CSM : 17

PHYSICS
PAPER - I

Time Allowed : 3 hours Full Marks : 100

Marks for each question is indicated against it.

Attempt any 5 (five) questions taking not more than 3 (three) questions from each Part.

PART - A

1. (a) State Kepler's laws of planetary motion. **(2+2+2=6)**

(b) Define the following: **(3×2=6)**

(i) Gravitational field

(ii) Gravitational potential

(iii) Gravitational self-energy

(c) Find the gravitational potential due to a spherical shell bonded by spheres of radii *a* and *b* at a point inside the shell. **(8)**

2. (a) Show that kinetic energy and momentum of the torque free motion of a rigid body is constant. **(6)**

(b) if $\vec{r}$ is the radius vector joining a particle of mass *m* with the centre of force and *A* is the area swept by the radius vector, show that **(6)**

$$\frac{dA}{dT} = \frac{1}{2m}\vec{j}$$

where $\vec{j}$ is the angular momentum of the particle about the force.

(c) State Hooke's law. Derive formula for inter relationship of elastic constants for an isotropic solid. Show that Poisson's ratio is less than 0.5 but cannot be less than -1. **(1+5+2=8)**

3. (a) Explain with a neat diagram the Michelson-Morley experiment. What conclusion can be drawn from this experiment? **(8+2=10)**

(b) Derive the formula for relativistic addition of velocities on the basis of Lorentz transformation. **(5)**

(c) Deduce mass-energy relation in relativistic mechanics. **(5)**

4. (a) Prove that the work done by a thermodynamic system depends not only on the initial and final states but also on the path of the process, whereas the internal energy function is independent of the path. **(4)**

(b) Derive Clausius – Clapeyron equation from thermodynamic relations. **(8)**

(c) Prove the following thermodynamic relations: **(4+4=8)**

(i) $\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$

(ii) $Tds = C_V dT + T\left(\frac{\partial P}{\partial T}\right)_V dV$

PART - B

5. (a) Explain the meaning of forced oscillations? Find an expression for the amplitude at resonance in the case of a damped vibration. **(1+6=7)**

(b) State Fermat's principle. Show how reflection and refraction can be established using Format's Principle. **(1+3+3=7)**

(c) Explain the terms spherical and chromatic aberrations. Give the methods to reduce spherical aberration. **(2+2+2=6)**

6. (a) Explain the construction of a plane transmission grating. Find the resultant intensity of the diffracted beams when parallel rays fall on a plane diffraction grating and hence deduce condition for principal maxima and secondary maxima. **(2+4+4=10)**

(b) Explain the meaning of Fresnel's half period zones/ Why are they so called? What is the phase difference between wavelets from successive half-period? Show that the amplitude due to complete wave front is half of what it would be caused by the first zone. **(2+1+2+5=10)**

7. (a) Develop Laplace's and Poisson equations. Give the significance of Laplace's equation. Show that the potential function given by $V=x^2+y^2-2z^2$ satisfies Laplace's equation. **(2+2+2+4=10)**

(b) A point charge +q is placed at a distance d from the centre of an earthed conducting sphere of radius R. Apply the method of electric images to calculate (a) field on the sphere, (b) strength and position of the image charge (c) surface charge density induced on the sphere. **(4+4+2=10)**

8. (a) Write down Maxwell's electromagnetic field equations and explain the physical significance of each. Show that for a plane electromagnetic wave in free space, the unit vector in the direction of propagation, the electric field vector and the magnetic field vector are mutually perpendicular. **(7)**

(b) The electric field **E** of a plane wave in air is given by

$\mathbf{E} = 4\times10^{-6}\ \cos(10^7\pi t - kz)\mathrm{i} + 4\times10^{-6}\sin\left(10^7\pi t - kz\right)j$ Volts/m. Find the values of k, the magnetic field intensity and the pointing vector. **(7)**

(c) What is magnetic vector potential? Derive an expression for magnetic vector potential. **(2+4=6)**

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