EASTERN UNIVERSITY, SRI LANKA

SECOND EXAMINATION IN SCIENCE – 2013/2014

SECOND SEMESTER (OCTOBER 2016)

PH 207 ELECTRICITY AND MAGNETISM II

e: 01 hour.

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u may find the following information useful:

Electron charge $e = 1.6 \times 10^{-19}\ C$

Electron mass $m = 9.1 \times 10^{-31}\ kg$

Permittivity of free space $\varepsilon_o = 8.85 \times 10^{-12}\ Fm^{-1}$

Divergence theorem

$$\int_S \bar{A}\,.\,\overline{da} = \int_V \bar{\nabla}\,.\,\bar{A}\ d\tau$$

Stokes theorem

$$\oint_C \bar{A}\,.\,\overline{dl} = \int_S (\bar{\nabla} \times \bar{A})\ \overline{da}$$

Q1.

Show that in a dielectric material, the bound surface charge density σ_b and volume charge density ρ_b are expressed by $\sigma_b = \vec{P}.\vec{n}$ and $\rho_b = -\vec{\nabla}.\vec{P}$, w is the polarization vector.

If the total charge density of a dielectric material is given by $\rho_{\text{total}} = \rho$ (where ρ_f is the free volume charge density), then prove the following relati

Displacement vector $\vec{D} = \varepsilon_o \vec{E} + \vec{P}$ and

Total free charge $Q_f = \oint_S \vec{D}.\overrightarrow{da}.$

A spherical conducting shell has inner radius R_1 and outer radius R_2. The between the spherical surfaces is filled with a medium having a permittivity,

$$\varepsilon(r) = \frac{\varepsilon_o}{1 + \lambda r}$$

where λ and ε_o are constants and r is the radial coordinate. A charge placed on the surface of the inner shell. When the outer surface is grounded,

i. The electric field $\vec{E}$ in the region $R_1 < r < R_2$
ii. The displacement vector $\vec{D}$ in the region $R_1 < r < R_2$
iii. The potential difference between the spherical surfaces
iv. The polarization vector $\vec{P}$ in the region $R_1 < r < R_2$
v. The capacitance of the capacitor
vi. Bound volume charge density
vii. Bound surface charge density at $r = R_1$ and $r = R_2$

e electric field $\vec{E}$ in a conducting medium with conductivity σ, permeability μ d permittivity ε satisfies the wave equation

$$\nabla^2 \vec{E} = \mu\sigma \frac{\partial \vec{E}}{\partial t} + \mu\varepsilon \frac{\partial^2 \vec{E}}{\partial t^2}.$$

onsider the solution of the above equation a travelling wave in x direction as $= \vec{E}_0 e^{i(\omega t - kx)}$. Show that the wave vector k and angular frequency ω satisfy e dispersion relation:

$$\omega^2 \mu\varepsilon = i\omega\mu\sigma + k^2.$$

nen the electric wave is travelling in an ionized gas with $\varepsilon = \varepsilon_o$ and $\mu = \mu_o$ ues equivalent to free space,

Show that the dispersion relation becomes

$$\frac{k}{\omega} = \sqrt{\left(1 - \frac{\omega_g^2}{\omega^2}\right) \varepsilon_o \mu_o}$$

where, ω_g is the frequency of ionized gas.

Find the frequency of the ionized gas.

Determine the refractive index of the medium, when the electron concentration is $2.5 \times 10^{10}\ m^{-3}$ and the frequency of the wave is 3 MHz.