**Anekant Education Society's**

**Tuljaram Chaturchand College**
**of Arts, Science and Commerce, Baramati**
***(Empowered Autonomous)***

**M.Sc DegreeProgram in Physics**

**(Faculty of Science)**

**CBCS Syllabus**

**M.Sc.Part-I (Physics) Semester –I**

**For**

**Department of Physics**

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

**Choice Based Credit System Syllabus**

**(2026 Pattern)**

**(As Per NEP- 2020)**

**To be implemented from Academic Year 2026-2027**

# Title of the Programme: M.Sc. (Physics)

## Preamble

AES's Tuljaram Chaturchand College has made the decision to change the syllabus of across various faculties from June, 2024 by incorporating the guidelines and provisions outlined in the National Education Policy (NEP)2020. The NEP envisions making education more holistic and effective and to lay emphasis on the integration of general (academic) education, vocational education and experiential learning. The NEP introduces holistic and multidisciplinary education that would help to develop intellectual, scientific, social, physical, emotional, ethical and moral capacities of the students. The NEP 2020 envisages flexible curricular structures and learning based outcome approach for the development of the students. By establishing a nationally accepted and internationally comparable credit structure and courses framework, the NEP 2020 aims to promote educational excellence, facilitate seamless academic mobility and enhance the global competitiveness of Indian students. It fosters a system where educational achievements can be recognized and valued not only within the country but also in the international arena, expanding opportunities and opening doors for students to pursue their aspirations on a global scale.

In response to the rapid advancements in science and technology and the evolving approaches in various domains of Physicsand related subjects, the Board of Studies in Physicsat Tuljaram Chaturchand College, Baramati - Pune has developed the curriculum for the first semester of M.Sc. Physics, which goes beyond traditional academic boundaries. The syllabus is aligned with the NEP 2020 guidelines to ensure that students receive an education that prepares them for the challenges and opportunities of the 21$^{st}$ century. This syllabus has been designed under the framework of the Choice Based Credit System (CBCS), taking into consideration the guidelines set forth by the National Education Policy (NEP) 2020, LOCF (UGC), NCrF, NHEQF, Prof. R.D. Kulkarni's Report, Government of Maharashtra's General Resolution dated 20$^{th}$ April and 16$^{th}$ May 2023and the Circular issued by SPPU, Pune on 31$^{st}$ May 2023.Physics is concerned with the study of the universe from the smallest to the largest scale: it is about unravelling its complexities to discover the way it is and how it works. Discoveries in physics have formed the foundation of countless technological advances and play an important role in many scientific areas. Many techniques usedin medical imaging, nanotechnology and quantum computing are derived from physics instrumentation. Even the World Wide Web was a spin-off from the information processing and communications requirements of high-energy particle physics. The contributions of physics to solving global problems such as energy production, environmental protection, global warming and public health are essential and have an enormous impact on our society.

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, Energy Studies, Physics of Thin Film, Material Science, 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 Specific Outcomes (PSOs)

PSO1: To develop an ability to become a specialist in various areas of Physics and apply the same in day to day life.

PSO2: To acquire knowledge about the nature, concepts, methods, techniques and objectives in the core physics subjects.

PSO3: To make the students in mastering in the field of materials science and prepare them for research.

PSO4: Identify, formulate, and analyse complex problems using basic principles of mathematics, physics, and statistics.

PSO5: Design, construct and analyse basic electronic and digital circuits. Understand the basics of programming language and apply it to various numerical problems.

PSO6: To cultivate scientific approach and culture of research aptitude.

PSO7: To enhance the problem-solving skills of the students so that they will be able to tackle the national level competitive exams like NET, GATE and SET etc.

PSO8: To understand the links of Physics to other disciplines and also to the societal issues.

PSO9: To train the students to develop their skill development, employability and entrepreneurship skills

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## Board of Studies (BOS) in Physics

**From 2025-26 to 2027-28**

| Sr. No. | Name | Designation |
|---|---|---|
| 1 | **Dr. Kale Rajendra Devidas**<br>Head,<br>Department of Physics,<br>T. C. College, Baramati. | Chairperson |
| 2 | **Dr. PathanH.M.**<br>Associate Professor, Department of Physics,<br>Savitribai Phule Pune University, Pune | Vice-Chancellor NomineeSubject Expert from SPPU, Pune |
| 3 | **Prof.Dr. Patil Vikas Baburao**<br>Professor & Head, Department of Physics<br>Punyashlok Ahilyadevi Holkar Solapur University, Solapur | Subject Expert from Outside the Parent University |
| 4 | **Dr.Patil Umakant Mahadev**<br>Associate Professor, D.Y. Patil University, Kolhapur | Subject Expert from Outside the Parent University |
| 5 | **Mr. Bhabale Amar Ramesh**<br>Head - Production Planning at Piaggio Vehicles Pvt. Ltd ,Pune | Representative from industry/corporate sector/allied areas |
| 6 | **Mr. Mahanavar Balbhim Sahebrao**<br>Assistant Professor, Department of Physics,<br>Dada Patil Mahavidyalaya, Karjat | Member of the College Alumni |
| 7 | **Dr.Sapkal Ramchandra Tukaram**<br>Associate Professor, Department of Physics,<br>T. C. College, Baramati | Member |
| 8 | **Dr. Kulkarni Sachin Babasaheb**<br>Assistant Professor, Department of Physics,<br>T. C. College, Baramati | Member |
| 9 | **Mr. KakadeSandip Bhimrao**<br>Assistant Professor, Department of Physics,<br>T. C. College, Baramati | Member |
| 10 | **Dr.Mohite Vijay Sampat**<br>Assistant Professor, Department of Physics,<br>T. C. College, Baramati | Member |
| 11 | **Mrs. Bhosale Shubhangi Eknath**<br>Assistant Professor, Department of Physics,<br>T. C. College, Baramati | Member |
| 12 | **Mr. Thorat Sopan Muralidhar**<br>Assistant Professor, Department of Physics,<br>T. C. College, Baramati | Member |

| | | |
|---|---|---|
| 13 | **Mr. Shinde Pratik Kishor**<br>Assistant Professor, Department of Physics, T. C. College, Baramati | Member |
| 14 | **Mr. Madhare Pratik Laxman**<br>Assistant Professor, Department of Physics, T. C. College, Baramati | Member |
| 15 | **Miss. Jadhav Sai Vikas** | UG Student |
| 16 | **Miss. Phadtare Dnyaneshwari Rajendra** | PG Student |

## Credit distribution structure for Two Years PG as per National Education Policy (2026 Pattern): (M.Sc.)

| PG Program for First Year | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Level** | **Sem.** | **Major (MD)** | **Major (Ele)** | | | | **RM** | **OJT** | **RP** | | | | | **Cum.Cr.** |
| **6.0** | I | 8(T)+4 (P)/ 14(T) | 2(T)+2 (T/P)/ 4(T) | -- | -- | --- | 4 (RM)(T) | -- | -- | -- | -- | -- | -- | **20/ 22** |
| | II | 8(T)+4 (P) 14(T) | 2(T)+2 (T/P) 4(T) | -- | 0 | --- | 0 | 4 (OJT) | | 0 | 0 | 0 | 0 | **20/ 22** |
| **Cum. Cr. For PG Diploma** | | **24/28** | **8** | | | | **4** | **4** | | | | | | **40/44** |
| **Exit option : PG Diploma (40-44 Credits) after Three Year UG Degree** | | | | | | | | | | | | | | |
| **PG Program for Second Year** | | | | | | | | | | | | | | |
| **6.5** | III | 8(T)+4(P)/ 14(T) | 2(T)+2 (T/P)/ 4(T) | | | | | | 4 (RP) | | 0 | 0 | 0 | **20/ 22** |
| | IV | 8(T)+2(P)/ 12(T) | 2(T)+2 (T/P)/ 4(T) | | | | | | 6 (RP) | | 0 | 0 | 0 | **20/ 22** |
| **Cum. Cr. For PG Degree** | | **22/26** | **8** | | | | | | **10** | | | | | **40/44** |
| **Cum. Cr. For 2 Yr. PG Degree** | | **46/54** | **16** | | | | **4** | **4** | **10** | | | | | **80/88** |
| **Exit option : PG Degree (80-88 Credits) after Three Year UG Degree** | | | | | | | | | | | | | | |

**Abbreviations:** Yr.: Year; Sem.: Semester; MD: Mandatory, Ele : Electives, OJT: On Job Training: Internship/ Apprenticeship; FP: Field projects; RM: Research Methodology; Research Project: RP; Cumulative Credits: Cum. Cr., T : Theory, P : Practical

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# Department of Physics
# Course and Credit structure for
# M.Sc. –I Physics NEP-2020(2026 Pattern)

| Level | Sem | Course Type | Course Code | Title of Course | Theory / Practical | No. of Credits |
|---|---|---|---|---|---|---|
| 6.0 | I | Major (Mandatory) | PHY-501-MRM | Mathematical Methods in Physics | Theory | 4 |
| | | | PHY-502-MRM | Classical Electrodynamics | Theory | 4 |
| | | | PHY-503-MRM | Classical Mechanics | Theory | 2 |
| | | | PHY-504-MRM | Major Physics Practical-I | Practical | 2 |
| | | | PHY-505-MRM | Major Physics Practical-II | Practical | 2 |
| | | Major (Elective) | PHY-506-MJE(A) | Physics of 2D Materials-I | Theory (Any One) | 2 |
| | | | PHY-506-MJE(B) | Electronics | | |
| | | | PHY-507-MJE(A) | Major Elective Practical-I | Practical (Any One) | 2 |
| | | | PHY-507-MJE(B) | Major Elective Practical-II | | |
| | | Research Methodology | PHY-508-RM | Research Methodology | Theory | 4 |
| | | | | | **Total Credits Sem-III** | **22** |
| 6.0 | II | Major (Mandatory) | PHY-551-MRM | Atoms, Molecules and Laser | Theory | 4 |
| | | | PHY-552-MRM | Quantum Mechanics | Theory | 4 |
| | | | PHY-553-MRM | Physics of Semiconductor Devices | Theory | 2 |
| | | | PHY-554-MRM | Major Physics Practical-III | Practical | 2 |
| | | | PHY-555-MRM | Major Physics Practical-IV | Practical | 2 |
| | | Major (Elective) | PHY-556-MJE(A) | Physics of 2D Materials-II | Theory (Any One) | 2 |
| | | | PHY-556-MJE(B) | Advanced Electronics | | |
| | | | PHY-557-MJE(A) | Major Elective Practical-III | Practical (Any One) | 2 |
| | | | PHY-557-MJE(B) | Major Elective Practical-IV | | |
| | | OJT | PHY-558-OJT | On Job Training | Practical | 4 |
| | | | | | **Total Credits Sem-III** | **22** |
| | | | | | **Cumulative Credits for PG Diploma – I and II** | **22+22 =44** |

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# Post-Graduate programme Outcomes: 2026 Pattern Faculty of Science

According to National Education Policy2020 Programme Outcomes for M.Sc. Programme (P.G.) 2026 Pattern w.e.f Academic Year 2026-2027

On Successful completion of the Post-Graduate Programme in Science, the learners will be able to:

| | |
|---|---|
| PO1 | **Advanced Disciplinary Knowledge & Originality:** Demonstrating comprehensive and advanced knowledge in the chosen field of science, extending beyond the undergraduate level, providing a specialized foundation for developing and applying original Ideas, particularly within a research context |
| PO2 | **Research, Analysis, and Complexity:** Ability to formulate hypotheses and design experiments while demonstrating the capacity to integrate knowledge and handle complex information, even when it is incomplete or limited |
| PO3 | **Problem Solving in New Contexts:** Apply theoretical knowledge and problem-solving abilities to unfamiliar, real-world, or multidisciplinary environments, moving beyond standard classroom scenarios to innovative applications. |
| PO4 | **Technical Mastery and Scientific Reasoning**: Utilize modern tools, specialized techniques, and instruments with high proficiency, underpinned by a deep rationale and scientific reasoning for the choice of methodology. |

| | |
|---|---|
| PO5 | **Integrated Communication:**<br>Clearly and unambiguously communicate complex scientific conclusions, and the knowledge/rationale supporting them, to both specialist peers and non-specialist stakeholders. |
| PO6 | **Ethical, Social, and Professional Judgment:**<br>Adhere to strict ethical standards in research while reflecting on the social and environmental responsibilities linked to the application of scientific knowledge and professional judgments. |
| PO7 | **Autonomous and Lifelong Learning:**<br>Exhibit the learning skills necessary to pursue further study or professional development in a largely self-directed and autonomous manner. |
| PO8 | **Employability, Innovation, and Entrepreneurship:**<br>Translate advanced technical skills and independent thinking into professional excellence within industry, academia, or entrepreneurial ventures. |

# CBCS Syllabus as per NEP 2020 for M.Sc Physics (2026 Pattern)

**Name of the Programme** : M.Sc. Physics

**Programme Code** : PSPH

**Class** : M.Sc-I

**Semester** : I

**Course Type** : Major Mandatory (Theory)

**Course Code** : PHY-501-MRM

**Course Title** : Mathematical Methods in Physics

**No. of Credits** : 04

**No. of Teaching Hours** : 60

## Course Objectives:

1. The educational methodology of this subject proposes to integrate the domain of concepts and knowledge from mathematics into practical application of physics phenomena, and the development of abilities and skills to solve example problems.
2. Student discussion in interactive forums, which aim to improve the instrumental aspects learned through the lectures and experiences outside the walls.
3. The educational methodology of this subject proposes to integrate the domain of concepts and knowledge from mathematics into practical application of physics phenomena, and the development of abilities and skills to solve example problems.
4. The educational methodology of this subject proposes to integrate the domain of concepts and knowledge from mathematics into practical application of physics phenomena, and the development of abilities and skills to solve example problems.
5. The educational methodology of this subject proposes to integrate the domain of concepts and knowledge from mathematics into practical application of physics phenomena, and the development of abilities and skills to solve example problems.
6. Student discussion in interactive forums, which aim to improve the instrumental aspects learned through the lectures and experiences outside the walls.

7.The educational methodology of this subject proposes to integrate the domain of concepts and knowledge from mathematics into practical application of physics phenomena, and the development of abilities and skills to solve example problems.

## Course Outcomes:

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

CO1:Fromthiscourse,thestudentsareexpectedtolearnsomemathematicaltechniques required to understand the physical phenomena at the postgraduate level.

CO2:Thestudentsareexpectedtobeabletosolvesimpleproblemsinprobability,understandthe concept of independent events and work with standard continuous distributions.

CO3: The students will have idea of the functions of complex variables; solve non homogeneous differential equations and partial differential equations using simple methods.

CO4:Thestudents are expected to be able to solve simple problems on Fourier series and Fourier transform, Laplace transform etc.

CO5: Students are able to solve ordinary second order differential equations important in the physical sciences; solve physically relevant partial differential equations using standard methods like separation of variables, series expansion, and integral transforms.

CO6: Students have a good grasp of the basic elements of complex analysis, including the important integral theorems.

CO7:Students are able to apply variational calculus to find optimal curves and surfaces

## Topics and Learning Points

**Unit 1: Complex Analysis** **(15L)**

Complex number, Complex function (polynomial, Exponential, Trigonometric complex function, Logarithm), differentiation, Analytical function, Cauchy-Riemann condition, Line integrals, Cauchy integral formula, Derivative of analytical functions, Power Series, Taylor's theorem, Laurent's theorem, Calculus of residues, Evaluation of real definite integrals

References: 1-5

**Unit 2: Vector Space and Matrix Algebra** **(15L)**

Revision on Vector space: Vectors (dependent and independent), Vector space, Hilbert space, Dimension of vector space, Matrix representation, Similarity transformation, Eigen values and Eigen vectors, Inner product, Orthogonality, Introduction only to Gramm-Schmidt orthogonalization procedure.

Matrix: Types of matrix, Rank of matrix, Eigen values and Eigen vectors, Unitary transformation, Diagonalization

References: 6, 7

**Unit 3: Special Functions (15L)**

Bessel function, Legendre, Hermite, and Laguerre functions – Generating function, Recurrence relations and their differential equations, Orthogonality properties, Bessel's function of first and second kind.

References: 4, 5, 7

**Unit 4: Fourier Series and Integral Transforms (15L)**

Fourier series: Definition, Dirichlet's Condition, Fourier Integral and Fourier transform, convolution theorem, Parseval's identity, Laplace transform and its properties, Fourier transform and Laplace transform, Dirac Delta function.

References: 3, 4, 7

**References:**


1. Complex Variables and Application- J. W. Brown, R. V. Churchill - McGraw Hill
2. Complex Variables – Seymour Lipschutz
3. Mathematics for Physical Sciences – Mary Boas, John Wiley and Sons
4. Mathematical methods in Physics- B. D. Gupta
5. Mathematical methods in Physics- Satyaprakash
6. Linear algebra – Seymour Lipschutz, Schaum Outline Series McGraw Hill Edition
7. Mathematical Method for Physicists, Arfken and Weber, 6th Edition, Academic Press
8. Fourier Series - Seymour Lipschutz, Schaum Outlines Series

## Mapping of Program Outcomes with Course Outcomes

**Class**: M.Sc-I, Semester-I **Subject**: Physics

**Course**: Mathematical Methods in Physics **Course Code**: PHY-501-MRM

**Weightage**: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

| | Course Outcomes (CO) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Programme Outcomes (PO)** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** | **CO6** | **CO7** |
| **PO1** | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **PO2** | 3 | 2 | 3 | 3 | 3 | 2 | 3 |
| **PO3** | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **PO4** | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **PO5** | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **PO6** | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **PO7** | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **PO8** | 3 | 2 | 3 | 3 | 3 | 2 | 3 |

### Justification

**PO1: Advanced Disciplinary Knowledge & Originality**

- CO1, CO3–CO7: Focus on advanced mathematical techniques (PDEs, transforms, variational calculus, complex analysis), building research-level understanding.
- CO2: Probability concepts are fundamental, not highly advanced → moderate (2).

**PO2: Research, Analysis, and Complexity**

- CO1, CO3–CO5, CO7: Mathematical and PDE skills directly support analyzing complex problems and integrating knowledge → strong (3).
- CO2, CO6: Provide analytical support but less central → moderate (2).

**PO3: Problem Solving in New Contexts**

- CO1–CO5, CO7: Techniques are applicable in unfamiliar or interdisciplinary contexts → strong (3).
- CO6: Complex analysis moderately supports problem-solving → moderate (2).

**PO4: Technical Mastery and Scientific Reasoning**

- CO1, CO3–CO7: Advanced techniques require technical skill and rationale → strong (3).
- CO2: Basic probability is less technically demanding → moderate (2).

**PO5: Integrated Communication**

- All COs: Explaining results and rationale requires moderate communication skills → moderate (2).

**PO6: Ethical, Social, and Professional Judgment**

- All COs: Course is primarily technical → weak (1).

**PO7: Autonomous and Lifelong Learning**

- CO1, CO3–CO7: Advanced topics require self-directed learning → strong (3).
- CO2: Probability basics support autonomous learning moderately → moderate (2).

**PO8: Employability, Innovation, and Entrepreneurship**

- CO1, CO3–CO5, CO7: Strongly enhance employability and ability to innovate in research/industry → strong (3).
- CO2, CO6: Moderate relevance to employability → moderate (2).

# CBCS Syllabus as per NEP 2020 for M.Sc Physics (2026 Pattern)

**Name of the Programme** : M.Sc. Physics

**Programme Code** : PSPH

**Class** : M.Sc-I

**Semester** : I

**Course Type** : Major Mandatory (Theory)

**Course Code** : PHY-502-MRM

**Course Title** : Classical Electrodynamics

**No. of Credits** : 04

**No. of Teaching Hours** : 60

## Course Objectives:

1. To apprise the students regarding the concepts of electrodynamics and Maxwell equations and use them various situations.
2. To introduce the basic mathematical concepts related to electromagnetic vector fields.
3. To impart knowledge on the concepts of electrostatics, electric potential, energy density and their applications.
4. To impart knowledge on the concepts of magnetostatics, magnetic flux density, scalar and vector potential and its applications.
5. To impart knowledge on the concepts of Faraday's law, induced emf and Maxwell 's equations.
6. To impart knowledge on the concepts of Concepts of electromagnetic waves.
7. To familiarize the students about the electric field in material space and learn to solve boundary value problems.

## Course Outcomes:

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

CO1. Understand the concept of multipole expansions and deeper meaning of Maxwell's equations.

CO2. Understand the technique of deriving formulae for the electromagnetic waves in stationary and conducting medium.

CO3. Calculate the electromagnetic radiations from moving charges, considering retardation effects and make a detailed account for Gauge transformations.

CO4. Embracing the concepts of special relativity as emerged through the laws of electrodynamics.

CO5. To formulate and solve the electromagnetic problems skills In all the topics covered.

CO6.Explain classical electrodynamics based on Maxwell's equations including its formulation in covariant form.

CO7.Solve problems involving the calculation of fields, the motion of charged particles and the production of electromagnetic waves and Analyse the solution of these problems in the context of a range of applications.

## Topics and Learning Points

**Unit 1: Multiple Expansions and Time Varying Fields (18L)**

Multipole expansions for a localized charge distribution in free space, linear quadrupole potential and field, static electric and magnetic fields, boundary conditions, Faraday's law for stationary and moving media, Maxwell's displacement current, differential and integral forms of Maxwell's equations, Maxwell's equations for moving medium. Problems.

**Unit2: Energy, Force, Momentum Relations & Electromagnetic Wave Equations (20**L)

Energy relations in quasi-stationary current systems, Magnetic interaction between two current loops, Energy stored in electric and magnetic fields, Poynting's theorem, General expression for electromagnetic energy, Electromagnetic wave equations, Electromagnetic plane waves in stationary medium, Reflection and refraction of electromagnetic waves at plane boundaries (Oblique incidence), Electromagnetic waves in conducting medium, Skin effect and skin depth, wave guides ,Dispersion relations for solids

**Unit 3: Inhomogeneous Wave Equations (10L)**

Inhomogeneous wave equations, Lorentz's and Coulomb's gauges, Gauge transformations, Wave equations in terms of electromagnetic potentials, D' Alembertian operator, Hertz potential.

**Unit4: Relativistic Mechanics and Covariance (12L)**

Revision of relativity concepts Galilean Transformation, Lorentz transformations, Length contraction, Time Dilation, Twin Paradox, Relativistic velocity addition, Minkowski's space-time diagram, Four vector potential, Lorentz force on a charged particle.

## References:

1) Introduction to Electrodynamics, (3rd Edition) by David J. Griffith Publication: Prentice-Hall of India, New Delhi.
2) Introduction to Electrodynamics, by A.Z. Capri and P.V. Panat Narosa Publishing House.
3) Foundations of Electromagnetic theory by Reitz & Milford, World student series Edition.
4) Classical Electrodynamics, by J.D. Jackson, 3rd Edition John Wiley.
5) Electromagnetic theory and Electrodynamics by Satya Prakash, Kedar Nath and Co-Meerut.
6) Electromagnetics by B.B. Laud, Willey Eastern.
7) Matrices and Tensors in Physics by A. W. Joshi, 3rd Edition, New Age International.
8) Electrodynamics by Kumar Gupta and Singh.

## Mapping of Program Outcomes with Course Outcomes

**Class**: M.Sc-I, Semester-I **Subject**: Physics

**Course**: Classical Electrodynamics **Course Code**: PHY-502-MRM

**Weightage**: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

| | Course Outcomes (CO) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Programme Outcomes (PO)** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** | **CO6** | **CO7** |
| **PO1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO5** | 2 | 2 | 2 | 2 | 2 | 2 | 3 |
| **PO6** | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **PO7** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO8** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

### Justification

**PO1: Advanced Disciplinary Knowledge & Originality**

- CO1–CO7: All COs involve advanced concepts in electrodynamics, Maxwell's equations, relativity, and electromagnetic radiation—clearly extending beyond undergraduate knowledge and forming a foundation for original thinking and research.
  Weightage: 3 (Strong/Direct)

**PO2: Research, Analysis, and Complexity**

- CO1–CO7: Students analyze complex electromagnetic phenomena, integrate theoretical concepts (like gauge transformations and relativistic formulations), and tackle intricate calculations—mirroring research-level problem solving. Weightage: 3 (Strong/Direct)

**PO3: Problem Solving in New Contexts**

- CO1–CO7: All COs prepare students to apply theoretical knowledge to unfamiliar or advanced electrodynamics problems, such as moving charges, radiation, and field calculations, in novel or multidisciplinary scenarios. Weightage: 3 (Strong/Direct)

**PO4: Technical Mastery and Scientific Reasoning**

- CO1–CO7: Mastery of Maxwell's equations, multipole expansions, covariant formulation, radiation, and relativistic effects demonstrates advanced technical skill and rigorous scientific reasoning. Weightage: 3 (Strong/Direct)

**PO5: Integrated Communication**

- CO1–CO6: Moderate weight (2) as students need to describe concepts and derivations to peers or instructors, but the primary focus is technical.
- CO7: Stronger weight (3) because analyzing and explaining complex problem solutions in a variety of applications requires clear, integrated communication.

**PO6: Ethical, Social, and Professional Judgment**

- CO1–CO7: The course is technical and concept-driven, so direct ethical or social judgment applications are minimal. Weightage: 1 (Weak/Low)

**PO7: Autonomous and Lifelong Learning**

- CO1–CO7: The course requires independent study of advanced topics (special relativity, gauge theory, radiation, covariant formulation) → promotes autonomous learning.
  Weightage: 3 (Strong/Direct)

**PO8: Employability, Innovation, and Entrepreneurship**

- CO1–CO7: Advanced technical mastery in electrodynamics and problem-solving prepares students for research roles, industry applications (communications, accelerator physics, EM design), and innovation. Weightage: 3 (Strong/Direct)

# CBCS Syllabus as per NEP 2020 for M.Sc Physics (2026 Pattern)

**Name of the Programme** : M.Sc. Physics

**Programme Code** : PSPH

**Class** : M.Sc-I

**Semester** : I

**Course Type** : Major Mandatory (Theory)

**Course Code** : PHY-503-MRM

**Course Title** : Classical Mechanics

**No. of Credits** : 02

**No. of Teaching Hours** : 30

## Course Objectives:

1. Understand Constrained Mechanical Systems.
2. Apply Principles of Analytical Mechanics.
3. Analyse Energy and Conservation Laws
4. Derive and apply Hamilton's canonical equations of motion.
5. Formulate Lagrangian and Hamiltonian for relativistic particles.
6. Apply variational principles to relativistic systems and light rays.
7. Derive conditions for canonical transformations.

## Course Outcomes:

After successful completion of the course, the student will be able to:

CO1: Classify constraints in mechanical systems and determine degrees of freedom using generalized coordinates and configuration space concepts.

CO2: Formulate equations of motion using the principles of virtual work, D'Alembert's principle, and Lagrange's equations for constrained systems.

CO3: Analyse conservation laws, cyclic coordinates, Jacobi integrals, and total energy theorem in dynamical systems.

CO4: Construct Hamiltonian functions from given Lagrangians using Legendre transformations and derive Hamilton's canonical equations of motion.

CO5: Interpret dynamical evolution in phase space and apply Hamiltonian formalism to physical systems including relativistic particles and light rays.

CO6: Apply variational principles to derive Euler–Lagrange equations and solve mechanics problems using calculus of variations.

CO7: Perform canonical transformations using generating functions and verify conditions for canonical transformations.

## Topics and Learning Points

**Unit 1: Constrained Motion, Lagrangian and Hamilton's formulation (15L)**

Constrained Motion, Constraints and their Classification**,** Degrees of freedom, generalized coordinates, Virtual Displacement, Principle of Virtual Work, D'Alembert Principle, Configuration space, Lagrange's equation of motion, Theorem on total energy, Cyclic coordinates, Generalized momenta, Hamilton's function and Hamiltonian equation of motion, Phase space, Jacobi integrals and energy conservation, Lagrangian and Hamiltonian of relativistic particles and light rays.

**Problems solving**

**Unit 2: Variational Principle, Canonical Transformations & Poisson's Bracket (15L)**

Variational principle, Euler's equation, Applications of Variational principle, Concept of symmetry. Introduction of Poisson's bracket, Background and definition, Legendre transformations, Generating function, Conditions for canonical transformation, Poisson's bracket-definition, identities, Poisson's theorem, Jacobi identity, Invariance of Poisson Bracket under canonical transformation.

**Problems solving**

## References:

**1.** Classical mechanics by J.C. Upadhyaya, Himalaya Publishing House.

**2.** Classical mechanics by N.C. Rana and P.S. Jog, Tata Mc-Graw Hill Publishing Company limited, New Delhi.

**3.** Classical Mechanics by P.V. Panat, Narosa publishing Home, New Delhi.

**4.** Classical Mechanics by Kumar, Gupta, Sharma.

**5.** Classical Mechanics by H. Goldstein, Narosa Publishing Home, New Delhi.

**6.** Classical Mechanics by D. S. Mathur.

**7.** Introduction to Classical Mechanics by R. G. Takawale and P. S. Puranik, Tata Mc-Graw Hill Publishing Company Limited, New Delhi.

## Mapping of Program Outcomes with Course Outcomes

**Class**: M.Sc-I, Semester-I **Subject**: Physics

**Course**: Classical Mechanics **Course Code**: PHY-503-MRM

**Weightage**: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

| | Course Outcomes (CO) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Programme Outcomes (PO)** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** | **CO6** | **CO7** |
| **PO1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO5** | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **PO6** | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **PO7** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO8** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

### Justification

**PO1: Advanced Disciplinary Knowledge & Originality**

- CO1–CO7: All COs require deep understanding of advanced mechanics, Lagrangian & Hamiltonian formulations, variational calculus, and canonical transformations → extends knowledge beyond undergraduate level → strong (3).

**PO2: Research, Analysis, and Complexity**

- CO1–CO7: Students must analyze constrained systems, formulate equations, integrate conservation laws, and apply variational principles → research-level analysis of complex mechanical systems → strong (3).

**PO3: Problem Solving in New Contexts**

- CO1–CO7: Applying Lagrange/Hamiltonian mechanics to new or unfamiliar mechanical systems, including relativistic cases → strong (3).

**PO4: Technical Mastery and Scientific Reasoning**

- CO1–CO7: Mastery of generalized coordinates, Legendre transforms, variational methods, and canonical transformations requires high technical skill and rigorous reasoning → strong (3).

**PO5: Integrated Communication**

- CO1–CO7: Students must explain derivations, conservation principles, phase-space analysis, and canonical transformations clearly → moderate (2).

**PO6: Ethical, Social, and Professional Judgment**

- CO1–CO7: The course is primarily technical; ethical or social judgment application is minimal → weak (1).

**PO7: Autonomous and Lifelong Learning**

- CO1–CO7: Independent study of advanced mechanics, derivations, and variational methods promotes self-directed learning → strong (3).

**PO8: Employability, Innovation, and Entrepreneurship**

- CO1–CO7: Knowledge of advanced mechanics and Hamiltonian/Lagrangian methods is valuable in research, simulations, aerospace, robotics, and engineering → strong (3).

## CBCS Syllabus as per NEP 2020 for M.Sc Physics (2026 Pattern)

**Name of the Programme** : M.Sc. Physics

**Programme Code** : PSPH

**Class** : M.Sc-I

**Semester** : I

**Course Type** : Major Mandatory (Practical)

**Course Code** : PHY-504-MRM

**Course Title** : Major Physics Practical-I

**No. of Credits** : 02

**No. of Teaching Hours** : 60

### Course Objectives:

After completing this laboratory course, students will be able to:

1.Develop proficiency in handling advanced laboratory instruments such as interferometers, LASER sources, GM counters, and four-probe setups.

2.Determine Young's modulus using flexural vibrations and analyse elastic behaviour of materials.

3.Study interference phenomena using Fabry–Perot etalon and Michelson interferometer. Also able to determine wavelength of LASER using diffraction grating techniques.

4.Investigate Hall effect and determine carrier concentration and mobility. Measure resistivity of germanium using four-probe method and determine band gap.

5.Determine magnetic susceptibility using Gouy's method and classify materials.

6.Study counting statistics using GM counter.

7.Apply statistical tools, error propagation, and graphical methods for analysis of experimental data. Also able to interpret experimental results in light of theoretical models.

### Course Outcomes:

After successful completion of this practical course, the student will be able to:

CO1: Perform precision measurements to determine mechanical properties such as Young's modulus using vibrational techniques.

CO2: Analyse interference and diffraction patterns to determine wavelength and optical parameters using Fabry–Perot etalon, Michelson interferometer, and reflection grating.

CO3: Measure electrical properties such as Hall coefficient, carrier mobility, resistivity, and band gap of semiconductor materials.

CO4: Determine magnetic susceptibility of materials using Gouy's method and interpret magnetic behaviour.

CO5: Apply statistical analysis to radioactive decay data using GM counter and verify counting statistics.

CO6: Experimentally determine fundamental constants such as electronic charge (e) using Millikan oil drop method.

CO7: Verify quantum mechanical principles through electron diffraction experiments.

**List of Experiments: (Students have to perform Any 8 Experiments)**

1. Young's Modulus of steel by Flexural Vibrations of a bar.
2. Fabry-Parot Etalon.
3. Hall Effect.
4. Resistivity of Ge at various temperature by Four Probe method and determination of band gap.
5. Determination of wavelength of He-Ne LASER by Reflection grating.
6. Michelson Interferometer.
7. Magnetic Susceptibility by Gauoy's method.
8. 'e' by Millikan oil drop method.
9. G.M. Counter – I (Counting statistics).
10. Electron Diffraction.

**Additional Activity (Any one Activity equivalent to two experiments)**

Students must perform at least one additional activity out of two activities in addition to eight experiments mentioned above. Total Laboratory work with additional activities should be equivalent to ten experiments.

1. **Mini Projects**

2. **Industrial Visit / Study Tour/ Field visit**

## Mapping of Program Outcomes with Course Outcomes

**Class**: M.Sc-I, Semester-I **Subject**: Physics

**Course**: Major Physics Practical-I **Course Code**: PHY-504-MRM

**Weightage**: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

| | Course Outcomes (CO) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Programme Outcomes (PO)** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** | **CO6** | **CO7** |
| **PO1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO5** | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **PO6** | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **PO7** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO8** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

### Justification

**PO1: Advanced Disciplinary Knowledge & Originality**

- CO1–CO7: Performing precise experiments in mechanics, optics, semiconductors, magnetism, radioactivity, and quantum mechanics builds strong experimental knowledge and a foundation for original thinking in research → strong (3).

**PO2: Research, Analysis, and Complexity**

- CO1–CO7: Students must design, execute, and analyze experiments, integrate measurements with theory, and handle complex or incomplete data → strong (3).

**PO3: Problem Solving in New Contexts**

- CO1–CO7: Applying experimental techniques to measure diverse physical properties, validate quantum principles, or analyze counting statistics → directly supports problem-solving in novel contexts → strong (3).

**PO4: Technical Mastery and Scientific Reasoning**

- CO1–CO7: High technical skill required for precise measurements, instrument handling (interferometers, GM counter, Millikan apparatus), and reasoning underlying experimental choices → strong (3).

**PO5: Integrated Communication**

- CO1–CO7: Students must report experimental results, graphs, error analysis, and interpretation to peers or instructors → moderate communication emphasis → moderate (2).

**PO6: Ethical, Social, and Professional Judgment**

- CO1–CO7: Experiments are technical; minimal ethical/social judgment application → weak (1).

**PO7: Autonomous and Lifelong Learning**

- CO1–CO7: Students develop skills for self-directed experimentation, troubleshooting, and data interpretation → strong (3).

**PO8: Employability, Innovation, and Entrepreneurship**

- CO1–CO7: Practical experimental skills are highly valued in research labs, industrial R&D, optics/electronics, and semiconductor industries → strong (3).

# CBCS Syllabus as per NEP 2020 for M.Sc Physics (2026 Pattern)

**Name of the Programme** : M.Sc. Physics

**Programme Code** : PSPH

**Class** : M.Sc-I

**Semester** : I

**Course Type** : Major Mandatory (Practical)

**Course Code** : PHY-505-MRM

**Course Title** : Major Physics Practical-II

**No. of Credits** : 02

**No. of Teaching Hours** : 60

## Course Objectives:

After successful completion of this course, students will be able to:

1. Understand working principles of G.M. counter. Also able to determine end-point energy and absorption coefficient of beta radiation.
2. Determine wavelength of He–Ne LASER using transmission grating.
3. Analyse coherence length and spectral line width using Michelson interferometer.
4. Determine charge-to-mass ratio (e/m) of electron using Thomson method and understand motion of charged particles in electric and magnetic fields.
5. Determine Seebeck coefficient and study thermocouple operation.
6. Measure temperature dependence of resistance in semiconductors.
7. Determine energy band gap of semiconductor materials.

## Course Outcomes:

After successful completion of this laboratory course, students will be able to:

CO1: Operate a G.M. counter to determine end-point energy, absorption coefficient, and verify Gaussian statistics of radioactive decay.

CO2: Measure LASER wavelength using transmission grating and Analyse spectral line width and coherence using Michelson interferometer.

CO3: Determine charge-to-mass ratio (e/m) of electron using Thomson method and Analyse charged particle dynamics.

CO4: Evaluate thermoelectric properties by determining Seebeck coefficient and explain thermocouple working principles.

CO5: Analyse temperature dependence of resistance in semiconductors and determine energy band gap from experimental data.

CO6: Measure thermal and electrical conductivity of copper and verify Wiedemann–Franz law conceptually.

CO7: Calibrate semiconductor diode and Cu–Constantan thermocouple sensors for accurate temperature measurement.

**List of Experiments: (Students have to perform Any 8 Experiments)**

1. G.M. Counter –II End point energy and Absorption coefficient using G. M. tube.
2. Study of Gaussian distribution by G.M. tube.
3. Determination of wavelength of He-Ne LASER by transmission grating.
4. Coherence and width of spectral lines using Michelson Interferometer.
5. e/m by Thomson method.
6. Determination of Seebeck coefficient and understanding of Thermocouple working.
7. Temperature dependence of resistance (Semiconductor behavior).
8. Energy gap of Semiconductor.
9. Thermal & electrical conductivity of Cu.
10. Calibration of Si diode & a Copper constantan thermocouple temperature sensors.

**Additional Activity (Any one Activity equivalent to two experiments)**

Students must perform at least one additional activity out of two activities in addition to eight experiments mentioned above. Total Laboratory work with additional activities should be equivalent to ten experiments.

1. **Mini Projects**
2. **Industrial Visit / Study Tour / Field visit**

## Mapping of Program Outcomes with Course Outcomes

**Class**: M.Sc-I, Semester-I **Subject**: Physics

**Course**: Major Physics Practical-II **Course Code**: PHY-505-MRM

**Weightage**: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

| | Course Outcomes (CO) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Programme Outcomes (PO)** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** | **CO6** | **CO7** |
| **PO1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO5** | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **PO6** | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **PO7** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO8** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

### Justification

**PO1: Advanced Disciplinary Knowledge & Originality**

- CO1–CO7: Performing precision experiments in radioactive decay, optics, charged particle dynamics, thermoelectric effects, and semiconductor properties requires advanced disciplinary knowledge and builds a foundation for experimental originality → strong (3).

**PO2: Research, Analysis, and Complexity**

- CO1–CO7: Experiments involve design, analysis of data, application of Gaussian/statistical analysis, and interpreting physical phenomena → directly supports research and handling complex information → strong (3).

**PO3: Problem Solving in New Contexts**

- CO1–CO7: Applying experimental techniques to measure properties and analyze outcomes in varied contexts (semiconductors, thermocouples, LASER optics, electron dynamics) → strong (3).

**PO4: Technical Mastery and Scientific Reasoning**

- CO1–CO7: Technical proficiency is required in operating instruments like GM counters, interferometers, electron beam apparatus, thermocouples, and semiconductor calibration, combined with sound reasoning → strong (3).

**PO5: Integrated Communication**

- CO1–CO7: Students need to interpret and report experimental results, errors, and conclusions clearly → moderate communication emphasis → moderate (2).

**PO6: Ethical, Social, and Professional Judgment**

- CO1–CO7: Experiments are technical and controlled; minimal ethical/social judgment is directly involved → weak (1).

**PO7: Autonomous and Lifelong Learning**

- CO1–CO7: Independent execution of diverse experiments, calibration, and analysis develops self-directed learning → strong (3).

**PO8: Employability, Innovation, and Entrepreneurship**

- CO1–CO7: Skills in experimental physics, instrumentation, and semiconductor characterization are highly relevant to research labs, industrial R&D, and applied electronics → strong (3).

# CBCS Syllabus as per NEP 2020 for M.Sc Physics (2026 Pattern)

**Name of the Programme** : M.Sc. Physics

**Programme Code** : PSPH

**Class** : M.Sc-I

**Semester** : I

**Course Type** : Major Elective (Theory)

**Course Code** : PHY-506-MJE (A)

**Course Title** : Physics 2D Materials-I

**No. of Credits** : 02

**No. of Teaching Hours** : 30

## Course Objectives:

1. To make the students to understand about the difference between bulk and thin film, the optical, electrical, dielectric and magnetic properties of thin film, the theories explaining the formation of thin film and the fabrication and advantages of thin film devices.
2. Learn the fundamental atomistic mechanisms
3. Know thin film deposition techniques
4. Acquire knowledge on thin film device
5. Acquaint with thin film
6. Appreciate applications of thin films
7. Narrate various thin film deposition techniques

## Course Outcomes:

CO1: To understand the principle, differences and similarities, advantages, and disadvantages of different thin film deposition Techniques.

CO2: To understand and evaluate and use models for understanding nucleation and growth of thin films.

CO3: To understand about different instrumentation techniques and to analyze thin film properties to apply for various applications.

CO4: To improve problems solving skills related to evaluation of different properties of thin films.

CO5: Discuss the differences and similarities between different vacuum based deposition techniques

CO6: Evaluate and use models for nucleating and growth of thin films

CO7: Asses the relation between deposition technique, film structure, and film properties

## Topics and Learning Points

**Unit 1: Introduction to thin films (10L)**

Overview of vacuum techniques, Comparison of thin and thick films, Theory of growth of thin films: Nucleation, homogeneous nucleation, heterogeneous nucleation, critical nucleus size, energy barrier for nucleation, free energy change during cluster formation, volume free energy term, surface free energy term, critical radius calculation, nucleation rate expression, Frank-Van der Merwe model, Volmer-Weber model, Stranski-Krastanov model, comparison of models, various stages of film growth.

**Unit 2: Deposition Techniques and Measurement of thickness (20L)**

Physical methods: Vacuum Techniques (i) Thermal evaporation methods: Resistive heating, Electron Beam Evaporation, (ii) Sputtering system: Glow discharge, DC sputtering, Radio frequency sputtering, Magnetron sputtering. Chemical Methods: Chemical vapour deposition system (CVD), Chemical bath deposition: Ionic and solubility products, Electrochemical deposition: Deposition mechanism and Preparation of compound thin films, Spray pyrolysis Technique: Deposition mechanism and preparation of compound thin films. Sol-gel method, Spin coating, Chemical bath deposition (CBD), Successive Ionic Lauer of Adsorption& Reaction (SILAR), Hydrothermal method, Tolansky technique, Stress measurement by optical method, Gravimetric method, Wet difference method.

## References:

1. Hand book of Thin Film Technology: Maissel and Glang, (Mc Graw Hill)

2. Thin Film Phenomena: K. L. Chopra, (Mc Graw Hill)

3. Material Science of Thin Films: M. Ohring, (Academic Press)

4. Thin Film Process: J. L. Vossen and Kern, (Academic Press) 5. Vacuum Technology (2 nd revised edition), A. Roth, (North Hollad)

## Mapping of Program Outcomes with Course Outcomes

**Class**: M.Sc-I, Semester-I **Subject**: Physics

**Course**: Physics 2D Materials-I **Course Code**: PHY-506-MJE (A)

**Weightage**: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

| | Course Outcomes (CO) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Programme Outcomes (PO)** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** | **CO6** | **CO7** |
| **PO1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO2** | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **PO3** | 3 | 2 | 3 | 3 | 2 | 2 | 3 |
| **PO4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO5** | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **PO6** | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **PO7** | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **PO8** | 3 | 3 | 3 | 3 | 2 | 3 | 3 |

### Justification

**PO1: Advanced Disciplinary Knowledge & Originality**

- CO1–CO7: Understanding thin film deposition, growth models, instrumentation, and property analysis requires advanced knowledge in materials science and physics, extending beyond undergraduate learning → strong (3).

**PO2: Research, Analysis, and Complexity**

- CO1, CO2, CO3, CO4, CO6, CO7: Students evaluate models, analyze growth, and interpret thin film properties → strong (3).
- CO5: Comparison of deposition techniques is primarily descriptive → moderate (2).

**PO3: Problem Solving in New Contexts**

- CO1, CO3, CO4, CO7: Solving problems related to thin film growth, instrumentation, and structure–property relationships → strong (3).
- CO2, CO5, CO6: Focused more on understanding or evaluating models → moderate (2).

**PO4: Technical Mastery and Scientific Reasoning**

- CO1–CO7: Mastery in thin film deposition techniques, instrumentation, and model application requires technical skill and reasoning → strong (3).

**PO5: Integrated Communication**

- CO1–CO7: Moderate emphasis on explaining experimental results, model analysis, and technique comparisons → moderate (2).

**PO6: Ethical, Social, and Professional Judgment**

- CO1–CO7: Course is technical; direct ethical or social responsibility applications are minimal → weak (1).

**PO7: Autonomous and Lifelong Learning**

- CO1, CO2, CO3, CO4, CO6, CO7: Students need self-directed learning to understand complex deposition processes and evaluate models → strong (3).
- CO5: Moderate (2) as it mainly involves discussion and comparison.

**PO8: Employability, Innovation, and Entrepreneurship**

- CO1, CO2, CO3, CO4, CO6, CO7: Skills in thin film deposition, characterization, and analysis are directly relevant to research, industry, and technology development → strong (3).
- CO5: Moderate (2) since it focuses on discussion rather than technical application.

# CBCS Syllabus as per NEP 2020 for M.Sc Physics (2026 Pattern)

**Name of the Programme** : M.Sc. Physics

**Programme Code** : PSPH

**Class** : M.Sc-I

**Semester** : I

**Course Type** : Major Elective (Theory)

**Course Code** : PHY-506-MJE (B)

**Course Title** : Electronics

**No. of Credits** : 02

**No. of Teaching Hours** : 30

## Course Objectives:

After successful completion of this course, students will be able to:

1. Study characteristics and parameters of ideal and practical operational amplifiers.
2. Analyse input/output impedance, gain, bandwidth, CMRR, slew rate, and offset parameters.
3. Design and test inverting and non-inverting amplifiers, construct adder, subtractor, integrator, and differentiator circuits, design active filters: LPF, HPF, and BPF.
4. Design instrumentation amplifier for signal conditioning, construct waveform generators.
5. Apply Boolean identities and Karnaugh maps (SOP & POS) for logic minimization.
6. Study multiplexers and demultiplexers.
7. Design and verify flip-flops (RS, JK, MS-JK, D, T).

## Course Outcomes:

After successful completion of the course, the student will be able to:

CO1: Analyse operational amplifier characteristics and verify ideal op-amp assumptions experimentally.

CO2: Design and test basic and advanced op-amp circuits including amplifiers, filters, waveform generators, rectifiers, and sample-hold circuits.

CO3: Design and implement combinational logic circuits using Boolean algebra and Karnaugh map minimization.

CO4: Construct and verify sequential circuits including flip-flops, shift registers (IC 7495), and counters (IC 7490).

CO5: Design synchronous and asynchronous counters and analyse timing behaviour.

CO6: Implement and evaluate Digital-to-Analog and Analog-to-Digital converter circuits.

CO7: Interpret input-output waveforms using CRO/DSO and validate circuit performance.

## Topics and Learning Points

**Unit 1: Study and applications of Operational Amplifiers (15L)**

Characteristic of op-amp, Parameters of ideal op-amp, Applications of Operational Amplifiers: Inverting and Non-inverting amplifier, Adder and Subtractor, Integrator and Differentiator, Active filters: LPF, HPF, BPF, Instrumentation Amplifier, Function Generator – Square wave, triangular, saw tooth, sine wave. Half wave and full wave precision rectifiers, Sample and hold circuits.

**Unit 2: Digital Logic circuits and Data Converters (15L)**

Combinational Logic: Review of Boolean identities and its use to minimize Boolean Expressions, Minimization of Boolean Expressions using Karnaugh map: SOP and POS, Multiplexer and De multiplexer, Sequential Logic; Flip-flops (RS, JK, MS-JK, D and T),

Shift registers using IC 7495: Applications as SISO, SIPO, PISO, PIPO etc

Counters: Synchronous, asynchronous and combinational counters, Decade counter IC 7490 with applications, Up-down counter,

Digital to analog Converters: Binary weighted type, R-2R ladder, Analog to digital converters: Flash/Simultaneous type, Counter type, Successive approximation type

## References:


1. Operational Amplifiers – G. B. Clayton (5th edition) Newnes
2. Operational Amplifiers Applications – G. B. Clayton
3. Electronic Principles – A. P. Malvino (TMH Publication)
4. Op-amps and Linear Integrated circuits – Gayakwad (Prentice Hall)
5. Linear Integrated circuits – D. Roy Choudhury, Shail Jain
6. Integrated circuits – Botkar
7. Digital Principles and Applications: Leach and Malvino
8. Data Converters – B.S. Sonde.


**Mapping of Program Outcomes with Course Outcomes**

**Class**: M.Sc-I, Semester-I **Subject**: Physics

**Course**: Electronics **Course Code**: PHY-506-MJE (B)

**Weightage**: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

| | **Course Outcomes (CO)** | | | | | | |
|---|---|---|---|---|---|---|---|
| **Programme Outcomes (PO)** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** | **CO6** | **CO7** |
| **PO1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO5** | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **PO6** | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **PO7** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO8** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

## Justification

**PO1: Advanced Disciplinary Knowledge & Originality**

- CO1–CO7: Understanding and designing analog and digital circuits, operational amplifier applications, logic circuits, and converters builds advanced knowledge and provides a foundation for original design → strong (3).

**PO2: Research, Analysis, and Complexity**

- CO1–CO7: Students analyze circuit behavior, verify assumptions, troubleshoot, and design circuits → demonstrates research-level analytical ability and handling of complex information → strong (3).

**PO3: Problem Solving in New Contexts**

- CO1–CO7: Designing circuits for various applications, analyzing input-output behavior, and implementing ADC/DAC solutions involve solving practical and multidisciplinary problems → strong (3).

**PO4: Technical Mastery and Scientific Reasoning**

- CO1–CO7: Operation of test instruments (CRO/DSO), experimental verification, and circuit implementation requires technical proficiency and reasoning → strong (3).

**PO5: Integrated Communication**

- CO1–CO7: Students need to report experimental results, waveform interpretation, and design validation clearly → moderate (2).

**PO6: Ethical, Social, and Professional Judgment**

- CO1–CO7: The course is technical; direct ethical or social applications are minimal → weak (1).

**PO7: Autonomous and Lifelong Learning**

- CO1–CO7: Independent design, testing, and analysis of circuits fosters autonomous learning → strong (3).

**PO8: Employability, Innovation, and Entrepreneurship**

- CO1–CO7: Skills in analog/digital circuit design, logic implementation, and instrumentation are highly employable and relevant to innovation in electronics and embedded systems → strong (3).

## CBCS Syllabus as per NEP 2020 for M.Sc Physics (2026 Pattern)

**Name of the Programme** : M.Sc. Physics

**Programme Code** : PSPH

**Class** : M.Sc-I

**Semester** : I

**Course Type** : Major Elective (Practical)

**Course Code** : PHY-507-MJE (A)

**Course Title** : Major Elective Practical-I

**No. of Credits** : 02

**No. of Teaching Hours** : 60

### Course Objectives:

1. Enable students to learn and perform thin film preparation using methods such as vacuum evaporation, sputtering, spin coating, or chemical deposition.

2.Help students analyse different stages of film growth and relate experimental observations to theoretical growth models (layer-by-layer, island growth, etc.).

3.Train students to determine film thickness using techniques like interferometry, quartz crystal monitor, profilometer, or gravimetric methods.

4.Provide hands-on experience in analysing crystal structure, grain size, and phase using various characterization techniques.

5.Enable determination of optical constants such as refractive index, absorption coefficient, and band gap using UV-Vis spectroscopy.

6.Train students to measure resistivity, conductivity, and temperature coefficient of resistance using four-probe or two-probe methods.

7.Develop the ability to study the effect of deposition rate, substrate temperature, and annealing on structural, optical, and electrical properties of thin films.

### Course Outcomes:

After successful completion of the course, the student will be able to:

CO1. Prepare thin films using suitable deposition techniques such as thermal evaporation, sputtering, spin coating, or chemical methods under controlled conditions.

CO2. Measure and calculate the thickness of thin films using experimental methods such as wet difference method or gravimetric techniques.

CO3. Characterize the structural properties of thin films and determine parameters such as crystal structure, lattice constants, and grain size from XRD data.

CO4.Analyse the optical properties of thin films and evaluate optical constants such as refractive index, absorption coefficient and optical band gap.

CO5. Determine electrical properties such as resistivity, conductivity and temperature coefficient of resistance using two-probe or four-probe techniques.

CO6. Interpret experimental results and correlate deposition parameters (e.g., substrate temperature, deposition rate, annealing) with film properties.

CO7. Demonstrate good laboratory practices including vacuum handling, instrument calibration, data analysis, error estimation, and preparation of scientific reports.

**List of Experiments: (Students have to perform Any 8 Experiments)**

1. Preparation of thin film using vacuum evaporation method
2. Preparation of thin film using spray deposition method
3. Preparation of thin film using chemical bath deposition (CBD) method
4. Preparation of thin film using successive ionic layer of adsorption & reaction method (SILAR) method
5. Preparation of thin film using hydrothermal method
6. Preparation of thin film using electrodeposition method
7. Preparation of thin film using spin coating method
8. Preparation of thin film using sol-gel method
9. Measurement of thickness of thin film using gravimetric method
10. Preparation of thin film using chemical vapour

**Additional Activity (Any one Activity equivalent to two experiments)**

Students must perform at least one additional activity out of two activities in addition to eight experiments mentioned above. Total Laboratory work with additional activities should be equivalent to ten experiments.

1. **Mini Projects**

2. **Industrial Visit / Study Tour / Field visit**

## Mapping of Program Outcomes with Course Outcomes

**Class**: M.Sc-I, Semester-I **Subject**: Physics

**Course**: Major Elective Practical-I **Course Code**: PHY-507-MJE (A)

**Weightage**: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

| | Course Outcomes (CO) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Programme Outcomes (PO)** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** | **CO6** | **CO7** |
| **PO1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO5** | 2 | 2 | 2 | 2 | 2 | 2 | 3 |
| **PO6** | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| **PO7** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO8** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

### Justification

**PO1: Advanced Disciplinary Knowledge & Originality**

- CO1–CO7: All COs require a deep understanding of thin film deposition, structural, optical, and electrical properties, along with experimental analysis → strong (3).

**PO2: Research, Analysis, and Complexity**

- CO1–CO7: Experiments involve designing deposition processes, analyzing XRD/optical/electrical data, correlating parameters with outcomes → strong research-oriented skills → strong (3).

**PO3: Problem Solving in New Contexts**

- CO1–CO7: Students need to apply theoretical and practical knowledge to optimize thin film properties under varied deposition and measurement conditions → strong (3).

**PO4: Technical Mastery and Scientific Reasoning**

- CO1–CO7: Hands-on use of deposition systems, XRD, optical setups, electrical measurement techniques, and error analysis requires technical mastery → strong (3).

**PO5: Integrated Communication**

- CO1–CO6: Moderate communication (reporting, explaining results) → moderate (2).
- CO7: Stronger (3) because scientific report preparation, data presentation, and interpretation require integrated communication skills.

**PO6: Ethical, Social, and Professional Judgment**

- CO1–CO6: Minimal ethical/social component → weak (1).
- CO7: Moderate (2) since good laboratory practices, instrument handling, and safety require professional responsibility.

**PO7: Autonomous and Lifelong Learning**

- CO1–CO7: Students must learn independently to operate deposition systems, analyze results, and optimize thin film parameters → strong (3).

**PO8: Employability, Innovation, and Entrepreneurship**

- CO1–CO7: Hands-on experience with thin film deposition, characterization, and instrumentation is highly relevant for research, industry, and technological innovation → strong (3).

# CBCS Syllabus as per NEP 2020 for M.Sc Physics (2026 Pattern)

**Name of the Programme** : M.Sc. Physics

**Programme Code** : PSPH

**Class** : M.Sc-I

**Semester** : I

**Course Type** : Major Elective (Practical)

**Course Code** : PHY-507-ME (B)

**Course Title** : Major Elective Practical-II

**No. of Credits** : 02

**No. of Teaching Hours** : 60

## Course Objectives:

After completing this laboratory course, students will be able to:

1. Study characteristics and parameters of ideal and practical operational amplifiers.
2. Design and test inverting and non-inverting amplifiers. Also construct adder, subtractor, integrator, and differentiator circuits.
3. Design active filters: LPF, HPF, and BPF.
4. Design instrumentation amplifier for signal conditioning.
5. Study and test sample-and-hold circuits.
6. Apply Boolean identities and Karnaugh maps (SOP & POS) for logic minimization and study multiplexers and demultiplexers.
7. Design and verify flip-flops and study shift registers (IC 7495) as SISO, SIPO, PISO, PIPO.

## Course Outcomes:

After successful completion of this practical course, the student will be able to:

CO1: Analyse operational amplifier characteristics and verify ideal op-amp assumptions experimentally.

CO2: Design and test basic and advanced op-amp circuits including amplifiers, filters, waveform generators, rectifiers, and sample-hold circuits.

CO3:Design and implement combinational logic circuits using Boolean algebra and Karnaugh map minimization.

CO4: Construct and verify sequential circuits including flip-flops, shift registers (IC 7495), and counters (IC 7490).

CO5: Design synchronous and asynchronous counters and analyse timing behaviour.

CO6: Implement and evaluate Digital-to-Analog and Analog-to-Digital converter circuits.

CO7: Interpret input-output waveforms using CRO/DSO and validate circuit performance.

**List of Experiments: (Students have to perform Any 8 Experiments)**

1. Voltage to Frequency Convertor using OP-AMP.
2. DAC (4-bit R-2R Ladder Type).
3. Active filter- Low pass, High pass, Band pass Filter using OP-AMP.
4. Study of multiplexer and Demultiplexer.
5. Op-amp based clipper and clampers
6. Study of optocoupler using IC MCT-2E
7. Study of IC 7490 (Decade counter)
8. Design, built and test oscillator – Wien Bridge oscillator
9. 8-bit Analog to Digital converter (ADC).
10. Instrumentation Amplifier using three op-amps.

**Additional Activity (Any one Activity equivalent to two experiments)**

Students must perform at least one additional activity out of two activities in addition to eight experiments mentioned above. Total Laboratory work with additional activities should be equivalent to ten experiments.

1. **Mini Projects**

2. **Industrial Visit / Study Tour / Field visit**

## Mapping of Program Outcomes with Course Outcomes

**Class**: M.Sc-I, Semester-I **Subject**: Physics

**Course**: Major Elective Practical-II **Course Code**: PHY-507-MJE (B)

**Weightage**: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

| | Course Outcomes (CO) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Programme Outcomes (PO)** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** | **CO6** | **CO7** |
| **PO1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO5** | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **PO6** | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **PO7** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PO8** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

### Justification

**PO1: Advanced Disciplinary Knowledge & Originality**

- CO1–CO7: Understanding operational amplifier characteristics, logic design, sequential circuits, and ADC/DAC implementation requires advanced knowledge in electronics, providing a foundation for original design → strong (3).

**PO2: Research, Analysis, and Complexity**

- CO1–CO7: Students analyze circuit behavior, verify ideal assumptions, design, and troubleshoot circuits → strong (3).

**PO3: Problem Solving in New Contexts**

- CO1–CO7: Designing and testing circuits, analyzing waveform outputs, and interpreting results applies problem-solving in practical and unfamiliar contexts → strong (3).

**PO4: Technical Mastery and Scientific Reasoning**

- CO1–CO7: High proficiency is required in using CRO/DSO, logic ICs, and circuit instrumentation with sound reasoning for design and testing → strong (3).

**PO5: Integrated Communication**

- CO1–CO7: Reporting experimental results, circuit analysis, and waveform interpretation requires communication, though secondary to technical work → moderate (2).

**PO6: Ethical, Social, and Professional Judgment**

- CO1–CO7: Course is technical; minimal ethical/social components → weak (1).

**PO7: Autonomous and Lifelong Learning**

- CO1–CO7: Designing and testing circuits fosters independent learning and continuous skill development → strong (3).

**PO8: Employability, Innovation, and Entrepreneurship**

- CO1–CO7: Circuit design, instrumentation, and testing skills are highly relevant for electronics R&D, embedded systems, and industrial applications → strong (3).

# CBCS Syllabus as per NEP 2020 for M.Sc Physics (2026 Pattern)

**Name of the Programme** : M.Sc. Physics

**Programme Code** : PSPH

**Class** : M.Sc-I

**Semester** : I

**Course Type** : Research Methodology (Theory)

**Course Code** : PHY-508-RM

**Course Title** : Research Methodolgy

**No. of Credits** : 04

**No. of Teaching Hours** : 60

## Course Objectives:

1. Students should understand a general definition of research design.
2. Students should know why educational research is undertaken, and the audiences that profit from research studies.
3. Students should be able to identify the overall process of designing a research study from its inception to its report.
4. Students should be familiar with ethical issues in educational research, including those issues that arise in using quantitative and qualitative research.
5. Students should know the primary characteristics of quantitative research and qualitative research.
6. Students should be able to identify a research problem stated in a study.
7. Students should be familiar with how to write a good introduction to an educational research study and the components that comprise such an introduction

## Course Outcomes:

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

CO1: Actively consider and take up research and associated higher studies in large numbers.

CO2: Aware of the details associated with formal research.

CO3: Overcome common misconceptions that may be present in their minds.

CO4: Take up research activities in a more systematic and formal manner right from the beginning.

CO5: Demonstrate the ability to choose methods appropriate to research aims and objectives.

CO6: Understand the limitations of particular research methods.

CO7: Demonstrate the ability to choose methods appropriate to research aims and objectives

## Topics and Learning Points

**Unit 1: Research Methodology: An Introduction (15L)**

Meaning of Research, Objectives of Research, Motivation in Research, Characteristics of Research, Types of Research, Research Approaches, Significance of Research, Research Problem, Research Design, Importance of knowing how research is done, Research Process, Criteria of Good Research, Problems Encountered by Researchers in India

**Unit 2: Overview of Literature Survey (15L)**

Need of literature survey, sources of literature- open access, primary sources, secondary sources and Tertiary sources, INDEST arrangement, library subscriptions, research gate, academia.edu, sci-hub, some terminologies in literature, Awareness about- Journal impact factor, citation index, h-index, strategies to search-Keyword search, backward chronological search, forward chronological search, systematic manual search, citation information, publishers, major publishers, online access, research papers, thesis, reference manager, literature survey using-web of science, Scopus, Referencing using BibTex in LaTeX.

**Unit 3:Research Methods (15L)**

Research Methods: Research Methods versus Methodology, Research and Scientific Method, Characteristics of methods and their implications in research area. Development of Research Proposal: Research proposal and its elements, Formulation of research problem, Development of objectives and hypotheses. Report Writing: Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports, Conclusions

**Unit 4: Creativity and Ethics in Research (15L)**

Sternberg's theory of creativity, traits of a creative researcher, attributes of a good researcher, Important instances of creativity, types of intelligence, knowledge, thinking styles, motivation, environment, role of stress in research, principle way for occurrence of creativity, Flow and creativity in research, components of flow, management of creativity, Nobel prize winners and famous scientists in Physics, Lessons from history, key road blocks and aids to creativity, The research process, Ethics and research, ethical dimensions of research, consequences, ethical and associated issues, Research ethics, unethical behaviour, Evolution of modern research ethics, researchers obligations, other important issues in research.

## References:

1. Research in Education, 10th Edition- Best & Kahn

2. Research Methodology- C.R. Kothari.

3. Methodology of Educational Research- Lokesh Koul

4. Case Study Research- John McLeod

5. Foundations of Behavioural Research- Fred N Kerlinger

6. Research Methods- Rashmi Agrawal

**Mapping of Program Outcomes with Course Outcomes**

**Class**: M.Sc-I, Semester-I **Subject**: Physics

**Course**: Rearch Methodolgy **Course Code**: PHY-508-RM

**Weightage**: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

| | Course Outcomes (CO) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Programme Outcomes (PO)** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** | **CO6** | **CO7** |
| **PO1** | 3 | 3 | 2 | 3 | 3 | 2 | 3 |
| **PO2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 |
| **PO3** | 2 | 2 | 2 | 2 | 3 | 2 | 3 |
| **PO4** | 2 | 2 | 1 | 2 | 3 | 2 | 3 |
| **PO5** | 2 | 3 | 2 | 2 | 3 | 2 | 3 |
| **PO6** | 2 | 3 | 1 | 2 | 3 | 3 | 3 |
| **PO7** | 3 | 3 | 2 | 3 | 3 | 2 | 3 |
| **PO8** | 2 | 2 | 1 | 2 | 3 | 2 | 2 |

**Justification**

**PO1: Advanced Disciplinary Knowledge & Originality**

- CO1, CO2, CO4, CO5, CO7: Students develop foundational research knowledge, systematic planning, and method selection → strong (3).
- CO3, CO6: Overcoming misconceptions and understanding limitations involve some disciplinary understanding but less originality → moderate (2).

**PO2: Research, Analysis, and Complexity**

- CO1–CO7: Students learn to plan research, select methods, and analyze research constraints → strong (3).

**PO3: Problem Solving in New Contexts**

- CO5, CO7: Selecting research methods for specific aims requires problem-solving → strong (3).
- CO1–CO4, CO6: Learning research methodology and overcoming misconceptions involves moderate application → moderate (2).

**PO4: Technical Mastery and Scientific Reasoning**

- CO5, CO7: Choosing appropriate methods and reasoning about research designs → strong (3).
- CO1, CO2, CO4, CO6: Some technical understanding of research techniques → moderate (2).
- CO3: Overcoming misconceptions involves minimal technical mastery → weak (1).

**PO5: Integrated Communication**

- CO2, CO5, CO7: Research methodology requires clear articulation of objectives, methods, and reasoning → strong (3).
- CO1, CO3, CO4, CO6: Communication is involved but secondary → moderate (2).

**PO6: Ethical, Social, and Professional Judgment**

- CO2, CO5, CO6, CO7: Awareness of ethical standards, limitations, and appropriate method selection → strong (3).
- CO1, CO4: Initiating research systematically → moderate (2).
- CO3: Overcoming misconceptions involves minimal ethics → weak (1).

**PO7: Autonomous and Lifelong Learning**

- CO1, CO2, CO4, CO5, CO7: Students are encouraged to independently pursue research and systematically select methods → strong (3).
- CO3, CO6: Some guidance needed → moderate (2).

**PO8: Employability, Innovation, and Entrepreneurship**

- CO5, CO7: Selecting research methods and applying research systematically is directly employable → strong (3).
- CO1, CO2, CO4, CO6: Basic research awareness moderately contributes to employability → moderate (2).
- CO3: Overcoming misconceptions contributes minimally → weak (1).