RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. SECOND SEMESTER EXAMINATION, MAY 2019

FIRST YEAR (BATCH 2018-21)

Date : 27/05/2019 **PHYSICS (General)**

Time : 11.00 am – 1.00 pm **Paper : II** Full Marks : 50

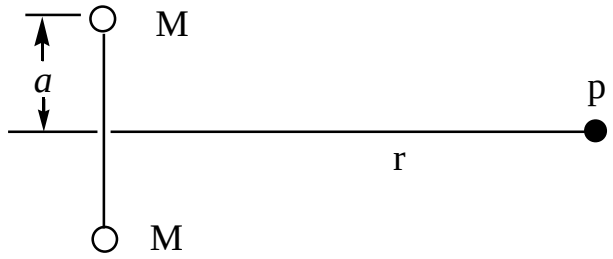
[Use a separate Answer Book for each group]

Group – A

Answer **any seven** questions of the following: [7×5]

1. a) A rod of length 30cm has linear density (mass per length) given by $\lambda = 50\ \text{g/m} + 20x\ \text{g/m}^2$, where x is the distance from one end, measured in meters.
   i) What is the mass of the rod?
   ii) How far from $x = 0$ end is its centre of mass? (2)
   b) i) Show that the total linear momentum of a system of particles about the centre of mass is zero. (1)
   ii) Show that the total angular momentum of a system of particles about any point equals the angular momentum of the total mass assumed to be located at the centre of mass plus the angular momentum about the centre of mass. (2)
2. a) What is the physical significance of moment of inertia? (1)
   b) Two particles of masses m_1 and m_2 respectively are connected by a rigid massless rod of length a and move freely in a plane. Show that the moment of inertia of the system about an axis perpendicular to the plane and passing through the centre of mass is μa^2 where the reduced mass $\mu = \dfrac{m_1 m_2}{m_1 + m_2}$. (2)
   c) State and prove the perpendicular axes theorem of moment of inertia. (2)
3. Calculate the moment of inertia of a solid sphere rotating about its diameter. (5)
4. a) What do you mean by conservative force? Explain with example. (2)
   b) i) Show that the force field of $\vec{F} = -m\omega^2\left(x\hat{i} + y\hat{i}\right)$ is conservative.
   ii) Find the potential energy for this force field.
   iii) Find the work done by the force in moving a particle from r = a to r = b. (1+1+1)
5. a) Write down the equation of motion for a particle moving in a central force in plane polar coordinates. (1)
   b) Show that the total energy for a particle moving under central force is a constant of motion. (2)
   c) State and prove Kepler's first law. Hint: Eccentricity of a conic section is related to total energy E and angular momentum L by the relation $\varepsilon = \sqrt{1 + \dfrac{2EL^2}{G^2M^2m^3}}$. (2)
6. a) What is radial velocity? For a particle moving under a force $\vec{F} = \hat{r}f\left(r\right)$, show that radial velocity is constant. (1+1)
   b) State and prove Kepler's third law. (1+2)
7. a) Define gravitational field and gravitational potential. (2)

b) Compute the magnitude and direction of the gravitational field at a point P on the perpendicular bisector of two equal masses separated by a distance 2*a*, as shown in the figure. (2)



c) Calculate the mass of the Earth, using the fact that the radius of the Earth is 6.38×10^6 m and $G = 6.67 \times 10^{-11} \text{Nm}^2/\text{kg}^2$. (1)

8. If the displacement equation of an SHM be $x = a\sin(\omega t + \phi)$; show that the velocity *v* and acceleration f satisfy $\omega^2 v^2 + f^2 = a^2\omega^4$ (5)

9. a) A wave is represented by the expression: $\phi(x,t) = f_1(vt + k) + f_2(vt - k)$, where v is the velocity of the wave. Obtain the differential equation of the wave.

   b) What type of wave is represented by the above expression? (4+1)

10. a) What is damped vibration? Write the differential equation of damped vibration. (1+1)

    b) A wooden cylinder of mass M and cross sectional area α is floating in equilibrium vertically in a liquid of density ρ. If the cylinder is depressed slightly and is then released, show that the cylinder undergoes SHM with time period $T = 2\pi\sqrt{\dfrac{m}{\rho\alpha g}}$. (3)

11. Find the velocity of plane longitudinal waves in a solid medium. Find the average energy per unit volume of a progressive wave. (5)

Group – B

Answer **any three** questions of the following : [3×5]

12. How Newton's rings are formed? Derive the relation for the diameter of dark rings. (2+3)

13. a) What is Fraunhofer diffraction? (1)

    b) With a suitable diagram explain Fraunhofer diffraction in a single slit. Write and draw the intensity distribution. (2+1+1)

14. What is a zone plate? Derive an expression for its focal length. (1+4)

15. a) What is meant by double refraction? (2)

    b) A beam of linearly polarized light is changed into circularly polarised light by passing it through a sliced crystal of thickness 0.003 cm. Calculate the difference in refractive indices of the two rays in the crystal assuming this to be of minimum thickness that will produce the effect (given $\lambda = 6 \times 10^{-7} m$). (3)

16. a) What is optical activity. Define specific rotation in this context. (1+1)

    b) A certain length of 5% solution causes an optical rotation of 20^o. How much length of 20% solution of the same substance will cause a rotation of 35^o? (3)

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