CSM – 58/18

Physics

Paper – I

Time : 3 hours

Full Marks : 300

The figures in the right-hand margin indicate marks.

Candidates should attempt Q. No. 1 from Section – A and Q. No. 5 from Section – B which are compulsory and ***three*** *of the remaining questions, selecting at least* ***one*** *from each Section.*

SECTION – A

1. (a) What do you understand by generalized coordinates ? Deduce Hamilton's Cononical equations of motions in generalized coordinates and explain the significance of Hamiltonian. 20

   (b) What is Coriolis force ? Under what conditions does it come into play ? Discuss in general terms the effect of Coriolis force produced as a result of the earth rotation.

A mass of 20 gm is placed at a distance of 10 cm from the axis of a rotating frame of reference, If the angular velocity of rotation of the frame be 10 radians per second, calculate Coriolis force. 15+5 = 20

(c) Derive the laws of refraction using Fermat's principle giving an example where the path of light is not a minimum rather a relative maximum. 20

(d) Described the Fraunhoffer diffraction due to a single slit. Explain the construction of Fresnel's half period zones on a plane ware front. 20

2. (a) Show that the total angular momentum of a system of particles about a reference point is given by the relation $J = R \times P + J_{CM}$, where $R \times P$ is the angular momentum of centre of mass about that point and J_{CM} is the angular momentum of the system about the centre of mass. Explain spin and angular momentum. 20

(b) Explain the thrust of a rocket and on what factors does it depend ? Show that the final velocity of the find stage of a multistage rocket is much greater. 20

(c) (i) Deduce the differential equation for a damped harmonic oscillator subjected to a sinusoidal force and obtain expression for maximum amplitude.

(ii) Explain, how the principle of super position of waves gives rise to phenomenon of "beats" and "stationary waves". In which case, the loss of energy is involved ? 10+10 = 20

3. (a) (i) Describe Michelson-Morley experiment. What implications do you draw from it ?

(ii) In a Michelson-Morley experiment if the effective length of each path is 6 meter and light has 6000 A. U. wavelength, what is the expected fringe shift if velocity of earth v is 3×10^4 m/sec. 12+8 = 20

(b) (i) Show that when $v << c$, Lorentz transformation reduces to Galilean transformation.

(ii) Derive an expression for the Kinetic energy of a relativistic particle. Hence, deduce the Einstein's mass energy relation. 10+10 = 20

(c) Show that when a particle moves with a uniform speed round a circle, the motion of the foot of the perpendicular drawn from the positions of the particle on a diameter of the circle is simple harmonic. Show that the sum of K. E. and P. E. of a particle executing SHM is constant. 20

4. (a) What is quarter wave plate ? Explain its action in producing circularly and elliptically polarised light. Show that if two coherent beams of circularly polarised light, one left handed and the other right handed are superimposed, the resultant is plane polarised. 20

(b) Discuss the properties of Cornu's spiral and explain its use in the quantitative study of diffraction pattern due to a straight edge. 20

(c) State the fundamental condition of interference of light. Describe the Michelson's interferometer. How will you use it to demonstrate that the sodium D line is really double ? 20

SECTION – B

5. (a) (i) Find the potential due to a uniformly magnetised sphere at an external point.

(ii) Define magnetic shell. Deduce an expression for the potential due to a magnetic shell at a point outside the shell. 10+10 = 20

(b) (i) Derive Poisson equations. In what way it is different from Laplace Equation ?

(ii) Explain electric multiple. Obtain expression for the potential due to a linear quadruple. 10+10 = 20

(c) State and explain Faraday's Laws of electromagnetic inductions, show that $\nabla \times E = -\frac{\partial B}{\partial t}$. Is there any difference between induced electric field and field due to static changes ? 20

(d) Deduce the values of electric field and potential of a dipole. Find the potential energy of an electric dipole in an external electric field. 20

6. (a) Derive the laws of reflection and refraction at the boundary of two dielectric media for a plane E. M. wave. Find the amplitude of the reflected wave. 20

(b) State Biot Savart law for the intensity of the field due to a current carrying conductor. Deduce the magnetic field due to a current flowing in a straight conductor of infinite length. 20

(c) What Planck's law of radiation ? Prove that if radiation of a particular wavelength corresponding to a definite temperature is adiabatically altered to another wavelength the temperature changes in the inverse ratio. 20

7. (a) What are Maxwell's Thermodynamical Relations ? Deduce Clapeyron's equation. How does it explain the effect of pressure on the boiling point of liquids ? 20

(b) What do you understand by dispersion? Discuss it for gaseous substance and show that refractive index is given by $n^2 = A + \frac{B}{\lambda^2} + \frac{C}{\lambda^4}$, where A, B, C are constant and λ, wavelength of incident light. 20

(c) Write short notes on the following : 7+6+7 = 20

(i) Rayleigh Scattering

(ii) Adiabatic Demagnetisation

(iii) Gibb's Paradox

8. (a) Find the true mean value and root mean square value of an alternating current. An alternating emf is applied to a pure inductance. Find the phase relationship in current and emf. 20

(b) What is gauge invariance ? Show that Lorentz and Coulomb gauges are invariant. Using the Maxwell's relations, show the equation of continuity $\nabla \cdot J = -\frac{\partial \rho}{\partial t}$. 20

(c) Define adiabatic, isochoric and isobaric process. Deduce that the entropy of a perfect gas remains constant in a reversible process but increases in an irreversible process. 20