RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. THIRD SEMESTER EXAMINATION, MARCH 2022

SECOND YEAR [BATCH 2020-23]

Date : 09/03/2022

PHYSICS (GENERAL)

Time : 11 am – 1 pm

PAPER : III

Full Marks : 50

Answer **any five** of the following Questions: [5×10]

1. Given $\vec{F} = xy\hat{\imath} - xz\hat{\jmath} + xy^2z\hat{k}$ and $\varphi = x(y^2 - 3zx^2)$ then find (i) $div(\vec{F})$, (ii) $Curl(\vec{F})$, (iii) $grad(\varphi)$ (iv) $div\{grad(\varphi)\}$ (v) $Curl(Curl(\vec{F}))$ [2+2+2+2+2]

2. Using two suitable reference frame define Coriolis force for mass m with proper justification. In continuation derive centrifugal force. [5+5]

3. a) Find moment of inertia (I) of a ring and a disk about their diameters having same mass and radius. Which one is more and why?

   b) An oscillator of mass 0.01 kg draws maximum power at a frequency of 96 Hz with half power points at 93 Hz and 99 Hz. If the maximum average power drawn by the oscillator is 20 W, calculate (i) resonant frequency ω_0, (ii) Q-factor, (iii) the damping factor γ, (iv) the amplitude of the driving force F_0 and (v) the amplitude of the oscillator at $\omega = \omega_0$. [5+5]

4. a) A particle oscillates with simple harmonic motion of amplitude 4 cm and a frequency 5 Hz. At time $t = 0$ the particle is at its equilibrium position ($\psi = 0$)

   i) Write down the equation describing the position of the particle as a function of time in the form $\psi = A\cos(\omega t + \varphi)$, giving the numerical values of A, ω and φ.

   ii) What are the values of ψ, $\frac{d\psi}{dt}$ and $\frac{d^2\psi}{dt^2}$ at $t = \frac{10}{3}$s?

   b) A particle is vibrating in SHM with an amplitude of 10 cm. What fraction of the total energy is kinetic when the displacement of the particle from the mean position is 5 cm? At what displacement is the energy half kinetic and half potential?

   c) A system is subjected to a resistive force $F = -pv$, where p is a constant and v is the velocity. The system is at rest initially when a velocity of 6.8 cm/s is given to it. If $k = 10$ Nm^{-1}, $m = 10$ kg and $p = 8$ Ns/m, determine the subsequent displacement and velocity of the mass. [(1+3)+2+4]

5. a) Young's modulus of a substance is equal to 7×10^{11} dyne/cm^2 and the rigidity modulus for the same substance is equal to 3×10^{11} dyne/cm^2. Calculate the bulk modulus of elasticity and Poisson's ratio of the substance.

   b) A cylinder of radius r and length l is recast into a pipe of same length. If the pipe possesses torsional rigidity which is 19 times greater than that of the original cylinder, calculate the inner radius of the pipe.

   c) A spherical ball of radius 1 mm and density 10^4 kg/m^3 falls freely under gravity through a distance h before entering a tank of water. If after entering the water, the velocity of the ball does not change, find h. The coefficient of viscosity of water is 9.8×10^{-4} Ns/m^2.

   d) Water flows through a horizontal tube of length 20 cm and internal radius 0.081 cm under a constant head of the liquid of 20 cm high. In 12 minutes 864 cc of liquid issue from the tube. Calculate the viscosity of water and verify that the condition of streamline flow exist. Given that Reynold's number $R = 1000$. [2+3+2+3]

6. a) Establish the relation $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{r}$ for refraction at a spherical surface and prove the formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$.The symbols have usual meaning.

   b) Two thin convex lenses of 20 cm and 10 cm focal lengths are placed co-axially 10 cm apart in air. Find the equivalent focal length and the position of the equivalent lens. [5+5]

7. a) Considering the superposition of two light waves show that resultant intensity at a point in the region of overlapping is given by $I = I_1 + I_2 + 2\sqrt{I_1 I_2}cos\delta$, where the symbols have their usual meaning . Which term is called the interference term? Why is so called?

   b) Which condition is to be satisfied in order to observe sustained interference effect?

   c) In Young's double slit arrangement distance between the slits is 0.5 mm and wavelength of the light is 600 nm. At what distance the screen should be placed in order to get fringes of width of 1 mm? [5+2+3]

8. a) What is Fresnel's half period zone and how is it formed? Write down two differences between Fresnel and Fraunhoffer class diffraction.

   b) Define plane polarized and circularly polarized light.

   c) What is double refraction? define positive crystal and negative crystal. [(3+2)+2+(1+1+1)]

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