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Your Roll No.....

1207

B.Sc. (Hons.) PHYSICS/II Sem. A

Paper—PHHT-205

Electricity and Magnetism

Time : 3 Hours *Maximum Marks : 75*

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all, including

Q. No. 1 which is compulsory.

1. Attempt any *five* of the following :

(*a*) Establish a relationship between the magnetic moment (M) and the angular momentum (L) of an electron revolving around the nucleus of an atom with linear velocity, v and orbit radius r. 3

(*b*) Evaluate the root mean square value of the following time varying voltage : 3

$$e = 30.0 + 40.0 \sin \omega t + 40.0 \cos \omega t.$$

(*c*) Derive a relationship between three electric vectors $\vec{E}$, $\vec{P}$ and $\vec{D}$. 3

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(*d*) What should be the value of R in the following network so that it could absorb maximum power from the 100 V source : 3

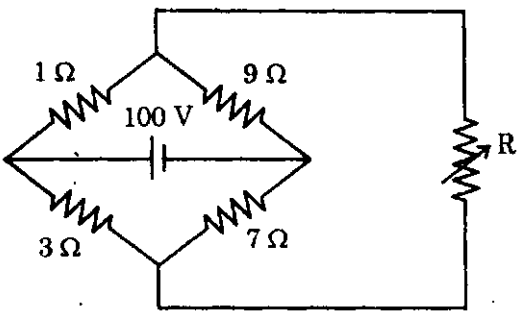

Fig. 1

(*e*) A solid insulating sphere is charged with density $\rho = k(1 - r/R)$ C/m^3, where k is a constant, r the distance from centre of the sphere and R the radius of the sphere. Evaluate the total charge contained in the sphere. 3

(*f*) Prove the conservative nature of an electrostatic field. 3

(*g*) A solid metal sphere of radius R is given a charge Q. Find electric potential at its centre. 3

2. (*a*) State and prove maximum power transfer theorem for a linear two terminal network. 5

(*b*) For a series circuit containing L, C and R, derive an expression for the band width (β) in terms of quality factor (Q) of the circuit. 6

(*c*) Calculate the current in the load resistance R_L of the following ladder network : 4

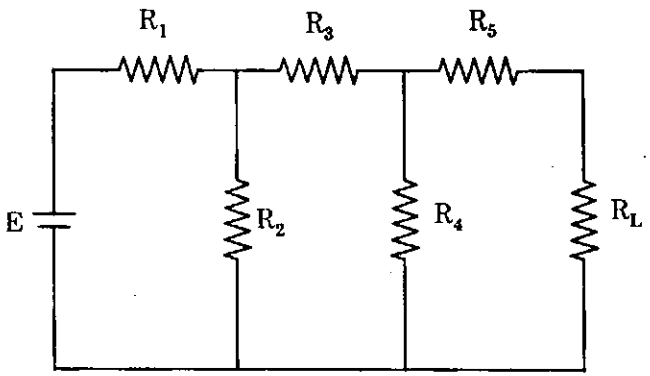

Fig. 2

3. (*a*) Derive Faraday's law of electromagnetic induction in differential form, *i.e.* : 5

$$\nabla \times \vec{E} = -\frac{d\vec{B}}{dt}.$$

(*b*) Show that the effective inductance L_{eff} of two inductances L_1 and L_2 connected in parallel is given by : 6

$$L_{eff} = \frac{L_1 L_2 - M^2}{L_1 + L_2 \pm 2M}$$

where M is the mutual inductance between them.

(*c*) In the AC series LCR circuit shown below, calculate the power factor : 4

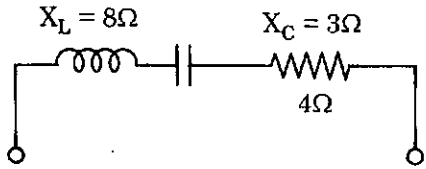

Fig. 3

4. (*a*) An electric field $\vec{E}$ exists in a region that consists of two different dielectrics characterized by the permittivities ϵ_1 and ϵ_2. Establish the boundary conditions of $\vec{E}$ and $\vec{D}$ at the boundary separating two mediums. 5

(*b*) Derive the expression for electrostatic energy for a continuous volume charge distribution : 5

$$U = \frac{1}{2}\int \vec{E}.\vec{D}\, dV.$$

(*c*) The uniform electric fields $\vec{E}_1$ and $\vec{E}_2$ shown below are near a dielectric-dielectric boundary but on opposite side of it. The relative permittivities of the dielectrics are $\epsilon_1 = 4$ and $\epsilon_2 = 4\sqrt{3}$. If $\theta_2 = 60°$, then find θ_1. 5

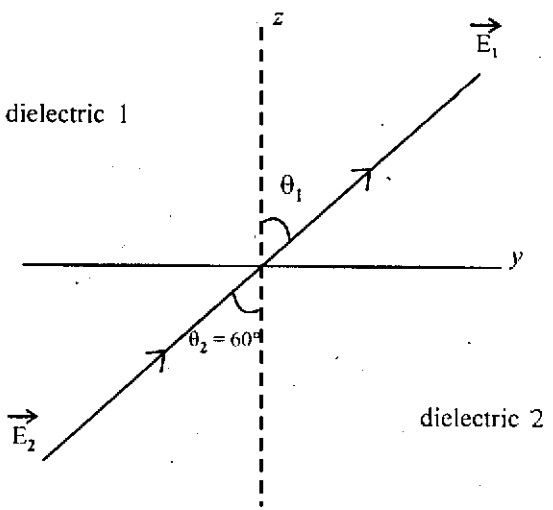

Fig. 4

5. (*a*) Show that the charge Q passing through a ballistic galvanometer is given by :

$$Q = \frac{T_0}{2\pi} i_s \theta_1 (1 + \lambda/2)$$

where T_0 is the time period of free oscillations, i_s is the current sensitivity and λ is the logarithmic decrement. 10

(*b*) A very long thin wire is bent in the shape shown below. A direct current i is flown through the wire. Find the direction and the magnitude of the magnetic field at point O : 5

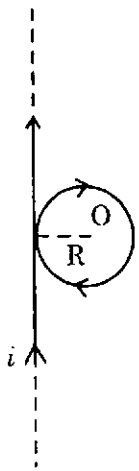

Fig. 5

6. (*a*) Establish a relationship between the vector magnetic potential $\vec{A}$ and the magnetic flux $\vec{B}$ through a given area. 6

(*b*) Derive an expression for the magnetic field at an axial point of a circular current carrying loop of radius *a*. Show that at far off points the circular loop behaves as a magnetic dipole. 9

7. Write short notes on any *three* of the following :

(*a*) Uniqueness theorem 5

(*b*) Equation of continuity 5

(*c*) Relation between $\vec{B}$ and $\vec{H}$ 5

(*d*) Electric potential of an arbitrary point of an electric quadrupole. 5