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: 2016

TIME: 2 HOURS

DATE: December 2016

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.**

$\varepsilon_0 = \frac{1}{36\pi} \times 10^{-9}\ F/m\ ;\ \mu_0 = 4\pi \times 10^{-7}\ H/m\ ;\ Z_{in} = Z_0\ (\frac{Z_L + jZ_0 \tan(\beta l}{Z_0 + jZ_L \tan(\beta l)})$

Do not write on the question paper.

Question ONE

(a) (i) Show that a section of transmission line can behave like a pure capacitor (Assume $Z_L = 0$ or $Z_L = \infty$, $\beta = \frac{2\pi}{\lambda}$, $l = \frac{\lambda}{8}$, and $Z_0 = 300\Omega$).

(ii) With reference to electric circuits highlight three features of a distributed circuit model. (6 marks)

(b) Point charges $10\mu C$ ($Q1$) and $50\mu C$ ($Q2$) are located at (2,4,0) and (3,5,0) respectively. Sketch and determine the:

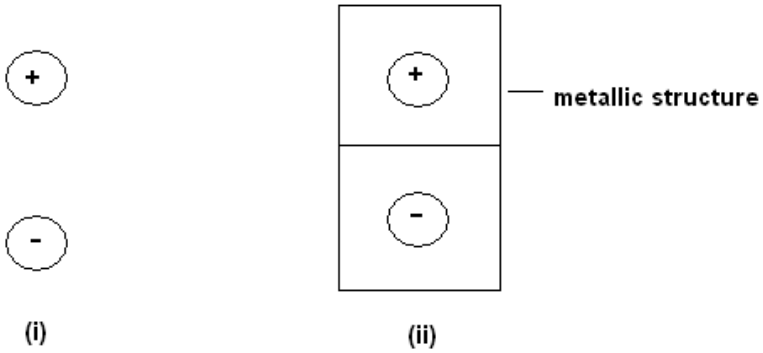
(i) Force on $100\mu C$ ($Q3$) at (7,3,1) due to $Q1$ and $Q2$ (ii) Electric field at (7,3,1) due to $Q1$ and $Q2$. (14 marks)

(c) A long straight wire carries a current of 5A along the y-axis. Determine the magnitude and direction of $\bar{B}$ at the point (0, 3, 2). (4 marks)

(d) Two point charges are placed in a rectangular coordinate system as follows, $Q_1 = 50\mu C$ is placed at (0,-2m,0) and $Q_2 = 10\mu C$ is placed at (0, 3m,0). Determine the voltage at a point (0, 0, 5m) with respect to the origin. (6 marks)

Question TWO

(a) Draw the approximate electric field lines for the following charge pairs (2 marks)



(b) Define the following electromagnetic quantities indicating their units:

(i) Electric flux density vector $\bar{D}$ (ii) Magnetic field intensity vector $\bar{H}$ (4 marks)

(c) A positive $30\mu C$ point charge and two negative $40\mu C$ and $50\mu C$ charges are placed on the corners of an equilateral triangle whose sides are of length 5m. Determine the magnitude of the electric field intensity at the centre of the triangle S (Fig Qu.2(c)). (10 marks)

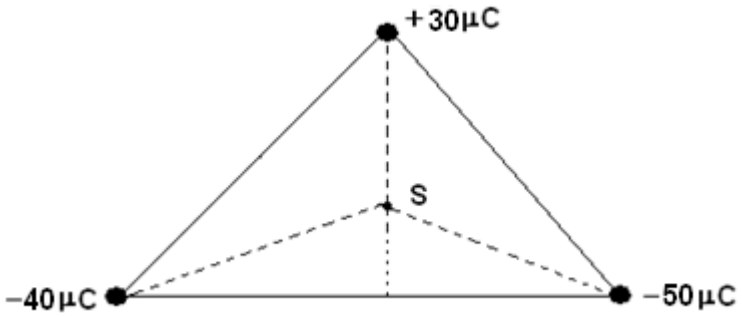


Fig. Qu. 2(c)

(d) A long straight wire carries a current I along the $x-axis$. A second wire carries a current $I/3$ out along the $y-axis$. Determine the location where the combined magnetic field is zero. (4 marks)

Question THREE

(a) The electric field in a certain region of space is given by $\bar{E} = E_x \hat{a}_x$ Determine how much flux passes through an area A if it is a portion of the :

(i) xy plane (ii) xz plane (iii) yz plane (4 marks)

(b) Consider Fig. Qu.3(b) and choosing path $C2$ and $C3$; show that the voltage between two points that are at radial distances r_a and r_b from point charge Q is given by $v_{ba} = \frac{Q}{4\pi\varepsilon}(\frac{1}{r_b} - \frac{1}{r_a})$. Justify any assumptions made in arriving at your solution. (6 marks)

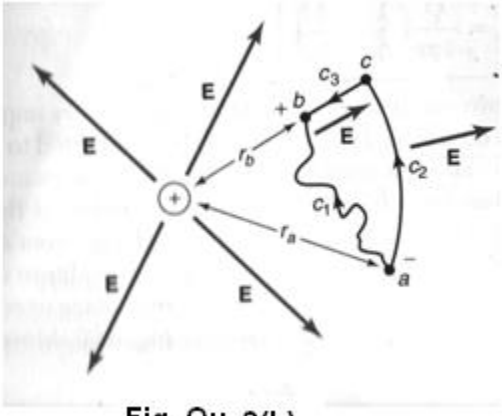


Fig. Qu. 3(b)

(c) Suppose that a 400 MHz uniform plane wave is travelling in the x-direction in a lossless dielectric ($\mu_r = 1$, $\varepsilon_r = 5$). with 10V/m electric field component in the –z direction:

(i) Draw the phasor diagram of the electric and magnetic field vectors.

(ii) Give the complete time-domain expressions for the electric and magnetic field vectors.

(iii) Determine the average power density of the wave. (10 marks)

Question FOUR

(a) (i) Distinguish between electrically small and electrically large structures

(ii) Determine the conditions for which lumped-circuit models are valid for a 30 GHz radar circuit. (4 marks)

(b) A volume charge distribution $P_v = \frac{2}{r}\ C/m^3$ is contained in a region defined in cylindrical coordinates as $0 \le z \le 2m\ ;\ 0 \le r \le 1m\ ; 45^0 \le \phi \le 90^0$.

(i) Draw the structure (ii) Determine the total charge contained in the region.

(6 marks)

(c) Using appropriate sketches explain how displacement current causes an antenna to radiate electromagnetic waves. (10 marks)

Question FIVE

(a) Consider Ampere's law:

(i) State this law mathematically (ii) Using an appropriate sketch explain the law in your own words. (3 marks)

(b) Using an appropriate sketch explain how you would prevent external magnetic fields from Interfering with sensitive electronic components within a circuit. (3 marks)

(c) Fig. Qu.5 (c) shows a straight wire of radius a carries a current I_1 along the axis of a metal tube with inner radius b and outer radius c. The tube carries a current I_1 in a direction opposite to that in the wire. Determine:

(i) H for $a < r < b$ (ii) H for $r > c$

Comment on the field along the wire and the usefulness of such cables. (9 marks)

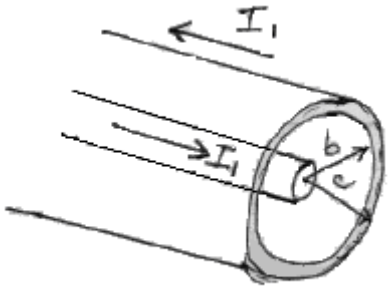


Fig. Qu.5(c)

(d) Discuss the parasitic effects of the component's connection leads as shown in Fig. Qu.5(d). (5 marks)

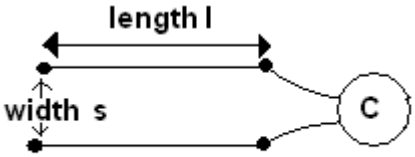


Fig. Qu.5(d)