PAPER TWO

TECHNICAL UNIVERSITY OF MOMBASA

School of Engineering and Technology

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

UNIVERSITY EXAMINATION FOR:

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

EEE 4203 ELECTROMAGNETICS I

END OF SEMESTER EXAMINATION

SERIES: JULY 2025

TIME: 2 HOURS

DATE: July 2025

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 (Compulsory 30 marks)

(a) State mathematically and describe using an appropriate sketch the concept of divergence of a vector $\overline{A}$. (4 marks)

(b) A spherical volume charge distribution $P_V = k r^2 C/m^3$ 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)

(c) Fig. Qu.1 (c) shows a straight wire of radius a carries a current I_1 along the axis of a metal tube with inner radius $b(30\,cm)$ and outer radius c. The tube carries a current $I_1(5\,A)$ 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 a cable. (9 marks)

(d) Determine the voltage V in the circuits shown in Fig.Qu.1(d). Show all your working clearly, motivate all the steps taken and show the corresponding Faraday sources using appropriate sketches. (10marks)

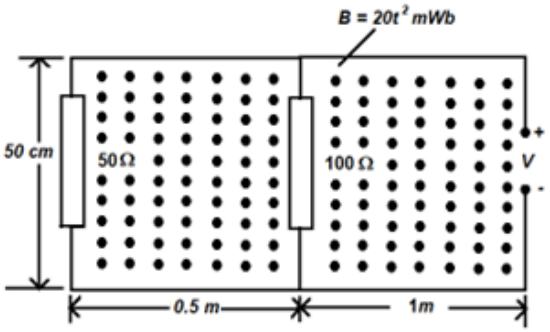


Fig. Qu.1(d)

Question TWO

(a) (i) State mathematically and explain the practical significance of Ampere's law in differential form.

(ii) Describe using relevant sketches the practical significance of the dot product of two vectors in parallel. (4 marks)

(b) A surface charge distribution $P_s = \frac{2}{r^2} C/m^2$ is contained in a region defined in cylindrical coordinates as

$0 \le r \le 2;\ \pi/4 \le \varnothing \le \pi/2;\ 0 \le z \le 2$

(i) Draw the structure (ii) Determine the total charge on the structure (10 marks)

(c) Given that $Z_{¿} = \frac{(z_L + j\, z_0 \tan \beta l) Z_0}{Z_0 + j\, z_L \tan \beta l}$ Show that a section of transmission line can behave either like a:

(i) Pure capacitor (ii) Pure inductor (6 marks)

Question THREE

(a) (i) State mathematically and explain the practical significance of Faraday's law in differential form.

(ii) Describe the practical significance of the dot product of two orthogonal vectors. (4 marks)

(b) Point charges $Q_1 = 10\,\mu C$, $Q_2 = 50\,\mu C$, & $Q_3 = 100\,nC$ are located at $(2,4,1)m$, $(5,1,0)m$, and $(7,7,1)m$. Determine the:

(i) Vector force exerted on Q_3 by Q_1 & Q_2

(ii) Electric field $\overline{E}$ on Q_3 by Q_1 & Q_2 (10 marks)

(c) Suppose a pcb with conductor length $l = 5\,cm$ and $\varepsilon_r = 2.1$ carries a digital clock signal with a fundamental frequency of $1\,GHz$. Determine:

(i) Time delay in nanoseconds (ii) Length l in terms of λ_g (iii) Phase shift in degrees (6 marks)

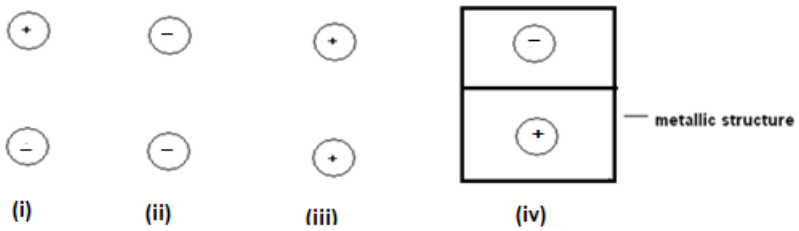
Question FOUR

(a) Given $\overline{A} = (2x^2 yz)a_x + (x^2 + z\,y^3)a_y + (y^2 - xyz)a_z;\ \overline{B} = (2x^2 z^2)a_x + (xz)a_y + (y + z^2)a_z$

Determine: (i) $¿\overline{A}$ (ii) $Curl\,\overline{A}$ (4 marks)

(b) By means of appropriate sketches describe the operation of (i) Capacitor (ii) Antenna (12 marks)

(c) Draw the approximate electric field lines for the following charge pairs. (4 marks)



Question FIVE

(a) If $\overline{A}=(6,4,-2)$; $\overline{B}=(-2,3,4)$, determine: (i) $\overline{A}\times\overline{B}$ (ii) The angle between $\overline{A}$ & $\overline{B}$ (6marks)

(b) Four $100\,\mu C$ point charges are located on the corners of a square that are defined in a rectangular coordinate system by $(1,0,0)m$, $(0,1,0)m$, $(-1,0,0)m$ and $(0,-1,0)m$. Determine the vector force exerted by another $100\,\mu C$ charge that is located at $(1,2,0)m$ (14 marks)