well, The box: an exact solution, Energy measurement in the box.	12	3
IV	Scattering and Dynamics, Quantum scattering (1-D), Scattering for $E > V_0$, Scattering for $E < V_0$, Tunneling, Quantum dynamics, A solution of the time dependent Schrödinger equation, Derivation of the particular solution $\Psi_E(x,t)$, Special properties of the product solution, General solution for time evolution, Time evolution: a more complicated example.	12	4

Continued on next page

Unit No.	Topics (Continued)	No. of Lectures	CO No.
V	Discussion on postulates of quantum mechanics, Eigenvalue problem, The Dirac delta function and the operator X, Postulates: final. Many particles, bosons, and fermions, Identical versus indistinguishable, Implications for atomic structure, Energy-time, uncertainty principle, Time-Independent Schrödinger Equation: Stationary States, The Infinite Square Well, The Harmonic Oscillator, Algebraic Method, Analytic Method, The Free Particle, The Delta-Function Potential, Bound States and Scattering States, The Delta-Function Well, The Finite Square Well.	12	5

4.2.5 Suggested Texts and References:

1. *Fundamentals of Physics II – Electromagnetism, Optics, and Quantum Mechanics (The Open Yale Courses Series)*, R. Shankar.

2. *Introduction to Quantum Mechanics*, 2nd Edition, D. J. Griffiths, Pearson Education 2008.

3. *Quantum Mechanics*, 3rd Edition, L. I. Schiff, Tata McGraw-Hill 2010.

4. *Quantum Mechanics I and II*, Claud Cohen Tannoudji, B. Diu and F. Laloe, Wiley 2006.

5. *Lectures on Quantum Mechanics*, S. Weinberg, Oxford University Press 2012.

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4.3 G401: Statistical Techniques and Applications

Program	Subject	Year	Semester
Int. M.Sc	Physics	2	IV
Course Code	**Course Title**		**Course Type**
G401	**Statistical Techniques and Applications**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
4	3	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

4.3.1 Learning Objective (LO):

The objective of this course is to provide a comprehensive introduction to statistical methods used to analyze data, interpret results, and make informed decisions based on statistical evidence. The skills gained in this course are valuable across fields that rely on data-driven research and decision-making.

4.3.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Learn about the purpose of studying statistics and understand the foundation for how probability influences statistical analysis.	U
2	Understand various probability distributions, including Binomial, Poisson, Normal, Gamma, and others.	U
3	Apply Monte Carlo techniques for generating and analyzing statistical distributions.	Ap
4	Learn deconvolution methods, model fitting, managing errors, and interpreting complex data patterns.	U
5	Understand different types of statistical tests and gain hands-on experience in statistical computing.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

4.3.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	1	2	2	3	1	-	3	2	3	3	2	1	3

CO2	3	3	3	1	2	2	3	1	-	3	2	3	3	2	1	-
CO3	3	3	3	2	2	2	3	1	-	3	2	3	3	2	3	-
CO4	3	3	3	2	2	2	3	1	-	3	2	3	3	2	3	-
CO5	3	3	3	2	2	2	3	1	-	3	2	3	3	2	3	-

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

4.3.4 Detailed Syllabus: G401 : Statistical Techniques and Applications

Unit No.	Topics	No. of Lectures	CO No.
I	Purpose of Statistics, Events and Probabilities, Assignments of probabilities to events, Random events and variables, Probability Axioms and Theorems. Probability distributions and properties: Discrete, Continuous and Empirical distributions. Expected values: Mean, Variance, Skewness, Kurtosis, Moments and Characteristics Functions.	12	1
II	Types of probability distributions: Binomial, Poisson, Normal, Gamma, Exponential, Chi squared, Log-Normal, Student's t, F distributions, Central Limit Theorem.	10	2
III	Monte Carlo techniques: Methods of generating statistical distributions: Pseudorandom numbers from computers and from probability distributions, Applications. Parameter inference: Given prior discrete hypotheses and continuous parameters, Maximum likelihood method for parameter inference. Error Analysis: Statistical and Systematic Errors, Reporting and using uncertainties. Propagation of errors, Statistical analysis of random uncertainties, Averaging Correlated/Uncorrelated Measurements.	13	3
IV	Deconvolution methods, Deconvolution of histograms, binning-free methods. Least-squares fitting: Linear, Polynomial, arbitrary functions: with descriptions of specific methods; Fitting composite curves. Hypothesis tests: Single and composite hypothesis, Goodness of fit tests.	12	4
V	P-values, Chi-squared test, Likelihood Ratio, Kolmogorov-Smirnov test, Confidence Interval. Co-variance and Correlation, Analysis of Variance and Covariance. Illustration of statistical techniques through hands-on use of computer programs.	13	5

4.3.5 Suggested Texts and References:

1. *Statistics: A Guide to the Use of Statistical Methods in the Physical Sciences*, R.J. Barlow, John Wiley 1989.
2. *The Statistical Analysis of Experimental Data*, John Mandel, Dover Publications 1984.

3. *Data Reduction and Error Analysis for the Physical Sciences*, 3rd Edition, Philip Bevington and Keith Robinson, McGraw Hill 2003.

4.4 PL401: Physics Laboratory - IV

Program	Subject	Year	Semester
Int. M.Sc	Physics	2	IV
Course Code	**Course Title**		**Course Type**
PL401	**Physics Laboratory - IV**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
3	-	-	6
Maximum Marks		**CIA**	**ESE**
100		60	40

4.4.1 Learning Objective (LO):

This course aims to develop students' skills in conducting physics and electronics experiments using the ExpEyes kit, including designing, conducting, and analyzing various experiments. It provides practical experience essential for further research or careers in applied physics.

4.4.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Apply the PHOENIX microcontroller system in conducting 20 physics experiments, including experiments on the Helmholtz resonator.	An
2	Understand and determine the resolving power of optical gratings and study atomic spectra of selected elements.	An
3	Conduct experiments involving gamma count detection using a Geiger-Muller (GM) counter and analyze the results.	An
4	Understand and experiment with black body radiation using both optical and thermal methods.	U
5	Analyze electrical and thermal conductivity of metals, as well as the normal and transient responses of electrically coupled oscillators.	An

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

4.4.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	1	2	2	3	2	1	3	2	3	2	2	3	1

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CO2	3	3	3	1	2	2	3	2	1	3	2	3	2	2	1	-
CO3	3	3	3	1	2	2	3	2	1	3	2	3	2	2	1	1
CO4	3	3	3	1	2	2	3	2	1	3	2	3	2	2	1	3
CO5	3	3	3	1	2	2	3	2	1	3	2	3	2	2	1	2

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

4.4.4 Detailed Syllabus: PL401 : Physics Laboratory - IV

Unit No.	Topics	No. of Lectures	CO No.
I	Application of PHOENIX (IUAC, New Delhi) microcontroller system for automation in 20 experiments (six sessions), study of acoustic resonance in Helmholtz resonator using PHOENIX system.	20	1
II	Resolving power of optical grating; study of atomic spectra in hydrogen, helium, mercury.	18	2
III	Application of gamma counts from detected by G.M. counter for study of Poisson and Gaussian distributions.	18	3
IV	Study of black body radiation by optical and thermal radiations.	16	4
V	Study of electrically coupled oscillators - normal and transient response. Assembling components for an experiment on thermal and electrical conductivity of metals and making of measurements.	18	5

4.4.5 Suggested Texts and References:

1. *Phoenix: Computer Interfaced Science Experiments*, available at `http://www.iuac.res.in/elab/phoenix/`.

2. *The Art of Experimental Physics*, D. W. Preston and D. R. Dietz, Wiley 1991.

3. *Manual of Experimental Physics with Indian Academy of Sciences, Bangalore kit*, R. Srinivasan and K.R.S. Priolkar.

SEMESTER - V

5.1 P501: Quantum Mechanics - II

Program	Subject	Year	Semester
Int. M.Sc	Physics	3	V
Course Code	**Course Title**		**Course Type**
P501	**Quantum Mechanics - II**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
5	4	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

5.1.1 Learning Objective (LO):

The course aims to equip students with a deep understanding of advanced quantum mechanics concepts, enabling them to solve eigenvalue problems, understand the quantum mechanical treatment of harmonic oscillators, central potentials, and to apply perturbation theory, variational methods, and scattering techniques.

5.1.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	understand and apply the formalism of quantum mechanics, including Hilbert spaces, Hermitian operators, and Dirac notation, to solve three-dimensional quantum systems such as the hydrogen atom and angular momentum problems.	Ap
2	analyze systems of identical particles, distinguish between bosons and fermions, apply the symmetrization principle, and comprehend the quantum basis of atomic structures and solid-state physics including band structures.	Ap

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3	employ time-independent perturbation theory to solve quantum mechanical problems involving nondegenerate and degenerate systems, and explain fine structure effects in hydrogen like relativistic corrections, spin-orbit coupling, and the Zeeman effect.	Ap
4	apply the variational principle and the WKB approximation to approximate solutions of quantum systems, including calculations for the ground state of helium, hydrogen molecules, and tunneling phenomena.	Ap
5	understand and apply quantum scattering theory, perform partial wave analysis, and use the Born approximation to analyze scattering processes in quantum mechanics.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

5.1.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	3	2	3	3	3	1	3	2	3	3	3	2	3
CO2	3	3	3	3	2	3	3	3	1	3	2	3	3	3	2	3
CO3	3	3	3	3	2	3	3	3	1	3	2	3	3	3	2	3
CO4	3	3	3	3	2	3	3	3	1	3	2	3	3	3	2	3
CO5	3	3	3	3	2	3	3	3	1	3	2	3	3	3	2	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

5.1.4 Detailed Syllabus: P501 : Quantum Mechanics - II

Unit No.	Topics	No. of Lectures	CO No.
I	Formalism of quantum mechanics: Hilbert Space, Observables, Hermitian Operators, Determinate States, Eigenfunctions of a Hermitian Operator, Discrete Spectra, Continuous Spectra, Generalized Statistical Interpretation, The Uncertainty Principle, Proof of the Generalized Uncertainty Principle, The Minimum-Uncertainty Wave Packet, The Energy-Time Uncertainty Principle, Vectors and Operators, Bases in Hilbert Space, Dirac Notation, Changing Bases in Dirac Notation Quantum Mechanics in Three Dimensions: The Schröger Equation, Spherical Coordinates, The Angular Equation, The Radial Equation, The Hydrogen Atom, The Radial Wave Function, The Spectrum of Hydrogen, Angular Momentum, Eigenvalues, Eigenfunctions, Spin, Spin 1/2, Electron in a Magnetic Field, Addition of Angular Momenta, Electromagnetic Interactions, Minimal Coupling, The Aharonov–Bohm Effect	15	1
II	Identical Particles: Two-Particle Systems, Bosons and Fermions, Exchange Forces, Spin, Generalized Symmetrization Principle, Atoms, Helium, The Periodic Table, Solids, The Free Electron Gas, Band Structure.	15	3
III	Time-Independent Perturbation Theory: Nondegenerate Perturbation Theory, General Formulation, First-Order Theory, Second-Order Energies, Degenerate Perturbation Theory, Two-Fold Degeneracy, "Good" States, Higher-Order Degeneracy, The Fine Structure of Hydrogen, The Relativistic Correction, Spin-Orbit Coupling, The Zeeman Effect, Weak-Field Zeeman Effect, Strong-Field Zeeman Effect, Intermediate-Field Zeeman Effect, Hyperfine Splitting in Hydrogen.	15	3
IV	The Variational Principle: Theory, The Ground State of Helium, The Hydrogen Molecule Ion, The Hydrogen Molecule The WKB Approximation, The "Classical" Region, Tunneling, The Connection Formulas	15	4
V	Scattering: Classical Scattering Theory, Quantum Scattering Theory, Partial Wave Analysis, Formalism, Strategy, Phase Shifts, The Born Approximation, Integral Form of the Schrödinger Equation, The First Born Approximation, The Born Series	15	5

5.1.5 Suggested Texts and References:

1. *Introduction to Quantum Mechanics*, 2nd Edition, D. J. Griffiths, Pearson Education 2008.
2. *Quantum Mechanics*, 3rd Edition, L. I. Schiff, Tata McGraw-Hill 2010.
3. *Quantum Mechanics I and II*, Claud Cohen Tannoudji, B. Diu, and F. Laloe, Wiley 2006.
4. *Lectures on Quantum Mechanics*, S. Weinberg, Oxford University Press 2012.

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5. *Quantum Mechanics: Theory and Applications*, A. Ghatak, S. Loknathan.

6. *Quantum Mechanics Concepts and Applications*, Nouredine Zettili, Second Edition.

5.2 P502: Classical Mechanics - II

Program	Subject	Year	Semester
Int. M.Sc	Physics	3	V
Course Code	**Course Title**		**Course Type**
P502	**Classical Mechanics - II**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
5	4	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

5.2.1 Learning Objective (LO):

The objective of this course is to provide a detailed understanding of advanced classical mechanics, focusing on Lagrangian and Hamiltonian formulations, canonical transformations, small oscillations, continuous media, and their applications. It aims to develop the theoretical foundation for analyzing complex dynamical systems.

5.2.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand the Lagrangian and Hamiltonian approach to dynamics, including constraints and generalised coordinates.	U
2	Apply canonical transformations and understand Poisson brackets and conservation theorems.	U
3	Analyze small oscillations in simple and coupled systems, including damped and forced oscillations.	U
4	Understand the Hamilton-Jacobi theory and the use of action-angle variables, and apply canonical perturbation theory.	U
5	Apply the Lagrangian formulation to continuous media and understand its implications.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

5.2.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	3	3	3	1	1	3	3	3	2	2	2	3

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CO2	3	3	3	2	3	3	3	1	1	3	2	3	2	2	2	3
CO3	3	3	3	2	3	3	3	1	1	3	2	3	2	2	2	3
CO4	3	3	3	2	3	3	3	1	1	3	3	3	2	2	2	3
CO5	3	3	3	2	3	3	3	1	1	3	3	3	2	2	2	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

5.2.4 Detailed Syllabus: P502 : Classical Mechanics - II

Unit No.	Topics	No. of Lectures	CO No.
I	Variational principle (revisited), Lagrangian formulation, constraints, generalized coordinates, applications. Hamilton's equations of motion (from Legendre transformation), Hamiltonian and total energy, cyclic coordinates, variational principle.	15	1
II	Small oscillations, single oscillator, damped and forced oscillations, coupled oscillators, normal modes.	15	3
III	Canonical transformations, Poisson brackets, conservation theorems.	15	2
IV	Hamilton–Jacobi theory, action–angle variables. Canonical perturbation theory, time-dependent and time-independent.	15	4
V	Lagrangian formulation of continuous media as a limiting case, extensions.	15	5

5.2.5 Suggested Texts and References:

1. *Classical Mechanics*, H. Goldstein, C. Poole, and J. Safko, Pearson Education 2002.
2. *Classical Dynamics of Particles and Systems*, J. B. Marion and S. T. Thornton, Brooks/Cole 2004.
3. *Mechanics*, L. D. Landau and E. M. Lifshitz, Butterworth-Heinemann 1976.
4. *Analytical Mechanics*, Fowles and Cassiday, Cengage Learning 2004.
5. *Mathematical Methods of Classical Mechanics*, V. I. Arnold, Springer 1989.

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5.3 P503: Atomic and Molecular Physics

Program	Subject	Year	Semester
Int. M.Sc	Physics	3	V
Course Code	**Course Title**		**Course Type**
P503	**Atomic and Molecular Physics**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
4	3	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

5.3.1 Learning Objective (LO):

The objective of this course is to provide a comprehensive understanding of atomic physics, focusing on many-electron atoms, atomic spectra, and the quantum behavior of atoms in external fields. It also includes an introduction to molecular physics, emphasizing ionic and covalent bonding, molecular spectroscopy, and interactions of atoms with external electric and magnetic fields.

5.3.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Apply atomic physics concepts with a problem-solving approach towards spectroscopy.	Ap
2	Understand the static properties of nuclei, nuclear forces, and nuclear models.	U
3	Understand the structure of the nucleus, radioactive decay, and nuclear reactions.	U
4	Analyze the interaction of nuclear radiation with matter.	U
5	Understand quantum behavior of atoms in external electric and magnetic fields.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

5.3.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	3	3	2	1	1	3	2	3	2	2	2	3
CO2	3	3	3	2	3	3	2	1	1	3	2	3	2	2	2	3

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CO3	3	3	3	2	3	3	2	1	1	3	2	3	2	2	2	3
CO4	3	3	3	2	3	3	2	1	1	3	2	3	2	2	2	3
CO5	3	3	3	2	3	3	2	1	1	3	2	3	2	2	2	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

5.3.4 Detailed Syllabus: P503 : Atomic and Molecular Physics

Unit No.	Topics	No. of Lectures	CO No.
I	Many-electron atoms: One-electron wavefunctions and energies in Coulomb potential (revision); Atomic orbitals, spin-orbit coupling, Thomas precession, fine structure; Alkali atoms; Helium ground state and excited states, direct and exchange integrals; Many-electron atoms: LS and jj coupling schemes; Hartree-Fock method; Pauli's principle and the Periodic Table; Nuclear spin and hyperfine structure.	10	1
II	Atoms in External Fields: Quantum theory of normal and anomalous Zeeman effect, Linear and quadratic Stark effect; Semi-classical theory of radiation; Absorption and induced emission; Einstein's A and B coefficients, dipole approximation, intensity of radiation, selection rules.	10	2
III	Two-level atoms in a coherent radiation field, Rabi frequency, radiative damping, optical Bloch equation, Broadening of spectral lines (Doppler, pressure, and power broadening).	10	3
IV	Lasers: Basic concepts, rate equation and lasing conditions, working of some common lasers. Doppler free laser spectroscopy; Crossed – beam method, saturated absorption spectroscopy, two photon spectroscopy; Laser cooling and trapping (descriptive); Atom interferometry (descriptive).	15	4
V	Molecules: Ionic and covalent bonding, Hydrogen molecular ion (H2 +), Born – Oppenheimer approximation; Bonding and anti – bonding orbitals, Hydrogen molecule; Heitler – London method, Molecular orbital method, hybridisation, quantum mechanical treatment of rotational and vibrational spectra (diatomic and polyatomic molecules); Electronic spectra, Raman effect (classical and quantum theory); Vibrational and rotational Raman spectra; Electron spin resonance.	15	5

5.3.5 Suggested Texts and References:

1. *Introduction to Atomic Spectra*, H. E. White, McGraw-Hill 1934.

2. *Physics of Atoms and Molecules*, 2nd Edition, B. H. Bransden and C. J. Joachain, Pearson Education 2003.

3. *Molecular Quantum Mechanics*, 4th Edition, P. W. Atkins and R. S. Friedman, Oxford University Press 2011.

4. *Lasers*, A. E. Siegman, University Science Books 1986.

5. *Spectra of Atoms and Molecules*, P. F. Bernath, Oxford University Press 2005.

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5.4 PL501: Physics Laboratory - V

Program	Subject	Year	Semester
Int. M.Sc	Physics	3	VI
Course Code	**Course Title**		**Course Type**
PL501	**Physics Laboratory - V**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
3	-	-	6
Maximum Marks		**CIA**	**ESE**
100		60	40

5.4.1 Learning Objective (LO):

In this course, students will go through rigorous customization and Python programming-based implementation of Expeyes. They will create their own programs and experimental arrangements to study various physical phenomena, thus gaining hands-on experience with physics experimentation and data analysis.

5.4.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand the structure of the nucleus, radioactive decay, nuclear reactions, and the interaction of nuclear radiation with matter.	An
2	Analyze and understand the behavior of a variable mass pendulum and a coupled pendulum.	An
3	Study electromagnetic induction (EMI) through experimental setups.	An
4	Study the characteristics of a solar cell and analyze its performance under different conditions.	An
5	Measure velocity and acceleration using experimental methods.	An

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

5.4.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	3	3	3	2	2	3	3	3	3	3	3	3
CO2	3	3	3	2	3	3	3	2	2	3	3	3	3	3	3	3

CO3	3	3	3	1	3	3	3	2	2	3	3	3	3	3	3	3
CO4	3	3	3	1	3	3	3	2	2	3	3	3	3	3	3	3
CO5	3	3	3	1	3	3	3	2	2	3	3	3	3	3	3	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

5.4.4 Detailed Syllabus: PL501 : Physics Laboratory - V

Unit No.	Topics	No. of Lectures	CO No.
I	Study of diffraction by single slit, double slit, and multiple slits leading to grating, quantitative determination, and comparison with simulation.	18	1
II	Study of Michelson interferometer and determination of refractive index of air; Study of Fabry-Perot interferometer.	18	2
III	Study of Zeeman effect using Fabry-Perot interferometer; Study of characteristics of scintillation counter used in nuclear radiation detection.	18	3
IV	Study of Hall effect in semiconductors	18	4
V	Introduction to LabVIEW software for automation and use of NI data acquisition card in PC	18	5

5.4.5 Suggested Texts and References:

1. *Practical Physics*, G. L. Squires, Cambridge University Press.
2. *Advanced Practical Physics for Students*, B. L. Worsnop and H. T. Flint, Methuen & Co Ltd.
3. *An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements*, John R. Taylor, University Science Books.
4. *LabVIEW for Everyone: Graphical Programming Made Easy and Fun*, J. Travis and J. Kring, Prentice Hall.
5. *The Art of Electronics*, P. Horowitz and W. Hill, Cambridge University Press.
6. Manuals and user guides for Expeyes and LabVIEW software.

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SEMESTER - VI

6.1 P601: Electrodynamics

Program	Subject	Year	Semester
Int. M.Sc	Physics	3	VI
Course Code	**Course Title**		**Course Type**
P601	**Electrodynamics**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
5	4	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

6.1.1 Learning Objective (LO):

The objective of this course is to develop an in-depth understanding of electrodynamics, focusing on gauge theory, various radiating systems, antenna theory, multipole expansion, scattering, diffraction problems, and the covariant formulation of electrodynamics.

6.1.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand gauge theory, different types of radiating systems, antennas, and solutions of the scalar wave equation.	U
2	Apply the concept of multipole expansion to electromagnetic fields.	Ap
3	Solve scattering and diffraction problems.	Ap
4	Understand the covariant formulation of electrodynamics.	U
5	Analyze the field produced by a moving charge, including Cerenkov radiation.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

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6.1.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	3	2	3	3	3	1	3	3	3	3	3	2	3
CO2	3	3	3	3	2	3	3	3	1	3	3	3	3	3	2	3
CO3	3	3	3	3	2	3	3	3	1	3	3	3	3	2	2	3
CO4	3	3	3	3	2	3	3	3	1	3	3	3	2	2	2	3
CO5	3	3	3	3	2	3	2	3	1	3	3	3	3	3	2	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

6.1.4 Detailed Syllabus: P601 : Electrodynamics

Unit No.	Topics	No. of Lectures	CO No.
I	Review of Maxwell's equations, vector and scalar potentials, gauge transformations. Radiating systems: electric dipole fields and radiation, magnetic dipole and electric quadrupole fields, antenna, spherical wave solutions of the scalar wave equation.	15	1
II	Multipole expansion of the electromagnetic fields, energy and angular momenta of multipole radiation, angular distribution of multipole radiation, multipole moments, multipole radiation in atoms and nuclei, multipole radiation from linear centre fed antenna.	15	2
III	Scattering and Diffraction problems: scattering at long wavelength, perturbation theory of scattering, explanation of blue sky (due to Rayleigh), scalar diffraction theory.	15	3
IV	Covariant formulation of electrodynamics: four vector potential, electromagnetic field tensor, covariant description of sources in material media, field equations in a material medium. Retarded potentials, Jefimenko's generalisations of Coulomb and Biot–Savart laws, Lienard–Wiechert potentials.	15	4
V	Fields of a moving charge. Cerenkov radiation. Covariant formulation of the conservation laws of electrodynamics.	15	5

6.1.5 Suggested Texts and References:

1. *Introduction to Electrodynamics*, 4th Edition, D. J. Griffiths, Addison-Wesley 2012.
2. *Classical Electricity and Magnetism*, 2nd Edition, W.K.H. Panofsky and M. Phillips, Dover 2005.
3. *Classical Electrodynamics*, 3rd Edition, J. D. Jackson, Wiley 2012.
4. *Lectures on Electromagnetism*, 2nd Edition, Ashok Das, Hindustan Book Agency 2013.

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6.2 P602: Statistical Mechanics - I

Program	Subject	Year	Semester
Int. M.Sc	Physics	3	VI
Course Code	**Course Title**		**Course Type**
P602	**Statistical Mechanics - I**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
5	4	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

6.2.1 Learning Objective (LO):

The objective of this course is to introduce students to the concept of understanding physical properties of complex systems via statistical microscopic analysis. Statistical Mechanics provides a framework to describe and predict the behavior of physical systems with many degrees of freedom, and it has broad applications in understanding various physical phenomena.

6.2.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand probability distributions and ensemble theory.	U
2	Differentiate and analyze the implications of dealing with classical and quantum mechanical systems.	Ap
3	Understand the differences and implications of Bosonic and Fermionic systems.	Ap
4	Apply statistical mechanics concepts to explain properties like paramagnetism and specific heat of materials.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

6.2.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	3	2	3	3	2	1	3	3	3	3	2	2	3
CO2	3	3	3	3	2	3	3	2	1	3	3	3	3	2	2	3
CO3	3	3	3	3	2	3	3	2	1	3	3	3	3	2	2	3

CO4	3	3	3	3	2	3	3	2	1	3	3	3	3	2	2	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

6.2.4 Detailed Syllabus: P602 : Statistical Mechanics - I

Unit No.	Topics	No. of Lectures	CO No.
I	Elementary probability theory; random walk; binomial, Poisson, log-normal distributions; Gaussian distribution. Kinetic theory of gases.	15	1
II	Ensembles; micro-canonical ensemble; canonical ensemble; grand canonical ensemble. Partition functions and their properties; calculation of thermodynamic quantities; Gibbs paradox; the equipartition theorem.	15	2
III	Two-level system and paramagnetism. Validity of the classical approximation; identical particles and symmetry; quantum distribution functions; Bose-Einstein statistics; Fermi-Dirac statistics.	15	3
IV	Quantum statistics in the classical limit; physical implications of quantum-mechanical enumeration of states; conduction electrons in metals.	15	4
V	Special topics: the Chandrasekhar limit; Saha ionization formula. Systems of interacting particles; Debye approximation; van der Waals equation; Weiss molecular-field approximation.	15	4

6.2.5 Suggested Texts and References:

1. *Thermodynamics and an Introduction to Thermostatistics*, 2nd Edition, H. B. Callen, Wiley 2006.

2. *Fundamentals of Statistical and Thermal Physics*, F. Reif, McGraw-Hill Book Company.

3. *Statistical Physics Part 1*, 3rd Edition, L. D. Landau and E. M. Lifshitz, Elsevier 2008.

4. *Statistical Mechanics*, 2nd Edition, R. K. Pathria and P. D. Beale, Academic Press 2011.

5. *Equilibrium Statistical Physics*, M. Plischke and B. Bergersen, World Scientific 2006.

6. *Introduction to Modern Statistical Mechanics*, D. Chandler, Oxford University Press 1987.

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6.3 P603: Condensed Matter Physics - I

Program	Subject	Year	Semester
Int. M.Sc	Physics	3	VI
Course Code	**Course Title**		**Course Type**
P603	**Condensed Matter Physics - I**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
4	3	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

6.3.1 Learning Objective (LO):

In this course, primarily focused on ordered crystals, students will gain an understanding of fundamental concepts of crystallography, lattice vibrations, the electronic properties of materials, and the basic principles of semiconductors, magnetism, and superconductivity. The objective is to build a solid foundation in understanding the microscopic behavior of materials and their physical properties.

6.3.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Apply the concepts of crystallography to understand crystal structures and the diffraction of X-rays by crystals.	Ap
2	Analyze lattice vibrations and understand their effects on the thermal properties of solids.	Ap
3	Understand the free electron model and its application to explain electrical and thermal conductivity in metals.	Ap
4	Understand the basics of semiconductors, including band structure, intrinsic and extrinsic semiconductors, and device applications.	Ap
5	Apply the basic concepts of superconductivity, including magnetic properties, the Meissner effect, and the BCS theory.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

6.3.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5

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CO1	3	3	3	3	2	3	3	2	1	3	3	3	3	2	2	3
CO2	3	3	3	3	2	3	3	2	1	3	3	3	3	2	2	3
CO3	3	3	3	3	2	3	3	2	1	3	3	3	3	2	2	3
CO4	3	3	3	3	2	3	3	2	1	3	3	3	3	2	2	3
CO5	3	3	3	3	2	3	2	2	1	3	3	3	3	2	2	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

6.3.4 Detailed Syllabus: P603 : Condensed Matter Physics - I

Unit No.	Topics	No. of Lec-tures	CO No.
I	Crystal Structure and x-ray diffraction: Crystalline and amorphous solids, translational symmetry. Elementary ideas about crystal structure, lattice and bases, cell, reciprocal lattice, fundamental types of lattices, Miller indices, lattice planes, simple cubic, f.c.c. and b.c.c. lattices. Simple crystal structures, Closed packed structure, Determination of crystal structure with X-rays, Neutrons and Electron diffraction-Diffraction of waves by crystals, Laue and Bragg equations, Brillouin Zones, Fourier Analysis of the basis. Debye waller factor, X ray broadening -size and temperature effects. X-ray diffraction of liquids and disordered solids- introduction to radial distribution functions.	12	1
II	Lattice Vibrations: Elastic waves, Thermal properties: Einstein's and Debye's theories of specific heats of solids, Thermal conductivity, Phonons, Lattice waves, Dynamics of a chain of similar atoms and chain of two types of atoms; optical and acoustic modes; Inelastic scattering of x-rays, neutrons and light by phonons, Optical properties of solids: interaction of light with ionic crystals. Raman scattering and Brillouin scattering.	12	2
III	The Free electron model: Drude Model, Electron conductivity, Heat capacity of conduction electrons, Fermi surface, Sommerfield model, Thermal conductivity of metals, Hall effect, AC conductivity and optical properties, Wiedemann-Franz law, Failure of the Free-electron model, optical properties of metals.	12	3

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Unit No.	Topics (Continued)	No. of Lectures	CO No.
IV	Basics of Semiconductors and device: Crystal structure, Band structure, Intrinsic and extrinsic semiconductors, Concept of majority and minority carriers, Energy gap, Mobility, conductivity, Hall effect, Diffusion, Optical properties: Absorption, Luminescence, Photoconductivity, effect of disorder on absorption. Interpretation of energy band diagrams. Devices: p-n diode (derivation of Shockley equation), tunnel diode, photodiode, solar cell, LED, Lasers.	12	4
V	Superconductivity: Introduction (Kamerlingh Onnes experiment), effect of magnetic field, Type- I and type-II superconductors, Isotope effect. Meissner effect. Heat capacity. Energy gap. Electrodynamics of superconductivity: London's equation, Thermodynamics of the transition, Intermediate state of Type 1, Mixed state of type 2, Flux Quantization, Salient points of BCS theory, Cooper problem, Definition of coherence length, Josephson effect.	12	5

6.3.5 Suggested Texts and References:

1. *Introduction to Solid State Physics*, 8th Edition, Charles Kittel, Wiley India Pvt. Ltd.
2. *Solid State Physics*, N. W. Ashcroft and N. D. Mermin, Cengage Learning.
3. *Elementary Solid State Physics*, M. A. Omar, Pearson Education.
4. *Solid State Physics*, S. O. Pillai, New Age International Publishers.
5. *Principles of the Theory of Solids*, J. M. Ziman, Cambridge University Press.
6. *Fundamentals of Solid State Physics*, J. R. Christman, John Wiley & Sons.

6.4 P604: Lasers

Program	Subject	Year	Semester
Int. M.Sc	Physics	3	VI
Course Code	**Course Title**		**Course Type**
P604	**Lasers**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
4	3	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

6.4.1 Learning Objective (LO):

After successful completion of this course, students will understand the operational principles, construction, and applications of lasers, along with their role in modern technological and scientific applications. The objective is to build a solid understanding of laser physics and the ability to relate these concepts to various fields including quantum mechanics, solid state physics, and optics.

6.4.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand the operational principles and construction of lasers.	Ap
2	Understand technological issues behind laser construction.	Ap
3	Understand optical components that can be used to tailor the properties of lasers.	Ap
4	Relate the laser operation principles to atomic and molecular physics, solid state physics, quantum mechanics, and physical optics.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

6.4.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	2	3	3	2	1	3	3	3	3	2	2	3
CO2	3	3	3	2	2	3	3	2	1	3	3	3	3	2	2	3
CO3	3	3	3	2	2	3	3	2	1	3	3	3	3	2	2	3

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CO4	3	3	3	2	2	3	3	2	1	3	3	3	3	2	2	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

6.4.4 Detailed Syllabus: P604 : Lasers

Unit No.	Topics	No. of Lectures	CO No.
I	Laser Characteristics –Spontaneous and stimulated emission, Einstein's quantum theory of radiation, theory of some optical processes, coherence and monochromacity, kinetics of optical absorption, line broadening mechanism, Basic principle of lasers, population inversion, laser pumping, two & three level laser systems, resonator, Q-factor, losses in cavity, threshold condition, quantum yield.	12	1
II	Laser Systems- Solid state lasers- the ruby laser, Nd:YAG laser, ND: Glass laser, semiconductor lasers – features of semiconductor lasers, intrinsic semiconductor lasers, Gas laser - neutral atom gas laser, He-Ne laser, molecular gas lasers, CO2 laser, Liquid lasers, dye lasers and chemical laser.	12	1, 2
III	Advances in laser Physics, Production of giant pulse -Q-switching, giant pulse dynamics, laser amplifiers, mode locking and pulling, Non-linear optics, Harmonic generation, second harmonic generation, Phase matching, third harmonic generation, optical mixing, parametric generation and self-focusing of light.	12	2, 3
IV	Multi-photon processes; multi-quantum photoelectric effect, Theory of two-photon process, three- photon process, second harmonic generation, parametric generation of light, Laser spectroscopy : Rayleigh and Raman scattering, Stimulated Raman effect, Hyper-Raman effect, Coherent anti-stokes Raman Scattering, Photo-acoustic Raman spectroscopy.	12	3, 4
V	Laser Applications – ether drift and absolute rotation of the Earth, isotope separation, plasma, thermonuclear fusion, laser applications in chemistry, biology, astronomy, engineering and medicine. Communication by lasers: ranging, fiber Optics Communication, Optical fiber, numerical aperture, propagation of light in a medium with variable index, pulse dispersion..	12	4

6.4.5 Suggested Texts and References:

1. Laud, B.B.: Lasers and nonlinear optics, (New Age Int.Pub.1996).
2. Ghatak, A.K.and Thyagarajan, K : Optical electronics (Cambridge Univ. Press 1999).
3. Seigman, A.E.: Lasers (Oxford Univ. Press 1986)

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4. Hecht, J.The laser Guide book (McGraw Hill, NY, 1986).

5. *Laser Fundamentals*, 2nd Edition, William T. Silfvast, Cambridge University Press.

6. *Optical Electronics*, Ajoy Ghatak and K. Thyagarajan, Cambridge University Press.

7. *Principles of Lasers*, O. Svelto, Springer.

8. *Lasers and Non-Linear Optics*, B. B. Laud, New Age International Publishers.

9. *Introduction to Quantum Electronics and Nonlinear Optics*, Vitaly V. Sautenkov, CRC Press.

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6.5 H601: Ethics of Science and IPR

Program	Subject	Year	Semester
Int. M.Sc	Physics	3	VI
Course Code	**Course Title**		**Course Type**
H601	**Ethics of Science and IPR**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
2	2	0	0
Maximum Marks		**CIA**	**ESE**
100		60	40

6.5.1 Learning Objective (LO):

After successful completion of this course, students will learn the significance of ethics in scientific practice and an overview of Intellectual Property Rights (IPR). The course aims to foster a thorough understanding of ethical conduct in science, the role of intellectual property, and the legislative frameworks guiding IPR.

6.5.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand the role and importance of ethics in science.	U
2	Understand plagiarism and the software tools available for plagiarism detection.	U
3	Describe various types of intellectual property.	U
4	Define patents and differentiate between patentable and non-patentable inventions.	U
5	Explain the evolution of institutions like GATT, WTO, and IPR provisions under TRIPS.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

6.5.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	2	2	2	2	3	3	3	3	3	3	2	2	2	2	2
CO2	3	2	2	2	2	3	3	3	3	3	3	2	2	2	2	2

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CO3	3	2	2	2	2	3	3	3	3	3	3	2	2	2	2	2
CO4	3	2	2	2	2	3	3	3	3	3	3	2	2	2	2	2
CO5	3	2	2	2	2	3	3	3	3	3	3	2	2	2	2	2

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

6.5.4 Detailed Syllabus: H601 : Ethics of Science and IPR

Unit No.	Topics	No. of Lectures	CO No.
I	Introduction to Ethics: Causes of unethical acts, definition - moral, values, ethics; Role and importance of ethics in science; Professional ethics - professional conduct, teaching ethical values to scientists, good laboratory practices, good manufacturing practices, basic approaches to ethics; Posthumanism and Anti-Posthumanism.	10	1
II	Medical Ethics: Different themes pertaining to medical ethics including ethical issues in public health. Environmental Ethics, Bioethics, Journals and Publishers: Monopolistic practices by academic publishers, plagiarism, and software for plagiarism detection.	5	2
III	Introduction to IPR: Types of Intellectual property - Patents, Trademarks, Copyrights, and related rights; Traditional vs. Novelty; Importance of intellectual property rights in the modern global economic environment, importance of intellectual property rights in India.	8	3
IV	Patents: Definition, patentable and non patentable inventions; types of patent application – Ordinary, Conventional, PCT, Divisional, and Patent of addition; Concept of Prior Art; Precautions while patenting disclosure / nondisclosure;	7	4
V	Case studies and agreements - Evolution of GATT and WTO and IPR provisions under TRIPS; Madrid agreement; Hague agreement; WIPO treaties; Budapest treaty; Indian Patent Act (1970)	5	5

6.5.5 Suggested Texts and References:

1. *Research Ethics: A Reader*, Deni Elliott and Judy E. Stern, University Press of New England.
2. *Introduction to Intellectual Property*, W.R. Cornish, D. Llewelyn, Oxford University Press.
3. *Intellectual Property Rights*, Deborah E. Bouchoux, Cengage Learning.
4. *Professional Ethics and Human Values*, M. Govindarajan, S. Natarajan, V.S. Senthilkumar, Prentice Hall of India.
5. *Intellectual Property Rights and Copyrights*, A. Subba Rao, Asian Law House.

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6.6 PL601: Physics Laboratory – VI

Program	Subject	Year	Semester
Int. M.Sc	Physics	3	VI
Course Code	**Course Title**		**Course Type**
PL601	**Physics Laboratory – VI**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
3	-	-	6
Maximum Marks		**CIA**	**ESE**
100		60	40

6.6.1 Learning Objective (LO):

After successful completion of this course, students should have procedural and conceptual understanding of the following experiments.

6.6.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Determination of specific charge (e/m) of an electron.	Ap
2	Study of Faraday rotation and determination of Verdet's constant in a glass material.	Ap
3	Study of quantum mechanics through acoustic analogue (four sessions).	Ap
4	Fourier analysis/synthesis – use of simulation.	Ap
5	Study of characteristics of a coaxial cable and determination of speed of electromagnetic waves in the coaxial cable.	Ap
6	Investigation of chaos in a spring-based coupled oscillator system.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

6.6.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	3	2	3	3	2	1	3	3	3	3	3	3	3
CO2	3	3	3	3	2	3	3	2	1	3	3	3	3	3	3	3
CO3	3	3	3	3	2	3	3	2	1	3	3	3	3	3	3	3

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CO4	3	3	3	3	2	3	3	2	1	3	3	3	3	3	3	3
CO5	3	3	3	3	2	3	2	2	1	3	3	3	3	3	3	3
CO6	3	3	3	3	2	3	2	2	1	3	3	3	3	3	3	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

6.6.4 Detailed Syllabus: PL601 : Physics Laboratory – VI

Unit No.	Topics	No. of Lectures	CO No.
I	Study of quantum mechanics through acoustic analogue (four sessions); Fourier analysis / synthesis – use of simulation.	18	1
II	Study of characteristics of a coaxial cable and determination of speed of electromagnetic waves in the coaxial cable.	18	2
III	Determination of specific charge (e/m) of electron.	18	3
IV	Study of Faraday rotation and determination of Verdet's constant in a glass material; investigation of chaos in a spring-based coupled oscillator system.	18	4
V	Introduction to workshop practice (two sessions); Introduction to vacuum practice (two sessions).	18	5

6.6.5 Suggested Texts and References:

1. *The Art of Experimental Physics*, D. W. Preston and D. R. Dietz, Wiley, 1991.

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7.1 P701: Astronomy and Astrophysics - I

Program	Subject	Year	Semester
Int. M.Sc	Physics	4	VII
Course Code	**Course Title**		**Course Type**
P701	**Astronomy and Astrophysics - I**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
4	3	1	0
Maximum Marks		**PIA**	**ESE**
100		60	40

7.1.1 Learning Objective (LO):

This is an introductory course for astronomy and astrophysics. It aims to develop foundational concepts that enable students to take more advanced courses in astronomy and astrophysics. The student will learn the basics of the universe, stellar structures, coordinate systems, and observational techniques.

7.1.2 Course Outcomes (CO):-

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CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand the concepts of distance scales of the universe and measurement of the brightness of astronomical objects.	Ap
2	Comprehend the physics behind the observed spectra of stars, and the stellar evolution using the Hertzsprung-Russell diagram.	Ap
3	Explain the working of telescopes and requirements for different telescopes for observations across various wavelengths.	Ap
4	Understand the basic properties of the Sun as a star, including its structure and activity.	Ap
5	Apply the knowledge of astronomical coordinate systems to understand celestial movements.	Ap
6	Gain proficiency in using astronomical databases and converting nomenclature of stars.	Ap
7	Build an essential background to study advanced topics in Astronomy and Astrophysics-II (P801).	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

7.1.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	2	3	3	3	2	3	3	3	3	2	3	3
CO2	3	3	3	2	2	3	3	3	2	3	3	3	3	2	3	3
CO3	3	3	3	2	2	3	3	3	1	3	2	3	3	2	3	3
CO4	3	3	3	2	2	3	3	2	1	3	2	3	3	2	3	3
CO5	3	3	3	2	2	2	3	2	1	3	2	3	3	2	3	3
CO6	3	3	3	2	2	2	3	2	1	3	2	3	3	2	3	3
CO7	3	3	3	2	2	3	3	2	1	3	3	3	3	2	3	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

7.1.4 Detailed Syllabus: P701 : Astronomy and Astrophysics - I

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Unit No.	Topics	No. of Lectures	CO No.
I	An understandable universe, The scale of the universe, Continuous radiation from stars, Brightness of starlight, The electromagnetic spectrum, Colors of stars, Quantifying color, Blackbodies, Planck's law and photons, Stellar colors, Stellar distances, Absolute magnitudes.	12	1
II	Spectral lines in stars, Spectral types, The origin of spectral lines, The Bohr atom, Quantum mechanics, Formation of spectral lines, Excitation, Ionization, Intensities of spectral lines, The Hertzsprung–Russell diagram.	12	2
III	Telescopes, What a telescope does, Light gathering, Angular resolution, Image formation in a camera, Refracting telescopes, Reflecting telescopes, Observatories, Ground-based observing, Observations from space, Data handling, Detection, Spectroscopy, Observing in the ultraviolet, Observing in the infrared, Radio astronomy, High energy astronomy	12	3
IV	The Sun: a typical star, Basic structure, Elements of radiation transport theory, The photosphere Appearance of the photosphere, Temperature distribution, Doppler broadening of spectral lines The chromosphere, The corona, Parts of the corona, Temperature of the corona, Solar activity Sunspots, Other activity	12	4
V	Place, time, and motion: Astronomical coordinate systems, The third dimension, Time, Motion Names, catalogs, and databases: Star names, Names and catalogs of non-stellar objects outside the Solar System, Objects at non-optical wavelengths, Atlases and finding charts, Websites and other computer resources, Solar System objects	12	5

7.1.5 Suggested Texts and References:

1. Textbook for UNIT I to IV: *Astronomy: A Physical Perspective* by Marc L. Kutner.
2. Textbook for UNIT V: *To Measure the Sky: An Introduction to Observational Astronomy* by Frederick R. Chromey.
3. References:
   - *Introduction to Modern Astrophysics* by B. W. Carroll and D. A. Ostlie.
   - *An Invitation to Astrophysics* by T. Padmanabhan.
   - *Astrophysical Concepts* by Martin Harwit.
   - *Introductory Astronomy and Astrophysics* by Zeilik and Gregory.
   - *The Physical Universe* by F. Shu.

7.2 P702: Quantum Mechanics – III

Program	Subject	Year	Semester
Int. M.Sc	Physics	4	VII
Course Code	**Course Title**		**Course Type**
P702	**Quantum Mechanics – III**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
4	3	1	0
Maximum Marks		**PIA**	**ESE**
100		60	40

7.2.1 Learning Objective (LO):

After successful completion of this course, students will understand deeper concepts of quantum mechanics including advanced topics such as the EPR paradox, quantum entanglement, and decoherence. They will be prepared to engage with relativistic quantum mechanics and build a foundation for future courses like Quantum Field Theory.

7.2.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand deeper concepts of quantum mechanics and comprehend advanced topics like the EPR paradox, quantum entanglement, and decoherence.	U
2	Understand symmetry in quantum mechanics.	U
3	Understand the development of relativistic quantum mechanics.	U
4	Understand Dirac's equation in an external electromagnetic field.	U
5	Solve relativistic one-body problems for spin 0 and 1 particles.	U
6	Learn the solutions of Dirac's equation and its interpretation.	U
7	Gain adequate background knowledge to take a course on Quantum Field Theory.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

7.2.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5

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CO1	3	3	3	2	2	3	3	3	2	3	3	3	3	2	2	3
CO2	3	3	3	2	2	3	3	3	2	3	3	3	3	2	2	3
CO3	3	3	3	2	2	3	3	3	1	3	2	3	3	2	2	3
CO4	3	3	3	2	2	3	3	2	1	3	2	3	3	2	2	3
CO5	3	3	3	2	2	2	3	2	1	3	2	3	3	2	2	3
CO6	3	3	3	2	2	2	3	2	1	3	2	3	3	2	2	3
CO7	3	3	3	2	2	3	3	2	1	3	3	3	3	2	2	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

7.2.4 Detailed Syllabus: P702 : Quantum Mechanics – III

Unit No.	Topics	No. of Lectures	CO No.
I	Foundations (Introductory ideas): The EPR paradox, quantum entanglement; Bell's theorem, the No-clone theorem, Schrödinger's cat; Decoherence, quantum Zeno paradox.	12	1
II	Symmetry and Conservation Laws: Transformation of the Wave Function under Coordinate Transformations, Group of Symmetry of the Schrödinger Equation and the Conservation Laws, Homogeneity of Time and Space: Conservation of Energy and Momentum, Isotropy of Space: Conservation of Angular Momentum, Symmetry of the Hamiltonian and Degeneracy, Space Inversion Symmetry, Time Reversal Symmetry and Time Reversal Operator Kramers' Degeneracy and Kramers' Theorem.	12	2
III	Relativistic Wave Equations: Generalization of the Schrödinger Equation, the Klein-Gordon equation, Plane Wave Solutions, Charge and Current Densities, Interaction with Electromagnetic Fields, Hydrogen-Like Atom, Nonrelativistic Limit.	12	3
IV	The Dirac equation, Dirac's Relativistic Hamiltonian, Position Probability Density, Expectation Values, Dirac Matrices, Plane Wave Solutions of the Dirac Equation; Energy Spectrum, The Spin of the Dirac Particle, Significance of Negative Energy States; Dirac Particle in Electromagnetic Fields.	12	4

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Unit No.	Topics (Continued)	No. of Lectures	CO No.
V	Relativistic Electron in a Central Potential: Total Angular Momentum, Radial Wave Equations in Coulomb Potential, Series Solutions of the Radial Equations: Asymptotic Behaviour, Determination of the Energy Levels, Exact Radial Wave Functions, Comparison to Non-Relativistic Case, Electron in a Magnetic Field—Spin Magnetic Moment, The Spin Orbit Energy.	12	5

7.2.5 Suggested Texts and References:

1. *Introduction to Quantum Mechanics*, 2nd Edition, D. J. Griffiths, Pearson Education, 2008. (Textbook for UNIT I)

2. *Fundamentals of Quantum Mechanics*, Ajit Kumar, Cambridge University Press. (Textbook for UNIT II)

3. *A Textbook of Quantum Mechanics*, Second Edition, P. M. Mathews and K. Venkatesan. (Textbook for UNIT III to V)

4. *Relativistic Quantum Mechanics vol. 1*, J. D. Bjorken and S. D. Drell, McGraw-Hill, 1998.

5. *Intermediate Quantum Mechanics*, H. A. Bethe and R. W. Jackiew, Perseus Books, 1997.

6. *Quantum Field Theory*, 2nd Edition, F. Mandl and G. Shaw, Wiley, 2010.

7. *Advanced Quantum Mechanics*, F. Schwabl, Springer, 2008.

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7.3 P703: Statistical Mechanics – II

Program	Subject	Year	Semester
Int. M.Sc	Physics	4	VII
Course Code	**Course Title**		**Course Type**
P703	**Statistical Mechanics – II**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
4	3	1	0
Maximum Marks		**PIA**	**ESE**
100		60	40

7.3.1 Learning Objective (LO):

In this course, students will develop an understanding of transport phenomena, diffusion, phase transitions, and critical phenomena, which are crucial in statistical mechanics. They will also gain insights into renormalization techniques and Monte Carlo methods that are essential for the analysis of physical systems.

7.3.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand transport phenomena and equations governing the transport in the presence and absence of collisions, including the random walk problem.	U
2	Comprehend the concept of diffusion and equations governing diffusion.	U
3	Understand the phenomena of phase transition, types of phase transitions, and the Landau theory of second-order phase transition.	U
4	Evaluate critical phenomena, critical exponents, and exponent inequalities.	E
5	Apply renormalization group techniques and Monte Carlo methods to analyze physical systems.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

7.3.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5

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CO1	3	3	3	3	2	3	3	2	1	3	3	3	3	2	2	3
CO2	3	3	3	3	2	3	3	2	1	3	3	3	3	2	2	3
CO3	3	3	3	3	2	3	3	2	1	3	3	3	3	2	2	3
CO4	3	3	3	3	2	3	3	2	1	3	3	3	3	2	2	3
CO5	3	3	3	3	2	3	3	2	1	3	3	3	3	2	2	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

7.3.4 Detailed Syllabus: P703 : Statistical Mechanics – II

Unit No.	Topics	No. of Lectures	PO No.
I	Transport theory using the relaxation time approximation; Boltzmann differential equation formulation; examples of the Boltzmann equation method. Stochastic Processes; Random Walk; Autocatalytic processes.	12	1
II	Diffusion equation; Langevin equation; Fokker-Planck equation.	12	2
III	Ising Model; mean-field theory; Landau theory of second order phase transition; Peierls argument; the Bethe-Peierls approximation; Kramers-Wannier duality argument; Pade Approximant.	12	3
IV	Phase transition and Critical Phenomenon: critical exponents; exponent inequalities; static scaling hypothesis; block spins and the Kadanoff construction.	12	4
V	Renormalization Group: Decimation; Migdal-Kadanoff method; general renormalization group prescription; examples. Monte-Carlo Methods in statistical mechanics; Metropolis algorithm; Gillespie method.	12	5

7.3.5 Suggested Texts and References:

1. *Fundamentals of Statistical and Thermal Physics*, F. Reif, McGraw-Hill Book Company.
2. *Statistical Physics Part 1*, 3rd Edition, L. D. Landau and E. M. Lifshitz, Elsevier 2008.
3. *Statistical Mechanics: A Set of Lectures*, R. P. Feynman, W. A. Benjamin, Inc. 1998.
4. *A Modern Course in Statistical Physics*, L. E. Reichl, Wiley 2009.

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7.4 PE10: Computational Physics - C

Program	Subject	Year	Semester
Int. M.Sc	Physics	5	X
Course Code	**Course Title**		**Course Type**
P704	**Computational Physics**		**Elective**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
5	4	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

7.4.1 Learning Objective (LO):

The objective of this course is to provide students with a thorough understanding of both quantum and classical computational tools. Specifically, students will:

- Gain hands-on experience with computational methods and techniques for solving physics-related problems using computers.
- Develop the skills needed to pursue Ph.D. programs in reputed national and international research institutes/universities.
- Learn how to formulate research proposals suitable for short-term or long-term projects, enhancing their ability to collaborate with eminent scientists and research institutes.

7.4.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Gain hands-on experience in modeling using computational methods.	Ap
2	Understand algorithm development for solving physical problems.	U
3	Implement and calculate physical quantities relevant to interacting many-body problems in physics.	U
4	Determine transition temperatures using Binder's cumulant and solve various differential equations, including linear, non-linear, and coupled equations.	E
5	Solve the Schrödinger equation in quantum mechanics using Numerov's algorithm, and the variational principle, and conduct classical molecular dynamics simulations using Lennard-Jones potential.	E

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

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7.4.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	3	2	2	3	2	2	3	2	3	3	3	3	-
CO2	3	3	3	3	2	2	3	2	1	3	2	3	3	3	3	1
CO3	3	3	3	3	2	2	3	2	3	3	2	3	3	3	3	1
CO4	3	3	3	3	2	2	3	2	2	3	2	3	3	3	3	1
CO5	3	3	3	3	2	2	3	2	2	3	2	3	3	3	3	1

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

7.4.4 Detailed Syllabus: Computational Physics

Unit No.	Topics	No. of Lect.	CO No.
I	Introduction of Fortran programming language, Random number generation and testing, Generation of random numbers with given distribution.	15	1
II	Numerical Integration: (a) Deterministic: Trapezoidal method and (b) Multi-dimensional Integration using stochastic methods.	15	2
III	Lattice Monte Carlo simulations using the Ising model to understand phase transitions: Metropolis algorithm, kinetic barriers, finite size effects, role of thermal fluctuations, principle of detailed balance, calculating thermodynamic averages.	15	3
IV	Determining transition temperature using Binder's cumulant, Solving differential equations, Linear, non-linear, and coupled differential equations.	15	4
V	Solving differential equations in Quantum Mechanics with the Schrödinger equation using Numerov's algorithm and the variational principle, Classical Molecular Dynamics simulations using Lennard-Jones' potential.	15	5

7.4.5 Suggested Texts and References:

1. *Computational Physics: Problem Solving with Python*, 3rd edition, Rubin H. Landau, Manuel J. Paez, Cristian C. Bordeianu

2. *Computational Physics, Fortran Version*, Steven E. Koonin, Dawn C. Meredith, CRC Press

3. *Computational Physics*, 2nd edition, Jos Thijssen, Cambridge Univ. Press

4. *Computational Physics*, T. Pang

5. *Computational Physics: An Introduction to Monte Carlo Simulations of Matrix Field Theory*, Ydri, Badis

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6. *Computer Programming in F90 & 95*, V. Rajaraman, PHI Learning Pvt. Ltd

7. *Numerical Recipes in F90*, Cambridge Publishers

8. *A First Course in Computational Physics*, P. L. DeVries and J. Hasbun, John Wiley and Sons Inc.

9. *Understanding Molecular Simulation*, Academic Press, Daan Frenkel and Berend Smit

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7.5 PL701: Advanced Physics Laboratory – I

Program	Subject	Year	Semester
Int. M.Sc	Physics	3	VI
Course Code	**Course Title**		**Course Type**
PL701	**Advanced Physics Laboratory – I**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
5	-	-	10
Maximum Marks		**PIA**	**ESE**
100		60	40

7.5.1 Learning Objective (LO):

After successful completion of this course, students should have procedural and conceptual understanding of various advanced physics experiments, specifically related to nuclear physics, condensed matter physics, structural characterization, low temperature measurements, and phase-sensitive measurements.

7.5.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Analyze spectral features of photoelectric absorption and Compton scattering using scintillation detectors.	Ap
2	Apply physical vapor deposition techniques to grow metallic thin films and understand vacuum techniques.	Ap
3	Operate a closed cycle cryostat and conduct low temperature measurements for materials characterization.	Ap
4	Use a dual-phase lock-in amplifier for phase-sensitive measurements and study superconducting transition temperatures.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

7.5.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**	**4**	**5**
CO1	3	3	3	2	3	3	3	2	1	3	3	3	3	3	3	3
CO2	3	3	3	2	3	3	3	2	1	3	3	3	3	3	3	3
CO3	3	3	3	2	3	3	3	2	1	3	3	3	3	3	3	3

CO4	3	3	3	2	3	3	3	2	1	3	3	3	3	3	3	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

7.5.4 Detailed Syllabus: PL701 : Advanced Physics Laboratory – I

Unit No.	Topics	No. of Lectures	CO No.
I	Nuclear Physics: Spectral features of photoelectric absorption and Compton scattering with scintillation detectors (i) Inorganic: NaI(Tl), BaF2 (ii) Organic: BC501A and plastic. Energy calibration, energy resolution, photopeak and total efficiency, relative intensity, photoelectric and Compton cross-sections, radiation shielding. Alpha spectroscopy with a silicon surface barrier detector. Fine structure of alpha spectrum and determination of age of source. Fast timing and coincidence measurements using BaF2 and BC501A detectors. Angular correlation of gamma rays using NaI(Tl) detectors. High-resolution, low-energy photon measurements with a silicon drift detector: Internal conversion studies, elemental composition through X-Ray Fluorescence (XRF) analysis. Geiger-Muller counter: operating characteristics, dead time measurement, determination of mass absorption coefficient, verification of inverse square law. Lifetime measurements: from nanoseconds through minutes using fast coincidence and decay studies. High-resolution gamma ray measurements with high-purity germanium detectors. Classic experiments: Rutherford scattering, cloud chamber, beta spectrometer. Spectrum analysis techniques and fitting routines: data/peak fitting, energy and efficiency calibration, 1D and 2D histograms. (Selected experiments from the above list are performed based on number of contact hours prescribed).	30	1
II	Condensed Matter Physics: Growth of metallic thin films by physical vapor deposition techniques like thermal evaporation and DC magnetron sputtering. Tuning of growth parameters to change the deposition rate and hence thickness of the films. Introduction to vacuum techniques: vacuum pumps, rotary pump, diffusion pump, and turbo molecular pumps. Measurement of vacuum: thermocouple gauges, hot and cold cathode gauges. Thickness measurement of thin films by quartz crystal monitor.	30	2

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Unit No.	Topics (Continued)	No. of Lectures	CO No.
III	Structural characterization of materials (some known and some unknown) by X-ray diffraction (XRD) and X-ray fluorescence (XRF): Phase identification, chemical composition, difference between powder diffraction pattern of single and polycrystalline systems, reasons for line broadening in XRD: Rachinger correction and estimation of particle size from Debye-Scherer formula, identifying crystal structure, and determination of lattice constant.	30	2
IV	Low Temperature Measurements: Operation of a closed cycle cryostat, low temperature thermometers, controlling temperatures using PID feedback, making electrical contacts on thin films and measuring DC resistance with sourcemeter using four probe method. Determination of superconducting transition temperature of a high temperature superconductor using electrical transport measurements. Determination of band gap of a semiconductor: highly doped Si by fitting the temperature dependent resistance to the standard variation in semiconductors. Concepts of measuring electrical resistance in labs: from metals to dielectrics. Introducing GPIB interfacing of electronic instruments with the computer and writing LABVIEW programs to interface temperature controller and sourcemeter.	30	3
V	Phase Sensitive Measurements: Use of a dual phase lock-in amplifier. Measurement of the superconducting transition temperature of a superconducting thin film using a mutual inductance technique down to 2.6K (working of a cryogen-free system). Measuring AC resistance of a milliohm resistor using phase sensitive detection and studying the frequency and amplitude variation of the resistance: introduction to noise, white noise, and 1/f noise.	30	4

7.5.5 Suggested Texts and References:

1. *Radiation Detection and Measurement*, Glenn F. Knoll, John Wiley, 2010.
2. *Techniques for Nuclear and Particle Physics Experiments*, William R. Leo, Springer, 1995.
3. *Basic Vacuum Technology*, 2nd Edition, A. Chambers, R. K. Fitch, and B. S. Halliday, IOP, 1998.
4. *Physical Vapor Deposition*, R. J. Hill, McGraw-Hill, 2005.
5. *Elements of X-ray Diffraction*, 3rd Edition, B. D. Cullity and S. R. Stock, Prentice Hall, 2001.
6. *Introduction to Solid State Physics*, 8th Edition, C. Kittel, Wiley, 2012.

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7.6 PPr701: Reading Project

<table>
<tr><th>Program</th><th>Subject</th><th>Year</th><th>Semester</th></tr>
<tr><td>Int. M.Sc</td><td>Physics</td><td>4</td><td>VII</td></tr>
<tr><td>Course Code</td><td colspan="2">Course Title</td><td>Course Type</td></tr>
<tr><td>PPr701</td><td colspan="2">Reading Project</td><td>Core</td></tr>
<tr><td rowspan="2">Credit</td><td colspan="3">Hours Per Week (L-T-P)</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>4</td><td>-</td><td>-</td><td>8</td></tr>
<tr><td colspan="2">Maximum Marks</td><td>CIA</td><td>ESE</td></tr>
<tr><td colspan="2">100</td><td>60</td><td>40</td></tr>
</table>

Reading project will be assigned by the supervisor.

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7.7 SEL701: Linux Operating System

Program	Subject	Year	Semester
Int. M.Sc	Physics	2	VII
Course Code	**Course Title**		**Course Type**
SEL701	**Linux Operating System**		**Skill Enhancement Course**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
2	2	0	0
Maximum Marks		**CIA**	**ESE**
100		60	40

7.7.1 Learning Objective (LO):

The aim of this course is to introduce students to the Linux operating system, focusing on Ubuntu Linux. Students will learn essential commands, system administration, file management, scripting, and customization. The course will enhance their proficiency in using Linux for scientific computing and everyday tasks.

7.7.2 Course Outcomes (CO):

CO No.	Expected Course Outcomes: At the end of the course, the students will be able to:	CL
1	Understand the basics of Ubuntu Linux Desktop environment and navigate through its features.	U
2	Customize the desktop environment and install software using various package managers.	Ap
3	Utilize fundamental Linux commands and manage the file system effectively.	Ap
4	Perform advanced file operations, manage processes, and understand file attributes.	An
5	Configure the Linux environment, perform basic system administration tasks, and use text processing tools.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understand; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

7.7.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	2	1	-	2	2	3	1	1	2	1	3	3	1	1	1

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CO2	3	3	2	-	3	2	3	2	1	2	1	3	2	2	1	1
CO3	3	3	3	-	3	2	3	2	1	2	1	3	2	2	1	2
CO4	3	3	3	-	3	2	3	1	1	2	1	3	2	2	1	2
CO5	3	3	3	-	3	2	3	1	1	2	1	3	2	2	1	2

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

7.7.4 Detailed Syllabus: SEL701: Linux Operating System

Unit No.	Topics	No. of Lectures	CO No.
I	**Introduction to Ubuntu Linux Desktop** - Ubuntu Linux Desktop latest release overview. - GNOME environment and desktop navigation. - The Launcher and commonly used icons: - Calculator - Gedit Text Editor - Terminal - Firefox Web Browser - Videos - LibreOffice Suite components - The Home folder	12	1
II	**Desktop Customization and Software Installation** - Customizing the Launcher: - Removing and adding applications - System Settings and Appearance: - Changing desktop themes - Workspace switcher and multiple desktops - Internet connectivity settings - Sound settings - Time and Date settings - User account management and switching - Installing software: - Via Terminal - Synaptic Package Manager - Ubuntu Software Center - Configuring proxy settings and repositories - Installing applications (VLC Player, Inkscape) - Performing system updates	12	2

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Unit No.	Topics (Continued)	No. of Lectures	CO No.
III	**Basic Linux Commands and File System** - General Purpose Utilities: - echo, uname, who, passwd, date, cal - Files and Directories: - pwd, ls, cat - Understanding the File System: - Files, Directories, Inodes - Types of Files - Home directory and Current directory - Navigating directories (cd) - Creating and removing directories (mkdir, rmdir) - Working with Regular Files: - cat, rm, cp, mv, cmp, wc - Basic Commands: - Command interpreter and shell - Using man, apropos, whatis, –help option	12	3
IV	**Advanced File Operations and Process Management** - File Attributes: - chown, chmod, chgrp - Displaying files with ls -l - Understanding permissions (u+, a-w, g+w, -r) - Inodes, hard links, symbolic links - Redirection and Pipes: - Input, output, and error streams - Redirection operators > and >> - Pipes | - Working with Linux Processes: - Understanding processes - Shell processes - Process spawning (parent and child processes) - Process attributes (pid, ppid) - Init process - User and system processes - Using ps with options	12	4

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Unit No.	Topics (Continued)	No. of Lectures	CO No.
V	**Environment Variables, System Administration, and Text Processing** - The Linux Environment: - Environment variables vs. Local variables - set and env commands - Common environment variables (SHELL, HOME, PATH, LOGNAME, PS1, PS2) - history command, using ! and , alias - Basics of System Administration: - Root login (su) - User management (UID, GID, useradd, usermod, userdel) - Disk usage (du, df) - Simple Filters: - head, tail, sort, cut, paste - The grep Command: - Searching file content - Using grep options (ignore case, invert match, line numbers, count) - Patterns and regular expressions - The sed Command: - Stream editor basics - Printing and modifying text with sed - Line and context addressing - Substituting, inserting, and deleting text	12	5

7.7.5 Suggested Texts and References:

1. Christopher Negus, *Linux Bible*, Wiley, 9th Edition.
2. Richard Blum, *Linux Command Line and Shell Scripting Bible*, Wiley, 3rd Edition.
3. William Shotts, *The Linux Command Line: A Complete Introduction*, No Starch Press.
4. Mark G. Sobell, *A Practical Guide to Linux Commands, Editors, and Shell Programming*, Pearson, 3rd Edition.
5. Ubuntu Official Documentation: Available online at `https://help.ubuntu.com/`
6. Machtelt Garrels, *Introduction to Linux: A Hands on Guide*, Free Ebook.
7. Ellen Siever, Stephen Figgins, Robert Love, *Linux in a Nutshell*, O'Reilly Media.
8. Jon Emmons, *Beginning Ubuntu Linux for Novices and Professionals*, Apress.

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SEMESTER - VIII

8.1 P801: Astronomy and Astrophysics – II

Program	**Subject**	**Year**	**Semester**
Int. M.Sc	Physics	4	VIII
Course Code	**Course Title**		**Course Type**
P801	**Astronomy and Astrophysics – II**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
4	3	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

8.1.1 Learning Objective (LO):

After successful completion of this course, students should understand stellar physics, galaxy structures, and cosmology, preparing them for advanced research and Ph.D. programs in reputed institutes. They will be capable of approaching eminent scientists and research institutes with well-developed research proposals for short or long-term projects.

8.1.2 Course Outcomes (CO):-

CO No.	**Expected Course Outcomes At the end of the course, the students will be able to:**	**CL**
1	Understand stellar physics including the equations governing the structure of stars.	E
2	Analyze various models of stellar structure with linear and quadratic density profiles.	U
3	Describe the evolution of stars from birth to potential end states.	U
4	Evaluate the structure of the Milky Way and understand the necessity of multi-wavelength observations in astronomy.	An
5	Analyze active galactic nuclei, introductory cosmology, and models of the universe.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

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8.1.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	3	3	3	3	2	2	2	2	3	3	3	3	-
CO2	3	3	3	3	3	3	3	3	2	1	2	3	3	3	3	-
CO3	3	3	3	3	3	3	3	2	2	1	2	3	3	3	3	-
CO4	3	3	3	3	3	2	3	3	2	1	1	3	3	3	3	-
CO5	3	3	3	3	3	2	3	3	1	1	1	3	3	3	3	-

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

8.1.4 Detailed Syllabus: P801 : Astronomy and Astrophysics – II

Unit No.	Topics	No. of Lectures	CO No.
I	Stellar Physics: Equations governing the structure of stars: Mechanical & Thermal equilibrium.Virial theorem. Modes of energy transfer in stars: radiative & convective transport of energy. Auxiliary input: equation of state, opacity and energy generation by thermonulcear processes. Boundary conditions at the stellar surface & at the centre.The main sequence, Stellar energy sources, Gravitational potential energy of a sphere, Gravitational lifetime for a star, Other energy sources, Nuclear energy for stars, Overcoming the fusion barrier, Stellar structure, Hydrostatic equilibrium, Energy transport, Stellar models, Solar neutrinos	15	1
II	Stellar old age, Evolution off the main sequence, Low mass stars, High mass stars, Cepheid variables Variable stars, Cepheid mechanism, Period–luminosity relation, Planetary nebulae, White dwarfs, Electron degeneracy, Properties of white dwarfs, Relativistic effects	9	2
III	The death of high mass stars, Supernovae , Core evolution of high mass stars, Supernova remnants Neutron stars, Neutron degeneracy pressure , Rotation of neutron stars, Magnetic fields of neutron stars, Pulsars, Discovery of Pulsars, What are pulsars? , Period changes, Pulsars as probes of interstellar space, Stellar black holes	9	3

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Unit No.	Topics (Continued)	No. of Lectures	CO No.
IV	THE MILKY WAY - OUR GALAXY: An overview of the Milky Way, The mass of the Milky Way, The disc of the Milky Way, The stellar halo and bulge of the Milky Way, The formation and evolution of the Milky Way, NORMAL GALAXIES: The classification of galaxies, The determination of the properties of galaxies, The determination of the distances of galaxies, The formation and evolution of galaxies, ACTIVE GALAXIES: The spectra of galaxies, Types of active galaxies, The central engine, Models of active galaxies, Outstanding issues	15	4
V	Cosmology, The scale of the universe, Expansion of the universe, Olbers's paradox Keeping track of expansion, Cosmology and Newtonian gravitation, Cosmology and general relativity, Geometry of the universe, Cosmological redshift, Models of the universe, Is the universe open or closed?	12	5

8.1.5 Suggested Texts and References:

1. *Astronomy: A Physical Perspective*, Marc L. Kutner.
2. *An Introduction to Galaxies and Cosmology*, Edited by Mark H.Jones and Robert J. Lambourne, Cambridge University Press.
3. *The Internal Constitution of Stars*, A. S. Eddington, Cambridge University Press, 1988.
4. *An Introduction to the Study of Stellar Structure*, S. Chandrasekhar, Dover Publications, 2003.
5. *The Structure and Evolution of the Stars*, M. Schwarzschild, Dover Publications, 1962.
6. *Cox and Giuli's Principles of Stellar Structure*, 2nd Edition, A. Weiss et al., Cambridge, 2003.
7. *The Physical Universe: An Introduction to Astronomy*, F. H. Shu, University Science Books, 1982.
8. *Galactic Astronomy*, James Binny and Michael Merrifield, Princeton University Press, 1998.
9. *An Introduction to Active Galactic Nuclei*, B. M. Peterson, Cambridge University Press, 1997.

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8.2 P802: Fluid Mechanics

Program	Subject	Year	Semester
Int. M.Sc	Physics	4	VIII
Course Code	**Course Title**		**Course Type**
P802	**Fluid Mechanics**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
4	3	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

8.2.1 Learning Objective (LO):

In this course, students will develop an understanding of fluid mechanics concepts to the level where they can formulate and present research proposals for both short-term and long-term projects in renowned research institutes.

8.2.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand various models of stellar structure with linear and quadratic density profiles, the concept of hydrodynamics, flow fields, and basic equations governing conservation of mass, momentum, and energy in hydrodynamical systems.	U
2	Analyze equations governing viscous flow, including the concept of shear and bulk viscosity, boundary layers, potential flow, water waves, and lubrication theory of flow.	An
3	Analyze the tensor representation of the virial theorem, flow in magnetic fluids, generalized Ohm's law, and ambipolar diffusion, including magneto-gravity-acoustic modes.	An
4	Understand the stability problems in classical hydrodynamics and hydromagnetics, particularly Rayleigh-Taylor and Kelvin-Helmholtz instabilities, Jeans' gravitational instability, Benard convection, Parker instability, and magnetic buoyancy.	U
5	Evaluate concepts related to accretion flows, accretion disks, shock waves, blast waves, hydrodynamics in supernovae, and physiological hydrodynamics such as blood flow.	E

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

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8.2.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	3	2	2	3	2	1	3	3	3	3	1	3	-
CO2	3	3	3	3	3	2	3	2	3	3	3	3	3	3	3	-
CO3	3	3	3	3	3	2	3	2	1	3	3	3	3	3	3	-
CO4	3	3	3	3	3	2	3	2	2	3	3	3	3	2	3	-
CO5	3	3	3	3	2	2	3	2	2	3	3	3	3	3	3	-

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

8.2.4 Detailed Syllabus: P802 : Fluid Mechanics

Unit No.	Topics	No. of Lectures	CO No.
I	Validity of hydrodynamical description. Kinematics of the flow field. Stress-strain relationship. Basic equations governing conservation of mass, momentum, and energy.	12	1
II	Navier-Stokes equation for viscous flows. Shear and bulk viscosity and radiative diffusivity in fluids. Viscous and thermal boundary layers, potential flows, water waves. Kelvin's circulation theorem, Stokes's flow, lubrication theory.	12	2
III	Virial theorem in the tensor form. Magnetohydrodynamic flows. Generalized Ohm's law in the presence of Hall current and ambipolar diffusion, magneto-gravity-acoustic modes.	12	3
IV	Classical hydrodynamic and hydromagnetic linear stability problems: Rayleigh-Taylor and Kelvin-Helmholtz instabilities, Jeans' gravitational instability, Benard convection, Parker instability, magnetic buoyancy, thermal instability. Non-linear Benard problem.	12	4
V	Spherical accretion flows onto compact objects and accretion disks. High-speed flow of gases, shock waves, and blast waves. Supernova hydrodynamics. Physiological hydrodynamics. Blood flow in the human heart.	12	5

8.2.5 Suggested Texts and References:

1. *Hydrodynamics*, 6th Edition, H. Lamb, Dover, 1945.
2. *An Introduction to Fluid Dynamics*, G. K. Batchelor, Cambridge University Press, 2000.
3. *Fluid Mechanics*, 2nd Edition, L. D. Landau and E. M. Lifshitz, Elsevier, 1987.

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8.3 P803: Nuclear and Particle Physics

Program	Subject	Year	Semester
Int. M.Sc	Physics	4	VIII
Course Code	**Course Title**		**Course Type**
P803	**Nuclear and Particle Physics**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
4	3	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

8.3.1 Learning Objective (LO):

The aim of this course is to enable students to develop a comprehensive understanding of nuclear reactions, nuclear structure, and particle physics, including concepts like phase shifts, resonance, cross sections, and symmetries. The course will also cover fundamental forces, particle classification, and cutting-edge nuclear structure models, fostering analytical skills needed for high-energy and radioactive ion beam physics.

8.3.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand the concept of phase shifts, partial wave decomposition, cross sections, and scattering processes, including the use of optical potentials.	U
2	Analyze and derive resonance cross sections, understanding barrier penetration, resonance scattering, and the compound nucleus model.	An
3	Apply knowledge of direct reactions, high-energy scattering, and radioactive ion beam physics to real-world problems, including nuclear shell models and deformation phenomena.	U
4	Comprehend advanced nuclear structure models, including the single-particle shell model, Fermi gas model, pairing theories, and collective nuclear motion.	U
5	Develop an understanding of particle physics, including particle classification, symmetries, gauge theories, and the role of quarks, gluons, and Higgs bosons.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

8.3.3 CO-PO/PSO mapping for the course:

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PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	2	2	3	2	2	3	3	3	2	2	2	3
CO2	3	3	3	2	2	2	3	2	2	3	3	3	2	3	2	3
CO3	3	3	3	2	2	2	3	2	2	3	3	3	2	2	2	3
CO4	3	3	3	3	2	2	3	2	3	3	3	3	2	2	2	3
CO5	3	3	3	2	2	2	3	2	1	3	3	3	2	2	2	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

8.3.4 Detailed Syllabus: P803: Nuclear and Particle Physics

Unit No.	Topics	No. of Lect.	CO No.
I	Nuclear Reactions: Partial wave decomposition, phase shifts and partial wave analysis of the cross sections in terms of phase shifts. Behavior of phase shifts in different situations. Black sphere scattering. Optical theorem and reciprocity theorem. Unitarity Optical potential: Basic definition. Relation between the imaginary part, W of the OP and σ_{abs}, and between W and mean free path. Folding model and a high energy estimate of the OP	12	1
II	Catagorisation of Nuclear Reaction mechanisms: Low energies: Discrete region, Continuum Region: (a) Discrete Region: Decaying states. Relation between the width and the mean life time. Energy definition: Lorentzian or Breit- Wigner. Resonance scattering. Derivation of the resonance cross section from phase shift description of cross section. Transmission through a square well and resonances in continuum. Coulomb barrier penetration for charged particles scattering and centrifugal barrier for l non-zero states. Angular distributions of the particles in resonance scattering. Application to hydrogen burning in stars. (b) Continuum Region: Bohr's compound nucleus model.	12	2

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Unit No.	Topics (Continued)	No. of Lect.	CO No.
III	Direct Reactions: Cross section in terms of the T-matrix. Phase space, and its evaluation for simple cases. Lippmann Schwinger equation for the scattering wave function, and its formal solution. On-shell and off-shell scattering. Plane wave and distorted wave approximation to the Tmatrix(PWBA, DWBA). Application to various direct reactions like, stripping, pick-up, knockout etc.High energy scattering. Glauber theory. Eikonal approximation to the scattering wave function.Evaluation of scattering cross section in eikonal approximation. Introduction to heavyion scattering and the physics with radioactive ion beams.	12	3
IV	Nuclear Structure: Generalization of the single-particle shell model, residual interactions, Fermi gas model. Single-particle energies in a deformed potential, shell corrections and the Strutinski method. Pairing: BCS model and the Bogolyubov transformation. Hartree-Fock method: general variational approach, Hartree-Fock equations and applications. Nuclear shape parametrization, quadrupole and higher- order deformations. Collective rotation and vibration; Giant resonances. Cranking model, phenomena at high spin including superdeformation. introduction to Density- Functional Models, including relativistic mean field. Selected contemporary research topics: Superheavy nuclei; Spectroscopy of drip-line nuclei.	12	4
V	Particle Physics: Symmetries and conservation laws, conserved quantities in reactions of particles. Relativistic kinematics in particle reactions, invariants, resonances, decays of resonances and their decays etc. Particle classification, mesons and baryons, SU(3) multiplets, quark model. Quarks, gluons, QCD interaction, colour. neutrality. Detection of quarks and gluons, structure function in deep inelastic reactions. Quark and lepton families, weak interactions asguage theory, W and Z bosons. Symmetry breaking and generation of masses, Higgs bosons. Present boundary (strings, grand unification, matter- anti-matter asymmetry, dark matter and energy - seminar, qualitative)	12	5

8.3.5 Suggested Texts and References:

1. *Subatomic Physics*, by E. M. Henley & A. Garcia, World Scientific
2. *Concepts of Nuclear Physics*, by B. C. Cohen, McGraw-Hill
3. *Introduction to Nuclear and Particle Physics*, by A. Das and T. Ferbel, World Scientific
4. *Structure of the Nucleus*, by M.A. Preston and R.K. Bhaduri, Levant Books, 2008
5. *Nuclear Models*, by W. Greiner and J.A. Maruhn, Springer, 1996
6. *Nuclear Structure from a Simple Perspective*, by R. F. Casten, Oxford University Press, 1990
7. *Theory of Nuclear Structure*, by M.K. Pal, Affiliated East-West Press, 1982

8. *An Introduction to Quarks and Partons*, by F. E. Close, Academic Press 1980

9. *Quarks and Leptons: An Introductory Course in Modern Particle Physics*, by F. Halzen and A. D. Martin, John Wiley 1984

10. *Introduction to High Energy Physics*, 4th Edition, by D. Perkins, Cambridge 2000

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8.4 P804: Condensed Matter Physics - II

Program	Subject	Year	Semester
Int. M.Sc	Physics	4	VIII
Course Code	**Course Title**		**Course Type**
P804	**Condensed Matter Physics - II**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
4	3	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

8.4.1 Learning Objective (LO):

The objective of this advanced course in condensed matter physics is to enable students to:

- Understand the fundamental phenomenon that governs superconductivity, including the underlying theoretical models.
- Explore various theoretical approaches to explain different kinds of magnetic phenomena.
- Introduce and apply density functional theory in understanding peculiar physical phenomena in solids.
- Understand advanced topics such as Kondo Physics, metamaterials, and quantum cascade lasers, which have significant applications in modern condensed matter research.

8.4.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand the fundamental principles governing superconductivity, including the BCS theory, Josephson effects, and the concept of flux quantization.	U
2	Comprehend the Modified London equation and analyze interactions between flux tubes, as well as phenomena such as flux pinning and magnetization of the mixed state.	U
3	Analyze various magnetic phenomena using quantum theory, including the Heisenberg Hamiltonian, Hubbard model, and Stoner model.	An
4	Introduce and apply density functional theory, and explore special phenomena such as the quantum Hall effect, topological insulators, and unconventional superconductivity.	U

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5	Understand advanced topics in condensed matter physics such as Kondo Physics, metamaterials, photonic band gap materials, quantum cascade lasers, and organic electronics.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

8.4.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	1	2	3	2	1	3	3	3	3	2	3	3
CO2	3	3	3	2	1	2	3	2	1	3	3	3	3	2	3	3
CO3	3	3	3	2	1	2	3	2	1	3	3	3	3	2	3	1
CO4	3	3	3	2	1	2	3	2	1	3	3	3	3	2	3	1
CO5	3	3	3	2	1	2	3	2	1	3	3	3	3	2	3	1

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

8.4.4 Detailed Syllabus: P804: Condensed Matter Physics - II

Unit No.	Topics	No. of Lect.	CO No.
I	Superconductivity: Revision, Introduction to second quantization, BCS theory, Electron tunneling and energy gap, Josephson effect (AC and DC). GL theory and concept of penetration depth, coherence length and surface energy, Flux quantization	12	1
II	Modified London Equation of Mixed Phase, Interaction between Flux tubes, Flux flow, Flux pinning, Magnetization of Mixed State: Bogoliubov transformation, Boundary between normal metal and superconductor, Andreev Reflection and Proximity effect	12	2
III	Magnetism: Quantum theory of magnetism: Rationalization of the Heisenberg Hamiltonian, Hubbard model and Stoner Model: Derivation of susceptibility, Spin wave using Holstein-Primakov transformation	12	3
IV	Introduction to Density Functional Theory Introduction to Special topics: Integer and Fractional Quantum Hall effect, unconventional superconductivity, frustrated magnets, Josephson junction qubits, Graphene physics, Topological insulators	12	4

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Unit No.	Topics (Continued)	No. of Lect.	CO No.
V	Kondo Physics, Metamaterials, Physics of photonic band gap materials, quantum cascade lasers, free electron lasers, organic electronics etc	12	5

8.4.5 Suggested Texts and References:

1. *Introduction to Superconductivity*, 2nd Edition, by M. Tinkham, Dover 2004
2. *Superconductivity*, by J. B. Ketterson and S. N. Song, Cambridge 1999
3. *Basic Solid State Physics*, by A. K. Raychaudhuri
4. *Magnetism in Solids*, by D. H. Martin, Butterworth 1967
5. *Quantum theory of Magnetism*, 3rd Edition, by R. M. White, Springer 2006
6. *Electronic Structure, Basic Theory & Practical Methods*, by R. Martin, Cambridge 2008

8.5 PL801: Advanced Physics Laboratory - II

Program	Subject	Year	Semester
Int. M.Sc	Physics	4	VII
Course Code	**Course Title**		**Course Type**
PL801	**Advanced Physics Laboratory - II**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
5	-	-	10
Maximum Marks		**CIA**	**ESE**
100		60	40

8.5.1 Learning Objective (LO):

The objective of this advanced laboratory course is to enable students to gain hands-on experience and develop a deep understanding of experimental techniques in advanced astrophysics. Specifically, students will:

- Study the orbital dynamics of visual binary stars, and verify Kepler's law of planetary motion through practical observation.
- Determine the rotational velocity and mass of celestial bodies like Saturn by analyzing the differential motion of ring particles.
- Investigate proper motion in stars and evaluate properties such as pulsar periods, dispersion, and distances using radio frequency data.
- Analyze quasar properties, including redshift, recessional velocity, and magnitude, to understand their structure and emissions.
- Conduct photometry and spectroscopy to construct HR diagrams, study variable stars, and derive cosmological parameters such as Hubble's constant and age of the Universe.

8.5.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Study the orbital motion of visual binary stars such as Kruger 60 and verify Kepler's law of planetary motion. Determine the rotational velocity of Saturn and its mass by analyzing ring particle motions.	An
2	Investigate the proper motion of stars, such as 61 Cygni, and evaluate the properties of pulsars by determining their periods and distances using radio frequency pulse profiles.	An
3	Analyze quasars, including determining redshift, recessional velocity, apparent magnitude, and absolute magnitude, to gain insights into their physical properties.	An

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4	Understand and apply Hubble's law by studying galaxy cluster spectra to determine the Hubble constant and estimate the age of the Universe.	An
5	Perform photoelectric photometry of star clusters, construct HR diagrams, and analyze light curves of Cepheid variable stars to determine cosmic distances.	An

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

8.5.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	3	3	3	3	2	2	3	3	3	3	3	3	-
CO2	3	3	3	3	3	3	3	2	2	3	3	3	3	2	3	-
CO3	3	3	3	3	3	3	3	2	2	3	3	3	3	3	3	2
CO4	3	3	3	3	3	3	3	2	2	3	3	3	2	3	3	2
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	1

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

8.5.4 Detailed Syllabus: PL801: Advanced Physics Laboratory - II

Unit No.	Topics	No. of Lect.	CO No.
I	Transmission of radiation through atmosphere, introduction to Optical, Infrared, UV, X-ray and Gamma-ray astronomy, and study of astronomical parameters such as magnitude, flux, and luminosity. Measuring energy resolution (R) of a Cadmium Telluride Detector using X-rays of different energies (E) from radioactive sources and deriving expression for variation of R with E.	30	1
II	Development and use of modern imaging detectors including CCDs, bolometers, and spectrometers in observational astronomy. Solar Constant measurement. Measurement of Solar Limb Darkening.	30	2
III	Study of interaction of radiation with matter, including ionization, Compton scattering, and applications in gas-filled radiation detectors.	30	3

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Unit No.	Topics (Continued)	No. of Lect.	CO No.
IV	Scintillation detectors, photomultiplier tubes, and applications in X-ray astronomy, including studies of neutron star binaries and black hole binaries.Observing an Optical Binary Star and deriving its light curve.Determine Pulsation period and binary light curve of an accreting Neutron star from X-ray data.Measuring X-ray Energy Spectrum of a Black Hole Binary and fit it with different spectral models.	30	4
V	Thermal and non-thermal emission processes, synchrotron radiation, and cyclotron lines in strongly magnetized stars.Characteristics of a Proportional Counter and dependence of its energy resolution on different parameters of the PC.	30	5

8.5.5 Suggested Texts and References:

1. *Introduction to Astronomy and Astrophysics*, by Zeilik and Gregory, Brooks Cole
2. *Radiative Processes in Astrophysics*, by George B. Rybicki and Alan P. Lightman, Wiley-VCH
3. *Observational Astrophysics*, by Pierre Lena, Springer
4. *Astrophysical Techniques*, by C.R. Kitchin, CRC Press
5. *High-Energy Astrophysics*, by Malcolm S. Longair, Cambridge University Press

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8.6 PPr801: Project

Program	**Subject**	**Year**	**Semester**
Int. M.Sc	Physics	4	VIII
Course Code	**Course Title**		**Course Type**
PPr801	**Project**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
4	-	-	8
Maximum Marks		**CIA**	**ESE**
100		60	40

Reading project will be assigned by the supervisor.

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8.7 SEPML801: LaTeX & XFig - Typesetting Software

Program	Subject	Year	Semester
Int. M.Sc	Physics	2	VIII
Course Code	**Course Title**		**Course Type**
SEPML801	**LaTeX & XFig - Typesetting Software**		**Skill Enhancement Course**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
2	2	0	0
Maximum Marks		**CIA**	**ESE**
100		60	40

8.7.1 Learning Objective (LO):

The aim of this course is to equip students with the skills to use LaTeX and XFig for professional typesetting of documents, reports, presentations, and diagrams. Students will learn to create well-formatted technical documents, incorporating mathematical equations, tables, figures, and bibliographies, enhancing their ability to communicate scientific and technical information effectively.

8.7.2 Course Outcomes (CO):

CO No.	Expected Course Outcomes: At the end of the course, the students will be able to:	CL
1	Install and configure LaTeX and its editors, and understand the basics of document creation.	U
2	Create structured documents using LaTeX, including reports, articles, and letters with proper formatting and layout.	C
3	Typeset complex mathematical expressions, equations, and matrices, and manage numbering and referencing of equations.	Ap
4	Incorporate tables, figures, and diagrams into LaTeX documents, and create presentations using Beamer.	Ap
5	Utilize advanced LaTeX features such as custom commands, environments, style files, and typeset documents in Indic languages using XeLaTeX.	C

CL: Cognitive Levels (**R**-Remember; **U**-Understand; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

8.7.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5

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CO1	3	2	1	-	3	3	3	1	1	2	1	3	3	1	1	1
CO2	3	3	3	-	3	2	3	2	1	2	1	3	2	2	1	1
CO3	3	3	3	-	2	2	3	2	1	2	1	3	2	2	1	3
CO4	3	3	3	-	3	2	3	1	1	2	1	3	2	1	1	3
CO5	3	3	3	-	3	2	3	1	1	2	1	3	2	1	1	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

8.7.4 Detailed Syllabus: SEPML801: LaTeX & XFig - Typesetting Software

Unit No.	Topics	No. of Lect.	CO No.
I	**Introduction to LaTeX** - Installing LaTeX and using LaTeX editors. - Document classes: Report, Article, Letter. - Structure of LaTeX documents: Chapters, Sections, Subsections. - Generating Table of Contents, Lists of Figures and Tables. - Handling compilation errors and troubleshooting.	12	1,2
II	**Document Formatting and Letter Writing** - Formatting text: Fonts, Styles, Paragraphs. - Creating letters: Address formatting, dates, salutations, signatures. - Environments: Itemize, Enumerate for lists. - Page layout: Margins, headers, footers. - Including special characters and symbols.	12	2
III	**Mathematical Typesetting** - Inline and display math modes. - Greek letters and mathematical symbols. - Fractions, superscripts, subscripts. - Creating equations, matrices, and aligning equations. - Numbering and referencing equations. - Packages: amsmath, handling errors with missing packages. - Using `frac`, `dfrac`, and cases.	16	3
IV	**Graphics, Tables, and Presentations** - Inserting images and creating figures. - Creating tables: Tabular environment, formatting tables. - Using XFig for creating diagrams and importing into LaTeX. - Exporting figures with special flags, handling text in figures. - Creating presentations using Beamer. - Cropping PDFs and tools like pdfcrop and Briss.	10	4

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Unit No.	Topics (Continued)	No. of Lect.	CO No.
V	**Advanced LaTeX Features** - Custom commands: `\newcommand`, parameters, redefining commands. - Custom environments: `\newenvironment`, parameters. - Writing and importing style files. - Packages: `\RequirePackage`, `\usepackage`, package management. - Typesetting in Indic languages using XeLaTeX. - Fonts installation and usage: Fontspec, Polyglossia. - Setting default and additional languages in documents.	10	5

8.7.5 Suggested Texts and References:

1. Leslie Lamport, *LaTeX: A Document Preparation System*, Addison-Wesley, 2nd Edition.

2. Tobias Oetiker, Hubert Partl, Irene Hyna, and Elisabeth Schlegl, *The Not So Short Introduction to LaTeX2e.*

3. George Grätzer, *More Math Into LaTeX*, Springer, 5th Edition.

4. Stefan Kottwitz, *LaTeX Beginner's Guide*, Packt Publishing.

5. Helmut Kopka and Patrick W. Daly, *A Guide to LaTeX*, Addison-Wesley.

6. XFig User Manual, available online at `http://www.xfig.org/userman/`.

7. *LaTeX Tutorials: A Primer*, Indian TeX Users Group.

8. Online resources like TeX Stack Exchange for troubleshooting and community support.

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SEMESTER - IX

9.1 PPr901: Project

Program	**Subject**	**Year**	**Semester**
Int. M.Sc	Physics	5	IX
Course Code	**Course Title**		**Course Type**
PPr901	**Project**		**Core**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
20	-	-	-
Maximum Marks		**CIA**	**ESE**
400		-	400

Reading project will be assigned by the supervisor.

SEMESTER - X

10.1 PE1: Quantum Field Theory

Program	Subject	Year	Semester
Int. M.Sc	Physics	5	X
Course Code	Course Title		Course Type
PE1	Quantum Field Theory		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	4	1	0
Maximum Marks		CIA	ESE
100		60	40

10.1.1 Learning Objective (LO):

The objective of this course is to enable students to understand the fundamental principles and need for Quantum Field Theory (QFT). Specifically, students will:

- Comprehend the reasons for the failure of relativistic quantum mechanics, such as the causality problem, and the necessity for quantum field theory.
- Develop an understanding of the origin of particles and forces within the framework of quantum fields.
- Gain skills to analyze statistical distributions of identical particles and apply Feynman rules to calculate probabilities for decay and scattering processes.
- Derive classical or non-relativistic limits from fully quantum models and identify the relativistic origin of effects such as the spin-orbit interaction.
- Learn effective field theory techniques for modeling large-scale behaviors, including phenomena such as superconductivity and spontaneous symmetry breaking.

10.1.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL

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1	Understand the reasons for the failure of relativistic quantum mechanics, such as the causality problem, and the need for quantum field theory.	U
2	Describe the origin of particles and fundamental forces within the context of quantum field theory.	U
3	Apply Feynman rules to calculate probabilities for basic processes involving particles, including decay and scattering. Analyze statistical distributions of identical particles.	Ap
4	Obtain classical or non-relativistic limits of fully quantum models and identify relativistic origins of effects such as spin-orbit interaction.	E
5	Use effective field theory techniques to develop models at large scales and describe effects like superconductivity, superfluidity, and ferromagnetism via gauge invariance and spontaneous symmetry breaking.	E

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

10.1.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	2	3	3	3	2	3	3	3	3	2	2	1
CO2	3	3	3	2	3	3	3	3	2	3	3	3	3	1	2	1
CO3	3	3	3	2	3	3	3	3	2	3	3	3	3	2	2	1
CO4	3	3	3	2	3	3	3	3	2	3	3	3	3	2	2	1
CO5	3	3	3	2	2	3	3	3	2	3	3	3	3	2	3	1

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

10.1.4 Detailed Syllabus: Quantum Field Theory

Unit No.	Topics	No. of Lect.	CO No.
I	Preliminaries: Why Quantum Field Theory, Creation and annihilation operators, Special relativity, Space and time in relativistic quantum theory, natural units	15	1
	Continued on next page		

Unit No.	Topics (Continued)	No. of Lect.	CO No.
II	Canonical Quantization: General Formulation, Conjugate Momentum and Quantization, Neutral Scalar Field, Commutation Relations, Normal Ordering, Bose Symmetry, Fock Space, Charged Scalar Field, U(1) Invariance, Charge Conservation, Particles and Antiparticles, Time Ordered Product, Feynman Propagator for Scalar Fields, Bose-Einstein Distribution, Propagators at Finite Temperature	15	2
III	Dirac Field: The Dirac Equation, Relativistic Covariance, Anti-Commutators, Quantization of the Dirac Field, Electrons and Positrons, Connection between Spin and Statistics, Discrete Symmetries, Parity, Charge Conjugation, Time Reversal, CPT Theorem	15	3
IV	Gauge Field: Gauge Invariance and Gauge Fixing, Quantization of the Electromagnetic Field, Propagator, Vacuum Fluctuations	15	4
V	Interacting Theory and Elementary Processes: Wick's Theorem, Feynman Rules and Feynman Diagrams for Spinor Electrodynamics, Lowest Order Cross-Section for Electron-Electron, Electron-Positron, and Electron-Photon Scattering	15	5

10.1.5 Suggested Texts and References:

1. *Quantum Field Theory,* by C. Itzykson and J. B. Zuber, McGraw-Hill Book Co, 1985
2. *Quantum Field Theory,* by L. H. Ryder, Cambridge University Press, 2008
3. *Field Theory: A Modern Primer,* by P. Ramond, Benjamin, 1980
4. *The Quantum Theory of Fields, Vol I,* by S. Weinberg, Cambridge University Press, 1996
5. *Introduction to The Theory of Quantum Fields,* by N. N. Bogoliubov and D. V. Shirkov, Interscience, 1960
6. *An Introduction to Quantum Field Theory,* by M. E. Peskin and D. V. Schroeder, Westview Press, 1995
7. *Quantum Field Theory,* by Mandl and Shaw
8. *A First Book of Quantum Field Theory,* by Amitabha Lahiri and Palash B. Pal, Alpha Science International Ltd., 2000

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10.2 PE2: General Relativity and Cosmology

Program	Subject	Year	Semester
Int. M.Sc	Physics	5	X
Course Code	**Course Title**		**Course Type**
PE2	**General Relativity and Cosmology**		**Elective**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
5	4	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

10.2.1 Learning Objective (LO):

The objective of this course is to enable students to develop a deep understanding of the principles and implications of General Relativity and Cosmology. Specifically, students will:

- Understand the concept of spacetime and its significance in the context of Einstein's Relativity.
- Grasp the nature of gravity as the curvature of spacetime and its implications for physical phenomena.
- Analyze astrophysical results such as the precession of planetary orbits and properties of black holes.
- Learn the fundamentals of cosmology, including the expansion of the universe and the application of cosmological models.
- Comprehend the phenomena of gravitational and cosmological redshifts and their significance in understanding the universe.

10.2.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand the concept of spacetime in the context of Einstein's Relativity.	U
2	Describe gravity as the curvature of spacetime and its impact on the motion of celestial bodies.	U
3	Analyze phenomena such as the precession of planetary orbits and the properties of black holes.	An
4	Explain the fundamentals of cosmology, including the expansion of the universe and key cosmological models.	U
5	Apply concepts such as gravitational and cosmological redshifts to analyze the universe's structure and evolution.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create)

10.2.3 CO-PO/PSO mapping for the course:

PO/CO	POs										PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	3	1	3	2	2	3	2	3	1	2	2	-
CO2	3	3	3	2	3	2	3	2	2	3	2	3	2	2	2	-
CO3	3	3	3	2	3	1	3	2	2	3	2	3	2	2	2	-
CO4	3	3	3	2	3	2	3	2	1	3	2	3	2	2	2	-
CO5	3	3	3	2	3	1	2	2	1	2	2	3	2	3	2	-

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

10.2.4 Detailed Syllabus: General Relativity and Cosmology

Unit No.	Topics	No. of Lect.	CO No.
I	Review of Newtonian Mechanics. Special theory of relativity. Prelude to General relativity, historical developments, 4-Vectors and 4-tensors, examples from physics	15	1
II	Principle of Equivalence, Equations of motion, Gravitational force, Tensor Analysis in Riemannian space, Effects of Gravitation, Riemann-Christoffel curvature tensor, Ricci Tensor, Curvature Scalar, Einstein Field Equations, Experimental tests of GT, Schwarzschild Solution	15	2
III	Introduction to Cosmology, The cosmic history and inventory, The expanding Universe	15	3
IV	Friedmann Equations and Cosmological Models, The Standard cosmological model, The inflationary Universe, Big-Bang Hypothesis	15	4
V	Primordial nucleosynthesis and the thermal history of the Universe. Perturbations in an expanding Universe, Growth of perturbations, Dark Matter Halos	15	5

10.2.5 Suggested Texts and References:

1. *A First Course in General Relativity*, by B. Schutz
2. *Gravity*, by H. J. Hartle
3. *The Classical Theory of Fields*, by L. Landau and E. Lifshitz
4. *Gravitation and Cosmology*, by S. Weinberg
5. *Introducing Einstein's General Relativity*, by R. D'Inverno
6. *The Early Universe*, by E. W. Kolb and M. S. Turner

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7. *Introduction to Cosmology*, by Barbara Ryden
8. *Modern Cosmology*, by S. Dodelson
9. *Principles of Physical Cosmology*, by P. J. E. Peebles
10. *Large Scale Structure of the Universe*, by P. J. E. Peebles
11. *Structure Formation in the Universe*, by T. Padmanabhan

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10.3 PE3: Experimental Techniques

Program	Subject	Year	Semester
Int. M.Sc	Physics	5	X
Course Code	**Course Title**		**Course Type**
PE3	**Experimental Techniques**		**Elective**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
5	4	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

10.3.1 Learning Objective (LO):

The objective of this course is to provide students with comprehensive knowledge and practical understanding of experimental techniques that are crucial in physics research. Specifically, students will:

- Understand the principles of vacuum technology, including gas flow, pressure measurement, and the use of vacuum pumps.
- Develop competence in optical systems and charged particle optics, focusing on the use of electrostatic lenses and optical materials.
- Gain knowledge of the different types of detectors, including particle, ionizing radiation, and optical detectors, and their respective properties.
- Learn about particle detectors, radioactive decay, and the interactions of charged particles with matter, including the operation of ionization detectors and scintillation counters.
- Acquire skills in the basics of electronics, focusing on analog and digital integrated circuits, signal processing, and data acquisition used in experimental physics.

10.3.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand the concepts of vacuum technology, including gases, gas flow, and the mechanisms of vacuum pumps and leak detection.	U
2	Analyze optical systems and charged particle optics, including the application of electrostatic lenses and energy/mass analyzers.	An
3	Understand the different types of detectors, such as optical, photoemission, and ionizing radiation detectors, and analyze their properties and performance.	U

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4	Analyze particle detectors, radioactive decay, and the interactions of charged particles with matter, including the working of scintillation and gaseous ionization detectors.	An
5	Understand the fundamentals of electronics, including electronic noise, signal processing, and data acquisition techniques used in experimental physics.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

10.3.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	3	2	3	2	2	3	2	3	2	3	2	-
CO2	3	3	3	2	3	2	3	2	2	3	2	3	2	3	2	-
CO3	3	3	3	2	3	2	3	2	2	3	2	3	2	3	2	-
CO4	3	3	3	2	3	2	3	2	2	3	2	3	2	3	2	2
CO5	3	3	3	2	3	2	3	2	2	3	2	3	2	3	2	1

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

10.3.4 Detailed Syllabus: Experimental Techniques

Unit No.	Topics	No. of Lect.	CO No.
I	Vacuum technology: gases, gas flow, pressure and flow measurement, vacuum pumps, pumping mechanisms, ultrahigh vacuum, leak detection	15	1
II	Optical systems: optical components, optical materials, optical sources, Charge particle optics: electrostatic lenses, charged-particle sources, energy and mass analyzer	15	2
III	Detectors: optical detectors, photoemission detectors, particle and ionizing radiation detectors, signal to noise ratio detection, surface barrier detector.	15	3
IV	Particle detectors and radioactive Decay: Interactions of charged particles and photons with matter; gaseous ionization detectors, scintillation counter, solid state detectors	15	4
V	Electronics: electronic noise, survey of analog and digital I/Cs, signal processing, data acquisition and control systems, data analysis evaluation	15	5

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10.3.5 Suggested Texts and References:

1. *The Art of Measurement*, by Bernhard Kramer, VCH publication
2. *Building Scientific Apparatus*, by J. H. Moore et al.
3. *Experiments in Modern Physics, Second Edition*, by Adrian C. Melissinos, Jim Napolitano
4. *Vacuum Technology*, by A. Roth, North-Holland Publisher
5. *Charge Particle Beams*, by Stanley Humphries, John Wiley and Sons
6. *Principles of Charged Particles Acceleration*, by Stanley Humphries, John Wiley and Sons
7. *Radiation Detection and Measurements*, by G. Knoll, 3rd Edition
8. *Techniques for Nuclear and Particles Physics Experiments*, by W. R. Leo, 2nd Edition, Springer
9. *The Physics of Micro & Nanofabrication*, by Ivor Brodie and Julius J. Murray, Springer
10. *Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM*, by R. Egerton, Springer, 2005
11. *Modern Spectroscopy*, by J. M. Hollas, John Wiley, 4th Edition, 2004

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10.4 PE4: CCD Imaging and Spectroscopy

Program	Subject	Year	Semester
Int. M.Sc	Physics	5	X
Course Code	**Course Title**		**Course Type**
PE4	**CCD Imaging and Spectroscopy**		**Elective**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
5	4	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

10.4.1 Learning Objective (LO):

The objective of this course is to provide students with in-depth knowledge and hands-on skills in CCD imaging and spectroscopy, essential for modern astrophysical research. Specifically, students will:

- Gain a comprehensive understanding of CCD technology, including manufacturing, operations, and their significance in astronomical observations.
- Develop skills in characterizing charge-coupled devices and understand their applications in imaging and spectroscopy.
- Learn the methods of CCD imaging, photometry, and astrometry for precise astronomical measurements.
- Understand the working principles of CCD spectrographs and apply them in astronomical spectroscopy.
- Explore the usage of CCDs in various spectral ranges, particularly in space applications and at short wavelengths.

10.4.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand the importance of CCDs, including their manufacturing process and operations in the context of astronomical applications.	U
2	Characterize charge-coupled devices, including aspects such as quantum efficiency, charge transfer efficiency, and noise characteristics.	C
3	Apply methods of CCD imaging, photometry, and astrometry for astronomical observations and data reduction.	Ap

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4	Analyze the working principles of CCD spectrographs and perform basic astronomical spectroscopy, including data reduction techniques.	An
5	Understand the usage of CCDs in space and their behavior at short wavelengths, including their performance under radiation exposure.	An

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

10.4.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	3	3	3	3	3	2	3	2	3	3	3	3	-
CO2	3	3	3	3	3	3	3	3	2	3	2	3	3	3	3	-
CO3	3	3	3	3	3	3	3	3	2	3	2	3	3	3	3	-
CO4	3	3	3	3	3	3	3	3	2	3	2	3	3	3	3	-
CO5	3	3	3	3	3	3	3	3	2	3	2	3	3	3	3	-

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

10.4.4 Detailed Syllabus: CCD Imaging and Spectroscopy

Unit No.	Topics	No. of Lect.	CO No.
I	Introduction: Why use CCDs?, CCD manufacturing and operation, CCD operation, CCD types, CCD coatings, Analog-to-digital converters	15	1
II	Characterization of charge-coupled devices: Quantum efficiency, Charge diffusion, Charge transfer efficiency, Readout noise, Dark current, CCD pixel size, pixel binning, full well capacity, and windowing, Overscan and bias, CCD gain and dynamic range	15	2
III	CCD imaging, Photometry and astrometry: Image or plate scale, Flat fielding, Calculation of read noise and gain, Signal-to-noise ratio, Basic CCD data reduction, CCD imaging, Stellar photometry from digital images, Two-dimensional profile fitting, Difference image photometry, Aperture photometry, Absolute versus differential photometry, High speed photometry, PSF shaped photometry, Astrometry, Pixel sampling	15	3

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Unit No.	Topics (Continued)	No. of Lect.	CO No.
IV	Review of spectrographs: CCD spectrographs, CCD spectroscopy, Signal-to-noise calculations for spectroscopy, Data reduction for CCD spectroscopy, Extended object spectroscopy, Slitless spectroscopy	15	4
V	CCDs used in space and at short wavelengths: CCDs in space, Radiation damage in CCDs, CCDs in the UV and EUV (300–3000Å) spectral range, CCDs in the X-ray (< 500Å) spectral range	15	5

10.4.5 Suggested Texts and References:

1. *Handbook of CCD Astronomy, Second edition*, by S. B. Howell

2. *Stellar Magnitudes from Digital Pictures*, by Adams, M., Christian, C., Mould, J., Stryker, L.,& Tody, D., 1980, Kitt Peak National Observatory publication

3. *The Next Generation Space Telescope*, by Bely, P.-Y., Burrows, C., & Illingworth, G. (eds.), 1989, Space Telescope Science Institute publication

4. *Instrumentation for Ground Based Optical Astronomy*, by Blouke, M., Yang, F., Heidtmann, D., & Janesick, J., Springer-Verlag, p. 462

5. *New Developments in Array Technology and Applications*, by Bonanno, G., 1995, eds. A. G. D. Philip, K. A. Janes, & A. R. Upgren, Kluwer, p. 39

6. *Principles of Optics*, by Born, M. & Wolf, E., 1959, MacMillan, Chap. VIII

7. *Astronomical Techniques*, by Bowen, I. S., 1960a, ed. W. A. Hiltner, University of Chicago Press, Chap. 2

8. *The Future of Space Imaging*, by Brown, R. (ed.), 1993, Space Telescope Science Institute publication, Chap. 4

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10.5 PE5: Biophysics

Program	Subject	Year	Semester
Int. M.Sc	Physics	5	X
Course Code	**Course Title**		**Course Type**
PE5	**Biophysics**		**Elective**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
5	4	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

10.5.1 Learning Objective (LO):

The objective of this course is to enable students to understand fundamental concepts in biophysics and gain the ability to model and analyze biological systems. Specifically, students will:

- Develop proficiency in applying mathematical methods to describe biophysical processes, including differential equations and statistical methods.
- Understand the quantum mechanical principles underlying biophysical methods and their application to molecular and atomic systems in biology.
- Gain insights into computational modeling of receptor-ligand interactions and cellular signaling processes.
- Analyze stochastic simulation techniques used in biophysics, focusing on practical applications and efficiency.
- Explore advanced biophysical measurement techniques such as fluorescence spectroscopy and electrophysiological methods for studying membrane proteins.

10.5.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Apply mathematical methods to solve problems related to biophysics, including diffusion equations, random walks, and Fourier transforms.	U
2	Understand the quantum mechanical foundations of biophysical techniques and their application in analyzing biological molecules and systems.	U
3	Use computational modeling techniques to simulate receptor-ligand binding and cellular signaling, and understand the limitations of these models.	U

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4	Analyze stochastic simulation algorithms, including Gillespie's SSA and Metropolis Monte Carlo, to model biophysical processes.	U
5	Understand the principles of fluorescence spectroscopy and electrophysiological methods for probing biological systems, including ion channel behavior.	An

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

10.5.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**	**4**	**5**
CO1	3	3	3	2	2	2	3	2	2	3	2	3	2	3	2	2
CO2	3	3	3	2	2	2	3	2	2	3	2	3	2	3	2	3
CO3	3	3	3	2	3	2	3	2	2	3	3	3	3	3	2	-
CO4	3	3	3	2	3	2	3	2	1	3	3	3	3	3	2	-
CO5	3	3	3	2	3	2	3	2	1	3	3	3	3	3	2	-

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

10.5.4 Detailed Syllabus: Biophysics

Unit No.	**Topics**	**No. of Lect.**	**CO No.**
I	Mathematical Methods in Biophysics: Functions of One Variable and Ordinary Differential Equations, Functions of Several Variables: Diffusion Equation in One Dimension, Random Walks and Diffusion, Random Variables, Probability Distribution, Mean, and Variance, Diffusion Equation in Three Dimensions, Complex Numbers, Complex Variables, and Schrödinger's Equation, Solving Linear Homogeneous Differential Equations, Fourier Transforms, Nonlinear Equations: Patterns, Switches, and Oscillator.	15	1
II	Quantum Mechanics Basic to Biophysical Methods: Quantum Mechanics Postulates, One-Dimensional Problems, The Harmonic Oscillator, The Hydrogen Atom, Approximate Methods, Many Electron Atoms and Molecules, The Interaction of Matter and Light.	15	2

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Unit No.	Topics (Continued)	No. of Lect.	CO No.
III	Computational Modeling of Receptor–Ligand Binding and Cellular Signaling Processes: Differential Equation-Based Mean-Field Modeling, Application: Clustering of Receptor–Ligand Complexes, Modeling Membrane Deformation as a Result of Receptor–Ligand Binding, Limitations of Mean Field Differential Equation-Based Modeling, Master Equation: Calculating the Time Evolution of a Chemically Reacting System.	15	3
IV	Stochastic Simulation Algorithms: Stochastic Simulation Algorithm (SSA) of Gillespie, Application of the Stochastic Simulation Algorithm (SSA), Free Energy-Based Metropolis Monte Carlo Simulation, Application of Metropolis Monte Carlo Algorithm, Stochastic Simulation Algorithm with Reaction and Diffusion: Probabilistic Rate Constant–Based Method, Mapping Probabilistic and Physical Parameters, Modeling Binding between Multivalent Receptors and Ligands, Multivalent Receptor–Ligand Binding and Multi-molecule Signaling Complex Formation, Application of Stochastic Simulation Algorithm with Reaction and Diffusion, Choosing the Most Efficient Simulation Method.	15	4
V	Fluorescence Spectroscopy: Fundamental Process of Fluorescence, Fluorescence Microscopy, Types of Biological Fluorophores, Application of Fluorescence in Biophysical Research, Dynamic Processes Probed by Fluorescence. Electrophysiological Measurements of Membrane Proteins: Membrane Bioelectricity, Electrochemical Driving Force, Voltage Clamp versus Current Clamp, Principles of Silver Chloride Electrodes, Capacitive Current and Ionic Current, Gating and Permeation Functions of Ion Channels, Two-Electrode Voltage Clamp for Xenopus Oocyte Recordings, Patch-Clamp Recordings, Patch-Clamp Fluorometry.	15	5

10.5.5 Suggested Texts and References:

1. *Fundamental Concepts in Biophysics*, Thomas Jue
2. *An introduction to systems biology: design principles of biological circuits*, Alon U., Chapman & Hall, 2006
3. *Random walks in biology*, Berg HC, Princeton UP, 1993
4. *Biological physics: energy, information, and life*, Nelson P., W.H. Freeman and Company, 2004
5. *Stochastic processes in physics and chemistry*, Van Kampen NG, North Holland, 1992
6. *Principles of quantum mechanics*, Shankar R., Plenum, 1994
7. *Quantum mechanics*, Cohen-Tannoudji C, Diu B, Laloe F, Wiley, 1977
8. *Models for binding, trafficking, and signaling*, Lauffenburger DA, Linderman JJ, Oxford UP, 1993
9. *Computational cell biology*, Fall CP, Marland S, Wagner JM, Tyson JJ, eds., Springer, 2002

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10.6 PE6: Particle Physics

Program	Subject	Year	Semester
Int. M.Sc	Physics	5	X
Course Code	**Course Title**		**Course Type**
PE6	**Particle Physics**		**Elective**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
5	4	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

10.6.1 Learning Objective (LO):

The objective of this course is to equip students with foundational and advanced knowledge of particle physics, enabling them to:

- Acquire in-depth knowledge to excel in national-level exams such as CSIR/UGC NET and state-level SET/SLET examinations in Physical Sciences.
- Develop competence to pursue Ph.D. programs in leading national and international research institutes or universities.
- Gain the ability to propose and conduct independent research by approaching eminent scientists and research institutions with well-formulated research proposals.
- Achieve conceptual clarity on the fundamental topics of particle physics to be effective science educators of high caliber.

10.6.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Recognize and name the six flavors of leptons and the six flavors of quarks, and understand their roles in particle physics.	U
2	Understand that all leptons and quarks have corresponding antiparticles and describe their characteristics.	U
3	Appreciate that quarks and antiquarks combine to form baryons, antibaryons, and mesons, and explain the significance of these particles in the Standard Model.	U
4	Write balanced equations for strong interactions and understand the role of gluons in these interactions.	An
5	Write balanced equations for weak interactions, explaining the role of W and Z bosons in mediating these processes.	Ap

CL: Cognitive Levels (R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create).

10.6.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	3	2	3	2	3	3	2	3	1	3	2	3
CO2	3	3	3	2	3	3	3	2	3	3	2	3	2	3	2	3
CO3	3	3	3	2	3	3	3	2	3	3	2	3	2	3	2	3
CO4	3	3	3	2	3	3	3	2	3	3	2	3	2	3	2	3
CO5	3	3	3	2	3	3	2	2	3	3	2	3	2	3	2	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

10.6.4 Detailed Syllabus: Particle Physics

Unit No.	Topics	No. of Lect.	CO No.
I	Elementary particles, discrete symmetries and conservation laws, Symmetries and Quarks.	15	1
II	Klein-Gordon equation, concept of antiparticle, Lorentz symmetry and scalar / vector / spinor fields.	15	2
III	Dirac equation, Scattering processes of spin-1/2 particles (Feynman's rules as thumb rule for QFT course), propagators.	15	3
IV	Current-current interactions, weak interaction, Fermi theory, Gauge symmetries, spontaneous symmetry breaking, Higgs mechanism.	15	4
V	Electroweak interaction, Glashow-Salam-Weinberg model, Introduction to QCD, structure of hadrons (form factors, structure functions), parton model, Deep inelastic scattering.	15	5

10.6.5 Suggested Texts and References:

1. *Quarks and Leptons: An Introductory Course in Modern Particle Physics*, Francis Halzen, Alan D. Martin

2. *Introduction to Elementary Particles*, David Griffiths

3. *Concepts of Particle Physics, Volume I*, Kurt Gottfried and Victor F. Weisskopf, 1986, Oxford University Press

4. *Classical Electrodynamics*, second edition, J.D. Jackson, 1975, John Wiley & Sons, Inc. (chapters 11 and 12)

5. *Introduction to High Energy Physics*, fourth edition, Donald H. Perkins, 2000, Cambridge University Press

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6. *Experimental Techniques in High Energy Physics*, Thomas Ferbel (editor), 1987, Addison Wesley

7. *Gauge Theory of Elementary Particle Physics*, Ta-Pei Cheng and Ling-Fong Li, 1984, Oxford University Press

8. *Weak Interactions of Leptons and Quarks*, E.D. Commins and P.H. Bucksbaum, 1983, Cambridge University Press

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10.7 PE7: Nonlinear Dynamics and Chaos

Program	Subject	Year	Semester
Int. M.Sc	Physics	5	X
Course Code	**Course Title**		**Course Type**
PE7	**Nonlinear Dynamics and Chaos**		**Elective**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
5	4	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

10.7.1 Learning Objective (LO):

The objective of this course is to provide students with a deep understanding of nonlinear dynamical systems and chaos theory. Specifically, students will:

- Develop an understanding of the concepts and classification of dynamical systems, including phase portraits and 1-D maps.
- Gain the ability to analyze stability through eigenvalue equations, fixed points, and limit cycles.
- Understand bifurcation theory and its role in explaining complex system behaviors.
- Explore the foundational concepts of chaos, fractals, and Hamiltonian dynamics, and their applications.
- Build a conceptual foundation to become effective educators in the field of nonlinear dynamics and chaos.

10.7.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand the classification of dynamical systems, create phase portraits, and solve eigenvalue equations to study stability properties.	Ap
2	Perform stability analysis of dynamical systems, including the identification of fixed points, limit cycles, and manifolds.	An
3	Apply linearization techniques to classify fixed points, and understand manifold theorems for advanced stability analysis.	U
4	Analyze bifurcations, understand classification, and create bifurcation diagrams for different types of bifurcations.	U
5	Explore chaos theory, fractals, and Hamiltonian dynamics, with a focus on sensitivity to initial conditions and symbolic dynamics.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

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10.7.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	3	2	3	2	2	3	2	3	3	2	2	-
CO2	3	3	3	1	3	2	3	2	1	3	2	3	3	2	1	-
CO3	3	3	3	2	3	2	3	2	3	3	2	3	3	2	2	-
CO4	3	3	3	1	3	2	3	2	2	3	2	3	3	2	1	-
CO5	3	3	3	3	3	2	3	2	1	3	2	3	3	1	3	-

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

10.7.4 Detailed Syllabus: Nonlinear Dynamics and Chaos

Unit No.	Topics	No. of Lect.	CO No.
I	Dynamical Systems, phase portraits, vector fields, nullclines, flows, discrete dynamical systems, 1-d maps. Fixed points, linearization of vector fields, canonical forms, generalized eigenvectors, semisimple – nilpotent decomposition, Jordan canonical form.	15	1
II	Classification of fixed points. Hartman -Grobman theorem, homeomorphism, Stable Manifold Theorem, Centre Manifold Theorem, examples of manifolds. Index theory, Lyapunov functions and stability analysis, Limit cycles, Poincare-Benedixon Dynamical Systems, phase portraits, vector fields, nullclines, flows, discrete dynamical systems, 1-d maps, Fixed points.	15	2
III	Linearization of vector fields, canonical forms, generalized eigen vectors, semisimple-nilpotent decomposition, Jordan canonical form, classification of fixed points. Hartman-Grobman theorem, homeomorphism, Stable Manifold Theorem, Centre Manifold Theorem, examples of manifolds. Index theory, Lyapunov functions and stability analysis, Limit cycles, Poincare-Benedixon Theorem. Gronwall's inequality.	15	3
IV	The Variational Equation, exploring neighbourhoods, Lyapunov exponents, Monodromy matrix, Floquet exponents. Bifurcations: Saddle-Node, Transcritical, Pitchfork and Hopf Bifurcation. 1-d maps, linear stability of fixed points and higher order fixed points, chain rule, lyapunov exponent, bifurcation diagram, finding period-n orbits in 1-d maps. 2-d maps, Linearization, the Henon map.	15	4

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Unit No.	Topics (Continued)	No. of Lect.	CO No.
V	Poincare surface of section. Symbolic dynamics, Sensitivity to initial conditions, Chaos, Partitions, Transition matrix, Entropies, Smale Horseshoe. Invariant density, the Perron-Frobenius operator. Fractals. Hamiltonian Dynamics.	15	5

10.7.5 Suggested Texts and References:

1. *Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering*, Steven H. Strogatz

2. *Chaos: An Introduction to Dynamical Systems*, Kathleen T. Alligood, Tim D. Sauer, and James A. Yorke

3. *Differential Equations, Dynamical Systems, and an Introduction to Chaos*, Morris W. Hirsch, Stephen Smale, Robert L. Devaney

4. *Introduction to Applied Nonlinear Dynamical Systems and Chaos*, Stephen Wiggins

5. *Chaos and Fractals: New Frontiers of Science*, Heinz-Otto Peitgen, Hartmut JÃ¼rgens, Dietmar Saupe

6. *Hamiltonian Chaos and Fractional Dynamics*, George M. Zaslavsky

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10.8 PE8: Reactor Physics and Radiation Science

Program	Subject	Year	Semester
Int. M.Sc	Physics	5	X
Course Code	Course Title		Course Type
PE8	Reactor Physics and Radiation Science		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	4	1	0
Maximum Marks		CIA	ESE
100		60	40

10.8.1 Learning Objective (LO):

The objective of this course is to provide students with a comprehensive understanding of reactor physics and radiation science. Specifically, students will:

- Develop a thorough understanding of the fission process, neutron interaction with matter, neutron diffusion, and the concept of microscopic cross-section.
- Understand neutron slowing down and chain reaction processes, focusing on their application in nuclear reactors.
- Gain competence to qualify for Ph.D. programs in reputed national and international research institutes/universities.
- Be capable of approaching eminent scientists and research institutions with research proposals for both short-term and long-term projects.

10.8.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Explain the fission process and describe neutron interactions with matter.	Ap
2	Understand the concept of microscopic cross-section and diffusion of neutrons, and explain the inelastic and elastic scattering processes.	U
3	Describe the chain reaction process and neutron slowing down in various moderators, including concepts like the Four Factor formula.	Ap
4	Understand the basic principles of reactor kinetics, neutron poisons, and the control of heterogeneous reactors.	U
5	Explain reactivity coefficients, including temperature and void coefficients, and their role in reactor safety.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create)

10.8.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	3	2	2	3	2	2	3	2	3	3	1	3	2
CO2	3	3	3	3	2	2	3	2	2	3	2	3	3	1	3	2
CO3	3	3	3	2	2	2	3	2	3	3	2	3	3	1	2	2
CO4	3	3	3	2	2	2	3	2	3	3	2	3	3	1	2	-
CO5	3	3	3	2	2	2	3	2	2	3	2	3	3	1	2	-

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

10.8.4 Detailed Syllabus: Reactor Physics and Radiation Science

Unit No.	Topics	No. of Lect.	CO No.
I	Fission process: Liquid drop model, fission rate, reactor power, prompt and delayed neutrons, fission gammas, fission products energy balance, photo neutrons. Fissile, fertile, and fissionable materials. Fission product activity and decay heat after shutdown. Interaction of Neutrons with Matter: Production of neutrons and nuclear reactions with thermal and fast neutrons, transmutation.	15	1
II	Concept of microscopic cross-section: Inelastic and elastic scattering, Maxwell-Boltzmann distribution and its departure. Variation of cross-section with energy, fast, resonance, and thermal ranges. 1/v law of neutron cross-section, resonance absorption, Doppler effect. Eta vs E curve, conversion and breeding concepts, thorium utilization. Diffusion of neutrons: Fick's law and its validity, steady state neutron diffusion equation, concepts of neutron flux and current, interface conditions, diffusion coefficient, diffusion length, and extrapolation distance.	15	2
III	Chain Reaction: Four Factor formula, conceptual treatment of diffusion of one group neutrons in non-multiplying and multiplying media, infinite and effective multiplication factors, bare homogeneous reactor concepts of material and geometric buckling, sub-criticality and super-criticality conditions.	15	3
IV	Reactor Kinetics and Control: Point kinetics equation, prompt jump, prompt critical, reactivity feedbacks. Neutron poisons: Xenon and Samarium, Burnable poisons, control rods, regulating systems in reactors, and start-up and shutdown procedures.	15	4

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Unit No.	Topics (Continued)	No. of Lect.	CO No.
V	Reactor Safety and Radiation Protection: Reactivity coefficients, temperature and void coefficients, SCRAM, radiation shielding, biological effects of radiation, dosimetry, ALARA principle, reactor safety systems, and emergency preparedness.	15	5

10.8.5 Suggested Texts and References:

1. *Introduction to Nuclear Reactor Theory*, John R. Lamarsh
2. *Nuclear Reactor Physics*, Weston M. Stacey
3. *Fundamentals of Nuclear Reactor Physics*, Elmer E. Lewis
4. *Radiation Detection and Measurement*, Glenn F. Knoll
5. *The Physics of Nuclear Reactors*, Serge Marguet
6. *Basic Radiation Protection Technology*, Daniel A. Gollnick
7. *Introduction to Health Physics*, Herman Cember and Thomas E. Johnson
8. *Nuclear Reactor Analysis*, James J. Duderstadt and Louis J. Hamilton

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10.9 PE9: Accelerator Physics and Applications

Program	Subject	Year	Semester
Int. M.Sc	Physics	5	X
Course Code	**Course Title**		**Course Type**
PE9	**Accelerator Physics and Applications**		**Elective**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
5	4	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

10.9.1 Learning Objective (LO):

The objective of this course is to provide students with a detailed understanding of the principles and applications of particle accelerators. Specifically, students will:

- Understand how different particle accelerators are designed, including linear accelerators, cyclotrons, and synchrotrons.
- Analyze the possibilities and limitations of various accelerator types for high-energy physics and other applications.
- Gain competence in selecting and applying to Ph.D. programs in reputed national and international research institutes/universities.
- Develop skills necessary for conducting research in accelerator physics and presenting proposals to leading institutions.

10.9.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand the design and working principles of different types of particle accelerators, including linear accelerators, cyclotrons, and synchrotrons, as well as their possibilities and limitations.	Ap
2	Perform calculations and utilize methods for numerical simulations describing how particle beams are accelerated, focused, and measured.	U
3	Acquire knowledge of high-energy physics machines, including current studies for future linear and circular colliders.	U
4	Understand the frontier of accelerator science research, including laser- and plasma wake field acceleration, and the main applications of particle accelerators in particle physics, material science, and medical technology.	U

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5	Master the theory and techniques for numerical simulations of charged particle beams and their interactions.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

10.9.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	3	2	3	2	2	3	2	3	3	1	2	-
CO2	3	3	3	2	3	2	3	2	2	3	2	3	3	1	2	-
CO3	3	3	3	2	3	3	3	2	2	3	2	3	3	1	2	-
CO4	3	3	3	2	3	3	3	2	2	3	2	3	3	1	2	-
CO5	3	3	3	2	3	2	3	2	1	3	2	3	3	1	2	-

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

10.9.4 Detailed Syllabus: Accelerator Physics and Applications

Unit No.	Topics	No. of Lect.	CO No.
I	Transverse beam dynamics: Accelerator coordinates; Canonical transformation to accelerators coordinates; Guide field; Dipole and Quadrupole Magnets; Hills equation and solution; Twiss parameters; Matrix formulation; Dispersion; Design of lattices; Field and gradient errors; Chromaticity; sextupole magnets and dynamics aperture.	15	1
II	Longitudinal beam dynamics: Fields and forces; acceleration by time varying fields; relativistic equations; Overview of acceleration; transit time factor; main RF parameters; momentum compaction factor; transition energy; Equations related to synchrotron; synchronous particle; synchrotron oscillations; principle of phase stability; RF acceleration for synchronous and for non-synchronous particle; small amplitude oscillations; Oscillations with Hamiltonian formalism; limits of stable region; adiabatic damping.	15	2
III	Linear accelerators: Basic methods of linear acceleration; Fundamental parameters of accelerating structures; Energy gain in linear accelerating structures; Q, Shunt-impedance, transit-time factor; periodic accelerating structures; RFQs; Microwave topics for linacs; Single particle dynamics in linear accelerators; Multi-particle dynamics in linear accelerators.	15	3

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Unit No.	Topics (Continued)	No. of Lect.	CO No.
IV	Synchrotron radiation: Introduction to electromagnetic radiation; Radiation of accelerated charged particles; radiation from wigglers and undulators; Electron dynamics with radiation; Low emittance lattices; synchrotron radiation sources.	15	4
V	Free-electron lasers: Introduction; electron dynamics in the undulator; spontaneous emission; electron dynamics in the laser field; dynamics of the laser field; dimensionless equations of motion; solution in the small-signal, small-gain regime; Madey theorem; three-dimensional effects; undulators; X-ray laser. Advanced accelerator concepts: Photo injectors; laser-wake field acceleration; plasma-wake field acceleration; linear colliders; muon colliders.	15	5

10.9.5 Suggested Texts and References:

1. *An Introduction to the Physics of High-Energy Accelerators*, D. A. Edwards & M. J. Syphers
2. *An Introduction to Particle Accelerators*, Edmund Wilson
3. *Introduction to Accelerator Physics*, Arvind Jain
4. *R. F. Linear Accelerators*, T. P. Wangler
5. *Classical Electrodynamics*, 3rd Edition, J. D. Jackson, Wiley 2012

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10.10 PE10: Glimpses of Contemporary Sciences

Program	Subject	Year	Semester
Int. M.Sc	Physics	5	X
Course Code	**Course Title**		**Course Type**
PE10	**Glimpses of Contemporary Sciences**		**Elective**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
5	4	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

10.10.1 Learning Objective (LO):

The objective of this course is to provide students with conceptual clarity of advanced topics in contemporary sciences. Specifically, students will:

- Develop a strong foundation to potentially become science teachers of high caliber.
- Gain insights into the intersection of physics with various life systems and other fields, such as astrochemistry and astrobiology.
- Understand and apply knowledge of complex systems, quantum mechanics, and astrophysical phenomena to model and analyze real-world problems.

10.10.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Explain how physics can be used to increase understanding of various life systems in nature.	U
2	Model thermodynamics and human population dynamics, as well as natural phenomena such as falling leaves and smoke rings.	U
3	Analyze studies conducted in the fields of astrochemistry and astrobiology, including their significance and applications.	Ap
4	Understand the process of bringing atoms to rest, laser tweezers, and their applications in modern physics.	U
5	Describe fundamental concepts of quantum mechanics and atomic interactions, including entanglement, light-atom interaction, and quantum computing.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

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10.10.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	2	2	3	2	3	3	2	3	2	1	2	-
CO2	3	3	3	2	2	2	3	2	3	3	2	3	3	1	2	-
CO3	3	3	3	2	2	2	3	2	3	3	2	3	1	1	2	-
CO4	3	3	3	2	2	2	3	2	3	3	2	3	3	1	2	-
CO5	3	3	3	2	2	2	3	2	3	3	2	3	3	1	2	-

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

10.10.4 Detailed Syllabus: Glimpses of Contemporary Sciences

Unit No.	Topics	No. of Lect.	CO No.
I	Physics in life systems: size and scale, diffusion, cell locomotion, force generated by acting growth and flagellum rotatory motion, ion channels, resting potential across the membrane, nerve conduction velocity, action potential, macro molecules of life, random walk model of polymer, single molecular experiments, optical tweezers, magnetic tweezers	15	1
II	Complex systems: dynamical chaos, logistic map, bifurcation, Universality, Feigenbaum constants, Mechanical demonstrations of chaos, Nano mechanical oscillators, Patterns, Reaction-diffusion systems, Nodal patterns, thermodynamics and human population, Falling leaves, Smoke ring physics.	15	2
III	At the turn of 1900: Silver threads, Discovery of the electron, Rutherford's nuclear atom, Wien's law, Black body radiation and Max Planck's action	15	3
IV	Astrophysics, Astrochemistry and Astrobiology	15	4
V	Quantum mechanics, atoms: Entanglement, Light-atom interaction, Bringing atoms to rest, Laser tweezers, How bright is laser, Quantum computing.	15	5

10.10.5 Suggested Texts and References:

1. *Modern Physics*, Kenneth S. Krane
2. *Introduction to Quantum Mechanics*, David J. Griffiths
3. *The Feynman Lectures on Physics*, Richard P. Feynman, Robert B. Leighton, and Matthew Sands
4. *Chaos: An Introduction to Dynamical Systems*, Kathleen Alligood and Tim Sauer
5. *Astrochemistry: From Astronomy to Astrobiology*, Andrew M. Shaw

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6. *Introduction to Astrobiology*, David A. Rothery, Iain Gilmour, and Mark A. Sephton
7. *Quantum Computing: A Gentle Introduction*, Eleanor G. Rieffel and Wolfgang H. Polak

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10.11 PE11: Earth Science and Energy & Environmental Sciences

Program	Subject	Year	Semester
Int. M.Sc	Physics	5	X
Course Code	**Course Title**		**Course Type**
PE11	**Earth Science and Energy & Environmental Sciences**		**Elective**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
5	4	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

10.11.1 Learning Objective (LO):

The objective of this course is to provide students with an in-depth understanding of Earth Science, Energy, and Environmental Sciences, preparing them to:

- Approach eminent scientists and research institutes with well-formulated research proposals to carry out short-term or long-term projects.
- Gain conceptual clarity of topics in Earth Science and Environmental Sciences to potentially become highly competent science educators.
- Understand the intersection of geophysics, environmental science, and energy, enabling them to contribute to sustainable development initiatives.

10.11.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand theories regarding the origin of Earth, the structure of different layers, plate tectonics, geodynamics, and the role of mantle plumes in sustaining these processes.	Ap
2	Analyze electrical and magnetic properties of different layers of the Earth, including geodynamo and the internal magnetic field of the Earth.	An
3	Explain natural calamities, hazards, and the impact of human activities on the environment, focusing on sustainability.	Ap
4	Understand the concept of sustainability and individual as well as societal actions for a sustainable future.	U
5	Describe the evolution of energy sources, power production, nuclear energy, and India's energy scenario.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

10.11.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	2	2	3	2	2	3	2	3	3	1	2	-
CO2	3	3	3	2	2	2	3	2	2	3	2	3	3	1	2	-
CO3	3	3	3	2	2	2	3	2	2	3	2	3	3	1	2	-
CO4	3	3	3	2	2	2	3	2	2	3	2	3	3	1	2	-
CO5	3	3	3	2	2	2	3	2	2	3	2	3	3	1	2	-

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

10.11.4 Detailed Syllabus: Earth Science and Energy & Environmental Sciences

Unit No.	Topics	No. of Lect.	CO No.
I	Earth Science: Origin of the earth, type of rocks in different layers, their physical and chemical properties, mechanism of their formation and destruction. Radioactivity and its role in geochronology, Plate tectonics and geodynamics and the role of mantle plumes in sustaining these processes.	15	1
II	Gravity, electrical and magnetic properties of the different layers in the earth. Their variations in different geological terrains. Instrumentation, field procedures used in these studies. Response of the earth to the elastic (Seismic) and electromagnetic waves, use of this phenomenon to study the earth's interior.	15	2
III	Geodynamo and the internal magnetic field of the earth. Paleomagnetic studies, Polar wandering and reversal, possible theoretical arguments for understanding the phenomena. Seismology and its use in understanding of the different layers in the earth's interior. Utility of the different geophysical techniques (discussed above) in exploration for academic as well as for harnessing resources.	15	3

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Unit No.	Topics (Continued)	No. of Lect.	CO No.
IV	Energy and Environmental Sciences: Introduction to Environmental Science. Natural Environments: Ecosystems and ecology, biodiversity. Socio-cultural environments: demography, population density, human organizations. Land use and its planning. Global climate change and effects on environment. Carbon cycle from human activity, calculation of carbon budgets. Water harvesting, storage and treatment. Natural calamities, hazards, and effects of human activity: Chemical and other technological hazards. Various case studies of natural calamities and human-induced disasters. Causes, effects, forecasting, preparedness, planning measures, technological solutions, social interventions. Concept of sustainability, individual and social, and local and global actions for a sustainable future.	15	4
V	Introduction to energy Sources- evolution of energy sources with time. Power production, per capita consumption in the world, and relation to development index. Energy scenario in India: Various issues related to consumption and demands-energy crisis issues in India. Renewable and non-renewable energy sources- technology and commercialization of energy sources, local (decentralized) versus centralized energy production, constraints and opportunities of renewable energy (hydrocarbon and coal based energy sources). Energy conservation– calculation of energy requirements for typical and home and industrial applications. Alternative to fossil fuels-solar, wind, tidal, geothermal. Bio-based fuels. Hydrogen as a fuel. Energy transport and storages ,comparison of energy sources- passage from source to delivery (source, production, transport, delivery)- efficiencies, losses and wastes. Nuclear energy: Power production: Components of a reactor and its working, types of reactors and comparison. India's three stage nuclear program. Nuclear fuel cycle. Thorium based reactors. Regulations on nuclear energy.	15	5

10.11.5 Suggested Texts and References:

1. *The Magnetic Field of the Earth*, R.T. Merill, M.W. McElhinny, P. L. McFadden. International Geophysical Series.

2. *Earth Science*, Edward J. Tarbuck, F.K. Lutgens.

3. *Introduction to Applied Geophysics: Exploring the Shallow Subsurface*, H.R. Burger, A.F. Sheehan, C.H.

4. *Mantle Plumes and Their Record in Earth History*, K.C. Condie, Cambridge University Press, 2001.

5. *Applied Geophysics (Paperback)*, W.M. Telford, Robert E. Sheriff, L.P. Geldart.

6. *Energy in Perspective*, J.B. Marion, Academic Press, 1974.

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7. *Energy and Environment*, R.A. Ristinen, J.J. Kraushaar, 2nd Edition, John Wiley and Sons, Inc., 2006.

8. *Renewable Energy*, Boyle Godfrey, Oxford University Press, 2004.

9. *Environment, Problems and Solutions*, D.K. Asthana, Meera Asthana, S. Chand and Co., 2006.

10. *Textbook on Environmental Chemistry*, Balaram Pani, I.K. International Publishing House, 2007.

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10.12 PE12: Circuits and Electronics

Program	Subject	Year	Semester
Int. M.Sc	Physics	5	X
Course Code	**Course Title**		**Course Type**
PE12	**Circuits and Electronics**		**Elective**
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
5	4	1	0
Maximum Marks		**CIA**	**ESE**
100		60	40

10.12.1 Learning Objective (LO):

The objective of this course is to develop students' understanding of basic electronics principles, focusing on the mathematical representation of circuit behavior and the corresponding real-life effects. Specifically, students will:

- Acquire knowledge and problem-solving skills needed to pass National level CSIR/UGC NET and State level SET/SLET examinations in Physical Science.
- Develop competence in applying electronics concepts, enabling them to pursue Ph.D. programs in reputed national and international research institutes/universities.
- Appreciate the practical significance of electronic systems and understand their impact in both academic and applied settings.

10.12.2 Course Outcomes (CO):-

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand the concepts of employing simple models to represent non-linear and active elements such as the MOSFET in circuits. Build circuits and take measurements of circuit variables using tools such as oscilloscopes, multimeters, and signal generators. Compare the measurements with the behavior predicted by mathematical models and explain discrepancies.	U
2	Understand the relationship between the mathematical representation of circuit behavior and corresponding real-life effects. Appreciate the practical significance of the systems developed in the course.	U
3	Determine in the laboratory the time-domain and frequency-domain behavior of an RLC circuit. Use operational amplifier models in circuits which employ negative feedback. Use complex impedances to determine the frequency response of circuits.	An

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4	Determine the power dissipation in digital gates and employ CMOS technology to reduce static power losses. Predict how a given circuit will affect an audio signal in the laboratory given the frequency response of the circuit.	An
5	Design, build, and test an audio playback system which includes both analog and digital components.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; Ap-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

10.12.3 CO-PO/PSO mapping for the course:

PO/CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	2	2	3	2	2	3	2	3	3	3	2	3
CO2	3	3	3	2	2	2	3	2	2	3	2	3	3	3	2	3
CO3	3	3	3	2	2	2	3	2	2	3	2	3	3	3	2	3
CO4	3	3	3	2	2	2	3	2	1	3	2	3	3	3	2	3
CO5	3	3	3	2	2	2	3	2	1	3	2	3	3	3	2	3

"3" = Strong; "2" = Moderate; "1" = Low; "-" = No Correlation

10.12.4 Detailed Syllabus: Circuits and Electronics

Unit No.	Topics	No. of Lect.	CO No.
I	Analysis of Nonlinear Circuits: Introduction to Nonlinear Elements, Analytical Solutions, Graphical Analysis, Piecewise Linear Analysis, Improved Piecewise Linear Models for Nonlinear Elements, Incremental Analysis The Digital Abstraction: Voltage Levels and the Static Discipline, Boolean Logic, Combinational Gates, Standard Sum-of-Products Representation, Simplifying Logic Expressions, Number Representation	15	1

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Unit No.	Topics (Continued)	No. of Lect.	CO No.
II	The MOSFET Switch: The Switch, Logic Functions Using Switches, The MOSFET Device and Its S Model, MOSFET Switch Implementation of Logic Gates, Static Analysis Using the S Model, The SR Model of the MOSFET, Physical Structure of the MOSFET, Static Analysis Using the SR Model, Static Analysis of the NAND Gate Using the SR Model, Signal Restoration, Gain, and Nonlinearity, Signal Restoration and Gain, Signal Restoration and Nonlinearity, Buffer Transfer Characteristics and the Static Discipline, Inverter Transfer Characteristics and the Static Discipline, Power Consumption in Logic Gates, Active Pull-ups The MOSFET Amplifier : Signal Amplification, Review of Dependent Sources, Actual MOSFET Characteristics, The Switch-Current Source (SCS) MOSFET Model, The MOSFET Amplifier, Biasing the MOSFET Amplifier, The Amplifier Abstraction and the Saturation Discipline, Large-Signal Analysis of the MOSFET Amplifier, v_{IN} Versus v_{OUT} in the Saturation Region, Valid Input and Output Voltage Ranges, Alternative Method for Valid Input and Output Voltage Ranges, Operating Point Selection, Switch Unified (SU) MOSFET Model The Small-Signal Model: Overview of the Nonlinear MOSFET Amplifier, The Small-Signal Model, Small-Signal Circuit Representation, Small-Signal Circuit for the MOSFET Amplifier, Selecting an Operating Point, Input and Output Resistance, Current and Power Gain.	15	2

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Unit No.	Topics (Continued)	No. of Lect.	CO No.
III	Energy Storage Elements: Constitutive Laws, Capacitors, Inductors, Series and Parallel Connections, Capacitors, Inductors, MOSFET Gate Capacitance, Wiring Loop Inductance, IC Wiring Capacitance and Inductance, Transformers, Sinusoidal Inputs, Step Inputs, Impulse Inputs, Role Reversal, Energy, Charge, and Flux Conservation. First-Order Transients in Linear Electrical Networks, Analysis of RC Circuits: Parallel RC Circuit, Step Input; RC Discharge Transient; Series RC Circuit, Step Input; Series RC Circuit, Square-Wave Input; Analysis of RL Circuits: Series RL Circuit, Step Input; Intuitive Analysis, Propagation Delay and the Digital Abstraction, Definitions of Propagation Delays, Computing t_{pd} from the SRC MOSFET Model, State and State Variables, The Concept of State, Computer Analysis Using the State Equation, Zero-Input and Zero-State Response, Solution by Integrating Factors, Effect of Wire Inductance in Digital Circuits, Ramp Inputs and Linearity, Response of an RC Circuit to Short Pulses and the Impulse Response, Intuitive Method for the Impulse Response, Clock Signals and Clock Fanout, RC Response to Decaying Exponential, Series RL Circuit with Sine-Wave Input, Digital Memory, The Concept of Digital State, An Abstract Digital Memory Element, Design of the Digital Memory Element, A Static Memory Element. Energy and Power in Digital Circuits: Power and Energy Relations for a Simple RC Circuit, Average Power in an RC Circuit and energy dissipation, Power Dissipation in Logic Gates, Static Power Dissipation, Total Power Dissipation, NMOS Logic, CMOS Logic, CMOS Logic Gate Design.	15	3

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Unit No.	Topics (Continued)	No. of Lect.	CO No.
IV	Transients in Second-Order Circuits: Undriven LC Circuit, Undriven, Series RLC Circuit, Under-Damped Dynamics, Over-Damped Dynamics, Critically-Damped Dynamics, Stored Energy in Transient, Series RLC Circuit, Undriven, Parallel RLC Circuit, Under-Damped Dynamics, Over-Damped Dynamics, Critically-Damped Dynamics, Driven, Series RLC Circuit, Step Response, Impulse Response, Driven, Parallel RLC Circuit, Step Response, Impulse Response, Intuitive Analysis of Second-Order Circuits, Two-Capacitor or Two-Inductor Circuits, State-Variable Method, State-Space Analysis, Numerical Solution, Higher-Order Circuits Sinusoidal Steady State: Impedance and Frequency Response, Analysis Using Complex Exponential Drive, Homogeneous Solution, Particular Solution, Complete Solution, Sinusoidal Steady-State Response, The Boxes: Impedance and its examples. Frequency Response: Magnitude and Phase versus Frequency, Frequency Response of Capacitors, Inductors, and Resistors; Intuitively Sketching the Frequency Response of RC and RL Circuits; The Bode Plot: Sketching the Frequency Response of General Functions; Filters, Filter Design Example: Crossover Network, Decoupling Amplifier Stages, Time Domain versus Frequency Domain Analysis using Voltage-Divider Example, Frequency Domain Analysis,Time Domain Analysis, Comparing Time Domain and Frequency Domain Analyses, Power and Energy in an Impedance, Arbitrary Impedance, Pure Resistance, Pure Reactance, Power in an RC Circuit Sinusoidal Steady State: Resonance, Parallel RLC, Sinusoidal Response; Homogeneous Solution, Particular Solution, Total Solution for the Parallel RLC Circuit, Frequency Response for Resonant Systems, The Resonant Region of the Frequency Response, Series RLC, The Bode Plot for Resonant Functions, Band-pass Filter, Low-pass Filter, High-pass Filter, Notch Filter, Stored Energy in a Resonant Circuit.	15	4

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Unit No.	Topics (Continued)	No. of Lect.	CO No.
V	The Operational Amplifier Abstraction: Historical Perspective, Device Properties of the Operational Amplifier, The Op Amp Model, Simple Op Amp Circuits, The Non-Inverting Op Amp, The Inverting Connection, Sensitivity, A Special Case: The Voltage Follower, An Additional Constraint: $v^{+} - v^{-} \cong 0$, Input and Output Resistances, Output Resistance, Inverting Op Amp, Input Resistance, Inverting Connection, Input and Output R For Non-Inverting Op Amp, Generalization on Input Resistance, Op Amp Current Source, Adder, Subtracter, Op Amp RC Circuits,, Op Amp Integrator, Op Amp Differentiator, An RC Active Filter, The RC Active Filter Impedance Analysis, Sallen-Key Filter, Op Amp in Saturation, Op Amp Integrator in Saturation, Positive Feedback, RC Oscillator, Two-Ports. Diodes, Semiconductor Diode Characteristics, Analysis of Diode Circuits, Method of Assumed States, Nonlinear Analysis with RL and RC, Peak Detector, Clamping Circuit, A Switched Power Supply using a Diode, Clipping Circuit, Exponentiation Circuit, Limiter, Full-Wave Diode Bridge, Zener-Diode Regulator, Diode Attenuator	15	5

10.12.5 Suggested Texts and References:

1. *Microelectronic Circuits*, Adel S. Sedra, Kenneth C. Smith, Oxford University Press.

2. *Electronic Devices and Circuit Theory*, Robert L. Boylestad, Louis Nashelsky, Pearson Education.

3. *Integrated Electronics*, Jacob Millman, Christos C. Halkias, Tata McGraw-Hill.

4. *Digital Design*, M. Morris Mano, Michael D. Ciletti, Pearson Education.

5. *Power Electronics: Circuits, Devices, and Applications*, Muhammad H. Rashid, Pearson Education.

6. *Operational Amplifiers and Linear Integrated Circuits*, David A. Bell, Oxford University Press.

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