NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

SPH 2105 – ELECTROMAGNETISM

BSc HONOURS PART II: DECEMBER 2005 *DURATION: 3 HOURS*

ANSWER **ALL** PARTS OF QUESTION **ONE** IN SECTION A AND ANY **THREE** QUESTIONS FROM SECTION B. SECTION A CARRIES 40 MARKS AND SECTION B CARRIES 60 MARKS

SECTION A

1 a) Use Laplace 's equation to find the capacitance of a parallel plate capacitor . $V = 0$ at $X = 0$ and $V = V_o$ at $X = X_2$

Hence determine E, D ,and Δs. [8]

b) Given $\mathbf{E} = E_m \sin(\omega t - B z)\,\mathbf{a}_y$ in free space, find **D**, **B**, and **H** . [6]

c) (i) What do you understand by the Poynting vector? [3]

(ii) Show that the Poynting vector, **P** , is given by $\mathbf{P} = \mathbf{E} \times \mathbf{B}$ [5]

d) At a dielectric –to –dielectric interface, what determines whether the reflected **E** field or the reflected **H** field is reversed in polarity from that of the incident wave? [4]

e) A plane wave at a frequency of 1000Hz is normally incident on a copper plate of conductivity $\sigma = 5.8 \times 10^7$ mhos/meter and $\mu = 1.26 \times 10^{-6}$ henry/meter. Calculate the depth of penetration of the wave. [5]

f) An antenna has a gain of 50 dB. Assuming that the main beam of the antenna is circular in cross section, find the beam width. [5]

f) Distinguish group velocity from phase velocity of an electromagnetic wave. [4]

SECTION B

2. (a) Use Laplace's equation in cylindrical co-ordinates to find the capacitance of a coaxial cable. Assume variations in V with respect to radial distance r from Mu cable axis . [12]

(b) (i) Define the reflection coefficient and transmission coefficient. Explain what causes these coefficients to be complex. [6]

(ii) What is the evanescent wave? [2]

3. (a) (i) Explain what a distortionless line is. If R and G are both zero, is the line distortionless? [4]

(ii) What is a quarter- wave transformer? Is it broad band? Clarify your answer. [4]

(iii) Describe the basic procedure for using a slotted line to measure load impedance. [4]

(b) Using the Smith's chart, determine the line admittance at a point with a line impedance of (50 + j50) Ω. The characteristic impedance of the line is 50 Ω. [8]

4. (a) (i) Define the terms "intrinsic impedance" and "skin depth". [4]

(ii) An $\overline{E}$ field is given by $\overline{E} = 50 \cos. (100t - 5x)\ \hat{z}\ Vm^{-1}$.

Find the direction of wave travel, the velocity of the wave,

wavelength and a complete description of the $\overline{H}$ field. [8]

(b) Use a good conductor approximation to find the wavelength, the skin depth and the refractive index of an electromagnetic wave of angular frequency $\omega = 2 \times 10^{10}\ s^{-1}$ and $g = 3.53 \times 10^{7}$ S/m propagating through aluminum. [8]

5. (a) (i) What is an antenna ? [3]

(ii) Define antenna gain and beamwidth. [4]

(iii) Find the radiation resistance of a single –turn circular loop with a circumference of ¼ wavelength.. What happens when the resistance of the wire due to its resistivity is very small compared to the radiation resistance? [5]

(b) An incident plane wave at 20 MHz has an rms field strength of 10mV m^{-1}. How much power is received by a properly terminated $\lambda/2$ dipole? [5]

(c) Make rough polar plots of the field pattern in the plane of symmetry for a pair of dipoles ;

(i) fed in phase at $\lambda/2$ apart and

(ii) fed 180° out of phase. [3]

6. (a) Explain the function of a coating on a lens. [5]

(b) In the case of a perfectly conducting surface, how much energy is lost in the reflection of an EM wave arriving from air? [5]

(c) Determine the standing wave ratio in front of a perfectly reflecting surface for a wave normally incident from a perfect dielectric. [5]

(d) Using Maxwell's space equations, show that $c = 1/(\mu\varepsilon)^{1/2}$ [5]