Maharashtra State Eligibility Test for Lectureship

महाराष्ट्र राज्य व्याख्यातापदासाठी राज्यस्तरीय पात्रता चाचणी (सेट) परीक्षा

Conducted by University of Pune

(AS THE STATE AGENCY)

SYLLABUS AND SAMPLE QUESTIONS

Subject Code No.	*Subject*
32	**Physical Sciences**

UNIVERSITY OF PUNE
Ganeshkhind, Pune-411007

[32] : PHYSICAL SCIENCES

The syllabus consists of two papers, as follows :

Paper II and Paper III will be of 75 minutes and 2½ hours duration respectively. Paper II will be of 100 marks and Paper III will be of 200 marks.

PAPER II

1. **Basic Mathematical Methods :** Plotting of graph, curve fitting, data analysis, elementary probability theory. Calculus : vector algebra and vector calculus. Linear algebra, martices. Linear differential equations. Fourier : series, Fourier transforms-Elementary complex analysis.

2. **Classical Dynamics :** Basic principles of classical dynamics. Lagrangian and Hamiltonian formalisms. Symmetries and conservation laws, Motion in the central field of force. Collision and scattering, Mechanics of system of particles. Rigid body dynamics. Noninertial frames and pseudoforces. Small oscillations and normal modes. Wave motion-wave equation, phase velocity, group velocity, dispersion. Special theory of relativity-Lorentz transformations, addition of velocities, mass-energy equivalence, energy-momentum four-vector.

3. **Electromagnetics :** Electrostatics-Leplace and Poission equations, boundary value problems, multiple expansion, dielectrics. Magnetostatics - Ampere's theorem, Biot-Savart Law, electromagnetic induction. Maxwell's equation in free space and in linear isotropic media. Boundary conditions on the field at interfaces. Scalar and vector potentials, Gauge invariance. Electromagnetic waves-reflection and refraction, dispersion, Rectangular wave guides. Interference, coherence, visibility of fringes.

   Diffraction, Polarization, Electrodynamics motion of a charged particle in electric and magnetic fields. Radiation from moving charges, radiation from a dipole.

4. **Quantum Physics and Applications :** Wave-particle duality. Heisenberg's Uncertainty Principle. Schrodinger equation. Particle moving in a one-dimensional potential. Orbital angular momentum. Motion in a central potential symmetry conservation laws and degeneracy. Operator formalism of quantum mechanics. Angular momenta algebra, spin. Addition of angular momenta. Time-independent perturbation theory. Time-dependent purturbation theory-adiabatic approximation. Fermi's Golden Rule. Elementary theory of scattering in a central potential. Phase shifts, partial wave analysis. Born approximation. Schrodinger equation in a periodic potential, Bloch's theorem, Tunnelling through a potential barrier. Identical particles, spin statitics connection.

5. Thermodynamics and Statistical Physics, laws of thremodynamics and their consequences. Thermodynamic potentials and Maxwell's relations. Chemical potential, phase equilibria. Phase space, Microstates and macrostates. Ensembles. Partition funcdtion, Free energy and connection with thermodynamic quantities. Classical and quantum statistics. Degenerate electron gas, Blackbody radiation and Planck's distribution law. Bose-Einstein condensation. Einestein and Debye models for lattice specific heat paramagnetism due to lacalized moments. Elementary ideas on phase transitions-Van der Walls fluid, Weiss molecular field theory of ferromagnetism.
6. Experimental Techniques, Measurement of fundamental physical constants, temperature, Pressure

and humidity sensors, photon and particle detectors. Oscilloscopes, function generator, voltage and current sources, power supply, Measurement of high and low resistance (voltage and current). AC bridges for L and C Measurement of magnetic field.

Principles and conceptual basis of : (i) Optical sources, interferometry for wavelength measurements, (ii) Production and measurement of low pressure (vacuum), (iii) Power and single crystal (Laue) X-ray diffraction techniques, (iv) Measurements of signals, signal to noise ratio.

PAPER III

Part A Weightage 50%

SYLLABUS SAME AS FOR PAPER II

Part B Weightage 50%

1. Electronics Semiconductor discrete devices (characteristic curves and physics of p-n junction). Schottky, Tunnel and MOS diodes, Bipolar junction transistor, junction field effect, transistor (JFET) Metal-oxide-Semiconductor. Field effect transistor (MOSFET), unijunction transistor and sillicon controlled rectifier (SCR), Opto-electronic devices (Photo-diode, solar cell, LED, LCD and photo transistor), Diffusion of impurities in sillicon, growth of oxide.

   Applications of semiconductor devices in linear and digital circuits-Zener regulated power supply, Transistor (bipolar, MOSFFT, JFET) as amplifier, coupling of amplifier stages (DC, RC and Transformer coupling), RC-coupled amplifier, dc and power amplifier Feedback in amplifiers and oscillators (phase swift, Hartley, Colpitts and crustal controlled) clipping and clamping circuits. Transistor as a switch OR, AND and NOT gates (TIL and CMOS gates). Multivibrators (using transistor) and sweep geneator (using transistors, UJT and SCR).

   Linear integrated circuits-Operational amplifier and its applications-Inverting and noninverting amplifier, adder, integrator, differentiator, waveform geneator, comparator and Schmittrigger, Butterwoth active filter, phase shifter, Digital integrated circuits-NAND and NOR gates building block, X-OR gate, simple combinational circuits-Half and full address, Flip-Flops, shift registers, counters, A/D and D/A coverters, semiconductor memories (ROM, RAM, and EPROM, basic, architecture of 8 bit microprocessor (INTEL 8085).

   Communication Electronics-Basic principle of amplitude frequency and phase modulation. Simple circuits for amplitude modulation and demodulation, digital (PCM) modulation and demodulation. Fundamentals of optical communication, Microwave Oscillators (reflex, klystron, megnetron and Gunn diode), Cavity resonaters. Standing wave detector.

2. Atomic and Molecular Physics : Atomic Physics-quantum states of an electron in an atom, Hydrogen atom spectrum, electron spin, Stern-Gerlach experiment, spin-orbit coupling, fine structure, spectroscopic terms and selection rules, hyperfine structure.

   Exchange symmetry of wave functions, Pauli exclusion priciples, periodic table, alkali-type spectra, LS and JJ coupling, Hund’s rules and term reversal.

Machanisms of line broadening.

Zeeman, Paschen-Back and Stark effects.

Inner-shell vacancy, X-rays and Auger transitions, Compton effect.

Principles of resonance Spectroscopy (ESR and NMR)

Molecular Physics-Covalent, ionic and Van der Waal's interaction, Born-Oppenheimer approximation. Heitler-London and molecular orbital theories of H_2.

Rotation, rotation-vibration spectra, Raman Spectra, selection rules, nuclear spin and intensity alteration, isotope effects, electronics states of diatomic molecules, Franck-Condon principle.

Laser-spontaneous and stimulated emission, optical pumping, population inversion, coherence (temporal and spatial), simple description of ammonia maser, CO_2 and He-Ne lasers.

3. Condensed Matter Physics-Crystal classes and system, 2d and 3d lattices, bonding of common crystal structure; reciprocal lattice, diffraction and structure factor, elementary ideas about point defect and dislocations, short and long range order in liquids and solids, liquid crystals, quasicrystals and glasses.

   Lattice vibrations, phonons, specific heat of solids. Free electron theory. Fermi statistics, heat capacity and Pauli paramagnetic susceptibility.

   Electron motion in periodic potentials energy bands in metals, insulators and semiconductors, tight binding approximation, impurity levels in doped semiconductors.

   Dielectrics-Polarization mechanisms, Clausius-Mossotti equation, piezo, pyro and ferroelectricity.

   Dia and Para magnetism, exchange interactions, magnetic order, ferro, anti ferro and ferromagnetism.

   Superconductivity-basic phenomenology, Meissner effect, Type I and Type II super conductors, BCS pairing mechanisms, High Tc materials.

4. Nuclear and Particle Physics

   Basic nuclear properties-size, shape, charge distribution; spin and parity, binding, empirical mass formula, liquid drop model, nuclear stability and radioactive decay.

   Nature of nuclear force, elements of deuteron problem and low energy N-N scattering Charge Independence + charge symmetry of nuclear forces. Evidence for nuclear shell structure. Single particle shell model-its validity and limitations.

   Interactions of charged particles and X-rays with matter, Basic principles of particle detectors-ionization chamber, proportional counter and GM counters, solid state detectors-scintillation and semiconductor detectors.

   Radioactive decays- [α β γ] decays, their classifications and characteristics. Basic theoretical understanding.

Nuclear reactions-Q values and kinematics of nuclear cross-sections, its energy and angular dependence, elementary ideas of reaction mechanisms, elementary ideas of fission and fusion.

Particle Physics-Classificationof fundamental forces and elementary, particles, Isopin, strangeness, Gell-Mann-Nishijima formula.

Quark model + SU (3) symmetry.

C.T.P invariances in different interactions, weak interactions, parity-non conservation, K-meson complex and time reversal invariance, elementary ideas of geuge theory of strong and weak interactions.

SAMPLE QUESTIONS

PAPER II

1. The value of the continued fraction

$$\cfrac{1}{1+\cfrac{1}{1+\cfrac{1}{1+\cfrac{1}{1+\cfrac{1}{1+\ldots\ldots\ldots}}}}}$$

is equal to

(A) 0, (B) 1,

(C) $(\sqrt{5} - 1)/2$, (D) $\sqrt{5}/2$, Answer [C]

2. The period of satellite in a circular orbit of radius R is T. The period of another satellite in a circular orbit of 4R radius is]

(A) at, (B) T/4

(C) 8T (D) T/8 Answer [C]

PAPER III

1. Show that if a particle decribes a circular orbit under the influence of an attractive central force directed towards a point on the circle, then attractive force various as r^{-5}.
2. A charged Harmonic oscillator is oscillating along x axos. A uniform electric field $\vec{E} = E_o \hat{i}$ is applied along x axis. Using second order perturbation theory find the correction to nth energy level.

   Given : $< n + 1 \mid x \mid n > = \frac{1}{\alpha} \sqrt{\frac{n}{2}}$

   $< n \mid x \mid n + 1 > = \frac{1}{\alpha} \sqrt{\frac{n+1}{2}}$

   Where $\alpha = (m\, w / \hbar)$ ½.