RAMAKRISHNA MISSION VIDYAMANDIRA

(A Residential Autonomous College under University of Calcutta)

First Year, Second Semester (January – June), 2011

Mid-Semester Examination, March, 2011

PHYSICS (Honours)

Date : 9 March 2011 Full Marks : 50

Time : 11am – 1pm

1. a) Obtain the Galilean transformation equations between two inertial frames in uniform relative motion, starting clearly assumptions you make. Hence find how the kinetic energy of a particle transforms under G.T. [4]

   b) Show that the two body (sun-planet) system interacting gravitationally is equivalent to a one-body central force motion of a particle of reduced mass μ, given by $\frac{1}{\mu} = \frac{1}{m} + \frac{1}{M}$ where M is mass of sun and m is mass of planet. [3]

   c) If the orbit in above question (b) is a circle of radius R and time period T, show that $T^2 = \frac{4\pi^2 R^3}{G(m+M)}$ where G is universal gravitational constant. [3]

OR,

1. a) A particle of mass m is projected from infinity with a velocity u towards a fixed centre of a repulsive inverse-square force, $\frac{k}{r^2}$ if p is the impact parameter, show that the distance of closest approach to the force centre is $r_0 = \frac{k}{mu^2} + \sqrt{p^2 + \left(\frac{k}{mu^2}\right)^2}$. [4]

   b) i) Define moment of inertia of a rigid body about an arbitrary axis $\hat{n}$ passing through a given point of the body. [2]

   ii) Using (i) obtain expressions for the moment of inertia I_x, I_y, I_z about x, y and z axes, and find their sum. [2]

   iii) Show that for a planar body, $I_x + I_y = I_z$. [2]

2. Find the velocity and acceleration of a particle in spherical polar and cylindrical polar coordinates. [6+4]

OR,

2. a) What do you mean by time integral and path integral of a force. Hence prove work-energy theorem. [2+2]

   b) What is a conservative force? Show that the total mechanical energy of a particle in a conservative force field remains constant if the potential energy is not an explicit function of time and velocity. [3]

   c) Prove that the following force field is conservative and find the corresponding potential function $\vec{F} = (2xy + z^2)\vec{i} + x^2\vec{j} + 2xz\vec{k}$. [3]

3. a) A cylindrical wire of length L and radius R is fixed at one end and twisted at the other end. Deduce an expression for torsional rigidity of the material of the wire. [4]

   b) Explain why a hollow shaft is much stronger than solid shaft. [3]

OR,

3. a) What do you understand by internal bending of a beam? [2]

   b) Deduce an expression for it. [5]

4. a) What do you mean by gravitational potential at a point? Find an expression for the gravitational potential due to a spherical shell at a point outside the shell. Use this relation to find the potential due to a uniform solid sphere at an external point. [1+3+1]

   b) Find the potential due to a circular disc of uniform surface density σ and radius *a* at a point on its circumference. [3]

OR,

4. a) Calculate the gravitational intensity due to a thin spherical shell of radius *a* and mass M at an external point. Hence find the intensity at an external point due to a solid sphere of radius a whose density varies as $\rho = \rho_0 r$ for $0 < r < a$ and $\rho_0 = 0$ for $r > a$. [3+2]

   b) From a uniform solid sphere of radius a and mass M, a small spherical part with diameter as the radius of the larger sphere is removed. Calculate the potential and intensity at an external point P such that the centres of the spheres and P lie on the same straight line. [3]

5. For a stretched string of length l the displacement is given by $y(x,t) = \sum_{n=1}^{\infty} C_n \sin\frac{n\pi x}{\ell}\cos(\omega_n t - \theta_n)$ where the symbols have their usual significance. Show that the total energy of the string is $E = \frac{M}{4}\sum_n \omega_n^2 c_n^2$, where M is the mass of the string. [5]

6. a) Starting from equation of damped vibration, show that in a damped vibration the motion will be oscillatory when the damping is small. [4]

   b) Show that if the damping force is constant magnitude, the frequency of vibration of a damped oscillator is not affected by the magnitude of damping. [3]

   c) Show that for a body in SHM the total energy is conserved. [3]

OR,

6. a) Show that in a forced vibration at steady state the power supplied by driving force fully spent in overcoming the damping force of the motion. [5]

   b) What is resonance? Distinguish between amplitude resonance and velocity resonance. When will be the two resonance frequencies be same? What is sharpness of resonance? [1+2+1+1]