RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous Degree College with P.G. Section under University of Calcutta)

B.A./B.SC. SECOND SEMESTER EXAMINATION, MAY 2011

FIRST YEAR

Date : 24/05/2011 **PHYSICS (Honours)**

Time : 11am – 2pm Paper : II Full Marks : 75

[Use Separate Answer Scripts for each group]

Group – A

Unit – I

Answer any three questions : [3×10]

1. a) Write down the Galilean transformation (G.T) equations between two inertial frames of references, and show that under a G.T. Newton's second law remains form-invariant. [3]
   b) Find expressions for the velocity and acceleration of a particle in cylindrical polar coordinates. Hence, obtain the corresponding expressions for a particle moving in a circle of radius R, with nonuniform angular velocity. [4]
   c) The bob of a simple pendulum moves on a vertical circle of radius R and when the string makes an angle θ with the downward vertical, the bob has a transverse velocity v, given by $v^2 = 2gR\cos\theta$, where g is a positive constant. Find the acceleration of the bob at this instant. [3]

2. a) A gun is fired straight up. Assuming that air drag on the bullet varies quadratically with speed, show that when the bullet hits the ground on its return its speed is equal to $v_0 v_t / (v_0^2 + v_t^2)^{1/2}$, where v_0 is initial upward speed and v_t is terminal speed. [7]
   b) Find the centre of mass of a uniform solid hemisphere of radius R. [3]

3. a) At some point its trajectory a ballistic missile of mass m breaks into three fragments of mass m/3 each. One of the fragments continues on with an initial velocity of one-half the velocity $\vec{v}_0$ of the missile just before breakup. The other two go off at right angles to each other with equal speeds. Find the initial speed of the latter two fragments. [6]
   b) Show that the angular momentum of a system of particles can be written as a sum of angular momentum for the motion of centre of mass and angular momentum for the motion about centre of mass. [4]

4. a) Set up the equation of motion of a body of variable mass m(t), moving in a force field $\vec{F}$, using the impulse-momentum theorem. [3]
   b) Use (a) to set up the equation of motion of a rocket ascending vertically upward from the earth. For a constant rate of burning of the fuel, what must be the minimum exhaust velocity of the gas for the rocket to ascend? [4]
   c) A particle moves in a spiral orbit $r = a\theta$. If θ increases linearly with time t, is the force a central field? If not determine how θ must vary with t for a central force. [3]

5. a) Calculate the inertial coefficients of a uniform rectangular plate of mass M and sides 4cm and 3cm, choosing the origin of the coordinates at any corner A of the plate. [3]
   b) Suppose the plate rotates about the diagonal through A with angular velocity $\vec{\omega}$, find the kinetic energy of rotation in terms of the inertial coefficients, I_{ij}. [3]
   c) A turntable rotates with a uniform angular velocity $\vec{\omega}$ around a vertical axis of symmetry through the centre. A man is trying to walk towards the centre with a constant speed v relative to the turntable, along a radius. What are the forces exerted on the man by the turntable? How should the man adjust to these forces? (assume the necessary formulas). [4]

Unit – II

Answer <u>any two</u> questions : [2×10]

6. a) Show that the depression of a cantilever at any point P due to a load at Q is the same as that at Q when the load is applied at P where Q represents the free end of the Cantilever. [6]
   b) For a homogeneous isotropic body show that $Y = 3K(1-2\sigma)$, where symbols have their usual meanings. [4]

7. a) A vessel has a hole of radius r at its bottom. Show that a liquid kept inside will come out of the vessel if its depth exceeds $h = 2T/\rho rg$, where T is the surface tension of the liquid and other symbols have their usual meanings. [3]
   b) What are streamline and turbulent flows? What do you mean by critical velocity in this respect? [3]
   c) A constant pressure difference P is maintained between two ends of a capillary tube of length ℓ and radius r. The tube is filled with water under steady condition find the velocity of water flow as a function of r. [4]

8. a) State and prove Gauss' theorem for a gravitational field due to a given mass distribution. [4]
   b) Two bodies of masses m_1 and m_2 are separated by a distance d. Prove that at the point where the value of gravitational intensity is zero, the potential is $V = -\frac{G}{d}(m_1 + m_2 + 2\sqrt{m_1 m_2})$ [3]

   Or,

   Two bodies A and B each of mass M, are placed at a separation 2d. A body of mass m is placed at C, at distance x on the perpendicular bisector of AB. Find the gravitational force on m, as a function of x. At what value of x is this force a maximum? [3]
   c) Calculate the amount of work done in scattering the constituent particles of a homogeneous sphere of mass 10kg and radius 10cm to infinity against their mutual gravitational attraction.
   Given G = $6{\cdot}67 \times 10^{-8}$ C.G.S unit. [3]

9. a) Set up Euler's equation of hydrodynamics for an incompressible fluid. [5]
   b) Use Euler's equation to set up Bernoulli's equation for steady streamline motion of an incompressible fluid. What conservation principle does Bernoullie's Theorem imply? [5]

<u>Group – B</u>

Answer <u>any two</u> questions from Q.No 10,11,12 [2×10]

10. a) Show that the velocity of acoustic waves travelling along a solid rod is $\sqrt{\frac{Y}{\rho}}$ where Y is Young's modulus and ρ is the density of the solid. [4]
   b) An intense plane harmonic wave in air at STP has an excess pressure of $10N/m^2$. The frequency is 1 KHz and the phase velocity $350m/s^2$. Calculate the maximum particle displacement. Given $\gamma = 1{\cdot}4$. [2]
   c) Show that the energy density of a progressive wave is half kinetic and half potential. [4]

11. a) State the conditions to be fulfilled for the production of sustained interference fringes. Is light energy destroyed in the region of destructive interference? [4]
   b) In Young's double slit experiment, derive an expression for the intensity of the interference pattern. Plot intensity distribution and find the conditions for constructive and destructive interference. [6]

12. a) Starting from one dimensional differential equation show that a string of infinite length can sustain any arbitrary frequency of vibration, but when the string is of finite length and rigidly fixed at both ends only certain discrete frequencies can be excited in it. [5]

b) The stationary wave on a string is represented by $y = 0{\cdot}3 \sin 4x \cos 500t$ meter

Calculate the distance between consecutive nodes and velocity of the wave. [2]

c) What are eigen values and eigen functions? Explain the conditions of orthogonality of eigen functions relevant to string vibration. [3]

Answer <u>any one</u> question from Q.No. 13 &14 [1×5]

13. a) When is the amplitude of forced vibration infinite? Is it possible in reality? What is called quality factor Q in forced oscillations? [3]

b) What are beats and combination tones? [2]

14. The dispersion relation for microwaves in ionosphere is given by, $\omega^2 = \omega_p^2 + c^2k^2$

where c is the velocity of light in free space and ω_p is a constant depending on the electron density of the ionosphere. Show that the phase velocity $c_P > c$ but group velocity $v_g < c$. [5]