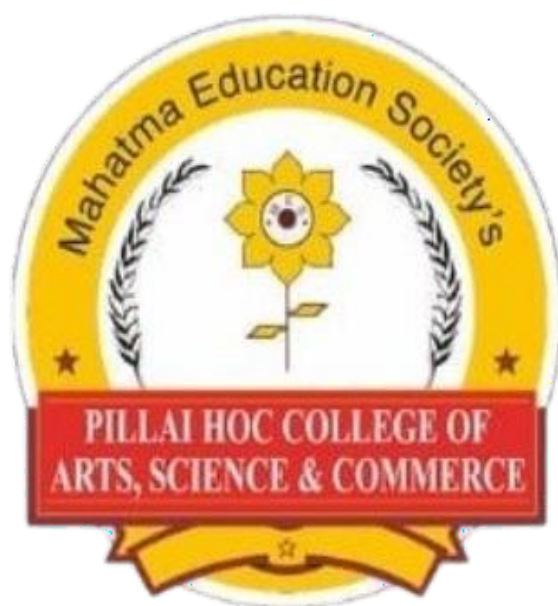


**Mahatma Education Society's**  
**Pillai HOC College of Arts, Science & Commerce (Autonomous)**  
**Rasayani**

**Affiliated to University of Mumbai**  
**NAAC Accredited with "A+" Grade in cycle II**  
**ISO 9001:2015 Certified**



## **SYLLABUS**

### **Master of Science (M.Sc.) in Physics**

**As per National Education Policy 2020**

**Academic Year 2026-27**



Mahatma Education Society's

College Code: 870

**PILLAI HOC COLLEGE OF ARTS, SCIENCE & COMMERCE**

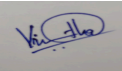

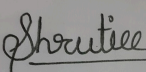




Pillai HOCL Educational Campus, HOC Colony, Rasayani, Via. Panvel, Dist. Raigad. Pin 410207

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(NAAC Accredited 'A+' Grade, CGPA - 3.26 in Cycle 2 & ISO 9001:2015 Certified)

Affiliated to the University of Mumbai, Approved by Government of Maharashtra

(AUTONOMOUS COLLEGE)

Sr.No.	Name	Designation	Signature
1	Dr. Vineetha P	Head of the Department of M.Sc. in Physics	
2	Dr. Rinkoo Shantnu	Principal	
3	Mr. Binit Kumar	Vice -Principal	Mr. Binit Kumar
4	Ms. Shruti Hogale	Member	
5	Dr. Dinesh Navale	Vice Chancellor Nominee	
6	Ms. Komal Kamble	Subject Expert	
7	Dr. Anand K Singh	Subject Expert	Dr. Anand Singh
8	Dr. Bapu Gawade	Industry Representative	
9	Mr. Rushikesh Ghodvinde	Alumni Representative	

## **Introduction**

The **M.Sc. Physics programme** is a two-year postgraduate degree that provides an advanced foundation in physics by seamlessly integrating theoretical concepts with practical applications. The course provides students with a strong foundation in classical and modern physics while cultivating analytical thinking, experimental skills, and research competency. Through well-structured laboratory sessions, hands-on experiments, simulations, and project work, students gain practical exposure to contemporary scientific tools and technologies. The programme aims to develop critical problem-solving abilities and prepare students for careers in research institutions, academia, industry, scientific organizations, and emerging technology sectors. It also equips learners with the essential skills required to pursue higher studies such as M.Phil. or Ph.D.

### Programme Outcomes (POs)

PO. No.	PO Title	PO's in Brief
PO1	<b>Fundamental Knowledge Acquisition</b>	Graduates will demonstrate a comprehensive and foundational knowledge of their chosen discipline along with an awareness of interdisciplinary connections.
PO2	<b>Critical Thinking and Analytical Reasoning</b>	Graduates will be able to analyse complex problems, synthesize data from multiple sources (qualitative and quantitative), and employ logical reasoning to formulate well-supported conclusions and arguments.
PO3	<b>Effective Communication</b>	Graduates will exhibit proficiency in both written and oral communication, articulating ideas clearly, persuasively, and ethically to diverse audiences
PO4	<b>Problem Solving</b>	Graduates will possess the ability to identify, formulate, and design solutions for real-world problems in their professional or social contexts, applying relevant theoretical knowledge and practical skills.
PO5	<b>Information and Digital Literacy</b>	Graduates will demonstrate the capability to locate, evaluate, and effectively use information from various sources, and utilize modern tools and Information and Communication Technology (ICT) for professional and academic tasks.
PO6	<b>Research Skills and Scientific Temperament</b>	Graduates will develop a sense of inquiry and research methodology, including the ability to design experiments (where applicable), collect and analyse data, and interpret results while maintaining scientific rigor and intellectual honesty.
PO7	<b>Ethical Reasoning and Professional Integrity</b>	Graduates will recognize ethical dilemmas, commit to professional and academic ethics, and demonstrate an understanding of moral and social responsibilities in their personal and professional conduct.
PO8	<b>Employability and Professional Skills</b>	Graduates will acquire the necessary job-ready skills, managerial competencies, and professional values to secure gainful employment or pursue advanced education in their respective fields.
PO9	<b>Environmental and Sustainability Consciousness</b>	Graduates will understand the importance of environmental conservation and sustainable development, displaying responsibility toward ecological challenges and advocating for healthy environmental practices.
PO10	<b>Life-Long Learning</b>	Graduates will develop the capacity for independent and self-directed learning to continuously upgrade their knowledge and skills, enabling them to adapt to rapid technological and societal changes.
PO11	<b>Civic and Social Responsibility</b>	Graduates will act as responsible citizens with an informed awareness of constitutional values, engaging proactively in community development and addressing social needs.
PO12	<b>Empathy and Social Intelligence</b>	Graduates will be able to cultivate and demonstrate affective, interpersonal, social and emotional intelligence.

### Programme Specific Outcomes (PSOs)

PSOs. No.	PSO Title	PSOs in brief
PSO1	Advanced Scientific Understanding and Analytical Skills	Graduates will master analytic and critical thinking abilities through in-depth knowledge of major branches of physics, enabling them to apply fundamental principles to complex scientific and real-world problems.
PSO2	Research Competency and Professional Growth	Graduates will be able to perform basic, applied, and collaborative research using modern scientific methods, while continuously sustaining their intellectual curiosity through lifelong learning at national and international levels..
PSO3	Communication, and Scientific Writing Proficiency	Graduates will enhance their pedagogical, scientific writing, and communication skills through contemporary instructional practices and technological tools, preparing them for careers in academics, research, and science communication.
PSO4	Innovation, Entrepreneurship, and Social Responsibility	Graduates will develop entrepreneurial abilities and leadership qualities while upholding ethical, social, and environmental responsibilities, contributing positively to society and sustainable development..

### Evaluation Pattern

Marking Code	Marking Scheme
A	50 Marks Semester End Exam, 50 Marks Continuous Assessment (distributed within 20 Marks Class Test, 20 Marks Presentation , 10 Marks Assignment)
B	50 Marks Practical Examination (distributed within 30 Marks Practical, 10 Marks Journal, 10 Marks Viva)
C	50 External Evaluation (distributed within 20 Marks Completing Of Hours, 20 Marks Quality/Performance and 10 Marks Punctuality/Regularity, 50 Marks Internal Evaluation (distributed within 15 Marks Weekly Reporting, 20 Marks Written report and 15 Viva-Voce/ Presentation)
D	50 External Evaluation (distributed within 10 Marks Presentation, 25 Marks Dissertation and 15 Marks Viva, 50 Marks Internal Evaluation (distributed within 10 Marks Attendance, 25 Marks Literature Survey and 15 Marks Scheme/Outline of Project/Methodology)

## Course Structure

<b>SEMESTER III</b>							
<b>Course Code</b>	<b>Course Type</b>	<b>Course Title</b>	<b>Theory/ Practical</b>	<b>Marks</b>	<b>Credits</b>	<b>Lectures/ Week</b>	<b>Evaluation Pattern</b>
<b>HPSPH201</b>	Major	Nuclear Physics	Theory	100	4	4	A
<b>HPSPH202</b>	Major	Electronics	Theory	100	4	4	A
<b>HPSPH203</b>	Major	Statistical and Thermal Physics	Theory	100	4	4	A
<b>HPSPH204</b>	Elective II	Semiconductor Physics and Renewable Energies	Theory	100	4	4	A
<b>HPSPH205P</b>	Major - Practical	Practical III	Practical	50	2	4	B
<b>HPSPH206</b>	Project	Research Project	NA	100	4	4	D
<b>Total</b>				<b>550</b>	<b>22</b>	<b>**</b>	<b>**</b>

# **SEMESTER III**

<b>BOS</b>	<b>Natural and Physical Sciences</b>				
<b>Course</b>	<b>Nuclear Physics</b>				
<b>Course Code</b>	<b>HPSPH201</b>	<b>Level</b>	<b>6.5</b>		
		<b>Type</b>	<b>Theory</b>	<b>Practical</b>	<b>Total</b>
<b>Semester</b>	<b>III</b>	<b>Credits</b>	4	-	4
<b>Type</b>	<b>Major</b>	<b>No of Teaching Hours</b>	60	-	60
<b>Evaluation Pattern</b>	<b>Total Marks</b>	<b>Semester End</b>	<b>Continuous</b>		<b>Practical</b>
	100	50	50		-

<b>Learning Objectives</b>	
<b>1</b>	Analyze Fundamental Nuclear Properties and Two-Body Systems
<b>2</b>	Formulate and Apply Theories of Nuclear Decay
<b>3</b>	Evaluate and Compare Nuclear Models and Reaction Mechanisms
<b>4</b>	Classify Elementary Particles and their Interactions
<b>5</b>	Apply Symmetry Principles to Particle Physics

<b>Course Outcomes</b>	
After successful completion of this course, students would be able to: -	
<b>CO1</b>	Know about properties of nuclei, nuclear size, deuteron problem, nuclear scattering
<b>CO2</b>	Understand alpha, beta and gamma decay
<b>CO3</b>	Students will learn about nuclear models and nuclear reactions
<b>CO4</b>	Students will learn about Elementary particle Physics

#### **Modules at Glance**

<b>Module No.</b>	<b>Content</b>	<b>No. of Hours</b>	<b>CO Mapping</b>
1	Static properties and measurements in Nuclear Physics	15	CO1
2	Alpha, Beta and Gamma decay	15	CO2
3	Nuclear Models and Nuclear reactions	15	CO3
4	Introduction to the elementary particle Physics	15	CO4

### Syllabus

Module No.	Content	No. of Lectures
<b>1</b>	<p><b>Static properties and measurements in Nuclear Physics</b></p> <ol style="list-style-type: none"> <li>1. All static properties of nuclei (charge, mass, binding energy, size, shape, angular momentum, magnetic dipole moment, electric quadrupole moment, statistics, parity, isospin)</li> <li>2. Measurement of Nuclear size and estimation of <math>R_0</math> (mirror nuclei and mesonic atom method) Deuteron Problem and its ground state properties</li> <li>3. Estimate the depth and size of (assume) square well potential</li> <li>4. Tensor force as an example of non-central force</li> <li>5. nucleon-nucleon scattering- qualitative discussion on results</li> <li>6. Spin-orbit strong interaction between nucleon, double scattering experiment.</li> </ol>	15
<b>2</b>	<p><b>Alpha, Beta and Gamma decay</b></p> <ol style="list-style-type: none"> <li>1. Review of alpha decay</li> <li>2. Introduction to Beta decay and its energetic Fermi theory: derivation of Fermi's Golden rule, Information from Fermi–curie plots, Comparative half-lives, selection rules for Fermi and G-T transitions.</li> <li>3. Gamma decay: Multipole radiation, Selection rules for gamma ray transitions, Gamma ray interaction with matter, and Charge-particle interaction with matter.</li> </ol>	15
<b>3</b>	<p><b>Nuclear Models and Nuclear reactions</b></p> <ol style="list-style-type: none"> <li>1. Nuclear Models: Shell Model (extreme single particle): Introduction, Assumptions, Evidences, Spin-orbit interactions, Predictions including Schmidt lines, limitations, Collective model - Introduction to Nilsson Model.</li> <li>2. Nuclear Reactions: Kinematics, scattering and reaction cross sections, Compound nuclear reaction, direct nuclear reaction. Q-value equation, energy release in fusion and fission reaction.</li> </ol>	15
<b>4</b>	<p><b>Introduction to the elementary particle Physics</b></p> <ol style="list-style-type: none"> <li>1. Introduction to the elementary particle Physics, The Eight fold way, the Quark Model, the November revolution and aftermath, The standard Model</li> <li>2. Revision of the four forces, cross-sections, decays and resonances</li> <li>3. Introduction to Quantum Electrodynamics</li> <li>4. Introduction to Quantum Chromodynamics.</li> <li>5. Weak interactions and Unification Schemes (qualitative description)</li> <li>6. Revision of Lorentz transformations, Four-vectors, Energy and Momentum.</li> <li>7. Properties of Neutrino, helicity of Neutrino, Parity, Qualitative discussion on Parity violation in beta decay and Wu's Experiment,</li> </ol>	15

	Charge conjugation, Time reversal, Qualitative introduction to CP violation and TCP theorem	
<b>Case Study Scenario</b>		
<b>M1</b>	<p>In a nuclear reactor, Uranium-235 undergoes fission and releases neutrons. These neutrons cause further fission, creating a chain reaction. Initially, the reactor is working in a stable condition. Suddenly, more neutrons are produced, and the reaction becomes faster.</p> <p>Explain in simple terms:</p> <ol style="list-style-type: none"> <li>1. What is a nuclear chain reaction?</li> <li>2. What happens when the reactor becomes supercritical?</li> <li>3. How do control rods help in controlling the reaction?</li> </ol>	
<b>M2</b>	<p>A worker in a nuclear laboratory is accidentally exposed to radiation due to improper shielding. The exposure is small but continuous over time.</p> <p>Answer the following:</p> <ol style="list-style-type: none"> <li>1. What is nuclear radiation?</li> <li>2. Name two types of nuclear radiation</li> <li>3. What are the possible effects of radiation on the human body?</li> <li>4. Suggest two safety measures to reduce radiation exposure</li> </ol>	

**Reference Books:**

1. Introductory Nuclear Physics, Kenneth Krane, Wiley India Pvt. Ltd.
2. Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles, Robert Eisberg and Robert Resnick, Wiley (2006)
3. Introduction to Elementary Particles, David Griffith, John Wiley and sons

**Other References:**

1. Introduction to Nuclear Physics, H. A. Enge, Eddison Wesley
2. Nuclei and Particles, E. Segre, W. A. Benjamin
3. Concepts of Nuclear Physics, B. L. Cohen
4. Subatomic Particles, H. Fraunfelder and E. Henley, Prentice Hall
5. Nuclear Physics : Experimental and Theoretical, H. S. Hans, New Age International

**Semester End Evaluation (50 Marks)**

**Time : 2 Hours**

**Paper Pattern**

Question No.	Questions	Total Marks : 50
Q1	Attempt 3 out of 5	15
Q2	Attempt 3 out of 5	15
Q3	Attempt 3 out of 5	15
Q4	Case Study	05

<b>BOS</b>	<b>Natural and Physical Sciences</b>				
<b>Course</b>	<b>Electronics</b>				
<b>Course Code</b>	<b>HPSPH202</b>	<b>Level</b>	<b>6.5</b>		
		<b>Type</b>	<b>Theory</b>	<b>Practical</b>	<b>Total</b>
<b>Semester</b>	<b>III</b>	<b>Credits</b>	4	“-”	4
<b>Type</b>	<b>Major</b>	<b>No of Teaching Hours</b>	60	“-”	60
<b>Evaluation Pattern</b>	<b>Total Marks</b>	<b>Semester End</b>	<b>Continuous</b>	<b>Practical</b>	
	100	50	50	“-”	

<b>Learning Objectives</b>	
<b>1</b>	Explain the fundamental principles, internal operation, and practical applications of operational amplifiers in electronic circuits.
<b>2</b>	Analyze and apply operational amplifiers in the design of filters, oscillators, and other signal-processing circuits.
<b>3</b>	Differentiate and interpret the functioning of combinational and sequential logic circuits, including the operation of D/A and A/D converters.
<b>4</b>	Explain the 8051 architecture and write assembly programs for timers, interrupts, and serial communication.

<b>Course Outcomes</b>	
After successful completion of this course, students would be able to: -	
<b>CO1</b>	Describe the fundamental principles, operation, and applications of the operational amplifier.
<b>CO2</b>	Understand the applications of operational amplifiers, particularly in filters, oscillators, and related circuits.
<b>CO3</b>	Demonstrate an understanding of combinational and sequential circuits, along with D/A and A/D converters.
<b>CO4</b>	Explain the 8051 architecture and implement programming for timers, counters, interrupts, and serial communication using assembly language.

### Modules at Glance

<b>Module No.</b>	<b>Content</b>	<b>No. of Hours</b>	<b>CO Mapping</b>
1	Operational Amplifier	15	CO1
2	Active Filters and Nonlinear Applications	15	CO2
3	Multiplexers, ADC and DAC	15	CO3
4	8051 Microcontroller	15	CO4

## Syllabus

Module No.	Content	No. of Lectures
<b>1</b>	<p><b>Operational Amplifier</b></p> <ol style="list-style-type: none"> <li>1. The Operational Amplifier, Block Diagram, Representation of a Typical OPAMP, Schematic Symbol.</li> <li>2. The Ideal OPAMP, Ideal Voltage Transfer Curve, Open Loop Configurations,</li> <li>3. The Practical OPAMP, Input off-set Voltage ,Input Bias Current, Input Offset Current, Common Mode Configuration &amp; CMRR,</li> <li>4. Frequency Response, Closed loop frequency response, Slew Rate</li> <li>5. Summing Scaling and Averaging Amplifiers- Voltage to Current Converter ( with Floating Load and Grounded Load), Current to Voltage Converter,</li> <li>6. The Integrator- The Differentiator.</li> </ol>	15
<b>2</b>	<p><b>Active Filters and Nonlinear Applications</b></p> <ol style="list-style-type: none"> <li>1. Introduction-Active filters, First order low-pass Butterworth Filter, First order high pass butterworth filter</li> <li>2. Oscillators, Square wave generator, triangular wave generator, saw tooth wave generator</li> <li>3. Basic Comparator, Zero Crossing Detector, Schmitt Trigger, Comparator Characteristics</li> <li>4. Limitations of OPAMP as Comparator, Voltage Limiters. (Book 3: 7.1, 7.2, 7.3, 7.5, 7.11, 7.15, 7.16, 7.17, 8.2, 8.3, 8.4,8.5, 8.6, 8.7)</li> </ol>	15
<b>3</b>	<p><b>Multiplexers, ADC and DAC</b></p> <ol style="list-style-type: none"> <li>1. Applications of Multiplexers, Demultiplexers (Book 4: 7.24, 7.25 &amp; 7.26)</li> <li>2. Flip-flops and Timing circuits: Introduction, Classification of sequential circuits</li> <li>3. Latches and flip flops, Asynchronous inputs, flip-flop operating characteristics</li> <li>4. Clock skew and time race, Race around condition, Master slave flip flops,</li> <li>5. Application of flip flops. (Book 4: 10.1 to 10.12)</li> <li>6. Analog to Digital &amp; Digital to Analog Converters: Introduction, Digital to Analog conversion, The R-2R ladder type DAC, The weighted resistor type DAC, The counter type ADC, The Successive approximation type ADC (Book 4: 17.1, 17.2, 17.3, 17.4, 17.7,17.8 &amp; 17.12)</li> </ol>	15
<b>4</b>	<p><b>8051 Microcontroller</b></p> <ol style="list-style-type: none"> <li>1. Pin diagram, Timer/Counters, Interrupts, Serial communication Programming 8051 Timers, Counter Programming (MMM - Ch 9: 9.1, 9.2)</li> </ol>	15

	2. Basics of Serial Communication, 8051 Connection to RS232, 8051 Serial Port Programming in assembly. (MMM - Ch 10: 10.1, 10.2, 10.3 8051) 3. Interrupts, Programming Timer Interrupts, Programming External hardware Interrupts. 4. Programming the Serial Communication Interrupt, Interrupt Priority in 8051/52.	
<b>Case Study Scenario</b>		
<b>M1</b>	Design a second-order active high-pass filter using an operational amplifier for a cutoff frequency of 5 kHz. Draw the circuit diagram, select suitable component values, and explain the working of the circuit.	
<b>M2</b>	Describe the steps involved in programming the timer in mode 2 of the microcontroller.	

**Reference Books:**

- (a) Principles of Electronics – V. K. Mehta and Rohit Mehta. (S. Chand –Multicolour revised edition).
- (b) Electronic Devices and Circuit Theory (Eleventh Edition)- Robert L. Boylested & Louis Nashelsky (PHI)
- (c) OPAMPs and Linear Integrated Circuits (Fourth Edition)- Ramakanth A.Gayakwad (Pearson).
- (d) Fundamentals of Digital Circuits (Fourth Edition) - A. Anand Kumar (PHI).
- (e) Electronic devices and circuits – An introduction Allan Mottershead (PHI Pvt. Ltd.– EEE – 1986).
- (f) Digital Principles and Applications - Leach, Malvino, Saha\_ 6th edition.
- (g) Electronic Principles (SIE) -7th edition by Albert Malvino and Daviid J Bates.
- (h) MMM- The 8051 Microcontroller & Embedded Systems by M.A. Mazidi, J.G. Mazidi and R.D. Mckinlay, Second Edition, Pearson.
- (i) Microcontrollers by Ajay V. Deshmukh, Tata-Mcgraw Hill Publication.
- (j) Microcontrollers by Ajay V. Deshmukh, Tata-Mcgraw Hill Publication.

**Semester End Evaluation (50 Marks)**

**Time : 2 Hours**

**Paper Pattern**

<b>Question No.</b>	<b>Questions</b>	<b>Total Marks : 50</b>
Q1	Attempt 3 out of 5	15
Q2	Attempt 3 out of 5	15
Q3	Attempt 3 out of 5	15
Q4	Case Study	05

<b>BOS</b>	<b>Natural and Physical Sciences</b>				
<b>Course</b>	<b>Statistical and Thermal Physics</b>				
<b>Course Code</b>	<b>HPSPH203</b>	<b>Level</b>	<b>6.5</b>		
		<b>Type</b>	<b>Theory</b>	<b>Practical</b>	<b>Total</b>
<b>Semester</b>	<b>III</b>	<b>Credits</b>	4	-	4
<b>Type</b>		<b>No of Teaching Hours</b>	60	-	60
<b>Evaluation Pattern</b>	<b>Total Marks</b>	<b>Semester End</b>	<b>Continuous</b>	<b>Practical</b>	
	100	50	50	-	

<b>Learning Objectives</b>	
<b>1</b>	Explain the fundamentals of thermodynamics, distinguish between microscopic and macroscopic states, and describe the microcanonical ensemble.
<b>2</b>	Analyze thermodynamic systems using the canonical ensemble and compute related statistical quantities.
<b>3</b>	Apply the grand canonical ensemble to systems with variable particle number and interpret physical significance.
<b>4</b>	Describe the principles of quantum statistics and compare classical and quantum mechanical ensembles.

<b>Course Outcomes</b>	
After successful completion of this course, students would be able to: -	
<b>CO1</b>	Know about basics of Thermodynamics, Microscopic and macroscopic states, microcanonical ensemble etc.
<b>CO2</b>	Gain knowledge about canonical ensemble
<b>CO3</b>	Gain knowledge about Grand canonical ensemble
<b>CO4</b>	Know about basics of quantum statistics, quantum mechanical ensemble

### Modules at Glance

<b>Module No.</b>	<b>Content</b>	<b>No. of Hours</b>	<b>CO Mapping</b>
1	Statistical Foundations of Thermodynamics	15	CO1
2	Canonical Ensemble Theory	15	CO2
3	Grand Canonical Ensemble Theory	15	CO3
4	Quantum Statistical Mechanics	15	CO4

## Syllabus

Module No.	Content	No. of Lectures
1	<p><b>Statistical Foundations of Thermodynamics</b>                      The Statistical Basis of Thermodynamics - The macroscopic and the microscopic states, contact between statistics and thermodynamics, the simple random walk problem in one dimension, the classical ideal gas, The entropy of mixing and the Gibbs paradox, the enumeration of the microstates Elements of Ensemble Theory - Phase space of a classical system, Liouville's theorem and its consequences. The microcanonical ensemble - Examples Quantum states and the phase space</p>	15
2	<p><b>Canonical Ensemble Theory:</b>                      The Canonical Ensemble - Equilibrium between a system and a heat reservoir, a system in the canonical ensemble, physical significance of the various statistical quantities in the canonical ensemble, expressions of the partition function, the classical systems, energy fluctuations in the canonical ensemble, correspondence with the microcanonical ensemble, the equipartition theorem and the virial theorem, system of harmonic oscillators, statistics of paramagnetism, thermodynamics of magnetic systems.</p>	15
3	<p><b>Grand Canonical Ensemble Theory:</b>                      The Grand Canonical Ensemble - Equilibrium between a system and a particle-energy reservoir, a system in the grand canonical ensemble, physical significance of the various statistical quantities, Examples, Density and energy fluctuations in the grand canonical ensemble, correspondence with other ensembles.</p>	15
4	<p><b>Quantum Statistical Mechanics:</b>                      Formulation of Quantum Statistics - Quantum-mechanical ensemble theory: the density matrix, Statistics of the various ensembles, Examples, systems composed of indistinguishable particles, the density matrix and the partition function of a system of free particles.                      Note: Problems form an integral part of the course</p>	15
<b>Case Study Scenario</b>		
M1	<p>A container is filled with gas molecules that move randomly in one dimension due to thermal motion. A researcher models the motion of a molecule as a simple random walk to understand how microscopic motion leads to macroscopic diffusion behaviour.</p> <ul style="list-style-type: none"> <li>● What is meant by a microstate in the context of molecular motion?</li> <li>● How does a one-dimensional random walk represent molecular motion?</li> </ul>	
M2	<p>Two containers hold ideal gases at the same temperature and pressure. In Experiment A, the gases are different (e.g., O<sub>2</sub> and N<sub>2</sub>). In Experiment B, the gases are identical. The partition between the containers is removed and entropy change is studied.</p> <ul style="list-style-type: none"> <li>● Define entropy of mixing.</li> <li>● Why does entropy increase when two different gases mix?</li> <li>● What does Gibbs paradox predict for identical gases?</li> </ul>	

**Reference Books:**

1. Statistical Mechanics - R. K. Pathria & Paul D. Beale (Third Edition), Elsevier 2011 – Chap. 1 to 5
2. Fundamentals of Statistical and Thermal Physics – Fedrick Rief, McGraw Hill Series in Fundamental Physics, (1965)
3. Thermodynamics and Statistical Mechanics, Greiner, Neise and Stocker, Springer 1995.
4. Introduction to Statistical Physics, Kerson Huang, Taylor and Francis 2001.
5. Thermal and Statistical Physics, F Reif.
6. Statistical Physics, D Amit and Walecka.
7. Statistical Mechanics, Kerson Huang.
8. Statistical Mechanics, J.K. Bhattacharjee.
9. Non-equilibrium Statistical Mechanics, J.K. Bhattacharjee.
10. Statistical Mechanics, Richard Feynman.
11. Statistical Mechanics, Landau and Lifshitz. 10. Thermodynamics, H.B. Callen

**Semester End Evaluation (50 Marks)****Time : 2 Hours****Paper Pattern**

<b>Question No.</b>	<b>Questions</b>	<b>Total Marks : 50</b>
Q1	Attempt 3 out of 5	15
Q2	Attempt 3 out of 5	15
Q3	Attempt 3 out of 5	15
Q4	Case Study	05

<b>BOS</b>	<b>Natural and Physical Sciences</b>				
<b>Course</b>	<b>Semiconductor Physics and Renewable Energy</b>				
<b>Course Code</b>	<b>HPSPH204</b>	<b>Level</b>	<b>6.5</b>		
		<b>Type</b>	<b>Theory</b>	<b>Practical</b>	<b>Total</b>
<b>Semester</b>	<b>III</b>	<b>Credits</b>	4	-	4
<b>Type</b>	<b>Major</b>	<b>No of Teaching Hours</b>	60	-	60
<b>Evaluation Pattern</b>	<b>Total Marks</b>	<b>Semester End</b>	<b>Continuous</b>	<b>Practical</b>	
	100	50	50	-	

<b>Learning Objectives</b>	
<b>1</b>	Explain the charge transport mechanism and current–voltage characteristics of p–n junction, tunnel diode, and Schottky barrier diode.
<b>2</b>	Analyze heterojunction band structures and evaluate the working and efficiency of semiconductor optical devices such as solar cells.
<b>3</b>	Understand the scientific principles and technological aspects of major renewable energy systems.
<b>4</b>	Analyze performance, efficiency, and environmental impact of renewable energy technologies.

<b>Course Outcomes</b>	
After successful completion of this course, students would be able to: -	
<b>CO1</b>	Understand and compare the operating principles and I–V characteristics of different semiconductor diodes.
<b>CO2</b>	Apply heterojunction concepts to interpret the performance of semiconductor optical devices, including solar cells.
<b>CO3</b>	Evaluate different renewable energy technologies and compare their feasibility for specific applications.
<b>CO4</b>	Apply technical knowledge to assess renewable energy systems considering efficiency, sustainability, and economic factors.

### Modules at Glance

<b>Module No.</b>	<b>Content</b>	<b>No. of Hours</b>	<b>CO Mapping</b>
1	Diodes	15	CO1
2	Semiconductor Heterojunctions & Optical Device	15	CO2
3	Solar and Wind Energy Systems	15	CO3
4	Bioenergy, Hydro and Emerging Renewable Technologies	15	CO4

## Syllabus

Module No.	Content	No. of Lectures
<b>1</b>	<p><b>Diode</b></p> <ol style="list-style-type: none"> <li>1. Qualitative Description of Charge Flow in a p-n Junction</li> <li>2. Ideal Current–Voltage Relationship</li> <li>3. Boundary Conditions</li> <li>4. Temperature Effects</li> <li>5. The tunnel diode</li> <li>6. The Schottky barrier diode and their qualitative Characteristics</li> <li>7. Ideal Junction Properties ; Current–Voltage Relationship,</li> <li>8. Comparison of the Schottky Barrier Diode and the p-n Junction Diode</li> </ol> <p>Chap. 8: 8.0, 8.1, 8.1.1, 8.1.2, 8.1.3. Chap. 9: 9.0, 9.1, 9.12, 9.15</p>	15
<b>2</b>	<p><b>Semiconductor Heterojunctions &amp; Optical Device</b></p> <ol style="list-style-type: none"> <li>1. Heterojunctions, Heterojunctions material, Energy-Band Diagrams, Two-Dimensional Electron Gas, Equilibrium Electrostatics, Current–Voltage Characteristics.</li> <li>2. Optical Devices, Optical absorption, LASER, He-Ne and CO<sub>2</sub> LASER</li> </ol> <p>Chap. 9: 9.3, 9.3.1, 9.3.3, 9.3.4, 9.3.5, Chap 14: 14.0, 14.1, 14.6</p>	15
<b>3</b>	<p><b>Solar and Wind Energy Systems</b></p> <ol style="list-style-type: none"> <li>1. Global energy scenario and need for renewable energy</li> <li>2. Solar radiation: measurement and estimation</li> <li>3. Solar thermal energy: flat plate and concentrating collectors</li> <li>4. Solar photovoltaic (PV) systems: principle, materials, I–V characteristics</li> <li>5. Energy storage systems for solar applications</li> <li>6. Wind energy: origin of wind, wind energy potential</li> <li>7. Wind turbine components and working principle</li> <li>8. Betz limit and power coefficient</li> <li>9. Grid integration and performance assessment of wind energy systems</li> </ol>	15

<b>4</b>	<b>Bioenergy, Hydro and Emerging Renewable Technologies</b> <ol style="list-style-type: none"> <li>1. Biomass energy sources and conversion methods (thermochemical and biochemical)</li> <li>2. Biogas plants: construction and working</li> <li>3. Small hydropower systems: classification and working principle</li> <li>4. Ocean energy: tidal, wave, and Ocean Thermal Energy Conversion (OTEC) (qualitative study)</li> <li>5. Geothermal energy resources and power generation</li> <li>6. Hydrogen energy and fuel cells</li> <li>7. Energy storage technologies (battery, pumped storage, hydrogen storage)</li> <li>8. Environmental and economic aspects of renewable energy systems</li> <li>9. Policy framework and sustainability considerations</li> </ol>	15
<b>Case Study Scenario</b>		
<b>M1</b>	<p>An electronics company is designing a high-frequency switching circuit for a communication system. The engineer must choose between a p–n junction diode, tunnel diode, and Schottky barrier diode to achieve fast switching with minimal power loss.</p> <ol style="list-style-type: none"> <li>1. Compare the I–V characteristics of the three diodes.</li> <li>2. Which diode is most suitable for high-speed operation? Justify.</li> </ol>	
<b>M2</b>	<p>A wind turbine with rotor diameter 40 m operates at a site where average wind speed is 10 m/s. Air density, <math>\rho = 1.225 \text{ kg/m}^3</math>, Power coefficient (<math>C_p</math>) = 0.42 and Mechanical and electrical efficiency combined = 85%. Calculate the swept area of the turbine and the total power available in the wind.</p>	

**Reference Books:**

- (a) Semiconductor Physics and Devices, Basic Principles, Donald A. Neamen, Fourth edition, University of New Mexico
- (b) Renewable Energy: Power for a Sustainable Future” by Godfrey Boyle (Ed.)
- (c) Solar Engineering of Thermal Processes” — John A. Duffie & William A. Beckman
- (d) Wind Energy Explained: Theory, Design and Application” — J.F. Manwell, J.G. McGowan & A.L. Rogers
- (e) Renewable and Efficient Electric Power Systems” — Gilbert M. Masters

**Semester End Evaluation (50 Marks)**

**Time : 2 Hours**

**Paper Pattern**

Question No.	Questions	Total Marks : 50
Q1	Attempt 3 out of 5	15
Q2	Attempt 3 out of 5	15
Q3	Attempt 3 out of 5	15
Q4	Case Study	05

<b>BOS</b>	<b>Natural and Physical Sciences</b>				
<b>Course</b>	<b>Practical III</b>				
<b>Course Code</b>	<b>HPSPH205P</b>	<b>Level</b>	<b>6</b>		
		<b>Type</b>	<b>Theory</b>	<b>Practical</b>	<b>Total</b>
<b>Semester</b>	<b>III</b>	<b>Credits</b>	-	2	2
<b>Type</b>	<b>Practical</b>	<b>No of Teaching Hours</b>	-	60	60
<b>Evaluation Pattern</b>	<b>Total Marks</b>	<b>Semester End</b>	<b>Continuous</b>	<b>Practical</b>	
	50	-	-	50	

<b>Learning Objectives</b>	
<b>1</b>	Design and verify op-amp based filters, oscillators, and waveform generation circuits.
<b>2</b>	Construct and test basic op-amp circuits such as inverting, non-inverting, and summing amplifiers.
<b>3</b>	Explain and test combinational and sequential logic circuits and examine the operation of D/A and A/D converters.
<b>4</b>	To develop fundamental skills in programming 8051 microcontrollers using assembly language.

<b>Course Outcomes</b>	
After successful completion of this course, students would be able to: -	
<b>CO1</b>	Design and verify op-amp based filters, oscillators, and waveform generation circuits
<b>CO2</b>	Apply operational amplifier principles to design and analyze basic analog circuits such as amplifiers, filters, oscillators, and waveform generators.
<b>CO3</b>	Demonstrate an understanding of combinational and sequential circuits, along with D/A and A/D converters.
<b>CO4</b>	Apply 8031/8051 assembly programming to control I/O devices and implement timers, counters, and interrupts for real-time applications.

### Modules at Glance

<b>Module No.</b>	<b>Content</b>	<b>No. of Hours</b>	<b>CO Mapping</b>
1	<b>Group A: Op Amp Applications, ADC and DAC</b>	30	CO1,CO2, CO3,CO4
2	<b>Group B: Microcontroller 8031/8051 based experiments</b>	30	CO1, CO2, CO3,CO4

## Syllabus

Sr. No.	Content	No. of Lectures	CO Mapping
1	<b>Group A: Op Amp Applications, ADC and DAC (Any 4)</b> <ol style="list-style-type: none"> <li>1. Phase Shift Oscillator</li> <li>2. Second order active high pass filter</li> <li>3. Second order active low pass filter</li> <li>4. Second order active band pass filter</li> <li>5. Multiplexer and Decoder</li> <li>6. Digital to Analog Converter (DAC)/Analog to Digital Converter(ADC)</li> <li>7. Op Amp Integrator and Differentiator</li> </ol>	60	CO1, CO2, CO3, CO4
2	<b>Group B: Microcontroller 8031/8051 based experiments: (Any two)</b> 8031/51 assembly language programming: <ol style="list-style-type: none"> <li>1. Study of IN and OUT port of 8031/51 by Interfacing switches, LEDs and Relays: to display bit pattern on LED's, to count the number of "ON" switches and display on LED's, to trip a relay depending on the logic condition of switches, event counter (using LDR and light source)</li> <li>2. Study of external interrupts (INT0/INT1) of 8031/51.</li> <li>3. Study of internal timer and counter in 8031/51.</li> <li>4. Interfacing 7-Segment Display in the multiplexing mode: to display a two-digit number.</li> </ol>		

### References:

1. 8031/8051 Manual Provided by the manufacturers
2. Microcontrollers by Ajay V. Deshmukh, Tata-McGraw Hill Publication
3. The 8051 Microcontroller & Embedded Systems by M.A. Mazidi, J.G. Mazidi and R.D. Mckinlay, Second Edition, Pearson
4. Principles of Electronics – V. K. Mehta and Rohit Mehta. (S. Chand –Multicolour revised edition).
5. OPAMPs and Linear Integrated Circuits (Fourth Edition)- Ramakanth A.Gayakwad (Pearson).

### Semester End Practical Evaluation

**Time: 2 Hours**

Question No.	Questions	Total Marks
Q.1	Experiment	30
Q.2	Journal	10
Q.3	Viva	10

**Note:**

1. Minimum number of four experiments from Group A and any two experiments from Group B to be performed and reported in the journal.
2. Evaluation in viva voce will be based on regular experiments.
3. After completing the required number of experiments in the semester and recording them in a journal, students will have to get their journal certified and produce the certified journal at the time of practical examination to be eligible to appear in the Semester End Practical Examination.
4. For practical examinations, the learner will be examined in one experiment from the list of experiments. Evaluation in viva voce will be based on regular experiments. A learner will be allowed to appear for the semester end practical examination only if he/she submits a certified journal with a certificate that the learners has completed the practical course respective semester as per the minimum requirements. The questions on slips for the same should be framed in such a way that the candidate will be able to complete the task within the specified time.

**Research Project**

The National Education Policy (NEP) 2020 emphasizes the importance of research at the postgraduate level as a way to enhance the quality of higher education in India. Research projects are vital for advancing knowledge and fostering innovation across various fields. They enhance critical thinking and problem-solving skills, allowing individuals to analyse complex issues and develop effective solutions. Engaging in research cultivates essential skills such as data analysis, scientific writing, and project management, while also providing opportunities for collaboration and networking with peers and experts. Furthermore, research projects address societal challenges by generating evidence-based solutions that inform public policy and improve community well-being. Ultimately, they contribute not only to personal growth and employability but also to the collective understanding of pressing issues, making them indispensable in both academic and professional contexts.