SYLLABUS FOR M.Sc. IN PHYSICS

UNDER

CHOICE BASED CREDIT SYSTEM (CBCS)

(To be effective from 2018 -19)

SEMESTER 1

MPHYCC-I: Classical Mechanics (5 Credits)

Course objectives:

1. To give students a solid foundation in classical mechanics.
2. To introduce general methods of studying the dynamics of particle systems.
3. To give experience in using mathematical techniques for solving practical problems
4. To apprise the students of Lagrangian and Hamiltonian formulations and their applications.
5. To apprise the students regarding the concepts of electrodynamics and its use in various situations.

The End Semester Examination will be of 3 hour duration and will carry 70 marks. The Question paper will be divided into three parts A, B and C. Part A will have ten compulsory questions (multiple choice type) covering the whole syllabus with 2 from each unit (10 X 2 = 20). Part B will have five short answer questions, with one question from each unit. The student is required to answer any four out of them (4 X 5 = 20). Part C will have five long answer questions with one question from each unit. The student is required to answer any three out of them (3 X 10 = 30).

Unit 1: Lagrangian Dynamics and Hamiltonian formulation: Constraints, Principal of Virtual Work, IV Alen1berCs principle and its applications. I aeranee-s equation and its applications. .Jacobi integral and energy conservation, Concept of symmetry, velocity dependent potential. Variational calculus and I.east Action principle- Hamilton •s principle. I ,agtunge's equation from Hamilton's principle, Legendre transfortnations. l lan)ilt01fs tunction and i lanulton•s equation 01 conliouration space and phase space I equal ions i't-onn Variat ional principl

Unit 2: Canonical transformations and Hamilton Jacobi theory: Generating function, canonical transformation and its examples, group property, Lagrange and Poisson brackets and other canonical invariants, equation of motions, Infinitesimal canonical theorem in Poisson bracket formalism, Jacobi identity, Angular momentum- Poisson bracket relations. The Hamilton-.l«obi equation tor i lami1101fs principal and characteristic functions with example; the harmonic oscillator, Separation of variable in Hamilton-Jacobi equation; Action-angle variables and its examples the Kepler problem in actionangle variables.

Unit 3: Central Force Motion and Rigid Body: Reduction to one-body problem, General Properties of central force, Effective potential, Motion in a central force field — general solution, Inverse Square Law force. Kepler's Laws laws of gravitation form Kepler s laws, Virial theorem. Scattering in a central force field and in Laboratory Co-ordinates. The rigid bodies, Kinematics of rigid body motion, (Orthoeonal trans(örnvcltions. Fuler•s theorelll and its applications. Finite and infinitesimal rotations,rate of change of a vector, the rigid body equation of motion, Coriolis effect, angular momentum and kinetic energy of motion about a point, the inertia tensor and the moment of inertia, theprincipal axis transformation, the Euler equations of motion.

Unit 4: Small Oscillation: Formulation of the problem, the eigenvalue equation and the principal axis transformation, frequencies of free vibrations and normal coordinates, forced vibrations and the effect of dissipative forces. Resonance and beats.

Unit 5: Relativity: Review of special theory of relativity - Lorentz transformations; 4-vectors, 4dimensional velocity and acceleration; 4-momentum and 4-force; Covariant equations of motion; Relativistic kinematics (decay and elastic scattering); Lagrangian and Hamiltonian of a relativistic particle. General theory of relativity: Curved space-time; Eotvos experiment and the equivalence principle.

Course Outcomes:

1. Know the difference between Newtonian mechanics and Analytic mechanics
2. Solve the mechanics problems using Lagrangian formalism, a different method from Newtonian mechanics
3. Understand the connection between classical mechanics and quantum mechanics from Hamiltonian formalism
4. Understanding of basic concepts of special and general theory of relativity

References:

1. NC Rana & P S Joag, Classical Mechanics, McGraw Hill, First Edition 2011
2. Herbert Goldstein, Charles P. Poole, and John L. Safko, Classical Mechanics, Pearson, Third Edition 201 1.
3. John R. Taylor, Classical Mechanics, University Science Books, First Edition 2005.
4. David Morin, Introduction to Classical Mechanics, Cambridge University Press, First Edition 2008.

MPHY CC-2 Mathematical Physics

Course Objectives:

1. To develop knowledge in mathematical physics and its applications.
2. To develop expertise in mathematical techniques that are required in physics.
3. To enhance problem solving skills
4. To give the ability to formulate, interpret and draw inferences from mathematical solutions.

The End Semester Examination will be of 3 hour duration and will carry 70 marks. The Question paper will be divided into three parts A, B and C. Part A will have ten compulsory questions (multiple choice type) covering the whole syllabus with 2 from each unit (10 X 2 = 20). Part B will have five short answer questions, with one question from each unit. The student is required to answer any four out of them (4 X 5 = 20). Part C will have five long answer questions with one question from each unit. The student is required to answer any three out of them (3 X 10 = 30).

(5 Credits)

Unit 1: Linear Differential equations and special functions:

Linear Differential Equations, Power series solutions; Special Functions: Hermite, Legendre, Bessel, Lauguerre Polynomials; Fourier and Laplace Transforms.

Unit 2: Elements of Complex analysis:

Analytic functions, Taylor and Laurent series, calculus of residues, nature of singularities, Evaluation of definite integtuls, Jordan-s lenuna Unit 3: Green's Function

Green's Function, Dirac Delta Function, Properties and applications

Unit 4: Group Theory:

Groups, subgroups, cosets, invariant subgroups, factor groups, homomorphism and isomorphism, orthogonality theorems, Continuous groups with special reference to 0(3), SU(2),SU(3).

Unit 5: Elementary Tensor Analysis

Coordinate transformations, Contravariant and covariant vectors, Contravariant, covariant and mixed tensors, tensor fields, symmetric and skew symmetric tensors, fundamental operations with tensors, metric tensor, conjugate tensors, and associated tensors

Course Outcome:

1. Master the basic elements of complex mathematical analysis
2. Solve differential equations that are common in physical sciences
3. Apply group theory and integral transforms to solve mathematical problems of interest in Physics
4. Understanding how to use special functions in various physics problems

References:

1. Arfken& Weber, Mathematical Methods for Physicists, Elsevier, Sixth Edition 2012.

2. Murray R. Spiegel, Schaum s Outline of Advanced Mathematics for Engineers and Scientists, McGraw Hill, First Edition 2009.

3. Mary L. Boas, Mathematical Methods in the Physical Sciences, John Wiley, Third Edition 2005.

4. Murray R. Spiegel, Seymour Lipschutz, John J. Schiller, and Dennis Spellman, Schaum's Outline of Complex Variables, McGraw Hill, Second Edition 2009.

MPH Y CC—3 Quantum Mechanics

Course Objectives:

l. To illustrate the inadequacy of classical theories and the need for a quantum theory

2. To explain the basic principles of quantum mechanics

3. To develop solid and systematic problem solving skills.

4. To apply quantum mechanics to simple systems occurring in atomic and solid state physics

The End Semester Examination will be of 3 hour duration and will carry 70 marks. The Question paper will be divided into three parts A, B and C. Part A will have ten compulsory questions (multiple choice type) covering the whole syllabus with atleast one from each unit (10 X 2 = 20). Part B will have six short answer questions, with one question from each unit. The student is required to answer any four out of them (4 X 5 = 20). Part C will have six long answer questions with one question from each unit. The student is required to answer any three out of them (3 X 10 = 30).

Unit 1: Basics of Quantum mechanics: Origin of quantum mechanics, particle aspects of radiation, wave aspect of radiation, particle versus waves, intermediate nature of microphysical world, quantization rules and wave packets.

Unit 2: Mathematical Foundations:

Linear vector spaces, dimensionality, basis, eigenvalue equations, orthogonality and completeness conditions; Observables, Dirac's Bra and Ket notation, Properties of Hermitian operators, unitary and similarity transformation; Operators, Fourier Transform, Wave function as a vector in Hilbert space, Superposition principle; Representations, Relation between ket and wave function, Eigenvalue spectrum of linear momentum and its wave functions; Transformation between coordinate and momentum representations, Ehrenfest Theorem.

Unit 3: Quantum Dynamics:

Schrodinger, Heisenberg and Interaction pictures; Linear Harmonic Oscillator solution using Schrodinger picture and Heisenberg picture (Matrix Mechanics),Angular Momentum, spin and parity operators: symmetry and conservation principle, definition of angular momentum, ladder operators, allowed values, construction of angular momentum matrices; Spin and Pauli spin matrices; Coupling of angular momentum, C.G. Coefficients.

Unit 4: Perturbation theory:

Time independent perturbation theory for discrete levels - non-degenerate and degenerate cases, removal of degeneracy, Spin-Orbit coupling, Fine Structure of Hydrogen, Variation method, Timedependent perturbation theory, - constant and periodic perturbations, Fermi Golden rule, W KB approximation, sudden and adiabatic approximations.

Unit 5: Scattering theory: Quantum Scattering theory — Differential and total cross sections, scattering amplitude, Formal expression for scattering amplitude Green s functions, Born approximation — Application to spherically symmetric potentials.

Unit 6: Relativistic quantum mechanics: The Klein-Gordon (KG) equation — Charged particle in an electromagnetic field, Interpretation of the KG equation, Dirac equation, free particle solution, equation

(5 Credits)

of continuity, Plane wave solutions of the Dirac equation, Non-relativistic limit of the Dirac equation, Fine structure of Hydrogen.

Course Outcome:

1 . To have a working knowledge of the foundations, techniques and key results of quantum mechanics

2. To comprehend basic quantum mechanical applications at the research level

3. Gain an ability to competently explain/teach quantum physics to others

References:

l. B.H. Bransden and C.J. Joachain, Quantum Mechanics, Pearson, Second Edition 2007. 2.
David J. Griffiths, Introduction to Quantum Mechanics, Pearson, Second Edition 2009.

3. Yoav Peleg, Reuven Pnini, ElyahuZaarur, and Eugene Hecht, Schaum •s Outline of Quantum Mechanics, McGraw Hill, Second Edition 2010.

4. P.M. Mathews and K. Venkatesan, Quantum Mechanics, McGraw Hill, Second Edition 2010.

MPHYCC4 Lab-I

Course Objectives:

1. To make the student familiarize with the basics of experimental physics.
2. To enable the student to explore the concepts involved in the thermodynamics and heat
3. To make the student understand the basic concepts in modern optics
4. To allow the student to understand the fundamentals of instruments involved

List of experiments (minimum12):

1. Measurement of Hall Coefficient of given semiconductor: identification of type of semiconductor and estimation of charge carrier concentration
2. Young' ln€)dulus Elliptical fringe method
3. Youne 1110dulus — Hyperbolic fringe method
4. Four Probe Method — Determination of resistivity of semiconductor at different temperatures
5. Determination of Ultrasonic velocity in given liquid for a fixed frequency
6. Determination of optical absorption coefficient and determination of refractive index of the liquids using He-Ne / Laser
7. Measurement of laser parameters using He — Ne laser / diode laser
8. Refractive index of liquids / Using — He-Ne laser / Diode laser
9. Determination of wavelength of a laser by Michelson Interferometer method 10. Determination of semiconductor band gap l l . Thermistor — Determination of energy gap
12. Determination of numerical aperture of an optical fiber
13. Determination of wavelength of a laser source using diffraction grating.
14. Determination of operating voltage of a GM tube and determine the linear absorption coefficient and verify inverse square lane.
15. Determination of operating voltage of a GM tube and verify inverse — square law
16. Direct reading of Zeeman effect (e/m of an electron) with a laser source
17. Compact microwave training system Experiment
18. Stefan's constant.
19. Susceptibility — (_iuoy and Quincke•s noeth0kls
20. Hydrogen spectrum and solar spectrum — Rydbere -s constant.

Course Outcome:

At the end of the course,

1. The student should have knowledge of the different experimental techniques.
2. The student should have understood the basics of physics involved in experiments
3. The student should be able to apply the concepts of physics and do the interpretation and acquire the result.

SEMESTER 11

MPHY CC-5 Modelin and simulation	5 Credits