MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre : **Department of Physics**

Course Code : **PHT501**

Course Name : **Classical Mechanics**

Credits : 4 **L -** 3 **T -** 1 **P -** 0
Course Type : Core
Prerequisites : Basic Newtonian Mechanics

Course Contents

Introduction and motivation, Mechanics of a system of particles, constraints and their classifications, virtual work and D'Alembert's principle, generalized coordinates, Lagrange's equation and its application, velocity dependent potentials and the dissipation function, calculus of variations, Hamilton's principle, Lagrange's equations from Hamilton's principle. Method of Lagrange's multipliers for nonholonomic systems, cyclic coordinates, conservation theorems and symmetry principles, Noether's theorem, Jacobi's integral.

Applications of Lagrangian formalism: central forces, Kepler's problem, Laplace-Runge-Lenz vector, virial theorem, scattering from a central force field in center of mass and laboratory coordinate systems, rigid body kinematics, orthogonal transformations, Eulerian angles, Euler theorem, Finite and infinite rotations, uniformly rotating frames, Coriolis force, force free motion of a rigid body small oscillations and normal modes. Free vibrations of a triatomic molecule.

Legendre Transformations and the Hamilton equations of motion, Routh's Procedure, derivation of Hamilton's equations from a variational principle, canonical transformations, examples of canonical transformations, phase space diagram, stability analysis, Poisson brackets, Liouville's Theorem Hamilton Jacobi theory.

Lorentz transformations, Minkowski spacetime, intervals, light cone, four-vector formalism, metric tensor, contravariant and covariant tensor, covariant Lagrangian and Hamiltonian formulation, four vector formalism of electrodynamics.

Recommended Readings

Text Books:
1. Classical Mechanics –Goldstein, Poole and Safko (Pearson Education).
2. Classical Mechanics – N. C. Rana and P. S. Joag (Tata McGraw Hill).
3. Introduction to Electrodynamics, David J. Griffiths

Reference Books:
1. Mechanics – L. D. Landau and E. M. Lifshitz (Pergamon Press, Oxford).
2. Classical theory of fields L. D. Landau and E. M. Lifshitz (Pergamon Press, Oxford).

3. Classical Mechanics: Kibble and Berkshir (World Scientific)
4. Introduction to Classical Mechanics: R. G. Takwale and S. Puranik (Tata McGraw Hill).
5 Classical Mechanics: W. Greiner (Springer).
6.Theory and Problems of Theoretical Mechanics: M.R. Spiegel (Mc Graw-Hill).
7. Introduction to Classical Mechanics with Problems and Solutions: David Morin (Cambridge University Press).-

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre : **Department of Physics**

Course Code : **PHT502**

Course Name : **Electronics**

Credits : 4 **L -** 3 **T -** 1 **P -** 0
Course Type : Core
Prerequisites : none

Course Contents

Basic of op-amps, Op-amps circuit analysis, applications of op-amps- summer, subtractor, integrator, and differentiator, amplifier designing, Comparators, The Schmitt Triger, summer, subtractor, integrator, and differentiator, Transfer function and Bode plots, Frequency and time response of filters, Active filters. Passive filters, Sallen-key topology, Higher order filters, Klystron-an introduction, Op-amp oscillators-Wien bridge and phase-shift oscillators, 555 timers: monostable and astable multivibrator, Regulated power supply, Analog Computers using op-amps.

Digital electronics- Boolean algebra, De Morgan’s theorems, standard forms of Boolean expressions, K-map, number systems and codes, Half and Full Adders. Flip-flops, Registers, Counters, D/A conversion and A/D conversion.

Recommended Readings

Text books-

1. Electronic Principles: Malvino Bates (Tata McGraw Hill).
2. The Art of Electronics: Horowitz and Hill
3. Digital Principles and Applications: A. P. Malvino and Donald P. Leach (TMH)
4. Fundamental of Digital Circuits: P Anand Kumar (PHI)
5. Electronic Devices and Circuit Theory: Robert Boylestad and Louis Nashdsky (PHI)

Reference books-

1. Op-Amps and Linear Integrated Circuits: Ramakanth A. Gayakwad (PHI)
2. Digital Fundamentals: Floyd & Jain (Pearson Education)
3. Digital Electronics: Morris Nano (Pearson)

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre : **Department of Physics**

Course Code : **PHT504**

Course Name : **Mathematical Physics**

Credits : 4 **L -** 3 **T -** 1 **P -** 0

Course Type : Core

Prerequisites :

Course Contents

Vector spaces, matrices, eigenvalues and eigenvectors, Cayley-Hamilton theorem, Gram-Schmidt orthogonalization process, groups, finite groups, non-Abelian groups, permutation groups, subgroups, SU(3) and O(3) groups.

Cartesian tensors, algebra of tensors, quotient law, isotropic tensors, improper rotations and pseudo tensors, dual tensors, physical applications of tensors, non-Cartesian coordinates, metric tensor, general coordinate transformations and tensors.

Laplace and Fourier transforms, their properties, inverse Laplace and Fourier transforms, application of Laplace and Fourier transforms in solving linear differential equations, Sturm-Liouville equation, Green's function and its applications.

Elements of complex analysis, analytic functions, Taylor and Laurent series, poles, residues and evaluation of integrals, applications towards Green's functions

Recommended Readings

Text Books:

1. Mathematical Methods for Physicists: G. Arfken, H. Weber and F. Harris (Academic Press).
2. Elements of Group Theory for Physicists: A. W. Joshi (Wiley Eastern Ltd.).
3. Mathematical Methods of Physics: Mathews and Wallker (Pearson Educations 2005).

Reference Books:

1. Mathematical Methods: Potter and Goldberg (Prentice Hall of India).
2. Mathematical Physics: Morse and Freshbach (2 vols.).
3. Mathematical Physics: I. C. Goyal.
4. Mathematical Physics: H. K. Das (S. Chand and Co.).
5. Introduction to Mathematical Physics: C. Harper (Prentice Hall of India 2006).
6. A Course of Modern Analysis: Whittaker and Watson (Cambridge University Press).

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre : **Department of Physics**

Course Code : **PHT 505**

Course Name : **Quantum Mechanics**

Credits : 4 **L -** 3 **T -** 1 **P -** 0
Course Type : Core
Prerequisites : none;

Course Contents

Basics of quantum mechanics: state vector, vector spaces, Hilbert space, Dirac notation, probabilities in coordinate and momentum space , operators and expectation values of dynamical variables, commutators and operator algebra, Schrodinger equation(time-dependent and time-independent), eigen values and eigen functions, eigen value problems, Schrodinger picture, Heisenberg picture

Expectation values and Ehrenfest's theorem, Heisenberg uncertainty principle, Harmonic oscillator: raising and lowering operators, two body problem, hydrogen atom

Symmetries, conservation laws, invariance under space and time translations and space rotation, angular momentum algebra, spin, addition of angular momenta, Clebsch-Gordan Coefficients

Time independent perturbation theory, normal Zeeman and Stark effects, WKB approximation and variational methods

Recommended Readings

4. Text books –
   (i) Quantum Mechanics, Theory and Applications: A.K. Ghatak and S. Loknathan,(McMillan India)
   (ii) Introduction to Quantum Mechanics: David J. Griffiths (Pearson Education)
   (iii) Quantum Mechanics – A Modern Approach: Ashok Das and A.C. Milissiones, (Gordon and Breach Science Publishers)
5. Reference books –
7. Quantum Mechanics: E. Merzbacher, (Wiley).
8. Quantum Mechanics: L.I. Schiff, (McGraw Hill).
9. Quantum Mechanics: L. D. Landau and E. M. Liefshitz (Pergamon Press).
10. Quantum Mechanics- An Introduction: Walter Greiner (Springer).
11. Modern Quantum Mechanics: J.J. Sakurai, (Addision Wesley Publishing Co.).
12. Quantum Mechanics: R. Shankar.
13. Feynmann Lecturers: Vol I, II & III.
14. Quantum Mechanics, B.H. Bransden, C.J. Joachain
15. Quantum Mechanics, Stephen Gasiorowicz.

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre : **Department of Physics**

Course Code : **PHT 506**

Course Name : **Atomic & Molecular Spectroscopy**

Credits : 4 **L -** 3 **T -** 1 **P -** 0
Course Type : Core
Prerequisites : Bachelors in Physics

Course Contents

Spectra of hydrogen and helium, spin-orbit interaction and relativistic shift, fine structure, Lamb shift (only qualitative treatment), Nuclear magnetic dipole interaction and hyper fine structure, General factors influencing spectral line width and intensities. LS & JJ Coupling, Interaction with external fields: Stark effect, Zeeman and Paschen-Back effect.
System with identical particles: exchange symmetry, hydrogen Molecular Ion, valence band theory, hydrogen molecule.
Born-Oppenheimer approximation; rotational, vibrational and electronic spectra of diatomic molecules, Frank-Condon principle, Raman Spectroscopy.

Recommended Readings

6. Text book- Atomic Physics: Christopher J. Foot (Oxford University Press), Fundamentals of Molecular Spectroscopy: C. N. Banwell and E. M. McCash (McGraw), Atomic and Molecular Spectra: Lasers by Raj Kumar (KNRN)
7. Reference book- Introduction to Atomic Spectra: H. E. White (McGraw Hill). Molecular Spectra and Molecular Structure, G. Herzberg, (Van Nostrand)
   Molecular Spectroscopy: K. V. Raman, R. Gopalan and P.S. Raghavan (Thomson).
8. Online resources- https://nptel.ac.in/courses/115/101/115101003/

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre : **Department of Physics**

Course Code : **PHT507**

Course Name : **Electrodynamics**

Credits : 4 **L -** 3 **T -** 1 **P -** 0
Course Type : Core
Prerequisites : None

Course Contents

Gauss's Divergence Theorem, Stokes' Theorem, Basics of Electrostatics, Poisson's and Laplace's equation, Uniqueness theorems, Electrostatic boundary value problems with Green's function, Method of images, Techniques for calculating potentials, Multipole expansion, Polarization.

Basic of Magnetostatics, Magnetic vector potentials, Equation of continuity, Maxwell's displacement current, Maxwell's equations, Maxwell's equations inside the matter for time varying fields, Poynting vector, Maxwells stress tensor.

Electromagnetic wave equation, Electromagnetic waves in vacuum, Electromagnetic waves in matter, Reflection and Transmission at normal and oblique incidence, Electromagnetic waves in conductors, Frequency dependence of permittivity, Wave guides.

Scalar and vector potentials, Potential formulation of Maxwell's equations, Gauge transformations, Coulomb and Lorentz gauge, Retarded potentials, Lienard-Wiechart potentials, Field of a uniformly moving point charge, Dipole radiation, Electric dipole and magnetic dipole, Power radiated by a point charge.

Recommended Readings

Text books-

1. Introduction to Electrodynamics: David J. Griffiths, (Prentice Hall of India).
2. Classical Electrodynamics: J.D. Jackson, (John Wiley and Sons).
3. Elements of Electrodynamics: Matthew N. O. Sadiku

Reference books-

1. Foundations of Electromagnetic Theory: J. Reitz and F.J. Milford (Addison-Wesley).
2. Classical Electricity and Magnetism: W.K.H. Panofsky, M. Phillips (Addison Wesley).
3. Fields and Waves Electromagnetics: David K. Cheng (Addison – Wesley).
4. Electromagnetic Waves and Radiating Systems: E.C. Jordan (Prentice Hall of India).
5. The Classical Theory of Fields: L.D. Landau, E.M. Lifshitz (Pergamon Press, Oxford).

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre : **Department of Physics**

Course Code : **PHT 508**

Course Name : **Nuclear and Particle Physics**

Credits : 4 **L -** 3 **T -** 1 **P -** 0

Course Type : Core

Prerequisites : none

Course Contents

Nuclear binding energy, electric and magnetic moments, nuclear force: deuteron, n-p and p-p scattering, semi-empirical mass formula: liquid drop model, nuclear shell model, shell model predictions, selection rules, nuclear isomerism, and collective nuclear model Nuclear decay, theories for α, β and γ decay, transition probabilities, selection rules, general characteristics of weak interaction, nuclear reactions, partial wave analysis, compound nucleus formation, resonance scattering and reaction, optical model, reactor physics: fission reactors, four factor formula, schemes for nuclear fusion.

Gas filled counters, scintillator counters, solid state detectors, surface barrier detectors, proton synchrotron, linear accelerations, acceleration of heavy ions.

Elementary particles and their interactions, hadrons and leptons, symmetry and conservation laws, elementary ideas of CP and CPT invariance, relativistic kinematics, classification of hadrons, Lie algebra - SU (2) - SU (3) multiplets, quark model, Gell-mann Okubo mass formula for octet and decuplet hadrons, parity non-conservation in weak interaction.

Recommended Readings

Text books-

16. Introductory Nuclear Physics: Kennath S Keane (Wiley).
17. Techniques for Nuclear and Particle Physics Experiments: W.R. Leo (Springer, 1994).
18. Radiation Detection and Measurement: G. F. Knoll (John Wiley, 1989).
19. Introduction to Elementary Particle Physics: David Griffith (Wiley).
20. Introduction to High Energy Physics: Donald H. Perkins (Cambridge University Press).
21. Nuclear Physics: DC Tayal (Himalaya Publishing House)
22. Concepts of Modern Physics: Aurthur Beiser (Mc GrawHill)

23. Quark and Leptons: An Introductory Course in Modern Particle Physics: Francis Halzen,Alan D. Martin (John Wiley and Sons).

Reference books-

6. Structure of Nucleus: M.A. Preston and R.K. Bhaduri (Addison Wesley).
7. Nuclear Physics: R.R. Roy and B.P. Nigam (Wiley Eastern).
8. Introduction to Nuclear Physics: H. Enge (Addison Wesley).
9. The Atomic Nucleus: R.D. Evans (McGraw Hill).
10. Nuclear Physics: Kaplan (Addison Wesley).
11. Introductory Nuclear Physics: S. Wong (Prentice Hall of India).
12. Concepts of Nuclear Physics: Cohen (Tata McGraw Hill).
13. Nuclear Reactor Engineering: Glasstone and Sesonske (Van Nostrand Reinhold Co.).
14. Introduction to Experimental Nuclear Physics: R.M. Singru (Wiley Eastern)

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre : **Department of Physics**

Course Code : **PHT 510**

Course Name : **Statistical Mechanics**

Credits : 4 **L -** 3 **T -** 1 **P -** 0
Course Type : Core
Prerequisites : Bachelors in Physics

Course Contents

Review of thermodynamics. Introduction to statistical methods: micro and macro states, phase space, Liouville's theorem, postulates of statistical mechanics, system in thermodynamic equilibrium, law of equipartition of energy and its applications.

Micro canonical ensemble, statistical interpretation of entropy, Gibbs paradox, Canonical ensemble, partition functions and its properties (factorizability), calculation of thermodynamic quantities, Fluctuations in energy and other thermodynamic quantities in canonical ensemble.
Grand Canonical ensemble, Calculation of thermodynamic quantities using grand canonical ensemble approach, fluctuations in energy and other thermodynamic quantities.

Quantum distribution functions: Bose-Einstein (BE) and Fermi-Dirac (FD) statistics, vis–a–vis classical M-B statistics, Applications of FD and BE statistics: such as paramagnetism, liquid Helium problem etc., Phase transitions and its classifications: order parameter critical exponents and some important phase transitions.

Recommended Readings

9. Text book- Statistical Mechanics: R. K. Patharia & Paul D. Beale (Elsevier, Academic Press). Statistical Mechanics, An Introduction: Evelyn Guha (Narosa Publishing House).
10. Reference book- Statistical Mechanics: K. Huang (John Wiley and Sons). Fundamentals of Statistical and Thermal Physics: Reif (McGraw Hill). Elementary Statistical Mechanics: C.Kittel (Dover Pub.). Treatise on Heat: Saha and Srivastava (Wiley) Statistical Mechanics: B.K. Agarwal and Melvin Eisner (John Wiley and Sons, 1988). Statistical and Thermal Physics: Loknathan and Gambhir (Prentice Hall India)
11. Online resources- https://nptel.ac.in/courses/115/101/115101003/ https://nptel.ac.in/courses/115/106/115106111/

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre : **Department of Physics**

Course Code : **PHT671**

Course Name : **Solid State Physics**

Credits : 3 **L -** 3 **T -** 1 **P -** 0
Course Type : **Core**
Prerequisites : None

Course Contents

Review of basic crystal structures and bondings in solids, liquid crystals and quasi crystals, X-ray diffraction and reciprocal lattice, electron and neutron diffraction, lattice vibrations: dispersion relations and their interpretation for one dimensional mono and diatomic lattice types, concept of phonons Einstein and Debye models.

Free electron theory, Bloch theorem, energy bands in solids: Kronig-Penney model, nearly free electron (NFE) model, tight binding approximation, concept of Fermi level and Fermi surfaces, Semiconductor Junctions: homo and heterojunctions.

Dielectric properties and losses, Thermal conductivity and thermal expansion, concept of thermoelectrics, phase transformations: classification

Classical and quantum Hall effect, Superconductivity: BCS theory and Josephson effect, quantum theory of magnetism: para- and ferromagnetism, antiferro- and ferrimagnetic materials.

Recommended Readings

Text books:

1. Introduction to Solid State Physics: C. Kittel, 7th Ed. (John Wiley and Sons).
2. Solid State Physics: N. Ashcroft and N.D. Mermin (Holt, Rinehart and Winston).
3. Solid State Physics: A.J. Dekker (Prentice Hall of India, New Delhi).
4. Magnetism in Condensed Matter: Stephen Blundel (Oxford Master Series in Condensed Matter Physics).

Reference books:

1. Solid State Physics: Azaroff (McGraw Hill).
2. Solid State Physics: M.S. Rogalski and S.B. Palmer (Gordon & Breach Science Pub.).
3. Introductory Solid-State Physics: H.P. Myers (Viva books Pvt. Ltd.).
4. Solid State Physics: Wahab (Narosa).
5. Solid State Physics: Gerald Burns (Academic Press).
6. Introduction to Nanotechnology: Poole Jr. and Owens (J. Wiley and Sons).

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre : **Department of Physics**

Course Code : **PHT 681**

CourseName : **Numerical Methods and Computer Programming**
Credits : 3 **L -** 3 **T -** 0 **P -** 0
Course Type : Program Elective
Prerequisites : preferred – basic understanding of computer programming

Course Contents

Module 1 [Lectures: 12]

Programming basics in C / C++ language, data types, decision control structure, loop control structure, case control structure, function etc.

Module 2 [Lectures: 15]

Solving numerical method problems through computer programming, finite difference
calculus, interpolation and extrapolation, roots of equations, solution of simultaneous linear algebraic equations, least squares curve fitting, monte carlo simulation for numerical integration, numerical solution of ordinary differential equations, runga kutta method IV order, matrix eigen value problems.

Module 3 [Lectures: 12]

Introduction to modelling and simulation, simple examples, particle in a box, random walk problem, Rutherford scattering.

Recommended Readings

Text Books:

1. Computer Oriented Numerical Methods: V. Rajaraman (Prentice Hall of India).
2. Introduction to Numerical Methods and Fortran Programming: T.R. McCalla (John Wiley and Sons).
3. Numerical Analysis: M. K. Jain.
4. Introduction to C++: Balaguruswamy.
5. Introduction Methods of Numerical Analysis: C.S. Sastry (PHI).

Reference Books:

1. Numerical Analysis: E. Krishnamurthy.
2. Monte Carlo Simulation: Binder and Herman.
3. An Introduction to Computation Physics: T. Tang (Cambridge Univ. Press 1997).
4. Schaum Series: (McGraw Hill).

Online resources:

NPTEL/Mooc Courses