ELIZADE UNIVERSITY, ILARA-MOKIN,

ONDO STATE

FACULTY OF ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

SECOND SEMESTER EXAMINATION, 2017/2018 ACADEMIC SESSION

COURSE TITLE: ELECTROMAGNETIC WAVES

COURSE CODE: EEE 314

EXAMINATION DATE: 3rd AUGUST, 2018

COURSE LECTURER: Dr. Akinwumi A. AMUSAN

TIME ALLOWED: 3 HOURS

HOD's SIGNATURE

INSTRUCTIONS:

1. ANSWER QUESTION ONE AND ANY OTHER FOUR QUESTION

2. ANY INCIDENT OF MISCONDUCT, CHEATING, POSSESSION OF UNAUTHORIZED MATERIALS DURING EXAM SHALL BE SEVERELY PUNISHED.

3. YOU ARE NOT ALLOWED TO BORROW CALCULATORS AND ANY OTHER WRITING MATERIALS DURING THE EXAMINATION.

4. ELECTRONIC DEVICES CAPABLE OF STORING AND RETRIEVING INFORMATION ARE PROHIBITED.

5. DO NOT TURN OVER YOUR EXAMINATION QUESTION PAPER UNTIL YOU ARE TOLD TO DO SO

Question #1 [16 Marks]

(a) (i) Summarize the four Maxwell's equations for time-varying fields in both differential (point form) and integral form (closed form) stating the corresponding physical laws. (4 Marks)

(ii) State the meaning and the units of the fields and source terms in the equations. (2 Marks)

(b) (i) Re-write the Maxwell's equations in point form for the case of static fields (Electro-statics and Magneto-statics) (1 Mark)

(ii) Derive the Poisson's equation starting from the Maxwell's equations for electric fields in electrostatics. (2 Marks)

(iii) State the assumptions for the case when Poisson's equation becomes Laplace's equation (1 Mark)

(c) Derive the electromagnetic wave equation for electric field vector ($\bar{E}$) or magnetic field vector ($\bar{H}$). Start from the Maxwell's equations for the time-varying fields; assume an exponential dependence ($e^{j\omega t}$) for the fields, and assume a region free of volume charge. (3 Marks)
(Hint: for a vector $\bar{A}$, $\nabla \times (\nabla \times \bar{A}) = \nabla(\nabla . \bar{A}) - \nabla^2 \bar{A}$)

(d) Given that the field $\bar{E} = \bar{E}_o \sin(\omega t - \beta z) a_y$ in free space, find the fields $\bar{D}$, $\bar{B}$, and $\bar{H}$ (3 Marks)

Question #2 [11 Marks]

(a) Highlight the summary of the boundary conditions for the propagation of electric and magnetic fields as it passes the interface between two different dielectric media (5 Marks)

(b) Consider the boundary between two dielectric medium (shown in Figure 1), in which electric field propagates from medium 1 to 2. The normal z is perpendicular to the x-y plane (tangential to the boundary).

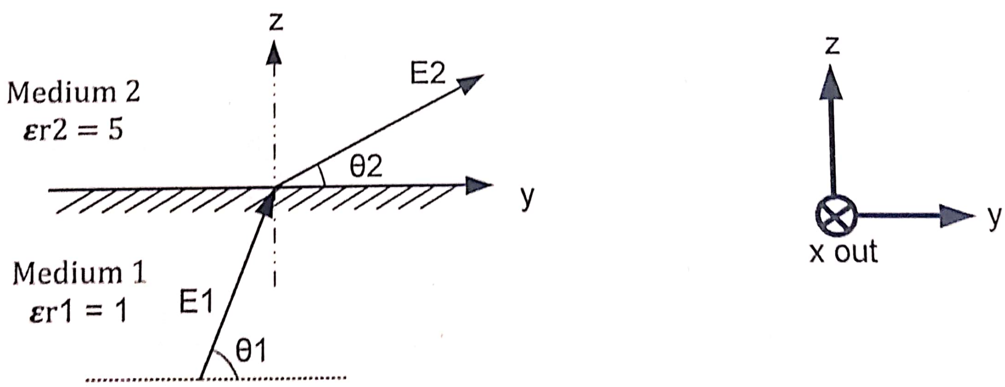

Figure 1

If the electric field in medium 1 is given as: $\overline{E1} = (2a_x - 3a_y + 5a_z)\ V/m$, and the dielectric constants in medium 1 and 2 are given as $\varepsilon r1 = 1$ and $\varepsilon r2 = 5$ respectively. Assuming the interface is charge free, determine:

(i) $\overline{E2}$ in medium 2 (2 Marks)

(ii) $\overline{D2}$ in medium 2 (1 Mark)

(iii) Angle $\theta 1$ (1 Mark)

(iv) Angle $\theta 2$ (1 Mark)

(v) $\frac{\tan\theta 1}{\tan\theta 2}$ (1 Mark)

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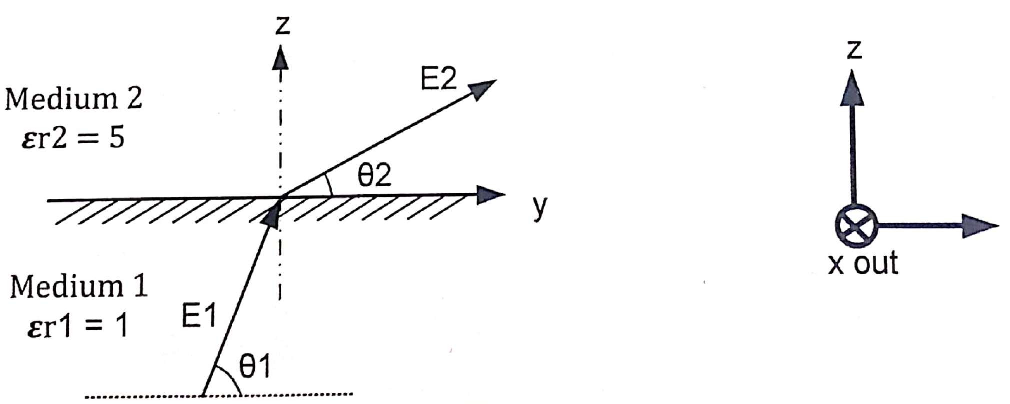

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(ii) $\overline{D2}$ in medium 2 (1 Mark)

(iii) Angle $\theta 1$ (1 Mark)

(iv) Angle $\theta 2$ (1 Mark)

(v) $\frac{\tan\theta 1}{\tan\theta 2}$ (1 Mark)

on #3 (11 Marks)

Given that $\overline{H} = \overline{H}_o\, e^{j(\omega t+\beta z)}\, a_x$ in free space, find:

(i) $\overline{D}$ (2 Marks) (ii) $\overline{E}$ (3 Marks)

(b) Region 1, for which, $\mu r1 = 3$, is defined by $z < 0$ and region 2 defined by $z > 0$ has, $\mu r2 = 5$ as illustrated in Figure 2. The field propagates in the z –direction (normal components), while the boundary is the x-y plane (tangential components). Assuming there is no sheet current at the interface, and $\overline{H1}$ is given as:

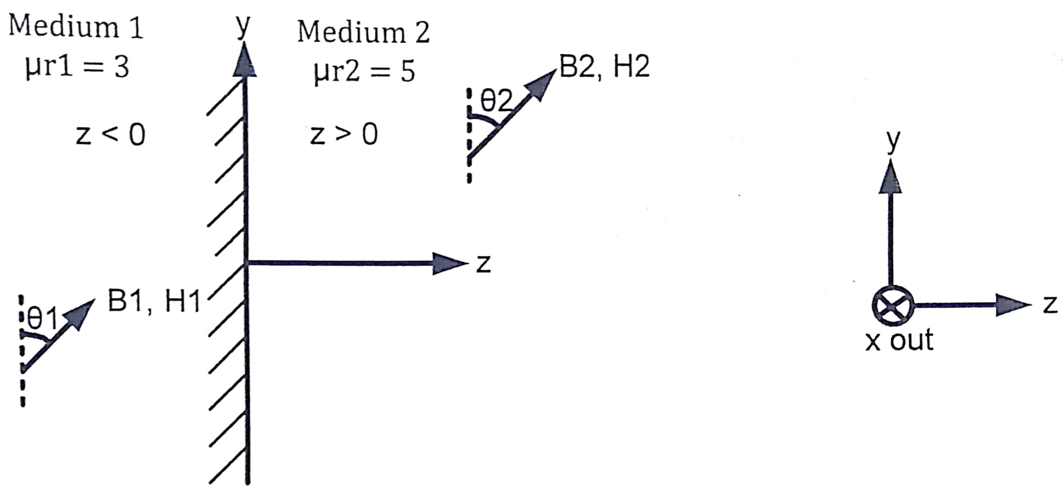

Figure 2

$\overline{H1} = (\,4a_x + 3a_y - 6a_z)\ {}^{A}/_{m}$, determine:

(i) $\overline{H2}$ (2 Marks) (ii) $\overline{B2}$ (1 Mark) (iii) $\theta 1$ (1 Mark)

(iv) $\theta 2$ (1 Mark) (v) $\frac{tan\theta 1}{tan\theta 2}$ (1 Mark)

Question #4 (11 Marks)

(a) (i) Define the skin depth or depth of penetration in a conductor. (1 Mark)

(ii) State the relationship between skin depth (δ), propagation frequency (f) and conductivity (σ). (1 Mark)

(iii) For silver with conductivity σ = 3.0 MSm^{-1}, at what frequency will the depth of penetration (δ) be equal to 1 mm? (Take $\mu = \mu_o = 4\pi\times10^{-7}$ H / m) (2 Marks)

(b) (i) Write the expression for Poynting vector in terms of fields $\overline{E}$ and $\overline{H}$? (1 Mark)

(ii) State two important properties of Poynting vectors (2 Marks)

(iii) Given that $E(z,t) = 100\cos(\omega t - \beta z)\ V/m$, in free space. Determine the average power crossing a circular area of radius 5 mm in the plane z = constant. (Note: intrinsic impedance in free space $\eta = 120\pi\ \Omega$). (4 Marks)

Question #5 (11 Marks)

(a) List three categories of medium for electromagnetic waves propagation with at least one example in each category. (3 Marks)

(b) Define the characteristics impedance of a transmission line. (1 Mark)
Write the expression for the characteristics impedance in terms of the parameters R, L, G and C. (1 Mark)

(c) A lossless line is a distortionless line, but a distortionless line is not necessarily lossless. Which is more desirable in (i) Power transmission and (ii) Communication Lines, lossless or distortionless transmission line? Justify (2 Marks)

(d) A distortionless coaxial line has R = 10 Ω/km, L = 100 μH / km, C = 20 μF / km. At a frequency of 1 kHz, obtain:
(i) Characteristic impedance of the line (1 Mark)
(ii) Phase constant (1 Mark)
(iii) Attenuation constant (1 Mark)
(iv) Phase velocity (1 Mark)
(Hint for a distortionless line $\frac{R}{L} = \frac{G}{C}$)

Question #6 (11 Marks)

(a) Why was Smith chart developed to solve high frequency transmission line problem? (1 Mark)

(b) (i) What is the value of the voltage standing wave ratio (s) and the load reflection coefficient (Γ_L) for a matched line. (1 Mark)
(ii) In which case is the maximum power transferred from the source to the load ? (open circuited, short circuited or matched line) (1 Mark)

(c) An antenna with impedance 20 – j15 Ω is to be matched to a 50 Ω lossless line using a shorted shunt stub. Determine the:
(i) Possible stub admittances (2 Marks)
(ii) Possible distances between the stub and the antenna (2 Marks)
(iii) Possible stub lengths (2 Marks)
(iv) Standing wave ratio of the system (1 Mark)
(v) Sketch the circuit for the two cases showing the stub position and length with respect to antenna (load) (1 Mark)
(Note: Use Smith chart to solve the problem)

Question #7 (11 Marks)

(a) (i) Briefly describe three different categories of modes that can propagate in a rectangular waveguide. (3 Marks)
(ii) State the E and H field components that exist or varnish for each category. (2 Marks)
(iii) Determine the cut off frequencies for the dominant TE and TM mode that can propagate in a rectangular waveguide with dimension a = 2.5 cm, b = 1 cm, if the guide is filled with a medium characterized by $\sigma = 0$, $\varepsilon = 4\varepsilon_o$, $\mu_r = 0$. ($\mu_o = 4\pi \times 10^{-7}$ H / m, $\varepsilon_o = \frac{1}{36\pi} \times 10^{-9}$ F / m) (2 Marks)

(b) (i) State two important need for use of antenna (1 Mark)
(ii) List four typical antennas examples (1 Mark)

(c) Define the following antenna characteristics: (i) Antenna pattern (ii) Directive gain (iii) Directivity (iv) Radiation efficiency (2 Marks) ronic PRODUCTS

TITLE	
NAME	DATE