M.Sc. (Previous) Physics-Energy
(Yearly Scheme)

Paper I-Classical and Quantum Mechanics

Max. Marks: 100; Duration: 3 hrs.

Note- Ten questions will be set in the question paper, taking two from each unit. Candidates are required to attempt five questions in all selecting at least one question from each unit. All questions will carry equal marks.

UNIT-I **Max. Period: 24**

Generalized Coordinates, Conservation laws and cyclic coordinates, Hamilton's principle of least action, Lagarngian, Lagrange's equation and its applications, Legendre transformation, Hamiltonian, Hamilton's Canonical equation, Canonical transformation, Calculus of variation and its application to simple problems, Derivation of Hamilton's canonical equations from Hamilton's variational principle, Method of Lagrange's multipliers, Action as a function of coordinate and time, action-angle variables, adiabatic invariance of action angle variables, Kepler problem in action angle variables.

UNIT-II **Max. Period: 24**

Theory of small oscillations in Lagrangian formulation, normal coordinates and its application, Eulerian angles, Euler theorem, Euler equations, Force free motion of rigid body. Rigid body dynamics- moment of inertia tensor, Eigen values of the inertia tensor, Non-inertial frames and pseudoforces.
Central force motions. Two body Collisions - scattering in laboratory and Centre of mass frames. Rutherford scattering.
Phase Space Dynamics, Liouville's theorem, Poisson brackets and canonical transformations, Equation of motion in Poisson brackets formulation, Infinitesimal canonical transformation and generators of symmetry, Hamilton Jacobi equation and its applications.

UNIT-III **Max. Period: 24**

Introduction to Quantum Mechanics, Hermitian operator, eigen values and eigen states, Superposition of states, Bra-Ket notation, commutability and compatibility, uncertainity relation, theory of representation, coordinate and momentum representation, unitary transformation, displacement operator, time translation operator, rotation operator, Heisenberg, Schrodinger and interaction picture.
Degenerate and non-degenerate systems, Perturbative solution (weak field and strong field cases), General description of a two state system, Energy eigen states of two state system, Pauli matrices, Ammonia molecule as an example of two state system.
Atom in a weak uniform external electric field and first and second order Stark effect, Interaction with External field, Polarizability of the ground state of H-atom and of an isotropic harmonic oscillator, Linear Stark effect for H-atom levels, spin orbit and weak magnetic field interaction, Zeeman effect, Paschen-Back Effect

UNIT-IV **Max. Period: 24**

Symmetries and Angular Momentum, Symmetry transformation and conservation laws, Invariance under space and time translation and space rotation, Conservation of momentum, energy and angular momentum. Angular momentum operators and their eigen values, Matrix representation of angular momentum operators and their eigen states, Coordinate representation of the orbital angular momentum operators and their eigen states (spherical harmonics), Composition of angular momentum, Clebsch-Gorden coefficient, Tensor operators and Wigner Eckart theorem, Commutation relations of J+, J-, J_Z with reduced spherical tensor operator, Matrix elements of vector operators, Time reversal invariance and vanishing of state electric dipole moment of stationary state, Time dependent perturbation theory, The Golden rule, Emission and absorption of radiation, Induced dipole transition and spontaneous emission of radiation, Energy width of a quasi stationary state.

UNIT-V **Max. Period: 24**

Systems with Identical Particles, Indistinguishability and exchange symmetry, Pauli's exclusion principle, Spectroscopic notations for atoms, The Helium atom, Variational method and its use in the calculation of ground state and excited state energy, Helium atom, Hydrogen molecule, Heitler London methods for H_2 molecule, WKB method for one dimensional problem, Application to bound states (Bohr Sommerfield quantization) and the barrier penetration (Alpha decay) problems, Raman spectra, Frank Condon principle. Lasers: spontaneous and stimulated emission, Einstein A & B coefficients. Optical pumping, population inversion, rate equation. Modes of resonators and coherence length.

References:

1. Classical Mechanics: Goldstein
2. Mechanics: L.D. Landau & E. M. Lifshitz
3. Classical Mechanics: A. Ray Chaudhary
4. Quantum Mechanics: A Modern Approach : Ashok Das & A.C.Melissions
5. Quantum Mechanics: P.A.M. Dirac
6. Quantum Mechanics (2nd ed.): E. Merzbecker
7. Quantum Mechanics: Non relativistic theory: L.D. Landau & E. M. Lifshitz
8. Quantum Mechanics: S. L. Kakani (Sultan Chand)
9. Quantum Mechanics: Thankapann (New Age International pub.)
10. Quantum Mechanics- Theory & Applications: A. Ghatak & S. Lokanathan
11. Atomic Spectra: White
12. Molecular Spectra: Herdetzberg
13. Atomic Molecular Physics: T.A. Littlefield
14. Elementary Atomic Structure: G.R.Woodgate
15. Quantum Physics Atoms, Molecules, Solid & Nuclear Particles: Eisenberg & Resnick

Paper-II- Electrodynamics

Max. Marks: 100; Duration: 3 hrs.

Note- Ten questions will be set in the in the question paper, taking two from each unit. Candidates are required to attempt five questions in all selecting at least one question from each unit. All questions will carry equal marks.

UNIT-I **Max. Period: 24**

Electric field, Gauss law, Differential from Gauss law, Surface distribution of charges and dipoles and discontinuities in one electric field and potential, Poisson and Laplace equations, Green's theorem, Uniqueness of the solutions with Dirichlet or Neumann boundary conditions, Formal solution of the electrostatics boundary value problem with Green's function, Electrostatics potential energy and energy density, Capacitance.
Method of images, Point charge in the presence of a grounded conducting sphere, Point charges in the presence of a charged insulated conducting sphere, Point charges near a conducting sphere at a fixed potential, Conducting sphere in an uniform electric field by method of images, Green function for the sphere, General solution for potential, Conducting sphere with Hemispheres at different potential, Orthogonal function and expansion.

UNIT-II **Max. Period: 24**

Multipole expansion, Multipole expansion of the energy of a charge distribution in an external field, Elementary treatment of electrostatics with permeable media, Boundary value problems with dielectrics, Molecular polarizability and electric susceptibility, Models for molecular polarizability, Electrostatic energy in dielectric media.
Introduction and definition, Biot Savart law, Differential equation of Magnetostatics and Ampere's law, Vector potential and magnetic induction for a circular current loop, Magnetic field of a localized current distribution, Magnetic moment, Force and torque on and energy of a localized current distribution in an external magnetic induction, Macroscopic equation, Boundary conditions on B & H, Methods of solving boundary value problems in magnetostatics, Uniformly magnetized sphere in an external field, Permanent magnetic, Shielding, Spherical shell of permeable material in an uniform field.

UNIT-III **Max. Period: 24**

Special theory of relativity- Lorentz transformations, relativistic kinematics and mass–energy equivalence. Four vectors, Lagrangian and Hamiltonian of charged particle in e. m. field. Lorentz equation of motion, Electromagnetic field tensor, field invariants.
Energy in a Magnetic field, Vector and scalar potential, Gauge transformations: Lorentz Gauge, Coulomb Gauge, Green function for the wave equation, Derivation of the equations of macroscopic electromagnetism, Poyntings theorem and conservation of energy and momentum for a system of charged particles in E.M. fields, Conversation laws for macroscopic media.

Plane waves in a nonconducting medium, Frequency dispersion characterirstics of dielectrics, Conductors and plasmas, Waves in a conducting or dissipative medium, Superposition of waves in one dimension, Group velocity, Cylindrical and rectangular waveguides, Causality in the connection between D and E, Kramers-Kroning relation.
Mathematical properties of the space time of special relativity, Invariance of electric charge, Covariance of electrodynamics, Transformation of electromagnetic field.

Unit-IV **Max. Period: 24**

Lienard-Wiechart potentials for a point charge, Total power radiated by an accelerated charge, Larmour's formula and its relativistic generalization, Angular distribution of radiation emitted by an accelerated charge, Radiation emitted by a charge in arbitrary extremely relativistic motion, Distribution in frequency and angle of energy radiated by accelerated charges, Thomson scattering and radiation, Scattering by quasi free charges.
Introductory considerations, Radiative reaction force from conservation of energy, Abraham Lorentz evaluation of the self force, difficulties with Abraham Lorentz model, Integro-differential equation of motion, including radiation damping, Line Breadth and level shift of an oscillator, scattering and absorption of radiation by an level shift of an oscillator, Scattering and absorption of radiation by an oscillator, Energy transfer to a harmonically bound charge.

Unit-V **Max. Period: 24**

Plasma Physics, Introduction of Lab and Space Plasma, Plasma Parameters, Debye Length, Electron and Ion Temperature, Electron and Ion Number Density, Characteristic Frequencies, Plasma Frequencies, Cyclotron Frequencies, Plasma Waves and Oscillations, Modes of a Cold, Warm and Hot Plasmas, Effect of Magnetic Field on Plasma Dispersion Characteristics, Instabilities ~ Hydrodynamic and Velocity Space, Linear and non-linear phenomena, MHD equations.

References:

1.Clssical electrodynamics : J. D. Jackson
2.Classical Electricity and magnetism : Pranofsky &Philips
3.Introducation to Electrodynamics : Griffiths
4.Classical theory of fields : Landau & Lifishtiz
5.Electrodynamics of continuous Media : Landau & Lifishtiz

Paper-III-Mathematical Physics and Computational Techniques

Max. Marks: 100; Duration: 3hrs

Note-: Ten questions will be set in the question paper, taking two from each unit candidates are required to attempt five questions in all selecting at least one question from each unit. All questions will carry equal mark

Unit-I **Max. Period: 24**

Special Functions, Hermite Polynomials, Bessel and Modified Bessel Function, Spherical Harmonics, Fourier series, Fourier integrals, Fourier's transform and inversion theorem, Faltung theorem, Application of integral transforms to pulse propagation.

Unit-II **Max. Period: 24**

Laplace transform, Laplace transform of derivatives and integrals, Derivatives integrals of Laplace transform, Laplace transform of periodic function, Inverse Laplace transform, Convolution theorem, Impulsive functions, Application of Laplace transform in solving linear differential equation with constant coefficients and with variable coefficients, .

Unit-III **Max. Period: 24**

Analytic functions, Cauchy-Riemann conditions, classification of singularities, Cauchy’s integral theorem, Derivatives of analytic functions, Taylor and Laurent series, integration and differentiation of power series, zeros of analytic functions, Singular point, poles, Residues, evaluation of improper integrals, Cauchy residue theorem, Jordan's lemma integration around a branch point.

Unit-IV **Max. Period: 24**

Interpolation, Extrapolation, Finite differences, Gauss central difference formula, Newton's formula for interpolation, Lagrange's interpolation formula, Double interpolation, Numerical differentiation, Newton and Starling’s formula, Solution of line systems, Direct and iterative, Eigen value problems, Gauss-Seidel method for solution of simultaneous equations, Matrix inversion, Gaussian quadrature formula, Trapezoidal and Simpson’s rules.

Unit-V **Max. Period: 24**

Bisection method, Newton Raphson method, Solution of differential equations by Runge-Kutta method, Curve fitting, Fast Fourier Transforms, Least squares fitting, computer simulation, Monte-Carlo evaluation of Integrals, Linear and nonlinear curve fitting, chi-square test, Overview of computer organization, hardware, software, scientific programming in FORTRAN.

References:

1. Complex Variables & Functions: Churechill, Brown, Varchy
2. Introductory Methods of Numerical Analysis : S.S.Sastry.
3.A first course in Numerical Analysis: A. Ralston & P. Rabinowitz (Me Graw Hill 1985).
4. Applied Mathematics for Engineers and Physicist: Pipes & Harvill.
5. Mathematical Methods: Potter &Goldberg
6. Mathematical Methods for Physicist: Arfken

7. Mathematical Physics: S. L. Kakani (Himalaya)
8. Mathematical Physics: A. Ghatak (McMillan)
9. Mathematical Physics: Satya prakash (Sultan Chand)

Paper: IV Energy Fundamentals

Max. Marks: 100; Duration: 3hrs

Note-: Ten questions will be set in the question paper. Taking two from each unit candidates are required to attempt five questions in all selecting at least one question from each unit. All questions will carry equal mark

Unit I **Max. Period: 24**

Sources of energy, Classification of energy sources, Terminology, Energy Scenario-Indian and Global, Fossil fuel resources (coal, oil, natural, gas), Composition and Energy Values, Gross calorific value and net calorific value, Computations of CO_2 emissions from Fossil fuel consumptions, Imperatives of Cleaner Technology and sustainable Development, Clean Development Mechanism, Energy Management, Energy Conservation and Efficiency, Standards (Bureau of Energy Efficiency), Energy Audit.

Unit-II **Max. Period: 24**

Implications of Energy Use, Environmental degradation, Primary and secondary pollutants. Thermal, radioactive pollution, Air & water pollution, Micro climatic effects of pollution, Pollution from stationary and mobile sources, Biological effects of radiation, Heat and radioactivity disposal, Acid rain, Global warming and green house gases, Ozone layer depletion.

Unit III **Max. Period: 24**

First law of thermodynamics, second law of thermodynamics (control mass, control volume systems and steady state steady flow processes).Thermodynamic power cycles, Carnot vapor cycle, Rankine vapor cycle, refinement of Rankine cycle, Otto cycle, Internal Combustion engines-classification, Vapor absorption and vapor compression refrigeration cycles.

Unit IV **Max. Period: 24**

Fundamentals and use of hydrogen as a fuel, hydrogen fuel cells, production of hydrogen from hydrocarbons (Steam Methane reforming), use of solar energy to produce hydrogen (active and passive methods), hydrogen separation and purification. Hydrogen transmission in pipelines and storage in pressurized and cryogenic tanks, hydrogen storage in metal hydrides and nano-carbon materials, hydrogen safety.
Importance, production and applications of bio-fuels, Themochemical conversion of biomass: Pyrolysis, Gasification and combustion. Anaerobic digestion.

Unit V **Max. Period: 24**

DC and AC circuits; electrical loads (resistive, capacitive and inductive), phasor diagrams, Basic principles of Transformers, single and three phase AC, star and delta connections, DC and AC generators, alternators, single and three phase motors, power measurement.

References:

1. Renewable Energy: Power for a sustainable future edited by Godfrey Boyle.
2. Problems and solutions: Energy Studies – W. Shepherd, D. W. Shepherd (Imperial College Press)
3. D. D. Hall & R. P. Grover, Biomass Renewable Energy John Wiley, New York, 1987.
4. Dictionary of Energy – Cleveland and Morris (Elsevier)
5. J. M. Fowler, Energy & Environment, 2nd Edn. McGraw Hill New York, 1984.
6. Energising our future – Rational choices for the 21st Century – John R. Wilson, Griffin Burgh (Wiley).
7. Renewable Energy: M. Kaltschmit, W. Streicher, A. Wiese, Springer 2007.
8. Energy Management Handbook, W.C. Turner, S. Doty, CRC Press, 2006.
9. Hydrogen Production Storage, Ram B. Gupta, CRC Press.
10. Fundamentals of electric circuit: Alexander & Sadiku, Tata McGraw Hill.
11. Thermodynamic: An Engineering Approach: T.A. Cengel & Boles (McGraw Hill).

Paper: V: Practicals

Scheme: The examination will be conducted for two days, 6-hrs. each day. The distribution of the marks will be as follows:

A Two experiments	125 marks (62.5 marks each)
B Seminar	25 marks
(Write up is to be prepared and submitted with references)	
C Record	25 marks
D Viva voce	25 marks
	Total 200 marks

Minimum Pass Marks 72 marks

List of Experiments:

1. Use of Michelson's 'Interferometer to determine:
   i. Wave length of monochromatic light.
   ii. D_1 for sodium doublet.
   iii. Thickness of the given mica sheet.
2. Use Fabry perot's interferometer to determine:

i. Wave length of sodium light.

ii. D_1 for sodium doublet.

3. Verify Fresnel's Laws.
4. Determine the wavelength of Neon light taking Hg source as a standard source applying Hartman's formula.
5. Use Babinat's compensator,

   i. To analyze elliptically polarized light.

   ii. To determine the phase difference introduced between ordinary & extraordinary rays.
6. Design a Double stage R.C. Coupled amplifier and study:

   i. Frequency response.

   ii. The amplitude characteristics.
7. Determine the capacitance, resistance and inductance of a coil at radio frequency and to study the variations of Z with frequency.
8. Study the series and parallel response circuit:

   (i).To plot the frequency response curve characteristics of series circuit.

   (ii).To plot the frequency response of parallel tuned circuit.
9. To study the waveform characteristics of actable multivibrator.

   (i) To design C.R.O. and determine its frequency by varying C&R.
10. To design and calibrate a Hartley Oscillator.
11. To study frequency response of phase characters tics of:

    (i) Low pass filter. (iii) Band pass filter

    (ii) High pass filter. (iv) Band elimination.
12. Study of clipping clamping circuit.
13. Study of an integrating and differentiating
14. Study of Lissajous figure using C. R. O.
15. Determination of wavelength of He-Ne Laser light by diffraction grating.
16. Study of diffraction of laser beam by a slit.
17. Efficiency of electrical motors.
18. Efficiency of solar cells.
19. Determination of efficiency of lighting system/loads.
20. Study of LC transmission line.
21. Any other experiment of equivalent standard can be added.

Note: Students are required to use computers to write and test computer program developed for the numerical methods using Fortran 77/90 in the practical Lab.