2001

NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS

SPH 4103 Electromagnetism II

Answer **all** questions in **Section A** and any **three** questions from **Section B**. Section A carries 40 Marks and Section B caries 60 Marks. Give neat diagrams wherever necessary.

Permittivity of Free space $= 8.65 \times 10^{-12}\ Fm^{-1}$
Permeability of the medium $= 4\pi \times 10^{-7}\ Hm^{-1}$
Speed of Light $= 2.9998 \times 10^{8}\ ms^{-1}$
Charge on Electron $= 1.6 \times 10^{-19}\ C$

SECTION A

Q 1 (a) The electric displacement is given by the expression:

$$D = 5Sin(\omega t - \beta x)$$

Calculate the displacement current.

[6]

(b) At 200 MHz a solid ferrite-titanate medium has complex constant $\mu_r = 15(1 - j\,3)$ and $\varepsilon_r = 50\,(1\text{-}j)$. Calculate Z/Z_o, where symbols have their usual meanings.

[6]

(c) Calculate the conductivity required for a sheet of space cloth (Z_o = 377 Ohm per sq.) which is 1 mm thick.

[6]

(d) A linearly polarized plane travelling wave is incident at an angle θ_I on the flat surface of a dielectric medium of large extent. The constants of the medium are $\sigma = 0$; $\mu_r = 1$ and $\varepsilon_r = 8$. Calculate the magnitude of the reflected field E_r and transmitted field E_t relative to the incident field E_I as afunction of θ_I.

[10]

(e) Show that a transmission line having no attenuation must also have non-reactive characteristic impedance.

[7]

(f) An air filled rectangular guide has cross sectional dimensions height 80 mm and width 40 mm. Calculate the frequency of TE dominant mode. Calculate the cutoff frequencies for TEM, TE_{10}, TE_{20} and TE_{21} modes. List the degenerate modes in this range if any. [8]

(g) Calculate the radiation resistance of a $\lambda/12$ antenna. If the loss resistance is 1 ohm, calculate the antenna efficieny

[5]

SECTION B

Q2. (a) Explain the terms: *phase velocity and group velocity.*
Show that:

$$V = V_p - \lambda \frac{d V_p}{d\lambda}$$

where the symbols have their usual meanings.

[8]

(b) You are given a medium with constants $\varepsilon_r = 60$, $\mu_r = 1$ and $\sigma = 20$.
Calculate the frequencies at which the medium will just start behaving as (i) lossy dielectric and (ii) conducting.

[6]

(c) Calculate attenuation constant, phase constant and loss tangent for the medium in (b) above.

[6]

Q3. (a) Explain the terms: (i) TEM, (ii) TE and (iii) TM modes of propagation of electro-magnetic waves. Why cannot a hollow guide support TEM mode?

[6]

(b) Starting from the Maxwell's equations obtain the field components for TE waves in a rectangular guide of width *a* and height *b*. Obtain an expression for the cutoff frequency for the guide and list the dominant TE mode in the guide.

[14]

Q 4 (a) Explain the following terms:

(i) Reflection Coefficient, (ii) Voltage Standing Wave Ratio,

(iii)Quarter Wave line and (iv)Space Cloth.

[6]

(b) Obtain an expression for the *input impedance* of an infinitely long transmission line at a distance x from the generator end.

[8]

(c) A transmission line at ω = 500 Mrad s^1 has L= 0.5 μH m^{-1} , C= 32 pF, G = 100 mho m^{-1} and R = 25 ohm m^{-1}. Calculate values for the attenuation constant, phase velocity and characteristic impedance. What distance down the line can a voltage wave travel before it is reduced to 10 % of its initial amplitude?

[6]

Q6. (a) Explain the terms: *Radiation Resistance, Induction Field, Radiation Field and Directivity of an Antenna.*

[6]

(b) Obtain an expression for the radiation pattern for a uniform array of "n" radiators separated by distance "d" and having currents of equal magnitude and varying with a uniform phase difference of δ.

[6]

(c) Determine the following parameters for an antenna consisting of 6 elements with $d = \lambda/2$.

(i) The direction of the main beam for $\delta = 0^\circ$, 45° and 120°,
(ii) The relative magnitude of the the first two minor lobes for $\delta = 0^\circ$,
(iii) The beam width between the first nulls for $\delta = 0^\circ$ and
(iv) Sketch the pattern for $\delta = 0^\circ$

[8]

END OF PAPER