DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

UNIVERSITY EXAMINATIONS 2019/2020

SECOND YEAR SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

SECOND YEAR SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION IN TECHNOLOGY (EEE)

EEE 2206/EET 2204 ELECTROMAGNETICS I

DATE: AUGUST 2019 TIME: 2 HOURS

INSTRUCTIONS:

1. This paper contains **FOUR** printed pages with **FIVE** Questions.
2. Answer **QUESTION ONE (COMPULSORY)** and **ANY** other **TWO** questions.
3. Clearly show all your working.

Free Space Permittivity $\varepsilon_0 = \frac{10^{-9}}{36\pi} F/m$

QUESTION ONE [COMPULSORY – 30 MARKS]

1 a) Distinguish between the following types of fields as used in Electromagnetics. Give two examples of each type of field.

i. Solenoidal field. **[2 Marks]**

ii. Irrotational/Conservative field. **[2 Marks]**

b) Determine the divergence and the curl of the following vector field: **[4 Marks]**

$$\overline{\boldsymbol{V}} = e^{xy}\,\hat{a}_x + \sin xy\;\hat{a}_y + \cos^2 xz\,\hat{a}_z$$

c) A uniform line charge of $2\mu\,{}^{C}/_{m}$ is located on the *z*-axis. Find $\overline{\boldsymbol{E}}$ in cartesian coordinates at a point $P(1,2,3)$ if the charge extends from *z* = -∞ to *z* = ∞. **[3 Marks]**

d) Enumerate **TWO** applications of Electro-magnetics **[2 Marks]**

d) State the **TWO** Maxwell's equations in their integral and differential forms for ***Static*** Electric (Electrostatic) fields. **[2 Marks]**

e) Given a potential field distribution $V = e^{-5x}\cos 13y \sinh 12z$, determine whether V satisfies Laplace's equation. **[4 Marks]**

f) Two extensive homogeneous isotropic dielectrics meet on plane $z = 0$. For $z \geq 0, \varepsilon_{r1} = 4$ and for $z \leq 0, \varepsilon_{r2} = 3$. A uniform electric field $\overline{\boldsymbol{E}}_{\boldsymbol{1}} = 5\,\hat{a}_x - 2\hat{a}_y + 3\hat{a}_z\ kV/m$ exists for $z \geq 0$. Determine:

i. $\overline{\boldsymbol{E}}_{\boldsymbol{2}}$ for $z \leq 0$. **[4 Marks]**

ii. The angles $\overline{\boldsymbol{E}}_{\boldsymbol{1}}$ and $\overline{\boldsymbol{E}}_{\boldsymbol{2}}$ make with the interface. **[4 Marks]**

iii. The energy densities in both dielectrics in $^{J}/_{m^3}$. **[3 Marks]**

QUESTION TWO [20 MARKS]

2 a) Two point charges $-4\mu C$ and $5\mu C$ are located at $(2,-1,3)$ and $(0,4,-2)$, respectively. Find the potential at $(1,0,1)$ assuming zero potential at infinity. **[6 Marks]**

b) The principle of charge conservation states that the time rate of decrease of charge within a given volume must be equal to the net outward current flow through the closed surface of the volume. Using this statement, show that the continuity of current equation is given by:

$$\nabla \cdot \bar{\boldsymbol{J}} = -\frac{\partial \rho_v}{\partial t}$$

where $\bar{\boldsymbol{J}}$ is the current density and ρ_v is the volume charge density. **[5 Marks]**

c) Point charges $Q_1 = 1\text{mC}$ and $Q_1 = -2\text{mC}$ are located at $(3,2,-1)$ and $(-1,-1,4)$ respectively.
Calculate:

i. The Electric force $\overline{\boldsymbol{F}}$ on a 10nC charge located at $(0,3,1)$. **[6 Marks]**

ii. The Electric Field Intensity $\overline{\boldsymbol{E}}$ at that point. **[3 Marks]**

QUESTION THREE [20 MARKS]

3 a) Express the point $S(-6,-8,-20)$ in Cylindrical and Spherical coordinates. **[4 Marks]**

b) With the aid of well-labeled diagram(s), illustrate the definition of coordinate variables for the Cartesian, Cylindrical and Spherical coordinate systems. Hence, state the relations between the Cartesian coordinate variables to the Cylindrical and Spherical coordinate variables. **[8 Marks]**

c) If the electric flux density is given by $\bar{\boldsymbol{D}} = (2y^2 + z)\hat{a}_x + 4xy\,\hat{a}_y + x\,\hat{a}_z \ {}^{C}/_{m^2}$, determine;

i. The volume charge density ρ_v at (-1, 0, 3). **[3 Marks]**

ii. The flux Ψ through the cube defined by $0 \leq x \leq 1$, $0 \leq y \leq 1$, $0 \leq z \leq 1$. **[3 Marks]**

iii. The total charge Q_{enc}, enclosed by the cube. **[2 Marks]**

QUESTION FOUR [20 MARKS]

4a) Using expressions in Cartesian coordinates, define the terms **gradient of a scalar** field and **divergence of a vector** field. What is the unique difference in the results of the two? **[2 Marks]**

b) Determine the electric flux density $\bar{\boldsymbol{D}}$ at (0,3,4) if there is a point charge -4π mC at (0,3,0) and a line charge 6π mC/m along the y-axis. **[7 Marks]**

c)

i. State Coulomb's law. **[2 Marks]**

ii. Derive Coulomb's law for N multiple charges. **[6 Marks]**

i. Hence deduce the expression for the Electric field intensity using the equation found in c(ii). **[3 Marks]**

QUESTION FIVE [20 MARKS]

5 a) Starting with Gauss's law given by $\Psi = Q_{enc}$, show that $\rho_v = \nabla \cdot \bar{\mathbf{D}}$, that is, the volume charge density is given by the divergence of the electric flux density. **[4 Marks]**

b) Transform the following vector to Cylindrical and Spherical coordinates. **[6 Marks]**

$$\bar{\boldsymbol{A}} = (x + z)\hat{a}_y$$

c) Point charges $Q_1 = 1$nC, $Q_2 = -2$nC, $Q_3 = 3$nC and , $Q_2 = -4$nC are positioned one at a time and in that order at $P_1(0,0,0)$, $P_2(1,0,0)$, $P_3(0,0,-1)$ and $P_4(0,0,1)$, respectively. Calculate the energy in the system after each charge is positioned. **[10 Marks]**

**********THE END**********