BACHELOR OF ENGINEERING EXAMINATION, 2013

(1st Year, 1st Semester)

PHYSICS IB

Time : Three hours Full Marks : 100

Answer any ***five*** questions.

1. a) Determine the value of α so that

$\vec{A} = 2\hat{i} + \alpha\hat{j} + \hat{k}$ and $\vec{B} = 4\hat{i} - 2\hat{j} - 2\hat{k}$

are perpendicular to each other.

b) Determine a unit vector perpendicular to the plane of

$\vec{A} = 2\hat{i} - 6\hat{j} - 3\hat{k}$ and $\vec{B} = 4\hat{i} + 3\hat{j} - \hat{k}$

c) What is meant by gradient of a scalar function ? Show that $\vec{\nabla}\varphi$ is a vector perpendicular to the surface given by $\varphi(x,y,z) = C$, where C is a constant.

d) Determine the gradient of the scalar field $\varphi = \frac{1}{|\vec{r}|}$ where

$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$. 2+5+1+5+7

2. a) i) What is meant by a conservative vector field ?

ii) Show that a force $\vec{F}$ represented by

$\vec{F} = \left(2xy + z^3\right)\hat{i} + x^2\hat{j} + 3xz^2\hat{k}$

represents a conservative force.

iii) Find the work done in moving an object in this field from (1, –2, 1) to (3, 1, 4).

b) What is a central force ? Give an example. Show that the motion of a particle moving in a central force field lies in a plane and its angular momentum is conserved. 1+4+5+10

3. a) State and prove the parallel axes theorem. 6

b) i) Calculate the moment of inertia of a circular disc of uniform mass density about an axis passing through its centre and perpendicular to its plane.

ii) What will be its moment of inertia about any diameter ? Which theorem did you apply to arrive at your result ?

iii) How will the expression in 'b(i)' be modified in the case of an anular ring ? 6+5+4+5

4. a) What is viscous force ? Define coefficient of viscosity. Distinguish between streamline and turbulent flow. 6

b) Deduce poiseuille's equation for the streamline flow of a fluid through a narrow unifore tube stating the assumptions made. 9

c) A capillary tube 1 mm in diameter and 20 cms in length is fitted horizontally to a vessel kept full of alcohol of density 0.8 gm/cc. The depth of the centre of the capillary tube below the surface of alcohol is 30 cms. If the viscosity of alcohol is 0.012 cgs units, find the amount that will flow out in 5 minutes. 5

5. a) What is meant by the root mean square speed of the molecules of a gas ? Derive an expression connecting the pressure of an ideal gas with its density and the root mean square speed of its molecules.

b) What is the interpretation of temperature of a gas in kinetic theory ?

c) Assuming hydrogen molecules to obey the Maxwell's law of distribution of molecular speeds, calculate the most probable speed of hydrogen molecules at $0^{\circ}C$ and a pressure of 1 atmosphere. The density of hydrogen at $0^{\circ}C = 9\times10^{-2}$ $kg.m^{-3}$. 10+5+5

6. a) What do you mean by degrees of freedom of a dynamical system ? State the law of equipartition of energy. Show how you can use the law to calculate the specific heats of gases and hence find the ratio γ of specific heats for diatomic and triatomic gases.

b) Air at $0^{\circ}C$ and 1 atmosphere pressure has a density of $1.291 \times 10^{-3} gm/cm^3$ and the speed of sound in air is 332 m/sec. Calculate the ratio of specific heats of air.

c) State the zeroth law of thermodynamics. What is its significance ? 10+5+5

7. a) Explain what is meant by internal energy of a thermodynamic system – Is it a state function ?

b) One mole of an ideal gas expands adiabatically from an initial temperature T_1 to a final temperature T_2. Prove that the work done by the gas is $C_V(T_1-T_2)$, where C_V is the molar specific heat at constant volume. What is the change in internal energy of the gas ?

c) Apply the first law of thermodynamics to deduce that the difference of molar specific heats of a gas

$$C_P - C_V = \left[\left(\frac{\partial U}{\partial V}\right)_T + P\right]\left(\frac{\partial V}{\partial T}\right)_P$$

Hence show that for an ideal gas $C_P - C_V = R$. 4+6+10

8. a) A carnot engine absorbs an amount of heat Q_1 from the source at temperature T_1 and rejects an amount of heat Q_2 to the sink at temperature T_2. Calculate Q_1 and Q_2. Show that $Q_1/Q_2=T_1/T_2$.

b) In order to increase the efficiency of a carnot engine most effectively, would you increase T_1 keeping T_2 constant, or would you decrease T_2 keeping T_1 constant ? Give reasons for your answer.

c) What do you mean by the entropy of a thermodynamic system ? What will be the increase in the entropy of a system if an infitesimal amount of heat dQ is supplied to it reversibly at the temperature T ?

d) Show that when a substance of mass m having a constant specific heat c is heated from an initial temperature T_1 to a final temperature T_2 the entropy change is

$$S_2 - S_1 = mc\ln\left(T_2/T_1\right).$$ 10+3+4+3