TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Applied & Health Sciences

DEPARTMENT OF MATHEMATICS & PHYSICS

UNIVERSITY EXAMINATION FOR:

BACHELOR OF SCIENCE IN APPLIED PHYSICS & INSTRUMENTATION & RENEWABLE ENERGY

APS 4105: ELECTRICITY MAGNETISM

END OF SEMESTER EXAMINATION

SERIES: APRIL 2014

TIME ALLOWED: 2 HOURS

Instructions to Candidates:

You should have the following for this examination

- *Mathematical tables*
- *Scientific Calculator*

This paper consist of **FOUR** questions

Answer question **ONE (COMPULSORY)** and any other **TWO** questions

Maximum marks for each part of a question are as shown

This paper consists of **FOUR** printed pages

Question One (Compulsory)

a) (i) A tiny ball is suspended on a thread. Some tests carried on it show that it gets attracted to a positively charged rod, and repelled by a negatively charged rod. What can be concluded about its net charge? **(1 mark)**

(ii) Name the quantity that is being used up when current flows through a resistor R. **(1 mark)**

(iii) Define an equipotential surface. What can you say about the electric field on a equipotential surface? **(2 marks)**

b) Briefly differentiate between insulators and conductors. Why do they behave differently? **(3 marks)**

c) Excess electrons are placed on a small lead sphere so that its net charge is -3.2 x 10-9C. Find the number of excess electrons on the sphere. **(2 marks)**

$$\varepsilon = NBA\,\omega \sin \omega t$$

d) The output voltage from an AC generator is given by

(i) If the AC generator a square 12cm by 12cm amarture coil with 480 turns rotating at 720rpm in a 0.5T magnetic field, how large is its peak voltage? **(3 marks)**

(ii) Find the root mean square voltage of the generator. **(2 marks)**

e) The terminal voltage of a battery is 7.5V with a load connected to it. When connected to a light bulb that draws a current of 0.5A, its terminal voltage drops to 6.2V. What is the internal resistance of the battery? **(2 marks)**

f) An electron moves from point A where the potential is V_A = +20kV to point B where the potential is V_B = -40Kv, these potentials being due to other charges:

(i) What is the charge in potential energy (in rules)? **(2 marks)**
(ii) What charge in kinetic energy (in joules) does the electron experience?
(iii) Give the answer in electron volts and explain the sign of your answers. **(2 marks)**

g) Two charges, Q_1 = -30 μC and Q_2 = 30 μC are arranged on the x-axis as shown below:

B

(i) Find the magnetic and direction of the electric field that Q_1 produces at point B. **(2 marks)**

(ii) The electric field that Q_2 produces at point B **(2 marks)**

(iii) The net electric field at point B **(2 marks)**

h) IF a particle, with charge Q = -1.0 μC floats at point B in the figure above, find the magnitude and direction of the electric force $\vec{F}$ that acts on it. **(2 marks)**

i) Without doing any calculation, give the direction in which the net electric field at A would point. Explain your answer. **(2 marks)**

Question Two

a)

d_2=10cm

Two long straight wires carry current perpendicular to the page as shown in the figure above:

(i) Find the x and y components of the magnetic field produced at point P. **(5 marks)**

(ii) Find the magnitude and direction of the net magnetic field at point P **(3 marks)**

b) A charged particle of mass m = 8 x 10^{-26}kg undergoes circular motion at a frequency of 2 x 10^{6}Hz in a uniform magnetic field of strength 1.0T. Suppose the particle is positively charged and the magnetic field is into the page.

(i) Draw a figure showing the direction of motion of the particle and the direction of the magnetic force acting on the particle. **(2 marks)**

(ii) Determine the charge of the particle in terms of the elementary charge **(3 marks)**

(iii) Find the radius of the circular motion described if the particle has kinetic energy of 2000CV.

c) A region has a uniform magnetic field pointing horizontally to the right as shown in the figure below:

B

(i) In which direction does the magnetic force in the proton instantaneously moving into the page points? **(2 marks)**

(ii) Suppose that, instead the proton moves in a plane inclined at an angle of 30^{o} to the magnetic field of strength 0.5T. Find the magnitude of the magnetic force on a proton moving at a speed of 1.0 x 10^{7}m/s **(3 marks)**

Question Three

a) Define capacitance and didetric applied to capacitors. **(2 marks)**

b) Derive the expression for capacitance, Co of a parallel plate capacitor, when the gap between the plater is filled with air (Assume the plater are separated by a distance d, and each les cross section A). **(6 marks)**

c) A metal slab, thickness a (a < d) and the same shape and size as the plates is inserted between the plates, parallel to the plates and not touching either plate as shown in the figure below.

a

(i) Which is the capacitance C, of this arrangement? Express C in terms of C_o, the capacitance when the metal slap is not present. **(6 marks)**

(ii) Discuss what happens to the capacitance in the limit $a \to 0$. **(1 marks)**

d) In capacitance electro stimulation, electrodes are placed on opposite side of a circle. A potential difference is applied to the electrodes, which is believed to be beneficial in treating bone defects. If the capacitance is measured to be 0.59 μF, the electrodes are 4.0cm in area, and the limb is 3.0cm in diameter, what is the (average) dielectric constant of the issue in the limb? **(5 marks)**

Question Four

a) (i) Find the length of a copper wire of diameter 0.6mm that will result into a resistance of 25 Ω (Use: Resistivity of copper is 1.72×10^{-8} Ω) **(3 marks)**

(ii) Suppose a current of 2.5A is carried by the copper wire (of radius 0.6mm). If the density of the conduction electrons is $8.47 \times 10^{28} m^{-3}$, what is the drift speed of the conduction electrons? **(2 marks)**

b)

I_1

(i) In the circuit shown above, are resistors R_1 and R_2 in series or parallel? **(1 mark)**

(ii) Find the equivalent resistance of R_1 and R_2 in the circuit. **(2 marks)**

(iii) If the currents through R_1 is 0.6A, how large in the current through R_2? **(2 marks)**

c) (i) Find the current through R_3 and R_4 in the circuit. (**7 marks)**

(ii) Find the rate of energy consumption in R_3 **(3 marks)**