KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012

SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE (TELECOMMUNICATION AND INFORMATION TECHNOLOGY

SPH 201: ELECTRICITY AND MAGNETISM II

DATE: **Friday 30th March 2012** **TIME:** **11.00a.m -1.00p.m**

INSTRUCTIONS

1. Answer question **one** and **any other two** questions. Question one carries two marks While each of the other questions carry 20 marks.

2. The following constants may be useful:

   i) Permittivity of free space $\varepsilon_o = 8.85 \times 10^{-12}\ C^2N^{-1}m^{-2}$
   ii) Permeability of free space $\mu_o = 4\pi \times 10^{-7}\ WbA^{-1}m^{-1}$
   iii) Acceleration due to gravity $g = 9.8\ ms^{-2}$
   iv) Charge of an electron $e = 1.6 \times 10\text{-}19\ C$

Q1. a) i) State Gauss's in words and in mathematical form. [2marks]

ii) A cylinder of radius R is immersed in a uniform electric field E with its axis parallel to the field. Prove that the electric flux through the cylinder is zero. [4marks]

iii) A surface encloses an electric dipole. What can you say about the flux through the surface ? [1mark]

b) A solid spherical insulator of radius R has a charge density ρ per unit volume. Derive expressions for electric field E at

i) $r < R$ [3marks]
ii) $r > R$ [2marks]
iii) Sketch a graph of the variation of E against r. [2marks]

c) The plates of a parallel plate capacitor are separated by a distance d = 1.0 mm. What must be the plate area if the capacitance is .1μF and the space between the plates is filled with air. [3marks]

d) An ac circuit has an inductive element with L = 230 mH, frequency ν = 60 Hz and $V_{L\ max} = 36$ V.

i) Find the inductive reactance X_L [2marks]

ii) Find the maximum current amplitude in the circuit. [1mark]

e) When a certain series circuit is connected to 100V dc source, the current is found to be 0.8 A and when it is connected to a 100 V ac source at a frequency of 500 Hz, the current is 0.4 A. What components are present in the circuit and what is the magnitude of each ? [4marks]

f) i) State Ampere's law. [1mark]

ii) A toroid has a total of 400 turns on the core with inner radius a = 4 cm and outer radius b = 6cm. If a current of 0.5 A is maintained in the windings, use Ampere's law to calculate the magnetic field B at a point mid-way between the inner and outer radii of the core of the toroid. [4marks]

(iii) Why is it that in practice the magnetic field outside the toroid is never completely equal to zero ? [1mark]

Q2. a) i) Show that the capacitance of a cylindrical capacitor with inner radius a and outer radius b having a length L and filled with air is given as

$$C = \frac{2\pi\varepsilon_o L}{\ln\left(\frac{b}{a}\right)}$$

Hence deduce any two geometrical factors that affect the capacitance C of the cylindrical capacitor. [5marks]

ii) The space between the conductors of a long coaxial cable used to transmit signals has an inner radius a = 0.15 mm and the outer radius b = 2.1 mm. What is the capacitance per unit length of the cable. [3marks]

b) Show that the electric field E at a point P on the Gaussian surface at a distance r from an infinite line charge having charge per unit length of λ is given as

$$E = \frac{\lambda}{2\pi\varepsilon_o r}$$ [6marks]

c) It is desired to increase the capacitance of a parallel plate capacitor by inserting a material of relative permittivity (dielectric constant) 5.0 into the space between the plates. There is only sufficient dielectric material to fill half the space between the plates. What is the most efficient of dielectric to use. [6marks]

Q3. a) i) State Biot-Savart law. [2marks]

ii) Show that the force of attraction per unit length between parallel current carrying wires a distance d meters apart carrying currents I_1 and I_2 is given as

$$F = \frac{\mu_o}{2\pi}\frac{I_1 I_2}{d}$$ [5marks]

b) Define magnetic moment and give its direction. [2marks]

c) The plane of a rectangular coil of wire 5.0 cm x 8.0 cm and having 20 turns is perpendicular to a magnetic field with magnitude of 0.2 T. The coil carries a current of 5 A. Calculate the:

i) magnetic moment of the loop. [2marks]

ii) potential energy when the coil is in the given orientation. [2marks]

iii) torque when the plane of the coil makes an angle of 30^o with the direction of magnetic field. [2marks]

d) A small sphere of mass 10^{-6} kg and a charge of 4×10^{-4} coulomb hangs from a silk thread at 60^o with a large charged conductor sheet. Calculate the surface charge density for the sheet. [5marks]

Q4. a) Sketch a phasor diagram for the following circuit elements:

i) a purely resistive element. [1mark]

ii) a purely capacitive element [1mark]

iii) an inductor with some resistance [1mark]

b) A series RLC circuit has the following values: resistance R = 160 Ω, inductance L = 230 mH, capacitance C = 15 μF, frequency ν = 60 Hz and V_{max} = 36 V. For this circuit, calculate the:

i) inductive reactance X_L [1mark]

ii) capacitive reactance X_C [1mark]

iii) impedance Z [3marks]

iv) current amplitude [1mark]

v) phase constant [1mark]

vi) resonance frequency [2marks]

vii) current amplitude at resonance [1mark]

viii) r.m.s. current at resonance [1mark]

ix) power factor [1mark]

c). An 8.0 μF capacitor is connected to the terminals of a 60 Hz AC source whose RMS voltage is 150V.

(i) Find the capacitive reactance and the RMS current in the circuit. [3marks]

(ii) What happens if the frequency is doubled? [2marks]

Q.5a). (i) Prove that the average value of a sinusoidal wave over one cycle is zero. [4marks]

(ii) Show that the *RMS* of a sinusoidally varying e.m.f is given by

$E_{RMS} = \frac{E_o}{\sqrt{2}}$ where the symbols have their usual meanings. [4 marks]

(iii) An electric kettle is connected to an A.C source (240V, 60Hz). Given that the resistance of the kettle coil is 1000 ohms. Calculate the cost of using this kettle for 20hrs if the cost of electricity is 11.5 ksh per KWhr. [2 marks]

b). An isolated water molecule has a permanent electric dipole moment of 6.24×10^{-30} Cm.

(i) Calculate the torque on this dipole when it is in an external electric field of 300 N/C, oriented with the dipole moment at , 70^{o} with respect to the field direction. [2 marks]

(ii) Find the work done by the field in rotating the dipole from this position to an orientation parallel to the field. [3 marks]

c). Explain how full wave rectification is achieve using four diodes. [5 marks]

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