The Open University of Sri Lanka
B.Sc. Degree Programme - Level 04
Final Examination - 2007/2008
Advanced Electromagnetism
PHU 2142 / PHE 4142

013

Duration: Two and a Half Hours (2½ Hrs.)

Date: 09.07.2008 **Time: 01.30 pm *to* 04.00 pm**

Useful Physical Constants		
Electronic charge (e)	=	1.602×10^{-19} C
Permittivity of free space, ε_o	=	8.85×10^{-12} Fm^{-1}
Permeability of free space, μ_o	=	$4\pi \times 10^{-7}$ Hm^{-1}

ANSWER FOUR QUESTIONS ONLY.

1. (a) Show that under static conditions, a region surrounded by a conducting surface must be completely shielded from electric fields.

(b) An insulated uncharged conductor contains a cavity. Show that if a charge q is placed inside the cavity and not touching the walls, the electric field outside the conductor is independent of the position of the charge in the cavity.

(c) Charges are distributed uniformly along a line of *1 m* long. The line charge density is 1 μCm^{-1}. Find the electrical potential at a point at *50 cm* from the line and opposite the centre of the line.

2. (a) Derive an expression for the electric energy stored in a charged parallel plate capacitor in terms of capacitance, C, and the potential difference, V.

(b) Show that the force, F, of attraction between the plates of a parallel plate capacitor can be given by,

$$F = \frac{1}{2}\frac{Q^2}{A\varepsilon_0}$$

where, Q is the charge and A is the area of the capacitor plates.

(c) The capacitance of a variable capacitor can be varied from 1×10^{-9} F to 20×10^{-9} F. Initially, the capacitor is set to 20×10^{-9} F and is charged by connecting it to a battery of e.m.f. 100V.

(i) What is the Charge on the plates?

(ii) The battery is then disconnected, and the capacitance is changed to 5×10^{-9} F. Assuming that no charge is lost from the plates, calculate the present potential difference between the plates.

(iii) Calculate the mechanical work done against electrical forces in changing the capacitance of the capacitor.

3. (a) What is Hall Effect?

(b) Derive an expression for the Hall Voltage in a conductor, in terms of current I, magnetic field B, breadth of the conductor b and hall-coefficient R.

(c) In a Hall-Effect experiment, a current of 10 A flows through a conductor of square cross section 6.25 mm^2. When a magnetic field of 5 Wb/m^2 is applied, the Hall-voltage induced is 12.5×10^{-6} V.

(i) Calculate the Hall-coefficient.

(ii) If the current carriers are electrons, find the density of the carriers in the conductor.

(iii) Find the drift-velocity.

4. (a) Discuss briefly the concepts of real current and virtual current in magnetism.

(b) Describe briefly the three major classes of materials based on their magnetic properties.

(c) Starting from Amperes circuital relation, deduce the relationship that relates the magnetic flux density (**B**), the magnetic field intensity (**H**) and the magnetic moment per unit volume (**M**).

(d) A uniformly magnetized bar with a volume of 0.01 m^3 has a magnetic moment of 500 Am^2. If the flux density in the bar is 0.5 T, find the magnetic field intensity in the bar.

5. The gap between the metal plates of a parallel-plate capacitor is completely filled with a dielectric whose dielectric constant $\kappa = 2.35$. Electrical susceptibility of the dielectric material χ is = 1.55. The electric field strength between the plates is 10^5 V/m and the separation of the plates is 3 mm. Calculate,

(a) the electric displacement D

(b) the electric polarization P

(c) the surface charge density of free charge on the plates

(d) the surface density of polarization charge

(e) the potential difference between the plates.

6. With respect to Maxwell's equations:

(a) Ampere's law in integral form reads $\oint B.dl = \mu_0 I$. Show how to obtain Ampere's law in differential form from the integral form.

(b) Explain how the equation $\nabla \times \vec{B} = \mu_o J$ is incomplete. Using conservation of electric charge, discuss how Maxwell modified this equation.

(c) Show that the Poynting vector, $S = \frac{1}{\mu_o} E \times B$ satisfies, $\nabla.S + \frac{\partial u}{\partial t} + E.J = 0$,

where $u_E = \varepsilon_0 E^2$ is the electric energy density, $u_B = \frac{1}{2\mu_o} B^2$ is the magnetic energy density, and $u = u_E + u_B$ is the total energy.

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