RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. THIRD SEMESTER EXAMINATION, MARCH 2021

SECOND YEAR [BATCH 2019-22]

Date : 20/03/2021 **PHYSICS (GENERAL)**

Time : 11 am - 1 pm **Paper : III** Full Marks : 50

Group - A

Answer **any three** questions: [3× 10]

1. a) Prove that $\left[\left(\vec{B}\times\vec{C}\right)\cdot\left\{\left(\vec{C}\times\vec{A}\right)\times\left(\vec{A}\times\vec{B}\right)\right\}\right] = [\vec{A}\cdot(\vec{B}\times\vec{C})]^2$. [2]

   b) The temperature at any point in space is given by $T = xy + yz + zx$. Determine the directional derivative of T in the direction of the vector $3\hat{\imath} - 4\hat{k}$ at the point $(1,1,1)$. [2]

   c) If $\vec{A} = 3xyz^2\hat{\imath} + 2xy^3\hat{\jmath} - x^2yz\hat{k}$ and $\varphi = 3x^2 - yz$, find $\vec{A}\cdot\vec{\nabla}\varphi$ and $\vec{\nabla}\cdot(\varphi\vec{A})$. [2+2]

   d) Verify whether the force $\vec{F} = (3x - 4y - 3z^2)\hat{\imath} + (4x + 2y + 2z)\hat{\jmath} + (xz - 4y^2 + 2x^3)\hat{k}$

   is conservative. [2]

2. a) Determine the moment of inertia of a solid cylinder about an axis perpendicular to the axis of the cylinder and passing through the diameter of its flat surface. [3]

   b) A particle of mass m moves along the space curve defined by $\vec{r} = a\cos\omega t\,\hat{\imath} + b\sin\omega t\,\hat{\jmath}$. Find (i) the torque and (ii) the angular momentum about the origin. [3]

   c) A student sits on a freely rotating stool holding two weights, each of which has a mass 3 kg. When his arms are extended horizontally, the weights are 1 m from the axis of rotation and he rotates with an angular speed of 0.75 rad/s. The moment of inertia of the student plus stool is 3 kgm^2 and is assumed to be constant. The student pulls the weights inward horizontally to a position 0.3 m from the rotational axis. Find (i) the new angular speed of the student and (ii) the kinetic energy of the system before and after he pulls the weights inwards. [2+2]

3. a) An *xyz* coordinate system rotates with angular velocity $\vec{\omega} = \cos t\,\hat{\imath} + \sin t\,\hat{\jmath} + \hat{k}$ with respect to a fixed *XYZ* coordinate system having the same origin. If the position vector of a particle is given by $\vec{r} = \sin t\,\hat{\imath} - \cos t\,\hat{\jmath} + t\hat{k}$ in the *xyz* coordinate system, then find (i) the apparent velocity, (ii) the true velocity, (iii) the apparent acceleration, (iv) the Coriolis acceleration and (v) the centripetal acceleration. [1+1+1+1+1]

   b) A steel stud (Shear Modulus, S = 8.27 x 10^{10} Pa) of 1 cm in diameter projects 4 cm from the wall. A 36,000 N shearing force is applied to the end. What is the deflection of the stud ? (Give answer in mm). [3]

   c) A hydrostatic press contains 5 litres of oil. Find the decrease in volume of the oil if it is subjected to a pressure of 3000 kPa. (Assume Bulk Modulus = 1700 MPa). [2]

4. a) A gold wire 0.32 mm. In diameter, elongates by 1 mm., when stretched by a force of 330 gm.wt., and twists through 1 radian, when equal and opposite torques of 145 dyne-cm are applied at its ends. Find the value of Poisson's ratio of gold. [4]

   b) A brass bar 1 cm. square in cross-section is supported on two knife edges 100 cms. apart. A load of 1 k.gm. at the centre of the bar depresses that point by 2.51 mm. What is Young's modulus for brass? [3]

   c) The breaking stress of Aluminium is 7.5 x 10^8 dynes cm^{-2} and of Copper, 22 x $l0^8$ dynes/cm^{-2}. Find the greatest lengths of the two wires that could hang vertically without breaking. Density of Aluminium = 2.7 gms./c.c. and of Copper = 8.9 gms/c.c. [3]

5. a) A gas bubble of diameter 2 cms., rises steadily through a solution of density 1.75 gms./c.c. at the rate of 0.35 cms /sec. Calculate the coefficient of viscosity of the solution. (Neglect the density of the gas). [3]

   b) Water is escaping from a cistern by way of a horizontal capillary tube, 10 cms. long and 0.4 mm. in diameter, at a distance of 50 cms, below the free surface of water in the cistern. Calculate the rate at which the water is escaping. [3]

   c) A capillary tube of radius 'a' and length L is fitted horizontally at the bottom of a cylindrical flask of cross-section area A. Initially there is water in the flask up to a height h. What time would be required for the liquid to flow out, if the coefficient of viscosity of liquid is η? [4]

Group - B

Answer **any two** questions: [2× 10]

6. a) What is Fermat's principle? Determine, from the principle, the laws of reflection of light at plane surface. [1.5+3.5]

   b) Find the equivalent focal length of two thin co-axial convex lenses separated by a a distance . Find also the position of the equivalent lens. [5]

7. a) Deduce the relation $\frac{\mu}{v} - \frac{1}{u} = \frac{\mu-1}{R}$ for refraction at spherical surface and hence deduce the formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$,where symbols have usual meaning. [5]

   b) Distinguish between lateral and longitudinal spherical aberration. Prove that the focal length of a plano-concave glass lens is equal to twice the radius of curvature of its concave surface. $\mu_{glass} = 1.5$ [5]

8. a) What is Fresnel's half period zone and how is it formed? Write down two differences between Fresnel and Fraunhofer class diffraction. [3+2]

   b) Define plane polarized and circularly polarized light. [2]

   c) What is double refraction? Define positive crystal and negative crystal. [3]

9. a) Explain the terms “spatial coherence” and “temporal coherence” with reference to Young’s double slit experiment for interference pattern. [5]

b) Give the theory of Newton’s rings to determine the wavelength of monochromatic light. [5]

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