PAPER 1

TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Engineering and Technology

DEPARTMENT OF MEDICAL ENGINEERING

UNIVERSITY EXAMINATION FOR:

BACHELOR OF SCIENCE IN MEDICAL ENGINEERING

EEE 4333 ELECTROMAGNETICS

END OF SEMESTER EXAMINATION

SERIES: DECEMBER 2021

TIME: 2 HOURS

DATE: Dec 2021

Instructions to Candidates

You should have the following for this examination

Answer Booklet, examination pass and student ID

This paper consists of **FIVE** questions. Attempt **Question ONE and ANY other TWO questions.**

Do not write on the question paper.

Question ONE

(a) Given that $Z_{¿}=\frac{\left(Z_L+j\,Z_0\,tan\beta l\right)Z_0}{Z_0+J\,Z_L\,tan\beta l}$ Determine the inductance of an open-circuited section of a transmission line. Assume $\beta=\frac{2\pi}{\lambda}$,$l=\frac{\lambda}{8}$, $Z_0=300\,\Omega$ and $f=2\,GHz$

(6 marks)

(b) (i) Charge is distributed non-uniformly over a disk of radius $2\,m$, height $z=2\,m$ and has the following distribution: $P_s=3\times10^{-6}\,r\,C/m^2$. Determine the total charge contained on the disk surface.

(ii) Determine using Gauss' law the electric field at a distance r due to a sphere of charge of radius a where the charge Q is uniformly distributed throughout the sphere with volume charge distribution $P_v\,C/m^3$ for $\left(r>a\right)$ (9 marks)

(c) (i) Define Faraday's law in integral form mathematically and using words.

(ii) Determine the voltage V in the circuit of Fig. Qu.1(c) (10 marks)

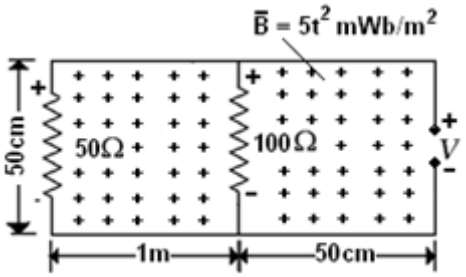

Fig. Qu.1(c)

(d) State the Poynting theorem describing all the FOUR elements of the equation. (5 marks)

Question TWO

(a) State Ampere's law in integral form and explain its practical significance using an appropriate sketch. (3 marks)

(b) With reference to Fig. Qu.2(b), medium 1 is air , and medium 2 is Epoxy-resin $(\mu_{r2}=1, \varepsilon_{r2}=3.6)$. Assume the Epoxy-resin is infinitely thick so that no reflected waves exist. Develop the time-domain expressions for all the fields in these two media if the incident electric field in medium 1 is measured as: (14 marks)

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

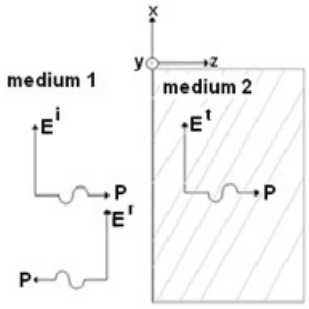

Fig. Qu. 2(b)

(c) The electric strength of air is about $3 \times 10^6 V/m$. Explain the practical meaning of the above statement. (3 marks)

Question THREE

(a) A spherical volume charge distribution $P_v = kr\, C/m^3$ is contained in a spherical volume of radius a and the medium is free space. Determine the (i) total charge enclosed by the volume

(ii) electric field intensity for $r \geq a$ (7 marks)

(b) Given the Maxwell's equations $\nabla X \hat{E} = -jw\mu\hat{H}$ and $\nabla X \hat{H} = jw\varepsilon_0\hat{E}$

Motivating all your steps prove that $\hat{H}_y = H_m^{+¿e^{-j\beta z}+H_m^{-¿e^{+j\beta z}¿}}$ (10 marks)

(c) Compare the conduction and displacement currents in a copper conductor at a frequency of $300\,MHz$. Assume the conductivity of copper is $5.8 \times 10^7 S/m$ and the permittivity of copper is that of free space. (3 marks)

Question FOUR

(a) With an appropriate sketch show that the energy contained in a magnetic field is given by $\frac{1}{2}\mu_0 \frac{\partial}{dt}|\overline{H}|^2$

(6 marks)

(b) A plane electromagnetic wave having a frequency of 500 MHz has an average Poynting vector of 1 W/m^2. If the medium is lossless with $\varepsilon_r = 4.3$ and $\mu_r = 1$, determine the:

(i) Velocity of propagation

(ii) Wavelength

(iii) Impedance of the medium

(iv) rms value of the electric field (7 marks)

(c) Two long parallel straight wires at 40 cm apart carry currents of 5A each. Determine the value of $\overline{B}$ midway between the two wires with:

(i) Currents in the same direction (ii) Currents reversed (7 marks)

Question FIVE

(a) Fig. Qu.5 (a) shows a straight wire of radius $a$carries a current $I_1(2A)$ along the axis of a metal tube with inner radius $b(20\,cm)$ and outer radius c. The tube carries a current I_1 in a direction opposite to that in the wire. Determine justifying any assumptions:

(i) H for$a \le r \le b$ (ii) H for$r > b$

Comment on usefulness of such a cable. (8 marks)

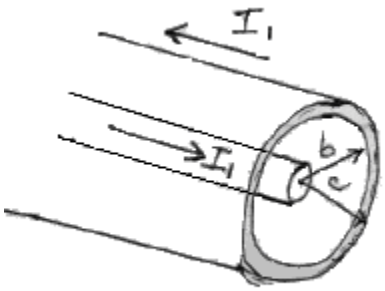

Fig. Qu.5(a)

(b) FOUR $100\,\mu F$ point charges are located on the corners of a square that are defined in a rectangular coordinate system (1,0,0)m, (0,1,0)m, (-1,0,0)m and (0,-1,0)m. Determine the vector force exerted on another $100\,\mu F$ charge located at (1,3,0). (12 marks)