MACHAKOS UNIVERSITY

University Examination 2018/2019

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

THIRD YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EEE 302: ELECTROMAGNETIC FIELDS

DATE: 13/5/2019 **TIME: 11.00-1.00 PM**

INSTRUCTIONS

Answer Question ONE and any other TWO Questions.

QUESTION ONE (30 MARKS) (COMPULSORY)

a) In free space, the electric flux density is given by:

$$\boldsymbol{D} = D_0 \cos(\omega t + \beta z)\boldsymbol{a_x}$$

Use Maxwell's equation to find $\boldsymbol{H}$ (3 marks)

b) i Write down the Amperes equation in integral form

ii Clearly explain the inconsistency of the equation in b(i) if applied to time varying fields

iii Starting from the equation of continuity, show how Maxwell modified the Amperes law to make it consistent with the time varying fields. (6 marks)

c) Write down the Maxwell's equations in point form (4 marks)

d) Define the following terms as used in Electrostatic field

i. Electric potential

ii. Potential difference (2 marks)

e) State the Faradays law. Write down Maxwell's version of the equation in integral form (3 marks)

f) A point charge Q = 40nC has a velocity 3×10^6 m/s in the direction $a_v = 0.2a_x + 0.75a_y - 0.3a_z$. Calculate the magnitude of the force on the charge due to the field $B = 3a_x - 4a_y + 6a_z mT$ (4 marks)

g) A parallel – plate capacitor has plates located at z =0 and z=d. the region between plates is filled with a material containing volume charge of uniform density ρ_0 C/m^3 and which has permittivity ε .Both plates are held at ground potential.

i. Use poisson's equation to determine the potential field between plates under assumption that *V* varies only with *z*.

ii. Determine the electric field intensity, E between the plates. (6 marks)

QUESTION TWO (20 MARKS)

a) i Write down the following equations

I. Laplace

II. Poisson

ii The electrostatic potential in a given region is given by $V = 2x + 3$y-z. Determine the electric field strength at this point. (4 marks)

b) The electric field intensity in free space is given by: $\vec{\boldsymbol{E}} = 5\sin(\omega t - 3z)\boldsymbol{a_y}$**.** Determine the expression for;

i. Electric flux density, $\vec{D}$

ii. Magnetic flux density, $\vec{B}$

iii. Magnetic field strength $\vec{H}$ (8 marks)

c) The electric flux density in free space produced by an oscillating electric charge placed at the origin is

$$\vec{D} = \vec{a}_r \frac{10^{-9}}{4\pi}\frac{1}{r^2}\cos(\omega t - \beta r)$$

where $\beta = \omega\sqrt{\mu_0\varepsilon_0}$ .Find the time-average charge that produces this electric flux density. (8 marks)

QUESTION THREE (20 MARKS)

a) State **three** factors that affect Coulomb's Force (3 marks)

b) Point charges 5nC and -2nC are located at (2, 0, 4) and (-3, 0, 5) respectively.

For the point (1, -3,7) determine the

i. force on a point charge located at the point

ii. electric field strength **E** at the point (7 marks)

c) A hollow spherical shell shown in Figure 1 carries a charge density $\rho = \frac{k}{r}$ in the region $a \leq r \leq b$. Determine the electric field in the region

i. $a < r < b$

ii. $r > b$ (10 marks)

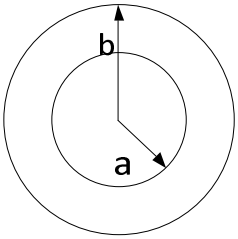

Figure 1

QUESTION FOUR (20 MARKS)

a) i Write down the Biot-Savart law equation. Explain all the symbols used. (4 marks)

ii A current **I** flows around the ring as shown in Figure 2. For a choice of $\overrightarrow{\boldsymbol{dl}}$ around the ring show that the magnetic field strength at the centre of the ring is given by: (6 marks)

$$\vec{\boldsymbol{B}} = \frac{\mu_0 I}{2R}$$

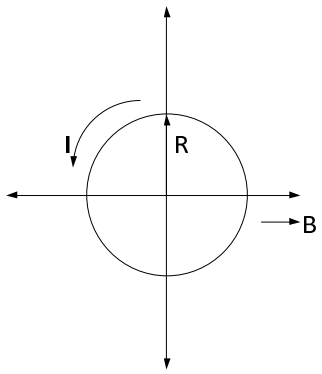

Figure 2

b) The electric field in air is given by $\vec{E} = \rho t e^{-\rho - t} a_{\Phi}$. Determine the:

i. Flux density $\vec{\boldsymbol{B}}$

ii. Current density $\vec{J}$ (10 marks)

QUESTION FIVE (20 MARKS)

a) i Starting from Maxwell's equations, show that the three dimensional wave equation in free space is given by:

$$\nabla^2 \vec{B} = \varepsilon_0 \mu_0 \frac{\partial^2 \vec{B}}{\partial t^2}$$

ii From the equation in (i), explain why Maxwell suggested that light is a form of electromagnetic wave. (10 marks)

b) An electric dipole of length L in free apace has radial field given in spherical system as $\boldsymbol{H_s} = \frac{IL}{4\pi r} \sin(\frac{1}{r} + j\beta) e^{-j\beta r} \boldsymbol{a_\phi}$. Find $\boldsymbol{E_s}$ using Maxwell's equations. (10 marks)