PAPER 2

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: NOVEMBER 2025

TIME: 2 HOURS

DATE: November 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

(a) With reference to electric circuits distinguish between lumped circuit and distributed circuit models. (6 marks)

(b) Point charges $Q_1 = 10\,\mu C$ and $Q_2 = 5\,\mu C$ are located at $(2,2,0)$m and $(5,7,0)$m respectively. Determine the

(i) Force on charge $Q_3 = ¿\ 100\mu C$ at $(7,3,0)$m (ii) Electric field at $(7,3,0)$m (12 marks)

(c) (i) Define the terms dot and cross products (ii) Determine the dot and cross product of the the vectors in Fig. Qu.1(c) (4 marks)

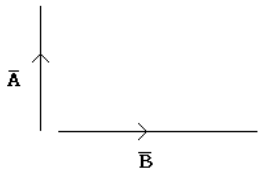

Fig. Qu.1(c)

d) A 600 MHz uniform plane wave is travelling in the following medium: Mylar (ε_r = 5 and μ_r = 1). Determine the:

(i) Phase constant β (ii) Intrinsic impedance η

(iii) Phase velocity of propagation ν (iv) wavelength λ (8 marks)

Question TWO

(a) With reference to electric fields define the following parameters giving their units.

(i) $\overline{E}$ (ii) $\overline{D}$ (iii) ε_0 (iv) ε_r (4 marks)

(b) Determine the charge contained on the surface charge distribution

$P_s = 8 \times 10^{-4} r\, C/m^2$ in a surface defined by $0 \le r \le 3;\quad 0 \le \phi \le \frac{\pi}{2};\qquad 0 \le \theta \le \frac{\pi}{2};$ (13 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 THREE

(a) (i) The electric field strength of air is $3 \times 10^6\, v/m$. Explain the practical meaning of this statement.

(ii) Determine the largest charge a $10\, cm$ radius metal sphere can hold if sparking is not to occur. (7 marks)

(b) Determine using Gauss' law, the electric field due to a sphere of charge of radius a for $r < a$ where the charge is uniformly distributed throughout the sphere volume with volume charge distribution $P_v\, C/m^3$ (7 marks)

(c) State the Poynting theorem describing all the four elements of the equation. (6 marks)

Question FOUR

(a) (i) Define mathematically and in words Faraday's law in integral form

(ii) Determine the voltage V in the circuit of Fig. Qu.4(a) using appropriate sketches (10 marks)

(b) Fig. Qu. 4(b) shows a straight wire of radius 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, justifying any assumptions: (i) H for $a \le r \le b$ (ii) H for $r > b$

Comment on the usefulness of such a cable. (10 marks)

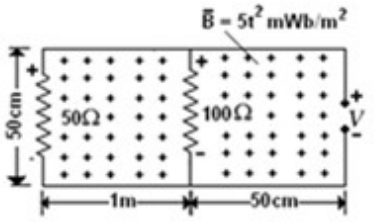

Fig. Qu.4(a)

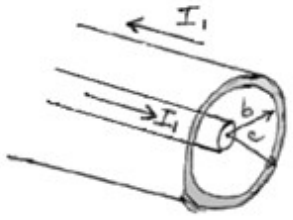

Fig. Qu.4(4b)

Question FIVE

(a) State Ampere's law in integral form and explain its significance. (3 marks)

(b) Determine whether the following fields in free space satisfy Ampere's law

$$\overline{B}=\frac{\beta E_m}{\omega}\cos(\omega t-\beta z)\hat{a}_y \qquad \overline{E}=E_m\cos(\omega t-\beta z)\hat{a}_z$$ (6 marks)

(c) With reference to Fig.Qu.5(b), medium 1 has $\mu_{r1}=16, \varepsilon_{r1}=4$ and medium 2 has $\mu_{r2}=1, \varepsilon_{r2}=9$. Write the time-domain expressions for all the fields in these two media if the reflected field is

$$E^r=20\cos\left(\omega t+\frac{4\pi}{3}z\right)\hat{a}_x$$

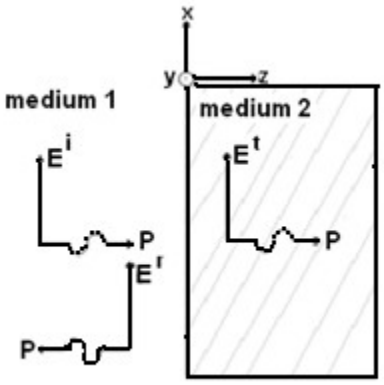

Fig. Qu. 5(b)

(d) Determine the (i) Average (ii) Reflected (iii) transmitted power density of the plane wave and show that energy is conserved across the boundary interface.