

**PG & RESEARCH DEPARTMENT OF PHYSICS  
NATIONAL COLLEGE (AUTONOMOUS)  
TIRUCHIRAPPALLI**

**M.Sc. Physics**

**SYLLABUS**

**FROM JUNE 2025 ONWARDS**

**PG AND RESEARCH DEPARTMENT OF PHYSICS  
NATIONAL COLLEGE (AUTONOMOUS), TIRUCHIRAPPALLI-620001**

**M.Sc. PHYSICS Program Syllabi 2025-26 onwards**

Sl. No.	Sem.	Code	Course	Title	Exam Hrs.	Instruction Hrs.	Credits	Internal Exam	External Exam	Total Marks
1	I	P25PH1	CCI	Mathematical Physics	3	6	5	25	75	100
2	I	P25PH2	CCII	Classical Mechanics	3	6	5	25	75	100
3	I	P25PH3	CCIII	Statistical Mechanics	3	6	5	25	75	100
4	I	P25PH4P	CCIVP	Practical 1: Advanced General and Electronics	4	6	4	25	75	100
5	I	P25PH5E1 P25PH5E2 P25PH5E3	CBEI	1. Special Electronics– I: Microelectronic Devices 2. Astrophysics 3. Photo, Radiation and Environmental Biophysics	3	6	4	25	75	100
6	II	P25PH6	CCV	Atomic and Molecular Spectroscopy	3	6	5	25	75	100
7	II	P25PH7	CCVI	Quantum Mechanics	3	6	5	25	75	100
8	II	P25PH8P	CCVIIP	Practical 2: Advanced General and Electronics	4	6	4	25	75	100
9	II	P25PH9E1 P25PH9E2 P25PH9E3	CBEII	1. Special Electronics– II: Microcontroller and Communication Electronics 2. Introduction to Spintronics 3. Medical Physics	3	6	4	25	75	100
10	II	P25PH10E1 P25PH10E2 P25PH10E3	CBEIII	1. Basics of Nano Science and its Applications 2. Non-conventional Energy Sources 3. Physics of Materials	3	6	4	25	75	100
11	III	P25PH11	CCVIII	Crystal Growth and Thin Film Physics	3	6	5	25	75	100
12	III	P25PH12	CCIX	Electromagnetic Theory	3	6	5	25	75	100
13	III	P25PH13	CCX	Nuclear and Particle Physics	3	6	5	25	75	100
14	III	P25PH14P	CCXIP	Practical 3: Digital Electronics and Processor Interfacing	4	6	4	25	75	100
15	III	P25PH15E1 P25PH15E2 P25PH15E3	CBEIV	1. Numerical Methods and C Programming 2. Vibrational Spectroscopy 3. Computational Physics with Python	3	6	4	25	75	100
16	IV	P25PH16	CCXII	Condensed Matter Physics	3	6	5	25	75	100
17	IV	P25PH17	CCXIII	Fiber Optics and Non-linear Optics	3	6	5	25	75	100
18	IV	P25PH18P	CCXIVP	Practical 4: Microcontrollers, C & Python Programming	4	6	4	25	75	100
19	IV	P25PH19E1 P25PH19E2 P25PH19E3	CBEV	1. X-ray Crystallography and Drug Design 2. Elements of Particle Physics 3. Instrumentation	3	6	4	25	75	100
20	IV	P25PHP20	CCXV	Project	-	6	4	75	25	100
				<b>Total</b>		<b>120</b>	<b>90</b>			<b>2000</b>

**CC: Core Course (Theory/Practical)**

**CBE: Core Based Elective A/B/C (Theory)**

### LIST OF CORE COURSES

Semester	Code	Course	Title
I	P25PH1	CCI	Mathematical Physics
I	P25PH2	CCII	Classical Mechanics
I	P25PH3	CCIII	Statistical Mechanics
I	P25PH4P	CCIVP	Practical 1: Advanced General and Electronics
II	P25PH6	CCV	Atomic and Molecular Spectroscopy
II	P25PH7	CCVI	Quantum Mechanics
II	P25PH8P	CCVIIP	Practical 2: Advanced General and Electronics
III	P25PH11	CCVIII	Crystal Growth and Thin Film Physics
III	P25PH12	CCIX	Electromagnetic Theory
III	P25PH13	CCX	Nuclear and Particle Physics
III	P25PH14P	CCXIP	Practical 3: Digital Electronics and Processor Interfacing
IV	P25PH16	CCXII	Condensed Matter Physics
IV	P25PH17	CCXIII	Fiber Optics and Non-linear Optics
IV	P25PH18P	CCXIVP	Practical 4: Microcontrollers, C & Python Programming
IV	P25PH20	CCXV	Project

### LIST OF ELECTIVE COURSES (Core Based/Interdisciplinary)

Semester	Code	Course	Title
I	P25PH5E1	CBE1	1. <b>Special Electronics– I: Microelectronic Devices</b> 2. Astrophysics 3. Photo, Radiation and Environmental Biophysics
II	P25PH9E1	CBE2	1. <b>Special Electronics– II: Microcontroller and Communication Electronics</b> 2. Introduction to Spintronics 3. Medical Physics
II	P25PH10E1	CBE2	1. <b>Basics of Nano Science and its Applications</b> 2. Non-conventional Energy Sources 3. Physics of Materials
III	P25PH15E1	CBE3	1. <b>Numerical Methods and C Programming</b> 2. Vibrational Spectroscopy 3. Computational Physics with Python
IV	P25PH19E1	CBE5	1. <b>X-ray Crystallography and Drug Design</b> 2. Elements of Particle Physics 3. Instrumentation

## **ABOUT THE PROGRAMME: M.Sc. in PHYSICS**

The M.Sc. program in Physics at National College (Autonomous), affiliated with Bharathidasan University, is designed to provide students with a solid foundation in core areas of physics, including Mathematical Physics, Classical Mechanics, and Statistical Mechanics. It equips them with the analytical and problem-solving skills necessary for advanced studies and research. The program also aims to develop practical expertise in experimental techniques through hands-on training in Advanced General Physics, Electronics, Digital Electronics, and Processor Interfacing, preparing students for real-world applications of theoretical principles.

Additionally, the program offers students the opportunity to specialize in core areas such as Quantum Mechanics, Nuclear Physics, and Condensed Matter Physics, while fostering research-oriented learning through discipline-specific electives like Computational Physics. Some of the elective courses are inspired by those offered at specialized departments in various state universities, each focusing on specific areas of physics. Interdisciplinary integration is encouraged by offering diverse electives such as Fiber Optics, Non-linear Optics, X-ray Crystallography, and Nanoscience, enabling students to apply physics principles across multiple scientific and engineering fields. To promote independent research and the practical application of theoretical knowledge, the curriculum includes a final-year project with mentorship from faculty members in various areas of physics. In summary, the M.Sc. program offers a combination of core courses, creative laboratory work, and a variety of elective courses within the field of physics. Students are also encouraged to pursue MOOCs through self-learning initiatives, earning additional credits. Students with a flair for research may join the Ph.D. program offered by the department, which is well-supported by a fully-equipped common instrumentation center and a digital library.

### Programme Outcome (POs) and Programme Specific Outcome (PSOs):

<b>PSO No.</b>	<b>Programme Specific Outcome (PSO)</b>	<b>Corresponding Common PO</b>
<b>PSO1</b>	Acquire in-depth knowledge of classical mechanics, quantum mechanics, electromagnetism, statistical physics, and condensed matter physics, applying these principles to real-world problems and advanced research.	<b>PO1: Disciplinary Knowledge</b>
<b>PSO2</b>	Effectively communicate complex physics concepts, experimental results, and computational findings through scientific writing, technical presentations, and research discussions.	<b>PO2: Communication Skills</b>
<b>PSO3</b>	Apply mathematical and computational techniques, such as differential equations, Fourier analysis, and numerical simulations, to analyze and solve physics problems in areas like quantum field theory, material science, and nonlinear dynamics.	<b>PO3: Critical Thinking, Problem-Solving, and Analytical Reasoning</b>
<b>PSO4</b>	Develop expertise in experimental techniques and data analysis through hands-on experience in spectroscopy, solid-state physics, nanotechnology, and high-energy physics, while fostering teamwork and leadership in collaborative research.	<b>PO4: Reflective Thinking, Scientific Reasoning, Teamwork with Leadership Qualities</b>
<b>PSO5</b>	Demonstrate ethical responsibility and awareness of the environmental impact of physics applications, including nuclear energy, radiation safety, and sustainable materials research.	<b>PO5: Moral and Ethical Awareness, Appreciating Environmental and Sustainability Issues</b>
<b>PSO6</b>	Engage in continuous learning and interdisciplinary research, integrating knowledge from physics with fields like astrophysics, biophysics, and computational physics, ensuring adaptability to technological advancements.	<b>PO6: Multicultural Competency and Self-Directed Lifelong Learning</b>

#### Correlation Level Indicators:

- **9-Strong Correlation**
- **3-Medium Correlation**
- **1-Lesser Correlation**

Programme Code	Course Code	Course Type	Category	Hrs./Week	Credits
PHYPG1963	P25PH1	CC	Lecture	6	5

<b>MATHEMATICAL PHYSICS</b>
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**Course Description:**

This postgraduate course on Mathematical physics helps the students to understand the advanced mathematical models like Fourier series, complex variation to be applied to certain physics applications. Students are also exposed to foundation of probability and matrices for physics-oriented problems.

**Course Objectives:** The course intends to facilitate the learner to

- Recall and state fundamental concepts of Fourier series, vector analysis, complex analysis, matrices, tensors, and probability.
- Explain and interpret the properties, theorems, and mathematical formulations associated with Fourier transforms, vector spaces, and probability distributions.
- Solve physics-related problems using Fourier transforms, vector calculus, matrix operations, tensor algebra, and probability models.
- Examine and compare different mathematical methods, such as Fourier and complex analysis, and analyze their role in solving physics problems.
- Assess the validity and effectiveness of mathematical techniques in physics applications and justify the selection of appropriate methods.
- Develop new problem-solving approaches by integrating multiple mathematical concepts, formulating advanced models for physics applications.

**UNIT - I: FOURIER SERIES AND TRANSFORMS (18 hours)**

Review of Trigonometric series and Euler's formula - Fourier series – Dirichlet's theorem and condition – Problems on periods with simple functions  $\sin(nx)$ ,  $\cos(nx)$  - Fourier transform – Integral theorem – Fourier Sine, Cosine transform - Shifting theorem – Change of scale.

**UNIT- II: VECTOR ANALYSIS AND VECTOR SPACE (18 hours)**

Vector Analysis - Concept of vector and scalar fields – Gradient, divergence, curl and Laplace operator – Line integral, surface integral and volume integral – Gauss divergence theorem-Green's theorem-Stoke's theorem.

Vector Space: Linear Dependence (LD) and Linear Independence (LI) of vectors – Schwarz inequality theorem-Gram-Schmidt's Orthogonalization process.

**UNIT -III: COMPLEX ANALYSIS (18 hours)**

Functions of complex variables – Differentiability – Cauchy-Riemann conditions –Cauchy's integral theorem and integral formula – Residues and singularities - Cauchy's residue theorem – Evaluation of definite integrals (Only Trigonometric functions around the unit circles).

**UNIT- IV: MATRICES AND TENSOR (18 hours)**

**MATRICES:** Rank of a matrix - Characteristic equation-Eigen values and Eigen vectors- Cayley-Hamilton Theorem-Diagonalization of a matrix – Trace of a matrix-Sylvester's theorem.

**TENSOR:** Transformation Co-ordinates-Summation Convention -Contravariant, Covariant and Mixed tensors - Algebra of tensors - outer and inner products - Symmetric and Anti- symmetric tensors.

**UNIT- V: PROBABILITY (18 hours)**

Definitions - Laws of probability - Mean, Standard deviation – Poisson distribution - Binomial distribution - Normal distribution - Moments of distribution - Recurrence relations - Sampling of variables - Variance - The t-distribution - The Chi - Square distribution.

**Text Books:**

1. L. A. Pipes and L. R. Harvill, Applied Mathematics for Engineers and Physicists – Mc Graw-Hill (1987).
2. Satya Prakash, Mathematical Physics, Sulthan, Chand & Sons., New Delhi (2006).
3. Goyal and Gupta Laplace and Fourier Transforms, Pragati Prakashan, Meerut (1995).
4. H.K. Dass and Dr. Rama Verma, Mathematical Physics, S. Chand Publishing, 8<sup>th</sup> Edition,(2019).

**Reference Books:**

1. B.D. Gupta, Mathematical Physics, Vikas Publishing House Pvt Ltd., New Delhi (2006).
2. A.K. Ghatak, I.C. Goyal and S. J. Chua, Mathematical Physics, Mac Millan India Ltd. (1995).
3. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley, 10th Edition, (2015).

**Online Resources:**

- NPTEL: [https://www.youtube.com/watch?v=M\\_Irtxhbq3E](https://www.youtube.com/watch?v=M_Irtxhbq3E)
- NPTEL: <https://youtu.be/Lf0fVcyWiLo>
- NPTEL: <https://youtu.be/IoRamPPXrCs>

**Course Outcomes Table for Mathematical Physics**

CO No.	Course Outcome	Knowledge Level
CO1	Recall and state fundamental concepts of Fourier series, vector analysis, complex analysis, matrices, tensors, and probability.	K1
CO2	Explain and interpret the properties, theorems, and mathematical formulations associated with Fourier transforms, vector spaces, and probability distributions.	K2
CO3	Solve physics-related problems using Fourier transforms, vector calculus, matrix operations, tensor algebra, and probability models.	K3
CO4	Examine and compare different mathematical methods, such as Fourier and complex analysis, and analyze their role in solving physics problems.	K4
CO5	Assess the validity and effectiveness of mathematical techniques in physics applications and justify the selection of appropriate methods.	K5
CO6	Develop new problem-solving approaches by integrating multiple mathematical concepts, formulating advanced models for physics applications.	K6

**Course Articulation Matrix** (Maps COs consistency with POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	1	1	1
CO2	9	9	3	3	1	1
CO3	9	9	9	3	3	1
CO4	9	9	9	9	3	3
CO5	9	9	9	9	9	3
CO6	9	9	9	9	3	3
<b>Weightage</b>	54	48	42	34	20	10
<b>Weightage percentage of Course contribution to POs</b>	<b>26 %</b>	<b>23 %</b>	<b>20 %</b>	<b>16%</b>	<b>10 %</b>	<b>5 %</b>

**R- Remember(K1); U- Understand (K2); Ap- Apply(K3); An- Analyze(K4); E- Evaluate(K5); C- Create(K6)**

**Mapping COs with Knowledge levels and POs:**

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/K1	PO1	PO3	PO4	PO6
CO2/K2	PO1, PO2	PO3	PO4, PO5	PO6
CO3/K3	PO1, PO2, PO3	PO4, PO5	PO6	-
CO4/K4	PO1, PO2, PO3	PO4, PO5	PO6	-
CO5/K5	PO1, PO2, PO3, PO4	PO5, PO6	-	-
CO6/K6	PO1, PO2, PO3, PO4	PO5, PO6	-	-

**Course Outcome (CO) Attainment Tools & Evaluation Procedure**

K Levels	C1	C2	C3	C4	Total scholastic marks	Non scholastic marks	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	Attendance 5 Marks	25 Marks	
K1	2	1	–	–	3	–	3	12
K2	1	2	–	–	3	–	3	12
K3	1	1	1	1	4	–	4	16
K4	1	1	1	1	4	–	4	16
K5	–	1	1	1	3	–	3	12
K6	–	–	1	2	3	–	3	12
Non Scholastic	–	–	–	–	–	5	5	20
<b>Total</b>	<b>5</b>	<b>6</b>	<b>4</b>	<b>5</b>	<b>20</b>	<b>5</b>	<b>25</b>	<b>100%</b>

**Declaration**

The COs and POs for the **MATHEMATICAL PHYSICS** Course in the M.Sc. Physics Programme is effectively matched.

**Course Designed by****Course Verified by****HoD**

Programme Code	Course Code	Course Type	Category	Hrs./Week	Credits
PHYPG1963	P25PH2	CC	Lecture	6	5

<b>CLASSICAL MECHANICS</b>
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**Course Description:**

This course in Classical Mechanics delves into advanced physical concepts, providing a rigorous exploration of Lagrangian and Hamiltonian formalisms. Students will engage with various applications, canonical transformations, and the Hamilton-Jacobi theory, culminating in a comprehensive understanding of linear oscillations and their physical implications.

**Course Objectives:** The course intends to facilitate the learner to

- List and define the key concepts in classical mechanics such as constraints, degrees of freedom, generalized coordinates, generalized momentum, and Lagrange's equation of motion.
- Describe the physical significance of generalized potential, cyclic coordinates, and the principles of conservation of angular momentum and total energy, explaining their roles in Lagrangian mechanics.
- Solve problems using the Lagrangian and Hamiltonian formalisms, such as deriving equations of motion for systems like the simple pendulum and Atwood's machine, and applying Hamilton's variational principle to physical scenarios.
- Analyze canonical transformations and their types, evaluating the role of generating functions and Poisson's brackets in ensuring invariance under these transformations, and applying these concepts to various physical systems.
- Evaluate the effectiveness of Hamilton-Jacobi theory and the action-angle variables in solving classical mechanics problems like the Kepler problem, comparing them with other methods like the Lagrangian and Hamiltonian formulations.
- Design a solution to a system involving linear oscillations, such as determining the normal modes and frequencies of a CO<sub>2</sub> molecule, and apply the theory of small oscillations to analyze real-world molecular systems.

**UNIT-I: FUNDAMENTALS AND LAGRANGIAN FORMALISM (18 hours)**

Constraints- Degrees of freedom - Generalized co-ordinates – Generalized momentum – Generalized Potential – D'Alembert's principle –Lagrange's equation of motion from D'Alembert's principle – Cyclic co-ordinates – Conservation of angular momentum and total energy.

**UNIT-II: HAMILTONIAN FORMALISM (18 hours)**

Hamilton as total energy operator – Physical significance of H- Hamilton's variational principle – Deduction of Hamilton's principle from D'Alembert's principle – Deduction of Lagrange equation of motion from Hamilton's principle – Hamilton's canonical equation of motion – Hamilton's equation of motion from Hamilton's variational principle.

**UNIT-III: APPLICATIONS AND CANONICAL TRANSFORMATIONS (18 hours)**

Applications of Lagrange formalism: Simple pendulum- Atwood's Machine - Transformations: point or contact, Canonical – Generating function of canonical transformation – Four types of canonical transformations -  $\Delta$  Variation – Principle of least action.

**UNIT-IV: BRACKETS AND HAMILTON – JACOBI THEORY (18 hours)**

Lagrange and Poisson's brackets – Symmetry, invariance of Poisson bracket under Canonical transformation – Hamilton's characteristic function – Hamilton-Jacobi equation – Physical significance of S – Action – angle variables- Kepler's problem and its solution by Hamilton- Jacobi method.

**UNIT-V: LINEAR OSCILLATIONS (18 hours)**

Theory of small oscillations –Equilibrium -stable and unstable equilibrium - Normal modes of oscillations and frequencies – Simple harmonic oscillator – CO<sub>2</sub> as linear symmetrical molecule, its normal frequencies and its normal modes.

**Text Books:**

1. Gupta-Kumar-Sharma, Classical Mechanics, S. Chand and Co. (1987).
2. J.C. Upadhyaya, Classical Mechanics, Himalaya Publishing House.(2019)

**Reference Books:**

1. H. Goldstein, Classical Mechanics, McGraw Hill Pvt., New Delhi (1981).
2. G. Aruldas – Classical Mechanics – PHI Learning Pvt., New Delhi (2009).

**Online Resources:**

NPTEL: <https://youtu.be/ohbmg53jDN0>

NPTEL: <https://youtu.be/bsybS5fZGjY>

NPTEL: <https://youtu.be/Q6Gw08pwhws>

NPTEL: [https://onlinecourses.nptel.ac.in/noc20\\_ph17/](https://onlinecourses.nptel.ac.in/noc20_ph17/)

NPTEL: <https://nptel.ac.in/courses/115105098>

**Course Outcomes Table**

CO No.	Course Outcome	Knowledge Level
CO1	List and define the key concepts in classical mechanics such as constraints, degrees of freedom, generalized coordinates, generalized momentum, and Lagrange's equation of motion.	K1
CO2	Describe the physical significance of generalized potential, cyclic coordinates, and the principles of conservation of angular momentum and total energy.	K2
CO3	Solve problems using the Lagrangian and Hamiltonian formalisms like simple pendulum and Atwood's machine, applying Hamilton's principle to physical systems.	K3
CO4	Analyze canonical transformations and generating functions, evaluate Poisson brackets, and apply them to different physical systems.	K4
CO5	Evaluate the effectiveness of Hamilton-Jacobi theory and action-angle variables, especially in solving problems like the Kepler problem.	K5
CO6	Design solutions for linear oscillations, determine normal modes and frequencies of molecular systems like CO <sub>2</sub> .	K6

**Course Articulation Matrix** (Maps COs consistency with POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	1	0	1
CO2	9	3	3	3	1	3
CO3	9	3	9	3	1	3
CO4	9	3	9	9	1	3
CO5	9	3	9	9	3	3
CO6	9	3	9	9	3	9
Weightage	54	18	42	34	9	22
Weightage percentage of Course contribution to POs	31 %	10 %	23 %	19 %	5 %	12 %

R- Remember(K1); U- Understand (K2); Ap- Apply(K3); An- Analyze(K4); E- Evaluate(K5); C- Create(K6)

Mapping COs with Knowledge levels and POs:

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/K1	PO1	PO3	PO4	PO6
CO2/K2	PO1, PO2	PO3	PO4, PO5	PO6
CO3/K3	PO1, PO2, PO3	PO4, PO5	PO6	-
CO4/K4	PO1, PO2, PO3	PO4, PO5	PO6	-
CO5/K5	PO1, PO2, PO3, PO4	PO5, PO6	PO6	-
CO6/K6	PO1, PO2, PO3, PO4	PO5, PO6	PO6	-

**Course Outcome (CO) Attainment Tools & Evaluation Procedure**

K Levels	C1	C2	C3	C4	Total scholastic marks	Non scholastic marks	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	Attendance 5 Marks	25 Marks	
<b>K1</b>	2	1	–	–	3	–	3	12
<b>K2</b>	1	2	–	–	3	–	3	12
<b>K3</b>	1	1	1	1	4	–	4	16
<b>K4</b>	1	1	1	1	4	–	4	16
<b>K5</b>	–	1	1	1	3	–	3	12
<b>K6</b>	–	–	1	2	3	–	3	12
<b>Non Scholastic</b>	–	–	–	–	–	5	5	20
<b>Total</b>	<b>5</b>	<b>6</b>	<b>4</b>	<b>5</b>	<b>20</b>	<b>5</b>	<b>25</b>	<b>100%</b>

**Declaration**

The COs and POs for the Classical Mechanics Course in the M.Sc. Physics Programme is effectively matched.

**Course Designed by**

**Course Verified by**

**HoD**

Programme Code	Course Code	Course Type	Category	Hrs./Week	Credits
PHYPG1963	P25PH3	CC	Lecture	6	5

<b>STATISTICAL MECHANICS</b>
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**Course Description:**

To study the fundamental principles of thermodynamics and various statistical distributions and to understand the basic ideas of particle behavior.

**Course Objectives:** The course intends to facilitate the learner to

- Identify the fundamental laws of thermodynamics, key principles of kinetic theory, and the basic postulates of statistical mechanics.
- Explain the concepts of entropy, phase transitions, Maxwell-Boltzmann distribution, and partition functions in classical and quantum statistical mechanics.
- Compute thermodynamic quantities using partition functions and apply kinetic theory to determine mean free path and distribution of molecular velocities.
- Differentiate between classical and quantum statistics (Bose-Einstein & Fermi-Dirac), and examine the implications of Bose-Einstein condensation and superfluidity.
- Assess the validity of the Boltzmann transport equation and Onsager reciprocal relations in irreversible thermodynamic processes.
- Develop mathematical models for statistical equilibrium, fluctuations in thermodynamic properties, and the behavior of ideal Bose and Fermi gases under extreme conditions.

**UNIT — I: REVIEW OF THERMODYNAMICS (18 hours)**

First law — Entropy and second law - Principle of degradation of energy- Thermodynamic Potentials and its reciprocity relations- Gibbs's-Helmholtz relation- Thermodynamic equilibria- Nernst heat theorem- Phase transitions- First order and Second order.

**UNIT — II: KINETIC THEORY (18 hours)**

Distribution function- Boltzmann transport equation for homogeneous and heterogeneous medium and its validity- Kinetic theory of gases- Maxwell Boltzmann distribution law of velocities- Mean free path- Expression and experimental determination.

**UNIT — III: CLASSICAL STATISTICAL MECHANICS (18 hours)**

Macro and micro states — Stirling's approximation — Classical Maxwell- Boltzmann distribution law - Principle of equipartition of energy- Phase space and ensembles - Liouville's theorem- Statistical equilibrium- Partition function - Relation between partition function and thermodynamic quantities- Bose Einstein statistics, Fermi Dirac statistics.

#### UNIT — IV: QUANTUM STATISTICAL MECHANICS (18 hours)

Ideal Bose gas - Energy, pressure of gas- Gas degeneracy-Bose- Einstein condensation — properties of liquid Helium I and II –Fluctuations: Fluctuations in energy, pressure, volume and enthalpy.

#### UNIT — V: ADVANCED STATISTICAL MECHANICS (18 hours)

Irreversible process-Onsager relations-linear law-Onsager reciprocal relations-Proof of Onsager reciprocal relations-Superfluidity- Tisza's two fluid model - second sound.

##### Text Books:

1. Gupta, Kumar, Sharma, Statistical Mechanics, Pragati Prakashan Publications(2005).
2. B.K Agarwal and N. Eisnor, Statistical Mechanics, Wiley Eastern Limited, NewDelhi, 2<sup>nd</sup> Edn.(1989).

##### Reference Books:

1. Sathya Prakash, Statistical Mechanics, Pragati Prakashan Publications (2004).
1. 2.K Huang, Statistical Mechanics, Wiley Eastern Ltd., New Delhi (1986).
2. F. Reif, Statistical and Thermal Physics, McGraw Hill, International Edition, Singapore (1975).
3. Mayer Joseph Edward, Statistical Mechanics, John Wiley and Son, New York (1949).

##### Online Resources:

1. <https://web.stanford.edu/~peastman/statmech/thermodynamics.html>
2. <https://www.sciencedirect.com/topics/physics-and-astronomy/two-fluid-model>
3. <https://www.sciencedirect.com/topics/chemistry/onsager-reciprocal-relation>
4. <https://new.nsf.gov/news/physicists-create-first-ever-bose-einstein>

#### Course Outcomes Table

CO No.	Course Outcome	Knowledge Level
CO1	Identify the fundamental laws of thermodynamics, kinetic theory, and postulates of statistical mechanics.	K1
CO2	Explain entropy, phase transitions, Maxwell-Boltzmann distribution, and partition functions in statistical mechanics.	K2
CO3	Compute thermodynamic quantities using partition functions and determine mean free path and molecular velocity distribution.	K3
CO4	Differentiate between classical and quantum statistics and analyze Bose-Einstein condensation and superfluidity.	K4
CO5	Assess the validity of Boltzmann transport equation and Onsager reciprocal relations for irreversible processes.	K5
CO6	Develop models of statistical equilibrium and predict behavior of ideal Bose and Fermi gases under extreme conditions.	K6

**Course Articulation Matrix** (Maps COs consistency with POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	1	0	1
CO2	9	3	9	3	1	1
CO3	9	1	9	3	0	1
CO4	3	1	9	9	1	3
CO5	3	1	9	9	3	3
CO6	1	1	3	3	9	9
<b>Weightage</b>	34	10	42	28	14	18
<b>Weightage percentage of Course contribution to POs</b>	<b>23 %</b>	<b>7 %</b>	<b>29 %</b>	<b>19 %</b>	<b>10 %</b>	<b>12 %</b>

**R- Remember(K1); U- Understand (K2); Ap- Apply(K3); An- Analyze(K4); E- Evaluate(K5); C- Create(K6)**

**Mapping COs with Knowledge levels and POs:**

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/K1	PO1, PO3	PO4, PO6	PO2	PO5
CO2/K2	PO1, PO3	PO4, PO6	PO2	PO5
CO3/K3	PO1, PO3	PO4, PO6	PO2	PO5
CO4/K4	PO3, PO4, PO6	PO5	PO2	PO1
CO5/K5	PO3, PO4, PO5	PO6	PO2	PO1
CO6/K6	PO3, PO4, PO5, PO6	PO2	PO1	None

**Course Outcome (CO) Attainment Tools & Evaluation Procedure**

K Levels	C1	C2	C3	C4	Total scholastic marks	Non scholastic marks	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	Attendance 5 Marks	25 Marks	
<b>K1</b>	1	2			3		3	12
<b>K2</b>	1	1	1		3		3	12
<b>K3</b>	2	1	1		4		4	16
<b>K4</b>	1	1	1	1	4		4	16
<b>K5</b>		1	1	2	4		4	16
<b>K6</b>				2	2		2	8
<b>Non Scholastic</b>	--	--	--	--	--	5	5	20
<b>Total</b>	<b>5</b>	<b>6</b>	<b>4</b>	<b>5</b>	<b>20</b>	<b>5</b>	<b>25</b>	<b>100%</b>

**Declaration**

The COs and POs for the **STATISTICAL MECHANICS** Course in the M.Sc. Physics Programme is effectively matched.

**Course Designed by**

**Course Verified by**

**HoD**

Programme Code	Course Code	Course Type	Category	Hrs./Week	Credits
PHYPG1963	P25PH4P	CC	Practical	6	4

<b>Practical 1: Advanced General and Electronics</b>
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**Course Description:**

This practical course explores advanced experimental techniques in physics and electronics, focusing on determining fundamental constants and studying various characteristics of materials and components. Students will perform 15 diverse experiments, including the determination of semiconductor band gaps, Planck's constant, and electron charge, as well as the analysis of oscillators, waveforms, and more.

**Course Objectives:** The course intends to facilitate the learner to

- Recall and define fundamental physical constants, semiconductor parameters, and wave properties measured through various experimental techniques.
- Explain the working principles, theories, and methodologies behind different experiments, such as interferometry, semiconductor band gap determination, and electronic circuits.
- Demonstrate the ability to perform experimental setups, operate measuring instruments, and obtain accurate data in determining physical constants and electronic characteristics.
- Interpret experimental data, analyze graphical relationships, and compare results with theoretical predictions to validate scientific models.
- Assess the accuracy, precision, and limitations of experimental outcomes, identifying sources of error and suggesting improvements in methodologies.
- Design and implement new experimental setups, modify circuit configurations, or develop alternative measurement techniques for enhanced accuracy and efficiency.

**Any Fifteen experiments**

1. Determination of  $q$ ,  $n$ ,  $\sigma$  by elliptical fringes method.
2. Determination of  $q$ ,  $n$ ,  $\sigma$  by Hyperbolic fringes method
3. Determination the band gap of a semiconductor using four probe method.
4. Study of LDR- characteristics and wavelength dependency.
5. Determination of wavelength by Michelson's interferometer.
6. FET Characteristics.
7. Waveform generators.
8. Determination of Planck's constant.
9. V to I & I to V converter-IC 741
10. Determination of Stefan's constant.
11. Determination of Rydberg's constant.
12. Determination of dielectric constant at high frequency by Lecher wire method.
13. Determination of wavelength of the monochromatic source using bi prism.

14. Determination of charge of the electron using spectrometer.
15. Determination of the wavelength of the predominant colors of a given Cu/Fe spectrum photo through Hartmann's formulas.
16. Full adder demonstration using NAND ICs only.
17. Design and study of Wien's bridge oscillator using OPAMP IC 741.
18. Determination of the compressibility of the given liquid using R.F oscillator output- Acoustic grating.
19. UJT- as relaxation oscillator.
20. Determination of e/m ratio of an electron using Thomson's method.

### Course Outcomes and Knowledge Levels Table

CO No.	Course Outcome	Knowledge Level
CO1	Recall and define fundamental physical constants, semiconductor parameters, and wave properties measured through various experimental techniques.	K1
CO2	Explain the working principles, theories, and methodologies behind different experiments, such as interferometry, semiconductor band gap determination, and electronic circuits.	K2
CO3	Demonstrate the ability to perform experimental setups, operate measuring instruments, and obtain accurate data in determining physical constants and electronic characteristics.	K3
CO4	Interpret experimental data, analyze graphical relationships, and compare results with theoretical predictions to validate scientific models.	K4
CO5	Assess the accuracy, precision, and limitations of experimental outcomes, identifying sources of error and suggesting improvements in methodologies.	K5
CO6	Design and implement new experimental setups, modify circuit configurations, or develop alternative measurement techniques for enhanced accuracy and efficiency.	K6

### Course Articulation Matrix (Maps COs consistency with POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	1	1	0	0
CO2	9	3	3	1	0	1
CO3	9	3	9	3	1	1
CO4	9	1	9	9	3	1
CO5	9	3	9	9	9	3
CO6	3	3	9	9	3	9
<b>Weightage</b>	48	16	40	32	16	23
<b>Weightage percentage of Course contribution to POs</b>	<b>27%</b>	<b>9%</b>	<b>23%</b>	<b>18%</b>	<b>9%</b>	<b>14%</b>

R- Remember(K1); U- Understand (K2); Ap- Apply(K3); An- Analyze(K4); E- Evaluate(K5); C- Create(K6)

**Mapping COs with Knowledge levels and POs:**

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/K1	PO1	PO2	PO3	PO4, PO5, PO6
CO2/K2	PO1	PO2, PO3	PO4	PO5, PO6
CO3/K3	PO1, PO3	PO2, PO4	PO5	PO6
CO4/K4	PO1, PO3, PO4	PO2, PO5	PO6	-
CO5/K5	PO1, PO3, PO4, PO5	PO2, PO6	-	-
CO6/K6	PO3, PO4, PO6	PO1, PO5	PO2	-

**Attainment & Evaluation Procedure Table\***

K Levels	C1	C2	C3	C4	Total scholastic marks	Non scholastic marks	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	Attendance 5 Marks	25 Marks	
K1	2	1	0	0	3	0	3	12
K2	1	2	1	0	4	0	4	16
K3	1	1	1	1	4	0	4	16
K4	1	1	1	2	5	0	5	20
K5	0	1	1	1	3	0	3	12
K6	0	0	0	1	1	0	1	4
Non Scholastic	--	--	--	--	--	5	5	20
<b>Total</b>	<b>5</b>	<b>6</b>	<b>4</b>	<b>5</b>	<b>20</b>	<b>5</b>	<b>25</b>	<b>100</b>

\*The seminar, assignment components are clubbed with model lab tests in practical courses.

**Declaration**

The COs and POs for the **Practical 1: Advanced General and Electronics** Course in the M.Sc. Physics Programme is effectively matched.

Course Designed by

Course Verified by

HoD

Programme Code	Course Code	Course Type	Category	Hrs./Week	Credits
PHYPG1963	P25PH5E	EC	Lecture	6	4

<b>SPECIAL ELECTRONICS– I: MICROELECTRONIC DEVICES</b>
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**Course Description:**

This course provides an in-depth exploration of microelectronic devices and circuits. Topics include the analysis and application of semiconductor diodes, special devices like FETs and thyristors, operational amplifiers, oscillators, and data converters. The course also covers the fabrication processes of integrated circuits, equipping students with the skills for advanced electronic system design.

**Course Objectives:** The course intends to facilitate the learner to

- Recall and define fundamental concepts of semiconductor and optoelectronic diodes, including their working principles and characteristics.
- Explain the structure, operation, and applications of special semiconductor devices such as JFET, MOSFET, and SCR.
- Apply operational amplifier principles to design and implement inverting, non-inverting, differential, and log/antilog amplifiers.
- Analyze the design and functionality of oscillators and converters, including Schmitt’s trigger, waveform generators, and ADC/DAC circuits.
- Evaluate the fabrication techniques of monolithic ICs, including masking, etching, and impurity diffusion, to assess their impact on circuit performance.
- Design and develop electronic circuits utilizing 555 timers for pulse width modulation, oscillators, and bistable multivibrators.

**Unit-I: SEMICONDUCTOR AND OPTO ELECTRONIC DIODES (18 hours)**

Continuity Equation: Conservation of charge carriers in a PN Junction -Tunnel diode - Backward diode -Varactor diode – PIN diode-Schottky diode - IMPATT Diode - Gunn diode -Optoelectronic diodes –Opto resistor- LED- Multi colour LED - photodiode, Laser diode.

**Unit-II: SPECIAL SEMICONDUCTOR DEVICES (18 hours)**

JFET- Structure and working - V-I Characteristics under different conditions - Biasing of JFET-DC load line-CS amplifier design-MOSFET: Depletion and enhancement type MOS–FFT - Comparison of p with n-channel FETs - Digital MOSFET circuits- Complementary MOS - FET as a Voltage Variable Resistor (VVR) — Common source and drain amplifier at high frequencies – SCR , DIAC, TRIAC -characteristics and applications

**Unit-III: OPERATIONAL AMPLIFIERS (18 hours)**

Operational amplifier characteristics-CMRR- Slew rate -Input offset current and voltage- Frequency response - Inverting and non-inverting amplifier -Voltage follower -Differential amplifier - Voltage to current and current to voltage conversions- Log and antilog amplifiers - Integrating and differential circuits-Solving first order simultaneous equations.

**Unit-IV: OP-AMP APPLICATIONS (OSCILLATORS AND CONVERTORS) (18 hours)**

**Oscillators:** Schmitt's trigger -Square (Astable multi vibrator)- Triangular-Sine wave generators-Phase shift and Wien bridge oscillator.

**Convertors:** Digital to Analog conversion: weighted resistor - Binary R-2R ladder - Analog to Digital conversion: counter type ADC - Successive approximation converter – Dual slope ADC.

**Unit-V: IC FABRICATIONS AND IC TIMER (18 hours)**

**Fabrications:** Fundamentals of monolithic ICs – Epitaxial growth -Masking -Etching - Impurity diffusion- Fabricating monolithic resistors, diodes, transistors, inductors and capacitors - Circuit layout - Contacts and inter connections.

**555 Timer** – Description of the functional diagram –Astable-Mono stable operation - Bistable multi vibrator - Applications-Missing pulse detector - Pulse width modulator - Schmitt's trigger – Voltage controlled oscillator.

**Text Books:**

1. D Chattopadhyay, P C Rakshit, B Saha, N.Purkait, Foundations of Electronics- New Age International Publishers, New Delhi(2006).
2. Roy Choudry , Operational Amplifier and Integrated Electronics, New Age International Publishers, New Delhi(2006).
3. B.L. Theraja, Basic Electronics- S.Chand and Co., New Age(2006).
4. J. Milmann and C.C. Halkias, Integrated Electronics, Mc Graw Hill , NewDelhi. (year ?)

**Reference Books:**

1. V. K. Mehta, Rohit Mehta, Principles of Electronics- S.Chand and Co, New Delhi, (2008).
2. A. Mottershed, Semiconductor Devices and Applications - New Age Int. Pub, New Delhi.
3. Michael Schur, Physics of Semiconductor Devices, Pearson, (1990).

**Online Resources:**

1. [https://youtu.be/\\_WicwmdaIMY](https://youtu.be/_WicwmdaIMY)- NPTEL Lecture on op-amp
2. [https://youtu.be/WFsPI8\\_ZKbc](https://youtu.be/WFsPI8_ZKbc)- NPTEL Lecture on Timer

**Course Outcomes and Knowledge Levels**

CO No.	Course Outcome	Knowledge Level
CO1	Recall and define fundamental concepts of semiconductor and optoelectronic diodes, including their working principles and characteristics.	K1
CO2	Explain the structure, operation, and applications of JFET, MOSFET, and SCR.	K2
CO3	Apply op-amp principles to design inverting, non-inverting, differential, and log/antilog amplifiers.	K3
CO4	Analyze the design and operation of oscillators and converters like Schmitt's trigger, waveform generators, ADC/DAC.	K4
CO5	Evaluate monolithic IC fabrication techniques like masking, etching, diffusion, and their impact on performance.	K5
CO6	Design and develop circuits using 555 timers for multivibrators, PWM, and voltage-controlled oscillators.	K6

**Course Articulation Matrix** (Maps COs consistency with POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	1	0	0
CO2	9	9	3	3	0	1
CO3	9	3	9	3	1	0
CO4	3	3	9	9	3	1
CO5	3	3	9	9	9	3
CO6	3	1	3	9	9	9
<b>Weightage</b>	<b>42</b>	<b>22</b>	<b>36</b>	<b>34</b>	<b>22</b>	<b>14</b>
<b>Weightage percentage of Course contribution to POs</b>	<b>24%</b>	<b>13%</b>	<b>21%</b>	<b>20%</b>	<b>13%</b>	<b>9%</b>

**R- Remember(K1); U- Understand (K2); Ap- Apply(K3); An- Analyze(K4); E- Evaluate(K5); C- Create(K6)**  
**Mapping COs with Knowledge levels and POs:**

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/K1	PO1	PO2	PO3	PO4, PO5, PO6
CO2/K2	PO1, PO2	PO3, PO4	PO6	PO5
CO3/K3	PO1, PO3	PO2, PO4	PO5	PO6
CO4/K4	PO3, PO4	PO1, PO5	PO2, PO6	--
CO5/K5	PO3, PO4, PO5	PO6	PO1, PO2	--
CO6/K6	PO4, PO5, PO6	PO3	PO1, PO2	--

### Course Outcome (CO) Attainment Tools & Evaluation Procedure

K Levels	C1	C2	C3	C4	Total scholastic marks	Non scholastic marks	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	Attendance 5 Marks	25 Marks	
<b>K1</b>	2	1			3		3	12
<b>K2</b>	1	1	1		3		3	12
<b>K3</b>	1	2	1		4		4	16
<b>K4</b>	1	1	1	1	4		4	16
<b>K5</b>		1	1	2	4		4	16
<b>K6</b>				2	2		2	8
<b>Non Scholastic</b>	--	--	--	--	--	5	5	20
<b>Total</b>	<b>5</b>	<b>6</b>	<b>4</b>	<b>5</b>	<b>20</b>	<b>5</b>	<b>25</b>	<b>100</b>

#### Declaration

The COs and POs for the **SPECIAL ELECTRONICS– I: MICROELECTRONIC DEVICES** Course in the M.Sc. Physics Programme is effectively matched.

Course Designed by

Course Verified by

HoD

Programme Code	Course Code	Course Type	Category	Hrs./Week	Credits
PHYPG1963	P25PH6	CC	Lecture	6	5

## ATOMIC AND MOLECULAR SPECTROSCOPY

**Course Description:** This course will equip students with the necessary theoretical and practical knowledge to pursue research or careers in spectroscopy-related fields.

**Course Objectives:** The course intends to facilitate the learner to

- Recall fundamental principles of atomic and molecular spectroscopy, including coupling schemes, spin interactions, external field effects, and molecular rotational-vibrational spectra.
- Explain the physical and quantum mechanical principles underlying atomic and molecular interactions, including spin-orbit coupling, Zeeman and Paschen-Back effects, and spectroscopic selection rules.
- Apply spectroscopic techniques such as microwave, infrared, Raman, electronic, and resonance spectroscopy to study molecular structure and interactions.
- Analyze spectroscopic data to determine molecular properties such as bond lengths, dissociation energies, electronic transitions, and hyperfine structures.
- Evaluate the effectiveness and limitations of different spectroscopic techniques in characterizing atomic and molecular systems for various scientific and industrial applications.
- Design and develop spectroscopic experiments or computational models to explore new aspects of atomic and molecular spectroscopy.

### UNIT-I: COUPLING SCHEMES AND SPIN INTERACTIONS (18 hours)

Concept of Vector atom model and its quantum numbers-Stern –Gerlach experiment – Fine structure of hydrogen lines – Spin-orbit interaction –Lande “g” factor– LS-JJ coupling schemes –Pauli’s exclusion principle and its physical significance- Periodic table- -Equivalent electrons- Differential series in Alkali spectra-Ritz Principle

### UNIT-II: ATOMS IN EXTERNAL FIELDS AND QUANTUM CHEMISTRY (18 hours)

Atoms in external fields:Experimental study of Zeeman effect-Quantum mechanical treatment of Normal and Anomalous Zeeman effect- Zeeman effect-Paschen-Back effect in two-electron systems  
Quantum chemistry of molecules: Born-Oppenheimer approximation-Heitler-London and molecular orbital theories of hydrogen molecule- Huckel’s molecular approximation-Application to butadiene molecule.

### UNIT-III: MICROWAVE AND IR SPECTROSCOPY (18 hours)

Classification of molecules-Rotational spectra of diatomic molecules-Effect of isotopic substitution-Non-Rigid rotator-Rotational spectra of polyatomic molecules-Linear, symmetric top, asymmetric top molecules-Experimental techniques-Vibrating diatomic molecule-Diatomic vibrating rotator-Linear and symmetric top molecules- Characteristic and group frequencies- IR spectrophotometer: Instrumentation.

### UNIT-IV: RAMAN AND ELECTRONIC SPECTROSCOPY (18 hours)

Raman Effect: Classical theory of Raman effect-quantum theory of Raman Effect- Pure rotational and vibrational Raman spectra of the diatomic molecules-Raman spectrometer.  
Electronic spectroscopy of diatomic molecules: Vibrational coarse structure- Franck-Condon principle - Dissociation energy and dissociation products-Fortrat Diagram.

### UNIT-V: RESONANCE SPECTROSCOPY (18 hours)

Nuclear magnetic resonance: Magnetic properties of nuclei-Resonance condition-NMR instrumentation  
Additional techniques-Relaxation processes-Bloch equation-Dipolar interaction-Electron Spin Resonance:  
Theory of ESR spectrometer and instrumentation- Fine Structure and Hyperfine Structure.

#### Books for Study

1. C.N.Banwell, Elaine M. Mc Cash, Fundamental of Molecular Spectroscopy, Mc Graw Hill, New Delhi (2010).
2. G.Aruldas, Molecular Structure and Spectroscopy, PHI Learning Private Limited, NewDelhi(2009).
3. Gupta, S.L.Kumar, Sharma, Elements of Spectroscopy, Pragati Prakashan Publication, Meerut(2009).

#### Books for Reference

1. P.S.Sindhu, Elements of Molecular Spectroscopy, NewAge International, (2007).
- 2.A.K.Chandra, Introductory Quantum Chemistry, Mc Graw Hill, New Delhi,(2003).

#### Online Resources:

1. [https://onlinecourses.nptel.ac.in/noc24\\_cy18/preview](https://onlinecourses.nptel.ac.in/noc24_cy18/preview)
2. <https://archive.nptel.ac.in/courses/115/101/115101003>

#### Course Outcomes and Knowledge Levels

CO No.	Course Outcome	Knowledge Level
CO1	Recall fundamental principles of atomic and molecular spectroscopy, including coupling schemes, spin interactions, and rotational-vibrational spectra.	K1
CO2	Explain quantum mechanical concepts like spin-orbit coupling, Zeeman effect, Paschen-Back effect, and selection rules.	K2
CO3	Apply techniques of microwave, IR, Raman, and resonance spectroscopy to analyze molecular structures and interactions.	K3
CO4	Analyze spectroscopic data to extract information like bond length, dissociation energy, and hyperfine structure.	K4
CO5	Evaluate different spectroscopic techniques for scientific and industrial applications.	K5
CO6	Design and develop experiments or computational models for exploring atomic and molecular spectroscopy.	K6

**Course Articulation Matrix** (Maps COs consistency with POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	1	0	1
CO2	9	3	9	3	1	3
CO3	9	3	9	3	1	3
CO4	9	1	9	9	1	3
CO5	9	1	9	9	3	3
CO6	9	3	9	9	3	9
<b>Weightage</b>	<b>54</b>	<b>14</b>	<b>48</b>	<b>34</b>	<b>9</b>	<b>22</b>
<b>Weightage percentage of Course contribution to POs</b>	<b>30%</b>	<b>8%</b>	<b>27%</b>	<b>19%</b>	<b>5%</b>	<b>11%</b>

**R- Remember(K1); U- Understand (K2); Ap- Apply(K3); An- Analyze(K4); E- Evaluate(K5); C- Create(K6)**

**Mapping COs with Knowledge levels and POs:**

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/K1	PO1	PO2	PO4	PO5
CO2/K2	PO1, PO3	PO2, PO4	PO5	PO6
CO3/K3	PO1, PO3	PO2, PO4	PO5	PO6
CO4/K4	PO1, PO3, PO4	PO6	PO2	PO5
CO5/K5	PO1, PO3, PO4	PO5, PO6	PO2	-
CO6/K6	PO1, PO3, PO4, PO6	PO2, PO5	-	-

### Course Outcome (CO) Attainment Tools & Evaluation Procedure

K Levels	C1	C2	C3	C4	Total scholastic marks	Non scholastic marks	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	Attendance 5 Marks	25 Marks	
<b>K1</b>	2	2	--	--	4	--	4	16
<b>K2</b>	1	2	--	--	3	--	3	12
<b>K3</b>	1	1	2	--	4	--	4	16
<b>K4</b>	1	1	1	2	5	--	5	20
<b>K5</b>	--	--	1	2	3	--	3	12
<b>K6</b>	--	--	--	1	1	--	1	4
<b>Non Scholastic</b>	--	--	--	--	--	5	5	20
<b>Total</b>	<b>5</b>	<b>6</b>	<b>4</b>	<b>5</b>	<b>20</b>	<b>5</b>	<b>25</b>	<b>100</b>

#### Declaration

The COs and POs for the **ATOMIC AND MOLECULAR SPECTROSCOPY** Course in the M.Sc. Physics Programme is effectively matched.

Course Designed by

Course Verified by

HoD

Programme Code	Course Code	Course Type	Category	Hrs./Week	Credits
PHYPG1963	P25PH7	CC	Lecture	6	5

## Quantum Mechanics

### Course Description:

This course on Quantum mechanics delves into the principles and applications of wave behavior of electron, formation of Schrodinger's equation and its application to ground state energy estimation of exactly solvable problems. Further students were exposed to advanced topics such as perturbation theory, angular momentum and approximation methods too.

**Course Objectives:** The course intends to facilitate the learner to

- Recall the basic concepts of quantum mechanics, including wave function, operators, and the Schrodinger equation.
- Explain the principles behind perturbation theory, including time-independent and time-dependent theories, and the Fermi Golden Rule.
- Apply the concepts of perturbation theory and the variation method to solve problems in quantum mechanics such as the hydrogen atom and harmonic oscillator.
- Analyze quantum systems using various approximations like the Born approximation and the W.K.B method.
- Evaluate the accuracy of different quantum mechanical methods, such as the variation method and perturbation theory, in explaining physical phenomena.
- Develop new quantum mechanical models by combining principles such as angular momentum, the Schrodinger equation, and perturbation theory.

### UNIT- I: INTRODUCTION TO QUANTUM MECHANICS (18 hours)

Wave Function – Operator formalism – Total energy, momentum, kinetic and potential energy operators - Derivation of Schrodinger's equation (time dependent and independent) - Ground state of Hydrogen – Linear Harmonic oscillator – Zeeman Effect (Semi classical treatment only)

### UNIT- II: PERTURBATION THEORY (18 hours)

Time independent – Time dependent perturbation theories - Evaluation of first order wave function and Energy– Degenerate and non-degenerate cases – Transition of continuum states – Fermi – Golden Rule – Einstein's coefficients.

### UNIT - III APPROXIMATIONS (18 hours)

Stark Effect – Zeeman Effect – Quantum Mechanical Treatment – Heisenberg, Schrodinger, Interaction Pictures – W.K.B Approximation – Validity – Born Approximation

### UNIT -IV: REPRESENTATION THEORY AND IDENTICAL PARTICLES (18 hours)

Variation method - Ground state of Hydrogen atom using variation method - Bracket notation - Harmonic oscillator in matrix theory – Identical particles – Symmetry and anti-symmetric wave functions.

### UNIT V ANGULAR MOMENTUM (18 hours)

Angular momentum - Angular momentum operator – commutation relation – eigen values and eigen functions of  $L^2$  and  $L_z$  – general angular momentum – eigen states and eigen values of  $J^2$  and  $J_z$  – angular momentum matrices – spin angular momentum.

**Text Books:**

1. Gupta, Kumar and Sharma, Quantum Mechanics, S. Chand and Company publications. (2018)
2. G. Aruldas - Quantum Mechanics – PHI Publications (2008).

**Reference Books:**

1. V.Devanathan, Quantum Mechanics, Narosa Publishing House (2005).
2. P.M. Mathews and K.Venkatesan, A Text Book of Quantum Mechanics, Tata McGraw Hill publications, New Delhi(1987).
3. V.K. Thankappan, Quantum Mechanics, Wiley –Eastern, New Delhi (1985).

**Online Resources:**

NPTEL: [https://youtu.be/AEedn\\_NiWN0](https://youtu.be/AEedn_NiWN0)

NPTEL: <https://youtu.be/k0QL1cmb2Es>

**Course Outcomes and Knowledge Levels**

CO No.	Course Outcome	Knowledge Level
CO1	Recall the basic concepts of quantum mechanics, including wave function, operators, and the Schrodinger equation.	K1
CO2	Explain the principles behind perturbation theory, including time-independent and time-dependent theories, and the Fermi Golden Rule.	K2
CO3	Apply perturbation theory and the variation method to solve quantum problems like the hydrogen atom and harmonic oscillator.	K3
CO4	Analyze quantum systems using approximations such as the Born and W.K.B methods.	K4
CO5	Evaluate the accuracy of various quantum mechanical methods in describing physical systems.	K5
CO6	Develop new quantum mechanical models using tools like angular momentum theory and Schrodinger's equation.	K6

**Course Articulation Matrix (Maps COs consistency with POs)**

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	3	0	1
CO2	9	3	3	3	1	0
CO3	9	3	9	3	3	1
CO4	3	3	9	9	3	1
CO5	3	3	9	9	3	3
CO6	3	1	9	9	9	3
<b>Weightage</b>	<b>36</b>	<b>16</b>	<b>42</b>	<b>36</b>	<b>19</b>	<b>9</b>
<b>Weightage percentage of Course contribution to POs</b>	<b>22%</b>	<b>10%</b>	<b>27%</b>	<b>23%</b>	<b>12%</b>	<b>6%</b>

**R- Remember(K1); U- Understand (K2); Ap- Apply(K3); An- Analyze(K4); E- Evaluate(K5); C- Create(K6)**

**Mapping COs with Knowledge levels and POs:**

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/K1	PO1	PO2, PO4	PO6	PO5
CO2/K2	PO1, PO3	PO2, PO4	PO5	PO6
CO3/K3	PO1, PO3	PO2, PO4	PO5, PO6	--
CO4/K4	PO3, PO4	PO1, PO5	PO2, PO6	--
CO5/K5	PO3, PO4	PO5, PO6	PO1, PO2	--
CO6/K6	PO4, PO5	PO3, PO6	PO1, PO2	--

**Course Outcome (CO) Attainment Tools & Evaluation Procedure**

K Levels	C1	C2	C3	C4	Total scholastic marks	Non scholastic marks	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	Attendance 5 Marks	25 Marks	
K1	2	1	--	--	3	--	3	12
K2	1	2	--	--	3	--	3	12
K3	1	1	2	--	4	--	4	16
K4	1	1	1	2	5	--	5	20
K5	--	1	1	1	3	--	3	12
K6	--	--	--	2	2	--	2	8
Non Scholastic	--	--	--	--	--	5	5	20
<b>Total</b>	<b>5</b>	<b>6</b>	<b>4</b>	<b>5</b>	<b>20</b>	<b>5</b>	<b>25</b>	<b>100</b>

**Declaration**

The COs and POs for the **Quantum Mechanics** Course in the M.Sc. Physics Programme is effectively matched.

Course Designed by

Course Verified by

HoD

Programme Code	Course Code	Course Type	Category	Hrs./Week	Credits
PHYPG1963	P25PH8P	CC	Practical	6	4

<b>Practical 2: Advanced General and Electronics</b>
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**Course Description:**

This practical course provides hands-on experience with advanced experimental techniques in physics and electronics. Students will explore ultrasonic waves, semiconductor properties, optical devices, oscillators, and more. Through the experiments, students will gain a deep understanding of physical phenomena, electronic circuits, and their real-world applications in modern technology.

**Course Objectives:** The course intends to facilitate the learner to

- Recall fundamental principles of physics and electronics related to ultrasonic waves, semiconductor properties, and optical methods.
- Explain the working principles of oscillators, multivibrators, and counters, and their applications in electronics.
- Apply experimental techniques to determine physical properties such as velocity of ultrasonic waves, magnetic susceptibility, and numerical aperture of fiber cables.
- Analyze the performance of different circuits, including Op-Amp applications, transistor oscillators, and K-map simplifications for logic design.
- Evaluate the accuracy of experimental results obtained in Hall effect studies,  $e/m$  ratio determination, and thermal conductivity measurements.
- Design and construct electronic circuits such as phase shift oscillators, bi-stable multivibrators, and up-down counters to meet specific requirements.

**Any Fifteen experiments**

1. Determination of Velocity of ultrasonic waves in a liquid and compressibility of a liquid using ultrasonic interferometer.
2. Full subtraction demonstration using both discrete ICs and NAND ICs only.
3. K map simplification-using basic gates.
4. Astable Multivibrator-IC 555.
5. Study of Hall's effect in a given semiconductor.
6. Integrator & Differentiator.
7. Determination of Specific rotator power-Laurent's polarimeter.
8. Clippers and clampers using diode.
9. V-I characteristics of solar cell.
10. Determination of the wavelength of a LASER source and thickness of wire using

- Plane diffraction grating method.
11. Determine the polarizability of the given liquid by finding the refractive indices at different wavelengths.
  12. Determination of Numerical aperture and other parameters of a fiber cable.
  13. Construction of Up-down counter.
  14. Study the thermal conductivity of the given probe using Forbe's method.
  15. Determination of Magnetic susceptibility by Quincke's method.
  16. Design and study of Phase shift oscillator using OPAMP IC741.
  17. Design and study of Bi-stable Multi vibrator using Transistor.
  18. Study of FTIR Spectrum.
  19. Op-AMP: Solving simultaneous linear equations
  20. Transistor Oscillators- Hartley and Colpitt's circuits
  21. Determination of e/m ratio of an electron using magnetron method.

#### Course Outcomes and Knowledge Levels

CO No.	Course Outcome	Knowledge Level
CO1	Recall fundamental principles of physics and electronics related to ultrasonic waves, semiconductor properties, and optical methods.	K1
CO2	Explain the working principles of oscillators, multivibrators, and counters, and their applications in electronics.	K2
CO3	Apply experimental techniques to determine physical properties such as velocity of ultrasonic waves, magnetic susceptibility, and numerical aperture.	K3
CO4	Analyze the performance of different circuits, including Op-Amp applications, transistor oscillators, and K-map simplifications for logic design.	K4
CO5	Evaluate the accuracy of experimental results obtained in Hall effect studies, e/m ratio determination, and thermal conductivity measurements.	K5
CO6	Design and construct electronic circuits such as phase shift oscillators, bi-stable multivibrators, and up-down counters to meet specific requirements.	K6

**Course Articulation Matrix** (Maps COs consistency with POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	1	1	0	0
CO2	9	3	3	1	0	1
CO3	9	3	9	3	1	1
CO4	9	1	9	9	3	1
CO5	9	3	9	9	9	3
CO6	3	3	9	9	3	9
<b>Weightage</b>	<b>48</b>	<b>16</b>	<b>40</b>	<b>32</b>	<b>16</b>	<b>23</b>
<b>Weightage percentage of Course contribution to POs</b>	<b>27%</b>	<b>9%</b>	<b>23%</b>	<b>18%</b>	<b>9%</b>	<b>14%</b>

R- Remember(K1); U- Understand (K2); Ap- Apply(K3); An- Analyze(K4); E- Evaluate(K5); C- Create(K6)

**Mapping COs with Knowledge levels and POs:**

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/K1	PO1	PO2	PO3	PO4, PO5, PO6
CO2/K2	PO1	PO2, PO3	PO4	PO5, PO6
CO3/K3	PO1, PO3	PO2, PO4	PO5	PO6
CO4/K4	PO1, PO3, PO4	PO2, PO5	PO6	--
CO5/K5	PO1, PO3, PO4, PO5	PO2, PO6	--	--
CO6/K6	PO3, PO4, PO6	PO1, PO5	PO2	--

**Course Outcome (CO) Attainment Tools & Evaluation Procedure\***

K Levels	C1	C2	C3	C4	Total scholastic marks	Non scholastic marks	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	Attendance 5 Marks	25 Marks	
<b>K1</b>	2	1	--	--	3	--	3	12
<b>K2</b>	1	2	--	--	3	--	3	12
<b>K3</b>	1	1	2	--	4	--	4	16
<b>K4</b>	1	1	1	2	5	--	5	20
<b>K5</b>	--	1	1	1	3	--	3	12
<b>K6</b>	--	--	--	2	2	--	2	8
<b>Non Scholastic</b>	--	--	--	--	--	5	5	20
<b>Total</b>	<b>5</b>	<b>6</b>	<b>4</b>	<b>5</b>	<b>20</b>	<b>5</b>	<b>25</b>	<b>100</b>

\*The seminar, assignment components are clubbed with model lab tests in practical courses.

**Declaration**

The COs and POs for the **Practical 2: Advanced General and Electronics** Course in the M.Sc. Physics Programme is effectively matched.

**Course Designed by**

**Course Verified by**

**HoD**

Programme Code	Course Code	Course Type	Category	Hrs./Week	Credits
PHYPG1963	P25PH9E	EC	Lecture	6	4

<b>Special Electronics– II: Microcontroller and Communication Electronics</b>
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**Course Description:**

This course introduces the architecture, programming, and applications of microcontrollers, focusing on widely used devices such as the 8051 and PIC microcontrollers. It explores the core concepts of embedded systems, addressing modes, instruction sets etc. This course provides a comprehensive understanding of the principles and applications of electronic communication systems. Students will study analog and digital modulation techniques and focus on communication circuits for both broadband and satellite systems.

**Course Objectives:** The course intends to facilitate the learner to

- Recall and define the fundamental architecture of the 8051 microcontroller, including its registers, memory organization, and I/O ports.
- Explain the concepts of assembly language programming for the 8051 microcontroller, including addressing modes, instruction syntax, and logical operations.
- Apply modulation techniques such as amplitude modulation (AM), frequency modulation (FM), and phase modulation (PM) to design and analyze modulator and demodulator circuits.
- Analyze pulse and digital modulation techniques, including Pulse Code Modulation (PCM) and Pulse Width Modulation (PWM), and evaluate their performance in digital communication systems.
- Evaluate broadband and satellite communication technologies, including frequency division multiplexing (FDM), time division multiplexing (TDM), and power budget calculations.
- Design and develop communication systems using microcontrollers and modulation techniques for real-world applications in modern communication networks.

**UNIT -I: MICROCONTROLLER ARCHITECTURE – 8051 (18 hours)**

The 8051 architecture - 8051 oscillator and clock - Program counter data pointer - CPU registers-Flags and the program status word (PSW) -Internal memory- Internal RAM and ROM -The stack and the stack pointers. Special function registers-Signals of 8051-I/O ports - Timers and counters.

**UNIT- II: ASSEMBLY LANGUAGE PROGRAMMING CONCEPTS (18 hours)**

8051-Programming - 8051 instruction syntax - Moving data: addressing modes – External data moves- Code memory- Read only data moves -Push and pop op codes- Data exchanges example programs - Logical operations: Byte-level logical operations –Bit level logical operations- Rotate and swap operations- Example programs.

**UNIT -III: ANALOG MODULATION (18 hours)**

Amplitude modulation- Amplitude modulation index-Modulation index for sinusoidal AM- Double sideband suppressed carrier (DSBSC) modulation- Amplitude modulator circuits- Amplitude demodulator circuits. Single sideband principles- Balanced modulators- SSB generation-SSB reception. Frequency modulation – Sinusoidal FM- Frequency spectrum for sinusoidal FM-Average power for sinusoidal FM- Modulation index for sinusoidal FM-Phase modulation- Equivalence between PM and FM.

#### **UNIT- IV: PULSE AND DIGITAL MODULATION (18 hours)**

Pulse Amplitude Modulation (PAM)- Pulse Code Modulation (PCM)- Pulse Frequency Modulation (PFM)- Pulse Time Modulation (PTM)- Pulse Position Modulation (PPM)-Pulse Width Modulation (PWM).Digital communication- Synchronization - Asynchronous transmission-Probability of Bit error in base band transmission –Digital carrier systems.

#### **UNIT- V: Broadband AND Satellite Communications (18 hours)**

Broad band communication: Multiplexing – Frequency division and Time division multiplexing – Short haul systems: Fibre optic, Microwave link, long haul systems: Sub-marine cables.

Satellite communications: Kepler’s laws – Orbits - Geostationary orbit-Altitude and attitude control-Satellite station keeping-Transponders uplink-Power budget calculation-Down link power budget calculations - Multiple access methods.

#### **Text Books:**

1. Kenneth J.Ayala, the 8051 Microcontroller, Architecture, Programming and Applications, 3rd Edition, 2007, Cengage Learning Publication, ISBN: 9788131502006, 8131502007
2. G.Kennedy, B. Davis and S.R.M. Prasanna, Electronic communication systems, Mc Graw Hill publications, 5<sup>th</sup> Ed.(2011).
3. Dennis Roddy,John Coolen, Electronic Communications- 4<sup>th</sup>Edition, Prentice Hall of India, 2004, ISBN:9780133120837.
4. Wayne Tomasi, Advanced Electronic Communication systems, Pearson Education, Advanced Electronic Communications Systems, 2004, 6th Edition, ISBN: 978-1-292- 02735-7.

#### **Reference books:**

1. Gupta S.L and Kumar - Hand book of Electronics, Pragati Prakasan Publications, 2012, ISBN:978-9350065365
2. P.S. Manoharan, Microprocessors and Microcontroller – Charulatha Publications (2013).

#### **Online Resources:**

- 1.<https://www.udemy.com/course/8051-microcontroller-an-assembly-language-programming/>
2. [https://onlinecourses.nptel.ac.in/noc22\\_ee10/preview](https://onlinecourses.nptel.ac.in/noc22_ee10/preview)

### Course Outcomes and Knowledge Levels

CO No.	Course Outcome	Knowledge Level
CO1	Recall and define the fundamental architecture of the 8051 microcontroller, including registers, memory organization, and I/O ports.	K1
CO2	Explain assembly language programming concepts of 8051 including addressing modes, instruction syntax, and logical operations.	K2
CO3	Apply modulation techniques like AM, FM, and PM to design and analyze modulator and demodulator circuits.	K3
CO4	Analyze pulse and digital modulation techniques (PCM, PWM) and evaluate performance in digital communication systems.	K4
CO5	Evaluate broadband and satellite communication technologies such as FDM, TDM, and satellite power budgeting.	K5
CO6	Design and develop communication systems using microcontrollers and modulation techniques for real-world applications.	K6

### Course Articulation Matrix (Maps COs consistency with POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	1	0	0
CO2	9	9	3	3	0	1
CO3	9	3	9	3	1	0
CO4	3	3	9	9	3	1
CO5	3	3	9	9	9	3
CO6	3	1	3	9	9	9
<b>Weightage</b>	<b>42</b>	<b>22</b>	<b>36</b>	<b>34</b>	<b>22</b>	<b>14</b>
<b>Weightage percentage of Course contribution to POs</b>	<b>24%</b>	<b>13%</b>	<b>21%</b>	<b>20%</b>	<b>13%</b>	<b>9%</b>

**R- Remember(K1); U- Understand (K2); Ap- Apply(K3); An- Analyze(K4); E- Evaluate(K5); C- Create(K6)**

**Mapping COs with Knowledge levels and POs:**

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/K1	PO1	PO2	PO3	PO4, PO5, PO6
CO2/K2	PO1, PO2	PO3, PO4	PO6	PO5
CO3/K3	PO1, PO3	PO2, PO4	PO5	PO6
CO4/K4	PO3, PO4	PO1, PO5	PO2, PO6	--
CO5/K5	PO3, PO4, PO5	PO6	PO1, PO2	--
CO6/K6	PO4, PO5, PO6	PO3	PO1, PO2	--

**Course Outcome (CO) Attainment Tools & Evaluation Procedure**

K Levels	C1	C2	C3	C4	Total scholastic marks	Non scholastic marks	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	Attendance 5 Marks	25 Marks	
K1	2	1	--	--	3	--	3	12
K2	1	2	--	--	3	--	3	12
K3	1	1	2	--	4	--	4	16
K4	1	1	1	2	5	--	5	20
K5	--	1	1	1	3	--	3	12
K6	--	--	--	2	2	--	2	8
Non Scholastic	--	--	--	--	--	5	5	20
<b>Total</b>	<b>5</b>	<b>6</b>	<b>4</b>	<b>5</b>	<b>20</b>	<b>5</b>	<b>25</b>	<b>100</b>

**Declaration**

The COs and POs for the **Special Electronics– II: Microcontroller and Communication Electronics** Course in the M.Sc. Physics Programme is effectively matched.

Course Designed by

Course Verified by

HoD

Programme Code	Course Code	Course Type	Category	Hrs./Week	Credits
PHYPG1963	P25PH10E	EC	Theory	6	4

### Basics of Nano Science and its Applications

#### Course Description:

The foundations of nanoscience, including quantum effects and surface-to-volume ratio impacts and study of CNT. Methods of nanomaterial synthesis and characterization, such as sol-gel processes, and microscopy techniques like TEM, AFM. Applications of nanotechnology in diverse fields such as medicine, electronics etc.,

**Course Objectives:** The course intends to facilitate the learner to

- Recall and define fundamental concepts of nanoscience, types of nanomaterials, and quantum structures.
- Explain the effects of nanostructures, including fullerenes, carbon nanotubes (CNTs), bio-mimetic materials, and band gap engineering.
- Apply various chemical, physical, and biological synthesis techniques for nanomaterial fabrication, such as sol-gel, laser ablation, and microbial synthesis.
- Analyze the principles, experimental setups, and applications of nanomaterial characterization techniques like AFM, TEM, and SPM.
- Evaluate the role of nanoelectronics and molecular electronics in advanced applications, including catalysis and quantum devices.
- Design and develop innovative nanomaterial-based solutions for biomedical and photonic applications, such as plasmon waveguides and CNT emitters.

#### UNIT-I: INTRODUCTION TO NANO AND TYPES OF NANOMATERIALS (18 hours)

Nanoscience and nanotechnology – Need for nano - Origins of concepts of nano -Nano and energetics – Top down and Bottom-up approaches – Types of nano materials (introductory ideas only): One dimensional(1D)– Two-dimensional(2D)- Three-dimensional(3D) nano structured materials – Quantum dots – Quantum wire-Quantum well –Quantum Dot – Excitation confinement in Quantum Dots.

#### UNIT-II: NANO STRUCTURES EFFECTS (18 hours)

Fullerenes - Properties of fullerenes-Carbon Nano Tubes (CNTs)- Types, properties, synthesis and applications of CNTs. -Polymers – Bio mimetics – Self assembled monolayers – Nano structured metals and alloys – Semiconductors – Band gap engineering and optical response.

#### UNIT-III: SYNTHESIS OF NANO SYSTEMS (18 hours)

*Chemical processes:* Chemical precipitation and co-Precipitation methods-Sol-Gel synthesis- Microemulsions synthesis. Synthesis methods of dimensionally modulated Inorganic nanostructured materials: Quantum dot (QDs) synthesis - Sonochemical assisted synthesis.

*Physical processes:* Arc discharge, Laser ablation synthesis methods.

*Biological synthesis:* role of plants, microorganisms (virus, bacteria) synthesis in nano materials.

#### UNIT- IV: NANOMATERIAL CHARACTERIZATION (18 hours)

Atomic Force Microscopy (AFM), Transmission Electron Microscopy (TEM) and Scanning Probe Microscopy (SPM) techniques- (Principle, experimental set up, procedure and utility for the all the techniques)

## UNIT- V: ELECTRONICS AND BIOMEDICAL APPLICATIONS (18 hours)

Molecular electronics and Nano electronics – Nano dots- Biological applications of Nano particles- Catalysis by gold Nano particles - band gap engineered quantum devices-Nano mechanics - CNT emitters- Photo electro chemical cells- Photonic crystals - Plasmon Wave guides.

### BOOKS FOR STUDY

1. T. Pradeep et al., A text book of Nano science and Nanotechnology, TMGH, New Delhi(2012).
2. Guozhong Cao, Nanostructures and Nano materials, Imperial College Press, London(2004).
3. C.P. Poole and F.J. Owens, Introduction to Nanotechnology, Wiley-India(2009).
4. Chemistry of Nanomaterials : Synthesis, properties and applications by CNR Rao et.al.

### BOOKS FOR REFERENCE

1. Lusía Filipponian Duncan Sutherland, Nanotechnologies: Principles, Applications, Implications and Hands-on Activities (ISBN 978 -92 -79 -21437 -0) European Commission, B-1049 Brussels(2013).
2. Hari Singh Nalwa, “Nano structured Materials and Nanotechnology”, Academic Press, (2002).
3. M. Wilson, K. Kannangara, G Smith, M. Simmons, B. Raguse, Nanotechnology: Basic Science and Emerging Technologies, Overseas Press India Pvt. Ltd, New Delhi, First Edition(2005).
4. S. Shanmugam, Nanotechnology, MJP Publishers, Chennai (2010).
5. Lynn E. Foster, Nano Technology, Science, Innovations and Opportunity, Pearson Education (2010).
6. Suhas Bhattacharya, a Text book of Nano Science and Technology, Wisdom Press, (2013).

### Online Resources:

1. <https://archive.nptel.ac.in/courses/118/102/118102003/>
2. <https://archive.nptel.ac.in/courses/113/104/113104102/>

### Course Outcomes and Knowledge Levels

CO No.	Course Outcome	Knowledge Level
CO1	Recall and define fundamental concepts of nanoscience, types of nanomaterials, and quantum structures.	K1
CO2	Explain the effects of nanostructures including fullerenes, CNTs, bio-mimetic materials, and band gap engineering.	K2
CO3	Apply chemical, physical, and biological synthesis techniques such as sol-gel, laser ablation, and microbial synthesis.	K3
CO4	Analyze principles, setups, and applications of nanomaterial characterization techniques like AFM, TEM, and SPM.	K4
CO5	Evaluate the roles of nanoelectronics and molecular electronics in applications like catalysis and quantum devices.	K5
CO6	Design and develop innovative nanomaterial-based solutions for biomedical and photonic applications like plasmon waveguides and CNT emitters.	K6

**Course Articulation Matrix (Maps COs consistency with POs)**

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	1	0	0
CO2	9	9	3	3	0	1
CO3	9	3	9	3	1	0
CO4	3	3	9	9	3	1
CO5	3	3	9	9	9	3
CO6	3	1	3	9	9	9
<b>Weightage</b>	<b>42</b>	<b>22</b>	<b>36</b>	<b>34</b>	<b>22</b>	<b>14</b>
<b>Weightage percentage of Course contribution to POs</b>	<b>24%</b>	<b>13%</b>	<b>21%</b>	<b>20%</b>	<b>13%</b>	<b>9%</b>

**R- Remember(K1); U- Understand (K2); Ap- Apply(K3); An- Analyze(K4); E- Evaluate(K5); C- Create(K6)**

**Mapping COs with Knowledge levels and POs:**

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/K1	PO1	PO2	PO3	PO4, PO5, PO6
CO2/K2	PO1, PO2	PO3, PO4	PO6	PO5
CO3/K3	PO1, PO3	PO2, PO4	PO5	PO6
CO4/K4	PO3, PO4	PO1, PO5	PO2, PO6	--
CO5/K5	PO3, PO4, PO5	PO6	PO1, PO2	--
CO6/K6	PO4, PO5, PO6	PO3	PO1, PO2	--

### Course Outcome (CO) Attainment Tools & Evaluation Procedure

K Levels	C1	C2	C3	C4	Total scholastic marks	Non scholastic marks	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	Attendance 5 Marks	25 Marks	
<b>K1</b>	2	1	--	--	3	--	3	12
<b>K2</b>	1	2	--	--	3	--	3	12
<b>K3</b>	1	1	2	--	4	--	4	16
<b>K4</b>	1	1	1	2	5	--	5	20
<b>K5</b>	--	1	1	1	3	--	3	12
<b>K6</b>	--	--	--	2	2	--	2	8
<b>Non Scholastic</b>	--	--	--	--	--	5	5	20
<b>Total</b>	<b>5</b>	<b>6</b>	<b>4</b>	<b>5</b>	<b>20</b>	<b>5</b>	<b>25</b>	<b>100</b>

#### Declaration

The COs and POs for the **Basics of Nano Science and its Applications** Course in the M.Sc. Physics Programme is effectively matched.

Course Designed by

Course Verified by

HoD

Programme Code	Course Code	Course Type	Category	Hrs./Week	Credits
PHYPG1963	P25PH11	CC	Lecture	6	5

### CRYSTAL GROWTH AND THIN FILM PHYSICS

#### Course Description:

This course explores the fundamental principles and advanced techniques in crystal growth and thin film physics. Students will examine nucleation, low and melt growth techniques, thin film deposition methods, and characterization techniques, integrating theoretical knowledge with practical applications in material science.

**Course Objectives:** The course intends to facilitate the learner to

- Recall the fundamental concepts of nucleation, crystal growth, and thin film deposition techniques.
- Explain the principles of different crystal growth techniques, including solution growth, melt growth, and gel growth methods.
- Apply various crystal growth and thin film deposition techniques for controlled material synthesis.
- 4. Analyze the growth mechanisms in nucleation, thin films, and different crystal growth processes.
- Evaluate the advantages and limitations of different thin film deposition techniques and crystal growth methods.
- Design and develop optimized crystal growth techniques and thin film deposition processes for advanced material applications.

#### UNIT -I: NUCLEATION AND GROWTH (18 hours)

Nucleation – primary nucleation -secondary nucleation- Classical theory of nucleation –Gibb’s Thomson for vapour- Modified Thomson equation for melt and solution- Energy formation of a nucleation -Spherical nucleus and cylindrical nucleus – Heterogeneous nucleation - CAP shaped nucleus-Disc shaped nucleus-Growth Kinetics - Singular and rough faces- Models on surface roughness.

#### UNIT -II: LOW TEMPERATURE GROWTH TECHNIQUES (18 hours)

Solution Growth Technique: Solution - Solubility and super solubility – Expression of supersaturation – Mier’s T-C diagram - Constant temperature bath and crystallizer – Seed preparation and mounting - Slow cooling and solvent evaporation methods. Gel Growth Technique: Principle – Various types – Structure of gel – Importance of gel – Experimental procedure–Chemical reaction method – Single and double diffusion method – Chemical reduction method –Complex and de complexation method – Advantages of gel method.

#### UNIT- III: MELT GROWTH TECHNIQUES (18 hours)

Melt Growth: Bridgman technique - Vertical Bridgman technique -Basic process – Various crucibles design - Crystal pulling method -- Czochralski technique – Experimental arrangement – Growth process.- advantages and disadvantages-Heat exchanger method(HEM)- merits and demerits-Verneuil technique advantages and limitations.

#### UNIT- IV: THIN FILM DEPOSITION TECHNIQUES (18 hours)

Introduction- Thin film growth stages- Application of thin films- Deposition techniques - Physical methods– Chemical methods- Resistive heating, Electron beam gun, Laser gun evaporation and flash evaporations, sputtering - Reactive Sputtering, Radio-Frequency sputtering - Chemical methods – Spray pyrolysis – Preparation of TCO tin oxide thin films.

### UNIT- V: CHARACTERIZATION TECHNIQUES (18 hours)

X – Ray Diffraction (XRD) – Powder and single crystal -Four Probe technique- Raman spectroscopy- Fourier Transform Infra-Red Analysis (FT-IR) – Elemental analysis – Elemental Dispersive X-ray Analysis (EDAX) - Scanning Electron Microscopy (SEM) – UV-Vis-NIR Spectrometer – Vicker’s micro hardness.

#### BOOKS FOR STUDY

1. J.C. Brice, Crystal Growth Processes, John Wiley and Sons, New York(1986).
2. P. Santhana Ragavan and P. Ramasamy, Crystal Growth Processes and Methods, KRU Publications, Kumbakonam(2006).
3. A. Goswami, Thin Film Fundamentals, New Age International (P) Limited, New Delhi(1996).
4. Kasturi L. Chopra, Thin film Phenomena, McGraw Hill Book Company(1969).
5. .K. Ravichandran, K. Swaminathan, B. Sakthivel and A.T. Ravichandran, Introduction to Thin Films and Crystal Growth(Jayam Publications, Trichy).

#### BOOK FOR REFERENCE

1. Smith Donald. L, Thin Film Deposition, McGraw Hill, London (1995).

#### Online Resources: (Min.: 2, Maximum suggestions -5):

1. <https://www.amrita.edu/course/thin-film-technology>
2. <https://www.coursera.org/learn/silicon-thin-film-solar-cells>
3. [https://onlinecourses.nptel.ac.in/noc25\\_mm09/preview](https://onlinecourses.nptel.ac.in/noc25_mm09/preview)

#### Course Outcome Table

CO No.	Course Outcome	Knowledge Level
CO1	Recall fundamental concepts of nucleation and thin film deposition techniques	K1
CO2	Explain principles of solution, melt, and gel growth methods	K2
CO3	Apply crystal growth and thin film methods for material synthesis	K3
CO4	Analyze nucleation and film growth mechanisms and surface morphology models	K4
CO5	Evaluate growth techniques and select appropriate methods for material applications	K5
CO6	Design optimized techniques for crystal and thin film growth for practical implementation	K6

**Course Articulation Matrix** (Maps COs consistency with POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	1	1	0	0
CO2	9	9	3	3	1	1
CO3	9	3	9	3	1	1
CO4	9	3	9	9	3	1
CO5	9	3	9	9	9	3
CO6	9	3	9	9	9	9
<b>Weightage</b>	<b>54</b>	<b>24</b>	<b>40</b>	<b>34</b>	<b>23</b>	<b>15</b>
<b>Weightage percentage of Course contribution to POs</b>	<b>28 %</b>	<b>13 %</b>	<b>21 %</b>	<b>18 %</b>	<b>12 %</b>	<b>8 %</b>

R- Remember(K1); U- Understand (K2); Ap- Apply(K3); An- Analyze(K4); E- Evaluate(K5); C- Create(K6)

**Mapping COs with Knowledge levels and POs:**

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/K1	PO1	PO2	PO3	PO4, PO5, PO6
CO2/K2	PO1, PO2	PO3, PO4	PO5	PO6
CO3/K3	PO1, PO3	PO2, PO4	PO5	PO6
CO4/K4	PO1, PO3, PO4	PO2	PO5, PO6	-
CO5/K5	PO1, PO3, PO4, PO5	PO2	PO6	-
CO6/K6	PO1, PO3, PO4, PO5, PO6	PO2	-	-

### Course Outcome (CO) Attainment Tools & Evaluation Procedure

K Levels	C1	C2	C3	C4	Total scholastic marks	Non scholastic marks	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	Attendance 5 Marks	25 Marks	
<b>K1</b>	2	2	–	–	4	–	4	16
<b>K2</b>	1	2	1	–	4	–	4	16
<b>K3</b>	1	–	2	1	4	–	4	16
<b>K4</b>	1	1	–	1	3	–	3	12
<b>K5</b>	–	1	–	2	3	–	3	12
<b>K6</b>	–	–	1	1	2	–	2	8
<b>Non Scholastic</b>	–	–	–	–	–	5	5	20
<b>Total</b>	<b>5</b>	<b>6</b>	<b>4</b>	<b>5</b>	<b>20</b>	<b>5</b>	<b>25</b>	<b>100</b>

#### Declaration

The COs and POs for the **CRYSTAL GROWTH AND THIN FILM PHYSICS** Course in the M.Sc. Physics Programme is effectively matched.

Course Designed by

Course Verified by

HoD

Programme Code	Course Code	Course Type	Category	Hrs./Week	Credits
PHYPG1963	P25PH12	CC	Lecture	6	5

## ELECTROMAGNETIC THEORY

### Course Description:

The course objectives are to apply vector analysis and Maxwell's equations to electromagnetic phenomena.

**Course Objectives:** The course intends to facilitate the learner to

- Recall the fundamental laws and concepts of electrostatics, magnetostatics, and electromagnetic theory.
- Explain Maxwell's equations, Poynting's theorem, wave propagation, and antenna characteristics.
- Apply Maxwell's equations to analyze electromagnetic waves and their propagation in different media.
- Analyze the behavior of electromagnetic waves in waveguides and different propagation modes.
- Evaluate the performance and efficiency of antennas and radio wave propagation mechanisms.
- Design and develop antenna systems and wave propagation models for practical applications.

### UNIT - I: INTRODUCTION TO ELECTROSTATICS AND MAGNETOSTATICS (18 hours)

Coulomb's law – Electric field – Electrostatic potential- Electric field and potential of a Dipole- Gauss law – Poisson and Laplace Equations in differential form - Ampere's force law - Biot and Savart law - Ampere's circuital law – Amperian loop- Magnetic scalar potential- Magnetic vector potential – Boundary conditions on E, D, B and H – Dirichlet and Neumann conditions.

### UNIT - II: ELECTRODYNAMICS (18 hours)

Equation of continuity- Maxwell's displacement current – Maxwell's equations – Differential and integral forms - Poynting's theorem - Differential form of Poynting's theorem - Electromagnetic Potential (A and  $\Phi$ ) – Maxwell's equations in terms of Electromagnetic potential- Gauge transformations – Lorentz gauge.

### UNIT - III: PLANE ELECTRO MAGNETIC WAVES AND WAVE PROPAGATION (18 hours)

Plane wave equation – Propagation of e.m. waves in free space - in a non conducting isotropic medium – in a conducting medium- Reflection and refraction of electromagnetic waves (Snell's Law) – Propagation of electromagnetic waves in a rectangular wave guide - TM and TE modes.

### UNIT - IV: CHARACTERISTICS OF ANTENNAS (18 hours)

Radiation by an oscillating dipole — Radiation patterns of antennas – Gain of an antenna – Linear array of antennas (N-arrays) – Qualitative analysis of a dipole antenna – Characteristics of micro strip antenna.

### UNIT - V RADIO WAVE PROPAGATION (18 hours)

Fundamental equation for free space propagation – Modes of propagation – Ground wave up to 2 MHz – UHF up to 300 MHz – Introduction to sky wave propagation – Mechanism of radio wave bending by the ionosphere – skip distance.

**Text Books:**

1. S.L.Gupta and V.Kumar, Electrodynamics, Pragati Prakashan Publications (2004).
2. K.K.Chopra and G.C.Agarwal, Electromagnetic Theory, K.Nath and Co.(1993).
3. Sathya Prakash, Electromagnetic Theory, Sulthan Chand and Sons, New Delhi (2005).
4. S.K. Dash and S.R. Khunita, Fundamentals of Electromagnetic Theory, PHI Publications, New Delhi (2011).

**Reference Books:**

1. D. Jackson, Classical Electrodynamics, Wiley Eastern Ltd., New Delhi,(1993).
2. D. Griffiths, Introduction to Electrodynamics, Cambridge University Press, 4<sup>th</sup> Edition, (2020).

**Online Resources:**

[https://onlinecourses.nptel.ac.in/noc21\\_ee83/](https://onlinecourses.nptel.ac.in/noc21_ee83/)  
<https://archive.nptel.ac.in/courses/115/104/115104088/>  
<https://archive.nptel.ac.in/courses/117/103/117103065/>  
<https://empossible.net/academics/emp3302>

**Course Outcome Table**

CO No.	Course Outcome	Knowledge Level
CO1	Recall the laws and fundamental concepts in electrostatics, magnetostatics, and electromagnetic theory	K1
CO2	Explain Maxwell's equations, Poynting's theorem, wave propagation, and antenna characteristics	K2
CO3	Apply Maxwell's equations to analyze wave propagation in free space, dielectrics, and conductors	K3
CO4	Analyze wave behavior in waveguides and different propagation modes	K4
CO5	Evaluate antenna characteristics and radio wave propagation mechanisms	K5
CO6	Design antenna systems and wave propagation models for real-world applications	K6

**Course Articulation Matrix** (Maps COs consistency with POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	1	1	0	0
CO2	9	9	3	3	1	1
CO3	9	3	9	3	1	1
CO4	9	3	9	9	3	1
CO5	9	3	9	9	9	3
CO6	9	3	9	9	9	9
<b>Weightage</b>	<b>54</b>	<b>24</b>	<b>40</b>	<b>34</b>	<b>23</b>	<b>15</b>
<b>Weightage percentage of Course contribution to POs</b>	<b>28 %</b>	<b>13 %</b>	<b>21 %</b>	<b>18 %</b>	<b>12 %</b>	<b>8 %</b>

**R- Remember(K1); U- Understand (K2); Ap- Apply(K3); An- Analyze(K4); E- Evaluate(K5); C- Create(K6)**

**Mapping COs with Knowledge levels and POs:**

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/K1	PO1	PO2	PO3	PO4, PO5, PO6
CO2/K2	PO1, PO2	PO3, PO4	PO5	PO6
CO3/K3	PO1, PO3	PO2, PO4	PO5	PO6
CO4/K4	PO1, PO3, PO4	PO2	PO5, PO6	-
CO5/K5	PO1, PO3, PO4, PO5	PO2	PO6	-
CO6/K6	PO1, PO3, PO4, PO5, PO6	PO2	-	-

### Course Outcome (CO) Attainment Tools & Evaluation Procedure

K Levels	C1	C2	C3	C4	Total scholastic marks	Non scholastic marks	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	Attendance 5 Marks	25 Marks	
<b>K1</b>	2	2	–	–	4	–	4	16
<b>K2</b>	1	2	1	–	4	–	4	16
<b>K3</b>	1	–	2	1	4	–	4	16
<b>K4</b>	1	1	–	1	3	–	3	12
<b>K5</b>	–	1	–	2	3	–	3	12
<b>K6</b>	–	–	1	1	2	–	2	8
<b>Non Scholastic</b>	–	–	–	–	–	5	5	20
<b>Total</b>	<b>5</b>	<b>6</b>	<b>4</b>	<b>5</b>	<b>20</b>	<b>5</b>	<b>25</b>	<b>100</b>

#### Declaration

The COs and POs for the **ELECTROMAGNETIC THEORY** Course in the M.Sc. Physics Programme is effectively matched.

Course Designed by

Course Verified by

HoD

Programme Code	Course Code	Course Type	Category	Hrs./Week	Credits
PHYPG1963	P25PH13	CC	Lecture	6	5

## NUCLEAR AND PARTICLE PHYSICS

### Course Description:

This course, "Nuclear and Particle Physics," explores the fundamental properties of atomic nuclei, radioactive decay processes, nuclear reactions, and theoretical nuclear models. It also covers particle accelerators, nuclear reactors, cosmic rays, and elementary particles, providing a comprehensive understanding of nuclear forces, quantum interactions, and modern nuclear physics applications.

**Course Objectives:** The course intends to facilitate the learner to

- Recall the fundamental properties of atomic nuclei, including nuclear size, shape, mass, and forces.
- Explain the principles of radioactive decays, including alpha, beta, and gamma decay, along with associated theories and detection methods.
- Apply nuclear reaction concepts to compute reaction energetics, Q-values, and threshold energies using theoretical models.
- Analyze different nuclear models such as the liquid drop model, shell model, and collective model to understand nuclear structure and stability.
- Evaluate the working principles of nuclear reactors and particle accelerators, assessing their efficiency and applications in research and energy production.
- Formulate theoretical models to describe cosmic ray interactions and the classification of elementary particles, integrating quark theory and fundamental interactions.

### UNIT -I: PROPERTIES OF ATOMIC NUCLEI (18 hours)

Nuclear size and shape –Parity- Nuclear forces –Nuclear mass-Dempster’s mass spectrograph-Properties of deuteron-Simple theory of ground state of deuteron– Spin dependence of nuclear forces– Singlet and triplet states in deuteron ground state - Properties of nuclear forces - Meson theory of nuclear forces.

### UNIT -II: RADIOACTIVE DECAYS (18 hours)

Range of alpha particles and Geiger-Nuttal law – Gamow’s theory - Neutrino hypothesis – Fermi theory of beta decay – Selection rules – Gamma decay-measurement of gamma energies by bent crystal spectrometer – Selection rules of gamma radiation – Gas filled detectors – G.M counters - Scintillation counter.

### UNIT -III: NUCLEAR REACTIONS AND NUCLEAR MODELS (18 hours)

Reaction Energetics -Q-Value-Threshold energy – Level width- Types of nuclear reactions- Compound nucleus theory – Breit - Wigner formula– Semi empirical mass formula -Liquid drop model-Shell model-Collective model.

### UNIT -IV: ACCELERATORS AND REACTORS (18 hours)

Linear accelerator-Cyclotron – Synchro cyclotron – Betatron–Nuclear fission –distribution of mass of fission products –Bohr-Wheeler’s theory of nuclear fission – nuclear reactor- classification of nuclear reactors- Research and power reactors- Nuclear fusion- Stellar energy- Research and power reactors.

## UNIT -V: COSMIC RAYS AND ELEMENTARY PARTICLES (18 hours)

Cosmic rays-primary and secondary cosmic rays-Geomagnetic effects -Cosmic ray showers- origin of cosmic rays-Classification of elementary particles-Fundamental interactions among particles-Quantum numbers specifying states of particles-Discovery of antiparticles- Quark and its types-Existence of quarks.

### Text Books:

1. Sathya Prakash, Text Book of Nuclear and particle Physics, Sultan Chand and Sons, New Delhi(2005).
2. M.L.Pandya and R.P.S Yadav, Elements of Nuclear Physics, Kedar Nath Ramnath, Meerut(2015).

### Reference Books:

1. V. Devanathan, Nuclear Physics, Narosa Publishing House (2006).
2. S. B. Patel, An Introduction to Nuclear Physics, (Wiley-Eastern) New Delhi (2008).
3. B. L. Cohen, Concepts of Nuclear Physics Tata Mc Graw Hill, New Delhi(1993).
4. D. Griffiths, Introduction to Elementary Particles, Wiley International, New York (1987).
5. Arora. C. L, Nuclear Physics, S.Chand and Co, New Delhi (1999).
6. Sharma.R. C, Nuclear Physics, K. Nath and Co, Meerut(1997).

### Online Resources:

<https://archive.nptel.ac.in/courses/115/103/115103101/>

<https://archive.nptel.ac.in/courses/115/102/115102017/#watch>

[https://onlinecourses.nptel.ac.in/noc24\\_ph41/preview](https://onlinecourses.nptel.ac.in/noc24_ph41/preview)

<http://www.sfu.ca/~mxchen/phys1021003/P102LN34.pdf>

### Course Outcome Table

CO No.	Course Outcome	Knowledge Level
CO1	Recall the fundamental properties of atomic nuclei such as size, shape, mass, forces, and deuteron structure.	K1
CO2	Explain the principles and theories behind alpha, beta, and gamma decay processes, and describe detection methods.	K2
CO3	Apply nuclear reaction principles to compute Q-values, threshold energies, and interpret reaction energetics.	K3
CO4	Analyze nuclear models like liquid drop, shell, and collective models to understand nuclear structure and stability.	K4
CO5	Evaluate the working principles of particle accelerators and nuclear reactors with regard to energy production and research.	K5
CO6	Formulate models of cosmic ray interactions and classify elementary particles using quantum numbers and quark theory.	K6

**Course Articulation Matrix** (Maps COs consistency with POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	1	0	1
CO2	9	3	3	3	1	1
CO3	9	3	9	9	3	1
CO4	9	3	9	9	3	3
CO5	9	3	9	9	3	3
CO6	9	3	9	9	3	3
<b>Weightage</b>	<b>54</b>	<b>18</b>	<b>42</b>	<b>39</b>	<b>11</b>	<b>12</b>
<b>Weightage percentage of Course contribution to POs</b>	<b>31 %</b>	<b>10 %</b>	<b>24 %</b>	<b>22 %</b>	<b>6 %</b>	<b>7 %</b>

**R- Remember(K1); U- Understand (K2); Ap- Apply(K3); An- Analyze(K4); E- Evaluate(K5); C- Create(K6)**  
**Mapping COs with Knowledge levels and POs:**

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/K1	PO1	PO2	PO4	PO5, PO6
CO2/K2	PO1	PO2, PO3	PO4	PO5, PO6
CO3/K3	PO1, PO3	PO2, PO4	PO5	PO6
CO4/K4	PO1, PO3, PO4	PO2	PO5	PO6
CO5/K5	PO1, PO3, PO4	PO2	PO5	PO6
CO6/K6	PO1, PO3, PO4	PO2	PO5	PO6

**Course Outcome (CO) Attainment Tools & Evaluation Procedure**

K Levels	C1	C2	C3	C4	Total scholastic marks	Non scholastic marks	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	Attendance 5 Marks	25 Marks	
K1	2	1			3			12
K2	1	2	1		4			16
K3		2	2		4			16
K4	1	1		1	3			12
K5	1			2	3			12
K6			1	2	3			12
Non Scholastic	--	--	--	--	--	5		20
<b>Total</b>	<b>5</b>	<b>6</b>	<b>4</b>	<b>5</b>	<b>20</b>	<b>5</b>	<b>25</b>	<b>100</b>

**Declaration**

The COs and POs for the **NUCLEAR AND PARTICLE PHYSICS** Course in the M.Sc. Physics Programme is effectively matched.

**Course Designed by****Course Verified by****HoD**

Programme Code	Course Code	Course Type	Category	Hrs./Week	Credits
PHYPG1963	P25PH14P	CC	Practical	6	5

<b>P-III: Digital Electronics &amp; Processor Interfacing</b>
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**Course Description:**

This laboratory course on Digital Electronics & Processor Interfacing explores the principles and applications of digital circuits and microprocessor interfacing. Students will engage in hands-on experiments, focusing on counters, data converters, memory design, and microcontroller applications, preparing them for advanced digital system design and implementation.

**Course Objectives:** The course intends to facilitate the learner to

- Recall fundamental concepts of number systems, Boolean algebra, logic gates, and combinational circuits.
- Explain the working principles of sequential circuits, flip-flops, registers, and counters.
- Implement combinational and sequential logic circuits to solve real-world digital problems.
- Analyze processor architecture, memory interfacing, and data transfer mechanisms.
- Evaluate different interfacing techniques for digital systems with microprocessors and microcontrollers.
- Design and develop microprocessor-based systems for industrial and embedded applications.

**Any FIFTEEN experiments only**

1. Scalar or Modulus counter.
2. Study the function of Decoder and Encoder.
3. Design and study of Digital comparator.
4. Study of DAC interfacing (DAC0900).
5. Study of ADC interfacing (ADC0809).
6. Digital to Analog Converter - R-2R and weighted resistor methods.
7. Study the function of Multiplexer and De multiplexer.
8. Traffic control system using microprocessor 8085.
9. Control of stepper motor using microprocessor 8085.
10. Digital Clock using microprocessor 8085.

11. Construction of all Flip-Flops using gates.
12. Construction of RAM cells.
13. Study of ALU.
14. Study of Voltage control oscillator.
15. Up-Down counter using J-K Flip-Flops.
16. Study of Shift registers – All modes of operations.
17. Regenerative waveform generator using 555timer.
18. ARM Cortex Microcontroller (32-bit)- LED Flasher.
19. ARM Cortex Microcontroller (32-bit)- Pulse generation for optical coupling.
20. ARM Cortex Microcontroller (32-bit)- ADC.

**Course Outcomes Table**

<b>CO No.</b>	<b>Course Outcome</b>	<b>Knowledge Level</b>
CO1	Recall fundamental concepts of number systems, Boolean algebra, logic gates, and combinational circuits.	K1
CO2	Explain the working principles of sequential circuits, flip-flops, registers, and counters.	K2
CO3	Implement combinational and sequential logic circuits to solve real-world digital problems.	K3
CO4	Analyze processor architecture, memory interfacing, and data transfer mechanisms.	K4
CO5	Evaluate different interfacing techniques for digital systems with microprocessors and microcontrollers.	K5
CO6	Design and develop microprocessor-based systems for industrial and embedded applications.	K6

**Course Articulation Matrix** (Maps COs consistency with POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	1	0	0
CO2	9	3	3	3	1	0
CO3	9	3	9	3	3	1
CO4	9	3	9	9	3	3
CO5	9	3	9	9	3	3
CO6	9	3	9	9	3	9
<b>Weightage</b>	<b>54</b>	<b>18</b>	<b>42</b>	<b>34</b>	<b>13</b>	<b>16</b>
<b>Weightage percentage of Course contribution to POs</b>	<b>31 %</b>	<b>10 %</b>	<b>24 %</b>	<b>19 %</b>	<b>7 %</b>	<b>9 %</b>

**R- Remember(K1); U- Understand (K2); Ap- Apply(K3); An- Analyze(K4); E- Evaluate(K5); C- Create(K6)**

**Mapping COs with Knowledge levels and POs:**

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/K1	PO1	PO2	PO3	PO4, PO5, PO6
CO2/K2	PO1, PO2	PO3	PO4	PO5, PO6
CO3/K3	PO1, PO3	PO2, PO4	PO5	PO6
CO4/K4	PO1, PO3, PO4	PO2	PO5, PO6	-
CO5/K5	PO1, PO3, PO4	PO2, PO5	PO6	-
CO6/K6	PO1, PO3, PO4, PO6	PO2, PO5	-	-

**Course Outcome (CO) Attainment Tools & Evaluation Procedure\***

K Levels	C1	C2	C3	C4	Total scholastic marks	Non scholastic marks	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	Attendance 5 Marks	25 Marks	
<b>K1</b>	2	1	0	1	4	–	4	16
<b>K2</b>	1	1	1	1	4	–	4	16
<b>K3</b>	1	1	1	1	4	–	4	16
<b>K4</b>	0	1	1	1	3	–	3	12
<b>K5</b>	1	1	1	1	4	–	4	16
<b>K6</b>	0	1	0	0	1	–	1	4
<b>Non Scholastic</b>	--	--	--	--	--	5	5	20
<b>Total</b>	<b>5</b>	<b>6</b>	<b>4</b>	<b>5</b>	<b>20</b>	<b>5</b>	<b>25</b>	<b>100</b>

\*The seminar, assignment components are clubbed with model lab tests in practical courses.

**Declaration**

The COs and POs for the **Practical 3: Digital Electronics and Processor Interfacing** Course in the M.Sc. Physics Programme is effectively matched.

**Course Designed by**

**Course Verified by**

**HoD**

Programme Code	Course Code	Course Type	Category	Hrs./Week	Credits
PHYPG1963	P25PH15E	EC	Lecture	6	4

<b>NUMERICAL METHODS AND C PROGRAMMING</b>
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**Course Description:**

The course is designed for postgraduate students and aims to develop problem-solving skills using numerical techniques. This course provides a comprehensive introduction to the C programming language, covering fundamental concepts, syntax, and programming techniques.

**Course Objectives:** The course intends to facilitate the learner to

- Recall and define different types of numerical errors, empirical formulas, and curve fitting techniques.
- Explain the concepts of solving algebraic and transcendental equations using various numerical methods, such as the Bisection and Newton-Raphson methods.
- Apply interpolation techniques, including Newton's and Lagrange's methods, to estimate unknown values from given data points.
- Analyze numerical differentiation and integration techniques, including Euler's and Runge-Kutta methods, for solving differential equations.
- Evaluate the efficiency and accuracy of numerical techniques, such as Simpson's and Trapezoidal rules, in approximating integrals.
- Develop C programs for implementing numerical methods, such as curve fitting, interpolation, differentiation, and integration.

**UNIT- I: ERRORS AND MEASUREMENTS (18 hours)**

General formula for Errors-Errors and its Types-Graphical Method - Empirical formula - Principle of Least Squares- Fitting a straight line-Fitting a Parabola-Fitting an Exponential Curve( $y=ae^{bx}$ )-Fitting the curve ( $y=ax^b$ )

**UNIT -II: ALGEBRAIC AND TRANSCENDENTAL EQUATIONS (18 hours)**

Bisection method-The Iteration Method –Method of false position-Newton-Raphson method –Convergence of Newton-Raphson Method – Order of Convergence for N-R Method. Linear Algebraic Equations: Gauss Elimination method-Jordan's modification-Gauss-Seidel method of Iteration.

**UNIT- III: INTERPOLATION (18 hours)**

Linear Interpolation-Gregory-Newton forward and Backward Interpolation formula-Central difference formula-Gauss forward and backward interpolation formula- Lagrange's interpolation formula for unequal intervals-Newton's formula for unequal intervals.

**UNIT- IV: NUMERICAL DIFFERENTIATION AND INTEGRATION (18 hours)**

Numerical Differentiation for solving first order differential equations:-Euler's method- Modified Euler's method-Improved Euler's method- –Runge - Kutta second and fourth order method for solving first order differential equations-Numerical Integration: Trapezoidal rule-Simpson's 1/3<sup>rd</sup> rule-Simpson's 3/8 the rule-formula and derivation.

## UNIT- V: C PROGRAMS (18 hours)

Structure of a C program-Primary data types-Constants-Integers-Variou types of operators and expressions-Control structure-if-if-else- go to – while – do, while – for statements- declaration and initialization of arrays (1-d, 2-d)-Functions-Calling a function-Return values and their types.

Development of C programs for

- 1) Fitting a straight line, 2) Newton-Raphson method,3)Euler’s method, 4) Runge - Kutta Second order method 5)Trapezoidal rule 6) Gauss Elimination method 7) Lagrange’s Interpolation

### BOOKS FOR STUDY

1. B.P.Flannery, S.A.Teukolsky, W.T.Vetterling, Numerical Recipes in C, W.H. Press, Cambridge University(1996).
2. M.K.Venkataraman, Numerical methods in Science and Engineering, National Publishing Company, Chennai (2004).
3. E.Balagurusamy, Programming in ANSI – C, Tata McGraw Hill publications (2004).

### BOOKS FOR REFERENCE

1. S.S.Sastry, Introductory Methods of Numerical Analysis, PHI, New Delhi(2003).
2. Numerical Methods in Science and Engineering – The National Publishing Co. Madras (2001).
3. Veerarajan, Numerical Methods in C and C++, S. Chand, New Delhi(2006).

### Online Resources:

1. [https://onlinecourses.nptel.ac.in/noc24\\_ge46/preview](https://onlinecourses.nptel.ac.in/noc24_ge46/preview)
2. <https://www.edx.org/learn/c-programming>

### Course Outcome Table

CO No.	Course Outcome	Knowledge Level
CO1	Recall and define different types of numerical errors, empirical formulas, and curve fitting techniques.	K1
CO2	Explain the concepts of solving algebraic and transcendental equations using numerical methods.	K2
CO3	Apply interpolation techniques to estimate unknown values from given data points.	K3
CO4	Analyze numerical differentiation and integration techniques for solving differential equations.	K4
CO5	Evaluate the efficiency and accuracy of numerical techniques in approximating integrals.	K5
CO6	Develop C programs for implementing numerical methods such as curve fitting, interpolation, and integration.	K6

**Course Articulation Matrix (Maps COs consistency with POs)**

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	1	0	0
CO2	9	9	3	3	0	1
CO3	9	3	9	3	1	0
CO4	3	3	9	9	3	1
CO5	3	3	9	9	9	3
CO6	3	1	3	9	9	9
<b>Weightage</b>	<b>42</b>	<b>22</b>	<b>36</b>	<b>34</b>	<b>22</b>	<b>14</b>
<b>Weightage percentage of Course contribution to POs</b>	<b>24%</b>	<b>13%</b>	<b>21%</b>	<b>20%</b>	<b>13%</b>	<b>9%</b>

R- Remember(K1); U- Understand (K2); Ap- Apply(K3); An- Analyze(K4); E- Evaluate(K5); C- Create(K6)

**Mapping COs with Knowledge levels and POs:**

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/K1	PO1	PO2	PO3	PO4, PO5, PO6
CO2/K2	PO1, PO2	PO3, PO4	PO6	PO5
CO3/K3	PO1, PO3	PO2, PO4	PO5	PO6
CO4/K4	PO3, PO4	PO1, PO5	PO2, PO6	--
CO5/K5	PO3, PO4, PO5	PO6	PO1, PO2	--
CO6/K6	PO4, PO5, PO6	PO3	PO1, PO2	--

### Course Outcome (CO) Attainment Tools & Evaluation Procedure

K Levels	C1	C2	C3	C4	Total scholastic marks	Non scholastic marks	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	Attendance 5 Marks	25 Marks	
K1	2	1	0	1	4	–	4	16
K2	1	1	1	1	4	–	3	16
K3	1	1	1	0	3	–	3	12
K4	0	1	1	1	3	–	3	12
K5	1	1	1	1	4	–	4	16
K6	0	1	0	1	2	–	1	8
Non Scholastic	--	--	--	--	--	5	5	20
<b>Total</b>	<b>5</b>	<b>6</b>	<b>4</b>	<b>5</b>	<b>20</b>	<b>5</b>	<b>25</b>	<b>100</b>

#### Declaration

The COs and POs for the **NUMERICAL METHODS AND C PROGRAMMING** Course in the M.Sc. Physics Programme is effectively matched.

Course Designed by

Course Verified by

HoD

Programme Code	Course Code	Course Type	Category	Hrs./Week	Credits
PHYPG1963	P25PH16	CC	Lecture	6	5

<b>CONDENSED MATTER PHYSICS</b>
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**Course Description:**

This advanced course delves into the principles and phenomena of condensed matter physics. Topics include crystal structures, electrical and magnetic properties of materials, dielectric behavior, and superconductivity. Through theoretical frameworks and experimental techniques, students will gain a comprehensive understanding of material behavior at the atomic and macroscopic levels.

**Course Objectives:** The course intends to facilitate the learner to

- Recall and define fundamental concepts of crystal structures, Bravais lattices, and different types of metallic and ionic structures.
- Explain the electrical and thermal properties of metals and semiconductors using classical and quantum theories.
- Apply band theory and Hall effect principles to determine carrier concentration in semiconductors.
- Analyze the magnetic behavior of materials using Langevin's and Weiss's theories and classify materials based on their magnetic properties.
- Evaluate dielectric properties, including polarization mechanisms and breakdown phenomena, in different dielectric materials.
- Design and propose applications of superconducting materials in modern technology based on Meissner effect, Josephson effect, and SQUID principles.

**UNIT- I: CRYSTAL STRUCTURE (18 hours)**

Crystals- Lattice representation - Crystals lattice points and space lattice- The Basis and crystal structure unit cell and the lattice parameters, symmetry elements in crystals- Bravais space lattices- metallic crystal structure- Diamond structure- NaCl structure- zinc blende structure- Cesium chloride structure- CsCl concept of reciprocal lattice - properties of reciprocal lattice- X-ray diffraction Bragg's law - Bragg's diffractometer.

**UNIT- II: ELECTRICAL PROPERTIES OF METALS AND SEMICONDUCTORS (18 hours)**

Classical free electron theory of metals- ohm's law- expression for Electrical conductivity and thermal conductivity- Wiedemann and Franz ratio- Quantum theory free electrons - Free electron gas in one dimension and three-dimension- Band theory of solids – Brillouin zone- I, II, and III Order Semiconductors – Intrinsic semiconductor-Carrier concentration in intrinsic Semiconductor-Hall effect- Experimental determination of Hall coefficient.

**UNIT- III: MAGNETIC PROPERTIES OF MATERIALS (18 hours)**

Terminology and definitions used in magnetism – Classification of magnetic materials – Atomic theory of magnetism– Langevin's classical theory of diamagnetism — Langevin's classical theory of para magnetism – Ferromagnetism – Weiss molecular field – Temperature dependence of spontaneous magnetization – The physical origin of Weiss molecular field - Ferromagnetic domains - Domain theory - Ferri magnetism – Structure of ferrites.

**UNIT- IV: DIELECTRICS AND RELATED PROPERTIES (18 hours)**

Dielectrics - dipole moment and polarisation- electronic polarization- ionic polarization- orientation polarization- Langevin's theory of polarisation in polar dielectrics- internal field in liquids and solids- evaluation of the local field for cubic structure- Lorentz formula - Dielectric constant of solids, liquids- Ferroelectricity- classification of Ferroelectric materials,-dielectric breakdown- intrinsic breakdown- thermal breakdown- discharge breakdown- electrochemical breakdown.

**UNIT-V: SUPERCONDUCTIVITY (18 hours)**

Occurrence of superconductivity - Meissner effect – Type I and Type II super conductors- Isotope effect - London equation - Coherence length - BCS theory of superconductivity- Flux quantisation in a superconducting ring - Josephson tunneling - DC Josephson effect - AC Josephson effect - Macroscopic quantum interference (SQUID) – High temperature superconductors – Applications.

**Text Books:**

1. Yu. L.S Iroin, M.P. Shaskolskaya, Fundamental of Crystal Physics, Mir Publics Moscow (1983).
2. C. Kittel, Introduction to Solid State Physics, Wiley Eastern, New Delhi(2008).
3. M. M. Woolfson, An Introduction to X-ray Crystallography, Cambridge University Press, Cambridge (1970).
4. S. O. Pillai, Solid State Physics, New Age International, New Delhi (2007).
5. M.A. Wahab, Solid State Physics, Narosa Publishing House,(2015).

**Reference Books:**

1. N. W. Ashcrof and N. D. Mermin, Solid State Physics, Holt, Rinehart and Winston, Philadelphia (1976).
2. J. S. Blakemore, Solid State Physics, Cambridge University Press, Cambridge (1974).
3. A. J. Dekker, Solid State Physics, McMillan, Madras (1998).
4. HP Myers, A Compendium based on Introductory Solid State Physics, C & C Press (1997).

**Online Resources:**1. **Feynman Lectures on Physics (Online)**

- Link: Feynman Lectures

2. **NPTEL: Condensed Matter Physics**

- Condensed Matter Physics (NPTEL)

**Course Outcome Table**

CO No.	Course Outcome	Knowledge Level
CO1	Recall and define fundamental concepts of crystal structures, Bravais lattices, and metallic/ionic structures.	K1
CO2	Explain electrical and thermal properties of metals and semiconductors using classical and quantum theories.	K2
CO3	Apply band theory and Hall effect principles to determine carrier concentration in semiconductors.	K3
CO4	Analyze the magnetic behavior of materials using Langevin's and Weiss's theories and classify magnetic materials.	K4
CO5	Evaluate dielectric properties, including polarization mechanisms and breakdown phenomena, in dielectric materials.	K5
CO6	Design and propose applications of superconducting materials using Meissner effect, Josephson effect, and SQUID principles.	K6

**Course Articulation Matrix** (Maps COs consistency with POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	1	0	1
CO2	9	3	9	3	1	1
CO3	9	3	9	3	1	3
CO4	9	3	9	9	3	3
CO5	9	3	9	9	9	3
CO6	9	3	9	9	9	9
<b>Weightage</b>	<b>54</b>	<b>18</b>	<b>48</b>	<b>34</b>	<b>23</b>	<b>20</b>
<b>Weightage percentage of Course contribution to POs</b>	<b>26 %</b>	<b>9 %</b>	<b>23 %</b>	<b>16 %</b>	<b>11 %</b>	<b>15 %</b>

R- Remember(K1); U- Understand (K2); Ap- Apply(K3); An- Analyze(K4); E- Evaluate(K5); C- Create(K6)

**Mapping COs with Knowledge levels and POs:**

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/K1	PO1	PO2	PO4	PO5
CO2/K2	PO1, PO3	PO2, PO4	PO5	PO6
CO3/K3	PO1, PO3	PO2, PO4	PO5	PO6
CO4/K4	PO1, PO3, PO4	PO2, PO6	PO5	--
CO5/K5	PO1, PO3, PO4, PO5	PO2, PO6	--	--
CO6/K6	PO1, PO3, PO4, PO5, PO6	PO2	--	--

**Course Outcome (CO) Attainment Tools & Evaluation Procedure**

K Levels	C1	C2	C3	C4	Total scholastic marks	Non scholastic marks	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	Attendance 5 Marks	25 Marks	
K1	2	1	0	1	4	–	4	16
K2	1	2	1	0	4	–	4	16
K3	1	1	1	0	3	–	3	12
K4	0	1	1	1	3	–	3	12
K5	1	1	1	1	4	–	4	16
K6	0	0	0	2	2	–	2	8
Non Scholastic	--	--	--	--	--	5	5	20
<b>Total</b>	<b>5</b>	<b>6</b>	<b>4</b>	<b>5</b>	<b>20</b>	<b>5</b>	<b>25</b>	<b>100</b>

**Declaration**

The COs and POs for the **CONDENSED MATTER PHYSICS** Course in the M.Sc. Physics Programme is effectively matched.

**Course Designed by****Course Verified by****HoD**

Programme Code	Course Code	Course Type	Category	Hrs./Week	Credits
PHYPG1963	P25PH17	CC	Lecture	6	5

## FIBER OPTICS AND NON-LINEAR OPTICS

### Course Description:

This postgraduate course on Fiber Optics and Non-Linear Optics delves into the principles and applications of optical communication systems, fiber transmission characteristics, semiconductor lasers, and non-linear optical phenomena. Students will explore advanced topics such as multiphoton processes, preparing them for innovative research and development in photonics.

**Course Objectives:** The course intends to facilitate the learner to

- Recall and define fundamental concepts of fiber optic communication components, transmission characteristics, and semiconductor lasers.
- Explain the working principles of transmission characteristics in optical fibers and dispersion mechanisms.
- Apply the principles of semiconductor laser physics to analyze threshold conditions for laser action.
- Analyze the effects of non-linear optics, including harmonic generation, optical mixing, and self-focusing of light.
- Evaluate multiphoton processes, including two-photon and three-photon interactions, in various materials and parametric light oscillators.
- Design and propose advanced optical systems utilizing fiber optics and non-linear optical techniques for real-world applications.

### UNIT- I: FIBER OPTIC COMMUNICATION COMPONENTS AND SYSTEM (18 hours)

Coupling components- Modulation methods and modulators-Switches-Transmitters- Receivers- Repeaters-Solitons-Wavelength Division Multiplexing (WDM)-Optical Time Division Multiplexing (TDM) - Data buses-LAN systems- SONET, SDH, ISDN, BISDN networks- Microwave technical applications of light wave systems

### UNIT- II: TRANSMISSION CHARACTERISTICS OF OPTICAL FIBERS (18 hours)

Attenuation-Losses: Material absorption-Linear scattering-Non-linear scattering-Fiber bending- Dispersion- Intermodal – Intra modal and overall fiber dispersion- Dispersion shifted fibers- Dispersion flattened fibers- Modal birefringence.

### UNIT- III: SEMICONDUCTOR LASERS (18 hours)

Central features- Intrinsic laser - doped semiconductors- Condition for laser action-injection lasers- injection laser threshold current- Advances in semiconductor lasers - Spin-flip Raman laser - $C^3$  laser.

### UNIT- IV: NON-LINEAR OPTICS AND LASER SPECTROSCOPY (18 hours)

Introduction - Harmonic generation-Second Harmonic Generation- Phase matching -Evaluation of SHG: The Kurtz-Perry powder technique- Third Harmonic Generation- Optical mixing-Parametric Generation of light-Self-focusing of light Rayleigh and Raman scattering-Stimulated Raman effect – Classical treatment of Hyper Raman effect-, Free-electron laser -Photo-acoustic Raman Spectroscopy (PARS).

### UNIT- V: MULTIPHOTON PROCESSES (18 hours)

Multi-quantum photoelectric effect – Theory of Two photon process – Experiments in two photon processes: –  $CaF_2:Eu^{++}$  crystals, Cesium vapor, Anthracene, KI, Two photon effect in a semiconductor, Two-photon ionization- Three photon process – Parametric light oscillator- Frequency Up conversion- Phase Conjugated Optics.

**Text Books:**

1. John M. Senior, Optical Fiber Communications, Prentice Hall India, 2<sup>nd</sup> Edition (2005) (For Units I and II).
2. B. B. Laud, Lasers and Non-Linear Optics, New Age International Publishers, New Delhi (2011) ( For Units III, IV and V).

**Reference Books:**

1. Govind. P. Agarwal, Fiber-Optics Communication Systems, 3<sup>rd</sup> Edn. JohnWiley and Sons, Singapore (2003).
2. D.C. Agarwal, Fiber Optic Communication, Sultan Chand, New Delhi(2009).
3. Y.R. Shen, *The Principles of Nonlinear Optics*, (Wiley & Sons, New Jersey, 2003)
4. Ralf Menzel, *Photonics* (Springer-Verlag Berlin Heidenberg, New York, (2007)

**Online Resources:**

- <https://nptel.ac.in/courses/104104085>
- <https://nptel.ac.in/courses/115102124>
- <https://nptel.ac.in/courses/115101008>

**Course Outcome Table**

CO No.	Course Outcome	Knowledge Level
CO1	Recall and define fundamental concepts of fiber optic communication, transmission characteristics, and semiconductor lasers.	K1
CO2	Explain the working principles of optical fiber transmission and dispersion mechanisms.	K2
CO3	Apply semiconductor laser principles to analyze threshold conditions for laser action.	K3
CO4	Analyze non-linear optical effects including harmonic generation, optical mixing, and self-focusing of light.	K4
CO5	Evaluate multiphoton processes and parametric light oscillators in various materials.	K5
CO6	Design and propose advanced optical systems using fiber optics and non-linear optical techniques.	K6

**Course Articulation Matrix (Maps COs consistency with POs)**

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	1	0	1
CO2	9	3	9	3	1	1
CO3	9	3	9	3	1	3
CO4	9	3	9	9	3	3
CO5	9	3	9	9	9	3
CO6	9	3	9	9	9	9
<b>Weightage</b>	<b>54</b>	<b>18</b>	<b>48</b>	<b>34</b>	<b>23</b>	<b>20</b>
<b>Weightage percentage of Course contribution to POs</b>	<b>26 %</b>	<b>9 %</b>	<b>23 %</b>	<b>16 %</b>	<b>11 %</b>	<b>15 %</b>

**R- Remember(K1); U- Understand (K2); Ap- Apply(K3); An- Analyze(K4); E- Evaluate(K5); C- Create(K6)**

**Mapping COs with Knowledge levels and POs:**

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/K1	PO1	PO2	PO4	PO5
CO2/K2	PO1, PO3	PO2, PO4	PO5	PO6
CO3/K3	PO1, PO3	PO2, PO4	PO5	PO6
CO4/K4	PO1, PO3, PO4	PO2, PO6	PO5	--
CO5/K5	PO1, PO3, PO4, PO5	PO2, PO6	--	--
CO6/K6	PO1, PO3, PO4, PO5, PO6	PO2	--	--

### Course Outcome (CO) Attainment Tools & Evaluation Procedure

K Levels	C1	C2	C3	C4	Total scholastic marks	Non scholastic marks	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	Attendance 5 Marks	25 Marks	
K1	2	1	0	0	3	–	3	12
K2	1	2	1	0	4	–	4	16
K3	1	1	1	0	3	–	3	12
K4	0	1	1	1	3	–	3	12
K5	0	1	1	2	4	–	4	16
K6	1	0	0	2	3	–	3	12
Non Scholastic	--	--	--	--	--	5	5	20
<b>Total</b>	<b>5</b>	<b>6</b>	<b>4</b>	<b>5</b>	<b>20</b>	<b>5</b>	<b>25</b>	<b>100</b>

#### Declaration

The COs and POs for the Core Course “**FIBER OPTICS AND NON-LINEAR OPTICS**” in the M.Sc. Physics Programme is effectively matched.

Course Designed by

Course Verified by

HoD

Programme Code	Course Code	Course Type	Category	Hrs./Week	Credits
PHYPG1963	P25PH18P	CC	Practical	6	5

<b>P-IV: Microcontrollers, C &amp; Python Programming</b>
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**Course Description:**

This laboratory course on Microcontrollers, C & Python Programming integrates theoretical knowledge with practical skills in microcontroller programming and numerical methods. Students will conduct experiments that bridge embedded systems and programming, focusing on interfacing techniques and algorithm implementation in C and Python, fostering comprehensive problem-solving skills.

**Course Objectives:** The course intends to facilitate the learner to

- Recall fundamental concepts of microcontroller programming, arithmetic operations, and basic interfacing techniques.
- Explain the working principles of numerical methods, microcontroller interfacing, and data handling techniques in C and Python.
- Implement microcontroller-based arithmetic operations, waveform generation, and numerical algorithms using C and Python.
- Analyze numerical methods and interfacing techniques for optimizing microcontroller applications.
- Evaluate the accuracy and efficiency of numerical computations and microcontroller-based system responses.
- Design and develop microcontroller-based systems and numerical computation solutions for real-world applications.

**Any FIFTEEN experiments**

(Choose experiments from Microcontroller and Computer programming in 1:3 ratio)

**Microcontroller Programming and Interfacing**

1. 8-Bit addition and subtraction.
2. 8 Bit multiplication and division.
3. 16Bit division and multiplication.
4. Ascending and Descending order.
5. Largest and Smallest number in an array.
6. Sum of the numbers in an array.
7. Interfacing a LED display
8. Interfacing a LCD display
9. Interfacing a Stepper motor
10. Waveform generation by interfacing with a DAC.

### **COMPUTER PROGRAMS - C**

1. Roots of algebraic equations - Newton-Raphson method.
2. Least-squares curve fitting – straight-line fit
3. Least-squares curve fitting – exponential fit.
4. Solution of simultaneous linear algebraic equations – Gauss elimination method.
5. Solution of simultaneous linear algebraic equations – Gauss-Seidal method.
6. Interpolation – Lagrange method.
7. Numerical differentiation – Euler method.
8. Solution of ordinary differential equations – Runge-Kutta 2<sup>nd</sup>order method.
9. Evaluation of definite integrals – Monte Carlo method.
10. Numerical integration –Trapezoidal rule
11. Numerical integration –Simpson’s 1/3<sup>rd</sup>rule.
12. Solution of ordinary differential equations – Runge-Kutta 4<sup>th</sup> order method.
13. Calculation of mean, standard deviation and probability distribution of a set of random numbers.

### **COMPUTER PROGRAMS - Python**

1. Roots of algebraic equations - Newton-Raphson method.
2. Least-squares curve fitting – straight-line fit
3. Least-squares curve fitting – exponential fit.
4. Least-squares curve fitting – logarithmic fit.
5. Numerical integration –Simpson’s 1/3<sup>rd</sup>rule.
6. Numerical integration –Trapezoidal rule
7. Calculation of mean, standard deviation and probability distribution of a set of random numbers.

**Course Outcome Table**

<b>CO No.</b>	<b>Course Outcome</b>	<b>Knowledge Level</b>
CO1	Recall fundamental concepts of microcontroller programming, arithmetic operations, and basic interfacing techniques.	K1
CO2	Explain the working principles of numerical methods, microcontroller interfacing, and data handling techniques in C and Python.	K2
CO3	Implement microcontroller-based arithmetic operations, waveform generation, and numerical algorithms using C and Python.	K3
CO4	Analyze numerical methods and interfacing techniques for optimizing microcontroller applications.	K4
CO5	Evaluate the accuracy and efficiency of numerical computations and microcontroller-based system responses.	K5
CO6	Design and develop microcontroller-based systems and numerical computation solutions for real-world applications.	K6

**Course Articulation Matrix** (Maps COs consistency with POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	1	0	0
CO2	9	3	3	3	1	0
CO3	9	3	9	3	3	1
CO4	9	3	9	9	3	3
CO5	9	3	9	9	3	3
CO6	9	3	9	9	3	9
<b>Weightage</b>	<b>54</b>	<b>18</b>	<b>42</b>	<b>34</b>	<b>13</b>	<b>16</b>
<b>Weightage percentage of Course contribution to POs</b>	<b>31 %</b>	<b>10 %</b>	<b>24 %</b>	<b>19 %</b>	<b>7 %</b>	<b>9 %</b>

R- Remember(K1); U- Understand (K2); Ap- Apply(K3); An- Analyze(K4); E- Evaluate(K5); C- Create(K6)

**Mapping COs with Knowledge levels and POs:**

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/K1	PO1	PO2	PO3	PO4, PO5, PO6
CO2/K2	PO1, PO2	PO3	PO4	PO5, PO6
CO3/K3	PO1, PO3	PO2, PO4	PO5	PO6
CO4/K4	PO1, PO3, PO4	PO2	PO5, PO6	-
CO5/K5	PO1, PO3, PO4	PO2, PO5	PO6	-
CO6/K6	PO1, PO3, PO4, PO6	PO2, PO5	-	-

**Course Outcome (CO) Attainment Tools & Evaluation Procedure\***

K Levels	C1	C2	C3	C4	Total scholastic marks	Non scholastic marks	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	Attendance 5 Marks	25 Marks	
<b>K1</b>	2	1	0	0	3	–	3	12
<b>K2</b>	1	2	1	0	4	–	4	16
<b>K3</b>	1	1	1	0	3	–	3	12
<b>K4</b>	0	1	1	1	3	–	3	12
<b>K5</b>	0	1	1	2	4	–	4	16
<b>K6</b>	1	0	0	2	3	–	3	12
<b>Non Scholastic</b>	--	--	--	--	--	5	5	20
<b>Total</b>	<b>5</b>	<b>6</b>	<b>4</b>	<b>5</b>	<b>20</b>	<b>5</b>	<b>25</b>	<b>100</b>

\*The seminar, assignment components are clubbed with model lab tests in practical courses.

**Declaration**

The COs and POs for the **Practical 4: Microcontrollers, C & Python Programming** Course in the M.Sc. Physics Programme is effectively matched.

**Course Designed by**

**Course Verified by**

**HoD**

Programme Code	Course Code	Course Type	Category	Hrs./Week	Credits
PHYPG1963	P25PH19E	EC	Lecture	6	4

## X-RAY CRYSTALLOGRAPHY AND DRUG DESIGN

### Course Description:

This course explores the intersection of crystallography and pharmacology. Students will learn about crystal geometry, experimental techniques, structure determination, drug design methodologies, and cheminformatics, equipping them with essential skills for modern drug discovery and development.

**Course Objectives:** The course intends to facilitate the learner to

- Recall and define fundamental concepts of crystal geometry, lattice structures, symmetry, and diffraction principles including Bragg's law and Laue's equations.
- Explain the experimental techniques in X-ray crystallography, including optical classification of crystals, birefringence, and single-crystal X-ray diffractometry.
- Apply structure factor calculations and diffraction techniques to analyze crystal properties and interpret X-ray scattering results.
- Analyze factors affecting X-ray intensities, methods of structure determination, and refinement techniques for crystal structure validation.
- Assess drug discovery methodologies, including molecular modeling, computer-aided drug design, and the role of crystallography in drug development.
- Design and develop cheminformatics-based models for structure representation, QSAR analysis, and virtual screening in drug discovery.

### Unit-I: Crystal Geometry and diffraction (18 hours)

Crystals-Lattice- Symmetry – Crystal systems – Primitive and non-primitive cells – Indexing in the hexagonal system – Bragg's law – Laue's equations – Reciprocal lattice- Diffraction directions– Scattering by an electron – Scattering by an atom – Scattering from a unit cell – Structure factor calculation.

### Unit-II: Experimental techniques (18 hours)

Optical classification of crystals : Uniaxial crystals – Birefringence – Biaxial crystals – Interference figures – Direction of scattering of X-rays by crystals : Laue's equations for X-ray scattering – Bragg's treatment of X-ray diffraction – Equivalence of Laue's and Bragg's treatment of X-ray diffraction –Single-crystal X-ray diffractometry : Instrument geometry – Rotation of the crystal into a diffracting position.

### Unit-III: X-ray crystal structure determination (18 hours)

Factors affecting X-ray intensities: Absorption of X-rays – Primary extinction – Secondary extinction – The temperature factor –Anomalous scattering. Methods: Direct method- The heavy-atom method – Isomorphous replacement – Anomalous scattering method. Data Collection- Structure solution- refinement – validation of Refinement factor (R-value).

### Unit-IV: Designing drugs (18 hours)

Drug discovery: the evolution and process- brief history-role of computer aided drug design-drug action-drug discovery process: computer tools and methodology- Crystallography and drug design-molecular geometry-conformation and configuration-Lipinski's rule of five- Docking- Virtual screening.

## Unit-V: Cheminformatics (18 hours)

Introduction to Cheminformatics-Structure representation of molecules- Structure descriptors- Structure databases- types-Quantitative Structure Activity Relationship (QSAR)- Statistical Methods-Types of QSAR methods.

### Text Books:

1. Giocovazzo, C. (Ed.), Fundamentals of Crystallography, IUCr Texts in Crystallography, Oxford Science Publishers, (2000).
2. Biophysics, Patabhi, V. & Gautam, N. Kluwer Academic Publishers, (2002).
3. Ananad Solomon, K. Molecular Modelling and Drug Design, MJP Publishers, (2019).

### Reference Books:

1. Stout G.H. , Jensen, L.H.: X-ray Structure Determination - A Practical Guide. John Wiley & Sons, 1989.
2. Glusker J.P. Trueblood K.N., Crystal Structure Analysis - A Primer (2<sup>nd</sup> Ed.), Oxford University Press, 1985.
3. Hammond, C., The Basis of Crystallography and Diffraction (3rd ed.), IUCr Texts in Crystallography, Oxford Science Publishers, 2009.
4. Kristian Strømgaard, Povl Krogsgaard-Larsen and Ulf Madsen. Textbook of Drug Design and Discovery, Fifth Edition, CRC Press, (2017).

### Online Resources:

- <https://www.iucr.org/education/pamphlets>
- <https://www.ccdc.cam.ac.uk/>
- <https://go.drugbank.com/>
- <http://www.swissadme.ch/>
- <http://projects.scbdd.com/chemdes.html>

### Course Outcomes Table

CO No.	Course Outcome	Knowledge Level
CO1	Recall and define fundamental concepts of crystal geometry, lattice structures, symmetry, and diffraction principles including Bragg's law and Laue's equations.	K1
CO2	Explain the experimental techniques in X-ray crystallography, including optical classification of crystals and single-crystal X-ray diffractometry.	K2
CO3	Apply structure factor calculations and diffraction techniques to analyze crystal properties and interpret X-ray scattering results.	K3
CO4	Analyze factors affecting X-ray intensities, methods of structure determination, and refinement techniques for structure validation.	K4
CO5	Assess drug discovery methodologies, including molecular modeling, computer-aided drug design, and the role of crystallography in drug development.	K5
CO6	Design and develop cheminformatics-based models for structure representation, QSAR analysis, and virtual screening.	K6

**Course Articulation Matrix (Maps COs consistency with POs)**

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	1	0	0
CO2	9	9	3	3	0	1
CO3	9	3	9	3	1	0
CO4	3	3	9	9	3	1
CO5	3	3	9	9	9	3
CO6	3	1	3	9	9	9
<b>Weightage</b>	<b>42</b>	<b>22</b>	<b>36</b>	<b>34</b>	<b>22</b>	<b>14</b>
<b>Weightage percentage of Course contribution to POs</b>	<b>24%</b>	<b>13%</b>	<b>21%</b>	<b>20%</b>	<b>13%</b>	<b>9%</b>

**R- Remember(K1); U- Understand (K2); Ap- Apply(K3); An- Analyze(K4); E- Evaluate(K5); C- Create(K6)**

**Mapping COs with Knowledge levels and POs:**

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/K1	PO1	PO2	PO3	PO4, PO5, PO6
CO2/K2	PO1, PO2	PO3, PO4	PO6	PO5
CO3/K3	PO1, PO3	PO2, PO4	PO5	PO6
CO4/K4	PO3, PO4	PO1, PO5	PO2, PO6	--
CO5/K5	PO3, PO4, PO5	PO6	PO1, PO2	--
CO6/K6	PO4, PO5, PO6	PO3	PO1, PO2	--

**Course Outcome (CO) Attainment Tools & Evaluation Procedure**

K Levels	C1	C2	C3	C4	Total scholastic marks	Non scholastic marks	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	Attendance 5 Marks	25 Marks	
K1	2	1	0	0	3	–	3	12
K2	1	2	1	0	4	–	4	16
K3	1	1	1	0	3	–	3	12
K4	0	1	1	1	3	–	3	12
K5	0	1	0	3	4	–	4	16
K6	1	0	1	1	3	–	3	12
Non Scholastic	--	--	--	--	--	5	5	20
Total	5	6	4	5	20	5	25	100

**Declaration**

The COs and POs for the **X-RAY CRYSTALLOGRAPHY AND DRUG DESIGN** Course in the M.Sc. Physics Programme is effectively matched.

**Course Designed by****Course Verified by****HoD**

Programme Code	Course Code	Course Type	Category	Hrs./Week	Credits
PHYPG1963	P25PHP20	CC	Hybrid	6	4

<i>Course Title:</i>	<b>PROJECT WORK</b>
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Each candidate shall be required to take up a Project Work and submit it at the end of the final year. The Head of the Department shall assign the Guide who, in turn, will suggest the Project Work to the student in the beginning of the final year. A copy of the Project Report will be submitted to the University through the Head of the Department on or before the date fixed by the College Principal.

The Project will be evaluated by an internal and an external examiner nominated by the COE. The candidate concerned will have to defend his/her Project through a Viva-voce.

### ASSESSMENT/ EVALUATION/ VIVA-VOCE

#### 1. PROJECT REPORT EVALUATION (Both Internal & External):

**I. Plan of the Project** **- 20 marks**

**II. Execution of the Plan/collection of** **- 45 marks**  
Data / Organization of Materials / Hypothesis, Testing etc and presentation of the report.

**III. Individual initiative** **- 10 marks**

**2. VIVA-VOCE / INTERNAL& EXTERNAL** **- 25 marks**

**TOTAL** **- 100 marks**

#### **PASSING MINIMUM:**

Project Vivo-Voce: 25 Marks, Minimum 40% out of 25 Marks (i.e. 10 Marks)

Dissertation 75 Marks: 40% out of 75 marks (i.e. 30 marks)

A candidate shall be declared to have passed in the Project work if he/she gets not less than 40% in each of the Project Report and Viva-voce but not less than 50% in the aggregate of both the marks for Project Report and Viva-voce.

A candidate who gets less than 40% in the Project must resubmit the Project Report. Such candidates need to defend the resubmitted Project at the Viva-voce within a month. A maximum of 2 chances will be given to the candidate.

**Note:** There are no specific evaluation scheme/components for internal component in the project work. The 100 marks will be awarded by the cumulative evaluation of both the internal and external examiner. However, the students are expected to faithfully follow the project course specific instructions from the HoD and Guide as in now and then to ensure smooth self-learning experience.