Physics
Paper-I

Time Allowed: Three Hours **Maximum Marks: 300**

*Note: Candidate should answer questions No. 1 and 5 which are compulsory and any **three** of the remaining questions, selecting at least **one** from each section.*

SECTION – A

1. (a) Derive the equation of motion for a simple pendulum using Lagrange's equation and hence deduce an expression for time period of simple harmonic motion. 15+05=20

   (b) What is the meaning of mass energy equivalence? Obtain Einstein's mass – energy relation. Find the velocity of a body if kinetic energy of the body is twice to rest mass energy. 04+10+06=20

   (c) Describe the principle, construction and working of He-Ne laser. 20

2. (a) Discuss the problem of scattering of charged particles by Coulomb field and obtain Rutherford's formula for scattering cross-section. Transform the results into laboratory co-ordinates. 15+15=30

   (b) Derive Euler's equations for motion of a rigid body. Discuss the rotational motion of a rigid body, which is symmetrical about an axis and has one point fixed on this axis, when there is no other force acting except the reaction force at a fixed point. 15+15=30

3. (a) State Huygen's principle. Derive laws of reflection and refraction using Huygen's principle. 06+12+12=30

   (b) Find the system matrix for a thin lens and derive the lens formula. Hence find the system matrix and focal length of a thin lens having radii of curvatures equal to 30 cm with material having refractive index equal to 1.5. 20+10=30

4. (a) Discuss the formation of Newton's rings.

What do you expect if the distance between plano-convex lens and glass plate is kept equal to one fourth of wavelength of light used?

What will happen to Newton's rings when the glass plate is replaced by a plane mirror?

The radius of curvature of a plano convex lens is 100cm. Calculate the diameter of 5^{th} bright ring (by reflection) formed with sodium light of $\lambda = 5893Å$.

15+08+02+05=30

(b) What is a zone plate? Describe its construction, working and derive an expression for its focal length. What are differences between zone plate and convex lens? 04+20+06=30

SECTION – B

5. (a) What is an electric dipole? Obtain the relation of electric field and potential by an electric dipole. Find the torque on an electric dipole when it is placed in a uniform electric field. 02+12+06=20

(b) A plane electromagnetic wave travelling in positive z-direction in an unbounded lossless dielectric medium with relative permeability $\mu r=1$ and relative permittivity $\varepsilon r=3$ has a peak field intensity Eo=6V/m. Find (i) Speed of wave (ii) Intrinsic impedance of medium (iii) Peak magnetic field intensity and (iv) Peak Poynting vector. 05×04=20

(c) Explain Maxwell-Boltzman distribution law of velocities and find the number of molecules per unit volume of a gas having velocity components between u and $u+du$, v and $v+dv$, w and $w+dw$. 10+10=20

6. (a) State Biot – Savart's law. Derive expressions for magnetic field intensity at any point on the axis of a circular coil carrying current and plot a graph between magnetic field intensity and distance on axis of circular coil from its centre. 05+20+05=30

(b) Find out (i) phase relationship between current and e.m.f. (ii) impedance (iii) Phase angle and power factor (iii) Resonance and (iv) Quality factor of LCR circuit. Also prove that quality factor is inversely proportional to band width. 06×05=30

7. (a) Using Maxwell's equations prove Coulomb's law and continuity equation. Also obtain the relation

$$\frac{1}{c}\frac{\partial}{\partial t}\left(\frac{E^2+B^2}{2}\right)+\vec{\nabla}.\left(\vec{E}\times\vec{B}\right)=0$$

07+08+15=30

(b) State and derive Plank's distribution law of black body radiation, Stefan-Boltzmann law and Wien displacement law. 14+08+08=30

8. (a) What is Joule – Kelvin effect? Obtain an expression for the cooling produced in a Vander Waal's gas. Why hydrogen show a heating effect at ordinary temperatures. 05+20+05=30

(b) Explain the thermodynamic behaviour of an ideal Fermi gas and obtain the relations for zero point energy and ground state pressure.

Calculate Fermi wavelength and Fermi energy (in eV) for a system of 4.2×10^{21} electrons confined in a box of volume 1cc. If electrons are replaced by protons, then what is Fermi wavelength and Fermi energy (in eV)?

15+15=30