The Open University of Sri Lanka
B.Sc. Degree Programme – Level 4
Department of Physics
Advanced Electromagnetism - PHU 2142 / PHE 4142
Open Book Test – 2009/2010
Duration: 1½ hrs.

Date: 15-03-2010 **Time: 04.00 p.m. to 05.30 p.m.**

Answer all Questions

1. (a) A parallel plate capacitor has plates of area A and separation d and stores a charge Q. Write down an expression for the energy stored in it.

   (b) It is isolated and the plates pulled apart so the separation of the plates is now $d + e$. What is now the stored energy and how much work has been done in pulling the plates apart?

   (c) Show that the force of attraction between the plates now is $\frac{Q^2}{2\varepsilon_o A}$

   (d) The electric field at a radius r, between the inner conductor of radius a and the screen conductor of radius b (i.e. $a < r < b$), in a coaxial cable is $E(r) = \frac{\lambda}{2\pi\varepsilon_o r}$, where λ is the charge per unit length on the inner conductor. The energy density is $\frac{\varepsilon_o E^2}{2}$. Using these two expressions calculate the total energy stored in the electric field.

(35 marks)

2. (a) A thin plastic disk of radius R has a charge q uniformly distributed over its surface and rotates at an angular frequency ω. Find the charge between the radii r and $r + dr$, where dr is a small element.

   (b) As the disk rotates this charge constitutes a current (say di) forming a circular loop. What is the value of this current?

   (c) This current produces a magnetic field (say dB) at the centre of the disk. What is this magnetic field?

(d) What is the total magnetic moment (say η) of the disk?

(e) If the field B along the axis of a dipole is $\frac{\mu_0}{4\pi}\eta\frac{2}{z^3}$, show that the magnetic field due to all the charge,

(i) at the centre of the disk is $B(0)=\frac{\mu_0\omega q}{2\pi R}$ and

(ii) at $z >> R$ along the z-axis is $B(z)=\frac{\mu_0\omega q R^2}{8\pi z^3}$

(40 marks)

3. (a) A very long solenoid of radius r_1 and number of turns per meter n_1 carries current I. A ring with radius $r_2 > r_1$ is put around the solenoid with its center on the solenoid's axis. What is the mutual inductance of the ring-solenoid system?

(b) What is the induced emf in the ring if there is a steady current I?

(c) Two long parallel wires, each of radius a, whose centers are a distance d apart carry equal currents in opposite directions. Show that, neglecting the flux within the wires themselves, the inductance (say L) of a length l of such a pair of wires is given by

$$L=\frac{\mu_0 l}{\pi}\ln\left(\frac{d-a}{a}\right)$$

(25 marks)

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