Syllabus

for

Four Year Under Graduate Program (FYUGP)

(Batch 2024 and onwards)

in

Physics

Under

National Education Policy-2020

Department of Physics
Islamic University of Science and Technology
Awantipora, Pulwama -192122

Approved in Board of Studies (BoS) Meeting held on 30-09-2025

Outline of the Program

The proposal for the initiation of a Four-Year Undergraduate Program (FYUGP) in Physics at the Islamic University of Science and Technology, Awantipora in compliance with the National Education Policy 2020 reflects a commendable commitment to academic excellence and the advancement of knowledge. This program, carefully crafted to provide students with a robust foundation in theoretical and experimental physics, aligns with the university's dedication to expanding educational offerings and empowering the next generation of knowledge seekers.

The program's emphasis on interdisciplinary exploration is particularly noteworthy, as it encourages students to explore the connections between physics and other fields such as computer science, quantum computation/information, and material science. This interdisciplinary approach not only broadens students' perspectives but also equips them with the skills necessary to tackle complex real-world challenges that often require a multidisciplinary approach.

Furthermore, the inclusion of skill-based courses, in accordance with the objectives of the National Education Policy 2020, ensures the holistic development of students and enhances their employability in a variety of sectors. The program's curriculum, comprising of Major Courses (MJ), Interdisciplinary Minor Courses (MN), Multidisciplinary Courses (MD), Skill Enhancement Courses (SEC), and Ability Enhancement Courses (AEC), is designed to provide students with a comprehensive education that encompasses both theoretical knowledge and practical skills.

The commitment of the faculty members, described as young, dynamic, and research-oriented, is instrumental in guiding students through their academic journey and nurturing their scientific curiosity and critical thinking skills. The combination of classroom teaching, laboratory work, and hands-on research experiences ensures that students graduate with analytical thinking, mathematical proficiency, problem-solving capabilities, and a deep understanding of natural phenomena.

The program's emphasis on preparing students for diverse career paths, including research and development in industrial sectors, academia, data science, engineering, and finance, as well as advanced studies in physics or related disciplines, underscores its relevance and potential impact. Overall, the proposed FYUGP in Physics at the Islamic University of Science and Technology holds great promise in shaping the next generation of physicists and contributing to the advancement of knowledge and innovation.

Intake, Eligibility and Fee Structure:

Initially, the intake capacity of the program will be 22

15 (General)+5 (Payment) +2 (Sponsored quota)

Eligibility

A student, who has passed the higher secondary examination with at least 55% marks with physics as subject from JKBOSE or from any other recognized board, will be eligible for admission to the program. The admission to the program will on the basis of CUET score merit.

Fee Structure

15,000/-INR per semester

50000/- INR for self finance seat

100000/-INR for sponsored seat

Pedagogy

The pedagogy of teaching physics will focus on fostering critical thinking, active engagement of students, conceptual understanding, problem solving, and application of physics principles in real world context. The course will be taught using a combination of classroom teaching, hands on experiments, group discussions, problem solving activities, interactive demonstrations, and research-oriented project work. Emphasis will be laid on the use of computer simulations, virtual laboratories, interactive multimedia, and online resources like Swayam, NPTEL etc to supplement classroom instructions. The teachers will adopt interdisciplinary approach by connecting physics principles to everyday experiences, engineering applications, technological advancement, and societal issues to demonstrate practicality and significance of subject. More importantly the pedagogy will focus on enthusing the students to follow the most recent advances in the field like quantum computation, bio-physics etc and choose research as a career option in these fields.

It is worthwhile mentioning that a robust system of advising of mentee by a mentor is in place in the department to help students overcome any problem/ shortcoming in studies or otherwise. Regular mentee-mentor meetings are held to notice the progress of the mentee. Appropriate counseling is given to students and they are treated with compassion and empathy whenever required.

Assessment:

Regular assessment plays a crucial role in monitoring student progress and identifying areas that require additional support. As already indicated, students will be evaluated through a combination of written examinations, practical exercises, quizzes, presentations, and assignments. The assessments will be designed in a way that they measure the student's understanding of the subject matter and their ability to apply the concepts to practical situations. The aim of the course is to base the learning around the concept of Student-Centered Learning. Focus will be on the needs and interests of individual students, allowing them to learn at their own pace and in their own way. Teachers can personalize the learning experience by providing students with choices, opportunities for self-reflection, and feedback.

Course Structure:

The undergraduate program will be a four-year degree with multiple entry and exit points as per NEP 2020. The multiple entry and exit points are as given in the table below:

S.No.	Course	Credits
1.	Certificate	42+ 4 Credits
2.	UG Diploma	83+4 Credits
3.	3-year UG Degree	125 Credits
4.	4-year UG Hons.	167 Credits
5.	4-year UG Hons. with Research	167 Credits

Multiple Entry Exit System (MEES):

As the program offers multiple entry exit system (MEES), the below strategy explains it:

1. **1stYear:**
   a. **Entry:** Any student who has passed the higher secondary examination with at least 55% marks will be eligible for the program.
   b. **Exit:** After successful completion of two semesters, a student can exit and shall qualify for an undergraduate certificate. However, he/she needs to qualify an additional 4-credit vocational course/internship/Community Engagement.
2. **2nd Year:**
   a. **Entry:** All the students who have obtained undergraduate certificate after completing the first year (two semesters) of the undergraduate programme are eligible for the entry to the 2nd year of the programme.
   b. **Exit:** After completion of four semesters, a student can exit and shall qualify for award of UG Diploma. However, he/she needs to qualify an additional 4-credit vocational course/internship/Community Engagement.

3. **3^{rd} Year:**

   a. **Entry:** The entry requirement for 3^{rd} year is a diploma obtained after completing two years (four semesters) of the undergraduate programme.

   b. **Exit:** After completion of six semesters, a student can exit and shall qualify for award of an UG Degree (3 Year) in Physics.

If a student scores a CGPA of 7.5 or higher, he/she shall become eligible for 4-year UG Hons with Research.

4. **4^{th}Year with Hons/Research:**

   a. **Entry:** An individual seeking admission to a Bachelor's degree (Hons/Research) in physics is required to have completed all requirements of the relevant three-year bachelor degree.

   b. **Exit-I:** After completion of eight Semesters, a student shall qualify for award of UG Hons Degree (4 Year) in Physics.

   Exit-II: After completion of eight Semesters with a 12 credit Research Project in Physics, the student shall qualify for the award of UG Hons Degree (4 Year) with Research in Physics.

Course Code fixation for FYUGP:

The following code system (5 characters) is adopted for FYUGP course in Physics.

ABC – Code of the Department which is offering the Course.

X – Specification of that Course

Y - Course Type

Example: PHY – 100 – MJ

Types of Courses included in the proposed draft

Major Courses: MJ
Minor Courses: MN
Multi-Disciplinary Courses: MD
Ability Enhancement Course: AE
Skill Enhancement Course: SE
Value Added Course: VA

Program Objectives (POs)

The program aims to:

- Provide students with a strong foundation in Physics thorough understanding of fundamental principles of physics and their applications across natural sciences, technology, and interdisciplinary domains.
- Encourage skill development by equipping students with experimental, computational, and analytical skills required for solving complex physical problems and for applications in research, industry, and emerging technologies.
- Cultivate a research mindset and innovation by involving students in projects, internships, and hands-on laboratory experiences.
- Promote interdisciplinary integration by connections of physics with mathematics, computer science, engineering, material sciences, life sciences, and other disciplines to address real-world challenges.
- Enable students to apply physics knowledge for sustainable development, renewable energy, healthcare, space sciences, and technological solutions aligned with national priorities.
- Inculcate scientific temper, ethical responsibility, teamwork, and lifelong learning in line with the holistic vision of NEP 2020.
- Prepare students for diverse career opportunities in academia, research, industry, teaching, civil services, and entrepreneurship.

Program Learning Outcomes (PLOs)

By the end of the program, Students will be able to:

- Demonstrate comprehensive understanding of core areas of physics including mechanics, electromagnetism, thermodynamics, quantum mechanics, statistical mechanics, Nuclear physics, solid state physics, modern Physics and electronics.
- Demonstrate computational, analytical and soft skills in solving the complex problems in various fields of physics.
- Apply critical thinking and mathematical tools to model, analyze, and solve physical problems in theoretical and practical contexts.
- Design and perform physics experiments, analyze data using modern instruments/software, and interpret results with scientific accuracy.
- Use programming languages, simulation tools, and computational techniques for solving physics-related problems.
- Formulate research questions, conduct mini-projects or dissertations, and develop innovative solutions with societal/industrial applications.
- Integrate knowledge of physics with other disciplines (chemistry, biology, computer science, environmental science, materials science) to address complex challenges.
- Present scientific ideas clearly in written, oral, and digital formats to both scientific and non-scientific communities.
- Work effectively in diverse teams, demonstrate leadership qualities, and contribute to collaborative scientific projects.
- Pursue higher education, research, or professional careers while adapting to new technologies and emerging fields of physics.

Course Structure, credit and marks distribution

SEMESTER I

Course Type	Course Code	Course Title	Credit Distribution				Marks Distribution			Total Credits
			L	T	P	Total	Int.	Ext.	Total	
Major 1	PHY-100-MJ	Fundamentals of Physics I	3	0	1	04	30+ 20*	50	100	21
Minor 1 (Choose One)	To be chosen from the Basket of Minor courses offered by SoS		3	1	0	04	30+ 20*	50	100	
Multidisciplinary (Choose One)	To be chosen from the Basket of Multidisciplinary courses offered by departments of university		2	1	0	03	30+20*	50	100	
Ability Enhancement Course (AEC) 1	DOELL-100-AE	Communication Skills	2	1	0	03	30+20*	50	100	
Skill Enhancement Course (SEC) (Choose One) 1	To be chosen from the Basket of SE courses offered by departments of university		2	1	0	03	30+20*	50	100	
Value Added Course (VAC) 1	DOCS-101-VA	Digital and Technological Solutions	2	0	0	02	15 + 10*	25	50	
Value Added Course (VAC) 2	DOPE-100-VA	Health and Wellness	2	0	0	02	15 + 10*	25	50	

* Assignment/Attendance

No. of Major Courses to be opted= 01 (04 Credits)

No. of Minor Courses to be opted= 01 (04 Credits)

No. of Multidisciplinary Courses to be opted = 01(03 Credits).

No. of Ability Enhancement Courses to be opted = 01 (03 Credits).

No. of Skill Enhancement Courses to be opted = 01 (03 Credits).

No. of Value-Added Courses to be opted = 02 of 2 credit each (04 Credits).

Total No. of credits = 21

SEMESTER II

Course Type	Course Code	Course Title	Credit Distribution				Marks Distribution			Total Credits
			L	T	P	Total	Int.	Ext.	Total	
Major 2	PHY-150-MJ	Fundamentals of Physics II	3	0	1	04	30+ 20*	50	100	21
Minor 2 (Choose One)	To be chosen from the Basket of Minor courses offered by SoS		3	1	0	04	30+ 20*	50	100	
Multidisciplinary (Choose One)	To be chosen from the Basket of Multidisciplinary courses offered by departments of university		2	1	0	03	30+ 20*	50	100	
Ability Enhancement Course (AEC) 2	DELL-201-AE	Modern Indian Language (MIL)	2	1	0	03	30+ 20*	50	100	
Skill Enhancement Course (SEC) (Choose One) 2	To be chosen from the Basket of SE courses offered by departments of university		2	1	0	03	30+ 20*	50	100	
Value Added Course (VAC) 3	CIR-150-VA	Understanding India	2	0	0	02	15 + 10*	25	50	
Value Added Course (VAC) 4		Environmental Science	2	0	0	02	15 + 10*	25	50	

* Assignment/Attendance

No. of Major Courses to be opted= 01 (04 Credits)

No. of Minor Courses to be opted= 01 (04 Credits)

No. of Multidisciplinary Courses to be opted = 01 (03 Credits).

No. of Ability Enhancement Courses to be opted = 01 (03 Credits).

No. of Skill Enhancement Courses to be opted = 01 (03 Credits).

No. of Value-Added Courses to be opted = 02 of 2 credits each (04 Credits).

Total No. of credits = 21

SEMESTER III

Course Type	Course Code	Course Title	Credit Distribution				Marks Distribution			Total Credits
			L	T	P	Total	Int.	Ext.	Total	
Major 3	PHY-200-MJ	Waves and Oscillations	3	1	0	04	30+ 20*	50	100	21
Major 4	PHY-201-MJ	Basic Electronics	3	0	1	04	30+ 20*	50	100	
Minor 3 (Choose One)	To be chosen from the Basket of Minor courses offered by SoS		3	1	0	04	30+ 20*	50	100	
Multidisciplinary (Choose One)	To be chosen from the Basket of Multidisciplinary courses offered by departments of university		2	1	0	03	30+ 20*	50	100	
Ability Enhancement Course (AEC) 3			2	1	0	03	30+ 20*	50	100	
Skill Enhancement Course (SEC) (Choose One) 3	To be chosen from the Basket of SE courses offered by departments of university		2	1	0	03	30+ 20*	50	100	

* Assignment/Attendance

No. of Major Courses to be opted= 02 of 4 credits each (08 Credits)

No. of Minor Courses to be opted= 01 (04 Credits)

No. of Multidisciplinary Courses to be opted = 01 (03 Credits).

No. of Ability Enhancement Courses to be opted = 01 (03 Credits).

No. of Skill Enhancement Courses to be opted = 01 (03 Credits).

Total No. of credits = 21

SEMESTER IV

Course Type	Course Code	Course Title	Credit Distribution				Marks Distribution			Total Credits
			L	T	P	Total	Int.	Ext.	Total	
Major 5	PHY-250-MJ	Mathematical Physics - I	3	1	0	04	30+ 20*	50	100	**20**
Major 6	PHY-251-MJ	Classical Electrodynamics	3	1	0	04	30+ 20*	50	100	
Major 7	PHY-252-MJ	Thermal Physics	3	1	0	04	30+ 20*	50	100	
Major 8	PHY-253-MJ	Optics	3	0	1	04	30 + 20*	50	100	
Minor 4 (Choose One)	To be chosen from the Basket of Minor courses offered by SoS		3	1	0	04	30 + 20*	50	100	

* Assignment/Attendance

No. of Major Courses to be opted= 04 (16 Credits)

No. of Vocational Minor Courses to be opted= 01 (04 Credits)

Total No. of credits = 20

SEMESTER V

Course Type	Course Code	Course Title	Credit Distribution				Marks Distribution			Total Credits
			L	T	P	Total	Int.	Ext.	Total	
Major 9	PHY-300-MJ	Classical Mechanics	3	1	0	04	30+ 20*	50	100	20
Major 10	PHY-301-MJ	Statistical Physics	3	1	0	04	30+ 20*	50	100	
Major 11	PHY-302-MJ	Quantum Mechanics I	3	1	0	04	30+ 20*	50	100	
Major 12	PHY-303-MJ	Lab - I	0	0	4	04	30+ 20*	50	100	
Minor 5 (Choose One)	To be chosen from the Basket of Minor courses offered by SoS		3	1	0	04	30 + 20*	50	100	

***** Assignment/Attendance

No. of Major Courses to be opted= 04 of 4 credits each (16 Credits)

No. of Minor Courses to be opted= 01 (04 Credits)

Total No. of credits = 20

SEMESTER VI

Course Type	Course Code	Course Title	Credit Distribution				Marks Distribution			Total Credits
			L	T	P	Total	Int.	Ext.	Total	
Major 13	PHY-350-MJ	Solid State Physics	3	1	0	04	30+ 20*	50	100	22
Major 14	PHY-351-MJ	Nuclear and Particle Physics	3	1	0	04	30+ 20*	50	100	
Major 15a	PHY-352-MJ	Quantum Computation	2	0	0	02	15+ 10*	25	50	
Major 15b	PHY-353-MJ	Python Programming	2	0	0	02	15 + 10*	25	50	
Major 15c	PHY-354-MJ	Lab - II	0	0	2	02	15 + 10*	25	50	
Minor 6 (Choose One)	To be chosen from the Basket of Minor courses offered by SoS		3	1	0	04	30 + 20*	50	100	
Skill Enhancement Course (SEC)	Internship		0	0	4	04	30 + 20*	50	100	

* Assignment/Attendance

No. of Major Courses to be opted= 02 of 4 credits each (08 Credits)

03 of 2 credits each (06 Credits)

No. of Minor Courses to be opted= 01 (04 Credits)

Internship =01 (04 Credits)

Total No. of credits = 22

SEMESTER VII

Course Type	Course Code	Course Title	Credit Distribution				Marks Distribution			Total Credits
			L	T	P	Total	Int.	Ext.	Total	
Major 16	PHY-400-MJ	Mathematical Physics-II	3	1	0	04	30+ 20*	50	100	20
Major 17	PHY-401-MJ	Quantum Mechanics-II	3	1	0	04	30+ 20*	50	100	
Major 18	PHY-402-MJ	Atomic and Molecular Physics	3	1	0	04	30+ 20*	50	100	
Major 19a	PHY-403-MJ	Research Methodology	2	0	0	02	15 + 10*	25	50	
Major 19b	PHY-404-MJ	Lab - III	0	0	2	02	15+ 10*	25	50	
Minor 7 (Choose One)	To be chosen from the Basket of Minor courses offered by SoS		3	1	0	04	30 + 20*	50	100	

* Assignment/Attendance

No. of Major Courses to be opted= 03 of 4 credits each (12 Credits)

02 of 2 credits each (04 Credits)

No. of Minor Courses to be opted= 01 (04 Credits)

Total No. of credits = 20

SEMESTER VIII (Hons.)

Course Type	Course Code	Course Title	Credit Distribution				Marks Distribution			Total Credits
			L	T	P	Total	Int.	Ext.	Total	
Major 20a	PHY-450-MJ	Numerical Methods	3	1	0	04	30+ 20*	50	100	22
Major 20b (Choose Only One)	PHY-451-MJ	Astrophysics	2	0	0	02	15+ 10*	25	50	
	PHY-452-MJ	Fourier Optics	2	0	0	02	15+ 10*	25	50	
	PHY-453-MJ	Physics of Functional Materials	2	0	0	02	15+ 10*	25	50	
	PHY-454-MJ	Advanced Nuclear Physics	2	0	0	02	15+ 10*	25	50	
Major 21	PHY-455-MJ	Laser and Fibre Optics	3	1	0	04	30+ 20*	50	100	
Major 22	PHY-456-MJ	Electronic Devices and Digital Electronics	3	1	0	04	30+ 20*	50	100	
Major 23 (Choose Any Two)	PHY-457-MJ	Plasma Physics	2	0	0	02	15+ 10*	25	50	
	PHY-458-MJ	Radiation Physics	2	0	0	02	15+ 10*	25	50	
	PHY-459-MJ	Experimental Techniques	2	0	0	02	15+ 10*	25	50	
	PHY-460-MJ	Atmospheric Physics	2	0	0	02	15+ 10*	25	50	
Minor 8 (Choose One)	To be chosen from the Basket of Minor courses offered by SoS		3	1	0	04	30 + 20*	50	100	

For 4 Year UG Hons:

No. of Major Courses to be opted= 03 of 04 Credits each (12 Credits)

03 of 02 Credits each (06 Credits)

No. of Minor Courses to be opted= 01 (04 Credits)

Total No. of credits = 22

SEMESTER VIII (Hons. with Research)

Course Type	Course Code	Course Title	Credit Distribution				Marks Distribution			Total Credits
			L	T	P	Total	Int.	Ext	Total	
Major 20a	PHY-450-MJ	Numerical Methods	3	1	0	04	30+ 20*	50	100	22
Major 20b (Choose Only One)	PHY-451-MJ	Astrophysics	2	0	0	02	15+ 10*	25	50	
	PHY-452-MJ	Fourier Optics	2	0	0	02	15+ 10*	25	50	
	PHY-453-MJ	Physics of Functional Materials	2	0	0	02	15+ 10*	25	50	
	PHY-454-MJ	Advanced Nuclear Physics	2	0	0	02	15+ 10*	25	50	
Skill Enhancement Course (SEC)		Research Project/Dissertation	0	0	12	12			300	
Minor 8 (Choose One)	To be chosen from the Basket of Minor courses offered by SoS		3	1	0	04	30 + 20*	50	100	

* Assignment/Attendance

For 4 Year UG Hons with Research:

No. of Major Courses to be opted= 01 (04 Credits)

01 (02 Credits)

No. of Minor Courses to be opted= 01 (04 Credits)

No. of Skill Enhancement Courses= 1 (12 Credits.)

Total No. of credits = 22

<u>Total credit and Marks distribution:</u>

Course Type	Certificate Course (After 2 Sems.)		UG Diploma (After 4 Sems.)		UG 3-Year (After 6 Sems.)		UG 4-Year Hons (After 8 Sems.)		UG 4-Year Hons with Research (After 8 Sems.)	
	Credits	Marks	Credits	Marks	Credits	Marks	Credits	Marks	Credits	Marks
Major	08	200	32	800	62	1550	96	2400	84	2100
Minor	08	200	16	400	24	600	32	800	32	800
Multidisciplinary	06	200	09	300	09	300	09	300	09	300
AEC	06	200	09	300	09	300	09	300	09	300
SEC	06	200	09	300	13	400	13	400	25	700
Value-Added Courses	08	200	08	200	08	200	08	200	08	200
TOTAL	42 +4*	1200 +100*	83 +4*	2300 +100*	125	3350	167	4400	167	4400

***For the Award of certificate and Diploma courses, a student needs to qualify an additional 4-credit (100 Marks)**

Semester I

Course Code: **PHY-100-MJ**
Credits: **04**
Type of Course: **Major**

Contact Hours: 4 hours per week (Total: 48 lectures + 16 Labs)

Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)

End-Term Examination: 50% (2. 5 Hours)

Course Objectives

The course aims to provide students with a solid understanding of mechanics principles and skills that are valuable in various academic and professional contexts.

Course Outcome

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

- Develop an understanding of the vector algebra and precise definition of vectors.
- Develop and grasp Understanding of foundational principles such as Newton's laws of motion and their extension to many particle systems, conservational laws and other concepts which form the backbone of classical mechanics.
- Gain skills in mathematical modeling and proficiency, problem analysis, and solution techniques by applying theoretical principles and using mathematical techniques such as calculus, differential equations, and vector algebra in solving problems involving motion, forces, and energy.
- Develop an intuitive understanding of how objects behave under different physical conditions, and predicting outcomes based on physical laws.
- Develop laboratory Skills by conducting experiments in laboratory to verify theoretical principles and gain practical experience in data collection and analysis.

Course Title: Fundamentals of Physics-I **Credits: 04**

Course Code: PHY-100-MJ **L 3 T 0 P 1**

Unit I

Vector algebra (dot and cross products), scalar and vector triple products, transformation of vector under rotation and inversion of coordinate axes, displacement, velocity, and acceleration in vector form, Newton‘s laws of motion in vector form and their applications to particle dynamics, work and energy, work–energy theorem, conservative and non-conservative forces, linear momentum and impulse, conservation of momentum in one and two dimensions, motion of systems of particles, centre of mass, two-body problem, and reduced mass.

Unit II

Angular velocity and angular acceleration, torque and angular momentum, relation between torque and rate of change of angular momentum, conservation of angular momentum and its applications, moment of inertia and its physical significance, calculation of moment of inertia for simple geometries, parallel and perpendicular axis theorems, rotational kinetic energy, work–energy theorem for rotational motion, rigid body dynamics, rotational equilibrium, rolling motion, gyroscope, and physical pendulum.

Unit III

Galilean relativity and its limitations, Michelson-Morley's experiment, Einstein‘s postulates of special relativity, Lorentz transformations, simultaneity, length contraction, time dilation, velocity addition theorem, relativistic momentum and energy, mass–energy equivalence ($E = mc^2$), and applications to high-energy and astrophysical systems.

Unit IV Lab

List of Experiments

1. Measurement of length (or diameter) using vernier calipers, screw gauge and travelling microscope.
2. To determine the Moment of Inertia of a Flywheel.
3. To determine g by Bar pendulum.
4. To determine g by Kater's pendulum
5. To determine the frequency using Melde's Apparatus.

Text Book:

1. An Introduction to mechanics, D. Kleppner, R. J. Kolenkow, 2019,McGraw-Hill 978-0-07- 06477877.

Reference Books:

2. Vector analysis and an introduction to tensor analysis, Murray P. Spiegel, Schaum's Outline Series, McGraw-Hill, ISBN: 07-060228-X
3. Introduction to Electrodynamics, David J. Griffiths, Pearson Education Limited, 978-93-325-5044-5
4. Mechanics Berkeley Physics course, v.1: Charles Kittel, et. Al. 2007, Tata McGraw-Hill.
5. Feynman Lectures, Vol. I, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education, ISBN 978-3319067896.

Semester II

Course Title: **Fundamentals of Physics - II**
Course Code: **PHY-150-MJ**
Credits: **04**
Type of Course: **Major**

Contact Hours: 4 hours per week (Total: 48 lectures + 16 Labs)

Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)

End-Term Examination: 50% (2. 5 Hours)

Course Objectives

The objective of the course is to provide students with a comprehensive understanding of the fundamental principles governing electricity and magnetism and its applications in engineering and daily use.

Course Outcomes

Completion of this core course will enable the students to:

- Gain understanding of fundamental concepts: electric charge, electric field, magnetic field, electromagnetic induction,
- Learn laws and rules governing electricity and magnetism, such as Coulomb’s, Gauss's law, and Ampere's law and their applications to calculating field intensities in various situations.
- Develop mastery of mathematical tools such as vector calculus, differential equations, and complex numbers in analyzing and solving problems in electricity and magnetism.
- Gain laboratory skills, as the course includes a laboratory component where students conduct experiments to observe and measure electric and magnetic phenomena, verify theoretical principles, and develop skills in data collection and analysis.

Course Title: Fundamentals of Physics - II **Credits: 04**
Course Code: PHY-150-MJ **L 3 T 0 P 1**

Unit I
Vector Calculus: Scalar and Vector fields, Gradient of scalar field, Divergence and curl of vector field, Line, surface and volume integrals. Gauss's divergence theorem, Stoke's theorem Coordinate Systems: Cartesian, spherical polar coordinates and cylindrical coordinate systems, Gradient, divergence and curl in spherical and cylindrical coordinates, Dirac delta function and its properties.

Unit II
Electric field: Divergence and curl of electric field, electric flux, and Gauss' Law with applications. Conservative nature of the electrostatic field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and electric field of a dipole. Force and torque on a dipole. Electrostatic energy of a system of charges. Electrostatic energy of a charged sphere. Method of Images, Conductors in an Electrostatic Field. Surface charge and force on a conductor.

Unit III
Dielectric Properties of Matter: Electric Field in Matter. Polarisation, Bound Charges and Their Physical Interpretation. Field inside a dielectric capacitor (parallel plate, spherical, cylindrical) filled with and without dielectric, electric displacement vector D and Gauss' Law in dielectrics, electrical susceptibility, permittivity and dielectric constant in linear dielectrics. Relations between E, P and D, Energy in Dielectric Systems.

Unit IV Lab
List of Experiments
1. Verification of Ohm's law
2. To study series and parallel combination of resistances
3. Study of Coloumb's Law
4. Study of Biot-Savart law
5. Study of Helmhortz coil
6. Determination of Capacitance of a parallel plate capacitor.
7. Study of Ballistic Galvanometer.

Text Book:

1. Introduction to Electrodynamics, David J. Griffiths, Pearson.

Reference Books:

1. Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
2. Electricity & Magnetism, J.H. Fewkes &J.Yarwood. Vol. I, 1991, Oxford Univ. Press
3. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
4. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Semester III

Course Title: **Waves and Oscillations**
Course Code: **PHY-200-MJ**
Credits: **04**
Type of Course: **Major**

Contact Hours: 4 hours per week (Total: 52 lectures+ 12 tutorials)

Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)

End-Term Examination: 50% (2. 5 Hours)

Course Objectives

The course aims to introduce the fundamental principles governing oscillatory motion and wave phenomena in physical systems and develops ability to model and analyze simple harmonic, damped, and forced oscillations mathematically and physically.

Course Outcome

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

- Understand and describe the basic concepts of oscillatory motion including simple, damped, and forced harmonic oscillations.
- Apply mathematical tools (differential equations, complex notation, phasors) to solve problems involving oscillatory systems.
- Explain and analyze the principles of superposition, interference, and beats in mechanical and sound waves.
- Interpret the concept of resonance and its applications in physical systems and instruments.
- Relate wave phenomena such as group and phase velocity, dispersion, and energy transport to real-world systems.

Course Title: Waves and Oscillations **Credits: 04**
Course Code: PHY-200-MJ **L 3 T 1 P 0**

Unit I
Oscillations: Simple harmonic motion, Differential equation of SHM and its solution, energy of a simple harmonic oscillator, Examples of SHM: compound pendulum, torsional pendulum, bifilar oscillations, LC circuit, oscillations of two masses connected by a spring. Lissajous figures, combination of two mutually perpendicular simple harmonic vibrations of same frequency and different frequencies

Unit II
Damped oscillations: Differential equation of damped harmonic oscillator and its solution, Logarithmic decrement, Energy of damped oscillator, Power dissipation, Quality factor, Relaxation time, Forced oscillations: Transient and steady state behavior, Resonance

Unit III
Plane and Spherical Waves. Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity.
Sound: Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient - Sabine's formula - measurement of reverberation time - Acoustic aspects of halls and auditoria

Unit IV
Standing Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves. Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence, Raman Scattering (Qualitative idea)

Text Book
1. Vibrations and Waves, A. P. French, CBS publishers.

References Books
1. An Introduction to Mechanics by Daniel Kleppner, Robert J. Kolenkow.
2. The Physics of Waves and Oscillations By N.K. Bajaj.
3. Waves and Oscillations. S. Badami, V. Balasubramanian and K. Ram Reddy Orient Longman.
4. Mechanics of Particles, Waves and Oscillations. Anwar Kamal, New Age International.
5. Waves and Oscillations. N. Subramaniyam and Brijlal Vikas Publishing House Private Limited.
6. Vibrations and Waves by George C. King.

Course Title: **Basic Electronics**
Course Code: **PHY-201-MJ**
Credits: **04**
Type of Course: **Major**

Contact Hours: 4 hours per week (Total: 48 lecture +16 Labs)

Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)

End-Term Examination: (2.5 Hours) 50%

Course Objectives

The aim of the course is to equip students with the knowledge, skills, and practical experience necessary to design, analyze, and troubleshoot analog electronic circuits in various applications.

Course Outcome

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

- Develop comprehensive understanding of the principles, devices, and circuits used in analog electronic systems.
- Learn the basic electronic devices, their fabrication, characteristics and potential application like diode. Zener diode, photo diode, tunnel diode, solar cells.
- Develop understanding of the transistor and transistor amplifiers including their ideal characteristics, practical limitations, and applications in various circuit configurations and analysis using two-port model.
- The laboratory component where students design, build, test, and troubleshoot analog electronic circuits, gaining hands-on experience with electronic instrumentation and measurement techniques.

Course Title: Basic Electronics **Credits: 04**
Course Code: PHY-201-MJ **L 3 T 0 P 1**

Unit I

Band theory of solids, Classification of materials, Occupational probability, Fermi level, Semiconducting Materials and properties, Conductivity in semiconductors, Direct and indirect band gap semiconductors, Variation of charge carrier concentrations and Fermi level with Doping and temperature in intrinsic semiconductors and extrinsic semiconductors.

Unit II

PN junction diode, diode equation, diode built in voltage, junction capacitance, Various types of PN junction diodes and their usage (LEDs, Photodetectors, Solar cells, Zener, laser, tunnel.), Diode Fabrication of band gap.

Circuit Analysis: Kirchoff's current and voltage laws with applications, Study of Network Theorems : Superposition, Thevenin, Norton, Maximum Power Transfer.

Unit III

Fundamentals of operation of UJT, Design and working of of BJT, BJT configuration and modes of operation, characteristics of BJT, transistor alpha and beta and their relationship, dc biasing load line and operating point, Stability of operating point against thermal and Beta variations, stabilization factor, transistor as an amplifier.

Unit IV Electronics lab

List of Experiments

1. To study V-I characteristics of PN junction diode, and Light Emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. Study of V-I and power curves of solar cells, and find maximum power point and efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To study the various biasing configurations of BJT for normal class A operation.
6. To study and design experiments using the XPS module.

Text Books:

1. Electronic devices and circuit theory, R. L. Boylestad and L. Nashelsky, Prentice Hall

Reference Books:

2. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
3. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
4. Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 2009, PHI Learning
5. Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 2012, Tata Mc-Graw Hill
6. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
7. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
8. Electronic Devices, Thomas L. Floyd, 2008, Pearson India

Semester IV

Course Title: **Mathematical Physics - I**
Course Code: **PHY-250-MJ**
Credits: **04**
Type of Course: **Major**

Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)
Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/presentations)
End-Term Examination: 50% (2. 5 Hours)

Course Objectives

The purpose of the course is to introduce students to methods of mathematical physics and to develop required mathematical skills to solve problems of interest to physicists.

Course Outcome

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

- Understand and apply the concepts of vector spaces, basis, dimension, linear independence, and linear transformations to physical and mathematical problems.
- Perform matrix operations including addition, multiplication, inversion, eigenvalue and eigenvector computation, and use them in solving systems of linear equations.
- Analyze and solve ordinary differential equations (ODEs) of first and higher orders using standard analytical methods and interpret their physical significance..
- Apply differential equations to model and describe dynamical systems in physics such as oscillations and electrical circuits
- Understand the fundamentals of tensors, their transformation properties, and apply tensor algebra to problems in mechanics, relativity, and field theory.
- Develop mathematical reasoning and computational skills necessary to handle abstract formulations and applications in advanced physics courses.

Course Title: Mathematical Physics - I **Credits: 04**
Course Code: PHY-250-MJ **L 3 T 1 P 0**

Unit I

Linear vector spaces: Basics, Inner Product spaces, Dual spaces, Subspaces, Hilbert space, Linear Operators, Matrix elements of linear operators, Active and passive transformation,
Matrices: Definition and types, Matrix operation and properties, transpose, inverse and adjoint. Determinants, rank of a matrix, solution of System of simultaneous linear equations, Eigen values and eigenvectors, Diagonalization and similarity transformation

Unit II

Ordinary Differential equations, First order ODEs, Second-Order Linear ODEs, Series Solutions Frobenius Method, Inhomogeneous Linear ODEs
Partial Differential Equations, Classes and Characteristics, Boundary Conditions, First-order, solution of partial differential equations; Separation of variables.

Unit III

Fourier Series: Definition, Properties, Convergence, Application of Fourier series, Fourier Integral and Fourier transform and inverse Fourier transform, Convolution theorem, Parseval's theorem, Laplace transform and its properties, inverse Laplace transforms, solution of differential equations using Laplace transforms

Unit IV

Tensor Analysis: Occurrence of tensors in physics, Notation and conventions, Tensors and their Ranks, Contravariant, covariant and mixed tensors, Addition and subtraction of tensors, Inner and Outer Product, Contraction, symmetric and anti-symmetric tensors, The Kronecker Delta, Quotient law, Conjugate symmetric tensors of second rank. The metric tensor, Contravariant metric tensor, Isotropic tensors. Examples: Moment of Inertia, dielectric susceptibility

Text Book:

1. Mathematical Physics Applications and problems, V. Balakrishnan, Springer

Reference Books:

2. Mathematical Methods for Students of Physics and Related Fields, Sadri Hassani, Springer, 2nd ed.
3. Mathematical Methods for Physicists, G. B. Arfken and H. J. Weber, Academic Press, 7th ed.
4. Advanced Engineering Mathematics, Michel D. Greenberg, Prentice Hall, 2nd ed.
5. Mathematical Methods for Physics and Engineering, K. F. Riley, M. P. Hobson and S. J. Bence, CUP, 3rd ed.,
6. Advanced Engineering Mathematics, E. Kreyszig, John Wiley, 10th ed.
7. Mathematical Physics, M. L. Boas, John Wiley, 3rd ed.

Course Title: **Classical Electrodynamics**
Course Code: **PHY-251-MJ**
Credits: **04**
Type of Course: **Major**

Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)
Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/presentations)
End-Term Examination: 50% (2. 5 Hours)

Course Objectives

To develop understanding of the advanced concepts related to Magnetostatics, electromagnetism and electromagnetic waves.

Course Outcome

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

- Use Biot-Savart law and Ampere's law to calculate magnetic fields.
- Explain Faraday's laws, Maxwell's equations and significance of displacement current.
- Explain electromagnetic field energy and momentum.
- Use of Maxwell's equations to explain the behaviour of electromagnetic wave propagation in different media, phenomenon of refraction, reflection, interference, diffraction and polarization.
- Understand Dispersion phenomena, physics of transmission lines and wave guides.
- Understand the concept of retarded and Lienard-Wiechert potentials, and electrodynamics of a point charge.

Course Title: Classical Electrodynamics **Credits: 04**
Course Code: PHY-251-MJ **L 3 T 1 P 0**

Unit I

Magnetostatics: Lorentz force law, Biot–Savart law, Divergence and Curl of magnetic fields, Ampère’s law, Magnetic vector potential, Magnetostatic boundary conditions, Multipole expansion of the vector potential.

Magnetic Fields in Matter: Dia, Para, and Fero-magnets, Field of a magnetized object, Auxiliary field H, Magnetic susceptibility and permeability.

Unit II

Electrodynamics: Electromotive force, motional emf, Electromagnetic induction, Faraday's laws, energy in magnetic fields, Maxwell’s equations, Magnetic Charge, Maxwell’s equations in matter, Boundary conditions.

Conservation Laws: Continuity equation, Poynting’s theorem, Momentum, Angular momentum. Electromagnetic waves: Waves in one dimension, Electromagnetic waves in vacuum and matter, Energy and momentum in electromagnetic waves, Guided waves.

Unit III

Potentials and Fields: Scalar and Vector potentials, Gauge transformations, Coulomb and Lorentz Gauge, Maxwell’s equations in terms of potentials, Retarded potentials, Lienard-Wiechert potentials, fields of a moving point charge.

Unit IV

Dipole radiation, Electric Dipole radiation and Magnetic dipole radiation, Radiation from an arbitrary source, power radiated by a point charge.

Electrodynamics and Relativity: Relativistic mechanics, Four-Vectors in Electrodynamics, Magnetism as relativistic phenomenon, Transformation of electric and magnetic fields under Lorentz transformations, Field Tensor, Electrodynamics in tensor notation, Relativistic potentials.

Text Book:

1. Introduction to Electrodynamics, D. J. Griffiths, Pearson, 4th ed.

Reference Books:

2. Classical Electrodynamics, J. D. Jackson, John Wiley, 3rd ed.
3. Lectures on Electromagnetism, A. Das, Hindustan Book Agency
4. Classical Electromagnetic Radiation, M. A. Heald and J. B. Marion, Suanders College Publishing.
5. Lectures on Physics , R.P. Feynman, (Vol. II),Addison-Wesley
6. Modern Electrodynamics, A. Zangwill, Cambridge Univ. Press

Course Title: **Thermal Physics**
Course Code: **PHY-252-MJ**
Credits: **04**
Type of Course: **Major**

Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)

Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)

End-Term Examination: 50% (2. 5 Hours)

Course Objectives

The course aims to provide students with a solid understanding of theoretical principles and practical applications of Thermal Physics course, including temperature, heat, laws of thermodynamics and kinetic theory.

Course Outcome

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

- Understand the properties and behavior of thermodynamic systems, thermodynamic state and state function.
- Explore the first, second, and third laws of thermodynamics, and their implications for energy transfer, entropy, and thermodynamic processes such as isothermal, adiabatic, isobaric, and isochoric processes, and analyze their behavior using thermodynamic principles.
- Analyze the thermodynamic cycles of heat engines and refrigerators, including the Carnot cycle, and understand their efficiency and limitations
- Explore the kinetic theory of gases and its application in describing the macroscopic properties of gases, including pressure, temperature, and the ideal gas law.
- Develop understanding of the behavior of real gases and the departures of an real gas from an ideal gas

Course Title: Thermal Physics **Credits: 04**
Course Code: PHY-252-MJ **L 3 T 1 P 0**

Unit I

Thermodynamic Description of state and state functions: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes. Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes.

Unit II

Second law and Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero. Thermodynamical Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications - Joule-Thompson Effect, Clausius-Clapeyron Equation, Expression for ($C_P - C_V$),C_P /C_V , TdS equations.

Unit III

Kinetic Theory of Gases: Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases.
Molecular Collisions: Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance.

Unit IV

Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO_2 Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. P-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule- Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion.

Text Book:

1. Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears and G.L. Salinger. 1988, Narosa University Physics.

Reference Books:

1. Fundamentals of Statistical and Thermal Physics, F. Reif, Waveland Press Inc.
2. Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
3. A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.

Course Title: **Optics**
Course Code: **PHY-253-MJ**
Credits: **04**
Type of Course: **Major**

Contact Hours: 4 hours per week (Total: 48 lecture + 16 labs)

Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)

End-Term Examination: (2.5 Hours) 50%

Course Objectives

The objective of the course is to provide students with the foundation in optics, preparing them for further study or careers in fields such as photonics, telecommunications, and biomedical imaging.

Course Outcome

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

- Develop an understanding of the nature and characteristics and importance of light and optics
- Develop understanding of the interference of light and the various methods of producing the interference
- Develop an understanding of the various types of diffraction and conditions for observing it.
- Gain skill in handling of optical benches, interferometers, spectrometers, lasers, and associated instrumentation related to interferometry and diffractrometry.

Course Title: Optics **Credits: 04**
Course Code: PHY-253-MJ **L 3 T 0 P 1**

Unit I

Transverse nature of light waves. Plane polarized light,, production and analysis, Circular and elliptical polarization, Methods of Polarization, Polarization by reflection, refraction, Double refraction, selective absorption, scattering of light, Brewster's law, Malus law, Nicol prism.

Unit II

Interference by division of wavefront: Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism.

Interference by division of amplitude: Thin Films parallel and wedge-shaped films, Newton's Rings, Michelson Interferometer its applications.

Unit III

Fraunhofer diffraction: Single slit; Double Slit. Multiple slits & Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis.

Unit IV

List of Experiments:

1. To determine the wavelength of a laser source by Young's double slit experiment
2. To determine the wavelength of sodium light by diffraction grating.
3. To determine the wavelength of prominent lines of mercury by diffraction grating.
4. To determine the dispersive power of crown/flint glass prism.
5. To determine the wavelength by Fresenel's Biprism.
6. To study single slit diffraction patter and determine the wavelength.

Text Book

1. Optics, Ajoy Ghatak. The McGraw-Hill company.

Reference Books:

2. Optics N. Subramaniyam and Brijlal. S. Chand & Co.
3. Optics and Spectroscopy. R. Murugeshan and Kiruthiga Siva Prasath. S. Chand & Co.
4. Modern Engineering Physics, A.S. Vasudeva. S.Chand& Co. Publications.
5. Feyman's Lectures on Physics Vol. 1,2,3 & 4. Narosa Publications.
6. Fundamentals of Optics, Jenkins A. Francis and White E. Harvey, McGraw Hill Inc.
7. D.P. Khandelwal, Optical and Atomic Physics" Himalaya Publishing House, Bombay.

Semester V

Course Title: **Classical Mechanics**
Course Code: **PHY-301-MJ**
Credits: **04**
Type of Course: **Major**

Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)
Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/presentations)
End-Term Examination: 50% (2. 5 Hours)

Course Objectives

The objective of this core course is to teach the students how complex classical systems could be studied using Lagrangian, Hamiltonian formulations, advanced technique of co-ordinate transformation – the canonical transformations, Poisson bracket and Hamilton-Jacobi theory. The students also study the mechanics of rigid-bodies and small oscillations.

Course Outcome

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

- Write the Lagrangian and Hamiltonian for various classical systems.
- Derive Lagrange's and Hamilton's equations of motion using various principles and techniques and explain the relationship between symmetries and conservation laws.
- Learn and solve the problems using canonical transformations, Poisson bracket and Hamilton-Jacobi theory.
- Understand the mechanics of rigid-bodies having large degrees of freedom and dig out the interesting dynamics using Euler-angles technique along with Euler's theorem and Euler equations.
- Understand and solve the problem of small oscillations using Lagrangian formalism.

Course Title: Classical Mechanics **Credits: 04**
Course Code: PHY-301-MJ **L 3 T 1 P 0**

Unit I
Generalized coordinates and constraints, degrees of freedom, virtual displacement, principle of virtual work, D'Alembert's principle, derivation of Lagrange's equations of motion, cyclic coordinates and conservation theorems, generalized momenta and energy function, applications of Lagrangian formulation to simple systems such as the simple pendulum, Atwood's machine, particle in a central potential, and small oscillations.

Unit II
Reduction of a two-body problem to an equivalent one-body problem, equations of motion under central forces, effective potential, classification of orbits, scattering by a central potential, inverse square law of force and Kepler's laws, stability of circular orbits, motion of rigid bodies, rotational kinetic energy, Euler's angles, angular velocity components, Euler's equations of motion, motion of a symmetrical top under gravity, precession and nutation.

Unit III
Hamilton's principle and its relation to Lagrange's equations, generalized momenta and Hamiltonian function, Hamilton's canonical equations of motion, applications to simple systems, cyclic coordinates and conservation laws, phase space and trajectories, Liouville's theorem, examples of one-dimensional motion in Hamiltonian formalism, comparison of Lagrangian and Hamiltonian approaches.

Unit IV
Canonical transformations, generating functions, examples of canonical transformations, Poisson brackets and their properties, equations of motion in Poisson bracket form, Hamilton–Jacobi equation and its applications, action–angle variables, applications to periodic systems, introduction to small oscillations in coupled systems, normal coordinates and normal modes.

Text Book:
1. Classical Mechanics by H. Goldstein, Charles P. Poole, John Safko, 3rd Edition, Pearson.

Reference Books:
2. Mechanics by Landau and Lifshitz, Butterworth-Heinemann
3. Classical Mechanics by R.D. Gregory,Cambridge University Press
4. Classical Mechanics by N.C. Rana and P.S. Joag, Tata McGraw-Hill.
5. An introduction to Mechanics, D. Kleppner and R. Kolenkow, Tata McGraw-Hill.
6. Classical Mechanics by S. N. Biswas, 998,.Books and Allied Pvt. Ltd.
7. Classical Mechanics by J. C. Upadhaya,2006, Himalaya Publishing House, Mumbai.
8. Classical Dynamics of particles and systems by S. T. Thornton and J. B.Marion, Cengage Learning, 2008.

Course Title: **Statistical Physics**
Course Code: **PHY-301-MJ**
Credits: **04**
Type of Course: **Major**

Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)
Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/presentations)
End-Term Examination: 50% (2. 5 Hours)

Course Objectives

To understand the probability theory and methods of statistical physics and thermodynamics. The aim of this course is to understand the basic as well as advanced concepts of both classical and quantum statistical physics.

Course Outcome

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

- Understand and apply the probability and statistical method and their importance in the course.
- Understand the connection between statistics and thermodynamics.
- Understand different ensemble theories used to explain the behavior of macroscopic systems.
- Understand the basic concepts of classical statistics
- Understand the difficulties with the classical statistical mechanics

Course Title: Statistical Physics **Credits: 04**
Course Code: PHY-301-MJ **L 3 T 1 P 0**

Unit I

Basic Concepts of Theory of Probability: Random Events, Probability, Probability and Frequency, Some Basic Rules of Probability Theory, discrete and continuous probability distributions, Random Variables, Mean Values of a Discrete and Continuous Random Variable, central limit theorem, Random Walk problem: One Dimensional random walk, Calculation of Mean Values, connection to diffusion and Brownian motion.

Unit II

Macroscopic and Microscopic Systems(, thermodynamic probability, macrostate and microstate phase space and density of states, postulates of statistical mechanics, principle of equal a priori probability, entropy and probability, Boltzmann's entropy formula, concept of most probable distribution, classical ideal gas, micro canonical treatment, concept of distinguishable and indistinguishable particles.

Unit III

Concept of Ensemble: Microcanonical, Canonical, and Grand Canonical ensembles. Ensemble Average and Time Average, Gibb's paradox, Canonical Ensemble: partition function, and its thermodynamic significance, Energy Fluctuations in Canonical ensemble, Grand Canonical Ensemble: Concept and applications to systems with variable particle number, Connection between Ensembles (qualitative).

Unit IV

Maxwell-Boltzmann distribution: Derivation and application, Bose-Einstein Distribution: Photons and phonons as examples (Blackbody radiation, Bose-Einstein condensation—qualitative), Fermi-Dirac Distribution: Application to electron gas (qualitative).Comparison of Distribution Laws: Classical limit of quantum statistics

Text Book:

1. Fundamentals of Statistical Mechanics, Rief ,F., 2018 Edition, New Age International

Reference Books

2. Fundamentals of Statistical Mechanics, Laud ,B. B., 2nd edition, New Age International
3. Statistical Mechanics, Pathria, R. K., 3rd edition, Academic press publication
4. Statistical Mechanics, Huang, K., 2nd edition, Wiley
5. Statistical Physics, Landau, L. D. and Lifshitz, E. M., 3rd edition, Butterworth Heinemann.
6. Introduction to statistical mechanics, S. K. Sinha, Narosa publications,

Course Title: **Quantum Mechanics - I**
Course Code: **PHY-302-MJ**
Credits: **04**
Type of Course: **Major**

Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)
Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/presentations)
End-Term Examination: 50% (2. 5 Hours)

Course Objectives

To understand the behavior of the physical world at the atomic level. Connect the historical development of quantum mechanics with previous knowledge and learn the basic properties of quantum world.

Course Outcome

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

- Learn the various mathematical tools involving linear algebra.
- To learn the quantum mechanical algebra of angular momentum.
- To learn the concept of symmetry in the context of quantum mechanics.
- The time-dependent and time-independent Schrödinger equation for simple potentials like for instance the harmonic oscillator and hydrogen like atoms, as well as the interaction of an electron with the electromagnetic field.
- Quantum mechanical axioms and the matrix representation of quantum mechanics.

Course Title: Quantum Mechanics - I **Credits:04**
Course Code: PHY-302- MJ **L 3 T 1 P 0**

Unit I

Blackbody Radiation: Quantum Theory of Light, Photoelectric Effect. Compton Effect, De-Broglie Hypothesis. Davisson-Germer Experiment. Heisenberg's uncertainty principle, Schrödinger's wave equation (Time independent form); linearity and superposition; Wave Function and its properties. Interpretation of Wave Function. Probability Current Density and Probability current, Expectation values; operators; Stationary state solutions of Schrödinger equation, Particle in a box; potential step, Potential Barrier, Tunnel effect,

Unit II

Solution of simple harmonic oscillator- Energy levels and Eigen functions using Frobenious method, Simple harmonic oscillator by operator method. Postulates of quantum mechanics, Time development of a quantum mechanical system: Schrodinger, Heisenberg and interaction pictures.

Unit III

Angular Momentum: Orbital, Spin and total angular momentum operators, ladder operators L_+ and L_-, their Commutation relations, Eigen values of J^2 and J_z operators, Matrix representation of J in |j,m> basis, Computation of angular momentum matrices for simpler cases (J = ½, 1), Pauli spin matrices, Addition of angular momenta, Computation of Clebsch-Gordon (CG) coefficients for simple cases. Qubits, Quantum entanglement.

Unit IV

Time independent Schrodinger's equation in spherical coordinates, Spherical Harmonics and their properties, Solution of Schrodinger equation for hydrogen atom,
Unitary transformation and symmetry in Quantum Mechanics, Space and Time translations, Discrete symmetries, Symmetry and conservation laws, Symmetry and degeneracy.

Text Book:

1. Quantum Mechanics, L. I. Schiff, McGraw Hill, 4thedition.

Reference Books:

2. Principles of Quantum Mechanics, R. Shankar, Springer, 2ndedition.
3. Modern Quantum Mechanics, J. J. Sakurai and J. J. Napolitano, Pearson Publications, 2ndedition.
4. Quantum Mechanics, L.D. Landau and E. M.Lifshitz, Elsevier, 3rdedition.
5. Quantum Mechanics Concepts and Applications, N. Zettili, John Wiley, 2nd edition.

Course Title: **Lab - I**
Course Code: **PHY-303-MJ**
Credits: **04**
Type of Course: **Major**

Contact Hours: 4 labs per week (Total 64 labs)
Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/presentations)
End-Term Examination: 50% (2.5 Hour)

Course Objectives

The main objective of the course is to train students to realize the various physics concepts learnt in the class room in the laboratory and understand the various aspects of scientific measurement which include error analysis, data fitting and data interpretation.

Course Outcome

On completion of the course, student will be able:

- To gain practical knowledge by applying the experimental methods to correlate with the physics theory.
- To learn the usage of electrical and optical systems for various measurements.
- To apply the analytical techniques and graphical analysis to the experimental data.
- To develop intellectual communication skills and discuss the basic principles of scientific concepts in a group.

Course Title: Lab - I **Credits:04**
Course Code: PHY-303- MJ **L 0 T 0 P 4**

A student will have to perform 10 experiments from the following list of experiments available.

1. To determine charge of an electron by Millikan's Oil drop experiment.
2. To study the characteristics of a G M tube and determine the operating voltage.
3. To study Attenuation coefficient/ absorption coefficient, using GM Counter.
4. Study of Lissajous Figures using CRO.
5. To find the frequency of AC supply using an Electrical Vibrator (Melde's experiments).
6. Study of Hall Effect
   (a) Determination of Hall Voltage and RH.
   (b) Determination of mobility of charge carriers and carrier concentration.
7. Design and study operational amplifier as adder and subtractor
8. To determine the band gap of semiconductor from temperature dependence of resistivity using Four Probe Method.
9. To design and study the V-I characteristics of BJT (Using breadboard).
10. Design and study of RC filters (Active and Passive).
11. To find the wavelength of sodium light by measuring the diameters of Newton's rings
12. Precision measurement of wavelength of monochromatic light using Michelson interferometer.

Reference Books:

1. A Textbook of Practical Physics, Indu Prakash, Ram Krishna and A. K. Jha Vol 1 and 2, Kitab Mahal
2. Practical Physics, C.L. Arora S. Chand Publication.
3. Advanced Practical Physics, B.L. Worsnop and H. T. Flint , Asia Publishing House

Semester VI

Course Title: **Solid State Physics**
Course Code: **PHY-350-MJ**
Credits: **04**
Type of Course: **Major**

Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)
Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/presentations)
End-Term Examination: 50% (2. 5 Hours)

Course Objectives

To learn some of the basic properties of the condensed phase of matter especially solids.

Course Outcome

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

- Differentiate between different Lattice types and explain the concepts of reciprocal lattice and crystal diffraction.
- Predict electrical and thermal properties of solids and explain their origin.
- Explain the concept of energy bands and effect of the same on electrical properties.
- Have an understanding of the magnetic and dielectric properties of condensed matter.
- Have an understanding of the elastic properties of solids and lattice vibrations

Course Title: Solid State Physics **Credits: 04**
Course Code: PHY-350-MJ **L 3 T 1 P 0**

Unit-I

Crystal Structure: Solids: Introduction to crystal structure, Crystal lattice, the unit cell, Bravais and non-Bravais lattice, Symmetry Elements, seven crystal systems, Crystal planes and Miller Indices, Packing fraction, Diffraction of X-rays by Crystals, Reciprocal Lattice, Brillouin Zones, Edwald construction, Laue Condition, Atomic and Geometrical Factor. Imperfections: Point defects, Colour Centres, grain boundaries etc.

Unit-II

Free Electron theory: Electrons in metals- Drude Model, Density of states, Fermi energy, Elementary band theory: Kronig Penny model, Bloch theorem, Band Gap, Electrical conductivity: Temperature dependence, Effective mass, mobility, Hall Effect (Metal and Semiconductor).
Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains, Acoustical and Optical Phonons, Qualitative Description of the Phonon Spectrum in Solids, Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids.

Unit-III

Magnetic Properties of Matter: Classification of materials on the basis of magnetic properties: Dia-, Para-, Ferri- and Ferromagnetic Materials, Classical Langevin Theory of dia, para and Ferromagnetic domains, Quantum Mechanical Treatment of Paramagnetism, Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains, B-H Curve Hysteresis, soft and hard material and Energy Loss.

Unit-IV

Dielectric Properties of Materials: Dielectric Polarization, Local Electric Field of an Atom, Electric Susceptibility and Polarizability, Clausius-Mosotti Equation.
Ferroelectric Properties of Materials: Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.

Text Book:

1. Elementary Solid State Physics: Principles and Applications, M. Ali Omar, Addison-Wesley Publishing Company, 1993

Reference Books:

2. Introduction to Solid State Physics, Charles Kittel, 8th Edn., 2004, Wiley India Pvt. Ltd.
3. Elements of Solid State Physics, J.P. Srivastava, 2nd Edn., 2006, Prentice-Hall of India.
4. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.
5. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning.
6. Solid-state Physics, H.Ibach and H. Luth, 2009, Springer.
7. Solid State Physics, Rita John, 2014, McGraw Hill
8. Solid State Physics, M.A. Wahab, 2011, Narosa Publications.

Course Title:	**Nuclear and Particle Physics**
Course Code:	**PHY-351-MJ**
Credits:	**04**
Type of Course:	**Major**

Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)
Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/presentations)
End-Term Examination: 50% (2. 5 Hours)

Course Objectives

- The purpose of this course is to make students understand the fundamental concept of Nuclear Physics and Nuclear Models and make them understand about the working of various detectors and accelerators used for research purposes.
- The objective of this core course is to understand the nature of particles and their interactions at fundamental level.

Course Outcome

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

- Gain the knowledge of general properties of nuclei
- Understand various types of radioactive decay processes
- Gain the fundamental understanding of the nuclear models like liquid drop model
- Understand the construction, working and applications of various types of detectors and accelerators
- Learn about the basic interactions and their mediating quanta.
- Classify the particles; learn about various particle quantum numbers and the role of symmetries in their interactions
- Understand Quark Model of hadrons and be able to calculate the charge and magnetic moment of particles.

Course Title: Nuclear and Particle Physics **Credits: 04**
Course Code: PHY-351-MJ **L 3 T 1 P 0**

Unit I
Review of the basic nuclear properties, Nuclear size and the distribution of nucleons, Parity and statistics, Nuclear force and its characteristics, nucleon-nucleon potential, Yukawa meson theory Simple theory of two-nucleon system –Deuteron problem, Spin states of two-nucleon system, Isotopic Spin, Effect of Pauli's exclusion principle, Magnetic dipole moment and electric quadrupole moment of Deuteron, The Tensor forces.

Unit II
Nuclear Models: Liquid drop model, Weizsacker’s semi-empirical mass formula and its applications, Evidence for Magic Numbers, Shell model: Shell structure, spin-orbit interaction, parity and magnetic moment of odd-A nuclei
Kinematics of nuclear reactions, standard Q-equation and its solution, Threshold Energy, nuclear fission and fusion, Radioactivity, Alpha Decay: Gamow’s Theory, Beta Decay: Fermi’s theory of beta decay, selection rules

Unit III
Particle Physics: Conservation laws in particle physics. Quark model, Gellmann Nishijima Relation, C, P, and T invariance. C-parity, CP and CPT invariance. Application of symmetry arguments to particle reactions. Parity non-conservation in weak interaction, parity of Pions, Helicity. The Standard Model of Particle Interactions.
Combining quarks into baryons and Mesons -SU(2), SU(3) isospin symmetry. Mass formula for baryons and mesons. Calculation of charge and magnetic moments of baryons. Confinement and QCD potential. Colour degree of freedom. Weak, electromagnetic and strong decays of particles, calculation of branching ratios, weak decays of strange particles and Cabbibo theory. Strangeness oscillations, K L —K S mass difference and CP non conservation in K 0 –decays.

Unit IV
Basic concept of Detectors, Gas detectors: estimation of electric field, mobility of particle for ionization chamber and GM Counter, Basic principle of Scintillation Detectors and photo-ultiplier tube (PMT), Semiconductor Detectors (Si and Ge) for charged particle and photon detection (concept of charge carrier and mobility).
Proton Synchrotron, Betatron, Colliding beam accelerator, Van-de Graff generator, Tandem accelerator, Linear accelerator

Text Books:
1. Introductory Nuclear Physics by Kenneth S, Krane, Wiley-India Publication, 2008
2. Introduction to Elementary Particles, D. J. Griffiths, 4th ed., John Wiley.

Reference Books:
4. Introductory Nuclear Physics, S. M. Wong, John Wiley, 2nd ed.
5. Nuclear Physics: principles and applications by John Lilley, Wiley Publication, 2006.
6. Introduction to High Energy Physics, D. H. Perkins, Addison Wesley, 4th ed.
7. Particle Physics, B. R. Martin and G. Shaw, John Wiley, 3rd ed.
8. Radiation detection and measurement, G.F. Knoll, John Wiley & Sons, 2010.

Course Title: **Quantum Computation**
Course Code: **PHY-352-MJ**
Credits: **02**
Type of Course: **Major**

Contact Hours: 2 hours per week (Total: 32 lecture)
Internal assessment: 50% (30% Exam (45 min) and 20% assignments/presentations)
End-Term Examination: 50% (1. 15 Hours)

Course Objectives

The objective of the course is to familiarize students with the emerging field of quantum computation. It will cover the mathematical formalism of Quantum Computation from Single Qubit concepts and progressing to multiple Qubits. The curriculum will delve into Quantum Computation Algorithms. Additionally, a concise overview of Error Correction and Cryptography in the context of quantum computation will be presented. The course will also explore various Models of Quantum Computation to enrich the students' knowledge in this cutting-edge domain.

Course Outcome

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

- Develop the comprehension of Quantum Computation.
- Get familiar with Quantum Algorithms.
- Develop basic understanding of Quantum Key Distribution and BB84 protocol.
- Get familiar with some realization of Quantum Computers.

Course Title: Quantum Computation **Credits: 02**
Course Code: PHY-352-MJ **L 2 T 0 P 0**

Unit I

Introduction, Review of Linear Algebra, Bra-Ket Notation, Postulates of Quantum Mechanics, Pauli matrices, Density Matrix, Composite Systems, Bell States, Bell Inequalities, Entanglement, Qubit, Bloch Sphere, Single Qubit Gates, Multiple Qubit Gate, Schmidt Number, No-cloning Theorem, Quantum Circuit, Quantum Teleportation, Universal Set of Quantum Gates.

Unit II

Deutsch's Algorithm, Deutsch-Jozsa Algorithm, Quantum Fourier Transform, Quantum Operations, Operator Sum Representation, Quantum Noisy Channel, Quantum Error Correction, Quantum Key Distribution, Brief Overview of BB84 Protocol, Simple Harmonic Oscillator and Optical Photon as Qubit.

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Text Books:

Quantum Computing Explained by David McMahon: 1st Edition, IEEE Press

Reference Books:

1. Quantum Computation and Quantum Information, Michael A. Nielsen & Isaac L. Chuang, Cambridge University Press.
2. Quantum Computer Science: An Introduction, N. David Mermin, Cambridge University Press.
3. Quantum Computing: A Gentle Introduction, Eleanor Rieffel& Wolfgang Polak, MIT Press.
4. An Introduction to Quantum Computing, Phillip Kaye, Raymond Laflamme, and Michele Mosca,
5. IBM Quantum Experience (https://quantum-computing.ibm.com/)
6. Qiskit Textbook: Learn Quantum Computation using Qiskit (https://qiskit.org/textbook)

Course Title: **Python Programming**
Course Code: **PHY-353-MJ**
Credits: **02**
Type of Course: **Major**

Contact Hours: 2 hours per week (Total: 32 lecture)
Internal assessment: 50% (30% Exam (45 min) and 20% assignments/presentations)
End-Term Examination: 50% (1. 15 Hours)

Course Objectives

To introduce the fundamental concepts of programming using Python, emphasizing problem-solving.

Course Outcome

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

- Understand Python fundamentals including syntax, variables, data types, and control structures.
- Apply Python functions, loops, and file handling for solving basic computational problems.
- Use Python libraries like NumPy and Matplotlib for data analysis and visualization.
- Develop small programs for automating tasks and solving real-world problems.
- Demonstrate the ability to process, interpret, and visualize data effectively using Python tools

Course Title: Python Programming **Credits: 02**
Course Code: PHY-353-MJ **L 2 T 0 P 0**

Unit I

Overview of programming; Installing Python; Using IDLE/Jupyter/Colab; Syntax, keywords, variables, data types, operators, expressions, and input/output. Conditional statements (if, elif, else); Loops (for, while); Range function; Functions and parameters; Lambda functions; Exception handling; Basic programming exercises.

Unit II

Lists, tuples, dictionaries, sets; Indexing and slicing; String manipulation; Reading and writing files; Handling CSV data; Basic data processing. Introduction to NumPy; Arrays, indexing, slicing, and vectorized operations; Simple computations and statistics; Introduction to Pandas for tabular data; Basic data analysis tasks.

Introduction to Matplotlib; Line, bar, and scatter plots; Multiple plots; Adding labels, legends, and styles; Visualizing datasets and trends. Introduction to Matplotlib; Line, bar, and scatter plots; Multiple plots; Adding labels, legends, and styles; Visualizing datasets and trends.

Text Books:

1. Mark Lutz, Learning Python, O'Reilly Media.

Reference Books:

2. Al Sweigart, Automate the Boring Stuff with Python.
3. Charles R. Severance, Python for Everybody.
4. Wes McKinney, Python for Data Analysis, O'Reilly.
5. Python documentation: https://docs.python.org/3/
6. NumPy and Matplotlib official documentation

Course Title: **Lab-II**
Course Code: **PHY-354-MJ**
Credits: **02**
Type of Course: **Major**

Contact Hours: 2 labs per week (Total: 32 Labs)
Internal assessment: 50% (30% Exam (45 min) and 20% assignments/presentations)
End-Term Examination: 50% (1. 15 Hours)

Course Objectives

The main objective of the course is to train students to realize the various physics concepts learnt in the class room in the laboratory and understand the various aspects of scientific measurement which include error analysis, data fitting and data interpretation.

Course Outcome

On completion of the course, student will be able:

- To gain practical knowledge by applying the experimental methods to correlate with the physics theory.
- To learn the usage of electrical and optical systems for various measurements.
- To apply the analytical techniques and graphical analysis to the experimental data.
- To develop intellectual communication skills and discuss the basic principles of scientific concepts in a group.

Course Title: Lab-II **Credits: 02**
Course Code: PHY-354-MJ **L 0 T 0 P 2**

A student will have to perform 05 experiments from the following list of experiments available

1. To determine the g-factor by the ESR Spectrometer.
2. To design and study the characteristics of FET (Using breadboard).
3. Study of Hysteresis loop of Magnetic Materials; To verify B-H curve and to find out the values of coercivity, retentivity and saturation magnetization of experimental materials.
4. Design and study operational amplifier as Integrator and differentiator
5. To study Poisson and Gaussian distributions using a GM counter.
6. To study the e/m ratio of an electron by Thompson Method.
7. To study the characteristics of PIN diode.
8. To study the specific heat of solids.
9. To identify the retrograde motion of Planets with respect to the Background stars.
10. To measure astronomical distances using Cepheid variables

Reference Books:

1. A Textbook of Practical Physics, Indu Prakash, Ram Krishna and A. K. Jha Vol 1 and 2, Kitab Mahal
2. Practical Physics, C.L. Arora S. Chand Publication.
3. Advanced Practical Physics, B.L. Worsnop and H. T. Flint , Asia Publishing House
4. Virtual Astronomy and Astrophysics Laboratory, https://va-iitk.vlabs.ac.in/?page=listexp

Semester VII

Course Title: **Mathematical Physics - II**
Course Code: **PHY-400-MJ**
Credits: **04**
Type of Course: **Major**

Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)
Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/presentations)
End-Term Examination: 50% (2. 5 Hours)

Course Objectives

To impart knowledge about various mathematical tools employed to study physics at an advanced level.

Course Outcome

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

- Learn the fundamentals and applications of complex variables, analytic functions, Cauchy Riemann relations, residues and Taylor and Laurent expansions of complex fuctions.
- Learn fundamentals and applications of group theory.
- Develops ability to handle physics problems involving tensors.
- Will be familiar with special functions like Bessel functions, Laguerre and Hermite polynomials and their properties.
- Learn Green's function and calculation of Green's function of second order linear differential equations.
- Handle special functions like the Dirac Delta function and beta and gamma functions to tackle various physical problems.

Course Title: Mathematical Physics - II **Credits: 04**
Course Code: PHY-400-MJ **L 3 T 1 P 0**

Unit I
Functions of a complex variable, Analytic functions, Cauchy-Riemann relations, Conjugate and harmonic nature of the real and imaginary parts of an analytic function, Cauchy's theorem, Cauchy's integral formula, Taylor and Laurent expansions, classification of singularities, The Point at Infinity; Calculus of Residues, Residues at Infinity, residue theorem, Evaluation of definite integrals using Cauchy's residues.

Unit II
Basic definition of a group, examples of groups in physics, conjugate elements and classes, subgroup, cyclic group, concept of isomorphism and homomorphism, representation of groups by matrices, reducible and irreducible representations (introductory ideas), orthogonality of representations.

Unit III
Bessel functions of First kind, Orthogonality, Neuman Functions, Hankel Functions, Modified Bessel Functions, Spherical Bessel Function; Legendre Functions, Orthogonality, Associated Legendre Function, Hermite Functions, Laguerre Functions.

Unit IV
Green's Functions in One Dimension: Calculation of Green's Functions for simple differential operators, Green's Function for the Laplacian, Green's Functions for Second order Linear Differential Operators (SOLDOs), Dirac delta function and its properties, Gamma and beta functions

Text Book:

1. Mathematical Methods for Physicists, G. B. Arfken and H. J. Weber, Academic Press

Reference Books:

2. Mathematical Methods for Students of Physics and Related Fields, Sadri Hassani, Springer,
3. Matrices and Tensors in Physics, A. W. Joshi, New age international publishers.
4. Advanced Engineering Mathematics, Michel D. Greenberg, Prentice Hall, 2^{nd} ed.
5. Elements of Group Theory for Physicists, A. W. Joshi, New Age Publishers, 4^{th} ed.

Course Title: **Quantum Mechanics - II**
Course Code: **PHY-401-MJ**
Credits: **04**
Type of Course: **Major**

Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)

Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance) End-Term Examination: (2.5 Hours) 50%

Course Objectives

The main objective of this course is to expose the students to the approximation methods in quantum mechanics such as the Variational Method, WKB approximation and perturbation theory. The other objectives are to teach scattering theory and the relativistic theory of quantum mechanics viz. Klein-Gordon equation and Dirac equation

Course Outcome

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

- Understand the physics behind such technologies as Nuclear Magnetic Resonance Imaging, Lasers etc.
- Learn the quantum mechanics of scattering and its role to understand matter at subatomic level.
- To learn the quantum mechanics of identical particle systems.
- To learn the advanced concepts of relativistic quantum mechanics involving the Klein-
- Gordon and the Dirac equations.

Course Title: Quantum Mechanics - II **Credits: 04**
Course Code: PHY-401-MJ **L 3 T 1 P 0**

Unit I

Time independent perturbation theory: Non-degenerate and Degenerate energy level, Applications, Variational Method, Applications: ground state of Helium atom.

Time dependent perturbation theory; Statement of the problem, Approximate solution of the Schrodinger equation, Transition probability, Constant perturbation, Harmonic perturbation, Transition to the continuum, The Fermi golden rule.

Unit II

WKB approximation, the classical region, connection formulae.

Definition and interpretation of Scattering cross-section, Asymptotic behaviour of wave function and scattering amplitude, Relation between scattering amplitude and scattering cross-section, Solution of Schrödinger equation for scattering (Lippmann-Schwinger equation), Born approximation,validity of Born's approximation. Scattering by a spherically symmetric potential, Coulomb Scattering.

Method of partial waves, Expansion of a plane wave in terms of partial waves, Scattering by a central potential, Optical theorem.

Unit III

Many particle systems, systems of identical particles, exchange degeneracy, symmetrization postulate, construction of symmetric and anti-symmetric wave functions from unsymmetrized functions, Slater determinant, The Pauli Exclusion Principle and spin statistics connection, spin angular momentum, Density operator and density matrix.

Unit IV

Klein-Gordon equation, charge and current densities for KG equation, Plane wave solution of KG equation, problems with KG equation, Dirac equation, Dirac matrices and their properties, plane wave solution of free particle Dirac equation, significance of negative energy solutions (Dirac's hole theory), spin angular momentum of the Dirac particle, Electron in electromagnetic field, Covariance of KG and Dirac equations.

Text Book:

1. . Principles of Quantum Mechanics, R. Shankar, 2ndedition, Springer

Reference Books:

2. Modern Quantum Mechanics, J. J. Sakurai and J. J. Napolitano, 2ndedition, Pearson Publications.
3. Quantum Mechanics, L. I. Schiff, 4thedition ,McGraw Hill
4. Quantum Mechanics by L.D. Landau and E. M.Lifshitz, 3rdedition, Elsevier.
5. Quantum Mechanics Concepts and Applications by N. Zettili, 2nd edition, John Wiley.

Course Title: **Atomic and Molecular Physics**
Course Code: **PHY-402-MJ**
Credits: **04**
Type of Course: **Major**

Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)

Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance) End-Term Examination: 50% (2.5 Hours)

Course Objectives

To develop basic theoretical and experimental knowledge in Atomic and Molecular Spectroscopy and appreciate its application in material characterization.

Course Outcome

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

Understand the quantum and classical foundations of radiative processes in atoms and molecules.
Apply quantum mechanical models to describe radiative transitions and predict spectral line shapes.
Analyze fine and hyperfine structures of atoms and explain spectroscopic effects under magnetic and electric fields.
Interpret rotational, vibrational, and electronic spectra of diatomic molecules and explain resonance-based spectroscopies

Course Title: Atomic and Molecular Physics **Credits: 04**
Course Code: PHY-402-MJ **L 3 T 1 P 0**

Unit I

Classical and quantum theories of radiative transitions, radiating dipole model, time-dependent perturbation theory (first-order), electric dipole (E1) transitions, dipole selection rules, magnetic dipole (M1) and electric quadrupole (E2) transitions (qualitative), radiative lifetimes, natural linewidth due to Heisenberg uncertainty, Doppler broadening due to thermal motion, pressure (collision) broadening, Lorentzian and Gaussian line shapes, Voigt profile (qualitative), converting between linewidth in frequency and wavelength units, resonant excitation via absorption and emission, non-resonant excitation and comparison with the classically bound electron model.

Unit II

Spin-orbit interaction and fine structure in hydrogen and hydrogen-like atoms, relativistic corrections and Lamb shift (Retherford experiment), hyperfine structure due to nuclear spin interactions, isotope shift including normal and specific mass shifts, term symbols and spectroscopic notation, Hund’s rules and energy ordering in multi-electron atoms, LS coupling and JJ coupling schemes, Lande interval rule, Breit scheme, external field effects including normal and anomalous Zeeman effect, Paschen–Back effect, Stark effect (linear and quadratic).

Unit III

Born–Oppenheimer approximation and molecular potential energy curves, rotational spectra of diatomic molecules using rigid and non-rigid rotator models, vibrational spectra using harmonic and anharmonic oscillator models, vibrational–rotational coupling, selection rules and isotope effects, electronic transitions in molecules and the Franck–Condon principle, vibrational structure in electronic spectra, dissociation energy, molecular term symbols, isotope effect in electronic spectra.

Unit IV

Raman effect with classical and quantum theory, selection rules and comparison with IR spectroscopy, resonance techniques including Electron Spin Resonance spectroscopy and applications, Nuclear Magnetic Resonance Spectroscopy: Hydrogen Nuclei, Nuclei other than Hydrogen, Techniques and Instrumentation, Principles of Mössbauer Spectroscopy, Applications of Mössbauer Spectroscopy.

Text Book:

1. Physics of Atoms and Molecules, B.H. Bransden and C.J. Joachain, Pearson Education.

Reference Books:

2. The Physics of Atoms and Quanta: Introduction to Experiments and Theory by H. Haken and H.C. Wolf, Springer.
3. Fundamentals of Molecular Spectroscopy, C.N. Banwell and E.M. McCash, McGraw Hill.

4. Molecular Spectra and Molecular Structure: Spectra of Diatomic Molecules, Gerhard Herzberg, Krieger Publishing Company.
5. Spectra of Atoms and Molecules, Peter F. Bernath, Oxford University Press.

Course Title: **Research Methodology**
Course Code: **PHY-403-MJ**
Credits: **02**
Type of Course: **Major**

Contact Hours: 2 hours per week (Total: 32 lecture)
Internal assessment: 50% (30% Exam (45 min) and 20% assignments/presentations)
End-Term Examination: 50% (1. 15 Hours)

Course Objectives

The purpose of this course is to make students understand how to carry out the scientific research and give them the knowledge of Scientific writing and presentation.

Course Outcome

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

- Learn various tools to carry out the research work.
- Know ethical issues in educational *research*.
- Learn scientific paper, thesis and project writing

Course Title: Research Methodology **Credits: 02**

Course Code: PHY-403-MJ **L 2 T 0 P 0**

Unit I

What is science? Scientific reasoning, Scientific Temper, Scientific Method, Scientific measurement, The Criteria for Good Measurement.

Introduction to Research, Types of research: exploratory, conclusive, modeling and algorithmic, Identification of research problems, formulation of a problem, Data collection: data analysis, interpretation of results and validation of results.

Unit II

Scientific Writing: Goals and Objectives, Structure of documents, importance of clear title, abstract or summary, Introduction, Methods, Results and Discussion, Illustrations and aids

Numbers and statistics, Tables and Figures, Language and grammar, writing proposals and instructions, making presentations, Formatting documents, Drafts and revisions, Editing, Writing popular science / journal article, Science fiction.

Text Book:

1. Research Methodology: Methods & Techniques, C.R. Kothari New Age International Publishers, New Delhi

Reference Books

2. Research Methodology: An introduction for science and engineering students, Stuart Milville & Wayne Goddard, McGraw Hill International.
3. Research Methodology, N. Thanulingon , Himalaya Publishing House, New Delhi
4. Research Methodology, R. Pannerselvam Prentice Hall of India Pvt. Ltd
5. The Craft of Scientific Writing, Michael Alley, Springer, New York.
6. Science and Technical Writing – A Manual of Style,Philip Reubens (General editor), Routledge, New York.
7. Writing Remedies – Practical Exercises for Technical Writing Edmond H. Weiss, Universities Press (India) Ltd., Hyderabad..
8. Effective Technical Communication, M. Ashraf Rizvi, Tata Mc Graw – Hill, New Delhi.

Course Title: **Lab-III**
Course Code: **PHY-404-MJ**
Credits: **02**
Type of Course: **Major**

Contact Hours: 4 labs per week (Total: 32 labs)
Internal assessment: 50% (30% Exam (45 min) and 20% assignments/presentations)
End-Term Examination: 50% (1.15 Hour)

Course Objectives

The main objective of the course is to train students to realize the various physics concepts learnt in the class room in the laboratory and understand the various aspects of scientific measurement which include error analysis, data fitting and data interpretation.

Course Outcome

On completion of the course, student will be able:

- To gain practical knowledge by applying the experimental methods to correlate with the physics theory.
- To learn the usage of electrical and optical systems for various measurements.
- To apply the analytical techniques and graphical analysis to the experimental data.
- To develop intellectual communication skills and discuss the basic principles of scientific concepts in a group.

Course Title: Lab - III **Credits: 04**
Course Code: PHY-404-MJ **L 0 T 0 P 2**

A student will have to perform 05 experiments from the following list of experiments available.

1. To determine the g-factor by the NMR Spectrometer.
2. To study the Meissner effect.
3. To determine magnetic susceptibility of a paramagnetic/diamagnetic material using Quincke's tube method.
4. Frank-Hertz Experiment: To demonstrate the concept of quantisation of energy levels according to Bohr's model of atom.
5. To study Zeeman Effect and to measure the value of Bohr Magnetron.
6. To verify de-Broglie hypothesis using electron diffraction.
7. Study of dielectric constant and determination of Curie temperature of Ferroelectric ceramics.
8. To identify some of the prominent spectral lines in the spectrum of the sun.
9. To measure planetary distances.
10. To determine observer's location by means of the stars.

Reference Books:

1. A Textbook of Practical Physics, Indu Prakash, Ram Krishna and A. K. Jha Vol 1 and 2, Kitab Mahal
2. Practical Physics, C.L. Arora S. Chand Publication.
3. Advanced Practical Physics, B.L. Worsnop and H. T. Flint , Asia Publishing House.
4. Virtual Astronomy and Astrophysics Laboratory, https://va-iitk.vlabs.ac.in/?page=listexp

Semester VIII (Hons.)

Course Title: **Numerical Methods**
Course Code: **PHY-450-MJ**
Credits: **04**
Type of Course: **Major**

Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)

Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance) End-Term Examination: 50% (2.5 Hours)

Course Objectives

- To develop an understanding of numerical methods for finding the roots of algebraic and transcendental equations and to analyse the propagation of errors in numerical computations.
- To introduce various interpolation techniques and spline functions for estimating unknown values and analysing errors in polynomial and numerical approximations.
- To enable students to understand and apply numerical techniques for differentiation and integration of tabulated data with error estimation.
- To familiarize students with numerical techniques for solving ordinary and partial differential equations using iterative and approximation methods.

Course Outcome

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

- apply appropriate numerical techniques to obtain approximate solutions of nonlinear equations with due consideration to error analysis.
- apply interpolation methods and spline techniques to approximate functions and datasets, and evaluate associated interpolation errors effectively.
- compute derivatives and definite integrals using numerical methods such as Trapezoidal, Simpson's, and Romberg rules, and analyse the accuracy of these approximations.

- apply numerical methods such as Euler’s, Runge-Kutta, Jacobi, and Gauss-Seidel techniques to obtain approximate solutions of ordinary and partial differential equations with reasonable accuracy.

Course Title: Numerical Methods **Credits: 04**
Course Code: PHY-450-MJ **L 3 T 1 P 0**

Unit I

Some mathematical preliminaries, Errors and their computations, General error formula, errors in a series approximation, Solution of Algebraic and Transcendental equations: Bisection Method, Method of False Position, Iteration Method, Newton- Raphson Method, Ramanujan’s Method, Secant Method.

Unit II

Interpolation, Errors in Polynomial Interpolation, Finite differences (forward, backward and central differences), symbolic relations and separation of symbols, Detection of Errors by use of difference tables, Differences of a polynomial, Newton’s formulae for interpolation. Central difference interpolation formula: Gauss central difference formula, Stirling’s formula. Spline functions: Linear, Quadratic and Cubic Splines.

Unit III

Numerical differentiation, Errors in numerical differentiation, Cubic Spline Method, Differentiation formulae with Function values, Maximum and minimum values of a tabulated function.Numerical Integration: Trapezoidal rule, Simpson’s 1/3 and 3/8 rule. Boole’s and Weddle’s rules, Romberg integration.

Unit IV

Numerical solution of ODEs: Solution by Taylor’s series, Picard’s Method of successive approximations, Euler’s Method, Error Estimates for the Euler’s Method, Modified Euler’s Method, Runge Kutta methods: Second and Fourth order. Numerical solution of Partial Differential Equations: Laplace’s Equation: Finite difference approximations to derivatives, Solution of Laplace’s equation by Jacobi’s method and Gauss Seidel method.

Text Books:

1. Introductory Methods of Numerical Analysis, S. S. Sastry, PHI.

Reference Books:

2. Numerical Mathematical Analysis, J. B. Scarborough, The John Hopkins University Press
3. An Introduction to Numerical Analysis, K. E. Atkinson, John Wiley.

4. Fortran For Scientists & Engineers, Stephen Chapman, McGraw Hill Education.

Course Title: **Astrophysics**
Course Code: **PHY-451-MJ**
Credits: **02**
Type of Course: **Major**

Contact Hours: 2 hours per week (Total: 32 lecture)

Internal assessment: 50% (30% Exam (45 min) and 20% assignments/attendance)

End-Term Examination: 50% (1.15 Hours)

Course Objectives

To familiarize and expose students to various fields, basic principles and theories of astronomy and astrophysics. The aim of this particular course is to provide knowledge of formation, evolution, classification of stars in particular. Also, this course will focus on large-scale structure and dynamics of the universe, including observational evidence for cosmic expansion

Course Outcome

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

- Understand the fundamental observational properties of stars and their role in stellar classification and evolution.
- Learn the physical principles governing the internal structure and energy transport in stars.
- Develop an overview of the large-scale structure and dynamics of the universe, including observational evidence for cosmic expansion.
- Familiarize themselves with key cosmological models and the role of dark matter and dark energy in modern cosmology

Course Title: Astrophysics **Credits: 02**
Course Code: PHY-451-MJ **L 2 T 0 P 0**

Unit I
Celestial coordinate systems: Horizontal and Equatorial coordinate system, Interstellar medium, Jeans instability, protostars, Apparent & absolute magnitude, colors, distance modulus, Luminosity, temperature, stellar classification, Main sequence, giants, dwarfs, Evolution across H–R diagram (qualitative), Hydrostatic equilibrium, Energy generation and Energy Transport, Mass–luminosity relation (qualitative)..

Unit II
Cosmology: Newtonian cosmology, simplifying assumptions, cosmological principle, Redshift, Hubble's law, Einstein universe (static), FLRW metric idea, Friedmann models (qualitative), CMBR, Dark Matter, Dark Energy, Steady state theory (Qualitative idea & observational failure).

Text Book:

1. An Introduction to Astrophysics, Baidyanath Basu, PHI Learning Pvt.
2. Introduction to Cosmology, 3rd Edition, J. V. Narlikar, Cambridge University Press.

Reference Books:

3. The Physical Universe: An Introduction to Astronomy, Frank H. Shu, Mill Valley: University Science Books.
4. Theoretical Astrophysics, Volume III: Galaxies and Cosmology, T. Padmanabhan, Cambridge University Press.

Course Title: **Fourier Optics**
Course Code: **PHY-452-MJ**
Credits: **02**
Type of Course: **Major**

Contact Hours: 2 hours per week (Total: 32 lecture)

Internal assessment: 50% (30% Exam (45 min) and 20% assignments/attendance)

End-Term Examination: 50% (1.15 Hours)

Course Objectives

To develop understanding of the optical systems using Fourier analysis

Course Outcome

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

- Understand the fundamentals of signal sampling.
- Understand Fourier domain analysis of diffraction theory
- To know frequency response of optical systems under coherent and incoherent illumination.
- To understand working of various imaging system

Course Title: Fourier Optics **Credits: 02**
Course Code: PHY-452-MJ **L 2 T 0 P 0**

Unit I
Signals and systems, Fourier Transform(FT), Sampling theorem; Diffraction theory; Fresnel-Kirchhoff formulation and angular spectrum method, brief discussion of Fresnel and Fraunhofer diffraction, FT Properties of lenses and Image formation by a lens; Frequency response of a diffraction-limited system under coherent and incoherent illumination, OTF- effects of aberration and apodization.

Unit II
Comparison of coherent and incoherent imaging, Analog optical information processing: Abbe-Porter experiment, phase contrast microscopy, Image restoration: Inverse and Wiener Filters; Coherent image processing: Vander Lugt filter; Joint-transform correlator; Synthetic Aperture Radar. Basics of holography, in-line and off-axis holography; Super-resolution: Structured Illumination microscopy; Ghost Imaging

Text Book:
1. Introduction to Fourier optics, Goodman, J. W., New York, McGraw-Hill.

Reference Book:
2. Fourier Optics and Computational Imaging. Khare, Kedar, John Wiley and Sons.

Course Title: **Physics of Functional Materials**
Course Code: **PHY-453-MJ**
Credits: **02**
Type of Course: **Major**

Contact Hours: 2 hours per week (Total: 32 lecture)

Internal assessment: 50% (30% Exam (45 min) and 20% assignments/attendance)

End-Term Examination: 50% (1.15 Hours)

Course Objectives

- To provide the students with the understanding of synthesis/growth, structure, and properties of the functional materials.
- To develop an understanding of the usage of functional materials as a component of modern devices.

Course Outcome

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

- Investigate and correlate the different way of synthesis, characterization, and application of functional materials.
- Integrate the understanding of functional materials' properties and their applications.

Course Title: Physics of Functional Materials **Credits: 02**
Course Code: PHY-453-MJ **L 2 T 0 P 0**

Unit I

Material synthesis and processing of functional materials: Bulk Synthesis: Solid state synthesis, Sol-Gel synthesis, Thin-Film synthesis: Sputtering, Molecular beam epitaxy, CVD, 3D printing, electrospinning.

Defects in solids: Defect types and dimensionality effect on defects, Characterization (morphological and spectroscopic), Control of defects.

Unit II

Semiconductor materials: Band structure, Doping, Band-Gap engineering.

Applications: Beyond Si semiconductors, GaN, GaAs, SiC, Ga2O3, LEDs, and photovoltaic cells (CdS, CIGS, CZTS, Perovskites and Organic solar cell materials).

Materials for energy applications: Thermoelectric materials: ZT value, Band-Gap, Heusler alloys, Peltier cooling, Thermoelectric generator, Dielectric, Piezoelectric, Ferroelectric materials and applications. Magnetic materials & applications: Magnetic exchange energy, anisotropy energy, Magnetic domains, Application of soft and hard magnetic materials, Magnetic data storage,

Optical materials: Optical lithography, and Electro-optic materials.

Text Book:

1. The Science and Engineering of Materials, Askeland, D.R., Phule, P.P., Wright, W.J., Cengage Learning, 2010.

Reference Books:

2. Materials science and Engineering: An Introduction, Callister, W.D., Rethwisch, D.G., 8th edition, Wiley, 2010.
3. An Introduction to Materials Engineering and Science for Chemical and Materials Engineers, Mitchell, B.S., Wiley- Interscience, 2003.
4. Introduction to Solid State Physics, . Kittel, C., 8th edition, Wiley, 2005.
5. Principles of Electronic Materials and Devices, Kasap, S.O., 3rd edition, McGraw-Hill, 2006.
6. Science & Engineering: Raghavan, V., Materials A first course, 5th edition, PHI Learning, 2004.
7. Online Course Material 1. Haridoss, P., Physics of Materials, NPTEL Course Material, Department of Metallurgy & Material Science, Indian Institute of Technology Madras, https://nptel.ac.in/courses/113/106/113106039/.

Course Title:	**Advanced Nuclear Physics**
Course Code:	**PHY-454-MJ**
Credits:	**02**
Type of Course:	**Major**

Contact Hours: 2 hours per week (Total: 32 lecture)

Internal assessment: 50% (30% Exam (45 min) and 20% assignments/attendance)

End-Term Examination: 50% (1.15 Hours)

Course Objectives

To understand the advanced concepts of nuclear physics in order to enable a student to take up research in nuclear theory. The other objective involves imparting the knowledge of some important theoretical tools such as the rotation of spherical harmonics and second quantization that are used in a variety of physical problems.

Course Outcome

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

- Understand the quantum mechanics of a 3D harmonic oscillator, both isotropic as well as anisotropic.
- Parametrization of a 3D surface and its rotation in terms of spherical harmonics.
- Understand the origin and need of second quantization.
- The student will learn the Nilsson model of nucleus.
- The student will learn the Particle Rotor Model of nucleus.

Course Title: Advanced Nuclear Physics **Credits: 02**
Course Code: PHY-454-MJ **L 2 T 0 P 0**

Unit I

Three-dimensional isotropic harmonic oscillator (wave-functions in cartesian, spherical and cylindrical coordinates), LS coupling.

Parametrization of surface deformation, Types of multipole deformations, Quadrupole deformation, Two-level mixing, Rotation of spherical harmonics, D-matrix and it's properties.

Unit II

Introduction of second quantization, Second quantization for bosons and fermions, One-body and two-body operator in second quantization.

Review of spherical shell model, Nilsson Model; The potential, Nilsson model (Qualitative treatment).

Nilsson model (exact treatment), solution of hypergeometric function, The asymptotic quantum numbers.

Particle-Rotor mode: Hamiltonian, wave-function and transition matrix elements.

Text Book:

1. The Nuclear many-Body Problem, Text & Monographs in Physics, Peter Ring and Peter Schuck, Springer-Verlag New-York.

Reference Books:

2. Theory of Nuclear Structure, M.K. Pal, Affiliated East - West, Madras.
3. Nuclear Models, Greiner and Maruhn, Springer International.
4. Atomic and Nuclear Physics, S. N. Ghosal, S. Chand.
5. Introduction to Nuclear Physics, H. A. Enge, Addison-Wesley.
6. Introductory Nuclear Physics, P. E. Hodgson, and E. Gadoili, OUP, illustrated ed.

Course Title: **Laser and Fiber Optics**
Course Code: **PHY-455-MJ**
Credits: **04**
Type of Course: **Major**

Contact Hours: 2 hours per week (Total: 52 lecture + 12 tutorials)

Internal assessment: 50% (30% Exam (45 min) and 20% assignments/attendance)

End-Term Examination: 50% (1.15 Hours)

Course Objectives

This course aims to introduce the fundamental principles of laser operation, characteristics and applications. It also covers essentials of optical fiber technology

Course Outcome

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

- Explain the mechanisms of laser action, including spontaneous and stimulated emission, and population inversion.
- Analyze and solve rate equations for two-, three-, and four-level laser systems. Understand different laser gain and broadening mechanisms and compute threshold conditions.
- Examine laser resonator designs, longitudinal and transverse modes, and Q-switching/ mode-locking methods.
- Describe and compare the working of key laser systems (e.g., He-Ne, Nd:YAG, CO_2, Dye, Ruby, Diode).
- Understand spatial and temporal coherence, CW and pulsed laser outputs, and evaluate laser applications in diverse fields.
- Develop an understanding of light propagation in optical fibers, including total internal reflection, numerical aperture, modes, and dispersion.
- Understand transmission characteristics of optical fibers, covering attenuation mechanisms, pulse broadening, and bandwidth considerations.
- Gain exposure to optical components, fabrication techniques, and measurement methods used in laser and fiber optic systems.

Course Title: Laser and Fiber Optics **Credits: 04**
Course Code: PHY-455-MJ **L 3 T 1 P 0**

Unit I

Spontaneous and stimulated emission, Einstein coefficients and their relations, Population inversion and conditions for amplification, Optical pumping mechanisms, Two-level, three-level, and four-level atomic systems, Role of metastable states in achieving population inversion, Rate equations for laser systems, Threshold condition for laser action, Concept of optical gain and saturation intensity, Broadening mechanisms: Natural, Doppler, and collision broadening, Line shape functions: Lorentzian and Gaussian, Temporal and spatial coherence, Pulse vs. continuous wave (CW) operation, Pulse duration, repetition rate, and power characteristics.

Unit II

Resonator configurations: Planar, confocal, and spherical; Longitudinal and transverse modes, Mode selection and resonator stability criteria, Quality factor (Q) of the cavity, Q-switching and mode-locking (qualitative), Detailed study of major lasers: Ruby laser, He-Ne laser, Nd:YAG laser, CO2 laser, Dye laser, and Semiconductor diode laser, CW and pulsed output characteristics, Applications of lasers in industry, medicine, communication, spectroscopy, and research, Basic laser safety and handling.

Unit III

Need for optical communication, Structure of an optical fiber, Salient features of optical fibers, Total internal reflection (TIR), ray theory of light guidance, Critical angle, acceptance angle, numerical aperture, types of optical fibers, modes of a fiber, step-index and graded-index fibers, single and multimode fibers, fiber fabrication techniques, Applications of optical fibers.

Unit IV

Transmission characteristics of optical fibers, pulse broadening mechanism , Attenuation Mechanisms, Absorption losses (material, impurity, UV/IR), Scattering losses (Rayleigh), Bending losses (macro & micro bending), Dispersion in fibers, Modal dispersion, Chromatic dispersion, Polarization mode dispersion (PMD), intermodal dispersion, bit rate - length product.

Text Book:

1. Lasers: Fundamentals and Applications, Thyagarajan, K., & Ghatak, A.K. – Springer.

Reference Books:

2. Principles of Lasers, Springer, Svelto, O., 5th Ed.
3. Optical Fiber Communications, John M. Senior, Pearson Prentice Hall.
4. Introduction to Fiber Optics, Ghatak, A. and Thyagrajan K., Cambridge University Press.
5. Quantum Optics: An Introduction, Fox, M., Oxford University Press.
6. Laser Spectroscopy and Instrumentation: W. Demtroder., fourth Edition, 2008, ISBN: 978-3-662-08260-7

Course Title: **Electronic Devices and Digital Electronics**
Course Code: **PHY-456-MJ**
Credits: **04**
Type of Course: **Major**

Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)

Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance) End-Term Examination: 50% (2.5 Hours)

Course Objectives

The objective of the course is to introduce digital electronics and its simple applications to physics students. The course is designed to familiarize the students with the different number systems (binary, octal and hexadecimal), laws of Boolean algebra, logic gates and combinational and sequential logic circuits utilized in designing counters and registers.

Course Outcome

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

- Digital signals, positive and negative logic, Boolean variables, truth table, various number system codes and their inter-conversions.
- Students will be able to learn to minimise a given Boolean function using laws of Boolean algebra and Karnaugh map to minimise the hardware requirement of digital logic circuits.
- Understand the working principle of data processing circuits, arithmetic circuits, sequential logic circuits, registers, counters based on flip flops

Course Title: Electronic Devices and Digital Electronics **Credits: 04**
Course Code: PHY-456-MJ **L 3 T 1 P 0**

Unit I

Biasing technique to BJT, fixed bias, emitter feedback bias, voltage divider bias, small signal BJT amplifiers, ac and dc equivalent circuits, hybrid model and hybrid parameters, approximate analysis of CE amplifier using h-parameters.
Field Effect Transistors (FET) and MOS-FET: Structure, Working, Derivations of the equations for I-V characteristics under different conditions.

Unit II

Feedback Principle, Negative feedback, effect of negative feedback on input/output resistances, voltage gain, gain stabilization, band width, Oscillators: Oscillator operation, Phase shift Oscillator, Wien-bridge Oscillator, Hartley Oscillator. Block diagram of an operational amplifier – Characteristics of an ideal operational amplifier, Differential amplifier: voltage gain. Applications of op-amp, summing amplifier, inverting and non-inverting configurations, subtractor, difference summing amplifier, Integrator. Instrumentation amplifier.

Unit III

Difference between analog and digital circuits, binary number, decimal to binary and binary to decimal conversion, BCD, octal and hexadecimal numbers, signed and unsigned form, 1's and 2's complement representation, binary addition, binary subtraction using 2's complement, AND, OR and NOT gates (realization using diodes and transistors), NAND and NOR gates as universal gates, XOR and XNOR gates, De Morgan's theorems, Boolean laws.

Unit IV

Simplification of logic circuit using Boolean algebra, fundamental products, idea of minterms and maxterms. conversion of truth table into equivalent logic circuit by (1) Sum of Products method and (2) Karnaugh map simplification (upto four variables). Multiplexers and its applications, de-multiplexers, decoders, encoders, Comparators.

Text Book:

1. Digital Principles and Applications, A. P. Malvino, D. P. Leach and Saha, 7th edition, 2011, Tata McGraw

Reference Books:

2. Fundamentals of Digital Circuits, A. Kumar, 2nd edition, 2009, PHI Learning Pvt. Ltd.
3. Digital Fundamentals, T. L. Floyd, 1994, Pearson Education Asia
4. Digital Principles and Applications, D. P. Leach and A. P. Malvino, 1995, Tata McGrawHill
5. Digital Design, M. M. Mano and M. D. Ciletti, 2007, Pearson Education Asia.
6. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
7. Digital Electronics G. K. Kharate, 2010, Oxford University Press

Course Title: **Plasma Physics**
Course Code: **PHY-457-MJ**
Credits: **02**
Type of Course: **Major**

Contact Hours: 2 hours per week (Total: 32 lecture)

Internal assessment: 50% (30% Exam (45 min) and 20% assignments/attendance)

End-Term Examination: 50% (1.15 Hours)

Course Objectives

The purpose of this course is to make students understand the physics of plasma. This course will convey how our understanding of plasma physics extends to a description of a huge diversity of systems over varying scales of space, time, density, and temperature

Course Outcome

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

- Understand the basics of plasma state and its defining features
- Explore the properties and applications of plasma physics
- Understand the behavior of charged particles under different configuration of electric and magnetic fields
- Understand the fluid behavior of plasma

Course Title: Plasma Physics **Credits: 02**
Course Code: PHY-457-MJ **L 2 T 0 P 0**

Unit I

Plasma: definition and elementary concepts, concept of temperature, Debye Shielding and Debye length, Plasma Parameters and criteria for plasma, plasma frequency, important applications of plasma physics: Controlled Thermonuclear fusion, The magnetohydrodynamic generator, Plasma Propulsions and other plasma devices.

Production of plasma in laboratory: DC discharge, RF discharge and photo-ionization.

Unit II

Single particle motion in uniform E and B fields, single particle motion in non-uniform E and B fields, motion in time varying electromagnetic fields, Guiding and center drifts, tokamak confinement.

Plasmas as fluids, the fluid equation of motion, equation of continuity and state, Linear wave analysis.

Text Book:

1. Introduction to Plasma Physics and Controlled Fusion, F. F. Chen, Springer, 2nd ed

Reference Books:

2. Fundamentals of Plasma Physics, J. A. Bittencourt, Springer, 3rd ed.
3. Principles of Plasma Physics, N. A. Krall, and A. W. Trivelpiece, Mc Graw Hill.
4. Space Plasma Physics, A. C. Das, Narosa Publishing House.

Course Title: **Radiation Physics**
Course Code: **PHY-458-MJ**
Credits: **02**
Type of Course: **Major**

Contact Hours: 2 hours per week (Total: 32 lecture)

Internal assessment: 50% (30% Exam (45 min) and 20% assignments/attendance)

End-Term Examination: 50% (1.15 Hours)

Course Objectives

To understand the basic concepts of radiation physics and its application in the medical science. Also, the aim is to make students familiarize with the construction of various radiotherapy units and their working principle.

Course Outcome

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

- Understand the basic principles of radiation physics and various radiotherapy units.
- Understand the basic physics of the electromagnetic and particulate forms of ionizing & non ionizing radiation.
- Understand the distinctions between the units of radiation quantity, exposure and dose.
- Understand the basic concepts of dosimetry

Course Title: Radiation Physics **Credits:02**
Course Code:PHY-458-MJ **L 2 T 0 P 0**

Unit I

Ionizing and Non-Ionizing Radiation: Electromagnetic spectrum: Introduction, Interaction of electromagnetic radiation with matter, Thomson scattering, Rayleigh scattering, Compton scattering, Photoelectric absorption, Pair production, Cerenkov radiation-mass-energy attenuation and absorption coefficient.

Radiation quantities and units, Radiometry, particle flux and fluence, energy flux and fluence, Linear and mass attenuation coefficients, Mass energy transfer and mass energy absorption coefficients, stopping power, LET, Radiation chemical yield, W value, Dosimetry, Measurement of Absorbed Dose, Definition of absorbed dose, relationship between kerma, exposure, and absorbed dose.

Unit II

Introduction, Considerations in the design of high energy beams, Physics of X-ray production, X-ray energy spectra, X-ray Therapy and its types, General Introduction to Tele, Bracy and Internal Therapy,

Linear Accelerator: Magnetron, Klystron, Medical Linacs, Betatron, Microtron, Cyclotron, Isotope Machines, Typical Cobalt 60 Units, Particles for radiotherapy.

Text Book:

1. The Physics of Radiation Therapy, Faiz M. Khan, J. P. Gibbons.

Reference Books:

2. The Physics of Radiology, Harold Elford Johns, J.R. Cunningham.
3. Basic Physics of Radiation Therapy, J. Selman.

Course Title: **Experimental Techniques**
Course Code: **PHY-459-MJ**
Credits: **02**
Type of Course: **Major**

Contact Hours: 2 hours per week (Total: 32 lecture)

Internal assessment: 50% (30% Exam (45 min) and 20% assignments/attendance)

End-Term Examination: 50% (1.15 Hours)

Course Objectives

The purpose of this course is to skill the students with techniques of data analysis with the help of various softwares.

Course Outcome

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

- Develop basics of data, its representation and error estimation and analysis
- Do the basic data analysis using ORIGIN and GNUPLOT software
- understand that how to gauge the more reliable data.
- understand functioning of the various types of transducers and fundamentals of vacuum technology.

Course Title: Experimental Techniques **Credits: 02**
Course Code: PHY-459-MJ **L 2 T 0 P 0**

Unit I

Measurement Concepts; Data Interpretation and Analysis; Precision and Accuracy; Error Analysis; Propagation of Errors. Plotting of Graphs using ORGIN and GNUPLOT software. Curve Fitting of Data; Least square fitting (Linear and non-linear); Chi-Square Test.

Unit II

Transducers (temperature, pressure/vacuum magnetic fields, vibration, optical and particle detectors)

Fundamentals of Vacuum Technology, Gas Flow Mechanism, Concept of Throughput and Pumping Speed; Mechanical Pump, Diffusion Pump, Gauges: Penning and Pirani.

Measurement and Control: Signal conditioning and recovery, impedance matching, shielding and grounding.

Text Books:

1. Probability and Statistics in Experimental Physics, B. P. Roe, Springer..
2. Vacuum Technology: Alexander Roth

Reference Books

3. Introduction to Experimental Nuclear Physics, R. M. Singura, John Wiley Eastern.
4. Elements of X-Ray Diffraction, B. D. Cullity, and S. R. Stock, Pearson.
5. Core Level Spectroscopy of Solids, F. De Groot, CRC Press.
6. Instrumentation Measurement Analysis, B. C. Nakra and B. C. Chudhary, McGraw Hill.
7. The Art of Experimental Physics, D. W. Preston and E. R. Dietz, John Wiley.
8. Introduction to Nuclear Physics, V. K. Mittal, R. C. Verma, and S. C. Gupta, PHI.
9. Material Science and Engineering: V. Raghavan

Course Title: **Atmospheric Physics**
Course Code: **PHY-460-MJ**
Credits: **02**
Type of Course: **Major**

Contact Hours: 2 hours per week (Total: 32 lecture)

Internal assessment: 50% (30% Exam (45 min) and 20% assignments/attendance)

End-Term Examination: 50% (1.15 Hours)

Course Objectives

This course is designed for those who aspire to take up higher studies in the field of atmospheric physics.

Course Outcome

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

- learn about the structure, composition, and temperature and density profiles of the earth's lower atmosphere, physics and importance of variations of these parameters with reference to terrestrial weather.
- learn about the upper atmospheric physics such structure, morphology, stratification, formation and the principal processes taking place in upper atmosphere as well as its importance with reference to communication and navigation

Course Title: Atmospheric Physics **Credits: 02**
Course Code: PHY-460-MJ **L 2 T 0 P 0**

Unit I

Atmosphere of earth, Origin, Composition and Structure and morphology, Vertical profiles of pressure, density and temperature, General Circulation of the Atmosphere, Energy Balance of the Earth, Global Patterns of Insulation, Heating Imbalances, Earth's Energy Budget, Surface Energy Budget Modeling Energy Balance, Global Heat Balance, Atmosphere's Energy Budget, Natural Greenhouse Effect, Effect on Surface Temperature.

Unit II

Ionosphere: origin, composition and morphology, formation of ionosphere, photo-ionization and recombination, major geographical divisions of ionosphere, importance of ionosphere, ionospheric variability, effect of solar disturbances on ionosphere, ionospheric disturbances and irregularities, Ionospheric observation techniques, ground and satellite based.

Magnetosphere: structure of magnetosphere, interaction of solar wind with magnetosphere, geomagnetic activity and geomagnetic indices, geomagnetic storms.

Text Books:

1. The Physics of atmosphere, J.T. Houghton, 1986
2. An introduction to ionosphere and magnetosphere, J. A. Ratcliff, CUP.

Reference Books:

3. Fundamentals of Climate, McIlveen R., Chapman Hall, 1992
4. An introduction to dynamic metrology, J. R. Holton, 3rdEd.
5. Ionospheric Radio, K. Davies, IET

Semester VIII (Hons. with Research)

Course Title: **Numerical Methods**
Course Code: **PHY-450-MJ**
Credits: **04**
Type of Course: **Major**

Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)

Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance) End-Term Examination: 50% (2.5 Hours)

Course Objectives

- To develop an understanding of numerical methods for finding the roots of algebraic and transcendental equations and to analyse the propagation of errors in numerical computations.
- To introduce various interpolation techniques and spline functions for estimating unknown values and analysing errors in polynomial and numerical approximations.
- To enable students to understand and apply numerical techniques for differentiation and integration of tabulated data with error estimation.
- To familiarize students with numerical techniques for solving ordinary and partial differential equations using iterative and approximation methods.

Course Outcome

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

- apply appropriate numerical techniques to obtain approximate solutions of nonlinear equations with due consideration to error analysis.
- apply interpolation methods and spline techniques to approximate functions and datasets, and evaluate associated interpolation errors effectively.
- compute derivatives and definite integrals using numerical methods such as Trapezoidal, Simpson’s, and Romberg rules, and analyse the accuracy of these approximations.
- apply numerical methods such as Euler’s, Runge-Kutta, Jacobi, and Gauss-Seidel techniques to obtain approximate solutions of ordinary and partial differential equations with reasonable accuracy.

Course Title: Numerical Methods **Credits: 04**

Course Code: PHY-450-MJ **L 3 T 1 P 0**

Unit I

Some mathematical preliminaries, Errors and their computations, General error formula, errors in a series approximation, Solution of Algebraic and Transcendental equations: Bisection Method, Method of False Position, Iteration Method, Newton- Raphson Method, Ramanujan's Method, Secant Method.

Unit II

Interpolation, Errors in Polynomial Interpolation, Finite differences (forward, backward and central differences), symbolic relations and separation of symbols, Detection of Errors by use of difference tables, Differences of a polynomial, Newton's formulae for interpolation. Central difference interpolation formula: Gauss central difference formula, Stirling's formula. Spline functions: Linear, Quadratic and Cubic Splines.

Unit III

Numerical differentiation, Errors in numerical differentiation, Cubic Spline Method, Differentiation formulae with Function values, Maximum and minimum values of a tabulated function.Numerical Integration: Trapezoidal rule, Simpson's 1/3 and 3/8 rule. Boole's and Weddle's rules, Romberg integration.

Unit IV

Numerical solution of ODEs: Solution by Taylor's series, Picard's Method of successive approximations, Euler's Method, Error Estimates for the Euler's Method, Modified Euler's Method, Runge Kutta methods: Second and Fourth order. Numerical solution of Partial Differential Equations: Laplace's Equation: Finite difference approximations to derivatives, Solution of Laplace's equation by Jacobi's method and Gauss Seidel method.

Text Books:

1. Introductory Methods of Numerical Analysis, S. S. Sastry, PHI.

Reference Books:

2. Numerical Mathematical Analysis, J. B. Scarborough, The John Hopkins University Press
3. An Introduction to Numerical Analysis, K. E. Atkinson, John Wiley.
4. Fortran For Scientists & Engineers, Stephen Chapman, McGraw Hill Education.

Course Title: Astrophysics **Credits: 02**
Course Code: PHY-451-MJ **L 2 T 0 P 0**

Unit I

Celestial coordinate systems: Horizontal and Equatorial coordinate system, Interstellar medium, Jeans instability, protostars, Apparent& absolute magnitude, colors, distance modulus, Luminosity, temperature, stellar classification, Main sequence, giants, dwarfs, Evolution across H–R diagram (qualitative), Hydrostatic equilibrium, Energy generation and Energy Transport, Mass–luminosity relation (qualitative)..

Unit II

Cosmology: Newtonian cosmology, simplifying assumptions, cosmological principle, Redshift, Hubble's law, Einstein universe (static), FLRW metric idea, Friedmann models (qualitative), CMBR, Dark Matter, Dark Energy, Steady state theory (Qualitative idea & observational failure).

Text Book:

1. An Introduction to Astrophysics, Baidyanath Basu, PHI Learning Pvt.
2. Introduction to Cosmology, 3rd Edition, J. V. Narlikar, Cambridge University Press.

Reference Books:

3. The Physical Universe: An Introduction to Astronomy, Frank H. Shu, Mill Valley: University Science Books.
4. Theoretical Astrophysics, Volume III: Galaxies and Cosmology, T. Padmanabhan, Cambridge University Press.

Course Title: **Fourier Optics**
Course Code: **PHY-452-MJ**
Credits: **02**
Type of Course: **Major**

Contact Hours: 2 hours per week (Total: 32 lecture)

Internal assessment: 50% (30% Exam (45 min) and 20% assignments/attendance)

End-Term Examination: 50% (1.15 Hours)

Course Objectives

To develop understanding of the optical systems using Fourier analysis

Course Outcome

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

- Understand the fundamentals of signal sampling.
- Understand Fourier domain analysis of diffraction theory
- To know frequency response of optical systems under coherent and incoherent illumination.
- To understand working of various imaging system.

Course Title: Fourier Optics **Credits: 02**
Course Code: PHY-452-MJ **L 2 T 0 P 0**

Unit I

Signals and systems, Fourier Transform(FT), Sampling theorem; Diffraction theory; Fresnel-Kirchhoff formulation and angular spectrum method, brief discussion of Fresnel and Fraunhofer diffraction, FT Properties of lenses and Image formation by a lens; Frequency response of a diffraction-limited system under coherent and incoherent illumination, OTF- effects of aberration and apodization.

Unit II

Comparison of coherent and incoherent imaging, Analog optical information processing: Abbe-Porter experiment, phase contrast microscopy, Image restoration: Inverse and Wiener Filters; Coherent image processing: Vander Lugt filter; Joint-transform correlator; Synthetic Aperture Radar. Basics of holography, in-line and off-axis holography; Super-resolution: Structured Illumination microscopy; Ghost Imaging

Text Book:

1. Introduction to Fourier optics, Goodman, J. W., New York, McGraw-Hill.

Reference Book:

2. Fourier Optics and Computational Imaging. Khare, Kedar, John Wiley and Sons.

Course Title: **Physics of Functional Materials**
Course Code: **PHY-453-MJ**
Credits: **02**
Type of Course: **Major**

Contact Hours: 2 hours per week (Total: 32 lecture)

Internal assessment: 50% (30% Exam (45 min) and 20% assignments/attendance)

End-Term Examination: 50% (1.15 Hours)

Course Objectives

- To provide the students with the understanding of synthesis/growth, structure, and properties of the functional materials.
- To develop an understanding of the usage of functional materials as a component of modern devices.

Course Outcome

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

- Investigate and correlate the different way of synthesis, characterization, and application of functional materials.
- Integrate the understanding of functional materials' properties and their applications.

Course Title: Physics of Functional Materials **Credits: 02**

Course Code: PHY-453-MJ **L 2 T 0 P 0**

Unit I

Material synthesis and processing of functional materials: Bulk Synthesis: Solid state synthesis, Sol-Gel synthesis, Thin-Film synthesis: Sputtering, Molecular beam epitaxy, CVD, 3D printing, electrospinning.

Defects in solids: Defect types and dimensionality effect on defects, Characterization (morphological and spectroscopic), Control of defects.

Unit II

Semiconductor materials: Band structure, Doping, Band-Gap engineering.

Applications: Beyond Si semiconductors, GaN, GaAs, SiC, Ga2O3, LEDs, and photovoltaic cells (CdS, CIGS, CZTS, Perovskites and Organic solar cell materials).

Materials for energy applications: Thermoelectric materials: ZT value, Band-Gap, Heusler alloys, Peltier cooling, Thermoelectric generator, Dielectric, Piezoelectric, Ferroelectric materials and applications. Magnetic materials & applications: Magnetic exchange energy, anisotropy energy, Magnetic domains, Application of soft and hard magnetic materials, Magnetic data storage,

Optical materials: Optical lithography, and Electro-optic materials.

Text Book:

1. The Science and Engineering of Materials, Askeland, D.R., Phule, P.P., Wright, W.J., Cengage Learning, 2010.

Reference Books:

2. Materials science and Engineering: An Introduction, Callister, W.D., Rethwisch, D.G., 8th edition, Wiley, 2010.
3. An Introduction to Materials Engineering and Science for Chemical and Materials Engineers, Mitchell, B.S., Wiley- Interscience, 2003.
4. Introduction to Solid State Physics, . Kittel, C., 8th edition, Wiley, 2005.
5. Principles of Electronic Materials and Devices, Kasap, S.O., 3rd edition, McGraw-Hill, 2006.
6. Science & Engineering: Raghavan, V., Materials A first course, 5th edition, PHI Learning, 2004.
7. Online Course Material 1. Haridoss, P., Physics of Materials, NPTEL Course Material, Department of Metallurgy & Material Science, Indian Institute of Technology Madras, https://nptel.ac.in/courses/113/106/113106039/.

Course Title: **Advanced Nuclear Physics**
Course Code: **PHY-454-MJ**
Credits: **02**
Type of Course: **Major**

Contact Hours: 2 hours per week (Total: 32 lecture)

Internal assessment: 50% (30% Exam (45 min) and 20% assignments/attendance)

End-Term Examination: 50% (1.15 Hours)

Course Objectives

To understand the advanced concepts of nuclear physics in order to enable a student to take up research in nuclear theory. The other objective involves imparting the knowledge of some important theoretical tools such as the rotation of spherical harmonics and second quantization that are used in a variety of physical problems.

Course Outcome

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

- Understand the quantum mechanics of a 3D harmonic oscillator, both isotropic as well as anisotropic.
- Parametrization of a 3D surface and its rotation in terms of spherical harmonics.
- Understand the origin and need of second quantization.
- The student will learn the Nilsson model of nucleus.
- The student will learn the Particle Rotor Model of nucleus.

Course Title: Advanced Nuclear Physics **Credits: 02**
Course Code: PHY-454-MJ **L 2 T 0 P 0**

Unit I
Three-dimensional isotropic harmonic oscillator (wave-functions in cartesian, spherical and cylindrical coordinates), LS coupling.
Parametrization of surface deformation, Types of multipole deformations, Quadrupole deformation, Two-level mixing, Rotation of spherical harmonics, D-matrix and it's properties.

Unit II
Introduction of second quantization, Second quantization for bosons and fermions, One-body and two-body operator in second quantization.
Review of spherical shell model, Nilsson Model; The potential, Nilsson model (Qualitative treatment).
Nilsson model (exact treatment), solution of hypergeometric function, The asymptotic quantum numbers.
Particle-Rotor mode: Hamiltonian, wave-function and transition matrix elements.

Text Book:

1. The Nuclear many-Body Problem, Text & Monographs in Physics, Peter Ring and Peter Schuck, Springer-Verlag New-York.

Reference Books:

2. Theory of Nuclear Structure, M.K. Pal, Affiliated East - West, Madras.
3. Nuclear Models, Greiner and Maruhn, Springer International.
4. Atomic and Nuclear Physics, S. N. Ghosal, S. Chand.
5. Introduction to Nuclear Physics, H. A. Enge, Addison-Wesley.
6. Introductory Nuclear Physics, P. E. Hodgson, and E. Gadoili, OUP, illustrated ed.