# B.Tech. Civil (Construction Management) / B.Tech. Civil (Water Resources Engineering)

## Term-End Examination

## June, 2011

## ET-105(A) : PHYSICS

04324

*Time : 3 hours* *Maximum Marks : 70*

***Note :*** *All questions are **compulsory**. Symbols have their usual meanings. Use of calculator is permitted.*

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**1.** Attempt *any five* of the following : **5x4=20**

(a) The distance of Mars from the Earth is 0.52 AU while that of Jupiter is 4.2 AU. If the orbital period of Mars is 1.88 years, find the orbital period of Jupiter.
1AU ($\equiv 1.5 \times 10^{11}$m) is the distance of the earth from the sun.

(b) A proton has a velocity of $4 \times 10^4 \hat{i}$ m/s. It enters an electric field

$\vec{E} = -835\hat{i} + 1670\hat{j}$ N/C. How far does the proton move in the $x$ direction before it comes to a stop ? At that instant how far has it travelled in the $y$ direction ?

(c) Find the moment of inertia of solid sphere of uniform density about any diameter and any tangent to its surface.

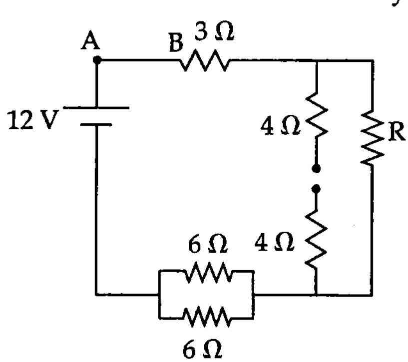
(d) The index of refraction of a substance is found to vary inversely as the wavelength in vacuum. Show that the group velocity is half the phase velocity.

(e) A 60 W bulb radiates energy equally in all the directions. Calculate the amplitude of the electric and magnetic fields at a distance of 1m from the bulb.

(f) A solenoid of length 10 cm has 400 turns. Its area of cross-section is 6 $cm^2$. Calculate the work done in establishing a current of 200 mA in the solenoid. What is the energy density in the interior volume of the solenoid ?

(g) A thin metallic shell of radius R carries a charge Q. At its centre is another point charge $-Q$. Find the electric fields at distances of 2R and R/2 from the centre of the shell.

(h) A 12 V battery runs the following circuit. If a current of 1.2 A is desired in the arm AB, find the resistance R if the key is open.



2. Attempt *any two* of the following : **2x5=10**

(a) Explain the concept of free body diagram. A mass m is released from the top of a smooth vertical track of radius R with negligible speed. Show that if leaves contact with the track at an angle $\theta = \cos^{-1}(2/3)$.

(b) State and prove the Work-Energy Theorem. Using this theorem calculate the speed of the bob of a simple pendulum when the bob is passing through the equilibrium position.

(c) In a scattering process involving a charged particle and a stationary nucleus, calculate the closest distance of approach. If the charged particle is 5 MeV $\alpha$ particle and the target nucleus is gold $(z = 79)$, find the closest distance of approach.

3. Attempt *any two* of the following : **2x5=10**

(a) Explain the physical significance of moment of inertia. Establish the theorem of perpendicular axes. Find the moment of inertia of a flat circular disk about any diameter.

(b) Show that the net external torque on a system of particles is given by ;

$$\vec{\tau}_o = \vec{\tau}_c + \vec{r}_c \times \vec{F}^{ext}$$

State Chasles's theorem and sketch the general displacement of a body.

(c) Write down the equations of motion of a rigid body about the $z$-axis. A billiard ball of mass m and radius R is hit by a cue at a point at a distance h above its centre. As a result the ball acquires a speed $v_0$ immediately after the impact. Discuss its subsequent motion with special reference to $h = 2R/5$.

4. Attempt *any two* of the following : **2x5=10**

(a) Discuss the composition of two simple harmonic motions along the $y$-axis having equal frequencies. Explain the phenomenon of beats. Can we hear beats if their frequency is 15 Hz ?

(b) Define the intensity of sound waves. Show that when they propagate in air their intensity varies inversely as the square of the distance.

(c) What should be the width of a slit so that it can produce a diffraction pattern ? Derive an expression for the positions of secondary maxima in the diffraction pattern of a grating.

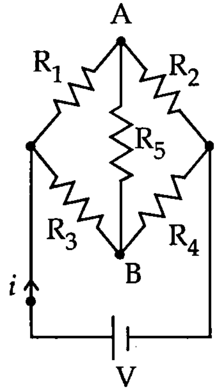
5. Attempt *any two* of the following : **2x5=10**

(a) What is an electric dipole ? Define its moment. An electric dipole is placed in a uniform electric field such that the dipole moment makes an angle $\theta$ with the electric field. Show that the configuration of minimum energy of the dipole is parallel to the field.

(b) Define electric potential. How is it related to the electric field ? Find the potential due to a line charge carrying charge $\lambda$ per unit length. Why do you have to fix the constant of integration at a finite distance from the line charge.

(c) In the following circuit find the condition for zero current through the branch AB.

A fully charged capacitor is allowed to discharge through a resistor. Find an expression for the flow of current in the circuit.



6. Attempt *any two* of the following : **2x5=10**

(a) Discuss the significance of the relations $\nabla \vec{B} = 0$ and $\nabla \vec{E} = \rho/\epsilon_0$. Compute magnetic induction due to a straight current along the z-axis and verify that the magnetic induction satisfies the relation $\nabla \vec{B} = 0$.

(b) A charged particle is projected in a plane perpendicular to a uniform field of magnetic induction $\vec{B}$. Discuss and sketch its subsequent motion. A dentron and an $\alpha$-particle describe circular orbits of the same radius in a plane normal to a uniform magnetic field. What is the ratio of the dentron speed to the $\alpha$-particle speed ?

(c) Explain the need to introduce displacement current in Maxwell's equations. Write down the equations modified by it. Derive wave equation in free space for the electric field.

Constants :

$$\frac{1}{4\pi\epsilon_0} = 9.0 \times 10^9 \text{ Nm}^2 \text{ C}^{-2}$$

$\mu_0 = 4\pi \times 10^{-7}$ Hm$^{-1}$

Mass of $\alpha$-particle $= 6.4 \times 10^{-27}$ kg

Mass of a proton $= 1.67 \times 10^{-27}$ kg

Charge of proton $= 1.6 \times 10^{-19}$ C

$g = 9.8$ m/s$^2$.