No. of Printed Pages : 6

ET-105(A)

B.Tech. Civil (Construction Management) / B.Tech. Civil (Water Resources Engineering) / BTCLEVI / BTMEVI / BTELVI / BTECVI / BTCSVI

Term-End Examination

December, 2016

00572

ET-105(A) : PHYSICS

Time : 3 hours *Maximum Marks : 70*

Note : *All questions are* ***compulsory****. Symbols have their usual meanings. Use of scientific calculator is permitted. Assume missing data suitably, if any.*

1. Attempt any ***five*** of the following : *5×4=20*

(a) State Newton's second law of motion. When two bodies interact through their mutual interaction, show that their net momentum is conserved.

(b) Define centre of mass. Show that the kinetic energy of a system of particles can be written as the kinetic energy associated with the centre of mass motion and the kinetic energy of all the particles with respect to the centre of mass.

(c) How would you identify that a motion is a simple harmonic motion ? Show graphically the variation of displacement and velocity with time in a simple harmonic motion.

(d) State and prove Gauss' theorem.

(e) Calculate the force on a particle with charge $q = 5e$ and velocity 8000 m/s when the velocity makes an angle of 30° with a uniform magnetic induction of 0·25 T.

(f) State the relation between a conservative force and potential energy. A particle is subjected to a two-dimensional conservative force $\vec{F} = \hat{i}y + \hat{j}x$. If the total energy of the particle at the point (2, 2) is 4 J, what is its kinetic energy at that point ?

(g) Explain how polarized light can be produced by reflection.

(h) Write down the expression for the energy stored in a capacitor. Show that the energy density of a parallel plate capacitor is given by $u = \frac{1}{2}\varepsilon_0 E^2$.

2. Attempt any ***two*** parts of the following : *2×5=10*

(a) Calculate the centrifugal force experienced by a particle of mass m on the surface of the Earth. Take the radius of the Earth as $6{\cdot}4 \times 10^6$ m.

(b) A biker is travelling with a constant speed when he negotiates a turn of radius 147 m. If the coefficient of static friction between the bike tyres and the road is 0·5, calculate the maximum speed the biker can have without slipping.

(c) Two bodies, each of mass M, are situated at a distance r from each other. A mass m on the perpendicular bisector of the line joining the two bodies is at a distance d from the mid-point of the line. Calculate the magnitude and direction of the force on this mass.

3. Attempt any ***two*** parts of the following : *2×5=10*

(a) Show that the acceleration of a body may be written as

$$\vec{a} = \left[\frac{d^2r}{dt^2} - \omega^2 r\right]\hat{r} + \left[r\frac{d\omega}{dt} + 2\omega\frac{dr}{dt}\right]\hat{\theta},$$

where ω is the angular velocity of the body.

(b) Derive an expression for the moment of inertia of a uniform solid sphere about a tangent to its surface.

(c) State and explain Chasles' theorem. Show that the velocity of any point B on a body is given by $\vec{v}_B = \vec{v}_A + \vec{\omega} \times \vec{\rho}_{B/A}$

where $\vec{v}_A$ is the velocity of another point A and $\vec{\rho}_{B/A}$ is the position vector of point B with respect to A.

4. Attempt any ***two*** parts of the following : *2×5=10*

(a) A pendulum clock has a time period of 2 s. How fast would the clock be in 24 hours, if the length of the pendulum is decreased by 2% ?

(b) Show that the function f(x – vt) represents a wave propagating along the +ve x-axis.

(c) If a sinusoidal wave is generated in a string fixed at both the ends, show that the result is a wave given by

$$u_t(x, t) = 2u_0 \sin kx \cos \omega t.$$

What is the nature of this wave ? Show that this equation satisfies the wave equation

$$\frac{\partial^2 u}{\partial x^2} = \frac{1}{v^2} \frac{\partial^2 u}{\partial t^2}.$$

5. Attempt any ***two*** parts of the following : *2×5=10*

(a) State Coulomb's law. Four particles of equal charge q are located at the corners of a square of side a. Find the force on each of the particles.

(b) A thin spherical metallic shell of radius R carries a charge Q. At its centre is a point charge of the same magnitude and sign. Find the electric field at a distance of 2R and R/2 from the centre of the shell.

(c) How many 1 pF capacitors must be connected in parallel to store a charge 1 nC when the combination is to be connected to a battery of 10 V.

6. Attempt any ***two*** parts of the following : *2×5=10*

(a) State Biot-Savart's law. An infinitely long current i is lined along the z-axis. Show that the field at the point A(x, y) is given by

$$\vec{B}(x, y) = \frac{\mu_0 i}{2\pi}\left[\frac{-\hat{i}y + \hat{j}x}{x^2 + y^2}\right].$$

Would the divergence of this field be zero ?

(b) Calculate the kinetic energy of a proton moving undeflected in crossed fields of magnitude $E = 2$ k V/m and $B = 0{\cdot}01$ T.

(c) Derive the differential equation governing the flow of current in an LCR circuit. Discuss underdamped and overdamped cases.

Physical Constants :

Mass of a proton = $1{\cdot}67 \times 10^{-27}$ kg

Charge on an electron = $1{\cdot}6 \times 10^{-19}$ C

$\varepsilon_0 = 8{\cdot}85 \times 10^{-12}$ $C^2/N\text{-}m^2$

$\mu_0 = 4\pi \times 10^{-7}$ N/A^2

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ $N\text{-}m^2/C^2$