ST ALOYSIUS
(DEEMED TO BE UNIVERSITY)
MANGALURU 575003 - INDIA
ESTD : 1880

Syllabus for PhD Entrance Exam
January -2025

Department: Physics

Part I – Research Methodology

Unit 1 **Research:**

Research – meaning, characteristics, objectives, motivation in research, need and importance of research. Types of Research.

Unit 2 **Ethics:**

Ethics – meaning and definition, Ethics vs moral philosophy, nature of moral judgments and reactions. Rights and obligations of Research Participants. Scientific conduct – ethics with respect to science and research, intellectual honesty and research integrity.

Unit 3 **Research Problem**

Meaning, selecting the problem, sources of problem, statement of a problem; Review of Literature – meaning and need for literature review, sources of literature review, reporting the review of literature, identification of research gap; Research Questions; Objectives of the study.

Unit 4 **Research Report**

meaning, features of a good Research Report, elements of Research Report, format of a Research Report, Appendices and References/ Bibliography – styles.

Research design, system of interest- experimental setup-characterization-data acquisition-data analysis-reproducibility-statistical and error analysis-application studies - relevance of research.

Unit 5 **Publication Ethics:**

Scientific misconduct – falsification, fabrication and plagiarism. Publication ethics – meaning and importance, conflicts of interest, publication misconduct – meaning, problems that lead to unethical behaviors, types of publication misconduct, identification of publication misconduct,

complaints and appeal.

References:

1. Kothari C R. Research methodology: Research & Techniques. New Age International Publishers, New Delhi.
2. A K Singh. Tests, Measurements and Research Methods in Behavioral Sciences. Bharathi Bhawan (Publishers & Distributors), New Delhi.
3. Singh Y K. Fundamentals of Research Methodology and Statistics. New International (P) Ltd., New Delhi.

Part II – Domain Specific

Unit 1 **Mathematical Physics:** Vector analysis, curvilinear coordinates, Matrices and determinants, differential equations, partial differential equations, special functions, complex analysis, group theory, Integral transforms and numerical techniques

Unit 2 **Classical mechanics:** Constraints, Lagrangian formalism, Hamiltonian formalism, central force problem, equation of orbits, rigid body problem, Euler's equations.

Unit 3 **Electrodynamics:** Electrostatics, magnetostatics, Maxwell's equations, conservation of energy, dipole radiation, electro magnetic waves.

Unit 4 **Quantum Mechanics:** Schrodinger equation, Potential well problem, Harmonic oscillator, Angular Momentum, Scattering, Relativistic quantum mechanics, Klein Gordon equation, Dirac's equation, Perturbation theory (Time independent and Time dependent), Variational method, WKB approximation.

Unit 5 **Condensed Matter Physics:** Crystallography, Free electron theory, Band theory, Magnetism, superconductivity, thin film technology, smart materials, nanotechnology.

Unit 6 **Nuclear Physics:** Properties of nuclei, Alpha, beta and gamma decay, nuclear radiation detection, nuclear reactions, nuclear forces, nuclear models, particle physics.

Unit 7 **Electronics:** OpAmps and applications. Integrators, Differentiators, Filters. Waveform generators. Transducers and Power amplifiers. Digital electronics: K map, flip-flops.

Unit 8 **Thermodynamics and Statistical Physics:**

Laws of thermodynamics and their consequences. Thermodynamic potentials, Maxwell relations, chemical potential, phase equilibria. Phase space, micro- and macro-states. Micro-canonical, canonical and grand-canonical ensembles and partition functions. Free energy and its connection with thermodynamic quantities. Classical and quantum statistics. Ideal Bose and Fermi gases. Principle of detailed balance. Blackbody radiation and Planck's distribution law.

Unit 9 **Atomic & Molecular Physics**

Quantum states of an electron in an atom. Electron spin. Spectrum of helium and alkali atom. Relativistic corrections for energy levels of hydrogen atom, hyperfine structure and isotopic shift, width of spectrum lines, LS & JJ couplings. Zeeman, Paschen-Bach & Stark effects. Electron spin resonance.

Nuclear magnetic resonance, chemical shift. Frank-Condon principle. Born-Oppenheimer approximation. Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules. Lasers: spontaneous and stimulated emission, Einstein A & B coefficients. Optical pumping, population inversion, rate equation. Modes of resonators and coherence length.

Unit 10 **Instrumentation**

Transducers (temperature, pressure/vacuum, magnetic fields, vibration, optical, and particle detectors). Measurement and control. Signal conditioning and recovery. Impedance matching, amplification (Op-amp based, instrumentation amp, feedback), filtering and noise reduction, shielding and grounding. Fourier transforms, lock-in detector, box-car integrator, modulation techniques. High frequency devices (including generators and detectors).

References:

1. Barron R F: Cryogenics Systems (2nd Edition (Oxford university Press 1985)
2. Roth A: Vacuum Technology (2nd Edition North Holland, 1982)
3. Arfken G B, Weber H J, Harris F E, 'Mathematical Methods for Physicists', (VII Edn. Academic Press, 2013)
4. Harper C, 'Introduction to Mathematical Physics', (PHI, 1978)
5. Mary L Boas, 'Mathematical Methods in the Physical Sciences', (John Wiley, 1983)
6. Kittel C, 'Introduction to Solid State Physics', (VIII Edn. Wiley India, 2005)
7. Ashcroft N W, Mermin N D, 'Solid State Physics', (Harcourt Asia, 1974)
8. Cullity B D, Stock S R, 'Elements of X-ray Diffraction', (Prentice Hall, 2001)
9. Goswami A, 'Thin film fundamentals', (New Age International, 1996)
10. Ohring M, 'The Materials Science of Thin films', (Academic Press, 1992)
11. Glenn F Knoll, "Radiation Detection and Measurement", Tata McGraw Hill (2007).
12. Krane K. S., "Introductory Nuclear Physics", Wiley Eastern (2010).
13. Schiff L I, 'Quantum Mechanics' (III Edn. McGraw Hill 1968)
14. Griffiths D J, 'Introduction to Quantum Mechanics', (II Edn. Pearson,21, 2011)
15. Goldstein H, Poole P.C, Safko J 'Classical mechanics', (III Edn, Pearson 2011)
16. Landau L D, Lifshitz E M, 'Mechanics - A course on theoretical Physics - Volume I', (Elsevier, 2007)
17. Griffiths D J, 'Introduction to Electrodynamics', (III Edn. PHI, 2009)
18. Jackson J D, 'Classical Electrodynamics', (III Edn. John Wiley,1999)