Syllabus for Two Years M. Sc. (Applied Physics)

(M. Sc. (Applied Physics) Course structure(First year))

Post Graduate Department of Applied Physics
C. V. Raman College of Engineering
(Autonomous status under section 2(f) of UGC, ACT 1956)
Under Biju Patnaik University of Technology

First semester (Theory)				Second semester (Theory)			
Code	**Subject**	**Contact Hours**	**Credit**	**Code**	**Subject**	**Contact Hours**	**Credit**
MPHY-101	Classical Mechanics	50	4	MPHY-201	Condensed Matter Physics	50	4
MPHY-102	Mathematical Physics	50	4	MPHY-202	Quantum Mechanics -II	50	4
MPHY-103	Classical Electrodynamics	50	4	MPHY-203	Statistical Mechanics	50	4
MPHY-104	Quantum Mechanics -I	50	4	MPHY-204	Numerical methods and Computational Techniques	40	3
		Total	16			Total	15
Practical /Sessional				**Practical /Sessional**			
MPHY-105	Electromagnetism and Optics Lab		6	MPHY-205	Numerical methods and Computational Techniques Lab		3
				MPHY-206	General Physics		6
		Grand Total	**22**		**Grand Total**		**24**

DETAILS OF SYLLABUS:

FIRST SEMESTER

MPHY-101 (CLASSICAL MECHANICS) Marks-100

UNIT-I (30 Marks)

Mechanics of a system of particles:

Inertial and Non-inertial frames of reference, Lagrangian Formulation, Velocity dependent potentials and Dissipation Function, Conservation theorems and Symmetry properties, Homogeneity and Isotropy of space and Conservation of linear and Angular momentum, Homogeneity of time and Conservation of energy.

Hamiltonian Formulation:

Calculus of variations and Euler Lagranges equation, Brachistochrone problem, Hamiltons principle, Extension of Hamiltons principle to nonholonomic systems, Legendre transformation and the Hamilton equations of motion, Physical significance of Hamiltonian, Derivation of Hamiltons equations of motion from a variational principle, Rouths procedure, Variation, Principle of least action.

UNIT II (35 Marks)

Canonical transformations:

Canonical Transformation, Types of generating function, Conditions for Canonical Transformation, Integral invariance of Poincare, Poissons theorem, Poisson and Lagrange bracket, Poisson and Lagrange Brackets as canonical invariant, Infinitesimal canonical Transformation and conservation theorems, Liouvilles theorem.

Hamilton -Jacobi Theory:

Hamilton - Jacobi equation for Hamiltons principal function, Harmonic oscillator and Kepler problem by Hamilton - Jacobi method , Action angle variables for completely separable system, Kepler problem in Action angle variables , Geometrical optics and wave mechanics.

UNIT-III (35 Marks)

Small oscillation:

Problem of small oscillations , Example of two coupled oscillator , General theory of small oscillations, Normal coordinates and Normal modes of vibration , Free vibrations of a linear tri-atomic molecule.

Rigid body motion:

The independent of coordinates of a rigid body, orthogonal transformations , The Eulers angles , The Cayley-Klein parameters, Eulers theorems on the motion of a rigid body, infinitesimal rotations , rate of change of a vector, The Coriolis Force.

Rigid body dynamics:

Angular Momentum and kinetic energy of motion about a point: The Inertia Tensor and momentum of Inertia, Eigenvalues of Inertia Tensor and the principal axis transformation. The heavy symmetrical top with one point fixed, Elementary idea about non-linearity and chaos.

BOOKS:

1. Classical Mechanics -H. Goldstein
2. Classical Mechanics - Landau and Liftshitz
3. Classical Mechanics - Corben & Sxztehle
4. Classical Dynamics - Marion & Thornton
5. Analytical Mechanics -L. Hand and J. Finch
6. Classical Mechanics -J.C. Upadhyaya

MPHY-102 (MATHEMATICAL PHYSICS) Marks-100

Unit-I (35 Marks)

Complex analysis: Line integral of complex function, Cauchy's integral theorem, Cauchy's integral formula, Taylor's Series and Laurent's series, Calculus of Residues: Cauchy's Residue theorem, Zeroes and Singularities of complex functions, simple poles, Evaluation of definite integrals, Generalised functions, Dirac's -delta function ; Representation by Gaussian function, Integral representation, Relation to Step function.

Differential equations: Linear ordinary differential equations of first & second order: singularities of differential equations and their classification, Power series method and Frobenius extended power series method of solving differential equations.

Unit-II (35 Marks)

Special functions: Solution of Bessel, Legendre, Laguerre, Hermite, Hypergeometric and confluent Hypergeometric equations and their properties, Generating functions, Recurrence relations and Roderigues Formula.

Partial Differential equations: Partial differential equations (Laplace, wave and heat equations in two and three dimensions), Greens function, Solution of inhomogeneous partial differential equation by Green function method. Fourier series, Fourier and Laplace transforms.

Unit-III (30 Marks)

Tensor analysis: Contravariant, Covariant and Mixed Tensors, Addition and subtraction of Tensors. Direct product, Inner product and Contraction of Tensors, Levi-Civita Tensor, Metric Tensor, Christoffel symbol.

Groups and Group representation: Definition of groups, Finite groups, Example from solid state physics, Sub groups and classes, Group Representation, Characters, Infinite groups and Lie groups, Lie algebra, Application, Irreducible representation of SU(2),SU(3)and O(3).

BOOKS:

1. Mathematical methods of physics - J. Mathews & R.L. Walker.
2. Mathematical methods of physics - Arfken and Weber.
3. Mathematical methods for physicists - Dennery & Krzywicki.
4. Mathematical methods of physics - H. K. Das
5. Mathematical methods of physics - Dr. Rama verma (S. Chand)
6. Mathematical methods of physics - Satyaprakash (S. Chand)
7. Mathematical methods of physics - Binoy Bhattacharya. (NCBA Publication)
8. Introduction to Tensor calculus - Goreux S. J.
9. Mathematical methods of physics - Dettman J.W.

MPHY-103 (CLASSICAL ELECTRODYNAMICS) Marks – 100

UNIT – I (40 Marks)

Maxwell's Equations and Electromagnetic waves:

Electrostatics: Gauss's law, Laplace and Poisson equations, Magnetostatics: Biot-Savart law, Ampere's theorem, Maxwell's equations in free space and linear isotropic media; boundary conditions on the fields at interfaces, Vector and scalar potentials, Lorentz and Coulomb Gauge, Gauge invariance, Plane electromagnetic waves in non conducting medium:

Poynting's theorem and conservation of energy and momentum: solution of the wave equation by Green's function formalism; Frequency dispersion characteristics of dielectrics, conductors and plasma, Lorentz invariance of Maxwell's equation, Polarisation, Linear and circular polarisation, Superposition of waves in one dimension, Reflection and refraction of electromagnetic waves at a plane surface between dielectrics, Polarisation by reflection and total internal reflection.

Waveguides & Resonant cavities: TE and TM modes in dielectric slab waveguides, cylindrical cavities and wave guide, modes in rectangular waveguide: resonant cavities.

UNIT – II (30 Marks)

Radiation Systems: Fields and radiation of a localized oscillating source: electric and magnetic dipole fields and radiation, center fed linear antenna with sinusoidal current, scattering by a small dielectric sphere in long wavelength limit.

Radiations by moving charges: Lienard - Wiechert potential and field due to a point charge, Field of a moving charge, Radiated power from an accelerated charge at low velocities, Larmour's power formula: Angular distribution of radiation from an accelerated charge, Thomson scattering of radiation.

UNIT – III (30 Marks)

Relativistic Mechanics and Electrodynamics: The four vector notation, Lorentz transformation of particle kinematics: covariant formulation of Maxwell's equations, electromagnetic field tensor: covariant definitions of electromagnetic energy and momentum: transformation of electromagnetic field components.

BOOKS:

1. Introduction to Electrodynamics - A. Z. Capri and P.V.Panat, Narosa Publishing House.
2. Classical electricity & Magnetism- Panofsky and Phillips, Addison Wesley.
3. Classical Electrodynamics - J.D. Jackson, John & Wiley Sons Pvt. Ltd, New York, 2004.
4. Introduction to Electrodynamics - D.J. Griffiths, Pearson Education Ltd., New Delhi,1991.
5. Classical Electromagnetic Radiation - J.B. Marion, Academic Press, New Delhi, 1995.
6. Classical Theory of Electrodynamics - L.D. Landau and E.M. Lifshitz, Addison,Wesley.
7. Classical Electricity and Magnetism - Wolfgang K. H. Panofsky and Melba Phillips, Dover Publications.
8. Foundations of Electromagnetic Theory - John R. Reitz, F. J. Milford, R. W. Christy, Narosa Publishing House
9. Priciples of Electromagnetics - Matthew N. O. Sadiku, Oxford University Press
10. Electromagnetic Field Theory Fundamentals - B. Guru, H. Hiziroglu, Cambridge University Press
11. Special theory of Relativity - Robert Resnick

MPHY-104 (QUANTUM MECHANICS-I) Marks-100

Unit-I (34 marks)

General principle of Quantum mechanics:

Linear vector space formulation: Linear vector space (LVS) and its generality. Vectors: Scalar product, Metric space, Basis vectors, Linear independence, Linear superposition of general quantum states, Completeness and Orthogonal relation, Schmidt's orthonormalisation procedure, Dual space, Bra and Ket vectors, Hilbert space formalism for quantum mechanics.

Operator:

Linear, Adjoint, Hermitian, Unitary, Inverse, Antilinear operators, Noncommutativity and uncertainty relation, Complete set of compatible operators, Simultaneous Measurement, Projection operator, Eigenvalue and Eigen vector of linear, Hermitian, Unitary operators, Matrix representation of vectors and operators, Matrix elements, Eigen value equation and Expectation value, Algebraic result on Eigen values, Transformation of basis vectors, Similarity transformation of vectors and operators, Diagonalisation, Vectors of LVS and wave function in co-ordinate, Momentum and Energy representations.

Unit-II (34 marks)

Quantum Dynamics:

Time evolution of quantum states, Time evolution of operators and its properties, Schrodinger picture, Heisenberg picture, Dirac/Interaction picture, Equation of motion, Operator method of solution of 1D Harmonic oscillator, Time evolution and matrix representation of creation and annihilation operators, Density matrix.

Rotation and orbital angular momentum:

Rotation matrix, Angular momentum operators as the generation of rotation, Components of angular momentum L_x, L_y, L_z and L^2 and their commutator relations, Raising and lowering operators (L_+ and L_-), L_x, L_y, L_z and L^2 in spherical polar co-ordinates, Eigen value and Eigen function of L_z, L^2(operator method), Spherical harmonics, matrix representation of of L_+, L_- and L^2, Spin angular momentum: Spin 1/2 particle, Pauli spin matrices and their properties Eigen values and Eigen function, Spinor transformation under rotation.

UNIT-III (32 Marks)

Addition of angular momentum:

Total angular momentum (J), Eigen value problem of J_z and J^2, Angular momentum matrices, Addition of angular momenta and C.G. Coefficients, Angular momentum states for composite system in the angular momenta (1/2,1/2) and(1,1/2).

Motion in Spherical symmetric Field:

Hydrogen atom, Reduction to one dimensional one body problem, Radial equation, Energy Eigen value and Eigen function, Degeneracy, Radial probability distribution.

Free particle problem:

Incoming and outgoing spherical waves, Expansion of plane waves in terms of spherical waves, Bound states of a 3-D square well, Particle in a sphere.

BOOKS:

1. Quantum Mechanics - S. Gasiorowicz
2. Quantum Mechanics - J. Sukurai
3. Quantum Mechanics - R. Shankar
4. Quantum Mechanics - S.N. Biswas
5. Quantum Mechanics - A. Das
6. Quantum Mechanics - A. Ghatak and S. Lokanathan
7. Advanced Quantum Mechanics - P. Roman
8. Quantum Mechanics (Non Relativistic theory) - L.D. Landau and E. M. Lifshitz
9. Elementary Theory of Angular Momentum - M.E. Rose
10. Principles of Quantum Mechanics - P.A.M. Dirac

MPHY-105 (ELECTROMAGNETISM AND OPTICS LAB) Marks-100

1. Determination of wavelength of monochromatic light by Michelson's Interferometer.
2. Determination of thickness of air film between half silvered plates by Febryparot Interferometer.
3. Analysis of elliptically polarized light Babinet Compensator.
4. Verification of Brewster's law.

5. Study of polarization using Malus law.
6. Study of diffraction pattern using Laser source.
7. Magnetic field measurement by search coil.
8. Determination of charge of electron by Milikans oil drop experiment.
9. Existence of discrete energy level by Frank Hertz experiment.
10. Determination of B-H curve of a given ferromagnet.
11. Ferroelectric transmission point by dielectric constant measurement.
12. Maxwell's A/C bridge and determination of inductive, capacitive and Ohmic impedance.

SECOND SEMESTER

MPHY-201 (CONDENSED MATTER PHYSICS) Marks-100

Unit-I (30 marks)

Crystal structure and Lattice dynamics:
Bravais lattices (crystalline periodicity and unit cells), Miller Indices, Reciprocal lattice and Brillouin zones, Crystal diffraction and the structure factor, Crystal imperfection: Point defects line defects and planer (stacking) faults.
Phonons and lattice vibrations, Vibrations of monoatomic and diatomic lattices, dispersion, Optics & acoustic modes, Quantum of lattice vibrations and phonon, Phonon momentum, Inelastic scattering of neutron and photons by phonons, Thermal properties of insulators Lattice heat capacity, Debye & Einstein model, Anharmonic Crystal interactions, Thermal conductivity & thermal expansion.

Unit-II (40 marks)

Free electron Fermi gas:
Free electron gas in three dimensions, Heat capacity of electron gas, electrical and thermal conductivity of metals (Drude model).
Band theory and Semiconductor Physics:
Electrons in periodic potential, Bloch theorem, Kronig Penney model, Origin of band gap, Distinction between metals, insulators and intrinsic semiconductors, Effective mass of electrons and concept of holes, Density of states and Fermi-Dirac distribution function for electrons and holes, Thermal equilibrium, Equilibrium distribution of electrons & holes: derivation of n and p from density of states and Fermi-Dirac distribution function for electrons and holes, Fermi level and carrier concentrations, The np product and the intrinsic carrier concentration. General theory of n and p, Carrier concentrations at extremely high and low temperatures: complete ionization, partial ionization and freeze-out. Energy-band diagram and Fermi-level, Variation of E_F with doping concentration and temperature,
Superconductivity:
Experimental survey, Meisners effect, Type-I & Type-II superconductors, Thermodynamics of superconductors, London theory, Josephson's effect, Basic concepts of cooper pairing in BCS theory, Ginz-Landau Theory, Applications of superconductors, High T_c superconductors and recent theories.

Unit-III (30 marks)

Dielectrics: Introduction, Review of basic formulae, Dielectric constant and displacement vector -different kinds of polarization-local electric field-Lorentz field-Clausius-Mossatti relation- expressions for electronic, ionic and dipolar polarizability, Ferroelectricity and Peizo electricity.
Magnetism: Review of basic formulae -classification of magnetic materials-Langevin theory of diamagnetism, para-magnetism and Ferromagnetism –domains-Weiss molecular field theory (classical)-Heisenberg exchange interaction theory-. Antiferro-magnetism and ferrimagnetism.

BOOKS:

1. Introduction to solid state physics- C. Kittel
2. Solid state physics- Ashcroft and Mermin
3. Principles of condensed matter physics- P.M. Chaikin and T.C. Lubensky
4. Solid state physics- A.J. Dekker
5. Solid state physics- O.E. Animaler
6. Quantum theory of solid State -J.Callaway
7. Solid state physics- C.G. Kuper, 8. Solid state physics -David W. Snoke (LPE Publication)
9. Solid state physics- Dan Wei (Cengauge Learning)
10. Solid State physics -A. Omar (Pearson)
11.Semiconductor Physics and Devices (Basic Principles) – Donal A Neamen (Tata McGraw-Hill)

MPHY-202 (QUANTUM MECHANICS-II) Marks-100

Unit-I (34 marks)

Approximation Method for stationary states:

Rayleigh Schrodinger Method for Time-independent Non degenerate Perturbation theory, First and second order correction, perturbed harmonic oscillator, Anharmonic oscillator, The stark effect, Quadratic Stark effect and polarizability of hydrogen atom, Degenerate perturbation theory, Removal of Degeneracy, Parity selection rule, Linear stark effect of hydrogen atom, Spin orbit Coupling, Relativistic correction, Fine structure of Hydrogen like atom, Normal and anomalous Zeeman effect, The strong- field Zeeman effect, The weak-field Zeeman effect and Lande's g-factor. Elementary ideas about field quantization and particle processes

Unit-II (33 marks)

Variational Methods:

General formalism, Validity of WKB approximation method, Connection Formulas, Bohr quantisation rule, Application to Harmonic oscillator, Bound states for potential well with one rigid wall and two rigid walls, Tunnelling through potential Barrier, Cold emission, Alpha decay and Geiger Nuttall relation.

Time dependent perturbation Theory:

Transition probability, Constant and harmonic perturbation, Fermi golden rule and Electric dipole Radiation and Selection Rule, Spontaneous emission Einstein's A, B - co-efficient, Basic principle of laser and Maser

Unit-III (33 marks)

Scattering Theory:

Scattering amplitude and Cross section, Born approximation, Application to Coulomb and Screened Coulomb potential, Partial wave analysis for elastic and inelastic Scattering. Effective range and Scattering length, Optical theorem, Black Disc Scattering, Hard sphere Scattering, Resonance Scattering from square well potential

BOOKS:

1. Quantum Mechanics - S. Gasiorowicz
2. Quantum Mechanics - J. Sukurai

3. Quantum Mechanics - R. Shankar
4. Quantum Mechanics - S.N. Biswas
5. Quantum Mechanics - A. Das
6. Quantum Mechanics - A. Ghatak and S. Lokanathan
7. Advanced Quantum Mechanics - P. Roman
8. Quantum Mechanics (Non Relativistic theory) - L.D. Landau and E. M. Lifshitz
9. Elementary Theory of Angular Momentum -M.E. Rose
10. Principles of Quantum Mechanics -P.A.M. Dirac

MPHY-203 (STATISTICAL PHYSICS) Marks-100

UNIT-I (34 marks)

Classical statistical mechanics:

Basic principles and application of classical statistical mechanics, Liouvilles theorem, Micro canonical Ensemble , Review of thermodynamics , Equi-partition theorem, Classical ideal gas , Gibbs paradox. Canonical ensemble and energy fluctuation, Grand canonical ensemble and density fluctuation, Equivalence of canonical and grand canonical ensemble.

UNIT-II (33 marks)

Quantum statistical mechanics:

The density matrix, Ensembles in quantum mechanics, Ideal gas in microcanonical and grand canonical ensemble, Equation of state for ideal Fermi gas , Theory of white dwarf stars. Ideal Bose gas, photons and Planck's law, Statistics of photon and phonon gas, Bose- Einstein condensation.

UNIT-III (33 marks)

Phase Transition:

Thermodynamics description of Phase Transitions, Phase Transitions of second kind, Landau theory of phase transition beyond mean field, Gaussian fluctuation and Ginzberg criteria, Discontinuity of specific heat , Change in symmetry in Phase a transition of second kind.

Ising model: Definition of Ising model, One dimensional Ising model.

BOOKS:

1. Statistical physics - K. Huang
2. Statistical physics - R.K. Pathria
3. Statistical physics - F. Mohling
4. Elementary statistical physics - C.Kittel
5. Statistical physics - Landau and Lifsitz
6. Physics Transitions & Critical Phonomena H.E. Stanly
7. Thermal Physics- C. Kittel
8. Fundamental of statistical & thermal physics- F. Reif

MPHY-204(NUMERICAL METHODS AND COMPUTATIONAL TECHNIQUES) Marks-100

Module-I (40 marks)

Errors and approximations in Numerical Computation, significant digits, Numerical solution of algebraic and transcendental equations by simple iteration method, Bisection method, Regula-falsi method (method of false position), Newton-Raphson method .

Solution of simultaneous linear system of equations by Cramer's Rule, Gauss- elimination method, Gauss-Jordan method, Matrix inversion by Gauss-Jordan method, Iterative method for solving linear equations by Gauss-Jacobin and Gauss-Seidel method, Methods for solution of Eigen value problems.

Module-II (30 marks)

Interpolation: Newton's forward and backward interpolation formulae, Lagrange's interpolation formula, Newton's divided difference formula, Inverse interpolation.

Numerical differentiation based on Newton's forward and backward interpolation formula, Numerical integration by Trapezoidal rule, Simpson's rule, Gaussian quadrature formulae (2-point,3-point and 4-point),

Module-III (30 marks)

Numerical solution of ordinary differential equation using Taylor Series method, Euler method, Modification of Euler's method, Picard's method, Runge-Kutta method of order two and four,

Introduction to Unix, Introduction to C/C++ Programming, Introduction to Fortran, Latex, Elementary treatment of Monte Carlo Method, Solutions to Nonlinear Equations.

BOOKS:

1. S. Rajasekaran, "Numerical methods in Science and Engineering: a practical approach", S. Chand and company Ltd., New Delhi.
2. T. Veerarajan and T. Ramachandran, "Theory and problems in Numerical methods", Tata McGraw-Hill Publications, New Delhi.
3. W. Chenny and D. Kincaid, "Numerical Mathematics and Computing", CENGAGE publication
4. J. H. Mathews, "Numerical methods for Mathematics, Science and Engineering", PHI publication
5. Atkinson K. E., "Numerical Analysis" John Wiley (Asia)
6. Chapra S. C. and Canale R. P., "Numerical Methods for Engineers", Tata McGraw Hill Press
7. W. H., Teukolsky S. A., Verlling W. T. and Flannery B. P., "Numerical Recipes in C++", Cambridge
8. Wong S. S. M. "Computational Methods in Physics", World Scientific

MPHY-205 (NUMERICAL METHODS AND COMPUTATIONAL TECHNIQUES LABORATORY)

Mark 100

Programming Language with Fortran / C/ Matlab:

Exercises for acquaintance:

1. To find the largest or smallest of a given set of numbers
2. To generate and print first hundred prime numbers
3. Sum of an AP series, GP series, Sine series and Cosine series
4. Factorial of a number
5. Transpose of a square matrix
6. Matrix multiplication and addition
7. Evaluation of log and exponentials
8. Solution of quadratic equation
9. Division of two complex numbers
10. To find the sum of the digits of a number

Numerical methods:

1. Interpolation by Lagrange methods
2. Numerical solution of simple algebraic equation by Newton-Raphson Methods
3. Least square fit using rational functions
4. Numerical integration: Trapezoidal methods, Simsons method, Romberg method, Gauss quadrature method.
5. Eigen values and Eigen vectors of a matrix
6. Solution of linear homogenous equations
7. Trace of a matrix (Least square Refinement method)
8. Matrix inversion
9. Solution of ordinary differential equation by Runge-Kutta Method
10. Introduction to Monte Carlo techniques

BOOKS:

1. Balagurusamy : "C Programming" Tata McGraw-Hill
2. Y. Kanitkar – "Let us C" BPB Publisher
3. C. Xavier –"Fortran 77 and Numerical Methods", New Age International (P) Ltd. Publishers
4. Rudra Pratap-"Getting Started With Matlab: A Quick Introduction For Scientists And Engineers "
5. William J Palm III- "Introduction To MATLAB 7.4", Tata McGraw-Hill

MPHY-206 (GENERAL PHYSICS LABORATORY) Marks-100

1. Young's modulus of glass by Cornu's method.
2. Determination of magnetic susceptibility of a paramagnetic solution using Quinckes tube method.
3. Determination of magnetic susceptibility of a paramagnetic solution using Gouy's method.
4. Measurement of dielectric constant by plate capacitor.
5. Calibration of an oscilloscope.
6. Determination of Planck's constant by total radiation method
7. Determination of Hall coefficient by Hall's apparatus
8. Determination of Surface tension of liquid by capillary rise method and verify Jurin's law.
9. Determination of thermal conductivity of material by Lee's Disc method.
10. Coefficient of linear expansion of solid by Fizeau's method.
11. Dielectric constant of solid (wax) by Lecher Wire.
12. Specific rotation by sugar solution using polarimeter