



EASTERN UNIVERSITY, SRI LANKA

SECOND EXAMINATION IN SCIENCE - 2002/2003

SECOND SEMESTER

(MARCH/APRIL 2004)

PH 207 ELECTRICITY AND MAGNETISM II

Time: 01 hour.

Answer ALL Questions

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You may find the following information useful.  
permittivity in free space  $\epsilon_0 = 8.85 \times 10^{-12} Fm^{-1}$   
mass of the electron  $m_e = 9.1 \times 10^{-31} Kg$   
charge of the electron  $e = 1.6 \times 10^{-19} Coulmb$

vector equation

$$\vec{\nabla} \times \vec{\nabla} \times \vec{A} = \vec{\nabla}(\vec{\nabla} \cdot \vec{A}) - \nabla^2 \vec{A}$$

The symbols have their usual meanings.

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1. Starting with Gauss's Theorem in electrostatics show that the Displacement vector  $D$  in a dielectric medium may be written as

$$D = \epsilon_0 E + P$$

A sphere of radius  $R$  made of a material of permittivity  $\epsilon$  carries a uniform charge distribution  $Q$  Coulomb  $m^{-3}$ .

- (i) Obtain expressions for Electric field  $E$  at a distance  $r$  from the center of the sphere when  $r > R$  and  $r < R$
- (ii) Hence determine the Displacement vector  $D$  and the Polarization vector  $P$  at a distance  $r$  from the center of the sphere when  $r > R$  and  $r < R$ .
- (iii) Show that an electron of mass  $m$  and charge  $e$  placed inside this sphere will oscillate with period  $T$  given by

$$T = 2\pi \sqrt{\frac{3\epsilon_0 \epsilon_r m}{Qe}}$$

- (iv) Calculate  $T$  when  $\epsilon_r = 3$  and  $Q = 10^{10}$  Coulomb  $m^{-3}$ .

The symbols have their usual meanings.

2. (i) Write down Maxwell's Equations in free space.
- (ii) Starting from Maxwell's equations obtain the wave equation for the Magnetic field.
- (iii) Show that the velocity  $C$  of an electromagnetic wave in free space is given by

$$C^2 \epsilon_0 \mu_0 = 1$$

- (iv) A plane electric wave traveling in vacuum is described by

$$E = E_0 e^{i(\omega t - kz)}$$

Using appropriate Maxwell's equations find the magnetic field and show that

$$\frac{E_0}{B_0} = \frac{\omega}{k}$$

(v) Hence show that

$$B_0 = \frac{E_0}{\sqrt{\epsilon_0 \mu_0}}$$

The symbols have their usual meanings.