



KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012

SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN COMPUTER ENGINEERING

SCE 319 ELECTROMAGNETIC FIELDS

DATE: TUESDAY, 17TH APRIL 2012

TIME: 11.00A.M – 1.00 P.M

INSTRUCTIONS

*Answer question ONE and any TWO of the remaining FOUR questions
All workings should be shown in a neat and legible manner*

You have been provided:

$$\text{permittivity of free space, } \epsilon_0 = \frac{10^{-9} \text{ F}}{36\pi \text{ m}} ; \text{ permeability of free space, } \mu_0 = 4\pi \times 10^{-7} \frac{\text{H}}{\text{m}}$$

Question 1 (Compulsory) - 30 marks

- (i) State Coulomb's Law. (2 marks)
- (ii) Use the spherical coordinate system to find the volume of a hemispherical shell of inner radius 1.6 m and outer radius of 2.2 m. (5 marks)
- (iii) Two point charges, $Q_1 = 50\mu\text{C}$ and $Q_2 = 100\mu\text{C}$ are located at (-1,1,-3) m and (3,1,0) m, respectively. Find the force on Q_1 . (5 marks)
- (iv) Using the principle of superposition, find the force, $\mathbf{F}$ on a $100\mu\text{C}$ charge at (0, 0, 3) m due to four like charges of $20\mu\text{C}$ located on the x and y axes at $\pm 4\text{ m}$ (8 marks)
- (v) Show that the electric field at an arbitrary point in space due to a uniformly distributed line charge of density ρ_l is given by

$$E = \frac{\rho_l}{2\pi\epsilon_0 r} a_r \frac{V}{m}$$

(10 marks)

Question 2 (20 marks)

- a) Explain what is meant by the following terms: (3 marks)
- (i) Dielectric strength
 - (ii) Dielectric relaxation time
 - (iii) Triboelectricity
- b) Calculate the magnitudes of **D** and **P** for a dielectric material in which $E = 0.55 \text{ MV/m}$ and electric susceptibility is 4.55 (7 marks)
- c) Calculate the work done in moving a point charge $Q = 50 \text{ } \mu\text{C}$ from the origin to $(3 \text{ m}, \pi/8, \pi/2)$ spherical coordinates through an electrostatic field given by

$$E = 15e^{-\frac{r}{4}}\mathbf{a}_r + \frac{100}{r \sin \theta}\mathbf{a}_\theta \frac{V}{m}$$

(10 marks)

Question 3 (20 marks)

- a) What is an electric dipole? (2 marks)
- b) Show that the capacitance due to concentric cylinders is given by the relation below whereby a is the radius of the inner cylinder and b is the radius of the outer cylinder

$$C = \frac{2\pi\epsilon}{\ln\left(\frac{b}{a}\right)} \frac{\text{Farads}}{\text{meter}}$$

(10 marks)

- c) A total charge of **20 nC** is uniformly distributed over a circular disk of radius 0.5 m.
- a. Find the potential due to this charge at the point on the z-axis 0.2 m from disk. Use the cylindrical coordinate system. (6 marks)
 - b. Compare your result to the potential which results if all of the charge is at the center of the disk. (2 marks)

Hint: $\int \frac{x}{(x^2 + a^2)^{1/2}} dx = \sqrt{x^2 + a^2}$

Question 4 (20 marks)

- a) State Gauss' Law (2 marks)
- b) Use the concept of special Gaussian surfaces to derive an expression for the electric flux density vector, **D** due to a uniform line charge of infinite length with density ρ_l . (12 marks)

- c) A sheet charge of uniform density $\rho_s = 0.3 \frac{nC}{m^2}$ covers the plane $2x - 3y + z = 6 \text{ m}$. Find $\mathbf{E}$ on the side of the plane containing the origin. (6 marks)

Question 5 (20 marks)

- (i) State two sources of static magnetic fields (2 marks)

- (ii) Apply Biot Savart's Law to show that the magnetic field on the axis of a circular coil of radius a carrying a current I is given by

$$\overline{B} = \frac{\mu_0 I \sin^3 \theta}{2a}$$

[12 marks]

- (iii) A scalar potential function $\phi = x^1 z^2 + y$ at a point $(-2, 3, -5)$. Calculate:

- The magnitude of the electric field intensity $\mathbf{E}$ (3 marks)
- The unit vector in the direction of $\mathbf{E}$ (3 marks)

