THE MOMBASA POLYTECHNIC UNIVERSITY COLLEGE

(A Constituent College of JKUAT)

Faculty of Engineering and Technology

DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING

UNIVERSITY EXAMINATION FOR DEGREE IN BACHELOR OF SCIENCE/ENGINEERING IN ELECTRICAL & ELECTRONIC ENGINEERING

YR 3, SEM 1

EEE 4303: ELECTROMAGENETIC WAVES
EEE 2304: ELECTROMAGNETICS II

END OF SEMESTER EXAMINATION

SERIES: DECEMBER 2011

TIME: 2 HOURS

Instructions to Candidates:

This paper consists of **FIVE** questions

- *Answer Booklet*

Answer question **ONE (COMPULSORY)** and any other **TWO** questions

Marks are indicated for each part of the question

This paper consists of **FOUR** printed pages

Question One

a) Write down Maxwell's equations in integral form and explain the significance of each in electromagnetic theory (4 marks)

$$\overline{E} = 20\cos(wt - 50x)\ a\hat{y}\ \ v/m$$

b) In free space (10 marks)
Determine:
(i) I_d
(ii) w
$\overline{H}$
(iii)

c) Suppose that a uniform plane wave is travelling in the x direction in a lossless dielectric (Mr =1) with the 100v/m electric field component in the $-z$ direction. If the wavelength is 25cm and the velocity of propagation is 2×10^8 ms^{-1}. Draw the phasor diagram of the electric and magnetic field vectors and determine the:

(i) Frequency of the wave
(ii) Relative permittivity of the medium
(iii) Complete time domain expressions for the electric and magnetic field expressions
(iv) Average power density (11 marks)

d) An electric EM wave travelling in medium 1 is incident on a material boundary with medium 2 as shown in figure Q1 (d). Determine the general phasor expressions for the electric and magnetic fields for the:

(i) Incident wave
(ii) Reflected wave
(iii) Transmitted wave (5 marks)

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Question Two

a) Determine using the phasor method, whether the following field vectors satisfy both Farady's and Ampere's laws in free space.

$$\hat{E}_x = 20\Pi e \quad v(wt - \beta z) \qquad v/m \quad \hat{a}x$$

$$\hat{B} = \mu_0 Hme \;\; v(wt - \beta z) \qquad \hat{a}y$$

(14 marks)

b) Write down the phasor and time domain expressions for a $5MH_z$ uniform plane wave travelling in free space. The 10V electric field intensity vector is directed in the $+z$ direction and the wave is propagating in –y direction (sketch the field vectors) (6 marks)

Question Three

Given Maxwell's equations.

$$\nabla \times \hat{E} = -J\omega\mu_o \hat{H}$$

$$\nabla \times \hat{H} = J\omega\varepsilon_o \hat{E}$$

$$\hat{\varepsilon} = E_m{}^{+} e^{-j\beta z} + E^{-}{}_{m^e} j\beta z$$

$$\hat{H}\, y = H^{+} e^{-j\beta z} + He^{j\beta z}$$

Prove that

Explain all your steps and justify any assumptions made (20 marks)

Question Four

a) With reference to fig Q4(a), medium 1 is air and medium 2 is Teylon $(\mu r = 1).$ Assume the Teylon $(\varepsilon r_2 = 2.1).$ is infinitely thick so that no reflected waves exist in the Teylon

x

Write the time domain expressions for all the fields in these two media if the transmitted electric

$$E^t = 10\cos\left(\omega t - \left(\frac{8\pi}{3}\right)z\right)\hat{a}_x$$

field in medium 2 is measured as (13 marks)

b) Determine the average incident, reflected and transmitted power density of the plane wave and show that energy is conserved across the interface (7 marks)

Question Five

a) Explain with the aid of a sketch, why TEM waves cannot exist in a single conductor hollow (or dielectric yelled) waveguide (5 marks)

b) Describe energy modes and show how they relate to the wave guide cut-off frequency

c) An air-filled rectangular waveguide has cross sectional dimensions:

X = 3.0 cm y= 1.5cm

Find the cut off frequency for the following modes:

(i) TE10
(ii) TE20
(iii) TE01
(iv) TE02

d) Identify with justifications the degenerate and dominant modes in (c) (15 marks)