**Anekant Education Society's**

# Tuljaram Chaturchand College

**of Arts, Science and Commerce, Baramati**

***(Autonomous)***

**M.Sc. Degree Program in Physics**

**(Faculty of Science & Technology)**

**CBCS Syllabus**

**M.Sc. Part – II (Physics) Semester – III**

**For**

**Department of Physics**

**Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati**

**Choice Based Credit System Syllabus (2023 Pattern)**

**(As Per NEP 2020)**

**To be implemented from Academic Year 2024-2025**

# PREAMBLE

Physics, a core discipline, is the fundamental and foremost to all natural sciences. It has been significant and influential through advances in its understanding that have translated into new technologies. Physics interact with the society and other discipline such as Medicine, Chemistry, Agriculture, Engineering etc. in many important ways. Physics Department in Tuljaram Chaturchand College has highly qualified faculty members and support staffs and is committed towards the development of innovative and handy ways of teaching at graduate, post graduate and developing a core research group for carrying out cutting edge research in various research fields like Condensed Matter Physics, Solid State Physics, Electronics, Theoretical Physics, Atomic & Molecular Physics and Nuclear Physics. The department also offers Doctoral Programme in order to nurture young minds towards embracing various scientific challenges. Extra care is taken to pay individual attention to the students in their laboratory work and tutorial sessions. Project work and problem sessions are encouraged to develop innovative and analytical approach to physics learning.

# Programme Outcomes (POs)

| | |
|---|---|
| PO1 | **Comprehensive Knowledge and Understanding:** Postgraduates will possess a profound understanding of their field, encompassing foundational theories, methodologies, and key concepts within a multidisciplinary context. |
| PO2 | **Practical, Professional and Procedural Knowledge:** Postgraduates will acquire practical skills and expertise necessary for professional tasks, including industry standards, regulations and ethical considerations, with effective application in real-world scenarios**.** |
| PO3 | **Entrepreneurial Mindset, Innovation and Business Understanding:** Postgraduates will cultivate an entrepreneurial mindset, identify opportunities, foster innovation and understand business principles, market dynamics, and risk management strategies. |
| PO4 | **Specialized Skills, Critical Thinking, and Problem-Solving:** Postgraduates will demonstrate proficiency in technical skills, analytical abilities, effective communication and leadership, adapting and innovating in response to changing circumstances. |
| PO5 | **Research, Analytical Reasoning and Ethical Conduct:** Postgraduates will exhibit observational and inquiry skills, formulate research questions, utilize appropriate methodologies for data analysis and adhere to research ethics while effectively reporting findings. |
| PO6 | **Communication, Collaboration, and Leadership:** Postgraduates will effectively communicate complex information, collaborate in diverse teams, demonstrate leadership qualities and facilitate cooperative efforts toward common goals. |
| PO7 | **Digital Proficiency and Technological Skills:** Postgraduates will demonstrate proficiency in using ICT, accessing information sources, analyzing data using appropriate software and adapting to technological advancements. |
| PO8 | **Multicultural Competence, Inclusive Spirit and Empathy:** Postgraduates will engage effectively in multicultural settings, respect diverse perspectives, lead diverse teams and demonstrate empathy and understanding of others' perspectives and emotions. |
| PO9 | **Value Inculcation, Environmental Awareness and Ethical Practices:** Postgraduates will embrace ethical and moral values, practice responsible citizenship, recognize and address ethical issues and promote sustainability and environmental conservation. |
| PO10 | **Autonomy, Responsibility and Accountability:** Postgraduates will apply knowledge and skills independently, manage projects effectively and demonstrate responsibility and accountability in work and learning contexts, contributing to societal well-being. |

## Credit Distribution Structure for M.Sc. Part-I (Physics)

| **Sem. (2 Yr.)** | **Major** | | **Research Methodology (RM)** | **OJT/ FP** | **R P** | **Cum. Cr.** | **Degree** |
|---|---|---|---|---|---|---|---|
| | **Mandatory** | **Electives** | | | | | |
| Sem-I | PHY-501-MJM: Mathematical Methods in Physics (Credit 04) | PHY-511-MJE:<br>A. Classical Mechanics<br>B. Electronics<br>C. Physics of Thin Films-I<br>(Credit 04) | PHY-521-RM Research Methodology<br>(Credit 04) | -- | - | 20 | PG Diploma (after 3 Year Degree) |
| | PHY-502-MJM: Classical Electrodynamics (Credit 04) | | | | | | |
| | PHY-503-MJM: Physics Laboratory-I (Credit 02) | | | | | | |
| | PHY-504-MJM: Physics Laboratory-II (Credit 02) | | | | | | |
| Sem- II | PHY-551-MJM: Atoms, Molecules and Laser (Credit 04) | PHY-561-MJE:<br>A. Physics of Semiconductor Devices<br>B. Biophysics<br>C. Physics of Thin Films-II<br>(Credit 04) | -- | PHY-581-OJT/FP (Credit 04) | - | 20 | |
| | PHY-552-MJM: Quantum Mechanics (Credit 04) | | | | | | |
| | PHY-553-MJM: Physics Laboratory-III (Credit 02) | | | | | | |
| | PHY-554-MJM: Physics Laboratory-IV (Credit 02) | | | | | | |

## Credit Distribution Structure for M.Sc. Part-II (Physics)

<table>
<tr><th rowspan="2">Sem. (2 Yr.)</th><th colspan="2">Major</th><th rowspan="2">RM</th><th rowspan="2">OJT/ FP</th><th rowspan="2">RP</th><th rowspan="2">Cum. Cr.</th><th rowspan="2">Degree</th></tr>
<tr><th>Mandatory</th><th>Electives</th></tr>
<tr><td rowspan="4">Sem-III</td><td>PHY-601-MJM: Statistical Physics (Credit 04)</td><td rowspan="4">PHY-611-MJE:<br>A. Experimental Techniques in Physics-I<br>B. Laser<br>C. Energy Studies-I<br>(Credit 02)<br>PHY-612-MJE: Practicals (Credit 02)</td><td rowspan="4"></td><td rowspan="4">--</td><td rowspan="4">PHY-621: Research Project<br>(Credit 04)</td><td rowspan="4">20</td><td rowspan="8"></td></tr>
<tr><td>PHY-602-MJM: Solid State Physics (Credit 04)</td></tr>
<tr><td>PHY-603-MJM: Physics Laboratory-V (Credit 02)</td></tr>
<tr><td>PHY-604-MJM: Physics Laboratory-VI (Credit 02)</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td rowspan="3">Sem-IV</td><td>PHY-651-MJM: Nuclear Physics (Credit 04)</td><td rowspan="3">PHY-661-MJE:<br>A. Experimental Techniques in Physics-II<br>B. Nanotechnology<br>C. Energy Studies-II<br>(Credit 02)<br>PHY-662-MJE: Practicals (Credit 02)</td><td rowspan="3">--</td><td rowspan="3">-</td><td rowspan="3">PHY-681: Research Project<br>(Credit 06)</td><td rowspan="3">20</td></tr>
<tr><td>PHY-652-MJM: Material Science (Credit 04)</td></tr>
<tr><td>PHY-653-MJM: Physics Laboratory-VII (Credit 02)</td></tr>
</table>

## Course Structure for M.Sc. Part-II(Physics)(2023 Pattern)

| Sem | Course Type | Course Code | Course Name | Theory/ Practical | No. of Credits |
|---|---|---|---|---|---|
| III | Major (Mandatory) | PHY-601-MJM | Statistical Physics | Theory | 4 |
| | Major (Mandatory) | PHY-602-MJM | Solid State Physics | Theory | 4 |
| | Major (Mandatory) | PHY-603- MJM | Practical Lab-V | Practical | 2 |
| | Major (Mandatory) | PHY-604-MJM | Practical Lab-VI | Practical | 2 |
| | Major (Elective) | PHY-611-MJE (A) | ETP-I | Theory | 2 |
| | | PHY-612-MJE (A) | ETP-I Practicals | Practical | 2 |
| | | PHY-611-MJE (B) | LASER | Theory | 2 |
| | | PHY-612-MJE (B) | Laser Practicals | Practical | 2 |
| | | PHY-611-MJE (C) | Energy Studies-I | Theory | 2 |
| | | PHY-612-MJE (C) | Energy Studies-I Practicals | Practical | 2 |
| | Research Project | PHY-621-RP | Research Project | | 4 |
| | | | **Total Credit Semester-III** | | **20** |
| IV | Major (Mandatory) | PHY-651-MJM | Nuclear Physics | Theory | 4 |
| | Major (Mandatory) | PHY-652-MJM | Material Science | Theory | 4 |
| | Major (Mandatory) | PHY-653- MJM | Physics Laboratory-VII | Practical | 2 |
| | Major (Elective) | PHY-661-MJE (A) | ETP-II | Theory | 2 |
| | | PHY-662-MJE (A) | ETP-II Practicals | Practical | 2 |
| | | PHY-661-MJE (B) | Nanotechnology | Theory | 2 |
| | | PHY-662-MJE (B) | Nanotechnology | Practical | 2 |
| | | PHY-661-MJE (C) | Energy Studies-II | Theory | 2 |
| | | PHY-662-MJE (C) | Energy Studies-II Practicals | Practical | 2 |
| | Research Project | PHY-681-RP | Research Project | Project | 6 |
| | | | | **Total Credit Semester-IV** | **20** |
| | | | | **Cumulative Credits Semester III and IV** | **40** |

**SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. II Physics**
**(w. e. from June, 2024)**

Name of the Programme : M.Sc. Physics

Program Code : **PSPH**

Class : **M.Sc. II**

Semester : **III**

Course Type : Major Mandatory Theory

Course Name : **STATISTICAL PHYSICS**

Course Code : **PHY-601-MJM**

No. of Lectures : **60**

No. of Credits : **4**

**PHY-601-MJM: STATISTICAL PHYSICS**

## Course Objectives:

1. To do the calculation of macroscopic (bulk) properties of pure substances and mixtures from the microscopic properties of the molecules and their interactions.
2. To derive the classical thermodynamics of materials in terms of the properties of their constituent particles and the interactions between them.
3. To provide the information on the nature of statistical errors and variations of thermodynamic parameters.
4. To evaluate the laws of classical thermodynamics for macroscopic systems using the properties of its atomic particles.

## Course Outcomes:

After completion of the course, the student should be able to:

CO1: Understand the relevant quantities used to describe macroscopic systems, thermodynamic potentials and ensembles.

CO2: Understand the concepts of statistical errors, partition functions by considering the different types of ensembles.

CO3: Describe the consequences in classical and quantum statistics.

CO4: Understand fermions, bosons and differentiate between FD statistics and BE statistics.

CO5: Show an analytic ability to solve the statistical mechanics problems.

CO6: Explore fluctuations and correlations in statistical systems.

CO7: Understand the connection between classical and quantum statistical mechanics.

## Topics and Learning Points

**Unit 1: Statistical Description and Thermodynamics of Particles (15L)**

Revision: Random walk problem, probability Distribution, Binomial Distribution etc. Specification of the state of the system: Macroscopic and Microscopic states, Phase space, Postulate of equal a priori probability, Probability calculations, Behaviour of density of states, Liouville's theorem (Classical) and constraints, Equilibrium conditions and constraints, Distribution of energy between systems in equilibrium, Approach to thermal equilibrium, Temperature, Heat reservoir, Equilibrium between interacting systems, Problems.

**Unit 2: Classical Statistical Mechanics (15L)**

Ensembles, Micro-canonical ensemble, System in contact with heat reservoir, Canonical ensemble, Applications of canonical ensembles (Paramagnetism, Molecule in an ideal gas, Law of atmosphere), System with specified mean energy, Calculation of mean values and fluctuations in a canonical ensemble, Grand-canonical ensemble, Physical interpretation of $\alpha$, Chemical potential in the equilibrium state, Mean values and fluctuations in grand canonical ensemble, Thermodynamic functions in terms of the Grand partition function, Problems.

**Unit 3: Applications of Statistical Mechanics and Quantum Distribution (15L)**

Calculations of thermodynamic quantities, Ideal monoatomic gas, Gibbs paradox, Equipartition theorem and its Simple applications: i) Mean kinetic energy of a molecule in a gas ii) Brownian motion iii) Harmonic Oscillator, Maxwell velocity distribution and mean values Symmetry of wave functions, Quantum distribution functions, Boltzmann limit of Boson and Fermions gases, Maxwell Boltzmann statistics, B-E statistics, F-D statistics, Evaluation of the partition function, Partition function for diatomic molecules, Equation of state for an ideal gas, Problems.

**Unit 4: Ideal Bose, Fermi Systems and Phase Transitions (15L)**

Photon gas – i) Radiation pressure ii) Radiation density iii) Emissivity iv) Equilibrium number of photons in the cavity. Einstein derivation of plank's law, Bose-Einstein Condensation, Specific heat, Photon gas – Einstein and Debye's model of solids. Mean energy of fermions at absolute zero, Fermi energy as a function of temperature, Phase Transitions, Conditions for phase equilibrium, First order Phase Transition: Clausius - Clapeyron equation, Second order phase transition, The critical indices, Weakly Interacting Gases, Weiss Molecular theory of Paramagnetism, the Ising Model of a Ferromagnetism, Problems

**Reference Books:**

1. Fundamentals of Statistical and Thermal Physics, - F. Reif,

2. Fundamentals of Statistical Mechanics, B.B. Laud, New Age International Publication

3. Statistical Mechanics, R.K. Pathria, Bufferworgh Heinemann (2nd Edition)

4. Statistical Mechanics, K. Huang, John Willey and Sons (2nd Edition)

5. Statistical Mechanics, Satya Prakash and Kedar Nath Ram, Nath Publication (2008)

6. Statistical Mechanics by Loknathan and Gambhir

**Mapping of Program Outcomes with Course Outcomes:**

| Course Outcomes | Program Outcomes | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | 3 | | | | | | | | | 3 |
| **CO2** | | 3 | | 3 | | | | | | 3 |
| **CO3** | 3 | | | | | | | | | 3 |
| **CO4** | 3 | | | | | | | | | 3 |
| **CO5** | | 3 | | 3 | | | | | | 3 |
| **CO6** | | | | | 3 | | | | | 3 |
| **CO7** | | | | | 3 | | | | | 3 |

**Justification**

**PO1: Comprehensive Knowledge and Understanding:**

CO1: Understand the relevant quantities used to describe macroscopic systems, thermodynamic potentials, and ensembles. Weightage: 3

Comprehensive knowledge and understanding are directly linked to understanding fundamental quantities and concepts in statistical mechanics.

CO3: Describe the consequences in classical and quantum statistics. Weightage: 3

A deep understanding of classical and quantum statistics is crucial for comprehensive knowledge and understanding of statistical mechanics.

CO4: Understand fermions, bosons and differentiate between FD statistics and BE statistics.
Weightage: 3

Knowing the statistical behaviours of fermions and bosons is fundamental to comprehensive knowledge and understanding in statistical mechanics.

**PO2: Practical, Professional and Procedural Knowledge:**

CO2: Understand the concepts of statistical errors, partition functions by considering the different types of ensembles. Weightage: 3

Practical knowledge of statistical errors and partition functions is essential for applying statistical mechanics concepts in real-world scenarios.

CO5: Show an analytic ability to solve the statistical mechanics problems. Weightage: 3

The ability to solve statistical mechanics problems analytically is a practical skill directly related to practical, professional and procedural knowledge.

**PO4: Specialized Skills, Critical Thinking, and Problem-Solving:**

CO2: Understand the concepts of statistical errors, partition functions by considering the different types of ensembles. Weightage: 3

Critical thinking and problem-solving skills are essential for understanding statistical errors and partition functions, which are critical aspects of statistical mechanics.

CO5: Show an analytic ability to solve the statistical mechanics problems. Weightage: 3

Specialized skills in analytic problem-solving are directly related to solving statistical mechanics problems effectively.

**PO5: Research, Analytical Reasoning, and Ethical Conduct:**

CO6: Explore fluctuations and correlations in statistical systems. Weightage: 3

Research and analytical reasoning skills are necessary for exploring fluctuations and correlations in statistical systems, while ethical conduct ensures the integrity of the research process.

CO7: Understand the connection between classical and quantum statistical mechanics.

Weightage: 3

Research and analytical reasoning skills are required to understand the connection between classical and quantum statistical mechanics, ensuring rigorous examination of the topic.

**PO10: Autonomy, Responsibility and Accountability:**

All COs: Understand the relevant quantities, statistical errors, consequences in statistics, fermions, bosons, fluctuations, correlations, and the connection between classical and quantum statistics. Weightage: 3

Autonomy, responsibility, and accountability are inherent in the pursuit of understanding these complex concepts, as individuals must take ownership of their learning and application. This is essential for developing digital proficiency and computational skills necessary for data analysis and modelling in statistical mechanics. Similarly, describing consequences in classical and quantum statistics

CO3: Describe the consequences in classical and quantum statistics. Weightage: 2

Enhances students' technological skills by familiarizing them with computational methods and digital tools used in advanced research and analysis.

# SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. II Physics

## (w. e. from June, 2024)

Name of the Programme : M.Sc. Physics

Program Code : **PSPH**

Class : **M.Sc. II**

Semester : **III**

Course Type : Major Mandatory Theory

Course Name : **SOLID STATE PHYSICS**

Course Code : **PHY-602-MJM**

No. of Lectures : **60**

No. of Credits : **4**

### PHY-602-MJM: SOLID STATE PHYSICS

**Course Objectives:**

The course gives an introduction to solid state physics, and will enable the student to employ classical and quantum mechanical theories needed to understand the physical properties of solids.

**Course Outcomes:**

After completion of the course, the student should be able to:

CO1: Explain mechanical, electrical and magnetic properties of solid matter

CO2: Explain simple theories for conduction of heat and electrical current in metals.

CO3: Know the basic physics behind dia, para and ferromagnetism.

CO4: Critically evaluate the approximations needed to build models to understand the solid state.

CO5: Explore the behaviour of magnetic materials, including ferromagnetism, Antiferromagnetism and Paramagnetism.

CO6: Explain the origins of the two energy levels involved in NMR transitions.

CO7: Learn the electronic band structure of carbon nanotubes and how it derived from graphene.

## Topics and Learning Points

**Unit 1: Band Theory of Solids (15L)**

Introduction, nearly free electron model, DC and AC electrical conductivity of metals, Bloch theorem (with proof), Kronig-Penney model, Motion of electron in 1-D according to band theory, Distinction between metals, insulators, and intrinsic semiconductors, Reduced, periodic & extended zone schemes, Cyclotron resonance, Quantization of electronic orbit in a magnetic field.

The electrical conductivity at low temperature, The thermal conductivity of metals, Dielectric Properties of insulators. Macroscopic electrostatic Maxwell equations, Theory of Local Field, Theory of polarizability, Clausius- Mossotti relation, Long- wavelength optical modes in Ionic crystals.

**Unit 2: Diamagnetism and Paramagnetism (15L)**

Introduction, Classical theory of diamagnetism, Langevin theory of Paramagnetism, Quantum theory of Paramagnetism, Paramagnetic susceptibility of conduction electron, Magnetic properties of rare earth ions & iron group ions with graphical representation, Crystal field splitting, Quenching of orbital angular momentum.

**Unit 3: Ferromagnetism, Antiferromagnetism and Ferrimagnetism (15L)**

Introduction, Ferromagnetism: Wiess theory, Curie point, Exchange integral, saturation magnetization and its temperature dependence, Saturation magnetization at absolute zero, ferromagnetic domains, Anisotropy energy, Bloch wall, Quantum theory of ferromagnetism Magnetic resonance, Nuclear magnetic resonance (NMR), The resonance condition, Antiferromagnetism: Neel temperature, Ferrimagnetism: Curie temperature, susceptibility of ferrimagnets.

**Unit 4: Carbon and its oxides (15L)**

**Allotropes of carbon:** Diamond, Graphite, Graphene, Amorphous carbon, Glassy carbon

**Carbon nanostructure:** Fullerenes, Carbon Nanotube (CNTs), Carbon Nanofiber (CNFs), Graphene

**Synthesis methods of graphene oxide:** Original Hummers method, modified Hummers method

**Graphene oxide reduction:** Thermal reduction mechanism, Thermal reduction in various atmospheres

**Graphene:** Applications

**Reference Books:**

1. Introduction to solid states Physics - Charles, Kittle 7th Edition
2. Introductory Solid States Physics – H. P. Myers
3. Solid States Physics - S.O. Pillai (latest edition)
4. Elementary Solid States Physics- M. Ali Omar
5. Problem in Solid State Physics – S.O. Pillai
6. Solid States Physics – A.J. Dekkar
7. Solid states Physics – Wahab
8. Solid State Physics: Neil W. Ashcroft, N. David Mermin
9. Solid States Physics – Ibach & Luth
10. Solid States Physics – C.M.Kacchawa
11. Wet Chemical Synthesis of Graphene for Battery Applications - Ida Johansen

**Mapping of Programme Outcomes with Course Outcomes**

| | **PO**1 | **PO**2 | **PO**3 | **PO**4 | **PO**5 | **PO**6 | **PO**7 | **PO**8 | **PO**9 | **PO**10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO**1 | 3 | | | | | | | | | |
| **CO**2 | | 3 | | | | | | | | |
| **CO**3 | | | | 3 | | | | | | |
| **CO**4 | | | | | 3 | | | | | |
| **CO**5 | | | | | | | | | | 2 |
| **CO**6 | | | | | | | | | | |
| **CO**7 | | | | | | | | | | |

**Justification**

**PO:1 Comprehensive Knowledge and Understanding**

CO :1 Explain mechanical, electrical, and magnetic properties of solid matter.

Weightage: 3

This directly aligns with the goal of possessing a profound understanding of the field. Explaining the properties of solid matter requires foundational knowledge of theories and concepts within a multidisciplinary context.

**PO :2 Practical, Professional, and Procedural Knowledge**

CO :2 Explain simple theories for conduction of heat and electrical current in metals.

Weightage: 3

Understanding theories for heat and electrical conduction in metals is crucial for acquiring practical skills and expertise necessary for professional tasks within the field.

**PO :4 Specialized Skills, Critical Thinking and Problem-Solving**

CO :3 Know the basic physics behind dia, para and ferromagnetism. Weightage: 3

Knowing the physics behind different types of magnetism demonstrates specialized skills and critical thinking necessary for analyzing and understanding magnetic properties.

**PO :5 Research, Analytical Reasoning, and Ethical Conduct**

CO :4Critically evaluate the approximations needed to build models to understand the solid state.

Weightage: 3

This objective directly relates to research, analytical reasoning, and ethical conduct. Critically evaluating approximations in building models requires observational skills, analytical reasoning, and adherence to research ethics.

**PO :10 Autonomy, Responsibility, and Accountability**

CO :5Explore the behaviour of magnetic materials, including ferromagnetism, antiferromagnetism, and Paramagnetism. Weightage: 2

Exploring the behaviour of magnetic materials requires autonomy in understanding the phenomena, responsibility in analysing data, and accountability in interpreting results.

# SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. II Physics

## (w. e. from June, 2024)

Name of the Programme : M.Sc. Physics

Program Code : **PSPH**

Class : **M.Sc. II**

Semester : **III**

Course Type : Major Mandatory Practical

Course Name : **Practical Lab-V**

Course Code : **PHY-603-MJM**

No. of Lectures : **60**

No. of Credits : **2**

**PHY-603-MJM: Practical Lab-V**

## Course Objectives:

The specific learning objectives of this paper are as follows:

1. Understand the depth knowledge of various subjects of Physics.
2. Demonstrate skills and competencies to conduct wide range of scientific experiments.
3. Identify their area of interest in academic and R & D. Perform job in various fields' viz.
4. To provide students a strong foundation education in Physics
5. To provide structured curricula, this supports academic development of students.
6. To provide and prepare the students for employment and higher studies in Physics.
7. To provide a good learning environment for Physics.

**Course Outcomes:**

After completion of the course, the student should be able to:

CO1: The students would be able to have strong foundation knowledge and comprehend the basic concepts and principles in Physics.

CO2: The students would be able to experience a well-resourced environment for learning physics

CO3: To motivate and inspire the students to create deep interest in physics, to develop broad and balanced knowledge and understanding of physical concepts, principles and theories of Physics.

CO4: Learn, design and perform experiments in the labs to demonstrate the concepts, principles and theories learned in the classrooms.

CO5: Develop the ability to apply the knowledge acquired in the classroom and laboratories to specific problems in theoretical and experimental Physics.

CO6: Emphasize the discipline of Physics to be the most important branch of science for pursuing the interdisciplinary and multidisciplinary higher education and/or research in interdisciplinary and multidisciplinary areas.

CO7: Problem solving ability

CO8: Critical Analysis

## List of Experiments

**(Students must perform Any 8 Experiments)**

1. Measurement of focal length of a given convex lens using a laser.
2. ‘e’ by Milikan oil drop method.
3. Determination of Seebeck coefficient and understanding of thermocouple working.
4. To plot the V-I characteristics of the solar cell and hence determine the fill factor.
5. Study of electromagnetic damping.
6. Temperature to frequency convertor (T to F convertor)
7. Deposition of CdS thin film by Spray Pyrolysis and determination of it’s thickness by gravimetric weight difference method.
8. Determination of band gap of given semiconducting thin film using UV-Vis spectrophotometer.
9. Ionic conductivity of NaCl.
10. Determination of the absorption coefficient of transparent liquid.
11. To verify Stefan’s law of radiation.
12. Determination of DC electrical conductivity of semiconducting thin film.

**Mapping of Programme Outcomes with Course Outcomes**

| Course Outcomes | Programme Outcomes (POs) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 |
| CO 1 | 3 | | | | | | | | | |
| CO 2 | 2 | | | | | | | | | |
| CO 3 | | | | | | | | | | |
| CO 4 | | 3 | | | | | | | | |
| CO 5 | | 3 | | | | | | | | |
| CO 6 | | | 2 | | | | | | | |
| CO7 | | | | 3 | | | | | | |
| CO8 | | | | 3 | | | | | | |

**Justification**

**PO1: Comprehensive Knowledge and Understanding**

CO1: The students would be able to have strong foundation knowledge and comprehend the basic concepts and principles in Physics. Weightage: 3

This directly relates to the goal of acquiring comprehensive knowledge and understanding. A strong foundation in basic concepts and principles is fundamental to developing a deep understanding of Physics.

CO2: The students would be able to experience a well-resourced environment for learning physics. Weightage: 2

While a well-resourced environment can enhance understanding, it is not directly tied to comprehensive knowledge. However, it does support the practical, professional, and procedural knowledge (PO2) aspect.

**PO2: Practical, Professional, and Procedural Knowledge**

CO4: Learn, design and perform experiments in the labs to demonstrate the concepts, principles and theories learned in the classrooms. Weightage: 3

This directly aligns with the practical, professional, and procedural knowledge aspect. Hands-on experience in labs helps students apply theoretical knowledge and develop practical skills.

CO5: Develop the ability to apply the knowledge acquired in the classroom and laboratories to specific problems in theoretical and experimental Physics. Weightage: 3

Application of knowledge to solve problems is a key component of practical, professional, and procedural knowledge.

**PO3: Entrepreneurial Mindset, Innovation and Business Understanding**

CO6: Emphasize the discipline of Physics to be the most important branch of science for pursuing interdisciplinary and multidisciplinary higher education and/or research in interdisciplinary and multidisciplinary areas. Weightage: 2

While this does emphasize the importance of Physics in interdisciplinary fields, it is not directly linked to entrepreneurial mindset or business understanding.

**PO4: Specialized Skills, Critical Thinking, and Problem-Solving**

CO7: Problem-solving ability. Weightage: 3

Problem-solving is a critical aspect of specialized skills, critical thinking, and problem-solving.

CO8: Critical Analysis. Weightage: 3

Critical analysis is directly related to developing specialized skills and critical thinking.

## SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. II Physics

## (w. e. from June, 2024)

Name of the Programme : M.Sc. Physics

Program Code : **PSPH**

Class : **M.Sc. II**

Semester : **III**

Course Type : Major Mandatory Practical

Course Name : **Practical Lab-VI**

Course Code : **PHY-604-MJM**

No. of Lectures : **60**

No. of Credits : **2**

**PHY-603-MJM: Practical Lab-V**

### Course Objectives:

**Learning Objectives:** The specific learning objectives of this paper are as follows:

1. Understand the depth knowledge of various subjects of Physics.
2. Demonstrate skills and competencies to conduct wide range of scientific experiments.
3. Identify their area of interest in academic and R & D. Perform job in various fields' viz.
4. To provide students a strong foundation education in Physics.
5. To provide structured curricula, this supports academic development of students.
6. To provide and prepare the students for employment and higher studies in Physics.
7. To provide a good learning environment for Physics.

### Course Outcomes:

After completion of the course, the student should be able to:

CO1: The students would be able to have strong foundation knowledge and comprehend the basic concepts and principles in physics.

CO2: The students would be able to experience a well-resourced environment for learning physics.

CO3: To motivate and inspire the students to create deep interest in Physics, to develop broad and balanced knowledge and understanding of basic concepts, principles, and theories of physics.

CO4: Learn, design and perform experiments in the labs to demonstrate the concepts, principles and theories learned in the classrooms.

CO5: Develop the ability to apply the knowledge acquired in the classroom and laboratories to specific problems in theoretical and experimental Physics.

CO6: Emphasize the discipline of Physics to be the most important branch of science for pursuing the interdisciplinary and multidisciplinary higher education and/or research in interdisciplinary and multidisciplinary areas.

CO7: The students would be able to experience a well-resourced environment for learning.

CO8: Problem solving ability.

CO9: Critical Analysis

## List of Experiments

**(Students must perform Any 8 Experiments)**

1. Determination of the optical power splitting using coupler.
2. To verify Wein's displacement law and to find the temperature of the source.
3. Study the inverse square law of gamma rays.
4. Deposition of a PbS thin film by spray pyrolysis and determination of its thickness and by gravimetric weight difference method.
5. Study of electrical to optical and optical to electrical characteristics of a given optical fiber.
6. Determination of Rydberg constant.
7. Study of loudspeaker/ microphone characteristics.
8. Study of power distribution within the laser beam.
9. Recording and analysis of B-H curve.
10. Determination of curie temperature of a given sample.
11. Fermi energy of copper.
12. Absorption spectra of 12 molecules

## Mapping of Program Outcomes with Course Outcomes

| Course Outcomes | Programme Outcomes | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
| **CO1** | 3 | | | | | | | | |
| **CO2** | | | | | | | 1 | 1 | |
| **CO3** | 2 | | | | | | | | |
| **CO4** | | | | 3 | | | | | |
| **CO5** | | | | | | 2 | | | |
| **CO6** | | | | | 3 | | | | |
| **CO7** | | | | | | | | | |
| **CO8** | | 3 | | | | | | | |
| **CO9** | | 3 | | | | | | | 2 |

## Justification

**PO1: Disciplinary Knowledge**

CO1: The students would be able to have strong foundation knowledge and comprehend the basic concepts and principles in physics. Weightage: 3

CO1 specifically mentions the development of foundational knowledge and comprehension of basic physics concepts, aligning directly with the disciplinary knowledge outlined in PO1.

CO3: To motivate and inspire the students to create deep interest in Physics, to develop broad and balanced knowledge and understanding of physical concepts, principles, and theories of physics. Weightage: 2

While CO3 emphasizes motivation and inspiration, it indirectly contributes to disciplinary knowledge by fostering a deep interest and understanding of physical concepts within the discipline of physics.

**PO2: Critical Thinking and Problem Solving**

CO8: Problem-solving ability Weightage: 3

CO8 explicitly mentions problem-solving ability, aligning directly with the critical thinking and problem-solving skills outlined in PO2.

CO9: Critical Analysis Weightage: 3

CO9 directly correlates with critical thinking by highlighting the importance of critical analysis, reinforcing the connection with the critical thinking aspect of PO2.

**PO4: Research-related Skills and Scientific Temper**

CO4: Learn, design, and perform experiments in the labs to demonstrate the concepts, principles, and theories learned in the classrooms. Weightage: 3

CO4 is closely related to research-related skills and scientific temper, as it involves practical application and experimentation, aligning with the research-oriented skills outlined in PO4.

**PO5: Trans-disciplinary Knowledge**

CO6: Emphasize the discipline of Physics to be the most important branch of science for pursuing interdisciplinary and multidisciplinary higher education and/or research in interdisciplinary and multidisciplinary areas. Weightage: 3

CO6 directly addresses the importance of physics in interdisciplinary and multidisciplinary contexts, aligning with the trans-disciplinary knowledge outlined in PO5.

**PO6: Personal and Professional Competence**

CO5: Develop the ability to apply the knowledge acquired in the classroom and laboratories to specific problems in theoretical and experimental Physics. Weightage: 2

**PO7: Effective Citizenship and Ethics**

CO2: The students would be able to experience a well-resourced environment for learning physics. Weightage: 1

CO2 focuses more on the learning environment and resources, which has a limited connection to effective citizenship and ethics as compared to other outcomes.

**PO8: Environment and Sustainability**

CO2: The students would be able to experience a well-resourced environment for learning Physics. Weightage: 1

Similar to PO7, CO2 has a weak connection to environmental and sustainability aspects, as it primarily addresses the learning environment without direct implications for environmental considerations.

**PO9: Self-directed and Life-long Learning**

CO9: Critical Analysis Weightage: 2

CO9, by promoting critical analysis, indirectly contributes to self-directed and lifelong learning, although it's not as direct as some other connections.

# SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. II Physics

## (w. e. from June, 2024)

Name of the Programme : M.Sc. Physics

Program Code : **PSPH**

Class : **M.Sc. II**

Semester : **III**

Course Type : Major Elective Theory

Course Name : **EXPERIMENTAL TECHNIQUES IN PHYSICS- I**

Course Code : **PHY-611-MJE (A)**

No. of Lectures : **30**

No. of Credits : **2**

## PHY-611-MJE (A): EXPERIMENTAL TECHNIQUES IN PHYSICS- I

**Course Objectives**

1.Develop a comprehensive understanding of vacuum technology principles, applications, and instrumentation.

2.Equip students with practical skills in operating, maintaining, and troubleshooting vacuum systems and pumps.

**Course outcomes:**

On successful completion of this course students will be able to do the following:

CO1: Understand the importance and various fields of applications of vacuum physics.

CO2: Demonstrate knowledge of the kinetic theory of gases and its relevance to vacuum physics.

CO3: Analyze gas transport properties including thermal conductivity, viscosity, and diffusion in vacuum environments.

CO4: Classify different ranges of vacuum and explain their significance, Evaluate gas conductance and impedance in vacuum lines.

CO5: Understand pumping speed and determine pump down times for various systems, Apply low-temperature techniques in vacuum systems.

CO6: Analyze the flow of gases through different components such as apertures, elbows, and tubes considering both viscous and molecular flow regimes.

CO7: Understand principles and operational characteristics of different types of vacuum pumps including Rotary, Molecular drag, Diffusion, Cryogenic, Getter, Titanium sublimation, Sputter ion, and Orbiton pumps.

CO8: Understand various vacuum measurement techniques including McLeod gauge, Thermocouple (Pirani) gauge, Penning gauge, and Hot cathode ionization gauge.

## Topics and Learning Points

**Unit 1: Vacuum Physics [10L]**

Important and fields applications of vacuum, kinetic theory of gases, impingement rate of molecules on a surface, average velocity of gas and mean free path, gas transport properties (thermal conductivity, viscosity and diffusion), various ranges of vacuum, gas conductance of a vacuum line, gas impedance of a vacuum line, pumping speed, flow of gases through apertures, elbows, tubes etc. for viscous and molecular flow regimes, pump down time, Numericals.

**Unit 2: Pumps for High Vacuum (HV) and Ultra High Vacuum (UHV) [10L]**

Principles of pumping concept, Types of vacuum pumps: Rotary, Molecular drag, Diffusion, Cryogenic, Getter, Titanium sublimation, Sputter ion, Orbiton

**Unit 3: Vacuum Measurements and Low Temperature Technique [10L]**

Vacuum Gauges: Mc Leod, Thermocouple (Pirani), Penning, Hot cathode ionization (triode type), Bayard-Alpert leak detection: simple methods of LD, palladium barrier and halogen leak detectors.

**References:**


1. Instrumentation: Devices and Systems, C.S. Rangan, G.R. Sarma and V.S.V. Mani, Tata Mc Graw Hill Publishing Co. Ltd.
2. Hand Book of Thin Film Technology, Maissel and Glange
3. Vacuum Physics and Techniques, T. A. Delchar, Chapman and Hall
4. Vacuum Technology, A. Roth, (North Holland, Elsevier Science B.V. 1990)
5. High Vacuum Techniques, J. Yarwood, (Chapman and Hall, Londong, 1967)
6. Experimental Principles and Methods below 1K, O. U. Lounasmaa, (Academic Press, Londonand, New York, 1974)
7. Thermometry at Ultra Low Temperatures, W. Weyhmann 10. Methods of Experimental Physics, Vol. II (R. V. Coleman, Academic Press, New York and London, 1974)
8. Cryophysics, K. Mendelssohn, Interscience (London, 1960)

9. Optical trapping and manipulation of neutral particles usingılasers, by Arthur Ashkin, Proceeding of National Academy of Sciences May 13, (1997) (4 (10) 4853-4860.
10. Atomic absorption spectroscopy - B.Welz (Verlag Chemie, New York) 1976.
11. Atomic absorption spectroscopy- R.J. Reynolds,K.Aldous& K.C. Thompson (CharlesGriffin and company Ltd. London) 1970.

**Mapping of Program Outcomes with Course Outcomes**

| Course Outcomes | Programme Outcomes | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO8 | PO9 | PO10 |
| CO1 | 3 | | | | | | | | | |
| CO2 | 3 | | | | | | | | | |
| CO3 | 3 | | | | | | | | | |
| CO4 | | 3 | | | | | | | | |
| CO5 | | 3 | | | | | | | | |
| CO6 | | 3 | | | | | | | | |
| CO7 | | | 3 | | | | | | | |
| CO8 | | | | 3 | | | | | | |

**Justification**

**PO1: Comprehensive Knowledge and Understanding:**

**CO1:** Understand the importance and various fields of applications of vacuum physics.

Weightage: 3

Vacuum physics forms the foundation of understanding various fields like material science, semiconductor manufacturing, space technology, and more. Therefore, a comprehensive knowledge and understanding of vacuum physics are crucial.

**CO2:** Demonstrate knowledge of the kinetic theory of gases and its relevance to vacuum physics. Weightage: 3

The kinetic theory of gases is fundamental to understanding the behavior of gases in vacuum conditions. Mastery of this theory is essential for a comprehensive understanding of vacuum physics.

**CO3:** Analyze gas transport properties including thermal conductivity, viscosity, and diffusion in vacuum environments. Weightage: 3

Gas transport properties are directly relevant to understanding vacuum physics, as they determine how gases behave under vacuum conditions.

**PO2: Practical, Professional, and Procedural Knowledge:**

**CO4:** Classify different ranges of vacuum and explain their significance, Evaluate gas conductance and impedance in vacuum lines. Weightage: 3

This directly relates to practical knowledge required in handling vacuum systems, understanding different vacuum levels, and assessing the performance of vacuum lines.

**CO5**: Calculate pumping speed and determine pump down times for various systems, Apply low-temperature techniques in vacuum systems. Weightage: 3

These skills are essential for practical operation and maintenance of vacuum systems, ensuring efficient functioning and performance.

**CO6:** Analyze the flow of gases through different components such as apertures, elbows, and tubes considering both viscous and molecular flow regimes. Weightage: 3

Understanding gas flow through components is crucial for designing and optimizing vacuum systems, demonstrating practical knowledge and skills.

**PO3: Entrepreneurial Mindset, Innovation, and Business Understanding:**

**CO7:**Understand the principles and operational characteristics of different types of vacuum pumps including Rotary, Molecular drag, Diffusion, Cryogenic, Getter, Titanium sublimation, Sputter ion, and Orbiton pumps. Weightage: 3

Understanding different types of vacuum pumps enables innovation in system design and selection, aligning with entrepreneurial and innovative mindsets.

**PO4: Specialized Skills, Critical Thinking, and Problem-Solving:**

**CO8:** Understand various vacuum measurement techniques including McLeod gauge, Thermocouple (Pirani) gauge, Penning gauge, and Hot cathode ionization gauge.

Mastery of vacuum measurement techniques is crucial for problem-solving and critical thinking in diagnosing and optimizing vacuum systems. Weightage: 3

**CO9:** Perform leak detection using Bayard-Alpert leak detection methods and understand simple methods of leak detection using palladium barriers and halogen leak detectors.

Leak detection skills are vital for ensuring the integrity and performance of vacuum systems, requiring specialized knowledge and problem-solving abilities.

**SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. II Physics**

**(w. e. from June, 2024)**

Name of the Programme : M.Sc. Physics

Program Code : **PSPH**

Class : **M.Sc. II**

Semester : **III**

Course Type : Major Elective Practical

Course Name : **EXPERIMENTAL TECHNIQUES IN PHYSICS- I**

Course Code : **PHY-612-MJE (A)**

No. of Lectures : **30**

No. of Credits : **2**

## PHY-612-MJE (A): EXPERIMENTAL TECHNIQUES IN PHYSICS- I [P]

**Course Objectives**

1. Gain practical knowledge of different types of vacuum pumps and their operating principles.
2. Understand the working principles of various vacuum gauges and leak detection techniques.
3. Learn how to set up and calibrate vacuum instruments for accurate pressure measurements.
4. Explore the applications and limitations of different vacuum technologies.
5. Develop skills in troubleshooting and maintaining vacuum systems.
6. Understand the importance of vacuum technology in various scientific and industrial applications.

**Course outcomes:**

On successful completion of this course students will be able to do the following:

**CO1**: Understand the principles of various vacuum pumps and their applications in different contexts.

**CO2**: Gain practical experience in setting up and operating different types of vacuum pumps.

**CO3**: Learn about the working principles of different vacuum gauges and their applications in measuring vacuum levels.

**CO4**: Acquire skills in conducting experiments related to vacuum technology, including leak detection and pressure measurement.

**CO5**: Enhance understanding of the importance of vacuum technology in various scientific and industrial processes.

**CO6**: Explore the practical applications of vacuum technology in research, manufacturing, and other fields.

**CO7**: Develop proficiency in using specialized equipment and techniques related to vacuum technology.

**CO8**: Learn about safety protocols and best practices for working with vacuum systems and associated equipment.

**CO9**: Improve critical thinking skills through analyzing and interpreting experimental results related to vacuum technology.

## List of Experiments

**(Students must perform Any 8 Experiments)**

1. To study of Rotary Pump Operation
2. To study with Molecular Drag Pump
3. To study Diffusion Pump
4. Titanium Sublimation Pump Experiment: to study titanium sublimation pump for achieving ultra-high vacuum conditions.
5. Sputter Ion Pump: Show how a sputter ion pump operates and discuss its advantages and limitations compared to other pump types.
6. Orbiton Pump Overview: Provide an overview of the concept and operation of an orbiton pump and its suitability for specific vacuum applications.
7. McLeod Gauge: to study McLeod gauge and its use in measuring low pressures.
8. Thermocouple (Pirani) Gauge Experiment: to study Pirani gauge and its principle of operation for measuring vacuum levels.
9. Penning Gauge Setup and Measurement: Set up a Penning gauge and demonstrate its use for measuring vacuum pressures.
10. Simple Methods of Leak Detection: Demonstrate simple methods of leak detection such as pressure rise tests and soap bubble tests.
11. Palladium Barrier Leak Detector Setup: Set up a palladium barrier leak detector and demonstrate its use for detecting leaks in vacuum systems.
12. Halogen Leak Detector Operation: Demonstrate the operation of a halogen leak detector and discuss its sensitivity and applications.

**Mapping of Program Outcomes with Course Outcomes**

| Course Outcomes | Program Outcomes | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO8** | **PO9** | **PO10** |
| **CO1** | 3 | | | | | | | | | |
| **CO2** | | 3 | | | | | | | | |
| **CO3** | 3 | | | | | | | | | |
| **CO4** | | 3 | | | | | | | | |
| **CO5** | 3 | | | | | | | | | |
| **CO6** | | | 2 | | | | | | | |
| **CO7** | | 3 | | | | | | | | |
| **CO8** | | | | | | | 2 | | | |
| **CO9** | | | | 3 | | | | | | |

**Justification**

**PO1: Comprehensive Knowledge and Understanding:**

**CO1:** Understand the principles of various vacuum pumps and their applications in different contexts. Weightage: 3

This learning outcome directly contributes to building comprehensive knowledge and understanding of vacuum technology by focusing on the principles and applications of different types of vacuum pumps.

**CO3:** Learn about the working principles of different vacuum gauges and their applications in measuring vacuum levels. Weightage: 3

Understanding the working principles of vacuum gauges is essential in comprehensively grasping the measurement aspect of vacuum technology, enhancing knowledge and understanding in this domain.

**CO5**: Enhance understanding of the importance of vacuum technology in various scientific and industrial processes. Weightage: 3

Exploring the importance of vacuum technology broadens the comprehension of its significance across diverse fields, thus contributing significantly to comprehensive knowledge and understanding.

**PO2: Practical, Professional, and Procedural Knowledge:**

**CO2:** Gain practical experience in setting up and operating different types of vacuum pumps. Weightage: 3

This directly relates to acquiring practical knowledge in operating vacuum pumps, which is crucial for professional competence in handling vacuum systems.

**CO4**: Acquire skills in conducting experiments related to vacuum technology, including leak detection and pressure measurement. Weightage: 3

Practical skills in conducting experiments are essential for professionals working with vacuum technology, directly contributing to practical, professional, and procedural knowledge.

**CO7**: Develop proficiency in using specialized equipment and techniques related to vacuum technology. Weightage: 3

Proficiency in using specialized equipment directly enhances practical and professional knowledge in the field of vacuum technology, fulfilling this aspect of professional competency.

**PO3: Entrepreneurial Mindset, Innovation, and Business Understanding:**

**CO6:** Explore the practical applications of vacuum technology in research, manufacturing, and other fields. Weightage: 2

While understanding practical applications contribute to innovation and business understanding, its direct relationship to entrepreneurial mindset may be moderate compared to other learning outcomes.

**PO4: Specialized Skills, Critical Thinking, and Problem-Solving:**

**CO9:** Improve critical thinking skills through analyzing and interpreting experimental results related to vacuum technology. Weightage: 3

Analyzing and interpreting experimental results requires critical thinking skills, directly contributing to the development of specialized skills and problem-solving abilities in the context of vacuum technology.

**PO7: Digital Proficiency and Technological Skills:**

**CO8**: Learn about safety protocols and best practices for working with vacuum systems and associated equipment. Weightage: 2

While safety protocols are crucial for digital proficiency and technological skills, the direct relationship may not be as strong as with other learning outcomes.

# SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. II Physics

## (w. e. from June, 2024)

Name of the Programme : M.Sc. Physics

Program Code : **PSPH**

Class : **M.Sc. II**

Semester : **III**

Course Type : Major Elective Theory

Course Name : **LASER**

Course Code : **PHY-611-MJE (B)**

No. of Lectures : **30**

No. of Credits : **2**

### PHY-611-MJE (B): LASER

**Course Outcomes:**

On successful completion of this course students will be able to do the following:

CO1: Explain the fundamental principles of laser operation, including population inversion, Stimulated emission, and amplification of light.

CO2: Describe different types of lasers, such as solid-state lasers, gas lasers, semiconductor lasers, and fiber lasers, and understand their applications.

CO3: Demonstrate knowledge of laser safety protocols, including the hazards associated with laser. Use and appropriate safety measures.

CO4: Identify and describe the components of a laser system, including gain medium, pump, Source, cavity, and optical elements.

CO5: Explain the principles of optical resonators and laser cavities and their role in laser emission.

CO6: Explore how lasers interact with different materials, including absorption, reflection, and Transmission, and their applications in cutting, welding, and ablation.

CO7: Discuss various applications of lasers in science, technology, medicine, communication, and Industry.

**Topics and Learning Points**

**Unit 1: Basic of Lasers (10L)**

Introduction, Historical background of laser, Spontaneous and stimulated emission, Types of Pumping, population inversion, Active/Gain Medium, Metastable State, Einstein coefficient, Types of lasers (He-Ne Laser, Dye Laser, Semiconductor Laser).

**Unit 2: Laser Beam Propagation (10L)**

Introduction, Laser beam propagation, properties of Gaussian beam, resonator, stability, various types of resonators, Resonator for high gain and high energy lasers, Gaussian beam focusing.

**Unit 3: Applications of laser (10L)**

Detection of optical radiation: Human eye, thermal detector (bolometer, pyro-electric), Photon detector (photoconductive detector, photo voltaic detector and photoemissive detector), p-i-n photodiode, APD photodiode,

Holography: Importance of coherence, Principle of holography and characteristics, Recording and reconstruction, classification of hologram and application, non-destructive testing, Injection laser diode (double heterostructure, distributed feedback)

## Reference Book:

1. Laser and Non-Linear Optics – B.B. Laud ($2_{nd}$ Edition)
2. Lasers – Nambiar
3. Introduction to Fiber Optics – A. Ghatak, K. Thyagarajan – Cambridge University Press
4. Principles of Laser and Their Applications – Callen O'shea, Rhodes
5. Introduction to Laser Theory and Applications – M.N. Avdhanulu, S. Chand Publication
6. Experiments with Laser – Sirohi

**Mapping of Program Outcomes with Course Outcomes**

| Course Outcomes | Programme Outcomes | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **P10** |
| **CO1** | 3 | | | | | | | | | |
| **CO2** | | | | | | | 3 | | | |
| **CO3** | | 3 | | | | | | | 2 | 3 |
| **CO4** | | | | | 2 | | | | | |
| **CO5** | | | | | | | | | | |
| **CO6** | | | | 3 | | | | | | |
| **CO7** | | | 3 | | | 3 | | | | |

## Justification

**PO1: Comprehensive Knowledge and Understanding:**

CO1: Explain the fundamental principles of laser operation, including population inversion, Stimulated emission, and amplification of light. Weightage: 3

PO1 requires a deep understanding of the fundamental principles of laser operation, which directly aligns with CO1 as it involves explaining concepts like population inversion, stimulated emission, and light amplification.

**PO2: Practical, Professional, and Procedural Knowledge:**

CO3: Demonstrate knowledge of laser safety protocols, including the hazards associated with laser. Use and appropriate safety measures. Weightage: 3

Understanding laser safety protocols and hazards associated with lasers directly relates to practical and procedural knowledge necessary for handling laser systems professionally and safely, aligning well with PO2.

**PO3: Entrepreneurial Mindset, Innovation, and Business Understanding:**

CO7: Discuss various applications of lasers in science, technology, medicine, communication, and Industry. Weightage: 3

CO7 involves discussing the wide array of applications of lasers, which ties directly into understanding the market potential, innovation opportunities, and business implications of laser technology, aligning well with PO3.

**PO4: Specialized Skills, Critical Thinking, and Problem-Solving:**

CO6: Explore how lasers interact with different materials, including absorption, reflection, and Transmission, and their applications in cutting, welding, and ablation. Weightage: 3

CO6 requires critical thinking and problem-solving skills to understand how lasers interact with materials and to apply this knowledge in various applications like cutting, welding, and ablation, which directly aligns with PO4.

**PO5: Research, Analytical Reasoning, and Ethical Conduct:**

CO4: Identify and describe the components of a laser system, including gain medium, pump, Source, cavity, and optical elements. Weightage: 2

While understanding the components of a laser system requires some level of analytical reasoning and research, it's not as directly tied to ethical conduct as other mappings. However, understanding the components is crucial for ethical conduct in ensuring proper handling and maintenance of laser systems.

**PO6: Communication, Collaboration, and Leadership:**

CO7: Discuss various applications of lasers in science, technology, medicine, communication, and Industry. Weightage: 3

CO7 involves discussing applications of lasers across various fields, which may require effective communication of ideas, collaboration with experts in different domains, and leadership in implementing laser technology effectively, aligning with PO6.

**PO7: Digital Proficiency and Technological Skills:**

CO2: Describe different types of lasers, such as solid-state lasers, gas lasers, semiconductor lasers and fiber lasers, and understand their applications. Weightage: 3

CO2 involves understanding different types of lasers and their applications, which directly relates to technological skills and digital proficiency needed to comprehend and work with advanced laser technologies, aligning with PO7.

**PO9: Value Inculcation, Environmental Awareness, and Ethical Practices:**

CO3: Demonstrate knowledge of laser safety protocols, including the hazards associated with laser. Use and appropriate safety measures. Weightage: 2

While primarily focused on safety, understanding laser safety protocols also involves ethical practices and environmental awareness in ensuring the well-being of individuals and the environment, though not as directly as other mappings.

**PO10: Autonomy, Responsibility, and Accountability:**

CO3: Demonstrate knowledge of laser safety protocols, including the hazards associated with laser. Use and appropriate safety measures. Weightage: 3

Understanding laser safety protocols and taking appropriate safety measures require autonomy, responsibility, and accountability in handling laser systems, aligning well with P10.

# SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. II Physics

## (w. e. from June, 2024)

Name of the Programme : M.Sc. Physics

Program Code : **PSPH**

Class : **M.Sc. II**

Semester : **III**

Course Type : Major Elective Practical

Course Name : **LASER Practicals**

Course Code : **PHY-612-MJE (B)**

No. of Lectures : **30**

No. of Credits : **2**

### PHY-612-MJE (B): LASER [P]

**Course Objectives**

1. Understand the depth knowledge of various subjects of Physics.
2. Demonstrate skills and competencies to conduct wide range of scientific experiments.
3. Identify their area of interest in academic and R&D. Perform job in various fields' viz.
4. To provide students a strong foundation education in Physics.
5. To provide structured curricula, this supports academic development of students.
6. To provide and prepare the students for employment and higher studies in Physics.
7. To provide a good learning environment for Physics.

**Course Outcomes:**

On successful completion of this course students will be able to do the following:

CO1: The students would be able to have strong foundation knowledge and comprehend the basic concepts and principles in lasers.

CO2: The students would be able to experience a well-resourced environment for learning laser.

CO3: To motivate and inspire the students to create deep interest in Physics, to develop broad and balanced knowledge and understanding of basic concepts, principles and theories of lasers.

CO4: Learn, design and perform experiments in the labs to demonstrate the concepts, principles and theories learned in the classrooms.

CO5: Develop the ability to apply the knowledge acquired in the classroom and laboratories to specific problems in theoretical and experimental Physics.

CO6: Emphasize the discipline of Physics to be the most important branch of science for pursuing the interdisciplinary and multidisciplinary higher education and/or research in interdisciplinary and multidisciplinary areas.

CO7: The students would be able to experience a well-resourced environment for learning

CO8: Problem solving ability.

CO9: Critical Analysis

## List of Experiments

**(Students must perform Any 8 Experiments)**

1. Determination of wavelength of He-Ne LASER by Reflection grating.
2. Determination of wavelength of He-Ne LASER by transmission grating
3. Measuring the size of remote objects.
4. Laser range-finding.
5. Polarization.
6. A double slit interference experiment.
7. Measuring the diameter of a human hair by studying diffraction patterns.
8. Determination of angle of divergence of a laser beam using He-Ne laser.
9. Determination of wavelength of laser light using semiconductor laser diffraction.
10. Laser & Diffraction Grating
11. Ultrasonic Grating
12. Serial Experiments of He-Ne Laser Resonator and Modes

## Mapping of Program Outcomes with Course Outcomes

| Course Outcomes | Programme Outcomes | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | P10 |
| CO1 | 3 | | | | | | | | | |
| CO2 | | | | | | | 1 | | | |
| CO3 | | | 3 | | | | | | | |
| CO4 | | 3 | | | | | | | | |
| CO5 | | | | | 3 | | | | | |
| CO6 | | | | | | | | | | 1 |
| CO7 | | | | | | 1 | | | | |
| CO8 | | | | 3 | | | | | | |
| CO9 | | | | | | | | | | |

## Justification

**PO1: Comprehensive Knowledge and Understanding:**

CO1: The students would be able to have strong foundation knowledge and comprehend the basic concepts and principles in lasers. Weightage: 3

PO1 emphasizes comprehensive knowledge and understanding, which directly aligns with CO1's objective of developing a strong foundation and comprehension of basic concepts and principles in lasers.

**PO2: Practical, Professional, and Procedural Knowledge:**

CO4: Learn, design and perform experiments in the labs to demonstrate the concepts, principles and theories learned in the classrooms. Weightage: 3

PO2 focuses on practical knowledge, and CO4 involves designing and performing experiments in labs to demonstrate learned concepts, aligning perfectly with the practical aspect of PO2.

**PO3: Entrepreneurial Mindset, Innovation, and Business Understanding:**

CO3: To motivate and inspire the students to create deep interest in Physics, to develop broad and balanced knowledge and understanding of basic concepts, principles and theories of lasers. Weightage: 3

Encouraging deep interest in Physics and developing broad knowledge aligns with fostering an entrepreneurial mindset and innovation, crucial for PO3. Understanding basic concepts and principles of lasers can also contribute to business understanding by identifying innovative applications.

**PO4: Specialized Skills, Critical Thinking, and Problem-Solving:**

CO8: Problem solving ability Weightage: 3

PO4 involves specialized skills, critical thinking, and problem-solving, all of which are encompassed in CO8's focus on developing problem-solving ability, especially within the context of laser physics.

**PO5: Research, Analytical Reasoning, and Ethical Conduct:**

CO5: Develop the ability to apply the knowledge acquired in the classroom and laboratories to specific problems in theoretical and experimental Physics. Weightage: 3

CO5 emphasizes applying acquired knowledge to specific problems, which aligns with PO5's focus on research, analytical reasoning, and ethical conduct, especially within the context of theoretical and experimental physics involving lasers.

**PO6: Communication, Collaboration, and Leadership:**

CO7: The students would be able to experience a well-resourced environment for learning Weightage: 1

While a well-resourced environment is beneficial for communication, collaboration, and leadership, this particular CO does not directly address those aspects. It's more about the learning environment rather than the skills of communication, collaboration, and leadership themselves.

**PO7: Digital Proficiency and Technological Skills:**

CO2: The students would be able to experience a well-resourced environment for learning laser. Weightage: 1

Similar to the previous mapping, while a well-resourced environment may include technological resources, CO2 does not specifically target digital proficiency and technological skills.

**PO10: Autonomy, Responsibility, and Accountability:**

CO6: Emphasize the discipline of Physics to be the most important branch of science for pursuing the interdisciplinary and multidisciplinary higher education and/or research in interdisciplinary and multidisciplinary areas. Weightage: 1

While CO6 emphasizes the importance of physics as a discipline, it doesn't directly address autonomy, responsibility, and accountability in the context of individual student actions. These aspects are more about personal conduct and professional ethics, which aren't explicitly covered in CO6.

# SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. II Physics

# (w. e. from June, 2024)

Name of the Programme : M.Sc. Physics

Program Code : **PSPH**

Class : **M.Sc. II**

Semester : **III**

Course Type : Major Elective Theory

Course Name : **LASER**

Course Code : **PHY-611-MJE (C)**

No. of Lectures : **30**

No. of Credits : **2**

## PHY-611-MJE (C): ENERGY STUDIES-I

**Course Objectives:**

1. To create awareness about use of renewable energy sources.
2. To develop the technologies have low cost.
3. To create surrounding without pollution.
4. To use the hydrogen as clean source of energy.
5. To use storage devices like batteries and super capacitors.
6. To foster scientific attitude, provide in-depth knowledge of scientific and technological concepts of Physics.
7. To familiarize with recent scientific and technological developments.
8. To create foundation for research and development in Physics.
9. To help students to build-up a progressive and successful career in Physics.

**Course Outcomes:**

After completion of the course, the student should be able to:

CO1: Describe environmental impacts of renewable sources of energy.

CO2: Describe hydrogen as clean sources of energy.

CO3: Understand the concept of superconductors and fuel cell energy resources.

CO4: Understand the batteries and super capacitors.

CO5: Understand the challenges and solutions for integrating renewable energy sources into existing energy grids.

CO6: Explore the role of energy storage and grid management in facilitating renewable energy integration.

CO7: Explore methods for promoting energy literacy and awareness.

## Topics and Learning Points

**Unit 1:Environmental Impacts of Renewable Energy Sources (10L)**

Oze layer, Ozone Layer depletion, Global Warnig, Acid rain, Ecological Niche, Green house effect. Environmental degradation due to conventional energy production and utilization: Asian Brown Cloud Effect, Environmental impacts of Biomass energy, solar energy systems and wind energy.

**Unit 2: Hydrogen as clean source of Energy (10L)**

Sources of hydrogen, Thermodynamics of water splitting, Hydrogen production methods, Photo electrolysis of water, Direct decomposition of water, Thermochemical production of hydrogen; Hydrogen storage methods: Conventional and Liquid Hydrogen storage.

**Unit 3: Batteries and Supercapacitors (10L)**

Energy storage systems, Faradaic & Non-Faradaic processes, Types of capacitors and batteries, Comparison of capacitor and battery, Charge discharge cycles, experimental evaluation using Cyclic Voltammetry and other techniques

**Reference Books:**

1) Biological paths to self reliance- Russell E. Anderson.

2) Encyclopedia of Environmental Energy Resources- G.R. Chhatwal Vol. 1 & 2.

3) Renewable Energy Sources and their Environmental Impacts- S.A. Abbasi & N. Abbasi.

4) Electrochemical supercapacitors by B. E. Conway, Kluwer Academic Press.

5) Hydrogen as an Energy Carrier- T. Carl-Jochen Winter, Joachim Nitsch (eds.)

6) Advances in Renewable Energy Technologies- S.H. Pawar, and L. A. Ekal (eds.)

7) Handbook of Batteries and Fuel Cells- David Linden.

**Mapping of Program Outcomes with Course Outcomes**

| Course Outcomes | Programme Outcomes | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO8** | **PO9** | **PO10** |
| **CO 1** | 3 | | | | | | | | | |
| **CO 2** | 3 | | | | | | | | | |
| **CO 3** | 3 | | | | | | | | | |
| **CO 4** | 3 | | | | | | | | | |
| **CO 5** | | 3 | | | | | | | | |
| **CO 6** | | 3 | | | | | | | | |
| **CO7** | 3 | | | | | | | | | |

**Justification**

**PO1: Disciplinary Knowledge**

CO1: Describe environmental impacts of renewable sources of energy.

CO2: Describe hydrogen as clean sources of energy.

CO3: Understand the concept of superconductors and fuel cell energy resources.

CO4: Understand the batteries and supercapacitors.

CO7: Explain the field applications of solar energy. Weightage: 3

All these course outcomes directly contribute to acquiring disciplinary knowledge in the field of renewable energy.

**PO2: Critical Thinking and Problem Solving**

CO5: Perform an initial design of a renewable energy system.

CO6: Use laboratories and emulators of renewable energy systems to analyze relevant issues.
Weightage: 3

Performing a design and analysing issues related to renewable energy systems involve critical thinking and problem-solving skills.

**PO8: Environment and Sustainability**

CO1: Describe environmental impacts of renewable sources of energy. Weightage: 2

Describing environmental impacts aligns with the environmental and sustainability aspect of PO8.

**SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. II Physics**

**(w. e. from June, 2024)**

Name of the Programme : M.Sc. Physics

Program Code : **PSPH**

Class : **M.Sc. II**

Semester : **III**

Course Type : Major Elective Practical

Course Name : **Energy Studies-I Practicals**

Course Code : **PHY-612-MJE (C)**

No. of Lectures : **30**

No. of Credits : **2**

**PHY-612-MJE (C): Energy Studies-I [P]**

**Course Outcomes:**

After completion of the course, the student should be able to:

CO1: Describe environmental impacts of renewable sources of energy.

CO2: Describe hydrogen as clean sources of energy.

CO3: Understand the concept of superconductors and fuel cell energy resources.

CO4: Understand the batteries and super capacitors.

CO5: Understand the challenges and solutions for integrating renewable energy sources into existing energy grids.

CO6: Explore the role of energy storage and grid management in facilitating renewable energy integration.

CO7: Explore methods for promoting energy literacy and awareness.

**List of Experiments**

**(Students must perform Any 8 Experiments)**

1 Recording the amount of sunlight receives throughout a day using Sunshine Recorder

2 Bio-gas Production from Kitchen waste.

3 Energy Content in Wind.

4 Utilizing the latent heat released by the condensing water steam using Solar Still

5 Performance evaluation of box type and concentrating type solar cooker

6 Find out the kinetics of photocatalytic reaction

7 Measure the solar radiation flux density using Pyrometer

8 Determining efficiency of lighting system/loads

9 Solar Dryer

10 IV characteristics of solar cells- Series combination

11 IV characteristics of solar cells- parallel combination

12 Study and use of Luxmeter

## Mapping of Program Outcomes with Course Outcomes

| Course Outcomes | Programme Outcomes | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | P10 |
| CO1 | 3 | | | | | | | | | |
| CO2 | 3 | | | | | | | | | |
| CO3 | 3 | | | | | | | | | |
| CO4 | | 3 | | | | | | | | |
| CO5 | 3 | | | | | | | | | |
| CO6 | | | 3 | | | | | | | |
| CO7 | | | 3 | | | | | | | |
| CO8 | | | | | | | | | | |
| CO9 | | | | | | | | | | |

**Justification**

**PO1: Comprehensive Knowledge and Understanding**

CO1: Describe environmental impacts of renewable sources of energy. (Weightage: 3)

Justification: This CO directly contributes to comprehensive knowledge and understanding by requiring students to grasp the environmental impacts of renewable energy sources.

Value Inculcation and Environmental Awareness (Weightage: 3)

This CO directly addresses environmental awareness and the value of understanding the environmental impacts of energy choices.

Community Engagement and Service (Weightage: 2)

While not directly engaging with the community, understanding the environmental impacts of renewable energy can lead to more informed decisions and potentially community engagement initiatives.

CO2: Describe hydrogen as clean sources of energy.

Describing hydrogen as a clean energy source requires students to understand its properties, production methods, and potential environmental impacts.

Value Inculcation and Environmental Awareness **(**Weightage: 3)

Hydrogen as a clean energy source contributes to environmental awareness and underscores the value of sustainable energy alternatives.

Entrepreneurial Mindset and Knowledge (Weightage: 1)

While hydrogen presents entrepreneurial opportunities, this CO primarily focuses on understanding hydrogen as an energy source rather than entrepreneurial aspects.

CO3: Understand the concept of superconductors and fuel cell energy resources.

Comprehensive Knowledge and Understanding (Weightage: 3)

This CO enhances students' understanding of advanced energy technologies, contributing to comprehensive knowledge.

Specialized Skills and Competencies (Weightage: 3)

Understanding superconductors and fuel cells involves specialized knowledge and skills in advanced energy technologies.

CO5: Understand the challenges and solutions for integrating renewable energy sources into existing energy grids.

Comprehensive Knowledge and Understanding (Weightage: 3)

This CO involves understanding both technical and logistical challenges in renewable energy integration, contributing to comprehensive knowledge.

**PO2: Practical, Professional and Procedural Knowledge:**

CO4: Understand the batteries and supercapacitors.

Comprehensive Knowledge and Understanding (Weightage: 3)

Exploring batteries and supercapacitors deepens students' understanding of energy storage technologies, contributing to comprehensive knowledge.

Specialized Skills and Competencies (Weightage: 3)

Understanding batteries and supercapacitors requires specialized knowledge in energy storage systems and electrochemistry.

**PO3: Entrepreneurial Mindset, Innovation and Business Understanding:**

CO6: Explore the role of energy storage and grid management in facilitating renewable energy integration.

Comprehensive Knowledge and Understanding **(**Weightage: 3)

Exploring the role of energy storage and grid management enhances students' understanding of the infrastructure needed for renewable energy integration.

Specialized Skills and Competencies (Weightage: 3)

Understanding energy storage and grid management involves specialized knowledge in energy systems engineering and management.

CO7: Explore methods for promoting energy literacy and awareness.

Communication Skills and Collaboration (Weightage: 3)

Exploring methods for promoting energy literacy requires effective communication skills to convey complex concepts to diverse audiences.

# SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. II Physics

# (w. e. from June, 2024)

Name of the Programme : M.Sc. Physics

Program Code : **PSPH**

Class : **M.Sc. II**

Semester : **III**

Course Type : Major Elective Practical

Course Name : **Research Project**

Course Code : **PHY-621-RP**

No. of Lectures : **30**

No. of Credits : **2**

## PHY-621-Research Project

### Course Objectives

The student will

- Gain experience in research.
- Understand the research methodology and will help them in their future research career.
- Explore interdisciplinary connections by integrating physics concepts with other disciplines
- Foster Creativity and innovations by design and implementation of original project idea.
- Develop expertise in experimental techniques, data acquisition and analysis methodology necessary for conducting research in physics.

### Course Outcome:

On successful completion of this course students will be able to do the following:

CO1: Understanding of concept research in various field applications.

CO2: Perform various experimentations through suitable method for research.

CO3: Able to characterize and analyse prepared samples as per applications point of view.

CO4: This will initiate innovations and thinking ability of students towards solution of societal problems.

CO5: Analyze data, plot appropriate graphs and reach conclusions from your data analysis.

CO6: Work individual or in a group to plan, implement and report on a project.

CO7: Experimental prototype models for easy understanding and explanation project purpose.

The student will have to perform the project course for semesters III. The continuous evaluation of the project will be done during this semester. Student must complete project work in semester III and evaluation will be done at the end of semester and credit will be assigned to the students according to their performance. Student should submit the dissertation of the project work and face the vivo-vice of the project.

- Selection of Research Problem
- Literature Survey about research wok
- Material Synthesis by suitable method
- Characterization study
- Dissertation report completion

**Guidelines:**

It is expected that,

1. The student does work equivalent to about 10 laboratory experiments.

2. The project work is a practical course, and it is intended to develop a set of skills pertaining to the laboratory work apart from the cognition of students. Therefore, the guides should not permit projects that involve no contribution on part of student.

3. The project must have a clear and strong link with the principles of basic physics and/or their applications.

4. The theme chosen should be such that it promotes better understanding of physics concepts and brings out the creativity in the students.

5. The evaluation of the project work must give due credit to the amount of the project work done by a student, skills shown by the student, understanding of the physics concepts involved and the presentation of the final report at the time of viva voce.

6. The viva voce should be conducted at the time of evaluation of project work at least for twenty minutes per student. Extra care must be taken in the evaluation of projects done in a

pair or group. Delegation of the work done by individuals must be sought from the students in such cases.

7. Any ready-made material used in the report (such as downloaded pages from the web) must be clearly referred to and acknowledged.

8. It is also recommended that a teacher will look after 4 projects at one time.

**The Project work shall consist of the following Criterions.**

1) Working model
   (Experimental or Concept based simulation/Demonstration Related to Physics).

2) Understanding of the project.

3) Experimental Details.

4) Data collection and Data Analysis.

5) Innovation.

6) Outcomes/Result.

7) Conclusion.