# Syllabus

## For

## Post Graduate Program in Physics

## New

# Credit Based Curriculum

## Under

## National Education Policy

By

**FIST Supported P G Department of Physics**
**National Institute of Technology Srinagar**
**Jammu and Kashmir**

July, 2023

**P. G. Department of Physics, NIT Srinagar (J&K)**

**29th July 2023**

# Dear Students

**Greetings from the Department of Physics**

On behalf of my dear colleagues and on my personal behalf as the Program Founder and Patron, we want to be among the first to congratulate and welcome you. **Earning a place in NIT Srinagar is an achievement and we are delighted that you will continue your intellectual journey in this prestigious institution, which is blessed with a diverse community. It is well known as Mini-India.** You will discover that one of our defining characteristics is our commitment to freedom of enquiry and expression. Mutual respect and civility are vital to all of us and you will find that you will be engaged in debates, discussions, deliberations and at times this may cause discomfort to you. I have been advocating for “that a university should be the open house of dialogue”.

This e-brochure is now updated and contains practical information on the **Master’s program in Physics** and has been updated according to the guidelines in **National Education Policy 2020,** the 3rd anniversary of which we are celebrating today. The program with its core-specialization structure offers a wide variety of possibilities, enabling you to pursue your particular ambitions and interests in these fascinating areas of Physics. Courses at different levels of specialization will enable you to deepen your physics knowledge and find out how it is applied in modern research and development. There are **various electives and optional subjects** to choose from, which are interdisciplinary and have immense applications in all spheres of life. We will keep on adding more electives as per your requirements and interests. Trust, the credit-based curriculum is at par with the existing syllabi of other universities and other NITs/IITs.

The department is equipped with modern and state-of-the-art laboratory facilities with sophisticated equipment. It is envisaged that in future the laboratories shall be made open to the interested students of the country, where they can carry their summer/winter internships also. Presently, a group of 18 Nanotechnology students from Islamia College Srinagar is under internship program in the department. We are convinced and satisfied that we have created a rewarding and challenging **postgraduate program in Physics** for the first time in the history of NIT Srinagar that keeps its promise to prepare you for future endeavors and struggles.

An African proverb says, **“If you want to go fast, go alone and if you want to go far, go together”.** At NIT Srinagar, in the PG Department of Physics, we choose to go together. We look forward to meeting and working with you in the mid of August 2023. If you have any questions regarding this brochure, please feel free to contact Shahji @ shahji@nitsri.ac.in.

**Once again, welcome and wish you a good start!**

**Prof (Dr.) M. A. Shah**
Founder & Head, P G Department of Physics

# Credit Based Curriculum
# For

# M Sc Physics

# @

## National Institute of Technology Srinagar

## From Year

## 2023 (Autumn)

# Revised Syllabus at a Glimpse

**SEMESTER - I** **Total Program Credits:** 75

| S.No. | Course Code | Theory Core Courses | L | T | P | Cr. | Page |
|---|---|---|---|---|---|---|---|
| 1. | PSPHY 101 | Classical Mechanics (Dr. H. Singh) | 2 | 1 | 0 | 3 | |
| 2. | PSPHY 102 | Quantum Mechanics (Prof. P. A. Ganai) | 2 | 1 | 0 | 3 | |
| 3. | PSPHY 103 | Mathematical Physics (Dr. M. Z. Ansari) | 2 | 1 | 0 | 3 | |
| 4. | PSPHY 104 | Solid State Physics (Prof. M. A. Shah) | 2 | 1 | 0 | 3 | |
| | | **Elective Courses (Students have to opt for 2 electives)** | | | | | |
| 5. | PSPHY EL1 | Renewable Sources of Energy (Prof. S. Rubab) | 2 | 0 | 0 | 2 | |
| 6. | PSPHY EL2 | Quantum Computation and Information (Dr. H. Singh) | 2 | 0 | 0 | 2 | |
| 7. | PSPHY EL3 | Thermoelectric Materials and Devices (Prof. M. Ikram) | 2 | 0 | 0 | 2 | |
| 8. | PSPHY EL4 | Biophysics and Biomaterials (Dr. V. Kumar) | 2 | 0 | 0 | 2 | |
| | | **Laboratory Courses** | | | | | |
| 9. | PSPHY LB1 | Solid State Physics & Materials Lab (Prof. M. A. Shah) | 0 | 0 | 3 | 1.5 | |
| 10. | PSPHY LB2 | Optics & Photonics Lab (Dr. H. Singh) | 0 | 0 | 3 | 1.5 | |
| 11. | PSPHY LB3 | Applied Physics Lab & Workshop (Dr. M. Z. Zubair) | 0 | 0 | 3 | 1.5 | |
| | Total | | | | | **20.5** | |

**SEMESTER – II**

| S.No. | Course Code | Theory Core Courses | L | T | P | Cr. | Page |
|---|---|---|---|---|---|---|---|
| 12. | PSPHY 201 | Thermodynamics and Statistical Mechanics (Dr. H. Singh) | 2 | 1 | 0 | 3 | |
| 13. | PSPHY 202 | Atomic & Molecular Physics (Prof. M. Ikram) | 2 | 1 | 0 | 3 | |
| 14. | PSPHY 203 | Electromagnetism and Electrodynamics (Prof. P. A. Ganai) | 2 | 1 | 0 | 3 | |
| 15. | PSPHY 204 | Nuclear and Particle Physics (Dr. Nadeem/ ) | 2 | 1 | 0 | 3 | |
| | | **Elective Courses (Students have to opt for 2 electives)** | | | | | |
| 16. | PSPHY EL5 | Physics at Nano-scale (Prof. M. A. Shah) | 2 | 0 | 0 | 2 | |
| 17. | PSPHY EL6 | Quantum Logic and Simulations (Dr. H. Singh) | 2 | 0 | 0 | 2 | |
| 18. | PSPHY EL7 | Physics of Semiconductors (Dr. V. Kumar/Dr Shah) | 2 | 0 | 0 | 2 | |
| 19. | PSPHY EL8 | Solar Photovoltaic (Dr. M. Z. Ansari/ Dr. Rubab) | 2 | 0 | 0 | 2 | |
| | | **Laboratory Courses** | | | | | |
| 20. | PSPHY LB4 | Electronics Tinkering Lab (Dr. M. Z. Ansari) | 0 | 0 | 3 | 1.5 | |
| 21. | PSPHY LB5 | Synthesis of Nano-Materials Lab (Prof. M. A. Shah) | 0 | 0 | 3 | 1.5 | |
| 22. | PSHY LB6 | Bio Engineering lab (Dr. V. Kumar) | 0 | 0 | 3 | 1.5 | |
| | Total | | | | | **20.5** | |

**SEMESTER – III**

| S.No. | Course Code | Theory Core Courses | L | T | P | Cr. | Page |
|---|---|---|---|---|---|---|---|
| 23. | PSPHY 301 | Astrophysics & Space Science (Prof. P. A. Ganai) | 2 | 1 | 0 | 3 | |
| 24. | PSPHY 302 | Atmospheric & Environmental Physics (Prof. M. A. Shah) | 2 | 1 | 0 | 3 | |
| 25. | PSPHY 303 | Condensed Matter Physics (Prof. M. Ikram) | 2 | 1 | 0 | 3 | |
| 26. | PSPHY 304 | Computational Physics (Dr. H. Singh) | 2 | 1 | 0 | 3 | |
| | | **Elective Courses (Students have to opt for pre-project seminar and 2 electives)** | | | | | |
| 27. | PSPHY EL9 | Medical Physics (Prof. S. Rubab) | 2 | 0 | 0 | 2 | |
| 28. | PSPHY EL10 | Superconductivity and superfluidity (Dr. H. Singh) | 2 | 0 | 0 | 2 | |
| 29. | PSPHY EL11 | General Theory of Relativity (Prof. P. A. Ganai) | 2 | 0 | 0 | 2 | |
| 30. | PSPHY EL12 | Principles of Spectroscopy (Prof. M. Ikram) | 2 | 0 | 0 | 2 | |
| 31. | PSPHY PPS | Pre-project Seminar | 1 | 0 | 0 | 1 | |
| | | **Laboratory Courses** | | | | | |
| 32. | PSPHY LB7 | Characterization Lab (Prof. M. A. Shah) | 0 | 0 | 3 | 1.5 | |
| 33. | PSPHY LB5 | Computational Physics Lab Dr. H Singh) | 0 | 0 | 3 | 1.5 | |
| | Total | | | | | **20** | |

**SEMESTER – IV**

| S.No | Course Code | Courses | L | T | P | Cr. | Page |
|---|---|---|---|---|---|---|---|
| 34. | PSPHY PR1 | Research Based Project with Faculty of choice (Even outside in Collaboration with institutions having MoUs) (Full Semester Dissertation, evaluated by External Expert) | 0 | 0 | 28 | **14** | |
| | Total | | | | | **75** | |
| | Students can take any courses from NPTEL of 5 credits (Essential) | | | | | | |

| CREDITS POINTS SUMMARY | | | | | |
|---|---|---|---|---|---|
| CREDIT POINTS SUMMARY | | | | | |
| Semesters | Sem-I | Sem-II | Sem-III | Sem-IV | Overall |
| **Credits** | **20.5** | **20.5** | **20** | **14** | **75** |

(B) **List of Departmental Pre Ph.D.-Course Work**

| S. No. | Course Code | Courses | L | T | P | Credits |
|---|---|---|---|---|---|---|
| 1. | PSPHD-1 | Scientific Writing and IPR | 3 | 0 | 0 | 3 |
| 2. | PSPHD-2 | Functional Materials and Applications | 3 | 0 | 0 | 3 |
| 3. | PSPHD-3 | Quantum Field Theory | 3 | 0 | 0 | 3 |
| 4. | PSPHD-4 | Simulation in material science | 3 | 0 | 0 | 3 |
| 5. | PSPHD-5 | Group Theory for Physicists. | 3 | 0 | 0 | 3 |
| 6. | PSPHD-6 | Nanoscience and nanotechnology | 3 | 0 | 0 | 3 |
| 7. | PSPHD-7 | Characterization Techniques | 3 | 0 | 0 | 3 |

# Summary Table

| Course details | L + T + L | Total Credits |
|---|---|---|
| Fundamental Courses | 2 + 1 + 0 | 12 x 3 = 36 |
| Electives | 2 + 0 + 0 | 6 x 2 = 12 |
| Laboratories | 0 + 0 + 3 | 8 x 1.5 = 12 |
| Pre Project-Seminar | 1 + 0 + 0 | 01 |
| Project | 14 | 14 |
| **Total** | | **75** |

Note: - For 5 credits, students can take NPTEL courses of their choice / interest.

# SEMESTER - I

| S. No | Course Code | Theory Courses | L | T | P | Credits |
|---|---|---|---|---|---|---|
| Core Courses | | | | | | |
| 1. | PSPHY 101 | Classical Mechanics | 2 | 1 | 0 | 3 |
| 2. | PSPHY 102 | Quantum Mechanics | 2 | 1 | 0 | 3 |
| 3. | PSPHY 103 | Mathematical Physics | 2 | 1 | 0 | 3 |
| 4. | PSPHY 104 | Solid State Physics | 2 | 1 | 0 | 3 |
| Elective Courses (Students have to choose 2 electives) | | | | | | |
| 5. | PSPHY EL1 | Renewable Sources of Energy | 2 | 0 | 0 | 2 |
| 6. | PSPHY EL2 | Quantum Computation and Information | 2 | 0 | 0 | 2 |
| 7. | PSPHY EL3 | Thermoelectric Materials and Devices | 2 | 0 | 0 | 2 |
| 8. | PSPHY EL4 | Biophysics and biomaterials | 2 | 0 | 0 | 2 |
| Laboratory Courses | | | | | | |
| 9. | PSPHY LB1 | Solid State Physics & Materials Lab | 0 | 0 | 3 | 1.5 |
| 10. | PSPHY LB2 | Optics & Photonics Lab | 0 | 0 | 3 | 1.5 |
| 11. | PSPHY LB3 | Applied Physics Lab and Workshop | 0 | 0 | 3 | 1.5 |
| | Total | | | | | 20.5 |

| **Subject: Classical Mechanics** **Course Code: PSPHY 101** | Year & Semester: M.Sc. Physics 1st year & 1st Semester. | | | | Credits: 3, L: 2, T: 1, P: 0 |
|---|---|---|---|---|---|
| Evaluation Policy | Mid-Term | Class Assessment | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks |

| Sr.No. | Course outcomes |
|---|---|
| CO1 | Solve problems using Lagrangian mechanics. |
| CO2 | Analyze the significance of Hamilton's equation. |
| CO3 | Solve transformation equations |
| CO4 | Analyze Lagrangian and Hamiltonian of simple harmonic oscillators. |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | Lecture 1-3: The Lagrangian Approach to Mechanics: degrees of freedom, constraints and generalized coordinates<br>Lecture 4: Virtual displacement, Virtual work and Generalized force.<br>Lecture 5: D'Alembert's principle and the Generalized equation of motion.<br>Lecture 6: The Lagrangian and the Euler Lagrange equation of motion<br>Lecture 7: Cyclic coordinates and canonical momenta<br>Lecture 8-10: Applications; pendulums, Particle in electromagnetic field | 10 |
| 02 | Lecture 1-2: Variational calculus and Hamiltonian dynamics: the variational calculus and the Euler equation<br>Lecture 3-4: The principle of least action and the Euler Lagrange equation, constraints in variational dynamics<br>Lecture 5-6: Legendre transformations<br>Lecture 7-8: Hamilton's equations, Conservation laws<br>Lecture 9-10: Phase space and Liouville's theorem | 10 |
| 03 | Lecture 1-2: Theoretical Mechanics: canonical transformations and generating functions,<br>Lecture 3-5: Poisson Brackets (PB); the angular momentum PB relations, invariance of PBs under canonical transformations, action-angle variables and adiabatic invariance<br>Lecture 6-9: The Hamilton Jacobi (HJ) Equation; HJ equation for Hamilton's characteristic function, separation of variables<br>Lecture 10: Particle motion under central force | 10 |
| 04 | Lecture 1-4: Oscillations: the simple harmonic oscillator; the damped harmonic oscillator,<br>Lecture 5-7: Coupled simple harmonic oscillators; couple pendulum, general method of solution<br>Lecture 8-10: Lagrangian and Hamiltonian of continuous systems: transition from discrete to continuous systems, the Hamiltonian formulation | 10 |

| Recommended Books | | |
|---|---|---|
| Sr. No. | Text Books | Author |
| 01 | Classical Mechanics | Goldstein, Poole and Safko (Pearson Education) |
| | Reference Books | |
| 01 | Classical Mechanics | Landau and Lifshitz (Pergamon press) |
| 02 | Analytical Mechanics | L. N. Hand and J. D. Finch (Cambridge University Press) |

| **Subject: Quantum Mechanics.** **Course Code: PSPHY 102** | Year & Semester: M.Sc. Physics 1st year & 1st Semester. | | | | Credits 3, L 2, T 1, P 0 |
|---|---|---|---|---|---|
| Evaluation Policy | Mid-Term | Class Assessment | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks |

| Sr. No | Course outcomes: Students will |
|---|---|
| CO1 | Understand basic formalism of quantum Mechanics. |
| CO2 | Make analysis of angular momenta and its physical applications. |
| CO3 | Apply different approximate methods to solve the problems which are not exact. |
| CO4 | Evaluate the dynamics of hydrogen atom. |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | Mathematical tools of Quantum Mechanics:<br>Lecture 1: Linear vector spaces and operators in Hilbert space<br>Lecture 2-5: Measurements, observables and the uncertainty relations, Change of basis<br>Lecture 6: Coordinate and Momentum representations<br>Lecture7: Equations of motion in Schrodinger and Heisenberg representations<br>Lecture 8: One dimensional potential problem<br>Lecture 9-10: Linear harmonic oscillator, operator method, matrix method and Analytic method | 10 |
| 02 | Theory of Angular Momentum:<br>Lecture1-3: Angular momentum operators, Eigenvalues and Eigenfunctions<br>Lecture 4: Relation between rotation and angular momentum<br>Lecture 5: Rotational symmetry and conservation of angular momentum.<br>Lecture 6: Reflection invariance and parity, Commutation rules<br>Lecture 7-9: Matrix representations, addition of angular momenta and Clebsch-Gordon coefficients.<br>Lecture 10: Pauli spin matrices | 10 |
| 03 | Approximation methods:<br>Lecture 1: Time independent perturbation theory<br>Lecture 2: Perturbation theory for degenerate states, Dalgarno's method<br>Lecture 3-4: Zeeman and Stark effects, WKB approximation and its applications<br>Lecture 5-7: Variational method and its applications to helium atom and many particle systems<br>Lecture 8-9: Time dependent Perturbation theory, Fermi's Golden rule<br>Lecture 10: Semi classical theory of interaction of atoms with radiation | 10 |
| 04 | Lecture 1-2: Motion in a centrally symmetric field<br>Lecture 3: Spherical waves<br>Lecture 5: Resolution of a plane wave<br>Lecture 6: Fall of a particle to the Centre<br>Lecture 7-9: Motion in a coulomb field (spherical polar coordinates), Discrete and continuous<br>Lecture 10: Coulomb problem in parabolic coordinate system | 10 |

| Recommended Books | | |
|---|---|---|
| Sr. No | Text Books | Author |
| 01 | Quantum Mechanics | Landau , E. M. Lifshitz (Pergamon press) |
| 02 | Quantum Mechanics | Ajoy Ghatak (Springer) |

| **Subject: Mathematical Physics**<br>**Course Code: PSPHY 103** | Year & Semester: M.Sc. Physics<br>1st year & 1st Semester. | | | | Credits: 3, L: 2, T: 1, P: 0 |
|---|---|---|---|---|---|
| Evaluation Policy | Mid-Term | Class Assessment | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8Marks | 50 Marks |

| Sr.No. | Course outcomes: |
|---|---|
| CO1 | Learn different methods of solving complex integrals, appearing in vast applications of physics. |
| CO2 | Solve special differential equations, which have potential applications in physics. |
| CO3 | Apply different Transforms to solve mathematical problems of interest in science. |
| CO4 | Learn different functions used to evaluate the potential applications of Greens function. |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | Vector Calculus:<br>Lecture 1-2: Vector analysis in spherical and curved coordinates<br>Lecture 3-4: Orthogonal coordinates in R3<br>Lecture 5-6: Special Coordinates system- Cylindrical and spherical coordinates<br>Lecture 7-8: Laplacian in cylindrical and spherical coordinates<br>Lecture 9-10: Vector integration- line, surface and volume- Gauss, Stokes and Green's theorem | 10 |
| 02 | Linear Algebra and Tensor:<br>Lecture 1-4: Matrices, Eigenvalues and eigenvectors, Cayley-Hamilton theorem<br>Lecture 5-6: Tensor analysis, Rank of a Tensor<br>Lecture 7: Metric tensor, Summation convention, Contraction theorem,<br>Lecture 8-10: Direct Product, Levi-Civita Symbol, Kronecker and alternative Tensor, Christoffel symbol | 10 |
| 03 | Complex Analysis:<br>Lecture 1-2: Functions of Complex Variables, Analytic Properties<br>Lecture 3-5: Cauchy–Riemann Conditions, Cauchy's Integral Theorem, Cauchy's Integral Formula<br>Lecture 6-8: Taylor series, Laurent Expansion, Calculus of Residues and evaluation of Integral,<br>Lecture 9-10: Introduction of Fourier transform and Laplace transform. | 10 |
| 04 | Differential Equations:<br>Lecture 1-3: First and second-order differential equations, Separation of Variables<br>Lecture 4-7: Greens function, Delta function, Legendre function<br>Lecture 8-10: Hermite function, Bessel Functions, Laguerre Functions | 10 |

Recommended Books

| Sr. No. | Text Book | Author |
|---|---|---|
| 01 | Mathematical Methods for Physicists | G.B. Arfken, H.J. Weber and F Harris |
| | Reference Book | |
| 01 | Mathematical methods in physical sciences | Mary L Boas (Wiley) |
| 02 | Introduction of Mathematical Physics | Charlie Harper (Prentice Hall of India) |

| | | | | | |
|---|---|---|---|---|---|
| **Subject: Solid State Physics** **Course Code: PSPHY 104** | Year & Semester: M.Sc. Physics 1st year & 1st Semester. | | | | Credits: 3, L: 2, T: 1, P: 0 |
| Evaluation Policy | Mid-Term | Class Assessment | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8Marks | 50 Marks |

| Sr.No. | Course outcomes: |
|---|---|
| CO1 | Basic knowledge of Crystal Systems and Symmetries |
| CO2 | Be able to perform structure determination of simple structures |
| CO3 | Concept of band theory and classification of Materials |
| CO4 | Evaluate the potential applications of magnetic materials. |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | **Crystal Physics**<br>Lecture 1: Review of Crystallography<br>Lecture2: Crystal symmetry, crystallographic point groups and their applications.<br>Lecture 3: General introduction of Space Groups (Brief)<br>Lecture 4: Concept of diffraction and Diffraction of waves by crystal<br>Lecture 5: X- ray Scattering amplitude<br>Lecture 6: Reciprocal lattice and its applications to diffraction techniques<br>Lecture 7: Crystal structure factor and atomic scattering factor<br>Lecture 8-12: Examples and Numerical Problems | 12 |
| 02 | **Theory of Metals**<br>Lecture 1: Free electron theory of Metals<br>Lecture 2-3: Density of state function, Electrons in a periodic lattice<br>Lecture 4-5: Bloch theorem, Bloch modes and Utility, Tight binding approximation<br>Lecture 6: Cyclotron resonance, Electron motion in a uniform magnetic field<br>Lecture 7: Landau Levels, Electronic structure of a two-dimensional electron gas<br>Lecture 8-12: Examples and Numerical Problems | 12 |
| 03 | **Band Theory of solids**<br>Lecture 1: One dimensional system; DOS, 1D sub-bands<br>Lecture 2: Electron Conduction in Solids<br>Lecture 3: Fermi Dirac probability function<br>Lecture 4: Formation of energy bands<br>Lecture 5/6: Kronig Penney Model<br>Lecture 7: Thermal & Electric Properties<br>Lecture 8-12: Examples and Numerical Problems | 12 |
| 04 | **Dielectric Properties and Magnetism**<br>Lecture 1: Dielectric Materials (Brief)<br>Lecture 2: Ferromagnetism: Weiss theory of ferromagnetism<br>Lecture 3: Curie-Weiss law for susceptibility<br>Lecture 4-6: Examples and Numerical Problems | 6 |

| Recommended Books | | |
|---|---|---|
| Sr. No. | Text Books | Author |
| 01 | Solid State Physics | Nell W Ashcroft and N D Mermin ) |
| 02 | Elementary Solid-State Physics | M A Omar (Pearson) |
| 03 | Introduction to solid state physics | Charles kittel |

| Subject: Renewable Sources of Energy<br>Course Code:<br>PSPHY EL1 | Year & Semester: M.Sc. Physics<br>1st year & 1st Semester. | | | | Credits: 2, L: 2, T: 0, P: 0 |
|---|---|---|---|---|---|
| Evaluation Policy | Mid-Term | Class Assessment | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks |

| Sr.No. | Course outcomes: Students will |
|---|---|
| CO1 | Understand the various types of energy sources. |
| CO2 | Design solar thermal energy systems. |
| CO3 | Able to evaluate the hydrogen production and storage |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | Lecture 1-2: Relevance of Renewable Energy in relation to depletion of fossil fuels<br>Lecture 3-4: Environmental considerations, green energy, sustainable energy<br>Lecture 5-6: Centralized and decentralized energy<br>Lecture 7-8: Wind Energy, wind turbines, economics and environmental impact<br>Lecture 9-10: Biomass, Energy from waste, Ocean thermal energy, Tidal energy | 10 |
| 02 | Lecture 1: Sun as a source of energy<br>Lecture 2: Basic Sun earth geometry<br>Lecture 3-6: Flat plate and evacuated tubular collectors, efficiency of collectors, overall heat loss coefficient and heat transfer correlations.<br>Lecture 7-8: Solar thermal applications like solar cooker and solar water heaters, solar dryers<br>Lecture 9-10: Active and passive heating of buildings, Daylighting, Refrigeration and Cooling | 10 |
| 03 | Lecture 1-2: Hydrogen Energy, Solar Hydrogen through photo electrolysis and photocatalytic process.<br>Lecture 3: Physics of material characteristics for production of solar hydrogen<br>Lecture 4: Brief discussion of various storage processes, new storage modes<br>Lecture 5-6: Various factors relevant for safety, use of Hydrogen as fuel, use in vehicular transport, hydrogen for electricity generation, Fuel Cells<br>Lecture 7-9: Magnetic and Electrical energy storage systems, SMES<br>Lecture 10: Supercapacitor | 10 |

| Recommended Books | | |
|---|---|---|
| Sr. No. | Text Book | Author |
| 01 | Renewable Energy. | Twidell and Wier, (E & FN Spon Ltd.) |
| | Reference Books | |
| 02 | Renewable Energy: Power for sustainable future, | Godfrey Boyle, (Oxford University Press) |
| 03 | Hydrogen and Fuel Cells: | Bent Sorensen & Giusepp Spazzafumo, (Academic Press) |

| Subject: Quantum Computation and Information<br>**Course Code: PSPHY EL2** | Year & Semester: M.Sc. Physics<br>1st year & 1st Semester. | Credits: 2, L: 2, T: 0, P: 0 | | | |
|---|---|---|---|---|---|
| Evaluation Policy | Mid-Term | Class Assessment | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks |

| Sr.No. | Course outcomes: Students will |
|---|---|
| CO1 | Argue basics of Quantum Computation and Information. |
| CO2 | Familiarized with the concept of qubits, entanglement, etc. |
| CO3 | Construct quantum algorithms |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | Lecture 1: Introduction to the Second Quantum Revolution<br>Lecture2: Overview of basic quantum phenomena, particles, waves, interference, quantized energy levels, measurements<br>Lecture 3: Stern-Gerlach experiment, spins<br>Lecture 4 -5: Two-level quantum systems, qubits, Representing quantum states as complex vectors (Hilbert space)<br>Lecture 6-8: Superposition states, Dirac bra-ket notation, Operators, observables<br>Lecture 9-10: Bloch Sphere, Distinguishability of states, Representation of multi-qubit states as direct products | 10 |
| 02 | Lecture 1-3: Entanglement, EPR, Bell inequalities<br>Lecture 4-6: CHSH inequality, GHZ states<br>Lecture 7: Causality and the no-signaling condition on 'spooky action at a distance'<br>Lecture 8: Cloning theorem<br>Lecture 9-10: Quantum teleportation, quantum dense coding | 10 |
| 03 | Lecture 1-3: Concept of Quantum Algorithm,<br>Lecture 4-5: Deutsch Algorithm,<br>Lecture 6-8: Deutsch - Jozsa Algorithm,<br>Lecture 9-10 : Quantum Fourier transform, Quantum Search Algorithm | 10 |

| Recommended Books | | |
|---|---|---|
| Sr. No. | Text Book | Author |
| 01 | Quantum Computation and Quantum Information | Michael A. Nielsen and Isaac L. Chaung (Cambridge University Press) |
| | Reference Books | |
| 01 | An Introduction to Quantum Computing | Philip Kaye, Raymond Laflamme (Oxford university Press) |

| Subject: **Thermoelectric Materials And Devices** **Course Code: PSPHY EL3** | Year & Semester: M.Sc. Physics 1st year & 1st Semester. | | | | Credits 2, L 2, T 0, P 0 |
|---|---|---|---|---|---|
| Evaluation Policy | Mid-Term | Class Assessment | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks |

| Sr. No | Course outcomes: Students will |
|---|---|
| CO1 | Analyze the general aspects of thermoelectric materials |
| CO2 | Learn the techniques for characterizing &synthesis of thermoelectric materials |
| CO3 | Design thermoelectric devices and evaluate recent development in properties of pentatellurides |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | **INTRODUCTION:**<br>Lecture 1: Concept of Heat Transfer.<br>Lecture 2-3: Fourierslaw ,Newtons law of cooling, Energy conversion.<br>Lecture 4-5 Seebeckeffect ,Pelteir effect , Thomson effect.<br>Lecture6-7: Conversion efficiencies, Figure of Merit, thermal conductivity, electrical resistivity.<br>Lecture 8-9: Techniques for the synthesis of thermoelectric materials.<br>Lecture 10: Thermal Analysis Methods: DSC, DTA & TGA. | 10 |
| 02 | **THERMOELECTRIC DEVICES**<br>Lecture 1-2: Design, fabrication,<br>Lecture 3:Optimization.<br>Lecture 4: Efficiencies.<br>Lecture 5-7:characteristics and challenges.<br>Lecture 8-9:Thermoelectric generators and cooling.<br>Lecture 10: Numerical Problems. | 10 |
| 03 | **RECENT DEVELOPMENT IN PROPERTIES OF PENTATELLURIDES :**<br>Lecture 1-2:Doping on the Transition Metal Site [$M_xA_yTe_5$,M=Hf,ZrA=Zr,Ti] .<br>Lecture 3-5: Doping on the Chalcogenl Site [$M_xTe_{5-x}Ch$,M=Hf,Zr;A=Se,Sb].<br>Lecture 6:Magnetotransport.<br>Lecture 7--9: Overview of Recent Results, Summary of Thermoelectric Properties.<br>Lecture 10:Numerical Problems. | 10 |

| Recommended Books | | |
|---|---|---|
| Sr. No | Text Books | Author |
| 01 | Recent Trends in Thermoelectric Materials. | *Terry M. Tritt.* |
| 02 | Thermoelectric Energy ConversionBasic Concepts and Device Applications. | *Diana Dávila Pineda AlirezaRezania.* |
| 03. | White, G.K., Measurement of solid conduction at low temperature, in Thermal Conductivity. | White, G.K.( Academic Press, London,) |

| | | | | | |
|---|---|---|---|---|---|
| **Subject: Biophysics and Biomaterials**<br>**Course Code: PSPHY EL4** | Year & Semester: M.Sc. Physics<br>1st year & 1st Semester. | | | | Credits: 2, L: 2, T: 0, P: 0 |
| Evaluation Policy | Mid-Term | Class Assessment | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks |

| Sr.No. | Course outcomes: Students will Understand |
|---|---|
| CO1 | Basic properties of nanoparticles and biomaterials |
| CO2 | Various methods for synthesis of nano-biomaterials |
| CO3 | Application of nano-biomaterials with novel optical behaviour |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | Introduction to nano biomaterials; development of nano biomaterials (current applications, nanostructured materials used in pharmaceutical/biomedical applications | 10 |
| 02 | Micro-, meso- and macroporous structures; nanostructured surfaces; examples of polymeric, metallic, inorganic, hybrid and composite nano biomaterials preparation | 10 |
| 03 | Functionalization/bioconjugation of nano biomaterials, biosensors; smart and stimuli-responsive nano biomaterials | 10 |

| Recommended Books | | |
|---|---|---|
| Sr. No. | Text Book | Author |
| 01 | Biomaterials: An Introduction | Park, Joon, Lakes, R. S.( Springer) |
| | Reference Books | |
| 01 | Nano biomaterials. Development and Applications | Kee Yi, D. Papaefthymiou, G.C., |
| 02 | Nano biomaterials. Classification, Fabrication and Biomedical Applications | Wang, X., Ramalingam, M., Kong, X., Zhao, L (Wiley) |

| Subject: Solid State Physics & Materials Lab<br>**Course Code: PSPHY LB1** | Year & Semester: M.Sc. Physics<br>1st year & 1st Semester. | Credits: 1.5, L: 0, T: 0, P: 3 |
|---|---|---|
| New Education / Evaluation Policy | Continuous Assessment<br>60 Marks | End-Term<br>40 Marks |

| Sr.No. | Course outcomes: |
|---|---|
| CO1 | Understand, how resistivity, Hall coefficient and other parameters of semiconductor vary with temperature. |
| CO2 | Calculate band gap, hall coefficient, coercivity, remanence and saturation magnetization, dielectric constant of materials |
| CO3 | Learn field dependence of magnetoresistance of a given semiconductor sample. |
| CO4 | Analyse Para magnetism, Ferromagnetism and antiferromagnetism by measuring magnetic susceptibility |

**List of Experiments**

Experiment No.1: To Study the temperature dependence of resistivity of semiconductor and to determine band gap of experimental material (Ge).

Experiment No. 2: To determine Hall Coefficient, carrier concentration of semiconductor at room temperature.

Experiment No. 3: To study the variation of Hall coefficient with temperature.

Experiment No. 4: To determine Planck's constant and work function using photoelectric effect.

Experiment No. 5: To Verify inverse square law of radiation using photoelectric effect.

Experiment No.6: To measure dielectric constant of a ferroelectric material as a function of temperature and to observe ferroelectric to Para electric transition.

Experiment No. 7: To study the magnetic field dependence of magnetoresistance of a given semiconductor sample.

Experiment No. 8: To plot the magnetic hysteresis loop for a ring-shaped massive iron core and to determine coercivity, remanence and saturation magnetization.

Experiment No. 9: Study of Thermoluminescence of F- centers in alkali halides crystals

Experiment No.10: To measure the magnetic susceptibility of paramagnetic solid by Gouy's method.

Recommended Text Books

| Sr. No. | Name of the book | Author |
|---|---|---|
| 01 | Lab in sky | MA Shah & Surbhi ( New Publishers) |
| 02 | Advanced practical physics for students | BL Worsnop & HT Flint ( Little Hampton Book Service Ltd) |

| **Subject: Optics & Photonics Lab** **Course Code: PSPHY LB8** | Year & Semester: M.Sc. Physics 1st year & 1st Semester. | Credits | L | T | P |
|---|---|---|---|---|---|
| | | 1.5 | 0 | 0 | 3 |
| Evaluation Policy | Continuous Assessment | End-Term | | | |
| | 60 Marks | 40 Marks | | | |

| Sr.No. | Course outcomes |
|---|---|
| CO1 | Apply the concepts of optics to evaluate various parameters |
| CO2 | Analyze behavior of light under different apparatus settings |
| CO3 | Develop understanding of optical instruments |
| CO4 | Calculate and interpret scientific data |

**List of Experiments**

Experiment No. 1 To find the wavelength of sodium light using Newton's rings.

Experiment No. 2 Determination of wavelength of monochromatic light with the help of Fresnel Bi-Prism.

Experiment No. 3 To find angle of prism, angle of minimum deviation and refractive index of prism.

Experiment No. 4 Determination of Plank's constant by measuring radiation in a fixed spectral range.

Experiment No. 5 To verify Malus Law.

Experiment No. 6 To determine splitting of lines by Zeeman effect experiment.

Experiment No. 7 Measurement of coherence length of laser using Michelson interferometer.

Experiment No. 8 To determine the specific rotation of sugar Lauren's half shade polarimeter.

Experiment No. 9 Determine of line width of a laser using monochromator.

Experiment No. 10 Thickness of enamel coating on a wire by diffraction.

Recommended Text Books

| Sr. No. | Name of the book | Author |
|---|---|---|
| 01 | Lab in Sky | MA Shah & Surbhi (New Delhi Publishers) |
| 02 | Advanced practical physics for students | BL Worsnop & HT Flint |

| **Subject: Applied Physics Lab With Workshop**<br>**Course Code: PSPHY LB3** | Year & Semester: M.Sc. Physics<br>1st year & 1st Semester. | Credits: 1.5, L: 0, T: 0, P: 3 |
|---|---|---|
| Evaluation Policy | Continuous Assessment | End-Term |
| | 60 Marks | 40 Marks |

| Credits | L | T | P |
|---|---|---|---|
| 1.5 | 0 | 0 | 3 |

| Sr.No. | **Course outcomes** |
|---|---|
| CO1 | Determine Planks constant its implications in real world. |
| CO2 | Develop Experimental skills for understanding the natural Laws |
| CO3 | Interaction of radiation with matter |

List of Experiments

Experiment No. 1
To determine Planck's constant and work function using photoelectric effect.

Experiment No. 2
To determine value of acceleration due to gravity with Bar pendulum.

Experiment No. 3
Experiment Name: To determine value of acceleration due to gravity with Kater's pendulum.

Experiment No. 4
To verify Stoke's law and determine the coefficient of viscosity of a highly viscous liquid.

Experiment No. 5
Determination of absorption coefficient of a liquid or solution with the help of a photovoltaic cell..

Experiment No. 6
To determine the Young's modulus of the material of a given beam supported on two knife edges and loaded at the middle point.

Experiment No. 7
To study variation of magnetic field along the axis of circular coil carrying current

Experiment No. 8
To find angle of prism, angle of minimum deviation and refractive index of prism

Experiment No. 9 :
Various activities in Workshop

Recommended Books

| Sr. No. | Name of the book | Author |
|---|---|---|
| 01 | Physics Lab In Sky | Shah And Surbhi (New Delhi Publishers) |

Workshop visit once in a week

# SEMESTER – II

| S. No | Course Code | Theory Courses | L | T | P | Credit |
|---|---|---|---|---|---|---|
| Core Courses | | | | | | |
| 12. | PSPHY 201 | Thermodynamics and Statistical Mechanics | 2 | 1 | 0 | 3 |
| 13. | PSPHY 202 | Atomic & Molecular Physics | 2 | 1 | 0 | 3 |
| 14. | PSPHY 203 | Electromagnetism and Electrodynamics | 2 | 1 | 0 | 3 |
| 15. | PSPHY 204 | Nuclear and Particle Physics | 2 | 1 | 0 | 3 |
| Elective Courses (Students have to choose 2 electives) | | | | | | |
| 16. | PSPHY EL5 | Physics at Nano-scale | 2 | 0 | 0 | 2 |
| 17. | PSPHY EL6 | Quantum Logic and Simulations | 2 | 0 | 0 | 2 |
| 18. | PSPHY EL7 | Physics of Semiconductors | 2 | 0 | 0 | 2 |
| 19. | PSPHY EL8 | Solar Photovoltaics | 2 | 0 | 0 | 2 |
| Laboratory Courses | | | | | | |
| 20. | PSPHY LB4 | Electronics Tinkering Lab | 0 | 0 | 3 | 1.5 |
| 21. | PSPHY LB5 | Synthesis of Nano-materials Lab | 0 | 0 | 3 | 1.5 |
| 22. | PSPHY LB6 | Bio Engineering Lab | 0 | 0 | 3 | 1.5 |
| | Total | | | | | 20.5 |

| Subject: **Thermodynamics and Statistical Mechanics** **Course Code: PSPHY 201** | Year & Semester: M.Sc. Physics 1st year & 2nd Semester. | | | | Credits: 3, L: 2, T: 1, P: 0 |
|---|---|---|---|---|---|
| Evaluation Policy | Mid-Term | Class Assessment | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks |

| Sr.No. | Course outcomes: |
|---|---|
| CO1 | Illustrate the fundamental concepts of thermodynamics and statistics. |
| CO2 | Distinguish various ensembles and their significance. |
| CO3 | Explain Bose-Einstein Condensate and Fermi Level. |
| CO4 | Relate different types of phase transitions. |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | **Lecture 1 -3:** Basic laws of thermodynamics, Thermodynamic Potentials, Maxwell Equations, Connection between statistics and thermodynamics;<br>**Lecture 4 -6:** Concept of microstates, phase space and its connection to Entropy<br>**Lecture 7:** Classical Ideal Gas and the Maxwell Boltzmann Distribution,<br>**Lecture 8:** Entropy of mixing<br>**Lecture 9-10:** Gibbs Paradox; Liouville's Theorem, problems | 10 |
| 02 | **Lecture 1-2:** Ensembles, Classifications of ensembles.<br>**Lecture 3-4:** Partition Function calculation for various systems;<br>**Lecture 5-7:** Partition Function calculation for various systems; Energy fluctuations in the Canonical Ensemble<br>**Lecture 8:** Grand Canonical Ensemble;<br>**Lecture 9:** Number Density and Energy Fluctuations in the Grand Canonical ensemble,<br>**Lecture 10:** numerical problems | 10 |
| 03 | **Lecture 1:** Quantum Statistics and calculation of the Density matrix for various systems;<br>**Lecture 2:** Indistinguishability of Particles, Symmetric and Anti-Symmetric wave functions<br>**Lecture 3-4:** Calculation of the Bose-Einstein and Fermi-Dirac Distribution for a quantum Ideal Gas;<br>**Lecture 5-6:** Thermodynamic behaviour of an Ideal Bose Gas, Bose-Einstein Condensate;<br>**Lecture 8-9:** Thermodynamic behaviour of an ideal Fermi gas<br>**Lecture 10:** Pauli Para magnetism | 10 |
| 04 | **Lecture 1-2:** Phase Transitions: General concepts of phase transitions, order parameter, continuous transition<br>**Lecture 3-4:** Landau theory of phase transition<br>**Lecture 5-6 : C**oncept of critical phenomena, critical exponents<br>**Lecture 7-8 :** Ising model and Van der Waals gas, exact solution of the Ising model in 1D<br>**Lecture 9 :** Description of Einstein-Smoluchowski theory of Brownian motion as a stochastic process,<br>**Lecture 10 :** The fluctuation-dissipation theorem | 10 |
| Recommended Books | | |

| Sr. No. | Text Books | Author |
|---|---|---|
| 01 | Statistical Mechanics | Pathria, R. K. (Academic Press) |
| 02 | Statistical Mechanics | Kerson Haung (Wiley) |

| **Subject: Atomic and Molecular Physics Course Code: PSPHY 202** | Year & Semester: M.Sc. Physics 1st year & 2nd Semester. | | | | |
|---|---|---|---|---|---|
| Evaluation Policy | Mid-Term | Class Assessment | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks |

| Credits | L | T | P |
|---|---|---|---|
| 3 | 2 | 1 | 0 |

| Sr.No. | Course outcomes: Students will be to |
|---|---|
| CO1 | Learn the solution Schrödinger equation for the hydrogen atom and interpretation of quantum numbers. |
| CO2 | Understand the theoretical models for multielectron system. |
| CO3 | Recognize and learn the Molecular Structure and Molecular Spectra. |
| CO4 | Distinguish different components of Laser Spectroscopy |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | **HYDROGEN ATOM:**<br>Lecture 1-2: Solution of Schrödinger's Equation for one Electron System.<br>Lecture 3: Quantum Numbers (n, l, m) and Wave Function of the H Atom.<br>Lecture 4-5: Normal and Analomous Zeeman effect.<br>Lecture 6: Relativistic Interaction and Fine Structure, Hyperfine Structure.<br>Lecture 7-8: The Electron Spin, The Stern-Gerlach Experiment.<br>Lecture 9: Spin-Orbit, Correction of Energy Terms.<br>Lecture 10. Lamb Shift, Vector Atomic Model. | 10 |
| 02 | **ATOMS WITH MORE THAN ONE ELECTRON:**<br>Lecture1-2: The central field approximation models, Spin orbital and Slater determinants.<br>Lecture 3-4: Thomas-Fermi model of atoms, Thomas-Fermi theory of multi-electron atoms.<br>Lecture 5-6: Introduction Hatree –Fock Method, Correlation effects, LS Coupling and JJ Coupling.<br>Lecture 6-10: Possible terms of a multi -electron configuration in LS coupling. | 10 |
| 03 | **MOLECULAR PHYSICS:**<br>Lecture 1 : Molecular Structure and Molecular Spectra.<br>Lecture 2-3: Rotational, Vibrational, Rotational-Vibrational Spectra.<br>Lecture 4-5: Electronic Spectra of Di-atomic Molecules, Selection Rules.<br>Lecture 6-8: ESR and Raman Spectroscopy<br>Lecture 9-10: Pure Rotational Raman Spectra, Vibrational Raman Spectra. | 10 |
| 04 | **LASER SPECTROSCOPY:**<br>Lecture 1: Absorption, spontaneous and stimulated emission.<br>Lecture 2: Einstein coefficient and numerical problems.<br>Lecture 3: Transition probability and life time of an atom in an exited state.<br>Lecture 4: Population inversion, Laser rate equation for two level systems.<br>Lecture 5: Rate equating for three level lasers.<br>Lecture 6: Line broadening mechanism, shape and width of spectral line.<br>Lecture 7-8: Optical resonator; Quality factor, Losses inside the cavity, threshold condition,<br>Lecture 9-10: Laser systems, He-Ne laser, $CO_2$ laser. | 10 |

| Recommended Books | | |
|---|---|---|
| Sr. No. | Text Book | Author |
| 01 | Fundamentals of Molecular Spectroscopy | C.N. Banwell (4th edition, McGraw-Hill) |
| 02 | Atoms, Molecules and Photons | Wolfgang D (3rd edition, Springer) |

| | | | | | |
|---|---|---|---|---|---|
| **Subject Electromagnetism and Electrodynamics** **Course Code: PSPHY 203** | Year & Semester: M.Sc. Physics 1st year & 2nd Semester. | | | | Credits 3, L 2, T 1, P 0 |
| Evaluation Policy | Mid-Term | Class Assessment | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks |

| Credits | L | T | P |
|---|---|---|---|
| 3 | 2 | 1 | 0 |

| Sr. | Course outcomes: Students will |
|---|---|
| CO1 | Evaluate Poisson and Laplace equations, Greens Function, Boundary value problems for dielectrics. |
| CO2 | Analyze Maxwell's equations, Gauge transformations, Poynting's theorem |
| CO3 | Evaluate Radiating Systems and Multipole fields. |
| CO4 | Develop Relativistic Electrodynamics, covariant formalism of Maxwell equations. |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | Lecture 1-2: Poisson and Laplace equations, Dirichlet and Neumann boundary conditions;<br>Lecture 3: Method of images<br>Lecture 4: Laplace equation in Cartesian, spherical and cylindrical coordinate<br>Lecture 5: Green function formalism: Green function for the sphere, expansion of Green function in spherical coordinates<br>Lecture 6: Multipole expansion; Boundary value problems for dielectrics<br>Lecture 7: Magnetic materials, boundary value problems<br>Lecture 9: Magnetic shielding, magnetic field in conductors, numerical problems | 10 |
| 02 | Lecture 1: Maxwell's equations<br>Lecture 2: Gauge transformations<br>Lecture 3-4: Poynting's theorem, Energy and momentum conservation.<br>Lecture 5: Electromagnetic waves: wave equation, propagation of electromagnetic waves<br>Lecture 6-9: Refraction, Total internal reflection, Goos-Hänchen shift, Brewster's angle | 10 |
| 03 | Lecture 1: Retarded potential<br>Lecture 2-3: Field and radiation of a localized oscillating source electric dipole fields<br>Lecture 4-5: Multipole expansion, energy and angular momentum, multipole radiations<br>Lecture 6-7: Scattering: scattering at long wavelengths, perturbation theory, scattering<br>Lecture 8: Radiation by Moving Charges: Lienard- Weichert potential<br>Lecture 9: radiation by nonrelativistic and relativistic charges, angular distribution of radiations,<br>Lecture 10: Thomson's scattering, bremsstrahlung in Coulomb collisions, numerical problems | 10 |
| 04 | Lecture 1: Electromagnetic Field Tensor<br>Lecture 2: Electrodynamics in tensor notation<br>Lecture 3-4: Covariant formalism of Maxwell's equations<br>Lecture 5: Transformation laws for fields, their physical significance<br>Lecture 6-7: Relativistic generalization of Larmor's formula, numerical problems and skills.<br>Lecture 8-9: Relativistic formulation of radiation by single moving charge, | 10 |

| Recommended Books | | |
|---|---|---|
| Sr. | Text Books | Author |
| 01 | Classical Electrodynamics | J. D. Jackson (John Wiley) |
| 01 | Electromagnetic Waves and Radiating Systems | E. C. Jordan and Balmain (Prentice Hall) |

| **Subject : Nuclear and particle Physics** <br> **Course Code: PSPHY 204** | Year & Semester: M.Sc. Physics <br> 1st year & 2nd Semester. | | | | Credits 3, L 2, T 1, P 0 |
|---|---|---|---|---|---|
| Evaluation Policy | Mid-Term | Class Assessment | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks |

| Credits | L | T | P |
|---|---|---|---|
| 3 | 2 | 1 | 0 |

| Sr.No. | Course outcomes: Students will Learn |
|---|---|
| C O1 | Analysis of Deuteron problem |
| CO2 | Evaluate Form Factors |
| CO3 | Develop different nuclear models |
| CO4 | Analysis of Quark model |

| **Course contents** | | Lecturers |
|---|---|---|
| Unit | Particulars | |
| 01 | Lecture 1: Fundamental Interactions,<br>Lecture 2 -3: The deuteron problem<br>Lecture 4: Deuteron magnetic moment,<br>Lecture 5: Deuteron electric quadrupole moment,<br>Lecture 6: Tensor forces and deuteron D-state<br>Lecture 7: Symmetry and conservation laws<br>Lecture 8: Pion-Nucleon Interaction<br>Lecture 9-10: Properties of Nucleon-Nucleon Force, Yukawa theory of nuclear forces | 10 |
| 02 | Lecture 1-2: Nuclear size, Rutherford and Mott Scattering,<br>Lecture 3-4: Electron scattering form factor, Charge radius and Charge density.<br>Lecture 5: Nucleon Elastic form factors<br>Lecture 6: High energy lepton scattering,<br>Lecture 7: Nuclear shape and electromagnetic moments,<br>Lecture 8: Magnetic dipole moment of odd nuclei, Ground state spin and isospin,<br>Lecture 9-10: Nuclear binding energy, Semi-empirical mass formulae, | 10 |
| 03 | Models of Nuclear Structure:<br>Lecture 1: Vibrational Model,<br>Lecture 2-3: Magic number and single-particle energy, Spin orbit interaction,<br>Lecture 4-6: Many bodies basic states, Hartree-Fock single-particle Hamiltonian<br>Lecture 7: Single Particle Shell model, Generalization of Single-Particle Model<br>Lecture 8-9: Nuclear deformation, Rotational spectra of spinless Nuclei,<br>Lecture 10: Fermi gas model | 10 |
| 04 | Lecture 1: The Gellmann-Nishijima scheme, the eight-fold way, the quark model.<br>Lecture 2: Quark structure of hadrons: the baryon decouplet, quark spin and color<br>Lecture 3-5: Electroweak Interactions: prediction and discovery of W /Z, weak isospin and,<br>Lecture 6-7: Feynman rules for electroweak interaction, Electron-positron annihilation<br>Lecture 7-8: Lepton and quark scattering:<br>Lecture 9-10: Strong Interactions: the evidence for quarks and color charge, strange particles, | 10 |

| Recommended Books | | |
|---|---|---|
| Sr. No. | Text Book | Author |
| 01 | Introduction to Nuclear Physics | Heral Enge (Addison Welsey) |
| 02 | Introduction to Elementary Particles | David J. Griffths (Wiley) |

| **Subject: Physics at Nanoscale** **Course Code: PSPHY EL5** | Year & Semester: M.Sc. Physics 1st year & 2nd Semester. | | | | Credits 2, L 2, T 0, P 0 |
|---|---|---|---|---|---|
| Evaluation Policy | Mid-Term | C.A | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks |

| Sr.No. | Course outcomes: Students will learn |
|---|---|
| CO1 | Fabrication of nano materials |
| CO2 | Analyze properties of Nano materials |
| CO3 | Learn different characterization techniques. |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | Lecture 1: The scientific revolutions – Nanoscience, Nature and Scope,<br>Lecture 2: Surface to volume ratio, quantum effects- classification of nanocrystals<br>Lecture 3: Dimensionality and size dependent phenomena;<br>Lecture 4-: Quantum dots, Nanowires and Nanotubes and their properties<br>Lecture 5: Concepts of Top down and Bottom-up Approach.<br>Lecture 6: Carbon based nanomaterials and their general properties<br>Lecture 7:Graphene and its properties, Potential applications of Graphene | 7 |
| 02 | Properties of nanomaterials<br>Lecture 1: Electrical and Transport properties<br>Lecture 2: Mechanical Properties and tribology<br>Lecture 3-: Optical properties<br>Lecture 4: Nanostructures under the influence of electrical or magnetic fields<br>Lecture 5: Dielectric properties | 5 |
| 03 | Characterization Techniques:<br>Lecture 1: Photoluminescence<br>Lecture 2: Scanning Electron Microscopy, HRTEM<br>Lecture 3: X ray Diffraction (In Detail)<br>Lecture 4: Vibrating Sample Magnetometer (VSM)<br>Lecture 5: Atomic Force Microscope (AFM)<br>Lecture 6: Fourier Transform Infrared Spectroscopy (FTIR)<br>Lecture 7: Electron spin resonance (ESR) and Nuclear Magnetic Resonance (NMR) | 7 |

| Recommended Books | | |
|---|---|---|
| Sr. N | Text Books | Author |
| 01 | Introductory nanoscience: physical and chemical concepts | Masaru Kuno, (Garland Science) |
| | Reference Books | |
| 01 | Nanoparticle and nanostructure film preparation, characterisation and application | J. H. Fredler (Wiley) |
| 02 | Nanoscience and Technology | Shah & Ahmad ( IK International) |

| **Subject: Quantum Logic and Simulations** **Course Code: PSPHY EL6** | Year & Semester: M.Sc. Physics 1st year & 2nd Semester. | | | | Credits: 2, L: 2, T: 0, P: 0 |
|---|---|---|---|---|---|
| Evaluation Policy | Mid-Term | Class Assessment | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks |

| Credits | L | T | P |
|---|---|---|---|
| 2 | 2 | 0 | 0 |

| Sr.No. | Course outcomes |
|---|---|
| CO1 | Demonstrate fundamentals of quantum computing |
| CO2 | Evaluate fundamentals of Quantum Cryptography and Entanglement. |
| CO3 | Design quantum algorithms to solve problems |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | Fundamentals<br>Lecture 1-3: Classical and quantum computers principals<br>Lecture 4-5: Probability; Statistics; Matrices<br>Lecture 6: Advantages of quantum computation<br>Lecture 7-8: Superposition; Entanglement; Interference<br>Lecture 9-10: Single qubit operations and measurements | 10 |
| 02 | Quantum Cryptography:<br>Lecture1: Classical and Quantum Cryptography; Physical implementations.<br>Lecture 2-3: Entanglement: Entangled states<br>Lecture 4-5: Bells inequality; von-Neumann entropy<br>Lecture 6-8: Quantification of pure state entanglement. Mixed state entanglement<br>Lecture 9-10: quantification of mixed state entanglement Concurrence. | 10 |
| 03 | Quantum Algorithms and Computation<br>Lecture 1-2: Quantum no-cloning; The Deutsch-Jozsa algorithm<br>Lecture 3-4 :Quantum Algorithms and Computation Quantum simulations<br>Lecture 5-6 :Quantum logic gates and circuits; Universal quantum gates<br>Lecture 7-8: Quantum Fourier Transform; Phase Estimation; Shor's algorithm; Grovers algorithm<br>Lecture 9-10:Quantum phase estimation. Decoherence and Quantum Error Correction: Decoherence; Errors in quantum computation and communication; Quantum error correcting codes; Elementary discussion of entanglement concentration and distillation. | 10 |

| Recommended Books | | |
|---|---|---|
| Sr. No. | Text Book | Author |
| 01 | An Introduction to Quantum Computing | Philip Kaye, Raymond Laflamme(Oxford university Press) |
| 02 | Quantum Computation and Quantum information, | Nielsen and Chuang (Cambridge University Press) |

| **Subject: Physics of Semiconductors**<br>**Course Code: PSPHY EL7** | Year & Semester: M.Sc. Physics<br>1st year & 2nd Semester. | | | | Credits: 2, L: 2, T: 0, P: 0 |
|---|---|---|---|---|---|
| Evaluation Policy | Mid-Term | Class Assessment | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks |

| Sr. No. | Course outcomes: Students will be able to |
|---|---|
| CO1 | Explain the basic properties of semiconductors |
| CO2 | Analyse the working, design considerations and applications of various semiconducting devices including p-n junctions, BJTs and FETs. |
| CO3 | Describe the working and design considerations for the various photonic devices like photodetectors, solar-cells and LEDs |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | Junctions: p-n junction and contact potential, Fermi levels, Space charge, Reverse and Forward bias, Zener and Avalanche breakdown. Capacitance of p-n junction, Schottky barriers; Schottky barrier height, C-V characteristics, current flow across Schottky barrier: thermionic emission, Rectifying contact and Ohmic contact. | 10 |
| 02 | Field Effect Transistors: JEFT amplifying and switching, Pinch off and saturation, Gate control, I-V characteristics. MOSFET, Operation, MOS capacitor, Debye screening length, Effect of real surfaces; Work function difference, Interface charge, Threshold voltage and its control, MOS C-V analysis and time dependent capacitance. Output and transfer characteristics of MOSFET. | 10 |
| 03 | Bipolar Junction Transistors (BJT): Fundamentals of BJT operation. Minority carrier distribution, Solution of diffusion equation in base region, Terminal current, Current transfer ratio, Ebers-Moll equations, Charge control analysis. BJT switching: Cut off, Saturation, Switching cycle. Photonics: LED: Radiative transition, Emission spectra, Luminous efficiency and LED materials, Solar cell and photodetectors: Ideal conversion efficiency, Fill factor, Equivalent circuit, Voc, Isc and Load resistance, Spectral response. Reverse saturation current in photodetector | 10 |
| Recommended Books | | |
| Sr.No. | Text Book | Author |
| 01 | Solid State Electronics | Streetman, B. and Banerjee (Prentice Hall India) |
| | Reference Books | |
| 01 | Physics of Semiconductor Devices, | S.M.Sze (John Wiley, (1981)) |

| | | | | | |
|---|---|---|---|---|---|
| **Subject: Solar Photovoltaics**<br>**Course Code: PSPHY EL8** | Year & Semester: M.Sc. Physics<br>1st year & 2nd Semester. | | | | Credits: 2, L: 2, T: 0, P: 0 |
| Evaluation Policy | Mid-Term | Class Assessment | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks |

| Sr.No. | Course outcomes: Students will be able |
|---|---|
| CO1 | Analyze the current solar energy conversion and utilization processes. |
| CO2 | Gain an insight of the photovoltaic system engineering aspects including modeling and up scaling of the PV systems with different approaches, and be able to advance photovoltaic systems. |
| CO3 | Evaluate difference between Hybrid organic, Inorganic solar cells, multi-junction solar cells etc |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | Lecture 1: Human and World energy consumption<br>Lecture 2-3: Method of energy conversion, Need for sustainable energy sources<br>Lecture 4: Limited fossil fuel, Renewable energy sources<br>Lecture 5: Current status of wind energy, Solar thermal, Biomass and Hydroelectricity<br>Lecture 6: Sustainable Sun energy, Solar radiation<br>Lecture 7: Black body radiation,<br>Lecture 8: Terrestrial solar radiation<br>Lecture 9: Solar spectrum<br>Lecture10: A brief review of different types of solar cells in the market. | 10 |
| 02 | Lecture 1 : Photoelectric effect Photoconductivity, Photo emissive effect and photovoltaic effect, A comparison,<br>Lecture 2 : Working principle of solar cells, Generation of charge carriers<br>Lecture 3 : Separation and collection solar cell parameters<br>Lecture 4 : Equivalent circuit, External solar cell parameters<br>Lecture 5 : External quantum efficiency and Equivalent circuit.<br>Lecture 6 : The thermodynamic limit, Shockley-Quiesser limit<br>Lecture 7 : Losses in Solar cell design, Design for high Isc, High Voc, High FF<br>Lecture 8 : Analytical techniques, Solar simulator<br>Lecture 9-10 : Quantum efficiency, measurement minority carrier life time | 10 |
| 03 | Lecture 1 : Silicon wafer based solar cell, basic silicon solar cell<br>Lecture 2: Strategies to enhance Absorption reduce surface recombination, reduce series resistance<br>Lecture3-6 : Thin film solar cells, Transparent conducting oxides, Chalcogenide solar cells, Organic photovoltaics, Perovskite<br>Lecture 7-9: Dye sensitized solar cells, Hybrid organic, Inorganic solar cells, multi-junction<br>Lecture 10 : Multi exciton generation, Photovoltaic system Design | 10 |

| Sr. | Text Books | Author |
|---|---|---|
| 01 | Solar Photovoltaics, Fundamentals, Technologies and applications, | Chetan Singh Solanki (PHI Learning) |
| 02 | Solar Energy Fundamentals, Technology and Systems | Klaus Jäger, Olindo Isabella (Delft University of Technology) |

| **Subject : Electronics Tinkering Lab** **Course Code: PSPHY LB4** | Year & Semester: M.Sc. Physics 1st year & 2nd Semester. | Credit: 1.5, L: 0, T: 0, P: 3 |
|---|---|---|
| Evaluation Policy | Continuous Assessment | End-Term |
| | 60 Marks | 40 Marks |

| Sr.No. | Course outcomes |
|---|---|
| CO1 | The course aims through a theoretical and experimental approach to give fundamental insights into solid state physics. |
| CO2 | Should know about: p-n junction diodes and transistors |
| CO3 | Understanding the principle of Solar cell and working. |
| CO4 | With the help of ExpEYES-17 kit students will be able to make circuit on breadboard using theoretical knowledge. |

List of Experiments

Experiment No. 1 Study of characteristics of semiconductor diode.

Experiment No. 2 Study of P-N junction with temperature.

Experiment No. 3: Investigation of transistor characteristics of n-p-n and p-n-p transistors

Experiment No. 4: To determine the h-parameters of a transistor.

Experiment No. 5 To plot the V-I Characteristics of the solar cell and hence determine the fill factor

Experiment No. 6: To study the Schmitt trigger characteristic using IC 741

Experiment by EXPEYES-17 kit
Title of experiments:

| | | |
|---|---|---|
| Half wave Rectifier | Full wave Rectifier | Diode Clipping |
| Diode Clamping | Diode Characteristics | Transistor Amplifier |
| Inverting Amplifier | Non-inverting Amplifier | Logic Gate |

Recommended Text Books

| Sr. No. | Name of the book | Author |
|---|---|---|
| 01 | Digital Principles and Applications, | D. P. Leach, A. P. Malvino (McGraw-Hill Education) |
| 02 | Digital Fundamentals: | Floyd & Jain (Pearson Education) |
| 03 | EXP EYES- 17 Kit Manual | Manual, PHDENIX Project, IUAC, New Delhi |

| | | | | | |
|---|---|---|---|---|---|
| **Subject: Synthesis of Nanomaterials Lab**<br>**Course Code: PSPHY LB5** | Year & Semester: M.Sc. Physics<br>1st year & 2nd Semester. | Credit | L | T | P |
| | | 1.5 | 0 | 0 | 3 |
| Evaluation Policy | Continuous Assessment | End-Term | | | |
| | 60 Marks | 40 Marks | | | |

| Sr. No. | Course outcomes: Students will |
|---|---|
| CO1 | Develop understanding about crystallization and synthesis |
| CO2 | Learn the techniques of nanomaterials preparation |
| CO3 | Understand the mechanism behind the preparation methods |
| CO4 | Prepare materials of choice |

**List of Experiments**

Experiment No. 1: Synthesis of nanomaterial sample using Sol-gel technique.

Experiment No. 2: Synthesis of polycrystalline sample using solid state reaction technique

Experiment No. 3: Synthesis of nanomaterials using microwave technique.

Experiment No. 4: Synthesis of nanomaterial using Ball Milling of bulk sample.

Experiment No. 5: Synthesis of nanomaterial using hydrothermal method

Experiment No. 6: Synthesis of nanomaterial using auto combustion method.

Experiment No. 7: Synthesis of nanomaterial using Co-precipitation method.

Experiment No. 8: Synthesis of nanomaterial using Sono chemical and spark discharge route.

Recommended Text Books

| Sr. No. | Name of the book | Author |
|---|---|---|
| 01 | Synthesis and Applications of Nanoparticles | Atul Thakur, Preeti Thakur |
| 02 | Science of Small | Shah and Shah (Wiley) |

| **Subject: Bio-Engineering Lab**<br>**Course Code: PSPHY LB6** | Year & Semester: M.Sc. Physics<br>1st year & 2nd Semester. | Credit 1.5, L 0, T 0, P 3 |
|---|---|---|
| Evaluation Policy | Continuous Assessment | End-Term |
| | 60 Marks | 40 Marks |

| Credit | L | T | P |
|---|---|---|---|
| 1.5 | 0 | 0 | 3 |

| Sr. No. | Course outcomes: Students will |
|---|---|
| CO1 | Synthesis of various polymers, hydrogel |
| CO2 | learn characterization techniques of Biomaterials |
| CO3 | Learn about synthesis of medical fibers |

**List of Experiments**

Experiment No. 1: Synthesis of Polymers

Experiment No. 2: Synthesis and Characterization of smart Materials

Experiment No. 3: Synthesis of Hydrogels

Experiment No. 3: Determination of Properties of Hydrogels

Experiment No. 4: Synthesis and Characterization of materials for energy applications

Experiment No. 5: Synthesis of Medical Fibers

Experiment No. 6: Medical Physics and Bio Physics experiments in collaboration with Skims

Experiment No. 7: Medical Implants, orthopedic materials

Recommended Text Books

| Sr. No. | Name of the book | Author |
|---|---|---|
| 01 | Synthesis and Characterization of Biomedical Materials | Leszek Adam D et al |
| 02 | Biomedical Polymers: synthesis and processing | Vinod B. Damodaran |

# SEMESTER – III

| S. No | Course Code | Theory Courses | L | T | P | Credit |
|---|---|---|---|---|---|---|
| Core Courses | | | | | | |
| 23. | PSPHY 301 | Astrophysics & Space Science | 2 | 1 | 0 | 3 |
| 24. | PSPHY 302 | Atmospheric & Environmental Physics | 2 | 1 | 0 | 3 |
| 25. | PSPHY 303 | Condensed Matter Physics | 2 | 1 | 0 | 3 |
| 26. | PSPHY 304 | Computational Physics | 2 | 1 | 0 | 3 |
| Elective Courses (Students have to opt for pre-project seminar and two electives) | | | | | | |
| 27. | PSPHY EL9 | Medical Physics | 2 | 0 | 0 | 2 |
| 28. | PSPHY EL10 | Superconductivity and superfluidity | 2 | 0 | 0 | 2 |
| 29. | PSPHY EL11 | General theory of relativity | 2 | 0 | 0 | 2 |
| 30. | PSPHY EL12 | Principles of Spectroscopy | 2 | 0 | 0 | 2 |
| 31. | PSPHY PPS | Pre-project Seminar | 0 | 0 | 0 | 1 |
| Laboratory Courses | | | | | | |
| 32. | PSPHY LB7 | Characterization Lab | 0 | 0 | 4 | 2 |
| 33. | PSPHY LB8 | Computational Physics Lab | 0 | 0 | 4 | 2 |
| | Total | | | | | 21 |

| Subject Astrophysics Physics & Space Science **Course Code: PSPHY 301** | Year & Semester: M.Sc. Physics 2nd year & 3rd Semester. | | | | Credits 3, L 2, T 1, P 0 |
|---|---|---|---|---|---|
| Evaluation Policy | Mid-Term | Class Assessment | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks |

| Sr.No. | Course outcomes: Students will be able |
|---|---|
| CO1 | Apply mathematical tools and physics laws to understand the nature of planets, stars, galaxies. |
| CO2 | Use online resources to analyse the data obtained from various astronomical observations. |
| CO3 | Evaluate the results of this analyses and interpret the nature of the Solar system, variety ofstars and galaxies. |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | **Lesson 1-3 Celestial Mechanics and Astrometry:** The celestial Sphere, Positions of stars, Proper motions of stars and planets, Distances of nearbystars. **Lesson 4-8: Tools of Astronomy:** Telescopes: Basic Optics, Optical Telescopes, Radio Telescopes, Infrared, Ultraviolet, X-ray,and Gamma-Ray Astronomy – detectors and observatories | 8 |
| 02 | **Lesson 1-3: The Solar System:** The Sun, The Physical Processes in the solar system, The Terrestrial and the Giant Planets,Formation of Planetary Systems. **Lesson 4-8: Basic Stellar Parameters:** The brightness of the stars, Color-magnitude diagrams (The HR diagrams), The luminosities of the stars, Angular radii of stars, Effective temperatures of stars, Masses and radii of stars: Binarystars, Search for Extrasolar Planets | 8 |
| 03 | Lesson 1-8: **The Nature of Stars:** Spectral classification, understanding stellar spectra, Population II stars, Stellar rotation, Stellarmagnetic fields, Stars with peculiar spectra, Pulsating stars, Explosive stars, Interstellar absorption **Our Galaxy and The Interstellar Matter:** The shape and size of our Galaxy, Interstellar extinction and reddening, Galactic coordinates,Galactic rotation, Stellar population, Inter Stellar Medium, The galactic magnetic field and cosmic rays<br>**Lesson9-12:** Lessons on Space Science and its importance | 12 |

| Sr. No. | Text Books | Author |
|---|---|---|
| 01 | Introduction to Stellar Astrophysics, Volume 1, *Basic stellar observations and data* | Erika Bohm-Vitense, (Cambridge University Press) |
| 02 | Astrophysics for Physicists | Arnab Rai Choudhuri, (Cambridge University Press, 2010) |

| | | | | | |
|---|---|---|---|---|---|
| **Subject Atmospheric & Environmental Physics**<br>**Course Code: PSPHY 302** | Year & Semester: M.Sc. Physics<br>2nd year & 3rd Semester. | | | | Credits: 3, L: 2, T: 1, P: 0 |
| Evaluation Policy | Mid-Term | Class Assessment | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks |

| Sr.No. | Course outcomes: Students will be able to |
|---|---|
| CO1 | Learn basics of Atmospheric physics |
| CO2 | Learn the concept of Electromagnetic Radiation, Energy balance at the earth's surface, transport of pollution in water and air. |
| CO3 | Evaluate the implications of Environmental Physics |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | Lesson 1: Basics of the atmospheric structure:<br>Lesson 2: Electromagnetic radiation, absorption and emission.<br>Lesson 3-5:The radiation balance and the greenhouse gases.<br>Lesson 6: Energy balance at the earth's surface.<br>Lesson 7-10: Water balance. Hydrological cycle.<br>Lesson 11-12: The water movements in ground and soil. Transport of pollution in water and air. Solar and terrestrial radiation. The Clausius Clapeyron equation. | 12 |
| 02 | Lesson 1: Source of ionization,<br>Lesson 2: Formation of an ionized layer,<br>Lesson 3-5: The ionospheric regions,<br>Lesson 6: Distribution of ions in the top side of ionosphere,<br>Lesson 7-10: Magnetic field variation and concepts of atmospheric dynamo and motor, Lession<br>Lesson 11-12: Moments in the atmospheric plasma and neutral atmospheric interaction, currents in ionosphere, Dynamics of Monson | 12 |
| 03 | Lesson 1-2: Scope of Environmental Physics,<br>Lesson 3: Properties of Liquids and Gaseous laws of Thermodynamics and Human body,<br>Lesson 5-7: Transport of Radiant. Energy Resources and Conservation of Environment.<br>Lesson 8-10: Pollution, Environmental Hazards and Risk Management, Smart Pollution Controlling Devices.<br>Lesson 11-12: Momentum continuity and energy equations, Thermodynamics of dry atmosphere, elementary applications of basic equations. The Circulation theorem, velocity, potential vorticity and vorticity equations | 12 |

| Sr. No. | Text Books | Author |
|---|---|---|
| 01 | An Introduction to atmospheric Physics 2nd Edition | David G Andrews (Cambridge) |
| 02 | Environmental Physics: Sustainable Energy and Climate Change | Egbert Boeker and Rienk van Grondelle (Wiley) |

| Subject: **Condensed Matter Physics**. **(Code: PSPHY 303** | Year & Semester: M.Sc. Physics<br>2nd year & 3rd Semester. | | | | Credits | L | T | P |
|---|---|---|---|---|---|---|---|---|
| | | | | | 3 | 2 | 1 | 0 |
| Evaluation Policy | Mid-Term | Class Assessment | Quiz | Attendance | End-Term | | | |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks | | | |

| Sr. No | Course outcomes: Students will |
|---|---|
| CO1 | Understand the general aspects of the electronic transport phenomena. |
| CO2 | Analyze the magnetic properties of solids |
| CO3 | Understand of the optical properties of the materials |
| CO4 | Learn general aspects of the superconductivity. |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | **TRANSPORT PROPERTIES:**<br>Lecture 1: Boltzmann Equation<br>Lecture 2-3: Relaxation Time Approximation; General Transport Coefficients.<br>Lecture 4-5: Electronic Conduction in Metals and Thermoelectric Effects.<br>Lecture 6-7: Magnetoresistance; Magnetotransport.<br>Lecture 8-9: Classical Theory of Magnetoconductivity; Hall Effect and Quantum Hall Effect.<br>Lecture 10: Numerical Problems. | 10 |
| 02 | **MAGNETISM:**<br>Lecture1: Magnetic Properties of Insulators.<br>Lecture 2-3: Langevin Diamagnetism and Van VleckParamagnetism.<br>Lecture 4-5: Curie Paramagnets and Curie-Weiss Ferromagnets.<br>Lecture 6-7:Neel Antiferromagnetsand Heisenberg model; Spin Waves.<br>Lecture 8: Elements of Magnetic Properties of Metals, Landau Diamagnetism, Pauli Paramagnetism.<br>Lecture 9-10: Magnetic Resonance and Numerical Problems. | 10 |
| 03 | **OPTICAL PROCESSES AND EXITONS:**<br>Lecture 1: Optical Reflectance.<br>Lecture 2-4:Kramers-Kronig Relations, Electronics- Interrand Transitions.<br>Lecture 5-6:Exitons: Frankel Exitons.<br>Lecture 7-8:Exiton Condensation into Electron-Hole Drops.<br>Lecture 9-10: Raman Effect in Crystals; Numerical Problems. | 10 |
| 04 | **SUPERCONDUCTIVITY:**<br>Lecture 1-3: History, General Properties, Measurements; Critical Field; Temperature, Current.<br>Lecture 4: Type-I and Type-II Superconductors and Meissner Effect,London Equation.<br>Lecture 5-6: Penetration Depth; Optical Properties, Cooper Pairing and BCS Theory;.<br>Lecture 7-8: Ginzburg-Landau Theory; Flux Quantization.<br>Lecture 9-10: Super current Tunnelling; DC And AC Josephson Effects; High-Tc Superconductors, Numerical Problems. | 10 |

| Recommended Books | | |
|---|---|---|
| Sr. No | Text Books | Author |
| 01 | Introduction to Solid State physics. | Kittel, C.,(Wiley Eastern Ltd.) |
| 02 | Solid State Physics. | A. J. Dekker, Macmillan, New Ed. |
| 03. | Principles of Condensed Matter Physics. | Chaikin and Lubensky (Cambridge University Press). |

| Subject: **Computational Physics** **Course Code: PSPHY 304** | Year & Semester: M.Sc. Physics 2nd year & 3rd Semester. | | | | Credits 3, L 2, T 1, P 0 |
|---|---|---|---|---|---|
| Evaluation Policy | Mid-Term | C.A | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks |

| Credits | L | T | P |
|---|---|---|---|
| 3 | 2 | 1 | 0 |

| Sr.No. | Course outcomes: |
|---|---|
| CO1 | Apply fundamental of MATLAB to run scripts. |
| CO2 | Construct scripts to evaluate roots of equation. |
| CO3 | Construct scripts to generate interpolation points. |
| CO4 | Construct scripts to evaluate differential equations. |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | Lecture 1: Introduction to MATLAB: Brief introduction, installation of MATLAB, Use of MATLAB, key features;<br>Lecture 2: MATLAB Software: MATLAB window, command window, Workspace, command history,<br>Lecture 3: working with the MATLAB user interface, basic commands, assigning variables,<br>Lecture 4-5: operation with variables, Data files and types: Character and strings,<br>Lecture 6-7: arrays and vectors; Basic mathematics: Arithmetic operations<br>Lecture 8-9: mathematical and logic operators; M files: Writing script files,<br>Lectures 10: executing script files, MATLAB editor, saving m files; Plots: 2D and 3D plots, Loops: if, else, ifelse. | 10 |
| 02 | Lecture 1: Determining roots of the equation by Bisection method<br>Lecture 2: Newton Raphson Method<br>Lecture 3-4: Matrix manipulation: Creating rows and columns matrix<br>Lecture 5-6: matrix operations, Finding transpose<br>Lecture 7-8: determinant and inverse, simultaneous method by Gauss elimination method<br>Lecture 9-10: Gauss Seidel iteration method, problems | 10 |
| 03 | Lecture 1-2: Interpolation, Newton's formula for forward interpolation<br>Lecture 3-4: Newton's backward interpolation, Divided difference<br>Lecture 5-6: Newton's general interpolation formula, Lagrange's interpolation formula<br>Lecture 7-8: cubic splines, least square approximation<br>Lecture 9-10: interpolation in multidimension, problems | 10 |
| 04 | Lecture 1: Numerical differentiation and integration<br>Lecture 2-4: Trapezoidal rule, Simpson 1/3 and Simpson 3/8 rule<br>Lecture 5-6: Solution of ordinary differential equation: Euler's method<br>Lecture 7: Modified Euler's method<br>Lecture 8-9: Runge-Kutta method<br>Lecture 10: Problems | 10 |

| Recommended Books | | |
|---|---|---|
| Sr. N | Text Books | Author |
| 01 | Getting Started with MATLAB | Rudra Pratap (Oxford) |
| | Reference Books | |
| 02 | | |

| | | | | | |
|---|---|---|---|---|---|
| **Subject: Medical Physics** **Course Code: PSPHY EL9** | Year & Semester: M.Sc. Physics 2nd year & 3rd Semester. | | | | Credits: 2, L: 2, T: 0, P: 0 |
| Evaluation Policy | Mid-Term | Class Assessment | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks |

| Credits | L | T | P |
|---|---|---|---|
| 2 | 2 | 0 | 0 |

| Sr.No. | Course outcomes: students will |
|---|---|
| CO1 | Learn Physics behind life. |
| CO2 | Understand basics of dosimetry concepts and radiation detectors |
| CO3 | Learn treatment of tumors |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | What is life, requirement and domain of life, atomic constituents of life, Molecular essential for life, water, protein, lipid, carbs, cholesterol, Nucliec Acid, Characterization of living cells, Forces and Molecular bonds, heat transfer in biomaterials, open system and chemical thermodynamics, diffusion and transport in living systems. | 10 |
| 02 | Electrical Impedance and Biological Impedance, Principle and theory of thermography its applications, Basic principles of radiation detection - Counting systems for alpha and beta radiation | 10 |
| 03 | Principles of Radiation detection ,properties of dosimeters, Theory of gas filled detectors, Ion chamber dosimetry systems, free air ion chamber, parallel plate chamber ,ionization chamber Laser Surgical Systems, Measurement of fluence from optical sources, Optical properties of tissues, theory and experimental techniques, interaction of laser radiation with tissues , microscopy in medicine Interaction of light (electrons and positrons) and heavy charged particles with matter ,Malignant Tumors, material response, deformation and failure ,friction and wear | 10 |

| Recommended Books | | |
|---|---|---|
| Sr. No. | Text Book | Author |
| 01 | Laser Photobiology and Photomedicine, Plenum Press | S. S. Martellucci and A. N. Chester (, New York, 1985) |
| | Reference Books | |
| 01 | Laser-Tissue Interactions | Markolf H. Neimz (Springer Verlag, Germany) |
| 02 | Principles of Biomedical Instrumentation and measurement, | Richad Aston (Merrill Publishing Co., London) |

| **Subject: Superconductivity and superfluidity** **Course Code: PSPHY EL10** | Year & Semester: M.Sc. Physics 2nd year & 3rd Semester. | | | | Credits: 2, L: 2, T: 0, P: 0 |
|---|---|---|---|---|---|
| Evaluation Policy | Mid-Term | C.A | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks |

| Sr.No. | Course outcomes: Students will |
|---|---|
| CO1 | Analyze the application of superconductivity |
| CO2 | Distinguish type I and type II superconductors and its applications |
| CO3 | Understand significance of superfluidity |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | Survey of Superconductivity, Perfect Conductivity, Magnetoquasistatic, London's Equations, Classical Model of a Superconductor, Electromagnetic Power, Transmission Lines, Perfect Diamagnetism, Macroscopic Quantum Model, Supercurrent Equation. | 10 |
| 02 | Basic Josephson Junctions, SQUID, Generalized Josephson Junctions, Josephson Circuits Type II Superconductors and Circuit Fields, Flux Flow, Pinning, Ginzburg- Landau Theory, Microscopic Interactions and Cooper Problem, BCS I, BCS II, High Temperature Superconductivity, Cuprates and Fe based Superconductors. | 10 |
| 03 | Phase diagram of Helium, Basic properties of superfluidity, Bose Einstein condensation, Quantized Vortex, Elementary excitation, Two fluid model and sound waves, Two dimensional superfluidity. | 10 |

| Recommended Books | | |
|---|---|---|
| Sr. N | Text Books | Author |
| 01 | Introduction to superconductivity | M. Tinkham |
| | Reference Books | |
| 01 | Superconductivity | Ketterson and Song |
| 02 | Superconductivity Vol I and II | R D Parks |
| 03 | Superconductivity, superfluids and condensates. | James F. Annett |

| **Subject General Theory of Relativity and Cosmology** **Course Code: PSPHY EL11** | Year & Semester: M.Sc. Physics 2nd year & 3rd Semester. | | | | Credits: 2, L: 2, T: 0, P: 0 |
|---|---|---|---|---|---|
| Evaluation Policy | Mid-Term | Class Assessment | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks |

| Sr.No. | Course outcomes: Students will |
|---|---|
| CO1 | Understand theoretical framework and experimental necessity of Einstein theory of general relativity |
| CO2 | Analyze principles of general relativity and physics in curved spacetime |
| CO3 | Develop tools to enable the quantitative calculation of general relativistic effects |

| **Course contents** | | Lectures required |
|---|---|---|
| Unit | Particulars | |
| 01 | Riemannian Geometry: Vectors and Tensors; parallel transport, covariant differentiation; Geodesics; Riemann-Christoffel curvature tensor - its symmetry properties, Ricci tensor; Bianchi identities; vanishing of the curvature tensor as a condition for flatness, Geodesic deviation equation. Principle of general covariance and principle of equivalence; Einstein field equations, derivation from a variational principle | 10 |
| 02 | Schwarzschild exterior solution, Birkhoff's theorem. Geodesics in a Schwarzschild geometry. Crucial tests of general relativity - perihelion shift, bending of light, gravitational redshift. Schwarzschild blackhole - event horizon and static limit, Kruskal - Szekere's diagram | 10 |
| 03 | Cosmological Models: Universe at large scales – Homogeneity and isotropy – distance ladder– Newtonian cosmology - expansion and redshift - Cosmological Principle - Hubble’s law - Robertson-Walker metric - Observable quantities – luminosity and angular diameter distances- Horizon distance- Dynamics of Friedman- Robertson-Walker models: Friedmann equations for sources with p=wu and w =−1, 0, 1/3, discussion of closed, open and flat Universes. | 10 |

| Recommended Books | | |
|---|---|---|
| Sr. N | Text Book | Author |
| 01 | Lecture on General Relativity and Cosmology | J. V. Narlikar, (The Macmillan Company of India Limited |
| | Reference Books | |
| 01 | Introduction to General Relativity, | R. Adler, M. Bazin and M. Schiffer (McGraw-Hill) |
| 02 | Cosmological Physics | J . A. Peacock (Cambridge University Press) |
| 03 | Introduction to Cosmology | J. V. Narlikar(Cambridge University Press, 1993 (For the lectures on Cosmology) |

| **Subject Principles of Spectroscopy** **Course Code: PSPHY EL12** | Year & Semester: M.Sc. Physics 2nd year & 3rd Semester. | | | Credits 2, L 2, T 0, P 0 |
|---|---|---|---|---|
| Evaluation Policy | Mid-Term | Class Assessment | Quiz | Attendance | End-Term |
| | 26 Marks | 8 Marks | 8 Marks | 8 Marks | 50 Marks |

| Credits | L | T | P |
|---|---|---|---|
| 2 | 2 | 0 | 0 |

| Sr.No. | Course outcomes |
|---|---|
| CO1 | Analysis of selection rules for transition spectra |
| CO2 | Evaluate molecular spectra of various molecules |
| CO3 | Evaluate Vibronic transition |

| **Course contents** | | | Lectures required |
|---|---|---|---|
| Unit | Particulars | | |
| 01 | Transition rates, Einstein coefficients, electric dipole (E1) approximation, E1 selection rules, oscillator strengths, line intensities, line shapes and line widths; retardation effects, magnetic dipole and electric quadrupole transitions, lifetimes of excited states; photoelectric effect, Bremsstrahlung Numerical Problems. | | 10 |
| 02 | Spectroscopic transitions, rotational spectra of molecules, rotational selection rules; vibrational spectra of diatomic molecules, vibrational selection rules, vibration-rotation spectra of diatomic molecules, Numerical Problems. | | 10 |
| 03 | Vibronic transitions, Franck-Condon principle, rotational structure of vibronic transitions, Fortrat diagram, dissociation energy of molecules, continuous spectra, Numerical Problems. | | 10 |
| Recommended Books | | | |
| Sr. N | Text Book | Author | |
| 01 | Physics of Atoms and Molecules | Bransden B. H. and Joachain C. J | |
| | Reference Books | | |
| 01 | Fundamentals of Molecular Spectroscopy | C. N. Banwell | |
| 02 | Molecular Quantum Mechanics | Atkins P. and Friedman R | |

| Subject: Characterization Lab<br>Course Code: PSPHY LB7 | Year & Semester: M.Sc. Physics<br>$2^{nd}$ year & $3^{rd}$ Semester. | Credit 1.5, L 0, T 0, P 3 |
|---|---|---|
| Evaluation Policy | Continuous Assessment | End-Term |
| | 60 Marks | 40 Marks |

| Credit | L | T | P |
|---|---|---|---|
| 1.5 | 0 | 0 | 3 |

| Sr.No. | Course outcomes: Students will |
|---|---|
| CO1 | Develop understanding of principles of various characterization instruments |
| CO2 | Analyze working of XRD, SEM, UV Visible Spectrometer. |
| CO3 | Learn X-ray Diffractometry, SEM and Spectroscopic techniques |
| CO4 | Develop thin flims |

**List of Experiments**

Experiment No 1: Phase identification of an unknown sample by X-ray diffraction spectroscopy.

Experiment No 2: Determination of Miller indices, space group, lattice parameters and unit cell volume of an unknown powder crystalline material by X-ray diffraction technique.

Experiment No 3: To carry out Williamson Hall plot analysis of X-ray diffraction data to estimate the strain and grain size for given samples.

Experiment No 4: To carry out X-ray diffraction measurements on single crystalline substrate (R-cut Sapphire, C-cut sapphire crystalline quartz).

Experiment No 5: To determine of Lattice parameters, particles sizes etc. of different powder samples of bulk-/nano-systems (ferrite, $\alpha$-$Fe_2O_3$, $\gamma$-$Fe_2O_3$) using X-ray diffractograms.

Experiment No 6: To determine the particle size and lattice strain of an unknown powder specimen using Origin software and Scherrer equation.

Experiment No 7: To study the porosity and grain size of thin film and powder samples by Scanning Electron Microscopy.

Experiment No 8: To study microstructure of pure metals.

Experiment No 9: Spectroscopy Experiments.
(a)- UV Visible
(b)- Photoluminescence
(c )- Raman

Recommended Text Books

| Sr. No. | Name of the book | Author |
|---|---|---|
| 01 | Elements of X-ray Diffraction | B.D Cullity (Pearson) |
| 02 | Material characterization Techniques | S. Zhang, L. Li&A. Kumar |
| 03 | Material characterization: Introduction to Microscopic and spectroscopic Methods | Yang Leng |
| 04 | Nanotechnology | MA Shah & Tokeer |

<table>
<tr><td>Subject: Computational Physics Lab<br>(Code: PSPHY LB2)</td><td>Year & Semester: M.Sc. Physics<br>2nd year & 3rd Semester.</td><td><table><tr><td>Credits</td><td>L</td><td>T</td><td>P</td></tr><tr><td>1.5</td><td>0</td><td>0</td><td>3</td></tr></table></td></tr>
<tr><td rowspan="2">New Education /<br>Evaluation Policy</td><td>Continuous Assessment</td><td>End-Term</td></tr>
<tr><td>60 Marks</td><td>40 Marks</td></tr>
</table>

| Sr.No. | **Course outcomes** |
|---|---|
| CO1 | Able to explain fundamentals of MATLAB. |
| CO2 | Able to write MATLAB Scripts. |
| CO3 | Able to apply programming knowledge to solve mathematical problems |
| CO4 | Able to construct, visualize and analyze algorithm to simulate systems and problems |

List of Experiments

Experiment No. 1: Write MATLAB script to simulate the decay of radioactive nucleus.

Experiment No. 2: Write MATLAB script for the numerical solution of equation of motion for a simple pendulum using the Euler method.

Experiment No. 3: Write MATLAB script for the numerical solution of equation of motion for a simple pendulum using the Runge Kutta method.

Experiment No. 4: Write a MATLAB script for the numerical solution of damped pendulum.

Experiment No. 5: Write a MATLAB script to simulate the planetary motion of earth around the sun.

Experiment No. 6: Write a MATLAB script to simulate the random walk.

Experiment No. 7: Write a MATLAB script to solve time dependent Schrodinger equation in 1D for particle in a box problem.

Experiment No. 8: Write a MATLAB script to simulate the Ising model of a ferromagnet.

Recommended Books

| Sr. No. | Name of the book | Author |
|---|---|---|
| 01 | Getting start with MATLAB<br>A Quick Introduction for Scientists &Engineers | Rudra Pratap (Oxford University Press) |

## SEMESTER – IV

| S. No. | Course Code | Courses | L | T | P | Credits |
|---|---|---|---|---|---|---|
| 34. | PSPHY PR1 | Research Based Project (Full Semester)/ Dissertation/ Presentation/ Group Discussion | 0 | 0 | 28 | 14 |
| | Total | | | | | 14 |

| **Subject Research Based Project (Full semester)**<br>**Course Code: PSPHY PR1** | Year & Semester: M.Sc. Physics<br>2nd year & 4th Semester | | | |
|---|---|---|---|---|
| Evaluation Policy:<br>Mid Term (20%) + End Term (80%) | Supervisor | External | HOD. | Sister Dept. |
| | 50 Marks | 20 Marks | 20 Marks | 10 Marks |

| Course contents | |
|---|---|
| Unit | Particulars |
| | Guidelines for Project in M.Sc. Course:<br>1. Projects would be allotted to M.Sc. (Previous) students which have to be carried out and completed in M.Sc. (Final).<br><br>2. A list of projects will be finalized and announced by the Department. The students will have an option to select the project in their field of interest with any other faculty even outside of Institute.<br><br>3. The project will comprise of the following:<br>a. Collection of data, procurement and fabrication of experimental set up and writing of computer programs if needed.<br>b. Writing a dissertation or project report. This will be submitted by the M.Sc. (Final) students in the first week of May.<br>c. Giving a preliminary seminar before the final presentation for the purpose of internal assessment whose weightage would be 25%.<br><br>4. The Final evaluation of the project work completed will be done by external and internal examiners appointed by the Board of Studies on the basis of an oral presentation and the submitted Project-Report.<br><br>5. The weight age of the final evaluation would be 75%. |

**Cos:**

1. **Design, Develop and carry out scientific experiments as well as accurately record the results of designed experiments**

2. **Communicate scientific knowledge related to Physics/ Materials Science/ Nanotechnology in oral, written and electronic formats**

3. **Explore new areas of research in the area of science and technology to meet the needs of society.**