THE MOMBASA POLYTECHNIC UNIVERSITY COLLEGE

DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING

Faculty of Engineering and Technology

THIRD YEAR SPECIAL/SUPPLEMENTARY EXAMINATIONS FOR THE DEGREE

OF BACHELOR OF SCIENCE IN ELECTRICAL & ELECTRONIC ENGINEERING

EEE 2304 ELECTROMAGNETICS II

MAY 2012 SERIES TIME: 2 HOURS

INSTRUCTION TO CANDIDATES

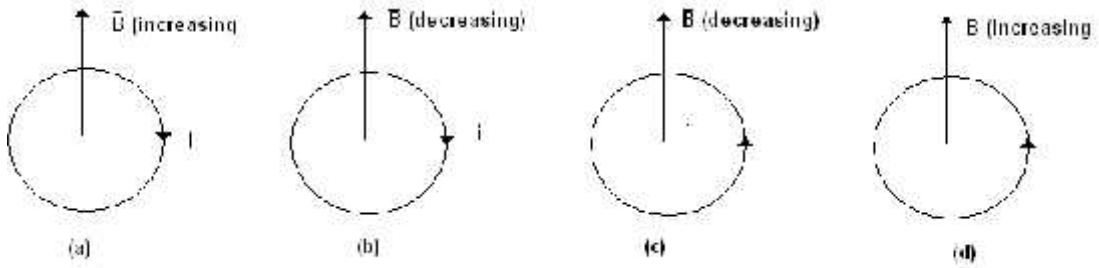
Answer question **ONE** and any other **TWO** questions.

1.(a) Write down and explain the physical interpretation of Maxwell's equations in point form. (4 marks)

(b) In free space $D = D_m \sin(\omega t + \beta z)\, a_x$. Using Maxwell's equations, show that

$$\bar{B} = \frac{-\omega\mu_0}{\beta} D_m sin(\omega t + \beta z) a_y$$ (10 marks)

(c) Assuming that current *I* is positive valued, which of the situations in fig. Qu.1(c) are not correct. Motivate your answer fully. (4 marks)



(d) State the Poynting's theorem and give the physical meaning of the Poynting vector. (3 marks)

(e) Highlight the essential characteristics of the following types of waves

(i) TEM

(ii) TE

(iii) TM (3 marks)

(f) Describe what happens to the reception of a car radio when one drives into a tunnel and why? (2 marks)

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

$$\bar{E} = 12.246\cos\left(\omega t - \left(\frac{8\pi}{3}\right)z\right)a_x$$

$$\bar{H} = 0.0325\cos\left(\omega t - \left(\frac{8\pi}{3}\right)z\right)a_y$$ (13 marks)

(b) A plane electromagnetic wave having a frequency of 10 MHz has an average Poynting vector of 1 W/m^2. If the medium is lossless with $\varepsilon_0 = 3$ and $\mu_0 = 2$, find:

(i) The velocity of propagation

(ii) Wavelength

(iii) Impedance of the medium

(iv) rms value of the electric field (4 marks)

(c) Assuming that seawater has a conductivity of $20\,S/m$, an $\varepsilon_r = 81$, determine the frequency at which the conduction current is 10 times the displacement current.

(3 marks)

3.(a) (i) Explain the concept of phase shift in the transmission of an electromagnetic wave through a given medium.

(ii) Explain one consequence of phase shift in relation to signal transmission.

(2 marks)

(b) The radiated electric field at a sufficiently large distance from a dipole antenna is of the form

$$\bar{E} = \frac{E_0}{r}sin\theta cos\,(\omega t - \beta r)\,a_\theta$$

Determine

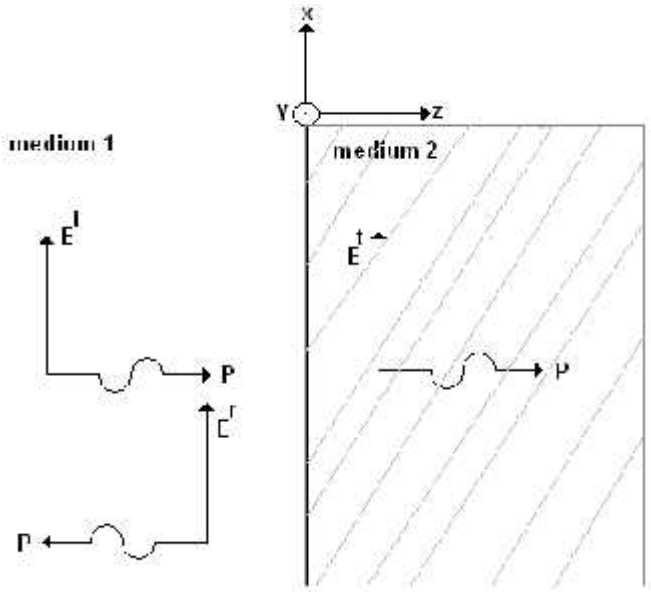
(i) The magnetic field

(ii) The total power radiated by the antenna. (10 Marks)

(c) With reference to fig. Qu.3(c), medium 1 is air, and medium 2 is Teflon ($\mu_{r1} = 1$). Assume the Teflon is infinitely thick so that no reflected waves exist in the Teflon.

Write the time-domain expressions for all the fields in these two media if the transmitted electric field in medium 2 is measured as

$$E^t = 10\cos\left(wt - \left(\frac{8\pi}{3}\right)z\right)a_x$$ (8 marks)



4.(a) Given the Maxwell's equations

$$\nabla X \hat{E} = -j\omega\mu\hat{H}$$

$$\nabla X \hat{H} = \hat{J} + j\omega\varepsilon\hat{E}$$

Prove that $\hat{E}_x = \hat{E}_m{}^{+} e^{-j\beta z} + \hat{E}_m{}^{-} e^{+j\beta z}$

$$\hat{H}_y = \hat{H}^{+} e^{-j\beta z} + \hat{H}^{-} e^{+j\beta z}$$

Explain all your steps and assumptions carefully. (20 marks)

5.(a) (i) Describe essential physical and electrical features of waveguides that make them so useful for propagating RF signals at microwave frequencies.

(ii) State the frequency range of operation of wave guides.

(iii) Explain the relationship between a given energy mode and the waveguide cut-off frequency.

(iv) Distinguish between dominant and degenerate modes in wave guides. (9 marks)

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

$$x = 3cm \qquad y = 4cm$$

(i) Find the cut-off frequency for the following modes, TE_{10}, TE_{20}, TE_{01} TE_{02}, TE_{11} $TE_{12,}$ and TE_{21} modes.

(ii) Determine the dominant mode

(iii) Determine the degenerate modes (11 marks)