M Sc PHYSICS

LOCF SYLLABUS 2025

Department of Physics

School of Physical Sciences

St. Joseph's College (Autonomous)

Tiruchirappalli - 620002, Tamil Nadu, India

SCHOOLS OF EXCELLENCE WITH CHOICE BASED CREDIT SYSTEM (CBCS) POSTGRADUATE COURSES

St. Joseph's College (Autonomous), an esteemed institution in the realm of higher education in India, has embarked on a journey to uphold and perpetuate academic excellence. One of the pivotal initiatives in this pursuit is the establishment of five Schools of Excellence commencing from the academic year 2014-15. These schools are strategically designed to confront and surpass the challenges of the 21st century.

Each School amalgamates correlated disciplines under a unified umbrella, fostering synergy and coherence. This integrated approach fosters the optimal utilization of both human expertise and infrastructure. Moreover, it facilitates academic fluidity and augments employability by nurturing a dynamic environment conducive to learning and innovation. Importantly, while promoting collaboration and interdisciplinary study, the Schools of Excellence also uphold the individual identity, autonomy, and distinctiveness of every department within.

The overarching objectives of these five schools are as follows:

1. Optimal Resource Utilization: Ensuring the efficient use of both human and material resources to foster academic flexibility and attain excellence across disciplines.

2. Horizontal Mobility for Students: Providing students with the freedom to choose courses aligning with their interests and facilitating credit transfers, thereby enhancing their academic mobility and enriching their learning experience.

3. Credit-Transfer Across Disciplines (CTAD): The existing curricular structure, compliant with regulations from entities such as TANSCHE and other higher educational institutions, facilitates seamless credit transfers across diverse disciplines. This underscores the adaptability and uniqueness of the choice-based credit system.

4. Promotion of Human Excellence: Nurturing excellence in specialized areas through focused attention and resources, thus empowering individuals to excel in their respective fields.

5. Emphasis on Internships and Projects: Encouraging students to engage in internships and projects, serving as stepping stones toward research endeavors, thereby fostering a culture of inquiry and innovation.

6. Addressing Stakeholder Needs: The multi-disciplinary nature of the School System is tailored to meet the requirements of various stakeholders, particularly employers, by equipping students with versatile skills and competencies essential for success in the contemporary professional landscape.

In essence, the Schools of Excellence at St. Joseph's College (Autonomous) epitomize a holistic approach towards education, aiming not only to impart knowledge but also to cultivate critical thinking, creativity, and adaptability – qualities indispensable for thriving in the dynamic global arena of the 21st century.

Credit system

The credit system at St. Joseph's College (Autonomous) assigns weightage to courses based on the hours allocated to each course. Typically, one credit is equivalent to one hour of instruction per week. However, credits are awarded regardless of actual teaching hours to ensure consistency and adherence to guidelines.

The credits and hours allotted to each course within a programme are detailed in the Programme Pattern table. While the table provides a framework, there may be some flexibility due to practical sessions, field visits, tutorials, and the nature of project work.

For postgraduate (PG) courses, students are required to accumulate a minimum of 92 credits, as stipulated in the programme pattern table. The total minimum number of courses offered by the department is outlined in the Programme Structure.

OUTCOME-BASED EDUCATION (OBE)

OBE is an educational approach that revolves around clearly defined goals or outcomes for every aspect of the educational system. The primary aim is for each student to successfully achieve these predetermined outcomes by the culmination of their educational journey. Unlike traditional methods, OBE does not prescribe a singular teaching style or assessment format. Instead, classes, activities, and evaluations are structured to support students in attaining the specified outcomes effectively.

In OBE, the emphasis lies on measurable outcomes, allowing educational institutions to establish their own set of objectives tailored to their unique context and priorities. The overarching objective of OBE is to establish a direct link between education and employability, ensuring that students acquire the necessary skills and competencies sought after by employers.

OBE fosters a student-centric approach to teaching and learning, where the delivery of courses and assessments are meticulously planned to align with the predetermined objectives and outcomes. It places significant emphasis on evaluating student performance at various levels to gauge their progress and proficiency in meeting the desired outcomes.

Here are some key aspects of Outcome-Based Education:

Course: A course refers to a theory, practical, or a combination of both that is done within a semester.

Course Outcomes (COs): These are statements that delineate the significant and essential learning outcomes that learners should have achieved and can reliably demonstrate by the conclusion of a course. Typically, three or more course outcomes are specified for each course, depending on its importance.

Programme: This term pertains to the specialization or discipline of a degree programme.

Programme Outcomes (POs): POs are statements that articulate what students are expected to be capable of by the time they graduate. These outcomes are closely aligned with Graduate Attributes.

Programme Specific Outcomes (PSOs): PSOs outline the specific skills and abilities that students should possess upon graduation within a particular discipline or specialization.

Programme Educational Objectives (PEOs): PEOs encapsulate the expected accomplishments of graduates in their careers, particularly highlighting what they are expected to achieve and perform during the initial years postgraduation.

LEARNING OUTCOME-BASED CURRICULUM FRAMEWORK (LOCF)

The Learning Outcomes-Centric Framework (LOCF) places the learning outcomes at the forefront of curriculum design and execution. It underscores the importance of ensuring that these outcomes are clear, measurable, and relevant. LOCF orchestrates teaching methodologies, evaluations, and activities in direct correlation with these outcomes. Furthermore, LOCF adopts a backward design approach, focusing on defining precise and attainable learning objectives. The goal is to create a cohesive framework where every educational element is in harmony with these outcomes.

Assessment practices within LOCF are intricately linked to the established learning objectives. Evaluations are crafted to gauge students' achievement of these outcomes accurately. Emphasis is often placed on employing authentic assessment methods, allowing students to showcase their learning in real-life scenarios. Additionally, LOCF frameworks emphasize flexibility and adaptability, enabling educators to tailor curriculum and instructional approaches to suit the diverse needs of students while ensuring alignment with the defined learning outcomes.

Some important terminologies

Core Courses (CC): *These are compulsory courses that students must undertake as essential components of their curriculum, providing fundamental knowledge within their primary discipline. Including core courses is essential to maintain a standardized academic programme, ensuring recognition and consistency across institutions.*

Discipline Specific Elective Courses (ES): *Elective courses are offered within the main discipline or subject of study. They allow students to select specialized or advanced options from a range of courses, offering in-*

depth exposure to their chosen area of study. Typically, ES are more applied in nature and provide a deeper understanding of specific topics.

Research Methodology/IPR(RM)*: It is a two-credit course offered in the third semester as a common program across disciplines within the school. It is designed to acquaint postgraduate learners with the research foundations and legal frameworks vital for innovation and entrepreneurship in technology and business.*

Open Elective Courses (OE): *These elective courses are chosen from disciplines unrelated to the student's main area of study, aiming to broaden their exposure and knowledge base. As per the Choice Based Credit System (CBCS) policy, students may opt for open elective courses offered by other disciplines within the college, enhancing the diversity of their learning experience.*

Ability Enhancement Course (AEC): *AE is designed to enhance skills and proficiencies related to the student's main discipline. It aims to provide practical training and hands-on experience, contributing to the overall development of students pursuing academic programmes.*

Skill Enhancement Course (SEC): *SE focus on developing specific skills or proficiencies relevant to students' academic pursuits. While it is open to students from any discipline, SE is particularly beneficial for those within the related academic programme.*

Self-Learning (SL): *A two-credit course designed to foster students' ability for independent and self-directed learning. There are* Three Self-Learning Courses:

- 'Global Citizenship Education' *a common online course offered to all PG students in Semester I on JosTEL.*
- *Compulsory MOOC on NPTEL-SWAYAM in Semester I or II*
- *A Department-Specific Self-Learning Course in Semester III on JosTEL*

Comprehensive Examination (CE): *These examinations cover detailed syllabi comprising select units from courses offered throughout the programme. They are designed to assess crucial knowledge and content that may not have been covered extensively in regular coursework.*

Extra Credit Courses: *To support students in acquiring knowledge and skills through online platforms such as Massive Open Online Courses (MOOCs), additional credits are granted upon verification of course completion. These extra credits can be availed across three semesters (2 - 4). In line with UGC guidelines, students are encouraged to enhance their learning by enrolling in MOOCs offered by portals like SWAYAM, NPTEL, and others. Additionally, certificate courses provided by the college are also considered for these extra credits.*

Outreach Programme (OR): *It is a compulsory course to create a sense of social concern among all the students and to inspire them to dedicated service to the needy.*

Course Coding

The following code system (10 alphanumeric characters) is adopted for Postgraduate courses:

25	**UXX**	**0**	**XX**	**00/X**
Year of Revision	PG Department Code	Semester Number	Course Specific Initials	Running Number/with Choice

Course Specific Initials

CC - Core Course

CP - Core Practical

ES - Discipline Specific Elective

AE - Ability Enhancement Course

SL - Self-Learning

OE – Open Elective

PW - Project and Viva Voce

CE - Comprehensive Examination

OR - Outreach Programme

IS – Internship

RM – Research Methodology

EVALUATION PATTERN (PG)

Continuous Internal Assessment

Sl No	Component	Marks Allotted
1	Mid Semester Test	30
2	End Semester Test	30
3	*Two Components (15 + 20)	35
4	Library Referencing	5
	Total	**100**

Passing minimum: 50 marks

* *The first component is a compulsory online test (JosTEL platform) for 15 marks comprising 7 questions (1 mark) at K1 level and 4 questions (2 marks) at K2 level;* The second component is decided by the course in-charge in accordance with the prescribed K levels.

Question Paper Blueprint for Mid and End Semester Tests

Duration: 2 Hours								**Maximum Marks: 60**
Section		**K levels**						**Marks**
		K1	**K2**	**K3**	**K4**	**K5**	**K6**	
A *(compulsory)*		7						7 × 1 = 7
B *(compulsory)*			5					5 × 3 = 15
C *(either…or type)*				3				3 × 6 = 18
D *(2 out of 3)*	Mid Sem				1(2)	1*		2 × 10 = 20
	End Sem					1(2)	1*	
							Total	**60**

***** *Compulsory*

Question Paper Blueprint for Semester Examination

Duration: 3 Hours						**Maximum Marks: 100**	
Section	**K levels**						**Marks**
	K1	**K2**	**K3**	**K4**	**K5**	**K6**	
A *(compulsory)*	10						10 × 1 = 10
B *(compulsory)*		10					10 × 3 = 30
C *(either…or type)*			5				5 × 6 = 30
D *(3 out of 5)*				1(2)	1(2)	1*	3 × 10 = 30
						Total	**100**

***** *Compulsory*

Evaluation Pattern for One/Two-credit Courses

Title of the Course	**CIA**	**Semester Examination**	**Final**
• Ability Enhancement Course	20 + 10 + 20 = 50	50 *(Department)*	100
• Self - Learning Course (Dept. Specific) • Comprehensive Examination	25 + 25 = 50	50 *(CoE)*	100
• Internship • Self - Learning Course (Common) • Self - Learning Online Course (NPTEL / SWAYAM)	100	-	100
• Skill Enhancement Course: Soft Skills	100	-	100
• Project Work and Viva Voce	100	100	100

Grading System

The marks obtained in the CIA and semester for each course will be graded as per the scheme provided in Table - 1.

From the second semester onwards, the total performance within a semester and the continuous performance starting from the first semester are indicated by Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA), respectively. These two are calculated by the following formulae:

$$SGPA \ and \ CGPA = \frac{\sum_{i=1}^{n} C_i Gp_i}{\sum_{i=1}^{n} C_i}$$

$$WAM = \frac{\sum_{i=1}^{n} C_i M_i}{\sum_{i=1}^{n} C_i}$$

Where,

Ci - credit earned for the Course i

Gpi - Grade Point obtained for the Course i

Mi - Marks obtained for the Course i

*n - Number of Courses **passed** in that semester*

WAM - Weighted Average Marks

Table - 1: Grading of the Courses for PG

Mark Range	Grade Point	Corresponding Grade
90 and above	10	O
80 and above and below 90	9	A+
70 and above and below 80	8	A
60 and above and below 70	7	B+
50 and above and below 60	6	B
Below 50	0	RA

Table - 2: Grading of the Final Performance for PG

CGPA	Grade	Performance
9.00 and above	O	Outstanding*
8.00 to 8.99	A+	Excellent*
7.00 to 7.99	A	Very Good
6.00 to 6.99	B+	Good
5.00 to 5.99	B	Above Average
Below 5.00	RA	Re-appear

**The Candidates who have passed in the first appearance and within the prescribed duration of the PG programme are eligible. If the Candidates Grade is O/A+ with more than one attempt, the performance is considered "Very Good".*

Vision

Forming globally competent, committed, compassionate and holistic persons, to be men and women for others, promoting a just society.

Mission

- Fostering learning environment to students of diverse background, developing their inherent skills and competencies through reflection, creation of knowledge and service.
- Nurturing comprehensive learning and best practices through innovative and value- driven pedagogy.
- Contributing significantly to Higher Education through Teaching, Learning, Research and Extension.

Programme Educational Objectives (PEOs)

1. Graduates will be able to accomplish professional standards in the global environment.
2. Graduates will be able to uphold integrity and human values.
3. Graduates will be able to appreciate and promote pluralism and multiculturalism in working environment.

Programme Outcomes (POs)

1. Graduates will be able to apply assimilated knowledge to evolve tangible solution to emerging problems.
2. Graduates will be able to analyze and interpret data to create and design new knowledge.
3. Graduates will be able to engage in innovative and socially relevant research and effectively communicate the findings.
4. Graduates will become ethically committed professional and entrepreneurs upholding human values.
5. Graduates imbibed with ethical values and social concern will be able to understand and appreciate cultural diversity, social harmony and ensure sustainable environment.

Programme Specific Outcomes (PSOs)

1. Gain the ability to identify and analyse complex Physics problems using the principles of Physics with suitable mathematical tools.
2. Acquire skills which will put the learners at an advantage in careers as drivers to associate with different subjects.
3. Mould to adopt, absorb and develop innovative ideas
4. Develop skills to communicate effectively with peers, professionals and society at large and demonstrate professional ethics
5. Exhibit effective individual talent, and engage themselves in lifelong learning and dissemination

M. Sc. Physics				
Programme Structure				
Semester	**Specification**	**No. of Courses**	**Hours**	**Credits**
1 – 4	Core Course	10	52	45
1 - 4	Core Practical	4	32	16
1, 3 & 4	Discipline Specific Elective	3	12	9
1 – 2	Open Elective	2	8	4
1	Ability Enhancement Course	1	2	1
1 – 3	Self-Learning	3	-	4
2	Skill Enhancement Course	1	4	2
3	Research Methodology	1	4	2
4	Project	1	6	3
4	Comprehensive Examination	1	-	2
2 – 4	Outreach Programme (SHEPHERD)	-	-	4
1 – 4	Extra Credit Course	4	-	12
	Total	**31**	**120**	**92 (12)**

M. SC. PHYSICS PROGRAMME PATTERN								
Course Details						Scheme of Exams		
Sem.	**Course Code**	**Course Type**	**Title of the Course**	**Hours**	**Credits**	**CIA**	**SE**	**Final**
1	25PPH1CC01	**CC Major**	**Core Course – 1:** Classical and Relativistic Mechanics	6	6	100	100	100
	25PPH1CC02		**Core Course – 2:** Mathematical Physics	6	5	100	100	100
	25PPH1CP01		**Core Practical – 1:** Physics Practical – 1	8	4	100	100	100
	25PPH1ES01A	**DSE**	**Discipline Specific Elective – 1:** Physics of Semiconductor Devices	4	3	100	100	100
	25PPH1ES01B		**Discipline Specific Elective – 1:** Analog and Digital Electronics					
	25PPH1AE01	**AEC**	**Ability Enhancement Course:** Framework for Physics Innovation and Entrepreneurship	2	1	100	-	100
	25PPH1OE01A	**OE**	**Open Elective - 1 (WS):** Solar Energy and Utilization	4	2	100	100	100
	25PPH1OE01B		**Open Elective – 1 (WS):** Renewable Energy Resources					
	25PGC1SL01	**SL**	Global Citizenship Education (Online)	0	1	100	-	100
			Extra Credit Course	0	(3)			
			Total	30	**22 (3)**			
2	25PPH2CC03	**CC Major**	**Core Course – 3:** Quantum Mechanics	5	5	100	100	100
	25PPH2CC04		**Core Course – 4:** Mathematical Methods of Computational Physics and Python Programming (Internship Embedded Course)	5	4	100	100	100
	25PPH2CC05		**Core Course – 5:** Artificial Intelligence in Physics	4	3	100	100	100
	25PPH2CP02		**Core Practical – 2:** Physics Practical – 2	8	4	100	100	100
	25PPH2OE02A	**OE**	**Open Elective – 2 (BS):** Physics for Competitive Exams	4	2	100	100	100
	25PPH2OE02B		**Open Elective – 2 (BS):** Nanoscience					
	25PSS2SE01	**SEC**	**Skill Enhancement Course:** Soft Skills	4	2	100	-	100
	25PPH2SL02	**SL**	Online Courses: NPTEL / SWAYAM	0	2	-	100	100
			Extra Credit Course	0	(3)			
			Total	**30**	**22 (3)**			
3	25PPH3CC06	**CC Major**	**Core Course – 6:** Condensed Matter Physics	5	4	100	100	100
	25PPH3CC07		**Core Course – 7:** Electromagnetic Theory	5	4	100	100	100
	25PPH3CC08		**Core Course – 8:** Methods of Spectroscopy	4	4	100	100	100
	25PPH3CP03		**Core Practical – 3:** Physics Practical – 3	8	4	100	100	100
	25PPH3ES02A	**DSE**	**Discipline Specific Elective – 2:** Materials Science	4	3	100	100	100
	25PPH3ES02B		**Discipline Specific Elective – 2:** Techniques of Materials Characterizations					
	25SPS3RM01	**RM**	Research Methodology and IPR	4	2	100	100	100
	25PPH3SL03A	**SL**	**Self-Learning:** Medical Physics*	0	1	50	50	50
	25PPH3SL03B		**Self-Learning:** Crystal Growth and Thin Films*					
	25PPH3SL03C		**Self-Learning:** Ultrasonics and its Applications*					
	25PPH3SL03D		**Self-Learning:** Forensic Physics*					
			Extra Credit Course	0	(3)			
			Total	**30**	**22 (3)**			
4	25PPH4CC09	**CC Major**	**Core Course – 9:** Nuclear and Particle Physics	6	5	100	100	100
	25PPH4CC10		**Core Course – 10:** Statistical Mechanics and Thermodynamics	6	5	100	100	100
	25PPH4CP04		**Core Practical – 4:** Physics Practical – 4	8	4	100	100	100
	25PPH4ES03A	**DSE**	**Discipline Specific Elective – 3:** Microcontroller Based Physics Instrumentation	4	3	100	100	100
	25PPH4ES03B		**Discipline Specific Elective – 3:** Physics of Sensors and Transducers					
	25PPH4PW01	**PW**	Project	6	3	100	100	100
	25PPH4CE01	**CE**	Comprehensive Examination*	0	2	50	50	50
			Extra Credit Course	0	(3)			
			Total	**30**	**22 (3)**			
	25PCW4OR01	**OR**	Outreach Programme	--	4			
1-4			**TOTAL**	**120**	**92 (12)**			

***For Grade Calculation:** Marks obtained out of 50 will be converted into 100 in the mark statements.

Open Elective - 1 (WS): 1st Semester

School	Course Code	Title of the Course
SPS		
Chemistry	25PCH1OE01	Advanced Materials and Nano Technology
Electronics	25PEL1OE01	Electronics Media
Physics	25PPH1OE01A	Solar Energy and Utilization
	25PPH1OE01B	Renewable Energy Resources

Open Elective – 2 (BS): 2nd Semester
Offered to students from other Schools

School	Course Code	Title of the Course
SBS		
Botany	25PBO2OE02	Sustainable Horticulture and Urban Landscaping
Biochemistry	25PBI2OE02	First Aid Management
Biotechnology	25PBT2OE02	Food Technology
SCS		
Artificial Intelligence and Machine Learning	25PAI2OE02	Cyber Security
Computer Science	25PCA2OE02A	Web Design
	25PCA2OE02B	Cyber Security
Information Technology	25PCS2OE02	Recent Trends in Computing
Data Science	25PDS2OE02	Discrete Mathematics
Mathematics	25PMA2OE02	Operations Research
Visual Communication	25PVC2OE02	Women and Media
SLAC		
English	25PEN2OE02	English for Digital Media
History	25PHS2OE02	Public Administration
Tamil	25PTA2OE02	விளம்பரக்கலை (Art of advertising)
SMS		
Commerce	25PCO2OE02	Basics of Tally Prime
Commerce Computer Application	25PCC2OE02	Behavioural Dynamics and Psychology
Counselling Psychology	25PCP2OE02	Artificial Intelligence in Psychology
Economics	25PEC2OE02	Managerial Economics
Human Resource Management	25PHR2OE02	Counselling and Guidance
SPS		
Chemistry	25PCH2OE02	Chemistry of Health and Nutrition
Electronics	25PEL2OE02	Computer Hardware and Networks
Physics	25PPH2OE02A	Physics for Competitive Exams
	25PPH2OE02B	Nanoscience

Semester	Course Code	Title of the Course	Hours/ Weeks	Credits
1	25PPH1CC01	**Core Course - 1:** Classical and Relativistic Mechanics	6	6

Course Objectives
To study the constraints and formulation of Lagrangian and Hamiltonian mechanics
To explain the Kepler problem, rigid body dynamics.
To apply the dynamics and reduce to the canonical equations
To explain the Euler's equation in relativistic dynamics
To extend their manipulative knowledge to non-inertial frames.

UNIT I: Fundamental Principles and Lagrangian Formulation (18 Hours)

Mechanics of a particle and system of particles – conservation laws – constraints – generalized coordinates – D'Alembert's principle and Lagrange's equation – applications on Lagrangian formulation: Atwood's machine – simple pendulum – compound pendulum- linear harmonic oscillator – Lagrange's equations in presence of non-conservative forces – generalized potential – Lagrangian of a charged particle in the presence of electromagnetic field – Hamilton's principle – Lagrange's equation of motion from Hamilton's principle – conservation theorems and symmetry properties.

UNIT II: Two-Body Central Force Problems (18 Hours)

Reduction to equivalent one – body central force problem – central force and motion in a plane – equation of motion and first integrals – differential equation for an orbit – the equivalent one – dimensional problem and classification of orbits – The Kepler problem: inverse square law of force – The Laplace – Runge – Lenz vector – scattering in a central force field – scattering in laboratory and centre of mass frames.

UNIT III: Hamilton's Formulation (18 Hours)

Hamiltonian – Hamilton's canonical equations of motion – physical significance of H-Cyclic coordinates – Hamilton's equations from variational principle – Applications on Hamilton's formulation: simple pendulum – compound pendulum – linear harmonic oscillator – particle in a central field of force – Δ-variation – principle of least action- statement and its proof – other forms of the action principle (Jacobi's form).

UNIT IV: Rigid Body Dynamics, Non-Inertial Frames and Oscillatory Motion (18 Hours)

Euler angles – Euler's theorem on the motion of the rigid body – infinitesimal rotations-rate of change of vector – moments and products of inertia – Euler's equations – symmetrical top – applications – non inertial frame of reference – pseudo force – centrifugal force – uniform rotating frames – Coriolis force – free fall of a body on earth's surface – Foucault's pendulum – theory of small oscillations and normal modes – frequencies of free vibration and normal coordinates – Linear tri-atomic molecule.

UNIT V: Relativistic Mechanics (18 Hours)

Inertial and non-inertial frames – Lorentz transformation equations – length contraction and time dilation – relativistic addition of velocities – Einstein's mass-energy relation – Minkowski's space – four vectors – position, velocity, momentum, acceleration and force in for vector notation and their transformations – force and energy equations in relativistic mechanics – Lagrangian and Hamiltonian formulation of relativistic mechanics – Relativistic Lagrangian and Hamiltonian of a charged particle in an electromagnetic field.

Teaching Methodology	Chalk and talk, PPT
Assessment Methods	MCQ Test, Seminar

Books for Study:

1. Herbert Goldstein, Charles P. Poole, John L. Safko, *Classical Mechanics*, 3rd Edition, Pearson Education, 2002.
2. J.C. Upadhyaya. (2017). *Classical Mechanics*, (2nd revised edition (re- print)) Himalaya publishing house.
3. G Aruldhas, Classical Mechanics, Eastern Economy Edition, PHI Learning Pvt Ltd, New Delhi

Unit	Book	Chapters	Sections
I	1	1	1.1-1.4, 1.6, 2.1, 2.3, 2.6
II	1	3	1.1-1.4, 1.6, 2.1, 2.3, 2.6
III	1	8,9,10	8.2, 8.5, 9.1, 9.2, 9.3, 9.5, 9.6, 9.7, 10.1, 10.6, 10.7, 10, 8
IV	1	4,5,6	4.4, 4.6, 4.8, 4.9,4.10, 5.3, 5.5, 5.7, 6.3-6.4
	2	11	11.1,11.2,11.3,11.4,11.5,11.6
	3	9	9.2,9.3
V	2	12,13,14	12.10,12.11,13.3-13.4, 13.11, 13.12,14.2,14.5,14.6

Books for Reference:

1. Gupta, Kumar, Sharma. (2012). *Classical Mechanics*, (27th edition) Pragathi Prakashan Publications.
2. Rana, N.C. and Joag, P. S. (1998), *Classical Mechanics*, New Delhi, Tata McGraw Hill.
3. Madhumangal Pal. (2009). *A course on Classical Mechanics*, Narosa publishing house, New Delhi.
4. AW Joshi. (2001). *Matrices & Tensors In Physics*, Weiley Eastern.

Websites and eLearning Sources:

1. http://poincare.matf.bg.ac.rs/~zarkom/Book_Mechanics_Goldstein_Classical_Mechanics_optimized.pdf
2. https://nptel.ac.in/courses/122/106/122106027/
3. https://ocw.mit.edu/courses/physics/8-09-classical-mechanics-iii-fall-2014/lecturenotes/
4. https://www.britannica.com/science/relativistic-mechanics

(* subject to availability – not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements**	**Cognitive Levels (K-Level)**
	On successful completion of this course, students will be able to	
CO1	Acquire knowledge about conservation laws, constraints and relativistic mechanics	**K1**
CO2	Understand Kepler problem, rigid body dynamics, relativistic mechanics Lagrangian and Hamilton's formulation.	**K2**
CO3	Analyse the Euler's equations and apply them for rigid body dynamics.	**K3**
CO4	Evaluate the concepts of inertial, non-inertial frames of references and rotating coordinate system in relativistic mechanics.	**K4**
CO5	Apply and formulate the Lagrangian and Hamiltonian to solve problems in mechanics and relativistic mechanics.	**K5**
CO6	Solve the Lagrangian and Hamiltonian in inertial and non inertial frame	**K6**

Relationship Matrix											
Semester	**Course Code**		**Title of the Course**						**Hours**	**Credits**
1	**25PPH1CC01**		**Core Course - 1:** Classical and Relativistic Mechanics						**6**	**6**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	2	3	2	2	2	3	3	2	1	**2.3**
CO2	3	3	3	2	2	2	2	2	2	2	**2.3**
CO3	3	2	2	2	2	2	2	3	2	2	**2.2**
CO4	2	2	2	2	2	3	2	2	2	2	**2.1**
CO5	2	3	3	2	2	3	2	2	2	2	**2.3**
CO6	2	3	3	2	2	3	2	2	2	2	**2.3**
									Mean Overall Score		**2.24 (High)**

Semester	Course Code	Title of the Course	Hours/ Weeks	Credits
1	25PPH1CC02	**Core Course - 2:** Mathematical Physics	6	5

Course Objectives
To equip students with the mathematical techniques needed for understanding theoretical treatment in different courses taught in their program.
To extend their manipulative skills to apply mathematical techniques in their fields.
To help students apply Mathematics in solving problems of Physics.
To simplify given complex problems on second-order differential equations in terms of simple special function solutions.
To interpret the essence of various complex mathematical forms in physics.

UNIT I: Matrices (18 Hours)

Types of Matrices and their properties, Adjoint of a matrix-Inverse of a matrix- Rank of a Matrix - Conjugate of a matrix- Hermitian and Unitary Matrices -Trace of a matrix- Transformation of matrices-Characteristic equation-Eigen values and Eigen vectors-Cayley– Hamilton theorem –Diagonalization. Matrix method in geometrical optics.

UNIT II: Complex Analysis (18 Hours)

Cauchy - Riemann conditions - Cauchy's integral theorem - applications to multiply connected region - Cauchy's II integral theorem - derivatives of analytic complex function - singular points and their classification - Laurent series - Cauchy's residue theorem - calculation of residue at a point - evolution of definite integrals: (i) around the unit circle, (ii) around a semi-circular contour, and (iii) integral of the form.

UNIT III: Fourier Transforms (18 Hours)

Definitions -Fourier transform – Properties of Fourier transform- Fourier transform of derivatives- Cosine and sine transforms of derivatives Functions of two or three variables – Finite Fourier Transforms -Fourier Transform of Dirac delta function – simple applications: Flow of heat in an infinite and in a semi-infinite medium-Wave equation- Digital signal processing.

UNIT IV: Laplace Transforms (18 Hours)

Laplace transform - properties of Laplace transform - Laplace transform of the derivative of function - Laplace transform of integral - Laplace transform of periodic function - Laplace transform of some special function gamma function, error function and delta function - inverse Laplace transform – simple problems - Applications –solving problems of differential equations, string stretched between two points and RLC circuits.

UNIT V: Second Order Differential Equations (18 Hours)

Second order differential equation-Series solution with simple examples-Hermite polynomials-Generating function-Orthogonality properties-Recurrence relations – Legendre polynomials-Generating function-Rodrigue formula – Orthogonality properties- Dirac delta function- One dimensional Green's function and Reciprocity theorem -Sturm-Liouville's type equation in one dimension.

Teaching Methodology	Chalk and talk, PPT, Mathematical models, Graphical representation using software, simulation
Assessment Methods	Seminar, Snap Test, MCQ

Books for Study:

1. Dass, H. K., & Verma, R. (2014). *Mathematical physics* (7th Revised Ed.). S. Chand & Company Pvt. Ltd.
2. Ghatak, A. (2024). *Optics* (8th Revised Ed.). McGraw Hill Education (India) Private Limited.
3. Mukhopadhyay, A. K. (1998). *Mathematical Methods for Engineers and Physicists*. Wheeler Publishing, New Delhi.
4. Prakash, S. (2014). *Mathematical Physics*. Sultan Chand & Sons Publications.

Unit	Book	Chapters	Sections
I	1	38, 39, 41	38.1, 38.2, 38.4, 38.9, 38.10-.38.13, 39.1,39.2, 41.24-41.26, 41.27, 41.34, 41.1-41.7, 41.18 -41.21
	2	5	5.2
II	3	14	14.2-14.5
III	4	10, 11	10.2-10.8, 11.3
IV	4	10	10.9-10.13; 10.14:1,3,5; 10.15 and Ex.47,49,52,53
V	1	13,27,30,28,48	13.1-13.11, 13.14,27.1-27.8,30.1-30.5,28.1-28.9,48.1-48.5,28.3

Books for Reference:

1. Kreyszig, E. (1983). *Advanced Engineering Mathematics*. Wiley Eastern.
2. Zill, D. G., & Cullen, M. R. (2006). *Advanced Engineering Mathematics,* (3rd Ed.). Narosa.
3. Lipschutz, S. (1987). *Linear algebra*. Schaum's Series. McGraw Hill.
4. Butkov, E. (1968). *Mathematical physics*. Addison - Wesley, Reading, Massachusetts.
5. Halmos, P. R. (1965). *Finite dimensional vector spaces,* (2nd Ed.). Affiliated East West.
6. Wylie, C. R., & Barrett, L. C. (1995). *Advanced Engineering Mathematics,* (6th Ed.). International Edition, McGraw-Hill.

Websites and eLearning Sources:

1. www.khanacademy.org
2. https://youtu.be/LZnRlOA1_2I
3. http://hyperphysics.phy-astr.gsu.edu/hbase/hmat.html#hmath
4. https://www.youtube.com/watch?v=_2jymuM7OUU&list=PLhkiT_RYTEU27vS_SlED56gNjVJGO2qaZ
5. https://archive.nptel.ac.in/courses/115/106/115106086/

(* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	CO-Statements	Cognitive Levels (K-Level)
	On successful completion of this course, students will be able to	
CO1	Recall fundamental concepts of matrices, complex analysis, Fourier transforms, Laplace transforms, and second-order differential equations.	K1
CO2	Explain the mathematical principles underlying different transformations, theorem proofs, and special functions in mathematical physics.	K2
CO3	Solve physics-related problems using matrix methods, Fourier and Laplace transforms, and differential equations.	K3
CO4	Examine the behaviour of physical systems through mathematical tools such as eigenvalue problems, series solutions, and Green's functions.	K4
CO5	Assess and compare different mathematical approaches to solving problems in optics, quantum mechanics, and electrodynamics	K5
CO6	Develop mathematical models for real-world physical phenomena using advanced mathematical techniques from the syllabus.	K6

Relationship Matrix											
Semester	**Course Code**		**Title of the Course**							**Hours**	**Credits**
1	**25PPH1CC02**		**Core Course - 2:** Mathematical Physics							**6**	**5**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	2	2	1	3	3	3	2	2	**2.4**
CO2	3	3	3	2	2	3	3	3	2	2	**2.5**
CO3	3	3	3	2	2	3	3	3	2	2	**2.5**
CO4	3	3	2	2	2	3	3	3	2	2	**2.5**
CO5	3	3	3	3	2	3	3	3	2	2	**2.7**
CO6	3	3	2	3	2	3	3	3	2	2	**2.6**
Mean Overall Score											**2.53 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
1	25PPH1CP01	**Core Practical - 1:** Physics Practical – 1	8	4

Any 14 Experiments

1. Absorption Spectrum of Iodine – spectral parameters
2. Susceptibility - Quincke's method and Guoy's method
3. e/m Magnetron and Thermionic Work function
4. Dielectric Constant Study and determination of Curie temperature - Solid, Liquid (kit)
5. Hall effect in semiconductor
6. Elastic Constants – Elliptic fringes
7. Laser – I: numerical aperture, spot size, absorption coefficient and wavelength
8. Planck's constant - determination
9. Study of Photo sensitive devices
10. Ultrasonic interferometer – velocity and compressibility
11. Electro optic modulation – depth of modulation, frequency range, voltage range
12. Determination of Stefan's constant
13. Characteristics of torque transducer
14. Calibration of thermistor – different range
15. Verification of Norton's, Thevenin's and Max power theorem
16. MOSFET characteristics, amplifier design and switching application
17. UJT – Characteristics and Applications
18. K-map simplification – implementation of logic functions using basic and universal gates by SOP & POS
19. Design and Study of ALU and Scalar
20. Op-amp: I to V, V to I and Square wave
21. Op-amp – Design of Instrumentation amplifier
22. 555 – Monostable, Bistable, Astable multi vibrators and its applications
23. Temperature coefficient using 555 timer
24. Op-amp applications: Phase shift and Wien's Bridge Oscillator:
25. Computational experiment: Experimental statistics, error analysis – Iodine absorption spectrum
26. Computational experiment: Lagrange interpolation and extrapolation
27. Computational experiment: Binding energy calculation for different mass numbers.
28. Computational experiment: Two body central force problem
29. Study of Transistor biasing and stability
30. Design of BJT voltage/power amplifier

Semester	Course Code	Title of the Course	Hours/ Weeks	Credits
1	25PPH1ES01A	**Discipline Specific Elective - 1:** Physics of Semiconductor Devices	4	3

Course Objectives
To know the basic concepts in semiconducting materials and its pn junction devices.
To understand the pn junction and its properties and the devices
To apply the concepts and using this to study the device characteristics
To analyse the working of semiconducting devices and evaluate is performance.
To develop and design the circuits for applications and real world problems

UNIT I: Electronic Levels in Semiconductors (12 Hours)

Particles in an attractive potential bound state - electrons in crystalline solids - occupation of states - band structure of semiconductor - mobile carriers - doping of semiconductors- Tailoring electronic properties - defect states.

UNIT II: Charge Transport in Materials and PN junction in semiconductors (12 Hours)

Charge Transport: Introduction -Transport under an electric field - carrier transport by diffusion - carrier generation and recombination - PN Junction in equilibrium - PN Diode under bias - solar cell and photo detector – LED.

UNIT III: Semiconductor Junction (12 Hours)

Metal semiconductor junctions - insulator semiconductor junctions - semiconductor hetero junctions - BJT design and device performance parameters - Kirk effect - thermal effect - early effect - avalanche breakdown.

UNIT IV: Temporal Response of Diodes and Bipolar Transistors (12 Hours)

Small-Signal equivalent circuit of a p-n diode - switching characteristics of diodes - high- frequency behaviour of BJT - BJT Junction voltages at saturation - bipolar transistor Small-Signal equivalent circuit - Small Signal figures of merit.

UNIT V: Field Effect Transistors and MOSFET (12 Hours)

FET: Current-Voltage characteristics - modulation efficiency -small signal characteristics - power-frequency limit.

MOSFET: Capacitance-Voltage characteristics of the MOS structure - operation - depletion and Enhancement MOSFETs - Complementary MOSFETs.

Teaching Methodology	Chalk and talk, PPT, Simulation
Assessment Methods	Written Assignment, MCQ Test, Mini Project

Books for Study:

1. Umesh K. Mishra, Jasprit Singh. (2008). *Semiconductor Device Physics and Design*, Springer.

Unit	Book	Chapters	Sections
I	1	2	2.1-2.4, 2.6, 2.7, 2.10, 2.12
II	1	3, 4	3.1, 3.4, 3.6, 3.8.1, 4.2, 4.3, 4.8.2, 4.9.1.
III	1	5, 6	5.3-5.6.1, 5.6.2, 6.4, 6.6.1-6.6.3, 6.6.5.
IV	1	7	7.2, 7.5, 7.4.1.
V	1	8, 9	8.1-8.3, 8.5.1, 8.8.1, 8.8.2, 9.1, 9.4, 9.5.

Books for Reference:

1. Simon M. Sze & Ming-Kwei Lee. (2010). *Semiconductor Devices: Physics and Technology*, third edition). John Wiley & Sons.
2. S. M. Sze and Kwok K. Ng. (2007). *Physics of Semiconductor Devices*, A John Wiley & Sons, Jnc., Publication.
3. Marius Grundmann. (2016). *The Physics of Semiconductors*, (third edition), Springer International Publishing.

Websites and eLearning Sources:

1. https://www.electronics-tutorials.ws/diode/diode_1.html
2. https://physics.info/semiconductors/
3. http://www.fulviofrisone.com/attachments/article/403/The%20Physics%20of%20Semiconductors.pdf
   (* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K-Level)**
CO1	Describe the structure of semiconducting materials and junction properties.	**K1**
CO2	Classify the semiconductors and the junction properties and characteristics	**K2**
CO3	Using the semiconductor concepts examine the working the semiconducting devices and circuits	**K3**
CO4	Analyze the functions of semiconductor devices and its applications	**K4**
CO5	Assess the electronic device problems and recommend the solutions.	**K5**
CO6	Synthesis new materials for semiconductor devices for applications	**K6**

Relationship Matrix											
Semester	**Course Code**	**Title of the Course**								**Hours**	**Credits**
1	**25PPH1ES01A**	**Discipline Specific Elective - 1:** Physics of Semiconductor Devices								**4**	**3**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	2	3	2	3	3	3	2	2	**2.6**
CO2	3	3	2	3	2	3	3	3	2	2	**2.6**
CO3	3	3	3	3	2	3	2	3	2	2	**2.6**
CO4	3	3	3	2	2	3	3	3	2	2	**2.6**
CO5	3	3	3	2	2	3	3	2	3	2	**2.6**
CO6	3	3	3	2	2	3	3	2	3	2	**2.6**
Mean Overall Score											**2.6 (High)**

Semester	Course Code	Title of the Course	Hours/ Weeks	Credits
1	25PPH1ES01B	**Discipline Specific Elective - 1:** Analog and Digital Electronics	4	3

Course Objectives
To describe and discuss functional blocks of Analog and Digital Electronics.
To discuss functional blocks of Analog and Digital Electronics.
To apply the methods to examine Analog and digital circuit problems.
To assess the limitations of Analog and Digital circuits and recommend the solutions.
To design and construct Analog and Digital circuits for demand.

UNIT I: Semiconductor Devices (12 Hours)

Semiconductor diode: IMPATT - PNPN diodes characteristics and applications - Gunn diode - construction, characteristics and applications of SCR and UJT. Optoelectronic devices: photo transistor - solar cells - photo detectors, OLED structure and working principle.

UNIT II: Applications of Semiconductor Devices (12 Hours)

Transistor CE Amplifier: Transistor as a two-port network - h-parameter equivalent circuit- Small signal analysis of single stage CE amplifier at low and High Frequencies - Miller's theorems - conductance and capacitance - cascaded CE transistor amplifier high frequency analysis - early effect - Gummel plots - transistor switching circuit - MOSFET -applications.

UNIT III: Op-Amp and its Applications (12 Hours)

Operational amplifiers - analog computation - design of Op-Amp active filters (first order only): low pass - high pass - band pass – comparators - sample and hold circuits - instrumentation amplifier - Wien's Bridge Oscillator - Schmitt trigger - V to I and I to V converter - DAC: design of Binary weighted - R-2R ladder - ADC: SAR method, timing circuits: 555 Timer and applications.

UNIT IV: Combinational Logic Design and Memories (12 Hours)

Standard representation of logic functions (SOP and POS) - minimization Techniques - analysis of combinational logic circuits - synthesis of combinational logic circuits - Quine -McCluskey minimization method - Petrick's algorithm - encoder and decoder design - multiplexer and demultiplexer design - adder and subtractor design - digital comparator - design of counters.

UNIT V: Sequential Circuit Design (12 Hours)

Models for sequential Circuits - synchronous sequential circuit models - sequential circuit Analysis - synchronous sequential circuit synthesis - state assignment and circuit realization - redundant states - state reduction in completely and incompletely specified circuits - sequential circuits with Programmable Logic Devices.

Teaching Methodology	Black board teaching, PPT, Video lectures, Demonstrations with models, Handouts.
Assessment Methods	Written Assignment, MCQ Test, Mini Project, open book test

Books for Study:

1. Robert Boylestad and Louis Nashelsky. *Electronic Devices and Circuit Theory*, (7thedition) Prentice Hall New Jersey.
2. Jacob Millman and Christos C. Halkias. (2009). *Microelectronics*, (2nd edition), McGraw Hill, New Delhi.
3. Victor P. Nelson. (1995). *Digital Logic Circuit Analysis and Design*, Prentice Hall.

Unit	Book	Chapters	Sections
I	1	5, 20, 21	5.7, 5.8, 21.13, 21.3, 21.4, 20.10
II	2	5, 8, 11 & 12	5.3, 8.11, 11.1, 11.2, 11.3, 12.10,
III	2	15 & 16	15.1, 16.5, 16.6, 16.7, 16.11, 16.12, 16.14, 16.15, 16.16
IV	3	2, 3, 4 & 5	2.4, 2.5, 3.9, 3.10, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 5.4
V	3	6, 8, 9 & 10	6.1, 8.1, 8.2, 8.3, 8.4, 9.1, 9.2, 9.3, 10.1, 10.2, 10.3, 10.4, 10.5

Books for Reference:

1. Anant Agarwal, Jeffrey H. Lang. (2005). *Foundation of analog and digital circuits*, Elsevier,
2. Daniel Adam Steck. (2017). *Analog and Digital Electronics*.
3. Hubert Kaeslin. (2003). *Digital Integrated Circuit Design*, Cambridge University Press.
4. Thomas L. Floyd. (2015). *Digital Fundamental*, (11th Edition), Pearson Education. Ltd.
5. S.M. Sze. (2007), *Physics of Semiconductor Devices*, Wiley-Inter science.

Websites and eLearning Sources:

1. https://www.electronicshub.org/analog-circuits-anddigitalcircuits/#:~:text=Analog%20Circuits%20and%20Digital%20Circuits%20is%20a%20classic%20way%20of,deals%20with%20discrete%20digital%20signals.
2. https://www.allaboutcircuits.com/video-tutorials/analog-and-digital-electronics/
3. https://www.ece.utoronto.ca/prospective-students/curriculum-streams/digital-analog/

(* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements**	**Cognitive Levels (K-Level)**
	On successful completion of this course, students will be able to	
CO1	Describe semiconductor devices and outline the concepts of analog and digital circuits.	**K1**
CO2	Understand the concepts and analyse the analog and digital circuits forvarious applications.	**K2**
CO3	Examine real time problems, implement with analog and digital circuits by employing modern tools.	**K3**
CO4	Assess the need of modern society with professional ethics inelectronics and recommend solutions for the same.	**K4**
CO5	Evaluate the electronic project to plan an eco-friendly environment.	**K5**
CO6	Design the analog and digital circuits for the real -world applications	**K6**

Relationship Matrix											
Semester	**Course Code**	**Title of the Course**								**Hours**	**Credits**
1	**25PPH1ES01B**	**Discipline Specific Elective - 1:** Analog and Digital Electronics								**4**	**3**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	2	3	2	3	3	2	3	2	**2.5**
CO2	3	3	2	3	2	3	3	3	3	2	**2.7**
CO3	3	3	3	3	2	3	3	3	3	2	**2.8**
CO4	3	3	3	2	2	3	3	3	2	2	**2.7**
CO5	3	3	3	3	2	3	3	2	3	2	**2.7**
CO6	2	3	2	3	3	3	3	2	3	2	**2.7**
										Mean Overall Score	**2.68 (High)**

Semester	Course code	Title of the Course	Hours/Week	Credits
1	25PPH1AE01	**Ability Enhancement Course:** Framework for Physics Innovation and Entrepreneurship	2	1

Course Objectives
To explore the continuity of Indian astronomical traditions and timekeeping systems.
To analyze the nature of genius, creativity, and leadership in scientific thought.
To develop skills in experimental physics, error analysis, and scientific publishing.
To understand technology transfer, innovation, and entrepreneurship in science.
To gain practical exposure through field visits and case studies.
To enhance problem-solving and critical thinking in physics applications.

UNIT I: Indological Truths of Physics (6 Hours)

Astronomers after Aryabhata – continuity in astronomical tradition – motion of celestial bodies relative to stars – pole star direction – equator and poles – Gregorian calendar.

UNIT II: Becoming Genius (6 Hours)

Recognizing genius - six questions - Why Does Genius Require Special Rules? – Team vs Individual creativity – Pilot and passenger – Ten rules for leading genius – the Einstein bomb – conclusion.

UNIT III: The art of experimental physics (6 Hours)

Physics: A Human Endeavor – scientific method to publish - Schematic diagram -Objectives of The Physics Laboratory - Measurements, Errors, and a Nobel Prize - Handling of Significant Figures In Calculations - Graphical analysis - How to publish your results: summary of twelve referenced journals, style manual of the American institute of physics - Responsibility of the experimentalist - Spectroscopy: an important class of experiments.

UNIT IV: Entrepreneurship and Innovation Practices (6 Hours)

Technology Management and Transfer-General Technology- Technology Transfer- Technology Transfer Mechanisms- Technology Transfer Models- The Vicious Circle of Underdevelopment Versus Technology Transfer- Technology Transfer Obstacles- Success Factors for Technology Transfer.

UNIT V: Field Visits and EVS (6 Hours)

Visit to Scientific plants / Reactors / scientific principle-oriented places for case studies - Visit to an area to document environmental assets, local polluted site – generate a model - Environment Laws: Environment Protection Act - Air (Prevention & Control of Pollution) Act - Water (Prevention and control of Pollution) Act - Wildlife Protection Act - Forest Conservation Act.

Teaching Methodology	Black board teaching, PPT, Video lectures, Demonstrations with models, Handouts and field visits
Assessment Methods	Written Assignment, MCQ Test, Mini Project, open book test

Books for Study:

1. Rao, S. B. (2000). *Indian astronomy: An introduction*. Orient Longman Ltd.
2. Hromas, R., & Hromas, C. (2018). *Einstein's boss: 10 rules for leading genius*. AMACOM
3. Preston, D. W., & Dietz, E. R. (1991). The Art of Experimental Physics. Wiley.
4. Elias G.Carayannis, Elpida T.Samara, YannisL. Bakouros. *Innovation and Entrepreneurship Theory, Policy and Practice.* Springer Cham Heidelberg New York Dordrecht London.

Unit	Book	Chapters	Sections
I	1	1,2,6	1.6, 1.8, 2.3-2.5, 2.7, 6.2
II	2	1,2,3	Relevant sections mentioned
III	3	--	Relevant sections mentioned
IV	4	7	7.1:7.1.1 – 7.1.8
V	**	**	** and 

** - a five-page summary of the field visit is attached as an evidence.

Books for Reference:

1. Link, A. N., & Link, J. R. (2020). *Innovation, entrepreneurship, and technological change*. Oxford University Press.
2. Gupta, R. C. (1995). *The astronomical instruments of ancient Indi*a. Indian National Science Academy.
3. Kuhn, T. S. (1970). *The structure of scientific revolutions* (2nd ed.). University of Chicago Press.
4. Ghosh, A. (2017). *Science and technology in ancient India*. Vivekananda International Foundation.
5. Schilling, M. A. (2020). *Strategic management of technological innovation* (6th ed.). McGraw-Hill.
6. Stokes, D. E. (1997). *Pasteur's quadrant: Basic science and technological innovation*. Brookings Institution Press."

Websites and eLearning Sources:

1. http://www.springer.com/series/8124
   (* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K-Level)**
CO1	Recall key environmental laws, international treaties, and fundamental concepts of technology transfer and entrepreneurship.	**K1**
CO2	Explain the contributions of Indian astronomers, the motion of celestial bodies, and the significance of genius in scientific advancements.	**K2**
CO3	Utilize experimental physics techniques, error analysis, and data representation in laboratory settings.	**K3**
CO4	Examine various technology transfer models, obstacles, and their role in economic and scientific development.	**K4**
CO5	Assess the effectiveness of environmental policies, innovation practices, and scientific entrepreneurship models in real-world applications.	**K5**
CO6	Design a field-based case study or model integrating physics, environmental conservation, and entrepreneurship	**K6**

Relationship Matrix											
Semester	**Course Code**	**Title of the Course**								**Hours**	**Credits**
1	**25PPH1AE01**	**Ability Enhancement Course:** Framework for Physics Innovation and Entrepreneurship								**2**	**1**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	3	2	2	1	3	3	3	3	**2.6**
CO2	3	3	3	2	2	1	3	3	3	3	**2.6**
CO3	3	3	3	2	2	2	3	3	2	3	**2.6**
CO4	3	3	3	2	2	1	3	2	3	2	**2.5**
CO5	3	3	3	2	2	1	3	3	2	2	**2.5**
CO6	3	3	3	2	2	2	3	3	2	3	**2.6**
									Mean Overall Score		**2.56 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
1	25PPH1OE01A	**Open Elective - 1 (WS):** Solar Energy and Utilization	4	2

Course Objectives
To acquire the fundamental knowledge on solar energy, solar energy conversion and energy storage devices.
To understand the different types of solar radiation measurement, solar cell testing, solar collectors and concentrators, solar thermal systems and energy storage devices.
To apply the concept of energy conversion on different energy storage and solar energy devices.
To identify the merits and demerits of different solar energy devices.
To analyze the various methods used for solar radiation measurement, testing of solar cells, solar energy collector and concentrator, solar thermal systems and energy storage devices.

UNIT I: Solar Energy and Insolation (12 Hours)

Solar energy - Basic parameters of the Sun - Kelvin-Helmholtz time scale - Energy source of the Sun - Solar Spectrum - Effects of Earth's Atmosphere - Measurement of Irradiance - Solar Simulation.

UNIT II: Photovoltaics (12 Hours)

Semiconductor solar cell - Crystalline silicon solar cell - Thin film solar cells - Tandem solar cells - Dye-sensitized solar cells - Bilayer organic solar cells - Solar Cell Testing Methods - The effect of temperature and illumination on cell efficiency - Loss Analysis.

UNIT III: Solar Collectors (12 Hours)

Solar Collectors - Flat Plate Collectors - Evacuated-tube collectors - Concentrating Collectors - Optical fundamentals for solar concentration - Parabolic Concentrators - Fresnel lens concentrators - Heliostats.

UNIT IV: Solar Energy Storage (12 Hours)

Sensible heat Storage - Phase Transition Chemical Storage - Rechargeable Batteries -Photocatalytic reactions.

UNIT V: Solar Thermal Systems (12 Hours)

Solar thermal systems - Water heating for domestic use - water heating for industrial use - Sludge drying - solar distillation - Water Desalination - Food Drying - Water detoxification.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials.
Assessment Methods	Written Assignment, MCQ Test, Seminar

Books for Study:

1. Chen, J. (2011). *Physics of Solar energy,* (1st Ed.). Wiley.
2. Alan, L.F., & Bube, R.H. (1983). *Fundamentals of Solar Cells – Photovoltaic Solar Energy Conversion.* Academic Press.
3. Foster, R. (2010). *Solar Energy*. CRC Press.
4. Goswami, Y.D. (2015). *Principles of Solar Engineering*. CRC press.

Unit	Book	Chapters	Sections
I	1 2	1, 2 2	1.1,3.1,3.2,3.3 Chapter-2
II	1 2	9,10 6	9.1, 9.5, 9.6, 9.7, 10.4,10.5 Chapter-6
III	3	4	4.2.1, 4.2.2., 4.2.3.,4.2.3.1., 4.2.3.4., 4.2.4., 4.2.5., 4.2.6.
IV	1 4	12 10	12.1., 12.2.1., 12.3., 12.3.1. – 12.3.4. 10.1
V	3	4	4.4., 4.4.1. – 4.4.5.

Books for Reference:

1. Garg, H.P. (2000). *Solar Energy Fundamentals and Applications*, Tata McGraw-Hill.

Websites and eLearning Sources:

1. https://www.e-education.psu.edu/earth104/node/950
2. https://www.britannica.com/science/solar-energy
3. https://science.sciencemag.org/content/184/4134/382

(* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K-Level)**
CO1	Acquire the knowledge on solar energy and predict its utilization.	**K1**
CO2	Understand the concepts of solar insolation and its effects.	**K2**
CO3	Apply the concepts of solar energy in the characteristics of different materials like flat plate, tubular, Fresnel etc.	**K3**
CO4	Analyze the different energy storage methods, test the solar cells.	**K4**
CO5	Assess annual solar savings and its conversion and design the rechargeable batteries.	**K5**
CO6	Design solar energy devices for domestic and industrial applications.	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**					**Hours**		**Credits**
1	**25PPH1OE01A**			**Open Elective - 1 (WS):** Solar Energy and Utilization					**4**		**2**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	3	2	2	3	3	2	2	2	**2.5**
CO2	3	3	2	2	2	3	3	3	2	2	**2.5**
CO3	3	3	2	2	2	3	3	3	2	2	**2.5**
CO4	3	3	2	2	2	3	3	2	2	2	**2.5**
CO5	3	3	2	2	3	3	3	2	2	3	**2.6**
CO6	3	3	2	2	3	3	3	2	2	3	**2.6**
Mean Overall Score											**2.53 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
1	25PPH1OE01B	**Open Elective - 1 (WS):** Renewable Energy Resources	4	2

Course Objectives
To acquire the fundamental knowledge on different types of renewable energy resources and storage systems.
To understand the basic concept of different forms of energy conversion.
To apply the fundamental concept of physics to different energy conversion devices.
To identify the merits and demerits of different renewable energy resources.
To analyse the various forms of energy resources based on its reliability and economic aspects.

UNIT I: Direct Solar Energy (12 Hours)

Solar Energy supply - History of solar energy utilization - Technologies based on capture of heat from sunlight - Solar water heating system - Solar cookers - Solar steam generating system for cooking - Passive solar heating / cooling of buildings - Solar air conditioning - Solar refrigeration – Solar desalination - Salt production and solar ponds - Crop drying - Technologies for converting solar energy to electricity - Heat engines: Concentrated solar thermal energy systems - Photovoltaics.

UNIT II: Biomass Energy (12 Hours)

Composition of biomass - Sources of biomass for energy generation - Food crops - Hydrocarbon - rich plants - Waste - Weed and Wild growths - Lignocellulosic biomass: Fast-growing greases and woody species - Technical routes for obtaining different types of fuels from biomass - Thermochemical conversion of biomass - Biochemical processing - Emerging technologies.

UNIT III: Wind and Wave Energies (12 Hours)

Using the wind and power in the wind - Design of windmills - Summary of wind electric energy systems - Wind turbine sizes - Wind sites and properties - Storage - Wave energy generation - Potential energy - Kinetic energy - Wave energy conversion devices - Wave energy conversion by floats - High-level reservoir wave machine - Dolphin-type wave power machine - other wave machines - Advantage and disadvantages of wave energy. Ocean thermal energy conversion.

UNIT IV: Geothermal Energy (12 Hours)

Origin and nature of geothermal energy - Energy extraction - High-enthalpy geothermal aquifers – Low enthalpy reserves - Wet steam systems - Dry steam systems - Limitations.

UNIT V: Storage of Renewable Energy (12 Hours)

Energy storage systems - Storage as electrical energy - Storage as mechanical energy - Storage as chemical energy - Storage as thermal energy.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials
Assessment Methods	Written Assignment, MQC Test

Books for Study:

1. Tasneem, A., & Abbasi, S.A. (2010). *Renewable Energy Sources*. PHI Learning Private Limited New Delhi.

Unit	Book	Chapters	Sections
I	1	3	3.2, 3.3, 3.4.1-3.4.9, 3.5.1, 3.5.2
II	1	4	4.3, 4.4.1-4.4.5, 4.5.1-4.5.3
III	1	6	6.3.1, 6.4, 6.5.1, 6.5.2, 6.6, 6.9, 6.10
IV	1	7 9	7.2.1, 7.2.2, 7.3.1-7.3.4, 7.4.1, 7.4.2 9.1.1, 9.3.1-9.3.4, 9.5
V	1	12	12.2.1-12.2.4

Books for Reference:

1. Tiwari and Ghosal (2007), *Renewable energy resources*, Narosa Publishing House.
2. Ramesh R & Kumar K.U (2004), *Renewable Energy Technologies*, Narosa Publishing House.
3. Rai G.D. (2011), *Non-Conventional Energy Sources*, Khanna Publishers.
4. Twidell & Wier (2011), *Renewable Energy Resources*, CRC Press (Taylor & Francis).

Websites and eLearning Sources:

1. https://www.energy.gov/eere/renewable-energy#:~:text=Renewable%20energy%20sources%2C%20such%20as,Bioenergy
2. https://www.un.org/en/climatechange/what-is-renewable-energy
3. https://www.nrdc.org/stories/renewable-energy-clean-facts
4. (* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements**	**Cognitive Levels (K-Level)**
	On successful completion of this course, students will be able to	
CO1	Acquire the knowledge of physics of solar radiation.	**K1**
CO2	Understand the classifications of the solar energy collectors and methodologies of storing solar energy.	**K2**
CO3	Know the applications of solar energy, wind energy and biomass and other forms of energy sources.	**K3**
CO4	Analysis the different forms of energy resources based on its economic aspects.	**K4**
CO5	Assess the generated renewable energies.	**K5**
CO6	Design the energy storage systems.	**K6**

Relationship Matrix											
Semester	**Course Code**		**Title of the Course**							**Hours**	**Credits**
1	**25PPH1OE01B**		**Open Elective - 1 (WS):** Renewable Energy Resources							**4**	**2**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	2	3	2	3	2	2	2	1	**2.3**
CO2	3	2	3	3	2	3	2	2	2	1	**2.3**
CO3	3	3	3	3	2	3	3	3	2	1	**2.6**
CO4	3	2	3	2	2	3	3	3	2	1	**2.4**
CO5	3	2	3	3	2	3	3	3	2	1	**2.5**
CO6	3	2	3	3	2	3	3	3	2	1	**2.5**
										Mean Overall Score	**2.43 (High)**

Semester	Course Code	Title of the Course	Hours/ Weeks	Credits
1	25PGC1SL01	Global Citizenship Education	Online	1

Course Objectives
To develop an understanding of global governance structures, rights and responsibilities.
To recognize and respect differences, multiple identities and diversity.
To examine beliefs and perceptions about social justice, equality and civic engagement.
To develop attitudes of care and empathy for others and the environment.
To develop global competence and ethical considerations by enhancing communication and collaboration skills across cultures

UNIT I: Introduction to Global Citizenship

01. Historical and Philosophical Foundations of Global Citizenship
02 Rights and Responsibilities of Global Citizenship
03. Key Organizations and Movements Promoting Global Citizenship

UNIT II: Globalization and Its Impact on Society

04. Globalization and Its Key Drivers
05. Positive and Negative Impacts of Globalization
06. Role of Education in Fostering a Global Perspective

UNIT III: Human Rights, Social Justice, Equality and Diversity

07. Key Human Rights Treaties, Frameworks and Declarations
08. Advocacy, Activism, and Movements for Social Justice and Equality
09. Global Challenges to Human Rights, Equality and Diversity

UNIT IV: Sustainable Development and Environmental Responsibility

10. The Sustainable Development Goals and Their Relevance to Global Citizenship
11. Climate Change, Environmental Degradation and Sustainable Development
12. Strategies for Promoting Environmental Responsibility

UNIT V: Building Global Competence and Engagement

13. Effective Communication and Collaboration Across Cultures
14. Volunteering and Community Engagement in Global Initiatives
15. Ethical Considerations in Global Citizenship

Teaching Methodology	Recorded Lectures/Videos, Reading Materials, PPTs, Case Studies, Collaborative Projects, Quizzes and Polls
Assessment Methods	Seminars, Assignments, MCQs, Reflection Essays, Group Project Presentations, Problem-Solving Scenarios

Books for Study:

1. Clapham, A. (2007). *Human rights: A very short introduction.* Oxford University Press.
2. Desai, A. (2018). *Global citizenship and cultural diplomacy: India's role in a changing world*. Routledge India.
3. Gould, J. A. (2012). *The ethics of global citizenship*. Routledge.
4. Held, D., et al. (2022). *Globalization and its impact on the developing world*. Cambridge University Press.
5. Sen, A. (2009). *The idea of justice*. Penguin Books India.

Books for Reference:

1. Ghosh, A. (2007). *The global impact of Indian civilization*. HarperCollins India.
2. Krecker, E. (2008). *The global citizen: A guide to creating an international life and career*. Career Press.
3. Kumar, R. (2017). *Sustainable development and environmental justice in India*. Oxford University Press.

4. Nair, K. G. (2014). *Human rights: A socio-political perspective*. Orient Blackswan.
5. Patel, V. (2015). *Social justice and equality in India: Theories and practices*. Oxford University Press.
6. Pillai, V. (2016). *Globalization and its impact on Indian society*. SAGE Publications India.

Websites and eLearning Sources:

1. https://www.unesco.org/en/global-citizenship-peace-education/need-know
2. TEDxCincinnati: Global Citizenship in the Classroom: Jenny Buccos at TEDxCincinnati https://www.youtube.com/watch?v=6jjLHmyBs7o
3. Social justice -- is it still relevant in the 21st century? | Charles L. Robbins | TEDxSBU https://www.youtube.com/watch?v=Wtroop739uU
4. Are We the Last Generation — or the First Sustainable One? | Hannah Ritchie | TED https://www.youtube.com/watch?v=Kl3VVrggKz4
5. Diversity, Equity & Inclusion. Learning how to get it right | Asif Sadiq | TEDxCroydon https://www.youtube.com/watch?v=HR4wz1b54hw

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K-Level)**
CO1	Recall the historical, philosophical and practical foundations of global citizenship.	**K1**
CO2	Explain the key drivers of globalization and the role of education in fostering a global perspective.	**K2**
CO3	Apply human rights frameworks, social justice principles, and advocacy strategies to real-world challenges.	**K3**
CO4	Analyze the relevance of the Sustainable Development Goals in addressing climate change and environmental degradation.	**K4**
CO5	Develop strategies for fostering global competence by enhancing communication and collaboration skills across cultures.	**K5**
CO6	Critically evaluate the effectiveness of current global strategies and policies in addressing social justice and environmental sustainability.	**K6**

Semester	Course Code	Title of the Course	Hours/ Weeks	Credits
2	25PPH2CC03	**Core Course - 3:** Quantum Mechanics	5	5

Course Objectives
To knows the fundamentals and the connection between classical and quantum mechanics
To understand different exactly solvable and complex potential problems in quantum mechanics.
To solve the problems in quantum mechanics using cartesian, spherical polar coordinates
To explain Schrodinger equation, various potentials, stationary and time dependent approximation methods
To assess the properties of 1D motion, 3D problems in spherical polar coordinates and transition probabilities.

UNIT I: Basic Postulates and Quantum Systems (15 Hours)

Introduction - The basic postulates of Quantum Mechanics (QM) - The state of a system - observables and operators - Measurement in QM: how measurements disturb systems - expectation values - CSCO - measurement and the uncertainty relation; Time Evolution of the system's state: time evolution operator - stationary states - Schrödinger equation and wave packets - conservation of probability - time evaluation of expectation values; Connecting Quantum Mechanics to Classical Mechanics.

UNIT II: One – Dimensional Problems (15 Hours)

Properties of 1D motions: Bound, unbound states, mixed spectrum - The free particle continuous states - the potential step - The potential barrier & well: E > Vo, E < Vo: Tunnelling - the infinite square well potential: Asymmetric square - symmetric; the finite square well potential: Scattering solutions (E > Vo), Bound state solution (0 < E < Vo) - Harmonic oscillator: Energy Eigenvalues, Energy Eigen states - Oscillator wave functions.

UNIT III: Angular Momentum (15 Hours)

General formalism - Geometrical representation - Spin angular momentum: Experimental evidence of spin, general theory of spin, spin ½ and Pauli Matrices - Eigen functions of orbital angular momentum: Eigen functions and Eigenvalues of L_z, Eigen functions of L^2 - Addition of Angular Momenta.

UNIT IV: Three – Dimensional Problems (15 Hours)

3D problems in spherical coordinates: central potential, the free particle, The Hydrogen atom: Separation of the Center of Mass Motion - Solution of the Radial Equation for the Hydrogen Atom - Degeneracy of the Bound States of Hydrogen - Degeneracy relation for the hydrogen atom - Probabilities and Averages.

UNIT V: Approximation Methods (15 Hours)

Time independent Perturbation Theory: Non-degenerate, Degenerate - Variational method - The Schrödinger picture, The Heisenberg picture, The Interaction picture – Time-dependent perturbation theory - Transition probability - Constant and Harmonic perturbation.

Teaching Methodology	Chalk and talk, Presentations (PPT)
Assessment Methods	Written Assignment, MQC Test.

Books for Study:

1. Zettili, N. (2009). *Quantum Mechanics: Concepts and Applications* (2nd Ed.). John Wiley & Sons.

Unit	Book	Chapters	Sections
I	1	3	3.1, 3.2, 3.3**,** 3.3.1, 3.3.2,3.4, 3.5, 3.5.1, 3.5.2, 3.5.3, 3.5.4, 3.6, 3.6.1, 3.6.2, 3.6.3, 3.6.4, 3.6.5, 3.8, 3.8.1, 3.8.2, 3.8.3
II	1	4	4.2.1, 4.2.2, 4.2.3, 4.3, 4.4, 4.5, 4.5.1, 4.5.2, 4.6, 4.6.1, 4.6.2, 4.7, 4.7.1, 4.7.2, 4.8, 4.8.1, 4.8.2, 4.8.3.
III	1	5,7	5.1, 5.2, 5.3, 5.5, 5.6.1, 5.6.2, 5.6.3, 5.7, 5.7.1, 5. 7.3, 7.3.1.
IV	1	6	6.2.1, 6.2.2, 6.3.1, 6.3.2, 6.3.5
V	1	9	9.1, 9.2, 9.2.1, 9.3, 10.1, 10.2, 10.2.1, 10.2.2, 10.2.3, 10.3, 10.3.1, 10.3.2, 10.3.3.

Books for Reference:

1. Shankar, R. (2014). *Principles of Quantum Mechanics* (2nd Ed.). Springer.
2. Feynman, R. (2012). *Feynman lectures on Physics - Vol 3* (new millennium edition), Pearson.
3. Merzbacher, E. (2011). Quantum *Mechanics*, (3rd Ed.). Wiley.
4. Bransden, B., & Joachain, C. (2004). *Quantum Mechanics* (2nd Ed.). Pearson.
5. Rogalski, M. S., & Palmer, S. B. (1999). *Quantum Physics*, (1st Ed.). CRC Press.
6. Leonard, I.S. (1968). *Quantum Mechanics*, (International student Edition), McGraw Hill.

Websites and eLearning Sources:

1. Visual quantum mechanics: https://vqm.uni-graz.at/ 2.
https://ocw.mit.edu/courses/physics/
3. https://epgp.inflibnet.ac.in/Home/ViewSubject?cat 4.
https://nptel.ac.in/courses/115/106/115106066/

(* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements**	**Cognitive Levels (K-Level)**
	On successful completion of this course, students will be able to	
CO1	Describe the principles and methods of wave mechanics and matrix mechanics based on Dirac notation.	**K1**
CO2	Explain quantum mechanical methods to study angular momentum and various perturbed systems.	**K2**
CO3	Apply the quantum theory to 1D potentials, 3D potentials, rotation & addition of angular momenta, stationary states and time-dependent systems.	**K3**
CO4	Analyse various properties using the quantum theory and compare it with the results of classical physics.	**K4**
CO5	Evaluate the methods and properties of various quantum mechanical systems.	**K5**
CO6	Summarize the methods and properties of various quantum mechanical systems	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**						**Hours**	**Credits**
2	**25PPH2CC03**			**Core Course - 3:** Quantum Mechanics						**5**	**5**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	2	2	1	3	3	3	2	2	**2.4**
CO2	3	3	3	2	2	3	3	3	2	2	**2.5**
CO3	3	3	3	2	2	3	3	3	2	2	**2.5**
CO4	3	3	2	2	2	3	3	3	2	2	**2.5**
CO5	3	3	3	3	2	3	3	3	2	2	**2.7**
CO6	3	3	2	3	2	3	3	3	2	2	**2.6**
										Mean Overall Score	**2.53 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	25PPH2CC04	**Core Course - 4:** Mathematical Methods of Computational Physics and Python Programming (Internship Embedded Course)	5	4

Course Objectives
To find the different computational techniques for physics applications.
To study the types of elements and symmetry operations and constructing the character tables based on the principles of the group theory.
To solve the differential equation using an appropriate numerical method and root finding methods Constructing a polynomial, like Newton Raphson & Gregory method for equally spaced points.
To study the modules and structure of python programming.
To study and use the arrays, control structures using python programming.

UNIT I: Basics of Group Theory (15 Hours)

Definition and nomenclature - Rearrangement theorem - cyclic groups - subgroups - conjugate elements and class structure - identification of symmetry element and operations - molecular point groups.

UNIT II: Representation of C_n Groups (15 Hours)

The Great Orthogonality Theorem (Qualitative treatments) - character of representation. Character table - Generating symmetry operators - construction of character tables - irreducible representation for C_{2v} and C_{3v}.

UNIT III: Numerical Methods Applied to Physics Problems (15 Hours)

Numerical integration: Trapezoidal, Simpson's 1/3 rules - Truncation error - composite trapezoidal and Simpson's 1/3 rules. **ODE:** Second – order & Fourth-order Runge-Kutta methods for first order ODE. **Interpolation:** Newton Raphson Method - Newton's interpolation - Linear interpolation - Higher-order polynomials - Divided differences - Gregory - Newton forward and backward interpolation formulae - error in interpolation *(no theory and derivation of formulae in the entire unit)*

UNIT IV: Basics of Python (15 Hours)

Installing Python - Launch Python - Python modules - Python expression - objects and their methods - Lists - Tuples - Strings - Loops - Development Tools

UNIT V: Python Structure and Control (15 Hours)

SciPy and NumPy - arrays - array operations - scripts - contingent behavior - nesting – importing data - exporting data - visualizing data - Functions - random numbers and simulation - histograms and bar graphs - contour plots and surfaces - matrix library - Interpolation - Fourier Transform - Sparse eigenvalue problem.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials
Assessment Methods	Written Assignment, MQC Test

Books for Study:

1. Joshi, A.W. (2010). *Matrix and Tensors in Physics*. New Age Publications.
2. Tinkham, M. (1974). *Group Theory and Quantum Mechanics.* McGraw Hill Ltd.
3. Venkataraman, M.K. (2013*). Numerical Methods in Science & Engineering.* National Pub. Co. Madras.
4. Jesse, M.K., & Philip, N. (2015). *Python for Physical modelling.* Princeton University Press Princeton and Oxford.
5. https://docs.python.org/3/library/tk.html

Unit	Book	Chapters	Sections
I	1	1 & 2	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 16.1, 16.2, 16.3, 16.4, 16.5, 16.6, 16.7, 16.8
II	2	1 & 2, 3, 5	1.1, 1.2, 2.1, 2.3, 2.4, 3.2, 3.3, 3.4, 5.2, 5.3, 5.4
III	3	1,3,7	All sections
IV	4	1, 2	1.2-1.4, 2.1, 2.2.1, 2.3, 2.4
V	4,5	2, 3, 5	2.2.2-2.2.10, 2.5-2.8, 3.1-3.3, 5.1-5.4

Books for Reference:

1. Pipes, L. A. & Harvill, L. R (2014). *Applied Mathematics for Engineers and Physicists,* Dover Publications Inc.
2. Arfken, Weber, Harris. (2013). *Mathematical Methods for Physicists,* (7th Ed.). Academic Press.
3. Boas, M.I. (2006). *Mathematical Methods in the Physical Sciences,* (3rd Ed.). John Wiley & Sons.
4. Kreyszig E. (2015). *Advanced Engineering Mathematics, (*10th Ed.). Wiley.
5. Burden, R. L., & Faires, J. D. (2011). *Numerical Analysis,* (9th Ed.). Brooks/Cole Cengage Learning.
6. Chan, J. (2014). *Python for Beginners*.
7. Stewart, A. (2016). *Python Programming*.
8. *NumPy*-1.17 and *SciPy*-1.6.1 reference manual.

Websites and eLearning Sources:

1. https://ocw.mit.edu/courses/mathematics/
2. https://nptel.ac.in/courses/115/103/115103036/
3. https://epgp.inflibnet.ac.in/Home
4. https://swayam.gov.in/explorer
5. http://www.learncodingfast.com/python
6. https://www.tutorialspoint.com/python/index.htm
7. https://www.python.org/

(* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K-Level)**
CO1	Remember the: definition of groups, subgroups, Numerical Integration and python modules.	**K1**
CO2	Understand the: important properties of group theory and its character tables, numerical integration and python structure.	**K2**
CO3	Apply the ideas learnt in the above COs: involving operators and constructing the character tables and numerical interpolation and python functions.	**K3**
CO4	Analyse the groups and subgroups, numerical integration and interpolation formulae applied to the physics problems and also using python programs.	**K4**
CO5	Evaluate: the groups, numerical problems, Python expression, objects and their methods.	**K5**
CO6	Create: the symmetry elements, numerical integration, array operations, scripts, histogram and bar graphs.	**K6**

Relationship Matrix											
Semester	**Course Code**	**Title of the Course**								**Hours**	**Credits**
2	**25PPH2CC04**	**Core Course - 4:** Mathematical Methods of Computational Physics and Python Programming (Internship Embedded Course)								**5**	**4**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	2	2	2	2	3	2	3	1	1	**2.1**
CO2	3	3	2	2	2	3	3	2	1	1	**2.5**
CO3	3	2	3	2	3	2	2	2	3	3	**2.6**
CO4	3	3	2	2	2	3	3	2	1	2	**2.3**
CO5	2	3	3	2	3	2	2	2	3	3	**2.5**
CO6	3	3	2	2	2	3	3	2	1	2	**2.3**
										Mean Overall Score	**2.38(High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	25PPH2CC05	**Core Course - 5:** Artificial Intelligence in Physics	4	3

Course Objectives
To identify AI and ML in physics
To understand AI algorithms to solve physics problems
To apply AI to model and predict physics experiments
To conclude AI to enhance physics results
To plan and develop AI system to solve physic problems

UNIT I: Artificial Intelligence and Machine Learning (12 Hours)

History and evolution of AI - Types of AI: Narrow AI - General AI - Machine Learning - Deep Learning - Supervised and unsupervised learning - Neural networks - Key algorithms: Linear regression, decision trees, clustering, and classification.

UNIT II: Data Analysis in Physics (12 Hours)

Experimental physics and large data sets - particle accelerators - astronomical observatories - noisy data - filtering - cleaning and normalizing data - dimensionality reduction.

UNIT III: Machine Learning Algorithms for Physics Data (12 Hours)

Regression and classification in physical systems - decision trees - random forests - support vector machines (SVM) - Cross-validation, bias-variance – trade off - overfitting - Loss functions and optimization techniques.

UNIT IV: Neural Networks and Deep Learning for Physics (12 Hours)

Introduction to Convolutional Neural Networks (CNN) - Recurrent Neural Networks (RNN) - Training deep networks using backpropagation - deep learning in image analysis, time-series data, and physics-based predictions - Particle collision prediction in high-energy physics - Image recognition in astrophysics.

UNIT V: Material Science and Condensed Matter Physics (12 Hours)

Predicting material properties using machine learning - High-throughput screening of new materials - Spin models, phase transitions, and AI approaches - AI for simulating electron interactions and lattice dynamics - black hole imaging - quantum simulations.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials, Simulations
Assessment Methods	Written Assignment, MQC Test

Book for Study:

1. Text Prepared by the Department.

Unit	Chapters	Sections
I	1	All
II	2	All
III	3	All
IV	4	All
V	5	All

Books for Reference:

1. Christopher M. Bishop, *Pattern Recognition and Machine Learning*,
2. Yoshua Bengio, and Aaron Courville, *Deep Learning by Ian Goodfellow*,
3. Kevin P. Murphy, *Machine Learning: A Probabilistic Perspective*,
4. Ray LaFlamme, *Introduction to Quantum Computing*,
5. R. C. V. K. Rao, *Computational Physics: Fortran and C*,

Websites and eLearning Sources:

1. https://link.springer.com/article/10.1007/s10462-024-10874-4

2. https://medium.com/@irshadhuzaifa/unlocking-the-cosmos-how-artificial-intelligence-is-transforming-physics-b49e248d04cd
3. https://news.mit.edu/2024/scientists-use-generative-ai-complex-questions-physics-0516
4. https://www.fz-juelich.de/en/news/archive/announcements/2024/ai-as-a-physicist
5. https://www.oecd.org/content/dam/oecd/en/publications/reports/2023/06/artificial-intelligence-in-science_4f3d6efd/a8d820bd-en.pdf

(* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements**	**Cognitive Levels (K-Level)**
	On successful completion of this course, students will be able to	
CO1	Describe AI and machine learning algorithms to analyze and model physical systems	**K1**
CO2	Infer the potential and limitations of AI in solving physics problems	**K2**
CO3	Use AI tools to assist in data processing, simulation, and optimization in various branches of physics.	**K3**
CO4	Analyse complex physics problems and contribute to the development of AI-enhanced research methods in physics.	**K4**
CO5	Critically assess the role of AI in advancing the frontiers of scientific discovery in physics, from experimental analysis to theoretical predictions.	**K5**
CO6	Develop AI system for physics applications with a scope to Gen AI	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**				**Hours**			**Credits**
2	**25PPH2CC05**			**Core Course - 5:** Artificial Intelligence in Physics				**4**			**3**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	2	2	2	3	3	3	3	2	**2.6**
CO2	3	3	3	2	2	3	3	3	3	2	**2.7**
CO3	3	3	3	2	2	3	3	3	3	2	**2.7**
CO4	3	3	2	3	2	3	3	3	3	2	**2.7**
CO5	3	3	3	3	2	3	3	3	2	2	**2.7**
CO6	3	3	3	3	2	3	3	3	2	2	**2.7**
Mean Overall Score											**2.68 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	25PPH2CP02	**Core Practical - 2:** Physics Practical - 2	8	4

Any 14 Experiments

1. Michelson Interferometer – wavelength, separation and thickness of thin sheet
2. Biprism – Optic bench - wavelength, separation and thickness of thin sheet
3. Energy Gap study of a semiconductor
4. Elastic Constants – Hyperbolic fringes
5. Laser: Magneto-striction, Faraday effect and Verdert constant of a given material
6. e-Millikan's oil drop method
7. Ultrasonic diffraction – velocity and compressibility in liquids
8. Determination of e/k using Ge and Si transistors
9. Permittivity of a liquid using RFO
10. Determination of phase transition temperatures of a binary liquid mixture at different concentrations
11. Polarizability of liquids
12. Fermi-Curie plot of the X-ray / Gamma ray spectrum and determination of end-point energy
13. Determination of transition temperature in liquid crystalline materials
14. Characteristics of laser and tunnel diode
15. Characteristics of LVDT
16. Characteristics of load cell
17. SCR – Characteristics and Applications
18. Study of regulated power supply – monolithic IC
19. Transmission Line Characteristics
20. Shift Registers using Flip-Flop & ICs
21. Design of ROM and RAM using diode / OR gate and flip flop
22. Design of Encoder and Decoder
23. Op-amp: Low, High and band pass Filters
24. Computational experiment: Curve fitting – Least square fitting
25. Computational experiment: Solving Schrodinger equation for hydrogen / LHO
26. Computational experiment: Op-Amp parameter study – Circuit simulation using Proteus
27. Computational experiment: Linear Harmonic Oscillator problem using Hamilton's equation
28. Determination of the wavelength of an unknown light source and the distance between the grooves of a compact disk.
29. Determination of band gap of a semiconductor sample using UV-VIS spectroscopy
30. Study of magnetic hysteresis in ferromagnetic materials

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	25PPH2OE02A	**Open Elective - 2 (BS):** Physics for Competitive Exams	4	2

Course Objectives
To describe the fundamental concepts, laws and constants in various branches of physics.
To interpret the relations and principles to understand the numerical problems.
To solve the physics problems by choosing the appropriate equations.
To illustrate the graphical representations of the given problem.
To judge the obtain results for its accuracy.
To invent short cut methods and to score high marks in the competitive exams.

UNIT I: General Mechanics and Properties of Matter (12 Hours)

Physical quantities - SI system of units - dimensions - scalars and vectors (Concepts) - Newton's equations of motion - impulse - principle of conservation of linear momentum - projectile motion - Kepler's laws - Newton's law of gravitation - acceleration due to gravity - escape velocity - angular momentum - banking of roads - simple harmonic motion -viscosity, surface tension.

UNIT II: Heat and Thermodynamics (12 Hours)

Different scales of temperatures - thermal expansions - calorimetry - specific heat - latent heat - triple point - transmission of heat - heat conductivity - Black body radiation - Stefan Boltzmann law - Wien's displacement law - Gas equation - Boyle's law - Charle's law - Law of equipartition of energy.

UNIT III: Light and Sound (12 Hours)

Reflection and refraction - Snell's law - total internal reflection - polarization - Brewster's Law - Huygen's principle - Youngs double slit interference and single slit diffraction - longitudinal and transverse waves - velocity of sound - Newton's formula, Laplace correction, effects of pressure - beats - laws of vibrating strings - open and closed organ pipes - resonance.

UNIT IV: Electricity and Magnetism (12 Hours)

Coulomb's Law - Electric field due to charged particles: a point charge, a dipole, a line of charge - electric flux - Gauss' law and applications - Biot - Savart law, magnetic field due to a current in: a long straight wire, a circular arc of wire - Ampere's Law - magnetic field outside and inside a long straight wire - solenoids and toroids - Faraday's laws and Lenz's law.

UNIT V: Modern Physics (12 Hours)

Postulates of Einstein's theory of relativity - Galilean and Lorentz transformation - time dilation - length contraction - Planck's radiation - photoelectric effect - Compton shift, matter waves - Bohr's atomic theory - nuclear properties - binding energy and mass defect -radioactive decay - alpha decay, beta decay and gamma decay - Radioactive dating.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials, Simulations
Assessment Methods	Written Assignment, MQC Test

Books for Study:

1. Walker, J., Halliday, D., & Resnick, R. (2007). *Fundamentals of Physics*, (10th Ed.). Wiley.
2. Verma, H. C. (2008). *Concept of Physics*. (Volume II), (1st Ed.). Bharati Bhawan Publishers Distributors.
3. Verma, H. C. (2008). *Concept of Physics*. (Volume I), (1st Ed.). Bharati Bhawan Publishers Distributors.

Unit	Book	Chapters	Sections
I	1	1,3,4,5,9,11, 13,14,15	1.3, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.5, 4.6, 5.3, 5.6. 5.8, 9.4, 9.5, 9.6, 9.7,11.7,13.2, 13.4, 13.6, 13.7, 14.8, 15.2, 15.3, 15.4,
II	2	23,24,25,27,28	23.3, 23.4, 23.5, 23.6, 24.7, 25.3, 25.4, 25.6,27.8, 28.1, 28.5, 28.5, 28.7, 28.9, 28.10
III	1 3	16,17,33,35, 36	33.7, 33.8, 33.9, 35.4, 36.4, 36.5, 16.3, 17.3, 16.4, 16.9, 16.11
IV	1	21, 22, 23, 29,30	21.4, 22.4, 22.5, 22.6, 23.2, 23.4, 23.7, 23.8, 23.9, 29.2, 29.3, 29.4, 29.5,30.3, 30.4
V	1	37, 38, 42,	37.2, 37.3, 37.5, 37.6, 38.1, 38.2, 38.3, 38.5, 42.2, 42.3, 42.4, 42.5, 42.6

Books for Reference:

1. Department of Physics. (2015). *A Book on Physics for Competitive Examinations.* St. Joseph's College.
2. Nelkon, M., & Parker, P. (1995). *Advanced Level Physics*, (7th Ed.). CBS Publishers.
3. Young, H. D., & Freedman, R. A. (2017). *University Physics with Modern Physics*, (14th Ed.). Pearson Education.

Websites and eLearning Sources:

1. https://testbook.com/physics
2. https://www.examsbook.com/physics-questions-and-answers
3. https://cracku.in/blog/physics-notes-pdf/
4. https://www.mphysicstutorial.com/2022/12/300-physics-mcq-for-competitive-exams.html
   (* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K-Level)**
CO1	Acquire the knowledge of the fundamental concept of physics	**K1**
CO2	Understand the concepts of fundamental physics	**K2**
CO3	Apply the concept of physics to solve various problems	**K3**
CO4	Analyse an appropriate problem-solving approach and select a step to describe the quantitative analysis.	**K4**
CO5	Evaluate the results of analytical problems and provide the explicit description for the solutions.	**K5**
CO6	Create a short cut method to solve the numerical and analytical problems and develop the exact solution.	**K6**

Relationship Matrix											
Semester	**Course Code**		**Title of the Course**							**Hours**	**Credits**
2	**25PPH2OE02A**		**Open Elective - 2 (BS):** Physics for Competitive Exams							**4**	**2**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	2	3	2	2	2	3	2	2	1	1	**2.0**
CO2	3	3	2	2	3	3	2	2	2	1	**2.3**
CO3	3	3	2	2	3	2	3	3	2	1	**2.4**
CO4	3	3	2	2	3	1	3	3	2	1	**2.3**
CO5	3	3	2	2	3	1	3	3	2	1	**2.3**
CO6	3	3	2	2	3	2	3	3	2	1	**2.4**
										Mean Overall Score	**2.38 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	25PPH2OE02B	**Open Elective - 2 (BS):** Nanoscience	4	2

Course Objectives
To acquire knowledge on the fundamentals of nanoscience.
To understand the various synthesis procedures of nanomaterials and their suitability in synthesizing materials for applications.
To illustrate the role of different nanostructures in energy, environmental and medical applications.
To analyze the environment remediation, energy alternatives and advancement in medicine through nanotechnology.
To assess the impact of nanomaterials in diverse fields, with special focus on energy, environment and medical.
To summarize the future potentialities/applications of nanomaterials.

UNIT I: Fundamentals of Nanoscience (12 Hours)

Definition of Nanoscience and Nanotechnologies- Uniqueness of the Nanoscale-Physical properties of Nanomaterials-Nanoscience in Nature- -Historical perspective: Lycurgus cups - ancient Maya fresco painting -Nanomaterials- classification of nanomaterials-strategies for synthesis of nanomaterials- significance of nanoscience.

UNIT II: Synthesis Techniques (12 Hours)

General synthetic approaches-top-down: Mechanical milling - Sputtering - Laser Ablation- Ultrasonic Spray Pyrolysis-Electrospray Deposition (ESD) Method- bottom-up approaches: Chemical Vapor Deposition-Hydrothermal/Solvothermal- Sol–Gel Method- Sonochemical Method.

UNIT III: Energy Applications (12 Hours)

Solar Energy and Nano - Quantum Dot Solar Cells - Organic Solar Cells - Carbon Nanotube Materials in Solar Cells – Batteries- Next Generation Batteries- High-Capacity Lithium-Ion Batteries with Germanium Nanowires - Carbon Nanotube Based Batteries - Hydrogen Production and Storage- Photocatalysis - Fuel Cells.

UNIT IV: Environmental Applications (12 Hours)

Introduction - Types of Environmental Sensors: Electrochemical sensors, Mass sensors-environmental Mitigation: Application of Catalysts, Photocatalysts - Immunosensor Detection of TNT - Nanoscale considerations of water treatment - Activated Carbon - Reverse Osmosis - Carbon Nanotube Water Filters - Air Quality, Monitoring and Mitigation - Carbon Nanotube–Nanocomposite Gas Sensors.

UNIT V: Medical Applications (12 Hours)

Nanoparticles for Medical Imaging-Nanoparticles for Targeting Cancer Cells-Drug Delivery to Tumors-Nanoparticles and Nanoencapsulation for Insulin Delivery- Nanoencapsulation for protection of implantation from immune system. Future Possibilities for Medical Nanotechnology: Nanomedicine.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials, Simulations
Assessment Methods	Written Assignment, MQC Test

Books for Study:

1. Narendra Kumar and Sunita Kumbhat, (2016), *Essentials in Nanoscience and Nanotechnology,* Wiley Publications.
2. Gabor L Hornyak, John J Moore, Harry F. Tibbals, Joydeep Dutta, (2009), *Fundamentals of Nanotechnology,* CRC press, Taylor & Francis, Boca Raton, Florida, US.

Unit	Book	Chapter	Sections
I	1	1	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8
II	1	2	2.2: 2.2.1, 2.2.4, 2.2.6, 2.2.8: 2.2.8.1, 2.2.8.2, 2.3: 2.3.1, 2.3.5, 2.3.7, 2.3.8
III	2	14	14.3.1, 14.3.2, 14.3.3, 14.3.4
IV	2	14	14.0.1, 14.0.3, 14.0.4, 14.0.5, 14.1.1, 14.1.3,14.1.4, 14.2 (intro only), 14.2.4
V	2	13	13.1.1,13.1.2,13.1.3, 13.1.5,13.1.6, 13.0.4

Books for Reference:

1. Cao G, (2004), *Nanostructures and Nanomaterials: Synthesis, properties, and applications,* Imperial College Press.
2. Fahrner R, (2005), *Nanotechnology and Nanoelectronics,* Springer-Verlag Berlin Heidelberg, New York.
3. Pradeep T, (2017), *The Essentials: Understanding Nanoscience and Nanotechnology (1st Edition),* McGraw Hill Education.

Websites and eLearning Sources:

1. https://www.nano.gov/about-nanotechnology/applications-nanotechnology
2. https://onlinelibrary.wiley.com/doi/full/10.1111/joim.13254
3. https://www.understandingnano.com/nanotechnology-energy.html
4. https://www.youtube.com/watch?v=0EWCqCIsFOA
5. https://www.emm-nano.org/what-is-nanoscience-nanotechnology/
6. https://www.youtube.com/watch?v=r753o8PMG_s&t=5shttps://www.nsf.gov/news/mmg/index.jsp?series_name=Nanotechnology:%20Super%20Small%20Science.

(* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K-Level)**
CO1	Acquire the knowledge on fundamentals of nanoscience, its properties, and applications.	**K1**
CO2	Understand the observable physical phenomena that are due to quantum size effects in nanoscale materials on various applications.	**K2**
CO3	Illustrate the synthesis procedures and use them to make nanomaterials for different applications.	**K3**
CO4	Analyze the applications of nanomaterials in energy, environment, and medicine.	**K4**
CO5	Correlate various properties of nanostructures with different applications.	**K5**
CO6	Compile the applications of nanomaterials according to their properties.	**K6**

Relationship Matrix											
Semester	**Course Code**		**Title of the Course**							**Hours**	**Credits**
2	**25PPH2OE02B**		**Open Elective - 2 (BS):** Nanoscience							**4**	**2**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	2	3	2	3	2	2	2	1	**2.3**
CO2	3	2	2	2	2	3	2	2	2	1	**2.1**
CO3	3	2	2	3	2	3	2	2	2	2	**2.3**
CO4	3	2	2	2	2	3	2	2	2	1	**2.1**
CO5	3	2	2	2	2	3	2	2	2	2	**2.2**
CO6	3	3	2	3	2	2	3	2	2	2	**2.4**
										Mean Overall Score	**2.23 (High)**

Semester	Course Code	Title of the Course	Hours/ Weeks	Credits
2	25PSS2SE01	**Skill Enhancement Course:** Soft Skills	4	2

Course Objectives
To provide a focused training on soft skills for students in colleges for better job prospects
To communicate effectively and professionally
To help the students take active part in group dynamics
To familiarize students with numeracy skills for quick problem solving
To make the students appraise themselves and assess others

Unit I: Effective Communication & Professional Communication (12 Hours)

Definition of communication - Barriers of Communication - Non-verbal Communication. Effective Communication - Conversation Techniques - Good manners and Etiquettes - Speech Preparations & Presentations - Professional Communication.

Unit II: Resume Writing & Interview Skills (12 Hours)

Resume Writing: What is a résumé? Types of résumés – Chronological - Functional and Mixed Resume - Purpose and Structure of a Resume - Model Resume.

Interview Skills: Types of Interviews - Preparation for an interview – Attire - Body Language - Common interview questions - Mock interviews & Practicum.

Unit III: Group Discussion & Personal effectiveness (12 Hours)

Basics of Group Discussion- Parameters of GD- Topics for Practice - Mock GD & Practicum & Team Building. *Personal Effectiveness*: Self Discovery - Goal Setting with questionnaires & Exercises.

Unit IV: Numerical Ability (12 Hours)

Introducing concepts - Average – Percentage - Profit and Loss - Simple Interest - Compound Interest - Time and Work - Pipes and Cisterns.

Unit V: Test of Reasoning (12 Hours)

Introducing Verbal Reasoning: Series Completion – Analogy - Data Sufficiency - Assertion and Reasoning and Logical Deduction. *Non-Verbal Reasoning*: Series - and Classification.

Teaching Methodology	Chalk and talk, PPT, Mathematical models, Video presentation

Books for Study:

1. Melchias G., Balaiah, J. & Joy, J. L. (Eds). (2018). Winner in the Making: A Primer on soft Skills. Trichy, India: St. Joseph's College.

Books for Reference:

1. Aggarwal, R. S. (2010). A Modern Approach to Verbal and Non- Verbal Reasoning. S. Chand.
2. Covey, S. (2004). 7 Habits of Highly effective people. Free Press.
3. Gerard, E. (1994). The Skilled Helper (5th Ed.). Brooks/Cole.
4. Khera, S. (2003). You Can Win. Macmillan Books.
5. Murphy, R. (1998). Essential English Grammar, (2nd Ed.). Cambridge University Press.
6. Sankaran, K., & Kumar, M. (2010). Group Discussion and Public Speaking (5th Ed.). M.I. Publications.
7. Trishna, K. S. (2012). How to do well in GDS & Interviews? (3rd Ed.). Pearson Education.
8. Yate, M. (2005). Hiring the Best: A Manager 's Guide to Effective Interviewing and Recruiting

Websites and eLearning Sources:

5. https://www.indeed.com/career-advice/resumes-cover-letters/communication-skills
6. https://www.seek.com.au/career-advice/article/50-communication-skills-for-the-workplace-your-resume
7. https://southeast.iu.edu/career/files/power-phrases.pdf
8. https://dese.ade.arkansas.gov/Files/20201209124449_Professional-Communication.docx

9. https://www.dol.gov/sites/dolgov/files/ETA/publications/00-wes.pdf
10. https://www.tmu.ac.in/other_websites/cdoe.tmu.ac.in.old/study-material/28-08-2024/COMMON/SEMESTER_2/MAIN_SOFT_SKILLS.pdf
11. https://byjus.com/maths/profit-and-loss-questions/
12. https://www.indiabix.com/

Course Outcomes		
CO No.	**CO-Statements**	**Cognitive Levels (K-Level)**
	On successful completion of this course, students will be able to	
CO1	Recall various soft skill sets	**K1**
CO2	Understand personal effectiveness in any managerial positions	**K2**
CO3	Apply verbal and non-verbal reasoning skills to solve problems	**K3**
CO4	Differentiate problems at work and home; and design solutions to maintain work-life balance	**K4**
CO5	Assess growth and sustainability and infuse creativity in employment that increases professional productivity	**K5**
CO6	Construct plans and strategies to work for better human society	**K6**

Relationship Matrix											
Semester	**Course Code**		**Title of the Course**							**Hours**	**Credits**
2	**25PSS2SE01**		**Skill Enhancement Course:** Soft Skills							**4**	**2**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	3	3	2	3	2	3	2	3	2.7
CO2	3	3	3	2	3	3	3	3	3	3	2.9
CO3	3	2	2	3	3	3	3	3	3	3	2.8
CO4	3	3	2	2	3	3	3	3	3	3	2.8
CO5	3	3	3	2	2	3	3	3	3	3	2.8
CO6	3	3	3	2	2	3	3	3	3	3	2.8
										Mean Overall Score	**2.8 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
3	25PPH3CC06	**Core Course - 6:** Condensed Matter Physics	5	4

Course Objectives
To recall the fundamentals and models related to metals, semiconductor crystals in terms of energy gap and Bloch functions and to understand the superconducting materials and dielectric materials
To interpret the behavior of semiconductor, metals, superconducting, magnetic, and dielectric materials based on classical and quantum mechanical approach
To explain the concepts and phenomena associated with different materials
To evaluate different parameters related to semiconductors, metals, superconducting, magnetic, and dielectric materials
To plan for different materials for the benefit of the society

UNIT I: Semiconductor Crystals (15 Hours)

Introduction to crystals -Origin and magnitude of energy gap-Bloch functions-Restatement of the Bloch Theorem- Kronig-Penney model-crystal momentum of an electron -number of orbitals in a band- Effective mass – intrinsic carrier concentration - intrinsic mobility – impurity conductivity - thermal ionization of donors and acceptors.

UNIT II: Fermi Surfaces and Metals (15 Hours)

Reduced zone scheme – periodic zone scheme – construction of fermi surfaces- nearly free electrons-electron orbits, hole orbits and open orbits – calculations of energy bands – Tight binding method for energy bands- Wigner – Seitz method–-De Haas-van Alphen effect – Fermi surface of copper.

UNIT III: Superconductivity (15 Hours)

Thermodynamics of the superconducting transition – London equation – Coherence length – BCS theory of superconductivity – BCS ground state – Flux quantization in a superconducting ring – Type I & II superconductors – vortex state – estimation of H_{c1} and H_{c2} – single particle tunnelling – Josephson superconductor tunnelling – Dc Josephson effect – Ac Josephson effect- High temperature superconductors.

UNIT IV: Magnetic Properties of Solids (15 Hours)

Langevin diamagnetism equation - quantum theory of diamagnetism – Paramagnetism - quantum theory of Paramagnetism - paramagnetic susceptibility of conduction electrons – ferromagnetic order - ferrimagnetic order - Curie temperature and susceptibility of ferrimagnets - antiferro magnetic order - susceptibility below the Neel temperature - ferromagnetic domains - origin of domains –coercivity and hysteresis.

UNIT V: Polaritons, Polarons and Dielectrics (15 Hours)

Plasmons-Electrostatic screening -polaritons -electron - electron interaction – polarons - Polarization – macroscopic electric field – local electric field at an atom – dielectric constant and polarizability – structural phase transitions - displacive transitions.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials, Simulations
Assessment Methods	Written Assignment, MQC Test

Books for Study:

1. Charles Kittel. (2004.), *Introduction to solid state physics* (8th Edition), John Wiley & Sons, Inc

Unit	Chapter
I	7 & 8
II	9
III	10
IV	11 & 12
V	14 & 16

Books for Reference:

1. Wahab. M.A. (2010), Solid State Physics (2nd Edition), Narosa
2. Ashcroft, N. W., & Mermin, N. D. (1976). *Solid State Physics.* Brooks/Cole; New edition.
3. J.P. Srivastava. (2015), Elements of Solid-State Physics (4th Edition), Prentice-Hall of India

Websites and eLearning Sources:

1. https://nptel.ac.in/courses/115/106/115106061/
2. https://nptel.ac.in/courses/115/103/115103102/
3. https://nptel.ac.in/courses/115/105/115105099/
4. https://nptel.ac.in/courses/113/104/113104090/
   (* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements**	**Cognitive Levels (K-Level)**
	On successful completion of this course, students will be able to	
CO1	Acquire knowledge about metals, semiconductor, superconducting, magnetic and dielectric materials	**K1**
CO2	Understand the formation of Brillouin zone and fermi surface in semiconductors, BCS theory, magnetic susceptibility and dielectrics	**K2**
CO3	Interpret the behavior of semiconducting, conducting, superconducting and dielectric materials based on classical and quantum theories	**K3**
CO4	Compare the properties of different materials	**K4**
CO5	Evaluate new materials behavior for specific requirement	**K5**
CO6	Plan to prepare different materials for the betterment of the society	**K6**

Relationship Matrix											
Semester	**Course Code**		**Title of the Course**							**Hours**	**Credits**
3	**25PPH3CC06**		**Core Course - 6:** Condensed Matter Physics							**5**	**4**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	2	2	2	3	3	2	2	1	**2.3**
CO2	3	2	2	2	2	3	2	2	2	2	**2.2**
CO3	2	2	3	2	2	2	2	2	3	2	**2.2**
CO4	3	2	3	1	2	3	2	3	2	2	**2.3**
CO5	2	3	2	3	1	2	3	2	3	1	**2.3**
CO6	3	2	2	2	1	3	3	2	2	1	**2.3**
										Mean Overall Score	**2.26 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
3	25PPH3CC07	**Core Course - 7:** Electromagnetic Theory	5	4

Course Objectives
To acquire knowledge of vector operations in electric and magnetic fields, boundary conditions, wave propagation of EM waves in waveguides
To understand the basics of Electrostatics and magneto statics, to comprehend the physical ideas contained in Maxwell's equation, Coulomb & Lorentz gauges and conservation laws
To solve boundary value problems, Gauss law problems in electrostatics, Ampere's law problems in magneto statics
To analyze the behaviour of EM waves in conducting surface through reflection, to deduce field equations, wave equations and Gauge transformations
To estimate and interpret different laws in electrostatics and magneto statics, scalar and vector potentials, energy and momentum of EM waves

UNIT I: Electrostatics (15 Hours)

Coulomb's law – The electric field – Continuous charge distributions- Field lines, Flux and Gauss's law – The Divergence of E – Applications of Gauss's Law – The curl of E – Electric potential - Poisson's and Laplace Equation Potential of a localized charge distribution – Electrostatic Boundary conditions – Uniqueness theorems – Method of images: The classic image problem – induced surface charge -Force and energy.

UNIT II: Magnetostatics (15 Hours)

The Lorentz Force Law – The Biot- Savart Law – The magnetic field of steady current - The Divergence and Curl of B – Applications of Ampere's Law – magnetic potential– from uniform surface current - of a long solenoid - torroidal coil – large parallel plate capacitor – magnetic field inside and outside a cylindrical wire - magnetic field inside and outside the slab Magnetic vector potential – magnetostatic boundary conditions.

UNIT III: Field Equations and Conservation Laws (15 Hours)

Ohm's law -Faraday's law – induced electric field - Inductance – Energy in magnetic fields – Maxwell's equations in free space and linear isotropic media - Boundary conditions on fields at interface- continuity equations – Poynting's theorem -Potential formulation – Lorentz and Coulomb Gauge transformations – retarded potentials.

UNIT IV: Electromagnetic Waves and Guided Waves (15 Hours)

Waves in one dimension – Reflection, transmission and polarization – The wave equation for E and B – monochromatic plane waves - Energy and momentum in EM waves – Propagation in linear media – Reflection and transmission at normal and oblique incidence EM waves in conductors – Absorption, dispersion and reflection at a conducting surface.

UNIT V: Guided Waves and Radiation (15 Hours)

Wave guides -TE and TM waves in a rectangular wave guide – The coaxial transmission line-Electric dipole radiation – Magnetic dipole radiation – Radiation from an arbitrary source -power radiated by a point charge – Radiation reaction - radiation damping of a charged particle – Physical basis of the radiation reaction.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials, Simulations
Assessment Methods	Written Assignment, MQC Test

Books for Study:

1. David J. Griffiths, *Introduction to Electrodynamics*, (Pearson, 2018) 4th edition

Unit	Title	Chapters	Sections
I	Electrostatics	1,2,3	1.2 -1.4, 2.1 – 2.4, 3.1, 3.3 -3.5
	Potentials	1,2	1.5, 1.6, 2.1 -2.3
II	Magnetostatics	1,2,3,4	1.1 – 1.3, 2.1, 2.2, 3.1-3.3, 4.1, 4.2
III	Electrodynamics	1,2,3	1.1, 2.1 - 2.4, 3.3 – 3.6
	Conservation Laws	1	1.1, 1.2
	Potentials and Fields	1,2	1.1-1.3, 2.1
IV	Electromagnetic Waves	1,2,3,4	1.1 – 1.4, 2.1 – 2.3, 3.1 – 3.3, 4.1, 4.2
V	Electromagnetic Waves	5	5.1-5.3
	Radiation	1,2	1.2,1.3, 2.1-2.3

Books for Reference:

1. Jackson. J.D. (1999), *Classical Electrodynamics* (3rd Edition) John Wiley, New York.
2. Edward C. Jordan & Keith G. Balmain (2015), *Electromagnetic waves and Radiating Systems* (Second Edition), Prentice Hall of India, New Delhi.
3. Panofsky. W. and Phillips. M, (1962), *Classical Electricity and Magnetism*, Addison Wesley, London.
4. Kraus. J. D and Fleisch. D. A, (1999), *Electromagnetics with Applications* (5^{th} Edition), WCB McGraw-Hill, New York.
5. Chakraborty. B (2002), *Principles of Electrodynamics*, Books and Allied Pvt. Ltd., Kolkata.
6. Dr. Sureka Tomar (2016), CSIR – UGC / NET / JRF/SET Physical Sciences, Upkar Prakashan, Agra.

Websites and eLearning Sources:

1. https://nptel.ac.in/courses/115/106/115106122/
2. https://.nptel.ac.in/courses/108/104/108104087/
3. https://.nptel.ac.in/courses/115/104/115104088/
4. https://ocw.mit.edu/courses/6-632-electromagnetic-wave-theory-spring-2003/
5. https://ocw.metu.edu.tr/course/view.php?id=226
6. https://ocw.metu.edu.tr/mod/resource/view.php?id=5135
   (* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements**	**Cognitive Levels (K-Level)**
	On successful completion of this course, students will be able to	
CO1	Remember and recall the relevant knowledge from Electrostatics, magnetostatics, EM equations and wave guide system.	**K1**
CO2	Understand and comprehend the knowledge of Electrostatics and magnetostatics as well as EM waves with wave guide system.	**K2**
CO3	Apply the principles of boundary conditions and EM field equations for finding the solutions in classic image problem, Maxwell's equations in various conditions and wave guide system.	**K3**
CO4	Analyze the image problems with various symmetries, as well as distinguish with various applications of EM waves and wave guide problems.	**K4**
CO5	Estimate and interpret the applications of Gauss, Biot -Savarts, Ampere's laws and magnetic vector potentials as well as EM field equations with free space and isotropic media.	**K5**
CO6	Design of boundary value problems with various vectors. Also formulate the solutions of wave guide system with different applications.	**K6**

Relationship Matrix											
Semester	**Course Code**		**Title of the Course**							**Hours**	**Credits**
3	**25PPH3CC07**		**Core Course - 7:** Electromagnetic theory							**5**	**4**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	2	3	3	2	3	2	3	2	2	**2.5**
CO2	2	3	2	2	2	3	2	2	3	2	**2.3**
CO3	3	2	2	3	2	3	3	2	1	2	**2.3**
CO4	3	2	2	2	2	3	3	2	1	2	**2.2**
CO5	3	3	2	2	2	3	3	3	1	2	**2.4**
CO6	2	3	2	2	2	3	3	3	1	2	**2.3**
Mean Overall Score											**2.3 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
3	25PPH3CC08	**Core Course - 8:** Methods of Spectroscopy	4	4

Course Objectives
To recall the fundamental concepts and principles of molecular spectroscopy, including microwave, infrared, Raman, electronic, and spin resonance spectroscopy.
To explain the theoretical foundations and mechanisms behind various spectroscopic techniques used to study molecular structures and interactions.
To apply spectroscopic principles to analyze rotational, vibrational, and electronic transitions in molecules.
To analyze spectral data to interpret molecular properties, energy transitions, and structural details using different spectroscopic methods.
To evaluate the advantages and limitations of different spectroscopic techniques in characterizing molecular systems.
To design and develop spectroscopic experiments or methodologies for advanced molecular analysis and research applications.

UNIT I: Microwave Spectroscopy (12 Hours)

Characterization of Electromagnetic Radiation - Quantization of energy - Regions of the Electromagnetic spectrum, width and Intensity of spectral lines - Rotation of Molecules, Rotational Spectra - A Diatomic Rigid Rotator –Non rigid rotator- Intensity of Spectral lines - Effect of isotopic substitution.

UNIT II: Infra-Red Spectroscopy (12 Hours)

Vibrating diatomic molecule - Simple Harmonic Oscillator - anharmonic oscillator, diatomic vibrating rotator, vibrations of polyatomic molecules - fundamental vibrations and their symmetry - overtones and combination frequencies.

UNIT III: Raman Spectroscopy (12 Hours)

Introduction - Quantum theory of Raman effect - Classical theory of Raman effect - Pure rotational Raman spectra - Linear molecules, symmetry top molecules, asymmetric top molecules - vibrational Raman spectra - Raman activity of vibrations - rule of Mutual Exclusion – rotational fine structure.

UNIT IV: Electronic Spectroscopy of Molecules (12 Hours)

Born Oppenheimer approximation - vibrational coarse structure, Frank-Condon Principle - Intensity of vibrational - electronic spectra - dissociation energy and dissociation products - Molecular photo-electron spectroscopy - X-ray photoelectron spectroscopy.

UNIT V: Spin Resonance Spectroscopy (12 Hours)

Spin and an applied field - nature of spinning particles - interaction between spin and a magnetic field - population of energy levels - the Larmor Precession - Fourier Transform Nuclear Magnetic Resonance spectroscopy - Electron-spin Resonance Spectroscopy - g factor - hyperfine structure due to electron - nucleus coupling - double resonance - techniques in ESR spectroscopy- Introduction to Mossbauer spectroscopy.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials, Simulations
Assessment Methods	Written Assignment, MQC Test

Books for Study:

1. Banwell, C. N., & Mccash, E. M. (2014). *Fundamentals of molecular spectroscopy,* (4th Ed.). Tata McGraw-Hill Ltd.

Unit	Chapters	Sections
I	1,2	1.1, 1.2, 1.3, 1.7, 2.1, 2.2, 2.3-2.3.1, 2.3.2, 2.3.3, 2.3.4
II	3	3.1-3.1.1, 3.1.3, 3.1.3, 3.2, 3.5-3.5.1, 3.5.2
III	4	4.1- 4.1.1, 4.1.2, 4.2-4.2.1, 4.2.2, 4.2.3, 4.2.3, 4.3-4.3.1, 4.3.2, 4.3.5
IV	6	6.1-6.1.1, 6.1.2, 6.1.3, 6.1.4, 6.5-6.5.1, 6.5.2
V	7	7.1- 7.1.1, 7.1.2, 7.1.3, 7.1.4, 7.1, 7.5-7.5.1, 7.5.2, 7.5.3, 7.5.4, 7.5.6

Books for Reference:

1. Aruldhas, G. (2014). *Molecular Structure and Spectroscopy,* (2nd Ed.). PHI Learning Private Ltd.
2. Svanberg, S. (2004). *Atomic and Molecular Spectroscopy,* (4th Ed.). Springer.
3. McHale, J. L. (2017). *Molecular Spectroscopy,* (2nd Ed.). CRC Press.
4. Straughan, B. P., & Walker, S. (1976). *Spectroscopy Volume 1-3,* Chapman & Hall Publishers.
5. Chatwal, G. R., & Anand, S. K. (2009). *Spectroscopy.* Himalaya Publishing House.

Websites and eLearning Sources:

1. https://epgp.inf1ibnet.ac.in/Home/ViewSubject?catid=+4mIqRALksfwQH9v8YSMrw —
2. https://swayam.gov.in/exp1orer?category=Physics
3. https://edu.rsc.org/resources/analysis
4. https://www.nist.gov/pml/molecular-microwave-spectral-databases
5. https://srdata.nist.gov/xps/Default.aspx

(* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements**	**Cognitive Levels (K-Level)**
	On successful completion of this course, students will be able to	
CO1	Recall the fundamental principles and concepts of microwave, infrared, Raman, electronic, and spin resonance spectroscopy.	**K1**
CO2	Explain the theoretical foundations and mechanisms of various spectroscopic techniques used to study molecular structures.	**K2**
CO3	Apply spectroscopic principles to interpret rotational, vibrational, and electronic transitions in different molecular systems.	**K3**
CO4	Analyze spectral data to determine molecular properties, energy transitions, and structural details.	**K4**
CO5	Evaluate the effectiveness and limitations of different spectroscopic techniques in molecular characterization.	**K5**
CO6	Design and develop spectroscopic experiments for advanced molecular analysis and research applications.	**K6**

Relationship Matrix											
Semester	**Course Code**		**Title of the Course**							**Hours**	**Credits**
3	**25PPH3CC08**		**Core Course - 8:** Methods of Spectroscopy							**4**	**4**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	2	3	2	3	2	3	2	3	2	1	**2.3**
CO2	3	3	2	2	3	3	2	2	2	1	**2.3**
CO3	3	2	2	3	3	2	2	3	2	1	**2.3**
CO4	3	2	2	3	3	2	3	3	2	1	**2.3**
CO5	3	3	2	3	3	2	2	3	2	1	**2.3**
CO6	3	2	3	3	3	2	2	3	2	1	**2.3**
										Mean Overall Score	**2.3 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
3	25PPH3CP03	**Core Practical - 3:** Physics Practical - 3	8	4

Any 14 Experiments

1. e/m - Zeeman effect
2. Microwave – Klystron /Gunn diode
3. Design of Multiplexer and De-multiplexer
4. Digital to Analog Converters design
5. Design of Asynchronous Counter
6. Study of Power Amplifier: IC
7. Modulation and De modulation Techniques: PAM, PPM, PWM and PCM
8. Laser III: Brewster angle and related parameters
9. Geiger Muller Counter – study of gamma rays
10. Analysis of XRD spectrum - Determination of lattice parameters of a crystal
11. Analysis of FTIR spectrum - Determination of vibration levels in a compound
12. Solar cell characteristics
13. Charge of an electron by spectrometer
14. Monte Carlo simulation of electronic distribution of hydrogen atom - Scilab
15. Characteristics of tri colour LED and production of different colours
16. Measurement and analysis of Raman Spectra of liquids and solids.
17. Magneto resistance of a semiconductor
18. Thin film preparation and measurement of its thickness
19. Determination of Rydberg constant
20. Study of porosity and grain size of thin film by SEM
21. Brass arc spectrum – emission spectral study
22. UV-Visible spectrometer - Analysis of spectrum - Determination of absorption coefficient and bandgap
23. Analysis of rotation and vibration spectrum
24. Computational experiment: Solution of Poison's equation
25. Computational experiment: 2-D Electrostatic Calculation
26. Computational experiment: Chaotic and Non-chaotic dynamics
27. Study characteristics of optocoupler
28. NMR SPECTROMETER – spectral parameters
29. Atomic Scattering power and geometrical structure factor
30. Non-Destructive Testing by Ultrasonics – flaw detection, depth and length
31. Magnetocaloric Effect
32. Quantum Cryptography Experiment

Semester	Course Code	Title of the Course	Hours/Week	Credits
3	25PPH3ES02A	**Discipline Specific Elective - 2:** Materials Science	4	3

Course Objectives
To know the basic concepts in materials science and characterization of materials.
To understand the structure and properties of various materials and the working of characterization techniques.
To choose materials based on characterization of properties for appropriate applications.
To analyze and evaluate various properties of materials.
To develop and suggest materials design for practical problems and applications.

UNIT I: Metal Alloys **(12 Hours)**

Elastic deformation– Stress-Strain behaviour- Anelasticity- Elastic properties- tensile properties-Hardness-Mechanism of strengthening in metals- Binary Phase diagrams- Phase transformation-microstructural and property changes in Iron-carbon alloy- types of metal alloys- fabrication - thermal processing of metals-Applications.

UNIT II: Ceramics **(12 Hours)**

Ceramic structure- crystal structure-silicate ceramics- Carbon-Ceramic Phase diagrams-mechanical properties- Stress-Strain Behaviour -mechanics of Plastic deformation- types of ceramic-fabrication and processing of ceramics- glasses and glass-ceramics- clay- powder pressing-tape casting- 3D printing-Applications of ceramics.

UNIT III: Polymers **(12 Hours)**

Hydrocarbon molecules- Polymer molecules-chemistry of polymer molecules – molecular weight-shape-structure- Thermoplastics and thermos settings- -stress strain behaviour-polymer types-Glass transition temperature – polymerization-polymeric biomaterials-Advanced polymeric materials

UNIT IV: Composites **(12 Hours)**

Particle-Reinforced Composites-Fibre- Reinforced Composites-Polymer -matrix composites-metal matrix composites- ceramic matrix composites- carbon -carbon composites-hybrid composites- -Processing of Fibre- Reinforced Composites -laminar composites- sandwich panels - Nanocomposites

UNIT V: Material Characterization **(12 Hours)**

Principle and Instrumentation: X-Ray Photoelectron spectroscopy and Auger Electron Spectroscopy-Scanning Tunnelling Microscopy and Atomic Force Spectroscopy– X-Ray Diffraction- Transmission Electron Microscopy- Scanning Electron Microscopy - Infrared Spectroscopy and UV/Vis Spectroscopy - Macro and Micro Thermal Analyses.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials, Simulations
Assessment Methods	Written Assignment, MQC Test

Books for Study:

1. Callister, Jr. W. D., & Rethwisch, D. G. (2018). Materials Science and Engineering an Introduction, (10th Ed.). Wiley.
2. Zhang, S., Li, L., & Kumar, A. (2008). Materials Characterization Techniques. CRC Press.
3. Gowariker, V. R., Viswanathan, N. V., & Sreedhar, J. (2005). Polymer Science. New Age International (P) Ltd. M Sc Physics 46 4. Gandhi, M. V., & Thompson, B. S. (1992). Smart Materials and Structures. Chapman & Hall

Unit	Book	Chapters	Section
I	1	6,7,8,9,10,11	6.3-6.10,7.8-7.10,9.7,10.2-10.9,11.1 – 11.10
II	1	12,13	12.2-12.10,13.2-13.10,13.11-13.15
III	1	14	14.1-14.14,14,15.2,15.15,15.12,15.19,15.20
IV	1	16	16.1 – 16.16
V	3	1,2,13	1.1-1.10,2.1-2.12,13.8-13.15

Books for Reference:

1. Billmeyer, F. W. (1994). Textbook of Polymer Science, (3rd Ed.). John Wiley.
2. Lee, J. D. (2008). Concise Inorganic Chemistry, (5th Ed.). Wiley Blackwell Publications.
3. Sze, S. M. (2007). Physics of Semiconductor Devices. Wiley-Inter Science.

Websites and eLearning Sources:

1. https://www.britannica.com/technology/materialsscience#:~:text=materials%20science%2C%20the%20study%20of,a%20material's%20composition%20and%20structure.
2. https://www.annualreviews.org/doi/pdf/10.1146/annurev.ms.24.080194.000245#:~:text=This%20is%20the%20same%20set,composition%2C%20properties%2C%20and%20performance.
3. https://www.coursera.org/learn/materials-science

(* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements**	**Cognitive Levels (K-Level)**
	On successful completion of this course, students will be able to	
CO1	Know the various types of materials, their applications and characterization techniques.	**K1**
CO2	Understand the structure and properties of various materials and the working of various characterization methods.	**K2**
CO3	Identify and choose materials based on properties characterized by various methods.	**K3**
CO4	Analyze and investigate the properties and characteristics of materials using various techniques.	**K4**
CO5	Evaluate and interpret the features of the materials for appropriate applications.	**K5**
CO6	Develop and modify materials design to address various problems	**K6**

Relationship Matrix											
Semester	**Course Code**	**Title of the Course**								**Hours**	**Credits**
3	**25PPH3ES02A**	**Discipline Specific Elective – 2:** Materials Science								**4**	**3**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	2	2	3	2	3	2	3	2	1	**2.3**
CO2	2	3	2	2	3	3	2	2	2	1	**2.2**
CO3	3	3	2	3	3	2	3	2	2	1	**2.4**
CO4	3	2	2	3	3	2	2	3	2	1	**2.3**
CO5	3	3	2	2	2	2	2	2	2	1	**2.1**
CO6	2	2	2	2	3	3	2	3	2	1	**2.2**
Mean Overall Score											**2.25 (High)**

Semester	Course Code	Title of the Course	Hours/ Weeks	Credits
3	25PPH3ES02B	**Discipline Specific Elective – 2:** Techniques of Materials Characterizations	4	3

Course Objectives
To know the fundamental theories and experiments of various characterization techniques
To understand the characteristics of crystals, thin films and nanocrystals
To identify an appropriate characterization technique to study the crystal structure, molecular structure, surface analysis and elemental analysis of various materials
To analyse the conceptual understanding to approach the problem mathematically and develop a skill to solve the problem numerically
To evaluate the results of XRD, FTIR, Fluorescence, absorption spectroscopy, Electron microscopy, XPS and thermal analysis and formulate an appropriate interpretation with a detailed justification for a new material.

UNIT I: Structural Analysis (12 Hours)

Powder XRD: determination of crystal structure - crystallites size - lattice parameters – Cubic and non-cubic system - point group and space group - single crystal XRD: determination of crystal systems - point group and space group. G-XRD - analysis of thin films.

UNIT II: Molecular And Electronic Structure Analysis (12 Hours)

1H-NMR and 13C-NMR - Chemical structure identification of solids and liquids - case study, Fourier Transform Infrared Spectroscopy - analysis of chemical bonds - case study optical analysis: Fluorescence spectroscopy - electronic structure analysis - case study - Time resolved spectroscopy - Absorption spectroscopy.

UNIT III: Surface Analysis (12 Hours)

SEM and FESEM - Morphology analysis, TEM and HR-TEM Morphology - Crystalline nature and structure - Atomic Force Microscope - Surface roughness - Scanning Tunnelling microscopy - Surface Topography - Chemical etching - Microstructure and dislocation - case study.

UNIT IV: Elemental and Thermal Analysis (12 Hours)

Elemental analysis: CHN analysis, Energy dispersive spectroscopy, X-ray fluorescence, X-ray photoelectron spectroscopy - case study. **Thermal analysis**: TG/DTG and DTA/DSC analysis - phase changes, melting point and thermal decomposition - case study.

UNIT V: Optical and Mechanical studies (12 Hours)

Optical Measurements - Nonlinear optics: Second harmonic generation - Phase matching and Kurtz - Perry powder method - Third order nonlinearity - Z-scan technique - Laser damage threshold measurements. Microhardness measurement: Brinell and Vickers hardness tests.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials, Simulations
Assessment Methods	Written Assignment, MQC Test

Books for Study:

1. Sam Zhang, Lin Li, Ashok Kumar (2008), *Materials Characterization Techniques*, Taylor &Francis Ltd. CRC press,
2. Cullity, B.D. Stock, S.R. (2001) *Elements of X-Ray Diffraction*, 3rd Edition, Pearson Education, Delhi.
3. Brundle, C.R. Charles A. Evans, Shaun Wilson, (1992) *Encyclopedia of Materials Characterization*, Butterworth-Heinemann.
4. Richard L Sutherland, Daniel G. McLean, Sean Kirkpatrick (2003)*, Handbook of Nonlinear Optics*, 2nd Edition, Marcel Dekker, Inc, 2003.

Unit	Book	Chapters	Sections
I	1 2	5	5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8 10
II	1 3	9 7	9.1, 9.2 7.1, 8.4
III	1	4, 6, 7	4.2, 4.3, 4.4, 6.1-6.5, 7.1-7.3
IV	1	3, 10	3.3, 3.4, 10.1, 10.4
V	4 4 4	1 4 10	III. A I.A, I.D 1.B

Books for Reference:

1. Keshra Sangwal, (1987) *Etching of Crystals: Theory, Experiment, and Application*, 1st Edition, North-Holland physics publishing, Netherland.
2. Laud B.B., *Lasers and non-linear optics* (1993) John Wiley & Sons, 2nd Edition.
3. Detlev Ristau (2015) *Laser-Induced Damage in Optical Materials*, Taylor & Francis Group, CRC Press, New York.
4. Robert W Cahn Frs, Eric Lifshin (1993), *Concise Encyclopedia of materials characterization*, 1st Edition, Pergamon Press Ltd, Oxford, New York.
5. Sulabha K. Kulkarni (2007) *Nanotechnology: Principles and Practices*, Capital publishing company, New Delhi.

Websites and eLearning Sources:

1. https://ocw.mit.edu/courses/3-014-materials-laboratory-fall-2006/
2. https://nanohub.org/
3. https://www-omcs.materials.ox.ac.uk/
4. https://www.msm.cam.ac.uk/Characterisation
5. https://nptel.ac.in/courses/115103030
   (* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K-Level)**
CO1	Acquire the knowledge on the fundamental of various characterization techniques	**K1**
CO2	Understand the physics principle to understand the characteristics of crystals, thin films and nanocrystals	**K2**
CO3	Identify an appropriate characterization technique to understand the crystal structure, molecular structure, surface analysis and elemental analysis of various materials	**K3**
CO4	Apply the conceptual understanding to approach the problem mathematically and develop a skill to solve the problem numerically.	**K4**
CO5	Evaluate the results of XRD, FTIR, Fluorescence, absorption spectroscopy, Electron microscopy, XPS and thermal analysis.	**K5**
CO6	Formulate an appropriate interpretation with a detailed justification for a new material.	**K6**

Relationship Matrix											
Semester	**Course Code**		**Title of the Course**							**Hours**	**Credits**
3	**25PPH3ES02B**		**Discipline Specific Elective – 2:** Techniques of Materials Characterizations							**4**	**3**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	2	3	2	2	2	3	2	1	2	1	**2.0**
CO2	3	3	3	2	2	3	2	1	2	1	**2.2**
CO3	2	3	3	2	2	3	3	3	2	1	**2.4**
CO4	3	3	3	2	2	2	3	3	2	1	**2.4**
CO5	3	3	3	2	2	2	2	3	2	1	**2.3**
CO6	2	3	2	2	2	3	2	1	2	1	**2.0**
Mean Overall Score											**2.26 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
3	25SPS3RM01	Research Methodology and IPR	4	2

Course Objectives
To spell the research methodology and IPR
To compare different methods of doing research
To experiment with various methodology
To evaluate applied method and IPR
To do the research by following appropriate method

UNIT I: Introduction to Research Methodology (12 Hours)

Definition and importance of research in Science - Types of research - fundamental - applied research - Scientific method: Observation – hypothesis – experimentation – conclusion - Identifying research gaps in science - Framing hypotheses and objectives - Importance of literature review in research - Tools for finding relevant research papers - evaluation and critical analysis of existing work.

UNIT II: Research Design, Planning and methodology (12 Hours)

Choosing a research problem in science - Formulating research objectives and specific goals - Creating a timeline for research work - Types of sampling methods - Tools and techniques for data collection in science experiments - Ethical considerations in scientific research - Plagiarism, falsification, and fabrication - Ensuring transparency and reproducibility in research - Quantitative Research Methods in Science - Qualitative Methods in science - Data Visualization and Interpretation - Experimental Research - Computational Research.

UNIT III: Writing a Research Paper (12 Hours)

Structure of a Scientific Paper: Sections of a research paper (Abstract, Introduction, Methods, Results, Discussion, Conclusion) - Writing tips for clarity and precision. Citing Sources and Referencing: Proper citation formats - Using reference management tools. Peer Review Process: Importance of peer review in scientific research - How to write and respond to peer reviews. Data Interpretation and Presentation: Analyzing Results - Presenting Research Findings.

UNIT IV: Intellectual Property Rights (IPR) (12 Hours)

Intellectual Property - Types of IPR - Importance of IPR in science and innovation - The role of IPR in academic and industrial collaborations – Patents - Patent Search and Filing - Copyrights in Scientific Research - Trade Secrets and Confidentiality.

UNIT V: Licensing and Commercialization of Research (12 Hours)

Licensing Agreements - Commercialization of Research - Legal and Ethical Considerations in IPR - IPR in Academia vs Industry - IPR Enforcement and Litigation - Case Studies and Recent Developments in IPR and Research - Emerging Trends in IPR

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials, Simulations
Assessment Methods	Written Assignment, MQC Test

Books for Study:

1.Text Prepared by the Department.

Unit	Book	Chapters	Sections
I	1	1	All
II	1	2	All
III	1	3	All
IV	1	4	All
V	1	5	All

Books for Reference:

1. Michael Alley (2018), *The Craft of Scientific Writing* (3rd Ed.), Springer.
2. Ranjit Kumar, *Research Methodology: A Step-by-Step Guide for Beginners*,

3. Lee and Wills, *Intellectual Property and Innovation Management in Small Firms*
4. Howard G. Birnberg, *Patent Law for Researchers and Engineers*
5. Frederick J. R. P, *Introduction to Scientific Research*.
6. Geoffrey Marczyk, David DeMatteo and David Festinger (2005), *Essentials of Research Design and Methodology,* John Wiley & Sons, Inc.

Websites and eLearning Sources:

6. https://paperpal.com/blog/academic-writing-guides/what-is-research-methodology
7. https://www.indeed.com/career-advice/career-development/research-methodology
8. https://research.com/research/how-to-write-research-methodology
9. https://ipindia.gov.in/
10. https://www.youtube.com/watch?v=nJza2kfI8GU
11. https://www.wto.org/english/tratop_e/trips_e/intel1_e.htm

(* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements**	**Cognitive Levels (K-Level)**
	On successful completion of this course, students will be able to	
CO1	Define research and different methods to be followed and IPR	**K1**
CO2	Understand different methodology adapted for scientific research and IPR	**K2**
CO3	Apply various methodology to do research	**K3**
CO4	Examine suitable methods for scientific research	**K4**
CO5	Evaluate and interpret the results of research	**K5**
CO6	Formulate scientific methods and do the research	**K6**

Relationship Matrix											
Semester	**Course Code**		**Title of the Course**							**Hours**	**Credits**
3	**25SPS3RM01**		Research Methodology and IPR							**4**	**2**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	2	3	2	3	2	3	2	3	2	1	**2.3**
CO2	3	3	2	2	3	3	2	2	2	1	**2.3**
CO3	3	2	2	3	3	2	2	3	**3**	**2**	**2.5**
CO4	3	2	2	3	3	2	3	3	2	1	**2.4**
CO5	3	3	2	3	3	2	2	3	**3**	**2**	**2.5**
CO6	3	2	3	3	3	2	2	3	2	2	**2.3**
									Mean Overall Score		**2.38 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
3	25PPH3SL03A	**Self – Learning:** Medical Physics	-	1

Course Objectives
To recall the concepts of mechanics, thermodynamics, optics, acoustics and electromagnetism.
To understand the anatomy and physiological functions of human body.
To use the acoustical and imaging techniques and to measure pressures, temperature and blood velocity of the body.
To analyse medical reports.
To evaluate the physiological functions of the human body.
To combine the principles of physics and biology and to develop sustainable life.

UNIT I: Biomechanics

Motion in the Human machine - the standard human - material components of the body - bone - ligaments and tendons - cartilage - bone shortening - energy storage in tendons and long bones, muscles: skeletal muscles - the structure of muscles - passive muscles - activating muscles - the effect of exercise - levers - the elbow - the hip - the back - elasticity of bone, tissue, visco elasticity. pressures in the body: pressure in the cardiovascular system - hydrostatic pressure - bladder pressure - respiratory pressures - foot pressures - eye and ear pressures - biomechanical measurement - X-ray imaging technique.

UNIT II: Cardiovascular and Respiratory System

Cardiovascular System: circulatory system and cardiac cycle - physics of the circulation system: properties of blood - blood pressure and flow in vessels - capillaries and osmotic pressure - blood flow rates and speeds - consequences of clogged arteries - work done by the heart and the metabolic needs of the heart - blood velocity measurement - The Doppler effect - ECG, lungs and breathing: lungs - alveoli - breathing - volume of the lungs - breathing under usual and unusual conditions - work needed to breathe.

UNIT III: Heat and Energy Transfer in Human Body

Metabolism: energy, heat, work, and power of the body - conservation of energy and heat flow - energy content of body fuel - energy storage molecules - loss of body heat - body temperature - energy requirement - energy from food - regulation of body temperature - resistance to cold - diffusion through membranes thin-film flowmeters - thermistor flowmeters - thermal dilution - thermal conductivity methods - thermography.

UNIT IV: Bio-Acoustics and Bio-Optics

Acoustic Buzzer - voice filtering theory - parameters of voice - energetic speaking. auditory sensitivity - connections to hearing perceptions. structure of the eye - imaging and detection by the eye - transmission of light in the eye - the eye as a compound lens - accommodation ultrasonic imaging - theory and instrumentation.

UNIT V: Electrophysiology and Nuclear Medicine

Biological potentials - the nervous system - neural communication, the interface between ionic conductors: Nernst equation - membranes and nerve conduction - muscle action potentials - neural stimulation - tissue as a leaky dielectric - low-frequency effects: (0.1 Hz-100 kHz) - higher frequencies (>100 kHz) - physiological effects of electricity - electricity in bone. nuclear medicine - MRI - general principles - slice selection - phase encoding - frequency encoding - K space formalism, instrumentation: magnet design - magnetic field gradient coils - RF coils imaging sequences - imaging characteristics - contrast agents functional MRI, applications: brain, liver, skeletal and cardiac systems.

Teaching Methodology	Self-learn
Assessment Methods	MQC Test

Books for Study

1. Herman, I.P. (2007). *Physics of Human Body,* (1st Ed.). Springer.
2. Davidovits, P. (2008). *Physics in Biology and Medicine*, (3rd Ed.). Elsevier.
3. Brown, B. H. (1999). *Medical Physics and Biomedical Engineering,* (1st Ed.). IOP Publishing.
4. Webb, A. G. (2003). *An Introduction to Biomedical Imaging,* (1st Ed.). Wiley.

Unit	Book	Chapters	Sections
I	1	1, 4	1.2, 1.3, 4.1, 4.2.3, 4.2.4, 4.6, 4.7
	2	1, 3, 8, 18	1.1, 3.2, 3.8, 8.5, 8.11, 18.4
	3	1, 2	1.2, 2.2
	4	1	1.3-1.9
II	1	8	8.1, 8.2.1-8.2.6, 9.6
	3	19	19.7.1
	1	6	6.1-6.6
III	2	9, 11	9.6, 11.1, 11.2, 11.9,
	3	19	19.4
	1	10, 11	10.2, 10.3, 11.3.1-11.3.3
IV	2	15	15.7
	4	3	3.1, 3.4-3.8
	3	8, 16	8.2, 8.5, 8.6, 8.8.1, 16.1.1-16.1.5, 16.5
V	2	13	13.3
	4	4	4.1, 4.7, 4.10

Books for Reference:

1. Maqbool, M. (2017). *An Introduction to Medical Physics.* Springer.
2. Jelinkova, H. (2013). *Lasers for Medical applications, diagnostics, therapy and surgery,* (1st Ed.)., Elsevier.
3. Khandpur, R. S. (2014). *Handbook of Biomedical Instrumentation,* (3rd Ed.). McGraw Hill.

Websites and eLearning Sources:

1. https://medicalphysics.duke.edu/about/what-is-medical-physics/
2. https://medicalphysics.duke.edu/about/what-is-medical-physics/
3. https://www.news-medical.net/health/The-Role-of-Physics-in-Medicine.aspx

(* subject to availability – not to be used for exam purpose)

Course Outcomes		
CO No.	CO-Statements	Cognitive Levels (K-Level)
	On successful completion of this course, students will be able to	
CO1	Acquire knowledge about the mechanics of human body, the energy transfer in metabolism, the fluid dynamics of blood flow through vessels, the mechanisms for speaking, hearing, vision and neural communications.	K1
CO2	Understand the anatomy and physiological functions of human body, medical imaging data in clinical use and	K2
CO3	Apply physics principles, instrumental design, data acquisition strategies and imaging modalities in biomedical imaging.	K3
CO4	Analyze physics concepts involved in human body and physiology.	K4
CO5	Evaluate the physiological functions of the human body	K5
CO6	Create the awareness of lab facilities for better medical treatment	K6

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**					**Hours**		**Credits**
3	**25PPH3SL03A**			**Self-Learning:** Medical Physics					**-**		**1**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	2	3	2	2	2	2	2	2	3	**2.3**
CO2	3	2	2	2	3	2	2	3	2	2	**2.3**
CO3	2	2	2	2	2	3	2	2	2	2	**2.1**
CO4	3	3	3	2	3	2	2	2	2	3	**2.5**
CO5	2	2	3	2	3	3	2	2	2	2	**2.3**
CO6	3	2	2	2	3	2	2	3	2	2	**2.3**
Mean Overall Score											**2.3 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
3	25PPH3SL03B	**Self-Learning:** Crystal Growth and Thin Films	-	1

Course Objectives
To recall the fundamental phases of matter and energy.
To understand the phase transitions, nucleation, growth and deposition.
To experiment various physico-chemical conditions to grow bulk crystals and to deposit films.
To categorize mechanisms involved in crystal growth and in thin film depositions.
To evaluate the growth techniques and to define crystallinity with their merits and challenges.
To modify the existing techniques and to build new techniques to harvest crystals and films with desired properties

UNIT I: Nucleation

Primary nucleation - Secondary nucleation - Solubility, super solubility and metastable zone - Crystal growth theories: surface energy theories, adsorption layer theories, kinematic theories, and diffusion reaction theories.

UNIT II: Crystal Growth from Melt and Vapour

Czochralski method - Bridgmann - Stockbarger method - Zone Melting Method - Vapour growth: direct vapour transport method, Chemical transport method.

UNIT III: Crystal Growth from Solution

Solution and Solubility - Choice of Solvent - Additives - Nucleation - Achievement of Supersaturation - Mason-Jar Method - Holden's Rotary Crystallizer - Temperature Differential Method - growth from silica gel - High temperature solution growth - Flux growth - Top seeded solution growth -Hydrothermal growth.

UNIT IV: Thin Film Deposition: Physical Vapour Deposition

Evaporation method: Vacuum evaporation, Electron beam evaporation - DC diode sputtering, Magnetron sputtering, Reactive ion sputtering, RF sputtering - Pulsed Laser Deposition - Molecular Beam Epitaxy.

UNIT V: Thin Film: Deposition Chemical Vapour Deposition and Liquid Phase Deposition

Chemical vapour deposition - typical chemical reactions - reaction kinetics - transport phenomena - CVD methods – Metal Organic Chemical Vapour Deposition - Plasma enhanced chemical vapour deposition - Langmuir-Blodgett films - Electrochemical deposition - Sol-gel films.

Teaching Methodology	Self-learn
Assessment Methods	MQC Test

Books for Study:

1. Mullin, W., & Butterworth-Heinemann, (2001). *Crystallization*, (4th Ed.). Oxford.
2. Bhat, H. L. (2015). *Introduction to crystal growth principles and practice.* CRC Press Taylor & Francis Group.
3. Frey, H., & Hamid, R. K. (2015). *Handbook of Thin-Film Technology*. Springer-Verlag Berlin Heidelberg.
4. Cao, G. (2006). *Nanostructures and nanomaterials: synthesis, properties and applications.* Imperial college press, Reprinted.

Unit	Book	Chapters	Sections
I	1	3, 5, 6	3.11, 3.12, 5.1, 5.2, 5.3, 6.1
II	2	8, 10	Relevant topics in page No. 124, 140, 155, 162, 242, 252
III	2	9	Relevant topics in page No. 183, 198, 207, 215
IV	3 2	3, 6, 9 11	3.5, 6.4, 6.6, 6.8, 6.9, 9.4 Relevant topics in page No. 262, 268
V	4 3	5 9	5.5, 5.5.1, 5.5.2, 5.5.3, 5.5.4, 5.9, 5.10, 5.11 9.4

Books for Reference:

1. Santhana, P.R, & Ramasamy, P. (2000). *Crystal growth processes and methods.* Kru Publications.
2. Krishna, S. (2002). *Handbook of thin film deposition, processes and techniques*, (2nd Ed.). Noyes Publication.
3. Leon, I. M., & Glang, R (1970). *Handbook of Thin Film Technology*. McGraw Hill Higher Education.

Websites and eLearning Sources:

1. https://en.wikipedia.org/wiki/Thin_film#:~:text=A%20thin%20film%20is%20a,fundamental%20step%20in%20many%20applications.
2. https://www.engr.colostate.edu/ECE581/fall07/Two%20dimensional%20structures.pdf
3. https://iisc.ac.in/wp-content/uploads/2017/12/PH351.pdf
   (* subject to availability – not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K-Level)**
CO1	Acquire the knowledge about the fundamentals of nucleation and various crystallization theories.	**K1**
CO2	Understand various crystallization theories, various crystal growth methods and thin film deposition techniques.	**K2**
CO3	Apply the essential processing parameters for different crystal growth and thin film deposition techniques.	**K3**
CO4	Analyze the different growth techniques and choose an appropriate technique to grow crystals and thin films.	**K4**
CO5	Evaluate the merits and demerits of different growth techniques	**K5**
CO6	Design a new growth approach to overcome the existing demerits.	**K6**

Relationship Matrix											
Semester	**Course Code**		**Title of the Course**							**Hours**	**Credits**
3	**25PPH3SL03B**		**Self-Learning:** Crystal Growth and Thin Films							**-**	**1**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	3	2	2	3	2	2	2	3	**2.5**
CO2	3	3	2	2	2	3	2	2	2	2	**2.2**
CO3	3	3	3	2	2	3	1	2	2	2	**2.3**
CO4	3	3	3	2	2	3	1	2	3	2	**2.4**
CO5	3	3	3	2	2	3	2	2	2	2	**2.4**
CO6	2	3	3	2	2	3	1	2	1	2	**2.1**
Mean Overall Score											**2.23 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
3	25PPH3SL03C	**Self- Learning:** Ultrasonics and its Applications	-	1

Course Objectives
To know the basics of Ultrasound and its transducers.
To understand the concepts of Ultrasonic measurement techniques.
To apply and realize the ultrasonic imaging in the sonochemistry.
To explore the importance of Non-destructive technique.
To compare various ultrasonic transducers.

UNIT I: Fundamentals of Ultrasonics

Introduction - Brief Early History - Underwater Sound (SONAR) - Medical and Biological Ultrasonics - Industrial Ultrasonics - Nondestructive Testing/Evaluation - Ultrasonics in Electronics - Physical Acoustics - Ultrasonic Systems: Transmitters and Receivers - Low- Intensity Applications - High-Intensity Applications - Modern Ultrasonics: An Interdisciplinary Field - Velocity of Sound in Solids - Velocity of Sound in Liquids - Velocity of Sound in Gases - Wave Incident on a Liquid - Solid Plane Interface, Semi-Infinite Media - Reflection, Refraction.

UNIT II: Basics of Ultrasonic Transducers

Piezoelectric Transducers - equivalent circuit of a simple piezoelectric transducer - efficiency of a simple piezoelectric transducer - maximum power transfer between Electronic Power Source and Simple Piezoelectric Transducers - Determining Transformation Factor (α) for the Piezoelectric Transducer Material - Quality Factor (Q) of Piezoelectric Transducers - Piezoelectric Transducers for High-Intensity Applications - Pulse-Type Transducers for Low-Intensity Applications Sensing - Piezoelectric Polymers for Transducers.

UNIT III: Measurement Techniques of Ultrasonics

Measurement of Velocity and Attenuation in Isotropic Solids - Measurement of Velocity and Attenuation in Fluids - Methods of Measuring Velocity of Sound - Interferometer Method - Resonance Method - "Sing-Around" Method - Pulse-Superposition Method - Pulse-Echo-Overlap Method - Measurements in Materials of High Attenuation - Measurements at High Temperatures - Measurements at High Pressures - Measuring Torsional Resonant Frequencies of Isotropic Bars.

UNIT IV: Applications of Ultrasonics

Electron Acoustic Image Converter - Schlieren Imaging - Liquid Levitation Imaging - Ultrasonic Imaging with Liquid Crystals - Photographic Methods of Imaging by Ultrasonics - Ultrasonic Holography - Acoustic Microscopy - Ultrasonic Arrays - Ultrasound in Process Industries - Monitoring Solidification (Interface Sensing) - Acoustic Time Domain Reflectometry - Three-Phase Reactors - Process Tomography Using Ultrasonic Methods - Ultrasonic Transducers. Process Industry Applications - Sonochemistry - Depolymerization - Polymerization – Precipitation - Metallurgical Effects.

UNIT V: Ultrasonic Non-Destructive Testing

Resonance Methods - Pulse Methods - Acoustic Emission Technique - Factors Affecting Resolution and Sensitivity - Near-Field Effects - Properties of the Materials - Eddy Sonic Inspection Method - Sonic Analysis - Acoustic Impact Technique - Ultrasonic Spectroscopy - Critical Angle Analysis - Instrumentation - Resonance Methods - Pulse Methods - Acoustic Emission Methods - Phased Arrays Systems - Methods Used to Determine Flaw Size.

Teaching Methodology	Self-learn
Assessment Methods	MQC Test

Books for Study:

1. Dale, E., & Bond, L.J. (2011). *Ultrasonics Fundamentals, Technologies and Applications*, (3rd Ed.). CRC Press, Taylor & Francis Group.

Unit	Book	Chapters	Sections
I	1	1,2	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 1.12, 2.3.1, 2.3.2, 2.3.3
II	1	5	5.3, 5.3.1, 5.3.2, 5.3.3, 5.3.4, 5.3.5, 5.3.7, 5.3.8, 5.3.9, 5.4.2
III	1	6	6.2.1, 6.2.2, 6.3, 6.3.1, 6.3.2, 6.3.3, 6.3.4, 6.3.5, 6.3.6, 6.3.7
IV	1	10,11	10.2.2, 10.2.3, 10.2.4, 10.2.5, 10.2.6, 10.2.7, 10.2.8, 10.2.9, 10.3.1, 10.3.4, 10.3.5, 10.3.6, 10.3.7, 10.3.8, 11.4, 11.4.1, 11.4.2, 11.4.4, 11.5
V	1	7	7.2.1, 7.2.2, 7.2.3, 7.3, 7.3.1, 7.3.2, 7.4.1, 7.4.2, 7.4.3, 7.4.4, 7.4.5, 7.5, 7.5.2, 7.5.3, 7.5.4, 7.5.5, 7.5.7.2,

Books for Reference:

1. David, J., & Cheeke, N. (2002). *Fundamentals and Applications of Ultrasonic Waves*, CRC Press.

Websites and eLearning Sources:

1. http://hyperphysics.phy-astr.gsu.edu/hbase/Sound/usound.html
2. https://www.sonotec.com/en/column/ultrasonic.html
3. https://www.britannica.com/science/ultrasonics
   (* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K-Level)**
CO1	Acquire the knowledge of ultrasonic science and technology.	**K1**
CO2	Understand the concepts of ultrasound, transducers and its working, measurements and applications.	**K2**
CO3	Identify and apply fundamentals of ultrasound, transducers on different measurement techniques and applications of ultrasound.	**K3**
CO4	Analyze and discuss basics and applications of ultrasound.	**K4**
CO5	Evaluate ultrasonic based measurements, applications and non destructive testing.	**K5**
CO6	Design ultrasonic devices by applying the principles of ultrasound.	**K6**

Relationship Matrix											
Semester	**Course Code**		**Title of the Course**					**Hours**			**Credits**
3	**25PPH3SL03C**		**Self-Learning:** Ultrasonics and its Applications					**-**			**1**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	2	3	2	3	2	3	2	3	2	1	**2.3**
CO2	3	3	2	2	3	3	2	2	2	1	**2.3**
CO3	3	2	2	3	2	2	3	3	2	1	**2.3**
CO4	3	2	2	3	3	2	2	3	2	1	**2.3**
CO5	3	3	2	2	2	2	2	3	3	1	**2.3**
CO6	3	2	2	3	2	2	3	3	2	1	**2.3**
Mean Overall Score											**2.3 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
3	25PPH3SL03D	**Self-Learning :** Forensic Physics	-	1

Course Objectives
To study the basic definitions and concepts involved in trace evidences.
To handle the evidences left out at the crime scene.
To Identify the Composition and Manufacture of Glass and Paint.
To Interpret of Physical aspects of Glass evidences.
To analyze the evidences with the help of various spectroscopic methods.

UNIT I: Trace Evidences

Preliminary definitions - Concepts and the production of physical evidence - Uses of trace evidence - The history of trace evidence - The scope of trace evidence - Associations based on physical pattern evidence - Associations based on material comparisons - The role of trace evidence databases - Complementary nature of trace evidence and DNA typing - Recognition and interpretation of trace evidence - Hair and fibre evidence - Glass evidence - Paint evidence - Miscellaneous types of trace evidence - Future Technology and trace evidence - Summary and conclusions.

UNIT II: Composition and Manufacture of Glass

Introduction - Definition of a glass - Commercial glass types - Glass-manufacturing process - Glass - forming processes - Secondary glass processing - Principal glass types and applications.

UNIT III: Interpretation of Physical aspects of Glass evidence

Glass as physical evidence - Recovery of evidence glass fragments - Physical matches of fractured glass - Fractures in flat glass - Fractures in other items - Glass fractures produced by fragments - Backward propagation of glass fragments - Glass in fires - Retention and persistence of glass fragments in clothing - Future directions for the physical examination of glass evidence.

UNIT IV: Interpretation of Paint Evidence

Introduction - Paint transfer mechanisms - Household paints - Vehicle paint - A Bayesian approach - Conclusion.

UNIT V: Elemental Analysis of Glass and Paint

Introduction - Forensic and analytical implications of the composition of glass - Atomic spectroscopy - X-ray methods - Introduction of Infrared spectroscopy - Infrared spectroscopy - Infrared instrumentation - Preparation of samples for analysis - Infrared analysis of paint - Interpretation of IR spectra of non-automotive (domestic) paints - Identification of automotive paints by interpretation of their infrared spectra. EDAX.

Teaching Methodology	Self learn
Assessment Methods	MQC Test

Books for Study:

1. Caddy, B. -Taylor & Francis Forensic science series (2001). *Forensic examination of Glass and Paint Analysis and interpretation*, Publication, London, United Kingdom.

Unit	Book	Chapters	Sections
I	1	1	1.1, 1.2, 1.3 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 1.12, 1.13, 1.14, 1.15, 1.16
II	1	2	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7
III	1	6	6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7,6.8, 6.9, 6.10
IV	1	12	12.1, 12.2, 12.3, 12.4, 12.5, 12.6
V	1	4,10	4.1, 4.2, 4.3, 4.4, 10.1, 10.2, 10.3, 10.4, 10.5, 10.6, 10.7

Books for Reference:

1. Richard, S., & Tiffany, R. (2020). *Criminalistics -An Introduction to Forensic Science.* Pearson - Education.

2. Hunter, H. (2014). *Solving Crimes with Physics.* Mason Crest publication.

Websites and eLearning Sources:

1. https://www.nist.gov/forensic-science#:~:text=Forensic%20science%20is%20the%20use,to%20anthropology%20and%20wildlife%20forensics.
2. https://www.merriam-webster.com/dictionary/forensic
3. https://nij.ojp.gov/topics/forensics

(* subject to availability – not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements**	**Cognitive Levels (K-Level)**
	On successful completion of this course, students will be able to	
CO1	Acquire knowledge about the concept and scope of forensic evidences.	**K1**
CO2	Understand the composition and manufacturing of different types of evidences.	**K2**
CO3	Identify and apply physical aspects of various evidences.	**K3**
CO4	Distinguish the different evidences with the help of spectroscopic analysis.	**K4**
CO5	Measure the characterization of paint and glass fragments.	**K5**
CO6	Integrate the principles and methods of glass and paint evidence.	**K6**

Relationship Matrix											
Semester	**Course Code**		**Title of the Course**						**Hours**		**Credits**
3	**25PPH3SL03D**		**Self-Learning:** Forensic Physics						**-**		**1**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	3	2	2	3	2	2	2	2	**2.4**
CO2	3	3	2	2	2	3	2	2	2	2	**2.3**
CO3	3	3	3	2	2	3	2	2	2	2	**2.4**
CO4	3	3	3	2	2	3	2	2	2	2	**2.4**
CO5	3	3	2	2	2	3	2	2	2	2	**2.3**
CO6	3	3	3	2	2	3	2	2	2	2	**2.4**
										Mean Overall Score	**2.36 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
4	25PPH4CC09	**Core Course - 9:** Nuclear and Particle Physics	6	5

Course Objectives
To acquire the knowledge of various nuclear decays and radioactivity.
To understand the basic structure, properties of nucleus and deuteron, Cosmic rays and Radio astronomy, symmetry properties & Quark model of elementary particles
To evaluate the different types of nuclear reactions.
To apply the knowledge of nuclear reactions for producing fission and fusion energy.
To analyse the properties of various fundamental particles, their decay modes and the interactions.

UNIT I: Basic Properties of Nucleus (18 Hours)

Nuclear mass and binding energy - atomic masses - systematics of nuclear binding energy -nuclear size - charge radius - potential radius - spin and parity - statistics of nucleus - magnetic dipole moment - electric moments - electric quadrupole moments - isospin - nuclear forces - ground state of the deuteron - wave equation for the deuteron and solution - excited state of deuteron - low energy proton neutron scattering - spin dependence of n-p interaction. Liquid Drop Model -

UNIT II: Nuclear Decay and Radio Activity (18 Hours)

Theory of alpha disintegration - hindrance and formation factors - fine structure of alpha decay - energetics of beta decay - neutrino hypothesis - Fermi theory of beta decay - selection rules -Sargent diagram - orbital electron capture - parity non-conservation - double beta decay - gamma ray spectra and nuclear energy level - radioactive transition in nuclei-nuclear isomerism - internal conversion-resonance fluorescence -angular correlation.

UNIT III: Nuclear Reactions (18 Hours)

Types of nuclear reactions - conservation laws - reaction energetics - Q value - threshold energy - nuclear reaction cross section - level width - compound nuclear theory - Breit Wigner dispersion formula and interpretation - direct reaction - striping and pickup reactions - nuclear fission - energy released in fission - nuclear chain reaction - four factor formula - nuclear reactor - nuclear fusion Stellar energy.

UNIT IV: Particle Physics (18 Hours)

Production of new particles in high energy reaction - classification of elementary particle - fundamental interaction - quantum numbers - antiparticles - resonances - law in production and decay process - symmetry and conservation laws - special symmetric groups - Gelman -Neumann theory - Quark model - SU(3) symmetry - unification of fundamental interactions - CPT invariance and applications of symmetry arguments to particle reaction, parity non conservation in week interaction.

UNIT V: Cosmic Rays and Applications of Nuclear Physics (18 Hours)

Nature of Cosmic rays - soft and hard components - instruments and apparatus used in research of cosmic rays - absorption of cosmic ray - discovery of positron - cosmic ray shower discovery of muons - properties of ì - meson - discovery of Pi meson - Trace Element Analysis - Diagnostic Nuclear Medicine - Therapeutic Nuclear Medicine.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials
Assessment Methods	Written Assignment, MQC Test

Books for Study:

1. Ghoshal. S. N. (2003). *Nuclear Physics*. S. Chand and company Ltd.,
2. Satya Prakash. (2014). *Nuclear Physics and Particle Physics,* (1st Ed.). Sultan Chand and sons.
3. Kakani, S. L., & Shubhrakakani (2013), *Nuclear Particle and Physics*, (2nd Ed.). Vivo books (private) Ltd.
4. Kenneth, S. K. (1988). *Introductory Nuclear Physics,* (3rd Ed.). John Wiley and Sons.

Unit	Book	Chapters	Sections
I	1	2,17	2.1, 2.13, 17.2, 17.3, 17.4, 17.6, 17.8
II	1	4,5,6	4.9-4.12,5.5-5.7,5.9,5.10,5.12,5.16,5.18,6.8-6.11,6.16, 6.19
III	2	8,9	8.1,8.2,8.4,8.5,8.7,8.10,8.12,8.13,8.15,8.16,9.2,9.4, 9.11, 9.12, 9.13, 9.17, 9.21
IV	2	11	11.4-11.14,11.15, 11.16
V	3 4	10,20	10.3,10.4, 10.7-10.12, 10.14 20.1, 20.4, 20.5

Books for Reference:

1. Pandya., & Yadav. (2004). *Nuclear and Particle Physics world*. Cambridge University Press.
2. Bernard, L. C. (2002). *Concepts of Nuclear Physics*. Tata McGraw Hill Publishing Co.
3. Kaplan, I. (2001). *Nuclear Physics*, (2nd Ed.). Addison-Wesley Pub. Co.

Websites and eLearning Sources:

1. https://phys.libretexts.org/Bookshelves/Nuclear_and_Particle_Physics
2. https://www.britannica.com/science/physics-science/Nuclear-physics
3. https://onlinecourses.nptel.ac.in/noc22_ph41/preview
   (* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K-Level)**
CO1	Recall and explain a clear picture of nuclear composition, Radio activity, cosmic rays and understand various nuclear models.	**K1**
CO2	Understand the working of nuclear detectors and counters, realize the importance of Cosmic rays and its effects on earth.	**K2**
CO3	Apply and evaluate the applications of Nuclear Physics to Medical field and various other fields related to Physics.	**K3**
CO4	Analyse the different types of nuclear particles and particle accelerators.	**K4**
CO5	Formulate the four-factor formula and compound nuclear theory based on nuclear fission and fusion concepts.	**K5**
CO6	Summarize the properties of various fundamental particles, their decay modes and the interactions.	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**					**Hours**		**Credits**
4	**25PPH4CC09**			**Core Course - 9:** Nuclear and Particle Physics					**6**		**5**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	2	3	2	2	3	3	2	2	2	**2.4**
CO2	2	2	3	2	2	3	2	2	2	2	**2.2**
CO3	3	2	2	2	2	2	2	3	2	2	**2.2**
CO4	3	3	2	2	2	2	3	2	2	2	**2.3**
CO5	2	2	2	2	2	3	2	2	2	2	**2.1**
CO6	3	3	2	2	2	2	3	2	2	2	**2.3**
										Mean Overall Score	**2.25 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
4	25PPH4CC10	**Core Course - 10:** Statistical Mechanics and Thermodynamics	6	5

Course Objectives
To know the relationship between the microscopic view to the macroscopic view of matter and develop tools for characterizing bulk matter at the macroscopic level.
To describe the laws of thermodynamics and how they regulate macroscopic physical process.
To establish the general laws and applications of thermodynamics and introduce the classical and quantum statistical mechanics.
To demonstrate postulates of statistical mechanics and develop the quantum statistical mechanics which is part of the foundation of several branches of Physics and has many applications.
To analyze the physics of phase transition and employ the concepts for its applications and to introduce the Boltzmann transport and transport properties and fluctuations in the various system.

UNIT I: Fundamentals of Statistical Mechanics (18 Hours)

Objectives of statistical Mechanics - Concept of Entropy and disorder - Thermodynamic potentials and reciprocity relations - chemical potential - description of systems of particles system - phase space - volume in phase space - concept of ensembles - micro canonical - canonical - grand canonical - Liouville's theorem - Statistical, thermal, mechanical and particle equilibrium.

UNIT II: Classical Statistics (18 Hours)

Micro and Macro states - classical Maxwell - Boltzmann distribution law - distribution of velocities - principle of equipartition of energy - connection between the partition function and thermodynamic quantities - mean values obtained from distribution law - Boltzmann's entropy relation - perfect gas in micro canonical ensemble.

Unit III: Quantum Statistics (18 Hours)

Postulatory foundations of Quantum Mechanics-Statistical weight - density matrix - Bose - Einstein - Fermi-Dirac - Maxwell - Boltzmann Statistics - black body radiation and Planck's radiation law - Thermodynamic behavior of ideal Bose and Fermi gas - Bose-Einstein condensation – strong degeneracy-Grand canonical ensemble and quantum statistics-Liquid Helium - Super fluidity - Tisza's two Fluid model - electron gas of metals - Free electron model and electronic emission.

Unit IV: Transport Properties and Fluctuations (18 Hours)

Boltzmann transport equations - Boltzmann transport equations for electrons and Lorentz solution - chambers equation - thermal conductivity of metals - mean square deviation - fluctuations in energy- Probability of one-dimensional random walk - Brownian movement - Fokker Planck equation - Nyquist's theorem.

Unit V: Phase Transitions And Its Models (18 Hours)

Phase transitions - first and second kind - critical exponent - YANG and LEE theory - phase transition of second kind - Ising model- Bragg-William's approximation - one dimensional model - adiabatic Demagnetization.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials
Assessment Methods	Written Assignment, MQC Test

Books for Study:

1. Gupta, S. L & Kumar, V. (2009). *Statistical Mechanics,* (23rd Ed.). Pragati Prakashan.

Unit	Book	Chapters	Sections
I	1	1	1-3, 7, 1.1, 1.1-1, 1.3, 1.7, 1.9, 1.10-1.13
II	1	2,3	2.1, 2.7, 2.10, 2.12, 2.14, 2.15, 2.16, 3.0-2
III	1	5,6,8 & 9	5.1,.8, 5.10, 6.2-6.4, 6.10, 8.0, 8.2, 9.0, 8.4, 8.4-1, 9(B), 9.3
IV	1	10,12	10.1, 10.2, 10.3, 10.5, 12.1, 12.5, 12.6, 12.10
V	1	13	13.1-13.7

Books for Reference:

1. Prakash, S., & Agarwal, J. P. (2002). Statistical Mechanics. Pragati Prakashan.
2. Agarwal, B. K., & Melvin Eisner. (2013). Statistical Mechanics, (3rd Edition). New Age International (P)ltd.
3. Tomar, S. (2017). CSIR-UGC NET/JRF/SET Physical Sciences, (3rd Ed.). (for problems).

Websites and eLearning Sources:

1. https://github.com/peastman/statmech.
2. https://www.damtp.cam.ac.uk/user/tong/statphys.html
3. https://link.springer.com/book
4. https://www.sciencedirect.com/topics/chemistry/statistical-mechanics
5. https://en.wikipedia.org/wiki/Statistical_mechanics
   (* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K-Level)**
CO1	Acquire the knowledge of different laws of thermodynamics.	**K1**
CO2	Understand about diverse thermodynamic potentials and their importance to deduce reciprocity relations and Bragg-Williams approximation.	**K2**
CO3	Apply the Knowledge about Liouville's theorem and its importance of MB distribution law, BE and FD distribution law.	**K3**
CO4	Analyze the statistical laws to study transport phenomena.	**K4**
CO5	Evaluate the probability of distribution of particle in different quantum states based on Bose-Einstein, Fermi-Dirac, Maxwell-Boltzmann statistics.	**K5**
CO6	Create solutions for different microstate problems based on different statistical theories.	**K6**

Relationship Matrix											
Semester	**Course Code**		**Title of the Course**						**Hours**		**Credits**
4	**25PPH4CC10**		**Core Course - 10:** Statistical Mechanics and Thermodynamics						**6**		**5**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	2	3	3	2	3	2	3	2	2	**2.5**
CO2	2	3	2	2	2	3	2	2	3	2	**2.3**
CO3	3	2	2	3	2	3	3	2	1	2	**2.3**
CO4	2	2	2	2	2	3	3	2	1	2	**2.1**
CO5	2	2	2	2	2	3	3	2	1	2	**2.1**
CO6	2	3	2	2	3	3	3	3	1	2	**2.4**
										Mean Overall Score	**2.28 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
4	25PPH4CP04	**Core Practical - 4:** Physics Practical - 4	8	4

Any 14 Experiments

1. AlO Band – spectral parameters
2. Laser IV: Fiber Optics cable parameters
3. Op-amp: Solving I order Simultaneous Equation
4. Analog to Digital Converter design
5. Design of Synchronous Counter
6. Digital Modulation: ASK, FSK and PSK
7. Four Probe and two probe Method
8. Optical constants of dielectric and metal films
9. Electron Spin Resonance Spectrometer
10. Determination of Fermi energy of copper
11. Measurement of radiant flux density and luminous intensity of emission source
12. Surface morphological characterization of nanomaterial by TEM
13. Jamin's interferometer - refractive index of air
14. Measurement of thermoelectric power
15. Computation through Origin: Mathematical functions
16. Computation through Origin: Curve Fitting
17. Computational experiment: Origin - Signal processing
18. Basic programs – Arduino
19. Frequency and humidity measurement - Arduino
20. Light intensity and distance measurement - Arduino
21. Pressure and density measurement - Arduino
22. Density and viscosity measurement - Arduino
23. Design of LCR meter - Arduino
24. Measurement and control of temperature - Arduino
25. Weather and astronomy related image processing using Python
26. Fast Fourier Transform using Python
27. Sound measurement – Arduino
28. Ellipsometer – Determination of n and k of a material
29. Design of MOSFET power inverter
30. Hydrogen Spectrum and Rydberg Constant
31. Nonlinear Optical Effects in Thin Films
32. Quantum Key Distribution (QKD) and Secure Communication

Semester	Course Code	Title of the Course	Hours/Week	Credits
4	25PPH4ES03A	**Discipline Specific Elective - 3:** Microcontroller Based Physics Instrumentation	4	3

Course Objectives
To describe the fundamentals of microcontroller, Arduino, IoT.
To provide the knowledge on the features of Arduino and understand its functions.
To discover Arduino and IoT circuits for physics applications.
To experiment the interfacing between microcontroller and sensors/actuator for Roll-to-Roll system.
To recommend microcontroller circuit for domestic and industrial applications and design the Arduino based physics instruments.

UNIT I: Microcontroller and Architecture of Arduino (12 Hours)

Microprocessor and Microcontroller - ATmega328/P: Introduction - Feature - Description - Block Diagram - Pin Configurations. **Arduino:** Block diagram - Architecture - Pin functions - features - I/O Ports - Timers - interrupts - serial port - variants - Introduction to Arduino IDE - writing, saving, compiling and uploading sketches.

UNIT II: Arduino Language Reference and Programming (12 Hours)

Language Reference: Variables - Operators - Control structures - Time and math functions Libraries and library management - Board management - digital I/O: blinking LED - interfacing Switch and 4x4 matrix keyboard - Interfacing LCD - simple programs.

UNIT III: Programing Arduino Peripherals (12 Hours)

ADC – Analog Read – Analog Reference - Pulse Width Modulation PWM - control of DC motor - Serial Communication - Inter Integrated Circuit I2C- Serial Peripheral Interface SPI- Ethernet shield.

UNIT IV: Microcontroller Instrument Design (12 Hours)

Pressure meter - thermometer - lux meter - Ultrasonic range finder - humidity meter - density meter - viscometer - dielectric meter - LCR meter

UNIT V: Internet of Things (IoT) (12 Hours)

Introduction - Block diagram - Networking with ESP8266 Wi-Fi module - MQTT Protocol - IoT service platform - IoT weather monitoring - IoT Physics Applications.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials
Assessment Methods	Written Assignment, MQC Test

Books for Study:

1. Atmega328/P Data sheet.
2. Evans, B. (2011). *Beginning Arduino Programing*. A press.
3. Waher, P. (2015). *Learning Internet of Things*. Packt Publishing.

Unit	Book	Chapters	Sections
I	1 2	1, 2, 4, 5, 11 & 12.1	1, 2, 4, 5, 11 & 12 1
II	2	2, 3, 4, & 5	2, 3, 4, & 5
III	2	6, 7 & 10	6, 7 & 10
IV	2		Programs
V	3	1, 2, 5, & 7	1, 2, 5, & 7

Books for Reference:

1. Simon Monk. (2016). *Programming Arduino, Getting Started with Sketches,* (2nd Ed.). McGraw-Hill Education.

Websites and eLearning Sources:

1. https://www.arduino.cc/
2. https://www.arduino.cc/en/Tutorial/HomePage
3. https://opensource.com/resources/what-arduino
   (* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K-Level)**
CO1	Describe the architecture of Microcontroller, Arduino and IoT.	**K1**
CO2	Outline the features of Arduino IDE, syntax and algorithm and understand the use of this to solve the problems.	**K2**
CO3	Identify the applications of Arduino, recommend the methods, design and construct various physics Instruments.	**K3**
CO4	Examine the problems encountered in interfacing the Arduino with the accessories to analyse the problems	**K4**
CO5	Recommend Arduino circuits for the applications and use professional ethics on using sensors to rate modern society.	**K5**
CO6	Design the automatic electronic devices and plan develop an instrument having self-sustainability, employability and overall Personality	**K6**

Relationship Matrix											
Semester	**Course Code**	**Title of the Course**								**Hours**	**Credits**
4	**25PPH4ES03A**	**Discipline Specific Elective - 3:** Microcontroller Based Physics Instrumentation								**4**	**3**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	2	2	2	3	3	3	3	2	**2.6**
CO2	3	3	3	2	2	3	3	3	3	2	**2.7**
CO3	3	3	3	2	2	3	3	3	3	2	**2.7**
CO4	3	3	2	3	2	3	3	3	3	2	**2.7**
CO5	3	3	3	3	2	3	3	3	2	2	**2.7**
CO6	3	3	3	3	2	3	3	3	2	2	**2.7**
Mean Overall Score											**2.68 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
4	25PPH4ES03B	**Discipline Specific Elective - 3:** Physics of Sensors and Transducers	4	3

Course Objectives
To introduce the fundamentals of sensors and transducers.
To provide the knowledge on the features of sensors and transducers and their principles.
To demonstrate the principles of sensors and their corresponding functions.
To analyze the working of electronic instruments and interfacing the sensors/actuator in electronic system.
To decide the sensors for a specific application and develop the transducers for various applications.

UNIT I: Data Acquisition and Sensors (12 Hours)

Sensors, Signals, and Systems - Sensor Classification - Mathematical models - Calibration - Computation of parameters - Hysteresis - Nonlinearity - Saturation - Repeatability - Dead - Resolution - Special Properties - Dynamic Characteristics – Uncertainty.

UNIT II: Physics Principles of Sensing (12 Hours)

Capacitance - Magnetism - Induction - Resistance - Piezoelectric Effect - Pyroelectric Effect - Hall Effect - Thermoelectric Effects - Temperature and Thermal Properties of Materials - Heat Transfer.

UNIT III: Physics of Detectors (12 Hours)

Ultrasonic Detectors - Microwave Motion Detectors - Linear Optical Sensors - Optoelectronic Motion Detectors - Optical Presence Sensors - Pressure-Gradient Sensors - Gesture Sensing - Tactile Sensors.

UNIT IV: Transducers I (Principle and Design) (12 Hours)

Metal detector - Magneto strictive detector - proximity detector - ablation transducer - cryogenic liquid level transducer - Tachometer - laser gyroscope - Inclinometer - Seismic transducer - piezoelectric accelerometer - pressure sensitive film - vacuum pressure gauge - ultrasonic flow transducer.

UNIT V: Transducers II (Principle and Design) (12 Hours)

Optical microphone - optical hygrometer - oscillating hygrometer - soil moisture - image detector - UV detector - thermal radiation detector - ceramic PTC transducer - chemical transducer - biological transducer.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials
Assessment Methods	Written Assignment, MQC Test

Books for Study:

1. Fraden, J. (2016). *Handbook of Modern Sensors - Physics, Designs, and Applications,* (5th Ed.). Springer.

Unit	Book	Chapters	Sections
I	1	1, 2, 3	1.1, 1.2, 2.1-2.3, 3.1-3.3, 3.5-3.12, 3.16, 3.21
II	1	4	4.2-4.9, 4.11, 4.12.
III	1	7	7.1, 7.2, 7.5, 7.8-7.13
IV	1	8, 9, 10	8.4.5, 8.4.8, 8.5.2, 8.6.1, 9.1.2, 9.2.3, 9.3.2, 9.3.3, 9.3.6, 10.3, 11.10, 12.4
V	1	13, 14, 15, 16, 17, 18	13.3, 13.5, 14.6-14.8, 15.6-15.8, 16.2, 17.4.5, 18.1-18.4, 18.9

Books for Reference:

1. Michael Stanley & Jongmin Lee. (2018). *Sensor Analysis.* Morgan & Laypool publishers.

Websites and eLearning Sources:

1. https://www.nap.edu/read/4782/chapter/4
2. https://www-physics.lbl.gov/~spieler/TSI-2007/PDF/Sensor_Physics_I.pdf
3. https://www.elprocus.com/tilt-sensor-types-working-principle-and-its-applications/

(* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements**	**Cognitive Levels (K-Level)**
	On successful completion of this course, students will be able to	
CO1	Describe the different signals from the sensors and physical principles involved in the sensors and transducers.	**K1**
CO2	Explain the working principle of different sensors and transducers	**K2**
CO3	Using the principle of sensors, and transducers to sense the physical quantity.	**K3**
CO4	Categorize the sensors, transducers and recommend this to suitable applications.	**K4**
CO5	Assess the performance of the circuits and interpret it's working.	**K5**
CO6	Examine the signals, design the transducers for the applications and synthesize a new sensors and transducers.	**K6**

Relationship Matrix											
Semester	**Course Code**		**Title of the Course**						**Hours**		**Credits**
4	**25PPH4ES03B**		**Discipline Specific Elective - 3:** Physics of Sensors and Transducers						**4**		**3**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	2	2	3	3	2	2	2	2	3	2	**2.3**
CO2	3	2	2	2	3	2	3	3	3	2	**2.5**
CO3	3	2	2	2	2	2	3	3	3	2	**2.4**
CO4	3	2	3	2	2	3	3	2	2	3	**2.5**
CO5	3	2	2	2	2	3	3	3	2	2	**2.4**
CO6	3	2	2	2	2	3	3	3	2	2	**2.4**
									Mean Overall Score		**2.42 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
4	25PPH4CE01	Comprehensive Examination	-	2

UNIT I: Classical and Quantum Mechanics

Generalized coordinates system, Lagrangian and Hamiltonian formulation and equation of motion, Central force motions, two body collisions - Scattering in laboratory and center of mass frames, Rigid body dynamics - nonlinear frame and pseudo forces, Special theory of relativity - Lorentz transformation, relativistic Kinematics and mass energy Equivalence. Basic postulates and quantum system - Schrodinger equation and wave packets - Properties of 1D motions, one- and three-dimensional problems - Tunneling through barrier - Eigen value problems - Harmonic oscillator and Hydrogen atom problem, Angular momentum - spin angular momentum - orbital angular momentum, Approximation methods - Time independent Perturbation Theory.

UNIT II: Mathematical Physics and Mathematical methods of Computational Physics

Mathematical tools of vector and matrix spaces - vector algebra and vector calculus, linear algebra, matrices, Eigen values and Eigen vectors, partial differential equations - Laplace, wave and heat equations in two and three dimensions- Cauchy's theorem - Laurent series, Fourier series - Fourier and Laplace transforms, Special function – series solution of Hermite and Legendre polynomial Rearrangement theorem - cyclic groups - subgroups - conjugate elements and class structure - identification of symmetry element and operations - molecular point groups - The Great Orthogonality theorem (Qualitative treatments) - Character table - generating symmetry operators - irreducible representation for C2v and C3v - Numerical integration - Interpolation.

UNIT III: Methods of spectroscopy and Condensed Matter Physics

Electronic, rotational, vibrational and Raman spectra of diatomic molecules - selection rule, Spin and applied field - NMR spectroscopy - Electron spin resonance spectroscopy - Mossbauer Spectroscopy Semiconductor crystals - Origin of energy gap - carrier concentration - mobility - conductivity - Fermi surface - construction of Fermi surface - nearly free electron model - Pseudo potential Thermodynamics of the superconducting transition - London equation - BCS theory of superconductivity - Type II superconductors - DC and AC Josephson effect - High temperature superconductors, Magnetic properties of solids - Dia, para and ferro magnetism, magnetic resonance, dielectric function of gas.

UNIT IV: Electromagnetic Theory

Gauss law and its applications - Laplace and Poisson equations - boundary value problems - Biot-Savart law - Ampere's theorem - Maxwell's equations in free space and linear isotropic media - Boundary conditions on fields at interface - Scalar and vector potential, Electromagnetic waves in free space, dielectrics and conductors, wave guides - Radiation from moving charges and retarded potential.

UNIT V: Nuclear Physics and Statistical Mechanics

Basic nuclear properties - nuclear models - Theories of alpha and beta decay, types of nuclear reactions, elementary particles and their quantum numbers - Quark model, Cosmic rays - discovery and applications, diagnostic nuclear medicine.

Fundamentals of statistical mechanics, classical statistical mechanics - micro and macro states, thermodynamic quantities, Maxwell's relations, Boltzmann's entropy relation, quantum statistical mechanics - ideal Bose and Fermi gas - Bose-Einstein condensation, Transport properties - Boltzmann transport equations - random walk - Brownian movement.

Books for Reference:

1. Gupta, A., & Tomar, S. (2022). *Upkar's CSIR-UGC NET /JRF/SET Physical Sciences*. Upkar Prakashan publication.
2. (2020). *NTA CSIR UGC NET SET (JRF & Lectureship) Physical Sciences*. Arihant Publications.