MACHAKOS UNIVERSITY COLLEGE

(A Constituent College of Kenyatta University)
University Examinations for 2015/2016 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION (SCIENCE)

SPH 401: ELECTRODYNAMICS

DATE: 3/8/2016 **TIME: 11:00 – 1:00 PM**

INSRUCTIONS:

Answer question ONE and any other two. Question one carries 30marks
While each of the others carry 20 marks
QUESTION ONE

a) i) Define the term displacement current (1 mark)

ii) In a material for which conductivity is 5 S/m and relative permittivity 1, the electric field intensity is $250\sin 10^{10}t$ (V/m). Find the displacement current density. (3 marks)

b) i) Define Faraday's law (1 mark)

ii) The circular loop conductor shown in Fig. 1 lies in the z=0 plane, has a radius of 0.1 m and a resistance of $5\,\Omega$. Given $\mathbf{B} = 0.2\sin 10^3\, t\mathbf{a_z}$ (T). Determine the current.

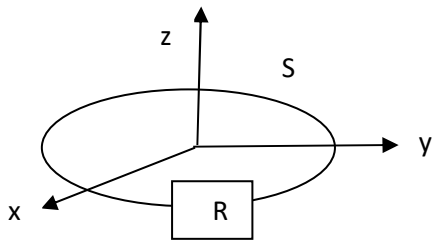

Figure 1

(3 marks)

iii) Find the work done in moving a point charge q = - 20μC from (4,0,0) in to (4,2,0) in the field $E = (\frac{x}{2} + 2y)a_x + 2xa_y$ (3 marks)

c) i) Define the term equipotential surface (1 mark)

ii) Show that the electric flux lines are perpendicular to equipotential surfaces (3 marks)

d) i) Differentiate between divergence and Stoke's theorems (2 marks)

ii) Use Gauss's law to obtain the electric field generated by a very long thin charge line with λ coulombs per metre (3 marks)

e) i) State the boundary condition for electric field across a dielectric interface (2 marks)

ii) Give three mathematical expressions of Maxwell's equations in integral forms (3 marks)

f) i) Explain why Laplace's and Poisson's equations are more important in determining the potential function V (2 marks)

ii) Show that the electric charge q distributed throughout the volume of a sphere of radius R and total charge Q is given by $q = \frac{Qr^3}{R^3}$ where r is the radius of a Gaussian surface (3 marks)

QUESTION TWO

a) Region 1, where $\mu_{r1} = 4$, is the side of a plane y + z = 1 containing the origin as shown in Fig. 2. In region 2, $\mu_{r1} = 6$. Given $\mathbf{B}_1 = 2.0\ \mathbf{a}_x + 1.0\mathbf{a}_y$ T, find $\mathbf{B}_2$ and $\mathbf{H}_2$ (8 marks)

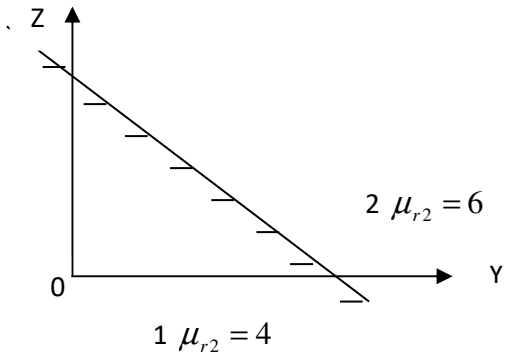

Figure 2

b) A current sheet, $\mathbf{K} = 9\mathbf{a}_y$ A/m, is located at z = 0, the interface between region 1, z < 0, with $\mu_{r1} = 4$, and region 2, z >0, $\mu_{r2} = 3$ as shown in Fig. 3. Given that $\mathbf{H}_2 = 14.5\,\mathbf{a}_x + 8.0\mathbf{a}_z$ A/m. Find $\mathbf{H}_1$ (7 marks)

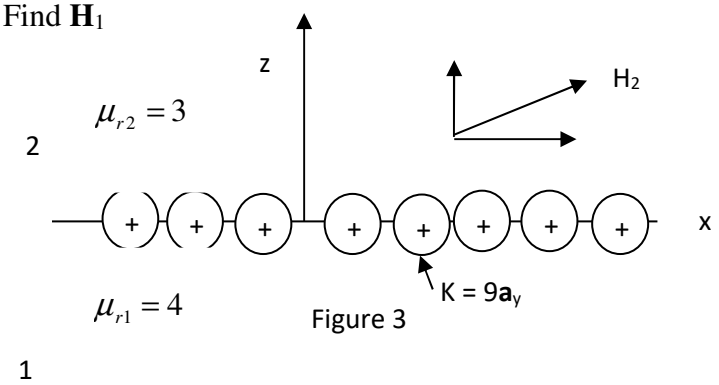

Figure 3

c) Show that electrostatic field **E** is conservative (5 marks)

QUESTION THREE

a) A conductor 1 cm in length is parallel to the z-axis and rotates at a radius of 25 cm at 1200 rev/min as shown in Fig. 4. Find the induced voltage if $B = 0.5a_r$ (T)

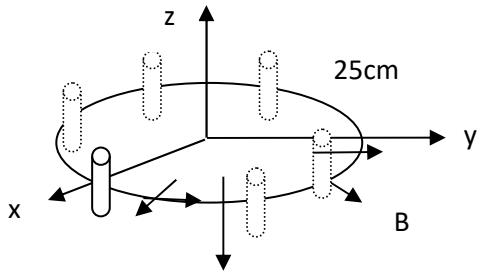

Figure 4

(7 marks)

b) In region 1 of Fig 5, $\mathbf{B}_1 = 1.2\,\mathbf{a}_x + 0.8\mathbf{a}_y + 0.4\,\mathbf{a}_z$ T. find H_2 (i.e. H at z = +0) and angles between the field vectors and a tangent to the interface. (9 marks)

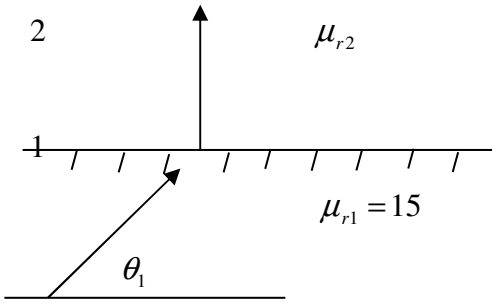

Figure 5

c) i) Define the term poynting 's vector (1 mark)

ii) Determine the propagation constant γ for a material having $\varepsilon_r = 8.\ \mu_r = 1, \sigma = 0.25 pS/m$ if the wave frequency is 1.6MHz (3 marks)

QUESTION FOUR

a) Determine the amplitudes of the reflected and transmitted **E** and **H** at an interface if E_{oi} = 1.5 x 10^{-3}V/m in region 1, in which $\varepsilon_{r1} = 8.5,\ \mu_{r1} = 1, \sigma = 0$. Region 2 is free space. Assume normal incidence (10 marks)

b) Find the force on a point charge of 50 μC at (0, 0, 5) m due to a charge of 500 π that is uniformly distributed over the disc $r \le 5m$, z = 0 as shown in Fig. 6 (5 marks)

c) i) Define the term dielectric material (1 mark)

ii) Show that when a dielectric is introduced in a parallel plate capacitor the capacitance is increased by a factor, which is equal to the relative permittivity of the dielectric. (4 marks)

QUESTION FIVE

a) Using relevant operators and Stoke's theorem only, derive two Maxwell's equations. (4 marks)

b) A normally incident **E** field has an amplitude E_{oi} = 1.0V/m in free space just outside of sea water in which, $\varepsilon_r = 80,\ \mu_{r1} = 1,$ and $\sigma = 2.5 S/m$. For a frequency of 30 MHz, at what depth will the amplitude of **E** be 1.0mV/m? (7 marks)

c) If a magnetic field B cuts an amperian closed loop, show that the components of *curl B* in Cartesian coordinates in the x, y and z directions is given by (9 marks)

$$(curlB)_x = \left(\frac{\partial B_z}{\partial y} - \frac{\partial B_y}{\partial z}\right),\ (curlB)_y = \left(\frac{\partial B_x}{\partial z} - \frac{\partial B_z}{\partial x}\right), (curlB)_z = \left(\frac{\partial B_y}{\partial x} - \frac{\partial B_x}{\partial y}\right)$$