KENYATTA UNIVERSITY

UNIVESITY EXAMINATIONS 2011/2012

SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN ELECTRICAL & ELECTRONICS ENGINEERING

EEE 302 ELECTROMAGNETIC FIELDS

DATE: THURSDAY, 19TH APRIL 2012 **TIME: 2.00 A.M. – 4.00 P.M.**

INSTRUCTIONS

(i) This paper contains **FIVE (5)** questions.

(ii) Answer question **ONE (1)** and any other **TWO (2)** questions.

Question 1 **30 marks**

a) State the three constitute relations. Define all the symbols used. (6 marks)

b) Give a clear distinction between a source field and a vortex field. State one example in each case. (4 marks)

c) A 1-metre cylindrical copper conductor of radius $1mm^2$ carrys a current of 0.2A. Determine:

(i) the current density in the conductor. (2 marks)

(ii) the resistance per unit of the conductor length (3 marks)

d) Write down the boundary condition forelectrostatic fields with:

i) the boundary between a good conductor and a dielectric material. (3 marks)

ii) the boundary between two dielectric materials having different dielectric constants. (3 marks)

e) Starting from the differential form of Gauss's law, derive Poisson's equation. (3 marks)

f) i) In an electrostatic field, the electric field lines are always orthogonal to the equipotential surfaces. Explain why? (3 marks)

ii) The sketch in Fig. Q1(f) below shows a cross sections of equipotential surfaces between two charged conductors that are shown in solid black. Various points on the equipotential surfaces near the conductors are labeled **A**, **B**, **C**, ..., **I**. At which of the labeled points will

the electric field have the greatest magnitude? Explain.

(3 marks)

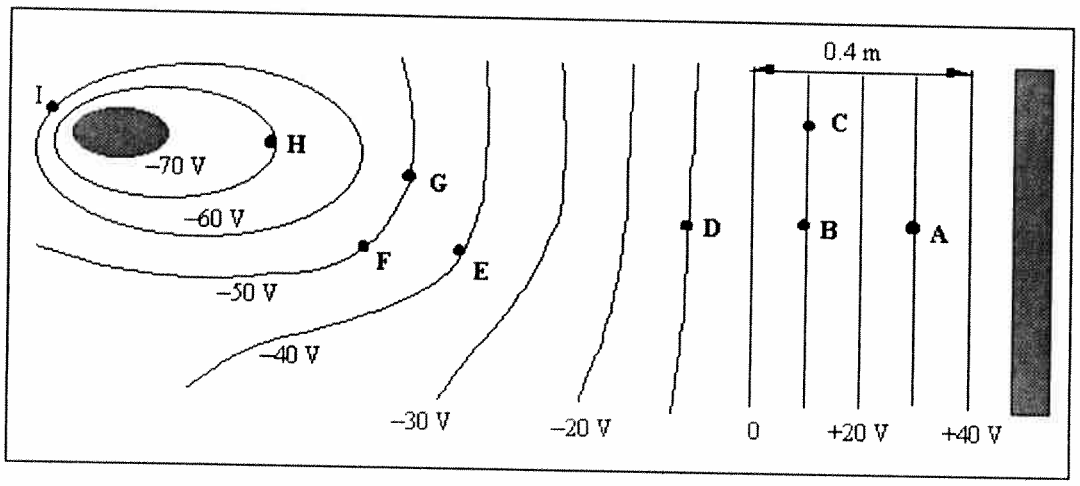

Fig. Q1(f)

Question 2 **20 marks**

a) State Ampere's circuital law. (2 marks)

b) Show, from Ampere's circuital law, that in a region of magnetic field, the magnetic field vector H is related to the conduction current density $\vec{J}$ through the equation: $\Delta \times \vec{H} = \vec{J}$. (4 marks)

c) Use Ampere's circuital law to determine the magnetic flux $\vec{B}$ for wire of radius, r_o carries a steady current, *I* uniformly distributed throughout its cross-sectional area:

i) Outside the conductor (i.e $r > r_o$). (3 marks)

ii) Inside the conductor (i.e $r < r_o$). (3 marks)

iii) Sketch a graph of B against r(x-axis) (2 marks)

d) Using Ampere's circuital law, determine the magnetic flux **B** for toroid with N turns of wire. (4 marks)

Question 3 **20 marks**

a) State Coulomb's law. Define carefully any sympols used and state the main assumption made. (3 marks)

b) Determine the total charge contained in the following charge configurations:

i) A line charge distribution ρ_l (x,y,z) = 2x + 3y – 4z C/m extending from point A(2, 1, 5) to point B(4, 3, 6). (4 marks)

ii) A circular disc of radius R with a surface charge density that increases away from the center, the constant of proportionality being k. (4 marks)

c) Consider a line charge with uniform charge distribution, ρ_l C/m. Determine an expression for the force exerted on a point charge q located at a distance d from the centre of the line charge when:

i) with a line charge of finite length, L. (4 marks)

ii) with a line charge of infinite length. (2 marks)

d) Given the vector field, $\vec{A} = \cos(\pi - y)\hat{i} + \sin(\pi x)\hat{j}$, find the divergence of the field. (3 marks)

Question 4 **20 marks**

a) Define the electrical scalar potential. Explain all the symbols used. (4 marks)

b) A potential distribution in air is given by $\Phi = 12x^3 + 6y^2 - 4z$. Calculate the electric field $\vec{E}$ and the volume charge density, ρ_l at the following positions: (0,0,0), (4,0,0) and (0,4,0). (6 marks)

c) Determine the electric field strength for the following systems in the region between the conductors:

i. A parallel parallel plate capacitor with conducting plates having areas A each and separated by a distance d and carrying uniform distributed charges +Q and –Q respectively. (3 marks)

ii. Two concentric conducting cylinders of length l with radii a and b such that a < b, carrying uniform distributed charges +Q and –Q respectively. (3 marks)

d) Calculate the capacitance of each of the systems described in part (c) abave. (4 marks)

Question 5 **20 marks**

a) Explain briefly what electrostatic shielding means. (2 marks)

b) See Fig. Q5(a). For each of the loops *a* to *d*, find $\oint \vec{B} \cdot d\vec{s}$. (4 marks)

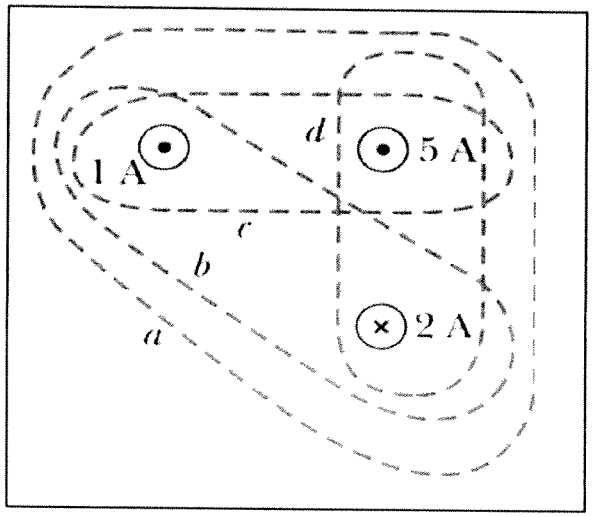

Fig. Q5(b).

c) Find the magnetic force between two parallel conductors separated by a distance *d* and carrying currents I_1 and I_2 respectively if:

i. the currents are in the same direction. (5 marks)

ii. the currents are in opposite direction. (2 marks)

d) For a thin, straight and infinite wire carrying a constant current, I, use Biot-Savart law to derive an expression for the total magnetic field at any point P at a distance R from the wire. (7 marks)