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22nd November, 2013

NOTICE

Physics Ph. D. Entrance Test (Paper II) will be held on **15th December (Sunday), 2013, at the Department of Physics, University of Pune, from 10:00 AM to 1:00 PM** (3 hours duration). Candidates who have qualified the Ph. D. Entrance Examination for Paper I conducted by the University of Pune are eligible for appearing for this test.

The question paper will be for 100 marks. The question paper will consist of 10 multiple choice questions (MCQs), each carrying 2 marks, and 10 Descriptive Questions (DQs), each carrying 10 marks. All of the MCQs are compulsory, carrying a total of 20 marks. Out of 10 DQs, any 8 have to be answered, carrying a total of 80 marks. There will be no negative marks for wrong answers.

The syllabus for the test is provided in the following pages.

Candidates should bring with them the Hall Ticket issued by the University of Pune for the Paper I Examination, conducted during the November, 2013. Those who have qualified Paper I Examination during the earlier years should bring with them some valid photo-identification (driving license, photo-identity card issued by the College/University, Aadhar card, passport).

The Head
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Ph.D. ENTRANCE TEST
UNIVERSITY OF PUNE
SYLLABUS FOR PHYSICS – (PAPER-II)

1) **Mathematical Methods of Physics -**

Dimensional analysis; Vector algebra and vector calculus; Linear algebra, matrices, eigenvalue problem; Linear differential equations; Special functions (Hermite, Bessel, Laguerre and Legendre); Fourier series, Fourier and Laplace transforms, Bromwich integral; Elements of complex analysis; Laurent series, poles, branch cuts, residues and evaluation of integrals; Elementary ideas about tensors; Introduction group theory, SU(2), O(3); Elements of computational techniques; Root of function, interpolation, extrapolation, integration by trapezoid and Simpson's rule. Elementary probability theory, random variables, binomial, Poisson and normal distributions.

2) **Classical Mechanics -**

Newton's laws; Phase space dynamics, stability analysis; Constraints; Central-force motion; Two body collision, scattering in laboratory and centre -of -mass frames; Rigid body dynamics, moment of inertia tensor, non-inertial frame and pseudo forces; Variational principles. Lagrangian and Hamiltonian formulations and equations of motion; Poisson brackets and canonical transformations; Symmetry, invariance and conservation laws, cyclic coordinates; Periodic motion, small oscillations and normal modes; Special theory of relativity, Lorentz transformation, relativistic kinematics and mass-energy equivalence.

3) **Electromagnetic Theory -**

Electrostatics: Gauss' Law and its applications; Laplace and Poisson equations, boundary value problems; Magnetostatics: Biot-Savart law, Ampere's theorem, Vectors potential; electromagnetic induction; Maxwell’s equations in free space and linear isotropic media; boundary conditions on fields at interfaces; Scalar and vector potentials; Gauge invariance; Electromagnetic waves in free space, dielectrics, and conductors; Reflection and refraction, polarization, Fresnel’s Law, interference, coherence, and diffraction; Dispersion relations in plasma; Lorentz invariance of Maxwell’s equations; Transmission lines and wave guides; Dynamics of charged particles in static and uniform electromagnetic fields; Radiation from moving charges, dipoles and retarded potentials.

4) **Quantum Mechanics –**

Wave-particle duality; Wave functions in coordinate and momentum representations; Commutators and Heisenberg’s uncertainty principle; Matrix representation; Dirac’s bra and ket notation; Schrödinger equation (time-dependent and time-independent); Eigenvalue problems such as particle-in-a-box, harmonic, oscillator, etc/; Tunneling through a barrier; Motion in a central potential; Orbital angular momentum, Angular momentum algebra; spin; Addition of angular momenta; Clebsch-Gordon coefficients; Hydrogen atom, spin-orbit coupling, fine structure; Time- independent perturbation theory and applications; Variational method; WKB approximation.

Time dependent perturbation theory and Fermi’s Golden Rule; Selection rules; Semiclassical theory of radiation; Elementary theory of scattering, phase shifts, partial waves, Born approximation; Identical particles, Pauli’s exclusion principle, spin statistics connection.

5) **Thermodynamic and Statistical Physics –**

Laws of thermodynamics and their consequences; Kinetic theory, Thermodynamic potentials, Maxwell relations; Chemical potential, phase equilibria; Phase space, micro- and macrostates; Microcanonical, canonical and grand-canonical ensembles and partition functions; Free Energy and connection with thermodynamic quantities; First-aid second-order phase transitions; Classical and quantum statistics, ideal Fermi and Bose gases; Principle of detailed balance; Blackbody radiation and Planck's distribution law; Bose-Einstein condensation.

6) **Electronics –**

Semiconductor device physics, including diodes, junctions, transistors, field effect devices, homo and heterojunction devices, device structure, device characteristics, frequency dependence and applications; Optoelectronic devices, including solar cells, photo detectors and LEDs; High-frequency devices, including generators, and detectors; Operational amplifiers and their applications; Digital techniques and applications (registers, counters, comparators and similar circuits); A/D and D/A converters; Microprocessor and microcontroller basics.

7) **Experimental Techniques and data analysis –**

Data interpretation and analysis; Precision and accuracy, error analysis, propagation of errors, least squares fitting, linear and nonlinear curve fitting, chi-square test; Transducers (temperature, pressure/vacuum, magnetic field, 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.

Applications of the above experimental and analytical techniques to typical undergraduate and graduate level laboratory experiments.

8) **Atomic & Molecular Physics –**

Atomic structure and atomic spectra, Quantum states of an electron in an atom; Electron spin; Stern-Gerlach experiment; Spectrum of Hydrogen, helium and alkali atoms; Relativistic corrections for energy levels of hydrogen; Hyperfine structure and isotopic shift; width of spectral lines; LS &JJ coupling; Zeeman, Paschen Back & Stark effect; X-ray spectroscopy; Electron spin resonance, Nuclear magnetic resonance, chemical shift; Rotational, vibrational, electronic, and Raman spectra and diatomic molecules; Frank – Condon principle and selection rules; Spontaneous and stimulated emission, Einstein A & B coefficients; Laser, optical pumping, population inversion, rate equation; Modes of resonators and coherence length.

9) **Condensed Matter Physics –**

Bravais lattices, Reciprocal lattice, diffraction and the structure factor; Bonding of solids, Elastic properties, lattice vibrations, 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; Diamagnetism, paramagnetism, and ferromagnetism; Electron motion in a periodic potential, band theory of metals, insulators and semiconductors; Superconductivity, type – I and type – II superconductors, Josephson junctions.

10) **Nuclear and Particle Physics –**

Basic nuclear properties; size, shape, charge distribution, spin and parity; Binding energy, magnetic moment, semi-empirical mass formula; Liquid drop model; Fission and fusion; Nature of the nuclear force, form of nucleon-nucleon potential; Charge-independence and charge-symmetry of nuclear forces; Isospin; 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; Nuclear reactions, reaction mechanisms, compound nuclei and direct reactions; Classification of fundamental forces; Elementary particles (quarks, baryons, mesons, leptons); Spin and parity assignments, isospin, strangeness.

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