RAMAKRISHNA MISSION VIDYAMANDIRA

(A Residential Autonomous College under University of Calcutta)

First Year

First-Semester Examination, December 2010

Date : 21-12-2010 **PHYSICS (General)** Full Marks : 50

Time : 11am – 1pm **Paper - I**

(Use separate answer script for each group)

Answer any five questions taking at least two from each group.

Group – A

1. a) If $\vec{A} = \hat{i} + 2\hat{j} - 3\hat{k}$ and $\vec{B} = 3\hat{i} - \hat{j} + 2\hat{k}$, find the angle between $\vec{A} + \vec{B}$ and $\vec{A} - \vec{B}$ [2]

   b) Show that $\vec{A} = 3y^4z^2\hat{i} + 4x^3z^2\hat{j} - 3x^2y^2\hat{k}$ is solenoidal whereas $\vec{B} = (6xy + z^3)\hat{i} + (3x^2 - z)\hat{j} - (3xz^2 - y)\hat{k}$ is irrotational. [1+2]

   c) Let a force $\vec{F} = 2\hat{i} - 3\hat{j} + 5\hat{k}$ is acting at a point A(2, –1, 3). Find the moment of the force about the point B(–1, 2, 1) [3]

   d) State Gauss' divergence theorem in vector calculus. [2]

2. a) For a particle of fired mass m moving under a force $\vec{F}$ show that $\frac{dT}{dt} = \vec{F}.\vec{v}$, where T = kinetic energy and $\vec{v}$ = velocity of the particle. [2]

   b) Find out the expression for the maximum velocity attained by a rocket shot vertically upward from rest in a uniform gravitational field in terms of the mass of the empty rocket (M), initial mass of the fuel (m) and the time required (T) for the total fuel to be used up. [6]

   c) A particle is moving in a plane in such a way that its instantaneous co-ordinates (r, θ) are given by r = 2t + 3 and $\theta = 3t - t^2$, where t is time. Find the radial and cross-radial components of velocity. [2]

3. a) State and prove the perpendicular axes theorem for moment of inertia of a plane laminar body. [2+3]

   b) Derive an expression for moment of inertia of a solid cylinder about an axis passing through centre of mass and perpendicular to its own axis. [3]

   c) A circular disc of mass 100 gm and diameter 4 cm rolls without slipping with velocity 5 cm/sec. Calculate the kinetic energy of translation and rotation. [1+1]

4. a) What do you mean by conservative force? [2]

   b) Calculate the gravitational potential and intensity due to a solid sphere at a point inside a solid sphere. [4]

   c) Prove that the least velocity with which a particle must be projected from the surface of a planet so that it may go beyond its gravitational field is given by $R\left(\frac{8\pi G\rho}{3}\right)^{1/2}$, where G, R and ρ are the gravitational constant, the radius and the mean density of the planet respectively. Calculate its value for earth where R = 6400 km and g = 9·8 m/sec^2. [2+2]

Group – B

5. a) Write down the basic assumptions of the Kinetic Theory of gases and obtain the expression for pressure of an ideal gas. [2+4]

   b) State the law of equipartition of energy. [2]

   c) The average kinetic energy of molecules of hydrogen at 0°C is $5{\cdot}64\times10^{-21}$ J. If molar gas constant (R_0) = 8·31 J/K, calculate Avogadro's number. [2]

6. a) Distinguish between isothermal and adiabatic processes. Deduce the relation between volume and temperature of a perfect gas in an adiabatic change. [2+3]

   b) Write down the second law of thermodynamics according to Kelvin-Planck. [2]

   c) The efficiency of a Carnot engine is 25% when the temperature of the sink is 102°C. Using the same source, what would be the temperature of the sink to obtain an efficiency of 50%? [3]

7. a) What is Boyle temperature? Find an expression for it for a Vander Waals' gas. [1+3]

   b) Derive Fourier equation for one-dimensional heat flow through a conductor. [3]

   c) Two metal plates having thickness d_1 and d_2 and conductivities K_1 and K_2 respectively are placed in contact side by side to form a composite slab. Find the equivalent conductivity. [3]

8. a) Define emissive and absorptive power of a body.

   State Stefan-Boltzmann's law of black body radiation. How can Newton's law of cooling be deduced from it? [2+2+2]

   b) If the sun radiates maximum energy at wavelength of 500nm, calculate its temperature. Given Wien's constant = 3×10^{-3}mK. [2]

   c) Calculate the change in entropy for the melting of 100 gram of ice. Given, latent heat of melting is 80 cal/gm [2]