TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF APPLIED &HEALTH SCIENCES

MATHEMATICS & PHYSICS DEPARTMENT

UNIVERSITY EXAMINATION FOR:

BACHELOR OF TECHNOLOGY IN APPLIED PHYSICS AND BACHELOR OF TECHNOLOGY IN ENVIRONMENTAL PHYSICS &RENEWABLE ENERGY

APS 4105: ELECTRICITY & MAGNETISM I

END OF SEMESTER EXAMINATION

SERIES: MAY 2016

TIME: 2 HOURS

DATE: MAY 2016

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of 4 questions.

Do not write on the question paper. Answer question ONE (compulsory) and any other two questions

DATA: Permeability of vacuum/free space, $\mu_0 = 4\pi \times 10^{-7}\ Hm^{-1}$

Permittivity of vacuum/ free space, $\varepsilon_0 = 8.85 \times 10^{-12}\ Fm^{-1}$

Electron charge, $q = 1.602 \times 10^{-19}\ C$

Mass of electron, $m_e = 9.11 \times 10^{-31}\ kg$

Proton mass, $= m_p = 1.67x10^{-27}\ kg$

Question ONE

(a) (i) State Coulomb's law for the electrostatic force between two point charges. (1 mark)

(ii) Three identical point charges, each $1\mu C$, are placed at the vertices of an equilateral triangle 10cm a part. Calculate the force on each charge. (4 marks)

(b) An isolated positive point charge $Q = 2\mu C$

(i) Determine the elective field $\vec{E}$ and also the potential, V, due to this charge at point P which is 10cm away from the charge. (4 marks)

(ii) Determine the work done in bringing identical charge form infinity to point P (3 marks)

(iii) Sketch the electric field lines and equipotential lines associated with this isolated point charge (3 marks)

(c) A point charge $Q_1 = +27«C$ is placed at coordinate $(0,0)$ while another charge $Q_2 = +3«C$ is at $(1,0)$. At what point (other than infinity) would the net force on a third point charge be zero. (3 marks)

(d) A parallel plate capacitor has plates with dimension 3cm by 4cm separated by 2mm. The plates are connected across a 60V battery.

(i) Determine the capacitance and charge on each plate. (3 marks)

(ii) Determine the electric field within the plates and the energy stored (3 marks)

(iii) A dielectric material of relative dielectric constant 6 is now inserted and completely fills the space between the plates of the capacitor. Calculate the new charge stored. (3 marks)

(iv) Compute the electric force between the plates when the dielectric is in place. (3 marks)

Question TWO

(a) (i) State Gauss's law for electrostatics

(ii) A point charge q is at the centre of a spherical metal shell of radius R that has a net charge – Q. Determine the electric field and potential at a distance of outside the shell. (4 marks)

(b) A non conducting disk of radius a has a uniform surface charge density $\pm Cm^{-2}$. Determine the electric field strength at a distance y from the centre along the central axis. (5 marks)

(c) An electron enters the region between two horizontal charged plates with an initial horizontal velocity of « $= 10^6 ms^{-1}$ midway between the two plates. The plates are 4cm long and 1.6cm apart, see figure 1 below. The electric field within the plates is $450 Vm^{-1}$.

(i) Determine the vertical displacement from the initial horizontal position that the electron undergoes within the plates.

(ii) Determine the magnetic field strength that can be introduced within the electric field so that the electron pass through the plates undeflected. Show the orientation of the magnetic field. (5 marks)

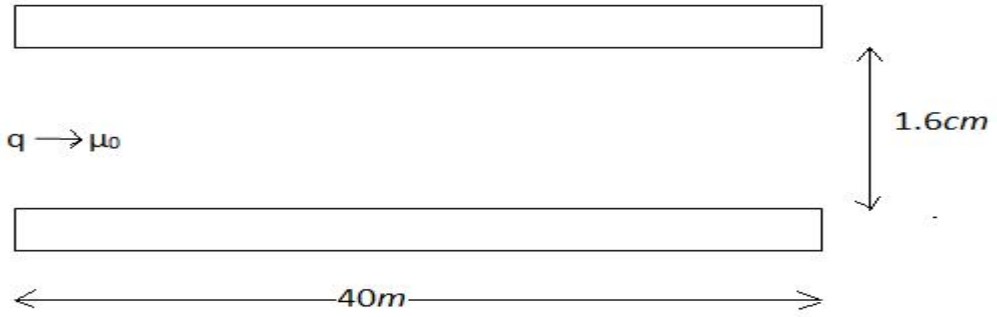

Figure 1

Question THREE

(a) The radius of a copper wire is 1.63mm. A potential difference (p.d) of 60V is applied across a 20m length of this wire. Resistivity of copper $=1.7x10^{-8}\Omega m$. Find

(i) The current (3 marks)

(ii) The electric field (2 marks)

(b) Derive an expression for the current density, J, for a current carrying wire of cross sectional area, A. Explain any symbols used. (3 marks)

(c) In the circuit of figure 2, the cell E_1 has an emf of 15V and internal resistance of 2Ω ; the cell E_2 has emf of 6V and internal resistance of 3Ω ; and the E_3 has emf of 4V and internal resistance of 1Ω . In the circuit $R_1 = 4\Omega$, $R_2 = 3\Omega$ and $R_3 = 2\Omega$. Determine the currents i_1, i_2 and i_3. (7 marks)

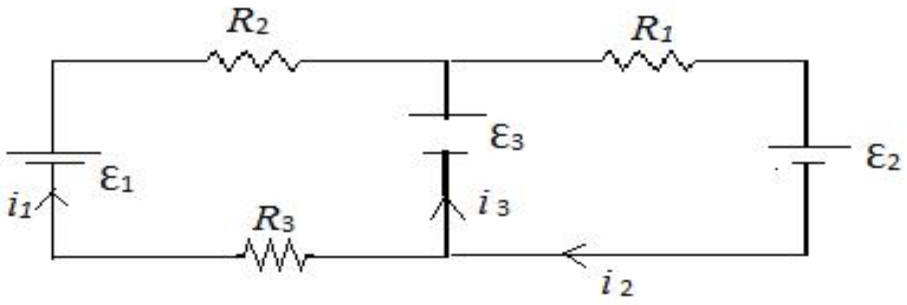

Figure 2

(d) Two capacitors $C_1 = 0.1\text{«}F$ and $C_2 = 0.25\text{«}F$ are connected to a12V battery.

(i) Determine the charge on each capacitor (2 marks)

(ii) Calculate the potential difference across each capacitor. (3 marks)

Question FOUR

(a) Two long straight wires are 3 cm apart. They carry currents I_1 =3A and I_2 =5A in opposite directions, as shown in figure3. I_1 is out of paper while I_2 is into the paper.

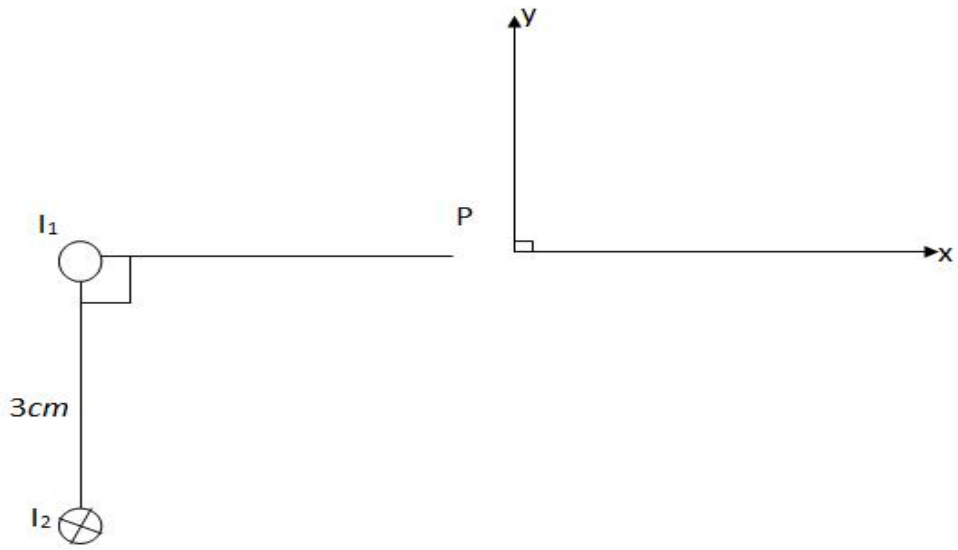

Figure 3

(i) Draw the magnetic field lines associated with these wires. (2 marks)

(ii) Indicate the force experienced by the wires and compute the force per unit length on the wire. (3marks)

(iii) Calculate the magnetic field strength at point P . (3marks)

(b) An electron with kinetic energy 10^3 eV moves perpendicular to the lins of a uniform B **B**=10^{-3} T

(i) If $\vec{B}$ is into the paper, sketch the path of the electron (1 mark)

(ii) Determine the period, and (3 marks)

(iii) Compute the radius of the electron orbit in the field. (4 marks)

(c) An electron has a velocity of $V = 10^6\ J\ ms^{-1}$ in the field $\vec{B} = 0.052T$. What is the force on the electron? (4 marks)