Tumkur University, Tumkur

Syllabus for Ph.D. Entrance examination:2020-21

Subject: Physics

Mathematical Methods of Physics:

Vector algebra and vector calculus, Linear algebra, matrices. Eigenvalues and Eigenvectors. Linear ordinary differential equations of first & second order, Special functions (Hermite, Bessel, Laguerre and Legendre functions). Fourier series, Fourier and Laplace transforms. Elements of complex analysis, analytic functions, poles, residues and evaluation of integrals. Elementary probability theory, random variables, binomial, Poisson and normal distributions.

Classical Mechanics:

Newton's laws. Dynamical systems, Phase space dynamics, stability analysis. Central force motion. Two body Collisions-scattering in laboratory and Centre of mass frames. Rigid body dynamics, moment of inertia tensor. Non-inertial frames and pseudoforces. Generalized coordinates. Lagrangian and Hamiltonian formalism and equations of motion. Conservation laws and cyclic coordinates. Periodic motion: small oscillations, normal modes. Special theory of relativity, Lorentz transformations, relativistic kinematics and mass-energy equivalence.

Electromagnetic Theory:

Electrostatics, Gauss's law and its applications, Laplace and Poisson equations, boundary value problems. Magnetostatics: Biot-Savart law, Ampere's theorem. Electromagnetic induction. Maxwell's equations in free space and linear isotropic media: boundary conditions on the fields at interfaces. Scalar and vector potentials, gauge invariance. Electromagnetic waves in free space. Dielectrics and conductors. Reflection and refraction, polarization, interference, coherence, and diffraction. Dynamics of charged particles in electromagnetic fields.

Quantum Mechanics:

Wave-particle duality. Schrodinger equation. Eigenvalue problems (particle in a box, harmonic oscillator etc.) Tunneling through a barrier. Wave-function in coordinate and momentum representations. Commutators and Heisenberg uncertainty principle. Dirac notation for state vectors. Motion in a central potential: orbital angular momentum, angular momentum algebra, spin, addition of angular momenta: Hydrogen atom. Stern-Gerlach experiment. Time independent perturbation theory and applications. Variational method. Time dependent perturbation theory and Fermi's golden rule, selection rules. Identical particles, Pauli exclusion principle.

Thermodynamic 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. Blackbody radiation and Planck's distribution law.

Electronics:

Semiconductor devices (diodes, junctions, transistors, field effect devices, homo and hetero junction devices), device structure, device characteristics, frequency dependence and applications. Opto-electronic devices (Solar cells, photo-detectors, LEDs). Operational amplifiers and their applications. Digital techniques and applications (registers, counters, comparators and similar circuits). A/D and D/A converters.

Atomic & Molecular Physics:

Quantum states of an electron in an atom. Electron spin. LS & JJ couplings. Zeeman, Paschen-Bach & Stark effects. Electron spin 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. Modes of resonators and coherence length.

Condensed Matter Physics:

Bravais lattices. Reciprocal lattice. Diffraction and the structure factor. Bonding of solids. Elastic properties, phonons, lattice specific heat. Free electron theory and electronic specific heat. Response and relaxation phenomena. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power. Electron motion in a periodic potential, band theory of solids: metals, insulators and semiconductors. Superconductivity: Type-I and Type- II superconductors. Josephson junctions. Superfluidity. Defects and dislocations. Quasi crystals.

Nuclear and Particle Physics:

Basic nuclear properties: size, shape and charge distribution, spin and parity. Binding energy, semiempirical mass formula, liquid drop model. Nature of the nuclear force, form of nucleon-nucleon potential, charge-independence and charge-symmetry of nuclear forces. Deuteron problem. Evidence of shell structure, single-particle shell model, its validity and limitations. Rotational spectra. Elementary ideas of alpha, beta and gamma decays and their selection rules. Fission and fusion. Nuclear reactions, reaction mechanism, compound nuclei and direct reactions. Classification of fundamental forces. Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.) Gellmann-Nishijima formula. Quark model, baryons and mesons. C, P and T invariance.

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Subject: Research Methodology

Unit 1. Objectives and types of research:

Motivation and objectives- Research methods vs Methodology. Types of research-prescriptive vs Analytical, Applied vs Fundamental, Quantitative vs Qualitative, Conceptual vs Empirical

Unit 2. Research Formulation:

Defining and formulating the research problem- Selecting the problem- Necessity of defining the problem- Importance of literature review in defining a problem- Literature Review-Primary and secondary sources-reviews, treatise, monographs-patents-web as a source-searching the web-critical literature review-identifying gap areas from literature Review-Development of working hypothesis

Unit 3. Research design and methods:

Research Design-Basic Principles-Need of research Design-Features of good Design-Important concepts relating to research Design-Observation and Facts, Laws and theories, Prediction and explanation, Induction, Deduction, Development of models. Development of models. Developing a research plan-exploration, Description, Diagnosis, Experimentation. Determining experimental and sample designs.

Unit 4. Data Collection and analysis:

Execution of the Research-Observation and collection of data- Methods of data Collection-Sampling Methods-Data processing and Analyses strategies- Data analysis with statistical packages- Hypothesis-Testing-Generalization and Interpretation.

Unit 5. Reporting and thesis writing:

Structure and components of scientific Reports-Types of Report-Technical reports and Thesis-Significance-Different steps in the Preparation-Layout, structure and Language of typical reports-illustrations and Tables-Bibliography, referencing and Footnotes-Oral Presentation-Planning-Preparation-Practice-Making presentation-use of visual Aids-Importance of effective communication.

Unit 6. Application of results and ethics:

Environmental impacts- Ethical issues- ethical Committees-Commercialization-Copy Right-Royalty-Intellectual Property Rights and patent law- Trade related aspects of actual property rights-reproduction of published material- Plagiarism-Citation, Acknowledgement- Reproducibility and accountability.