DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

UNIVERSITY EXAMINATION 2019/2020

THIRD YEAR FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGENEERING (CBD)

EEE2206 ELECTROMAGNETICS I

AUGUST 2019 **TIME: 2 HOURS**

Instructions:

This examination paper contain **five** questions. Attempts **question one** and any other **two question**. Question **ONE** is **Compulsory** and carries **30 Marks**. All the other questions **carry 20 Marks** each. **Neatness, good handwriting, clarity and precise explanations must be observed.**

See the last page for necessary data:

QUESTION ONE

a) i) State Coloumb's Law as it applies to Electrostatic.

ii) Define electric field strength and electric potential at a general point in free space due to a point charge at origin. **(5marks).**

b) Two charges each of 1pC are located 1m apart. At a point midway between and 50 cm above the line joining these two charges, find

i) Electric field and

ii) Electric potential. **(6marks).**

c) Given the vector field A=i(yz)+j(zx)+k(xy), Show that A is

i) Solenoidal and also

ii) Irrotational

iii) Find the unit vector in the direction of A at the point (1,1,1). **(7Marks).**

d) Using Maxwell's Divergence equation involving charge density and flux density, in point form, obtain the following:

i) Poisson's equation and

ii) Laplace equation. **(5marks)**

e) Calculate the work done in moving a 4C of electric charge in an electric field E=ix+j2y V/m from a point (3,0,0) to another point (0,3,0). **(7marks)**

QUESTION TWO

a) Obtain an expression for 'E' in free space due to an infinite line charge of uniform linear charge density. **(6marks)**

b)

i) Derive a formula for capacitance per unit length of a co-axial cable.

ii) A co-axial cable with ratio of diameters of 2 is 10 Km long. If the breakdown strength of the dielectric used is 25MV/m and the working voltage is 200KV, determine the energy stored in the cable. Assume ε_r =1 **(9marks)**

c) Two parallel conducting planes are situated at y=0 and y=o.o2m. Flux density D between the plates is 253nC/sq. m in y direction. Using one dimensional Laplac's equation, determine the conductor voltages if V=0 at Y=0.01m. **(5marks)**

QUESTION THREE

a) Derive boundary conditions for electrostatic fields E and D at the interface between two different charge free dielectric media. **(8marks)**

b) Given that D_1= 〖4a〗_x + 〖3a〗_y + 〖6a〗_z in a medium with ε_r1=3. X=0 is the boundary and the other medium has ε_r2=5. Find D_2 . **(6marks)**

c) Using differential quantity, obtain the expression for the following:

i) Curved surface area of a cylinder and **(6marks)**

ii) Volume of a sphere

QUESTION FOUR

a)

i) Three different charges are moved from infinity to some final different positions in a region which was initially charge free. Obtain an expression for energy stored in this electronic system.

ii) Generalize your result in (i) above for 'n' charges. **(8marks)**

b) Three charges of values 1nC, 3nC and 6nC are at the corners of an equilateral triangle of side 40 cm in free space. Determine the work required to move these charges towards the centroid of the triangle forming a new equilateral triangle of side 0.1 m. **(7marks)**

c) Potential function in free space is given as V=3x+4y volts. Find **(5marks)**

i) Energy density and

ii) Energy stored in a sphere of radius 50cm

QUESTION FIVE

a) i) Define an electric dipole

ii) Derive an expression for the potential at a point in the far field region of an electric dipole using spherical co-ordinates.

iii) Using (ii) above obtain an expression for E in space.

iv) Sketch equipotential lines of the dipole in X=0 plane if dipole axis coincides with z-axis. **(11marks)**

b) Write short notes on the following:

i) Theory of images

ii) Polarization in dielectrics and

iii) Band theory to distinguish between three types of solid materials used in electromagnetic applications. **(9mark)**

ESSENTIAL MATHEMATICS

A: Differential element of line, area and volume

Co-ordinate system	Differential length	Differential area	Differential volume
Cartesian	$d\ell = \mathbf{a}_x dx + \mathbf{a}_y dy + \mathbf{a}_z dz$	$ds_x = dydz$ $ds_y = dxdz$ $ds_z = dxdy$	$dv = dxdydz$
Cylindrical	$d\ell = \mathbf{a}_\rho d\rho + \mathbf{a}_\phi \rho d\phi + \mathbf{a}_z dz$	$ds_\rho = \rho d\phi dz$ $ds_\phi = d\rho dz$ $ds_z = \rho d\rho d\phi$	$dv = \rho d\rho d\phi dz$
Spherical	$d\ell = \mathbf{a}_r dr + \mathbf{a}_\theta r d\theta + \mathbf{a}_\phi r\sin\theta d\phi$	$ds_r = r^2 \sin\theta d\theta d\phi$ $ds_\theta = r\sin\theta dr d\phi$ $ds_\phi = r dr d\theta$	$dv = r^2 \sin\theta dr d\theta d\phi$

B: Differential vector operators

Gradient of scalar V

$$\nabla V = \left(\mathbf{a}_x \frac{\partial}{\partial x} + \mathbf{a}_y \frac{\partial}{\partial y} + \mathbf{a}_z \frac{\partial}{\partial z}\right) V \qquad \text{(Cartesian)}$$

$$\nabla V = \left(\mathbf{a}_\rho \frac{\partial}{\partial \rho} + \mathbf{a}_\phi \frac{1}{\rho}\frac{\partial}{\partial \phi} + \mathbf{a}_z \frac{\partial}{\partial z}\right) V \qquad \text{(Cylindrical)}$$

$$\nabla V = \left(\mathbf{a}_r \frac{\partial}{\partial r} + \mathbf{a}_\theta \frac{1}{r}\frac{\partial}{\partial \theta} + \mathbf{a}_\phi \frac{1}{r\sin\theta}\frac{\partial}{\partial \phi}\right) V \qquad \text{(Spherical)}$$

Divergence of vector **A**

$$\nabla \cdot \mathbf{A} = \frac{\partial A_x}{\partial x} + \frac{\partial A_y}{\partial y} + \frac{\partial A_z}{\partial z} \qquad \text{(Cartesian)}$$

$$\nabla \cdot \mathbf{A} = \frac{1}{\rho}\frac{\partial}{\partial \rho}(\rho A_\rho) + \frac{1}{\rho}\frac{\partial A_\phi}{\partial \phi} + \frac{\partial A_z}{\partial z} \qquad \text{(Cylindrical)}$$

$$\nabla \cdot \mathbf{A} = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 A_r) + \frac{1}{r\sin\theta}\frac{\partial}{\partial \theta}(A_\theta \sin\theta + \frac{1}{r\sin\theta}\frac{\partial A_\phi}{\partial \phi} \qquad \text{(Spherical)}$$

Curl of vector **A**

$$\nabla \times \mathbf{A} = \mathbf{a}_x\left(\frac{\partial A_z}{\partial y} - \frac{\partial A_y}{\partial z}\right) + \mathbf{a}_y\left(\frac{\partial A_x}{\partial z} - \frac{\partial A_z}{\partial x}\right) + \mathbf{a}_z\left(\frac{\partial A_y}{\partial x} - \frac{\partial A_x}{\partial y}\right) \qquad \text{(Cartesian)}$$

$$\nabla \times \mathbf{A} = \mathbf{a}_\rho\left(\frac{1}{\rho}\frac{\partial A_z}{\partial \phi} - \frac{\partial A_\phi}{\partial z}\right) + \mathbf{a}_\phi\left(\frac{\partial A_\rho}{\partial z} - \frac{\partial A_z}{\partial \rho}\right) + \mathbf{a}_z \frac{1}{\rho}\left(\frac{\partial(\rho A_\phi)}{\partial \rho} - \frac{\partial A_\rho}{\partial \phi}\right) \qquad \text{(Cylindrical)}$$

$$\nabla \times \mathbf{A} = \mathbf{a}_r \frac{1}{r\sin\theta}\left(\frac{\partial(A_\phi \sin\theta)}{\partial \theta} - \frac{\partial A_\theta}{\partial \phi}\right) + \mathbf{a}_\theta \frac{1}{r}\left(\frac{1}{\sin\theta}\frac{\partial A_r}{\partial \phi} - \frac{\partial(rA_\phi)}{\partial r}\right) + \mathbf{a}_\phi \frac{1}{r}\left(\frac{\partial(rA_\theta)}{\partial r} - \frac{\partial A_r}{\partial \theta}\right) \qquad \text{(Spherical)}$$

Laplacian of scalar V

$$\nabla^2 V = \left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}\right) V \qquad \text{(Cartesian)}$$

$$\nabla^2 V = \frac{1}{\rho}\frac{\partial}{\partial \rho}\left(\rho \frac{\partial V}{\partial \rho}\right) + \frac{1}{\rho^2}\left(\frac{\partial^2 V}{\partial \phi^2}\right) + \frac{\partial^2 V}{\partial z^2} \qquad \text{(Cylindrical)}$$

$$\nabla^2 V = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 \frac{\partial V}{\partial r}\right) + \frac{1}{r^2 \sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta \frac{\partial V}{\partial \theta}\right) + \frac{1}{r^2 \sin^2\theta}\frac{\partial^2 V}{\partial \phi^2} \qquad \text{(Spherical)}$$

Permittivity of air $\varepsilon_0 = \frac{1}{36\pi} \times 10^{-9}$ F/m