Unit	Content
Unit I	Elementary survey of Classical Mechanics: Newtonian mechanics for single particle and system of particles, Types of the forces and the single particle system examples, Limitation of Newton's program, conservation laws viz Linear momentum, Angular Momentum & Total Energy, work-energy theorem; open systems (with variable mass). Principle of Virtual work, D'Alembert's principle Applications (12)
Unit II	Constraints; Definition, Types, cause & effects, Need, Justification for realizing constraints on the system, Difficulties introduced by imposing constraints on the system, Examples of constraints, Introduction of generalized coordinates justification. Lagrange's equations; Linear generalized potentials, Generalized coordinates and momenta & energy; Gauge function for Lagrangian and its gauge invariance;. (12)
Unit III	Cyclic coordinates, Integrals of the motion, Concepts of symmetry, homogeneity and isotropy, Invariance under Galilean transformations Hamilton's equation of motion: Legendre's dual transformation, Principle of least action; derivation of equations of motion; variation and end points; Hamilton's principle and characteristic functions; Hamilton-Jacobi equation. (12)
Unit IV	Central force: Definition and properties, Two-body central force problem, closure and stability of circular orbits; general analysis of orbits; Kepler's laws and equation, Classification of orbits, differential equation of orbit, Varial Theorem. (12)
Unit V	Canonical transformation; generating functions; Properties; group property; examples; infinitesimal generators; Poisson bracket; Poisson theorems; angular momentum PBs; Transition from discrete to continuous system, small oscillations (longitudinal oscillations in elastic rod) ; normal modes and coordinates(12)

Course Material/Learning Resources

Text books:

1. Classical Mechanics Third Edition, Charles P. Poole Herbert Goldstein John L. Safko
2. Classical Mechanics, N C Rana and P S Joag (Tata Mc-Graw-Hill, 1971)
3. Classical mechanics, H Goldstein (addison Wesley, 1980)
4. Classical Mechanics, J.C. Upadhaya (Himalaya Pub).
5. Classical Mechanics, Waghmare (West Wiley)
6. Classical Mechanics, P.V. Panat
7. Classical Mechanics, G. Aruldas
8. Mathematical Physics - by B.D.Gupta (Vikas Pub.)

Reference Books:

1. Mechanics, by A Sommerfeld (Academic Press, 1952)
2. Introduction to Dynamics, by I Perceival and D Richards (Cambridge Univ. Press. 1982).
3. Classical Mechanics: An Introduction, Dieter Strauch

Weblink to Equivalent MOOC on SWAYAM if relevant:

1. https://bsc.hcverma.in/course/cm1
2. https://ocw.mit.edu/courses/8-09-classical-mechanics-iii-fall-2014/
3. https://nptel.ac.in/courses/115106123
4. https://ocw.mit.edu/courses/8-01sc-classical-mechanics-fall-2016/

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

1. https://www.youtube.com/watch?v=83QCm3LkuEg
2. https://www.youtube.com/watch?v=582_V290ozM
3. https://www.youtube.com/watch?v=lQIbcV6dQzw

COs (1PHY3: Quantum Mechanics-I)

Upon completion of the course successfully, students would be able to

1. be familiar with the main aspects of the historical development of quantum mechanics and be able to discuss and interpret experiments that reveal the wave properties of matter, as well as how this inspired replacing classical mechanics with a wave equation;
2. gain the knowledge about quantum mechanical axioms and the matrix representation of quantum mechanics;
3. solve the Schrödinger equation on their own for simple systems in one to three dimensions, both analytically and by using robust numerical methods; use these solutions to calculate their time evolution, associated probabilities, expectation values, and uncertainties, as well as give concise physical interpretations and reasoning underlying the mathematical results;

4. grasp the concepts of angular momentum and spin, as well as the rules for quantization and their additions;
5. distinguish between Schrodinger, Heisenberg and Interaction representations; use commutation relations to explain the outcome of measurements and apply Variation method to obtain the ground state energy of various systems and WKB method for one dimensional problems

Unit	Content
Unit I	Review of (i) failure of classical ideas – photoelectric effect, Compton effect, blackbody radiation, atomic spectra, (ii) wave-particle duality, (iii) Heisenberg uncertainty relation and (iv) wave function; Schrodinger's equation, probability, probability current and continuity equation; Wave packets, minimum uncertainty Gaussian wave packets, group velocity and dispersion, simple one-dimensional problems – infinite and finite potential wells, tunneling probabilities; One-dimensional harmonic oscillator.(14)
Unit II	General formalism of quantum mechanics – linear vector spaces and operators; Representations of states and dynamical variables; Hermitian operators, eigenstates and eigenvalues, completeness of eigenstates; Dirac bra andket notation, matrix representation of operators; Change of bases and unitary transformations; Diagonalization of the Hamiltonian.(12)
Unit III	Simple harmonic oscillator using energy representation - raising and lowering operators; Angular momentum and central forces; Representation of angular momentum operators and hamiltonian in spherical coordinates; Hydrogen electron wave functions and energy states - principal, orbital and magnetic quantum numbers, Laguerre polynomials and spherical harmonics; Spatial nature of hydrogen electron orbitals.(12)
Unit IV	Pauli spin matrices, angular momentum algebra; Simultaneous eigenstates of L2 and Lz, L+ and L- operators; Addition of angular momenta; Application to spin-orbitals of hydrogen, Clebesch-Gordan coefficients, examples of simple cases.(10)
Unit V	Symmetry and constants of motion, time evolution, commutators, complete sets of commuting physical observables; Schrodinger, Heisenberg and Interaction Pictures; Variational principle, Helium atom, WKB approximation, slowly varying potentials.(12)

Text books:

1. Introduction to quantum mechanics, David J. Griffiths
2. Quantum Mechanics: Concepts and Applications, (Wiley, 2nd Edition), Nouredine Zettili
3. Quantum Mechanics, (PHI-2nd Edition), G. Aruldas
4. Quantum Mechanics -Theory and Applications (5th Edition) Ajoy Ghatak

Reference Books:

1. Quantum Mechanics, Eugene Merzbacher (John-Wiley, 3rd Ed, 2005)
2. Quantum Mechanics, P M Mathews and K Venkatesan (Tata- McGraw Hill, 1976)
3. Quantum Physics, S. Gasiorowicz (John-Wiley)
4. Concepts of Modern Physics, (7th Edition) Arthur Beiser
5. Feynman Lectures On Physics: Quantum Mechanics, Volume 3
6. Quantum Mechanics, L I Schiff.
7. Quantum Mechanics, L. D. Landau and E. M. Lifshitz

Weblink to Equivalent MOOC on SWAYAM if relevant:

1. https://hcverma.in/QuantumMechanics
2. https://www.edx.org/course/quantum-mechanics-for-scientists-and-engineers-1
3. https://www.edx.org/course/quantum-mechanics-for-scientists-and-engineers-2
4. https://archive.nptel.ac.in/courses/115/101/115101107/

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

1. https://www.youtube.com/watch?v=hyctIDPRSqY
2. https://www.youtube.com/watch?v=xnt2xSNRNn0
3. https://www.youtube.com/watch?v=K4BF7MD69_U

COs (1PHY4: Computational Methods and Programming)

Upon completion of the course successfully, students would be able to

1. iteratively find the roots of smoothly varying functions with nonzero derivatives; carry out matrix operations, including inverses and determinants.
2. solve systems of linear equations using multiple methods, including Gaussian elimination and matrix inversion; determine eigenvalues and eigenvectors; use numerical methods for interpolation, finding roots of equations and curve fitting.

3. use numerical differentiation and integration for problems in physics; numerically, solve ordinary differential equations with boundary value problems.
4. independently program computers using high level programming language (C-programming).
5. formulate and computationally solve the selected problems in physics using C-programming.

Unit	Content
Unit I	Methods for determination of zeroes of linear and nonlinear equations and transcendental equations, convergence of solutions. Solution of simultaneous linear equations, Gauss elimination, Pivoting, Iterative method, Matrix inversion. (12)
Unit II	Eigen values and Eigen vectors of matrices, Power and Jacobi methods. Finite differences, Interpolation with equally spaced and unevenly spaced points, curve fitting, Least squares fitting, Cubic spline fitting. Numerical differentiation and integration, Newton-Cotes formulae, Error estimates, Gauss methods (12)
Unit III	Random variate, Monte Carlo evaluation of integrals, Methods of importance sampling, Random walk and metropolis methods. Numerical solution of ordinary differential equations, Euler and Runge Kutta methods, Predictor and Corrector methods, Elementary ideas of solutions of partial differential equations. (12)
Unit IV	Introduction to programming and study of logic. Elementary information about digital computer principles, compilers, interprets and operating system. C-Programming, Flow charts, C character set, Identifiers and key words, Data types, Declarations, Expressions, statements and symbolic constants, input output statements, Pre-processors commands, storage types, automatic external, register and static variables. (12)
Unit V	Operators and Expressions : Arithmetic, unary, logical, bitwise, assignment and conditional operators. Control statements : While, do-while for statements. Nested groups. If-else, switch, break, continue and go to statements, comma operators. Arrays : Defining and processing. Passing arrays to a function. Multidimensional arrays, Functions : Defining and accessing. Passing arguments. Function Prototypes. Recursion. Library functions. Static functions. (12)

Text books:

1. Introductory methods of numerical analysis Sastry
2. Numerical analysis Rajaraman
3. A first course in computational Physics, Paul L. DeVries & Javier E. Hasbun (Jones & Barlett Pub.
4. Complete reference with C, Tata McGraw Hill.
5. C Programming, E-Balagurusamy, Tata McGraw Hill.
6. Let us C by Kanetkar.

Reference Books:

1. Computer oriented numerical methods Rajaraman
2. Mastering C by Venugopal, Prasad, TMH.
3. Schaums outline of theory and Problems of programming with C. Gottfried.

Weblink to Equivalent MOOC on SWAYAM if relevant:

1. https://nptel.ac.in/courses/106104128
2. https://nptel.ac.in/courses/106105171
3. https://www.coursera.org/specializations/c-programming
4. https://www.coursera.org/learn/c-programming-getting-started
5. https://nptel.ac.in/courses/115106118
6. https://nptel.ac.in/courses/111107105

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

1. https://www.youtube.com/watch?v=We6zrqc9e18
2. https://www.youtube.com/watch?v=mzQFGOvH-mk
3. https://www.tutorialspoint.com/cprogramming/index.htm
4. https://www.youtube.com/watch?v=iT_553vTyzI
5. https://www.vitalsource.com/products/c-programming-absolute-beginner-39-s-guide-greg-perry-v9780133414240

Syllabus Prescribed for 2022-23 Year ~~UG~~/PG Programme

Programme: MSc Physics

Semester I

Code of the Course/Subject	**Title of the Course/Subject** (Laboratory/Practical/practicum/hands-on/Activity)	**(No. of Periods/Week)**
1PHY5	**Computer Lab**	**08**
1PHY6	**General Lab**	**08**

COs (1PHY5- Computer Lab)

Upon completion of the course successfully, students would be able to

1. Read, understand and trace the execution of programs written in C language.
2. Write the C code for a given algorithm.
3. Write programs that perform operations using derived data types.
4. Solve an algebraic or transcendental equation using an appropriate numerical method.
5. Develop and execute of C-language based programs.
6. Formulate codes to solve theoretical problems in physics using various computational tools

*** List of Practical/Laboratory Experiments/Activities etc.**

It is necessary to perform at least seven experiments from the list given below.

1.	Develop and execute a program to obtain volumes and areas of regular bodies and figures.
2.	Develop and execute a program to convert temperature from one system to other system (at least three).
3.	Develop and execute a program to fit a straight line to experimental data.
4.	Develop and execute a program to fit exponential function to experimental results.
5.	Develop and Execute a program to obtain integral of a tabular function.
6.	Develop and execute a program to obtain inverse of a matrix.
7.	Develop and execute a program to obtain roots of a polynomial by
8.	Newton-Raphson Method and b) Bisection Method.
9.	Develop and execute a program to obtain product of two matrices.
10.	Develop and execute a program to obtain solution of differential equation by a) Euler and B) Runge Kutta Method.
11.	Develop and execute a program to obtain value of an equation using subroutine.
12.	To use the various computational tools (Scilab/ Python/ Matlab/ Maple) to solve the problems in physics.

Reference Books:

1. Practical C Programming, 3rd Edition By Steve Oualline
2. http://www.baburd.com.np/books/LabManual-ComputrProgramming.pdf

Weblink to Equivalent Virtual Lab if relevant:

1. https://cse02-iiith.vlabs.ac.in/
2. https://www.youtube.com/watch?v=aXfyCax2mw8
3. https://sites.google.com/view/pankajnagpure/online-courses/physics-with-scilab/video-lectures-lecture-notes

COs (1PHY6- General Lab)

Upon completion of the course successfully, students would be able to

1. organize and assemble
   - Experiments on Mechanics
   - Experiments on Optics
   - Experiments on Modern Physics
2. perform data acquisition using assembled experiment.
3. engage in experimental troubleshooting with teaching assistants.
4. identify sources of error and fluctuations in the collected data.
5. construct graph on graph paper and also using computer based the collected data.
6. analyze the collected data.
7. distinguish between theoretical predictions and experimental measurements.

8. verify the fundamental laws and universal constants in Mechanics, Optics and Modern Physics.

*** List of Practical/Laboratory Experiments/Activities etc.**

It is necessary to perform at least seven experiments from the list given below.

1.	Study of variable mass by Atwood's Machine.
2.	To analyze elliptically polarized light by means of Babinet's Compensator.
3.	Determination of wavelength of sodium light and the difference between the wavelengths of sodium D-lines, using Michelson's Perot Interferometer.
4.	Determination of wavelength of sodium light and the difference between the wavelengths of sodium D-lines, using using Febry Perot Interferometer.
5.	Determination of Planck's constant using photoelectric cell.
6.	Determination of Rydberg's constant.
7.	Measurement of wavelength of Sodium Light and refractive index of given liquid using Newton's Rings Method.
8.	Determination of Planck's constant by measuring radiation in fixed spectral range.
9.	Verification Stefan–Boltzmann law for the tungsten filament of a light bulb.
10.	Determination of Stefan's Constant Using Black Body Radiation
11.	To study spectral characteristics of a Solar cell.
12.	Chi-square test
13.	Radioactive decay analogue experiment using dice
14.	To determine the prominent lines of mercury by plane diffraction grating.
15.	Study of Fourier Series and Verification of Fourier theorem using sharp filter.

Reference Books:

1. 1st Edition, Experimental Physics, Principles and Practice for the Laboratory, Edited By Walter Fox Smith
2. An Introduction to Practical Laboratory Optics, J.F. James
3. Experiments in Modern Physics, Adrian C. Melissinos, Jim Napolitano
4. *Advanced Practical Physics by S.P.Singh, Pragati Prakashan, Meerut*
5. *Advanced Physics Laboratory Manual by P. Mishra, J. C. Mohanty,2007, South Asian Publishers Pvt. Ltd, New Delhi*

Weblink to Equivalent Virtual Lab if relevant:

1. https://vlab.amrita.edu/?sub=1
2. https://www.vlab.co.in/broad-area-physical-sciences
3. http://vlabs.iitb.ac.in/vlab/labsps.html

Syllabus Prescribed for First Year 2022-23 PG Programme

Programme: MSc Physics

Semester II

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
2PHY1	**Electrodynamics – I**	**60**
2PHY2	**Quantum Mechanics – Ii**	**60**
2PHY3	**Solid State Physics**	**60**
2PHY4(i)	**Network Theorems and Solid State Devices**	**60**
2PHY4(ii)	**Lasers and Laser Applications**	**60**
1PHY-5	**Laboratory Course-1**	**60**
1PHY-6	**Laboratory Course-2**	**60**

COs (2PHY1 Electrodynamics-I)

Upon completion of the course successfully, students would be able to

1. solve electrostatic potential; Poisson and Laplace equations; Electrostatic energy density; electric energy of a charge distribution.
2. solve boundary value problems with the help of Poisson and Laplace equations; Green's function.
3. apply Biot-Savart Law and Ampere's law for straight wire, loop, solenoid, toroid, current sheet; Magnetic moment, magnetic force and torque on a circuit.
4. solve the multipole expansion of potential and field; Material media, boundary conditions; Dielectric sphere in uniform field; Susceptibility and polarizability, and apply to molecular model.
5. estimate time varying fields; scalar and vector potentials, gauge invariance, wave equations and to solve Poynting theorem.

Unit	Content
Unit I	Review of vector differential calculus Gauss' law; Electrostatic potential, Poisson and Laplace equations; Electrostatic energy density, electric energy of a charge distribution. (12)
Unit II	Laplace equation and boundary value problems – Potentials under Cartesian, cylindrical and spherical symmetries, two-dimensional problems – separations of variables, method of images, simple illustrative problems – point charge, linear conducting plane, cylinder ,sphere. Introduction to Green's function method. (12)
Unit III	Magnetostatics, Biot-Savart Law, Ampere's law; Magnetic fields of arbitrary current distributions, straight wire, loop, solenoid, toroid, current sheet; Magnetic moment, magnetic force and torque on a circuit. (12)
Unit IV	Charge distribution in finite region, multipole expansion of potential and field; Material media, boundary conditions; Dielectric sphere in uniform field; Susceptibility and polarizability, molecular model. (12)
Unit V	Time varying fields, displacement current, Faraday induction; Maxwell's equations for time varying fields, scalar and vector potentials, gauge invariance, wave equation, Poynting theorem. (12)

Text books:

1. Introduction to Electrodynamics, D. J. Griffiths (Prentice-Hall, 3rd Ed. 1999).
2. Electricity and Magnetism, A Mahajan and A Rangwala, TataMcGraw Hill, 2004).
3. **Concepts of Electrodynamics, Kumar V, Khajuria Y (Narosa)**
4. **Electrodynamics,** S.L. Gupta, S.P. Singh, V. Kumar (Pragati Publication)

Reference Books:

1. Classical Electrodynamics, J.D. Jackson (John-Wiley, 3rd Ed. 1998)
2. **Principles of electrodynamics, Melvin Schwartz**
3. Numerical Methods in EM fields, V. Subbarao (Narosa Pub. House Pvt. Ltd.)
4. **Electrodynamics: A Concise Introduction, Westgard James B. (Springer)**

Weblink to Equivalent MOOC on SWAYAM if relevant:

1. **https://bsc.hcverma.in/course/cee1**
2. **https://nptel.ac.in/courses/115101004**
3. **https://onlinecourses.nptel.ac.in/noc21_ph05/preview**
4. **https://nptel.ac.in/courses/108104099**
5. **https://www.udemy.com/course/electrodynamics/**
6. **https://www.udemy.com/course/physics-in-electrodynamics/**

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

1. **https://www.youtube.com/watch?v=LzabONBFSSM**
2. **https://www.youtube.com/watch?v=Lx64cq0HeXY**
3. **https://www.youtube.com/watch?v=FUUMCT7FjaI**
4. **https://www.youtube.com/watch?v=JSa7_pEVdpA**
5. **https://www.youtube.com/watch?v=ckUyN5XNG0Y**

COs (2PHY2: Quantum Mechanics-II)

Upon completion of the course successfully, students would be able to

1. derive from first principles, the expression for the first and second order energy shifts due to a perturbation for the non-degenerate and degenerate states and use this expression for obtaining fairly accurate energies corresponding to these states of perturbed systems;
2. solve the time dependent perturbation problems for quantum systems and predict the consequences; understand the possibility stimulated emission in the atomic systems as a result of interaction with the electromagnetic radiation.
3. understand the quantum theory of scattering and apply it to gain the knowledge about low and high energy physics scattering phenomenon.
4. construct the wave functions for the systems of identical particles; relate the symmetry property of the wave function to the spin of the particles (Bosons and Fermions) and applicability of Pauli's exclusion principle.
5. explain the KG equation and Dirac's equation (relativistic wave equations) and its free-particle solutions; be able to explain the KG equation (relativistic wave equation) and its free-particle solutions.

Unit	**Content**
Unit I	Time independent perturbation theory, non-degenerate and degenerate cases, secular equation, first and second order corrections to energy and wave functions, simple examples, Zeeman effect – normal and anomalous, Stark effect, example of hydrogen. (12)
Unit II	Time dependent perturbation theory, transition probabilities, harmonic perturbation, Fermi's golden rule. Transition probabilities for induced emission and absorption; Electric dipole interaction, forbidden transitions, selection rules; Application to atomic spectra. (12)
Unit III	Scattering from finite range potentials, differential and total scattering, cross-sections; Scattering in a central potential; Partial wave analysis, phase shifts, Born approximation, scattering from a square well potential and a perfectly rigid sphere. (12)
Unit IV	Systems of identical particles, symmetry with respect to interchange, indistinguishability of particles, Symmetric and antisymmetric wave functions, spin functions for many particles, spin-statistics relations; Creation and annihilation operators and their algebra for fermions and bosons; Representation of general one and two particle operators in this algebra. (12)
Unit V	Semi classical theory of radiation, Relativistic Wave Equations – The first order wave equations, the Dirac Equation. Properties of Dirac Matrices. Free Dirac Particles equation of continuity. Second order wave equations. The Klein-Gordon Equation (12)

Text books:

1. Introductory Quantum Mechanics, Richard Liboff
2. Quantum Mechanics, John L. Powell
3. Introduction to quantum mechanics, David J. Griffiths
4. Quantum Mechanics: Concepts and Applications, (Wiley, 2nd Edition), Nouredine Zettili
5. Quantum Mechanics, (PHI-2nd Edition), G. Aruldas
6. Quantum Mechanics -Theory and Applications (5th Edition) Ajoy Ghatak

Reference Books:

1. Advanced Quantum Mechanics, Schwabl Franz
2. Advanced Quantum Mechanics, Yuli V. Nazarov, Jeroen Danon , CAMBRIDGE
3. Quantum Mechanics, Eugene Merzbacher (John-Wiley, 3rd Ed, 2005)
4. Quantum Mechanics, P M Mathews and K Venkatesan (Tata- McGraw Hill, 1976)
5. Quantum Physics, S. Gasiorowicz (John-Wiley)
6. Concepts of Modern Physics, (7th Edition) Arthur Beiser
7. Feynman Lectures On Physics: Quantum Mechanics, Volume 3
8. Quantum Mechanics, L I Schiff.
9. Quantum Mechanics, L. D. Landau and E. M. Lifshitz
10. Lectures on Quantum Mechanics, Paul A M Dirac

Weblink to Equivalent MOOC on SWAYAM if relevant:

1. https://nptel.ac.in/courses/115103104
2. https://theoreticalminimum.com/courses/advanced-quantum-mechanics/2013/fall
3. https://hcverma.in/QuantumMechanics
4. https://www.edx.org/course/quantum-mechanics-for-scientists-and-engineers-1
5. https://www.edx.org/course/quantum-mechanics-for-scientists-and-engineers-2
6. https://archive.nptel.ac.in/courses/115/101/115101107/

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

1. https://www.youtube.com/watch?v=_OZXEb8FxZQ
2. https://www.youtube.com/watch?v=GWCXKzDY-Y0
3. https://www.youtube.com/watch?v=oEWsimmWy5E
4. https://www.youtube.com/watch?v=8mi0PoPvLvs
5. https://www.youtube.com/watch?v=ZfJn35DCyWg

6. https://www.youtube.com/watch?v=D36VXLx0hOc
7. https://www.youtube.com/watch?v=hyctIDPRSqY
8. https://www.youtube.com/watch?v=xnt2xSNRNn0
9. https://www.youtube.com/watch?v=K4BF7MD69_U

COs (2PHY3 Solid State Physics)

Upon completion of the course successfully, students would be able to

1. describe Single Crystal and Poly Crystals, Crystal Symmetry, Symmetry Elements, Crystal Types, Bravais Lattices.
2. use different X-ray techniques.
3. interpret the Powder Photograph; Bernel Chart; Brllioun Zones.
4. discuss the inter-Atomic Forces Cohesive Energy of a Solid; Infrared Absorption by Ionic Crystal Lattice; anharmonicity and thermal Expansion.
5. study the Dulong and Petit Law, Lattice Specific Heat, Einstein and Debye Theories, Electronic and Lattice Contributions to Specific Heat.

Unit	**Content**
Unit I	Crystallography: Single Crystal and Poly Crystals, Crystal Symmetry, Symmetry Elements, Crystal Types, Bravais Lattices in 2D and 3D, Point Groups and Space Groups in 2D and 3D. (12)
Unit II	Diffraction of X-Rays: Bragg's Law in 1D and 3D, Laue Diffraction Equation, Atomic Scattering Factor, Structure Factor. X-Ray Diffractions Techniques: Laue, Rotating Crystal Method, Oscillation and Burger Precession Method, Powder-Photograph Method. (12)
Unit III	Interpretation of Powder Photograph, Measurement of Bragg's Angle, Interplaner Spacing (d), Accurate Lattice Parameter Determination. Analytical and Graphical Methods for (Known Unit Cell), Bernel Chart, Interpretation of Oscillation Photographs. Concept of Reciprocal Lattice, Vector Demonstration of Reciprocal Lattice In Two Dimensions, Bragg's Diffraction Condition In Terms of Reciprocal Lattice, Brllioun Zones. Diffraction of Electrons and Neutrons, Inelastic Scattering, Applications. (12)
Unit IV	Inter-Atomic Forces Cohesive Energy of a Solid, Molecular Crystals, Ionic Crystals and Madelung Constant, Covalent Crystals and Metals, Lattice Dynamics of Mono Atomic and Diatomic Lattices. Infrared Absorption by Ionic Crystal Lattice, Localized Lattice Vibrations, Localized States and Associates Wave Function, Anharmonicity and Thermal Expansion, Thermal Conductivity. (12)
Unit V	Specific Heat: Dulong and Petit Law, Lattice Specific Heat, Temperature Dependence of Specific Heat, Einstein and Debye Theories, Electronic and Lattice Contributions to Specific Heat. (12)

Text books:

1. Introduction to Solid State Physics, C. Kittel (John-Wiley, 8th Ed. 2005).
2. Introduction to Solids, L V Azaroff (Tata-McGraw Hill, 1984).
3. Introduction to Modern Solid State Physics, Yuri M Galperin.
4. Solid State Physics, 9th Edition, S.O. Pillai (New Age International)
5. Solid State Physics, A.J. Dekker (Macmillan Education)
6. Solid State Physics R. K. Puri & V. K. Babbar

Reference Books:

1. Crystallography Applied to Solid State Physics, Verma, A.R., Srivastava, O.N., New Age International.
2. Solid State Physics, R. L.Sighal, Ram Nath Kedar Nath & Co., Publishers Meerut.
3. Solid State Physics by N W Ashcroft and N D Mermin (Cenage Learning India Pvt Ltd, 2009).
4. Problems In Solid State Physics With Solutions, Fuxiang Han

Weblink to Equivalent MOOC on SWAYAM if relevant:

1. https://onlinecourses.nptel.ac.in/noc19_ph14/preview
2. https://nptel.ac.in/courses/115106127
3. https://onlinecourses.nptel.ac.in/noc20_mm17/preview
4. https://nptel.ac.in/courses/115103108

5. https://onlinecourses.nptel.ac.in/noc20_mm22/preview

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

1. https://www.youtube.com/channel/UCFgtgeXkgWr1MsOTftce5BA
2. https://www.youtube.com/watch?v=49fSVb0tzVE
3. https://www.youtube.com/watch?v=AeChshw5fUM

COs (2PHY4 (i): Network Theorems and Solid State Devices)

Upon completion of the course successfully, students would be able to

1. analyze the circuits using Kirchhoff's law and network simplification theorems.
2. explain and understand the physical concepts underlying the operation of semiconductor devices; have ability to design and analyze simple FET and MOSFET amplifier circuits.
3. design and analyze simple rectifiers and voltage regulators using diodes; have ability to design and analyze simple circuits using semiconductor switching devices like triac, diac and SCR.
4. design and analyze simple BJT amplifier circuits; design and analyze simple BJT oscillator and multi-vibrator circuits.
5. understand the construction, working and uses of various transducers; understand the construction and operation of basic measuring instruments.

Unit	Content
Unit I	Network Analysis: Kirchoff's Voltage Law, Kirchoff's Current Law, Loop and Node Method, Thevenin's Theorem, Norton's Theorem, Superposition Theorem, Maximum Power Transfer Theorem Passive Components: Resistors, Capacitors, Inductors, Transformers, Relays, Fuses (their types, applications, common faults & testing). (12)
Unit II	Introduction to Semiconductors: Energy Band Diagram, Conductors, Semiconductors, Insulators, Intrinsic and Extrinsic Semiconductors(P&N), currents in semiconductors, Diffusion Junction, Depletion Layer, Barrier Potential. Junction Diodes: Rectifying diode, Forward and reverse bias characteristics, breakdown phenomenon, Zener Diodes, Varactor Diode, Photo Diode, Light Emitting Diode. Unijunction Transistor: Basic Working Principle, Characteristics, Applications as a switch and as time base generator. Field Effect Transistors: JFET, basic working principle, I/ O Characteristics, pinch off voltage, parameters, MOSFET, basic working principle, Characteristics (14)
Unit III	Rectifiers: Half wave, Full wave, Bridge (calculation of ripple factor and rectification efficiency), Filters (L, C, LC, π), Clipping and Clamping circuits. Power Supplies: Regulated power supply, zener regulated power supply, transistorised series and shunt regulated power supply, Voltage Regulator, Power Control Devices: Four Layer Diode (PNPN), Silicon Controlled Rectifier (SCR), Triac, Diac (Principle, Characteristics and Applications) (10)
Unit IV	Bipolar Junction Transistor: Basic working principle, Input and Output Characteristics, Basic configurations. Biasing, Operating point, Load line, Stabilization of Operating Point, Self-Bias Arrangement. Amplifiers: Classification of amplifiers, Class-A, B, AB and C Amplifiers, Properties of amplifiers (distortion, noise, thermal noise, shot noise, noise figure). Feedback in Amplifiers: Feedback concept, transfer gain with feedback, Effect of Negative Feedback on amplifiers performance. (12)
Unit V	Transducers: Basic idea of Transducers, Resistive transducers (PTC-PT-100, NTC-thermistors, capacitive (microphone) transducers, Inductive (LVDT) Transducers, Pressure transducers-Strain Gauge, photo voltaic cell, LDR, Photodiode and phototransistors (qualitative only). Basic Measuring Instruments: Analogue Multimeter, Digital Multimeter, Cathode Ray Oscilloscope, Function Generator (functional block diagram, basic working principle, measuring quantities) (12)

Text books:

1. Basic Electronics and Linear Circuits by Bhargava & Kulshreshtha (TTTI)
2. Integrated Electronics by Millman and Helkian
3. Circuits and Networks by A. Sudhakar and Shyam Mohan 4. Instrumentation Repair and Maintenance by R.G. Gupta
4. Basic Electronics, B.L. Thereja
5. Principles of Electronics, V.K. Mehta

Reference Books:

1. Electronic Devices and Circuits: An Introduction, Allen Mottershead

2. Basic Electronics, Debashis De
3. Electronic Principles (SIE) | 7th Edition, Albert Malvino and David J. Bates
4. How to Diagnose and Fix Everything Electronic, Second Edition, Michael Jay Geier

Weblink to Equivalent MOOC on SWAYAM if relevant:

1. https://hcverma.in/Physics%20of%20Semiconductors
2. https://onlinecourses.nptel.ac.in/noc21_ee80/preview
3. https://onlinecourses.nptel.ac.in/noc21_ee55/preview
4. https://nptel.ac.in/courses/122106025

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

1. https://www.youtube.com/watch?v=n-CYKFZKxX8
2. https://www.edx.org/course/circuits-and-electronics-1-basic-circuit-analysi-2
3. https://www.youtube.com/watch?v=bnjiLg4xfh8

COs (2PHY4 (ii): LASERS AND LASER APPLICATIONS)

Upon completion of the course successfully, students would be able to

1. discuss the Spontaneous emission, Stimulated emission, Population inversion, Fabry Perot etalon.
2. analyse Two level laser system, Threshold for three and four level laser systems.
3. apply solid state lasers, Semiconductor lasers, High power laser systems.
4. apply Raman scattering; Non-linear interaction of light with matter; Laser induced multi-photon processes.
5. apply Ultra high resolution spectroscopy; Optical fibers; Light wave communication and material processing.

Unit	Content
Unit I	Spontaneous emission, Stimulated emission, Population inversion, Fabry Perot etalon, Stable two mirror optical resonators, Longitudinal and transverse modes of laser cavity, Mode selection, Gain in a regenerative laser cavity. (12)
Unit II	Two level laser system, Threshold for three and four level laser systems, Mode locking, Pulse shortening- pico second and femto second operation, Spectral narrowing and stabilization, Gaussian beam and its properties. (12)
Unit III	Ammonia maser, Nitrogen laser, Carbon dioxide laser, Excimer laser, Dye laser, Ruby laser, Nd-YAG laser, Diode – pumped solid state lasers, Semiconductor lasers, High power laser systems.(12)
Unit IV	Laser induced fluorescence, Raman scattering and its applications, Non-linear interaction of light with matter, Laser induced multi-photon processes and their applications. (12)
Unit V	Ultra high resolution spectroscopy with lasers and its applications, Propagation of light in a medium with variable refractive index, Optical fibers, Light wave communication, Qualitative treatment of medical and engineering applications of lasers, Material processing. (12)

Text books:

1. Introduction to laser physics Koichi Shimoda
2. Introduction to laser physics B A Lengyl
3. An Introduction to Lasers : M.N.Avdahanulu

Reference Books:

1. Lasers Svelto
2. Optical electronics Yariv
3. Laser spectroscopy Demtroder
4. Nonlinear laser spectroscopy Letekhove
5. Laser physics Silfrast

Weblink to Equivalent MOOC on SWAYAM if relevant:

1. https://nptel.ac.in/courses/104104085
2. https://ocw.mit.edu/courses/res-6-005-understanding-lasers-and-fiberoptics-spring-2008/resources/laser-fundamentals-i/

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

1. https://www.youtube.com/watch?v=YToaWlQf6fM
2. https://www.youtube.com/watch?v=f8nG9kPcFv0
3. https://www.youtube.com/watch?v=FNp81kkxj5c

Syllabus Prescribed for 2022-23 Year ~~UG~~/PG Programme

Programme: MSc Physics

Semester II

Code of the Course/Subject	**Title of the Course/Subject** (Laboratory/Practical/practicum/hands-on/Activity)	**(No. of Periods/Week)**
2PHY5	**Lab on Solid State Physics**	**08**
2PHY6	**Lab on Electronics**	**08**

COs (2PHY5- Lab on Solid State Physics)

Upon completion of the course successfully, students would be able to

1. organize and assemble
   - Experiments on Laser/ Solid State Physics
   - Experiments on Modern Physics
   - Experiments on Nuclear Counters
2. perform data acquisition using assembled experiment.
3. engage in experimental troubleshooting with teaching assistants.
4. identify sources of error and fluctuations in the collected data.
5. construct graph on graph paper and also using computer based the collected data.
6. analyze the collected data.
7. distinguish between theoretical predictions and experimental measurements.
8. verify the fundamental laws of Modern Physics.

*** List of Practical/Laboratory Experiments/Activities etc.**

It is necessary to perform at least seven experiments from the list given below.

1.	Determination of e/m by magnetron method.
2.	Determination of e/m by helical method.
3.	Determination of e/m Thomson's method.
4.	Determination of 'e' by Millikan's Oil Drop method.
5.	To measure divergence and intensity distribution across the laser beam.
6.	Measurement of thickness of wire using Laser.
7.	Measurement of wavelength of Laser using ruler.
8.	To study Faraday Effect using He Ne Laser.
9.	Measurement of Hall coefficient of given semiconductor.
10.	To study a transformer, to determine its (i) transformation ratio, (ii) percentage efficiency and (iii) copper losses.
11.	To study characteristics of GM tube.
12.	To study random nature of radioactivity using GM counter.
13.	Determination of dead time of GM counter.
14.	To determine the range of beta particles in Aluminium (Al).
15.	Measurement of wavelength of radio waves at UHF or microwave frequencies using Lecher wires.
16.	Indexing of given XRD powder patterns and estimation of precise lattice parameters of cubic crystals.
17.	To Study the Crystal models of cubic crystal system

Reference Books:

1. 1st Edition, Experimental Physics, Principles and Practice for the Laboratory, Edited By Walter Fox Smith
2. An Introduction to Practical Laboratory Optics, J.F. James
3. Experiments in Modern Physics, Adrian C. Melissinos, Jim Napolitano
4. *Advanced Practical Physics by S.P.Singh, Pragati Prakashan, Meerut*
5. *Advanced Physics Laboratory Manual by P. Mishra, J. C. Mohanty,2007, South Asian Publishers Pvt. Ltd, New Delhi*

Weblink to Equivalent Virtual Lab if relevant:

1. https://vlab.amrita.edu/?sub=1
2. https://nptel.ac.in/courses/115105120
3. https://onlinecourses.nptel.ac.in/noc20_ph16/preview

COs (2PHY6- Lab on Electronics)

Upon completion of the course successfully, students would be able to

1. analyze the characteristics of different electronic devices such as diodes, transistors etc., and design simple circuits like rectifiers, amplifiers etc.
2. measure voltage, frequency and phase of any waveform using CRO.
3. generate sine, square and triangular waveforms with required frequency and amplitude using function generator.
4. engage in experimental troubleshooting of electronic circuit.

List of Practical/Laboratory Experiments/Activities etc.

It is necessary to perform at least seven experiments from the list given below.

1.	Verification of Network theorems : Thevenin's, Norton's, Milliman's, Superposition's and Maximum Power transfer theorem.
2.	Practical use of: (a) Multimeter (measurement of voltage, current, resistance). (b) Power Supply (study the variation in line and load voltage) (c) Oscilloscope (voltage and frequency measurement).
3.	Study of Electronic Components: (a) Resistor (study the types, colour coding, wattage rating, potential divider arrangement). (b) Capacitors (study the types, colour coding, working voltage). (c) Switches, Relays, Fuse (basic function, types, usage, testing).
4.	P-N Junction Diode (study the types, testing, manual study, V-I Characteristics and parameters).
5.	Study of PN diode as wave clipping element.
6.	Study of Zener Diode (testing, V-I Characteristics, design & study of voltage regulating properties).
7.	To study characteristics and application(s) of UJT.
8.	To study characteristics and applications of SCR.
9.	Study of Amplifiers (Design of CB/CE/CC, find Rin, Ro , Av , frequency response).
10.	Design and study of the Characteristics of JFET amplifier.
11.	Design and study of Characteristics of MOSFET amplifier.
12.	Study if Astable, monostable and bistable multivibrators by using BJT.
13.	Design and testing of transistorised oscillators: (a) RC-phase shift (b) Wein Bridge
14.	Design and testing of transistorised oscillators: (a) Hartley's (b) Colpitt's

Reference Books:

1. Basic Electronics, B.L. Thereja
2. Principles of Electronics, V.K. Mehta

Weblink to Equivalent Virtual Lab if relevant:

1. http://vlabs.iitkgp.ac.in/be/

1

Scheme of Teaching, Learning & Examination leading to the Degree Master of Science in the programme other than Mathematics, Bio-Technology & Computer Science

(Two Years - Four Semesters Degree Programme- C.B.C.S)

M. Sc. (Physics) Part-I Semester- I

S. N.	Subject	Subject Code	Teaching & Learning Scheme							Duration Of Exam Hours	Examination & Evaluation Scheme						
			Teaching Period Per Week				Credits				Maximum Marks					Minimum Passing	
											Theory		Practical		Total Marks		
			L	T	P	Total	L/T	Practical	Total		Theory+ MCQ External	Theory Internal	Internal	External		Marks	Grade
1	DSC – I		4	-	-	4	4	-	4	3	80	20	-	-	100	40	P
2	AEC		-		-	-	-	-	-	-	-	-	-	-	-	-	-
3	DSC- II		4	-	-	4	4	-	4	3	80	20	-	-	100	40	P
4	DSC- -III		4	-	-	4	4	-	4	3	80	20	-	-	100	40	P
5	DSC-IV		4	-	-	4	4	-	4	3	80	20	-	-	100	40	P
6	Lab- 1		-	-	8	8	-	4	4	6	-	-	-	100	100	50	P
7	Lab- 2		-	-	8	8	-	4	4	6	-	-	-	100	100	50	P
8	**#Internship/Field Work/Work Experience @**																
9	**Open elective/GIC/Open skill/MOOC***																
	TOTAL					32			24						600		

L: Lecture, T: Tutorial, P: Practical

Students may complete their Internship/Field Work/Work Experience in First OR Second OR Third Semester of Master of Science in the programme other than Mathematics, Bio-Technology & Computer Science according to their convenience; @ denotes Non-Examination Credit/Ancillary Credit

Note : Internship /Apprenticeship/Field Work / Work Experience (During vacations of Semester I to Semester III) for duration of minimum 60 hours to maximum 90 hours mandatory to all the students, to be completed during vacations of Semester I to III. This will carry 2 Credits for learning of 60 hours or 3 Credits for learning of 90 hours. Its credits and grades will be reflected in final semester IV credit grade report.

- OEC (Optional) can be studied during semester I to IV

L: Lecture, T: Tutorial, P: Practical.

Scheme of Teaching, Learning & Examination leading to the Degree Master of Science in the programme other than Mathematics, Bio-technology & Computer Science

(Two Years - Four Semesters Degree Programme- C.B.C.S)Appendix – A2

M. Sc. (Physics) Part-I Semester- II

S. N.	Subject	Subject Code	Teaching & Learning Scheme							Duration Of Exam Hours	Examination & Evaluation Scheme						
			Teaching Period Per Week				Credits				Maximum Marks					Minimum Passing	
											Theory		Practical		Total Marks		
			L	T	P	Total	L/T	Practical	Total		Theory+ MCQ External	Theory Internal	Internal	External		Marks	Grade
1	DSC – V		4	-	-	4	4	-	4	3	80	20		-	100	40	P
2	AEC		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	DSC- VI		4	-	-	4	4	-	4	3	80	20	-	-	100	40	P
4	DSC- -VII		4	-	-	4	4	-	4	3	80	20	-	-	100	40	P
5	DSE-I(A/B/C/D)		4	-	-	4	4	-	4	3	80	20	-	-	100	40	P
6	Lab- 3		-	-	8	8	-	4	4	6	-	-	-	100	100	50	P
7	Lab- 4		-	-	8	8	-	4	4	6	-	-	-	100	100	50	P
8	**#Internship/Field Work/Work Experience @**																
9	**Open elective/GIC/Open skill/MOOC***																
	TOTAL					32			24						600		

Students may complete their Internship/Field Work/Work Experience in First OR Second OR Third Semester of Master of Science in the programme other than Mathematics, Bio-Technology & Computer Science according to their convenience; @ denotes Non-Examination Credit/ Ancillary Credit

L: Lecture, T: Tutorial, P: Practical.