TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Applied & Health Sciences

DEPARTMENT OF MATHEMATICS & PHYSICS

UNIVERSITY EXAMINATION FOR DEGREE OF:

BACHELOR OF TECHNOLOGY IN RENEWABLE ENERGY
BACHELOR OF TECHNOLOGY IN APPLIED PHYSICS
(BTRE 14G/BTAP 14G)

APS 4105: ELECTRICITY & MAGNETISM I

SPECIAL/SUPPLEMENTARY EXAMINATION
SERIES: JUNE/JULY 2015
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

$$\varepsilon_o = 8.85\times10^{-12}\,Fm^{-1} \quad K = 1/4\pi\varepsilon_o = 9\times10^{9}\,Nm^2C^{-2}$$

Permittivity of free space

$$\mu_o = 4\pi\times10^{-7}\,Hm^{-1}$$

Permeability of free space

$$m_e = 9.11\times10^{-31}kg$$

Electron mass,

$$M_p = 1.67\times10^{-27}kg$$

Proton mass

$$\mu_o = 1.6\times10^{-19}$$

J

Question One (Compulsory)

a) (i) State Coulomb's law for the electrostatic force between two joint charges **(1 marks)**

(ii) Three identical point charges, each 1μC, are placed at the vertices of an equilateral triangle 10cm apart. Calculate the force on each charge **(4 marks)**

b) An isolated positive point charge Q = 2 μC:

(i) Determine the electric 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 an identical charge from 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 Q1 = +27μC is placed at coordinate (0, 0) while another charge Q2 = +3μC 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 dimensions 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 energy stored **(3 marks)**

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

(iv) Compute the electric force between the plates when the dielectric is in plate **(3 marks)**

Question Two

a) (i) State Gauss's Law for electrostatics **(1 mark)**

(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 r outside the shell **(4 marks)**

b) A non conducting disk of radius a has a uniform surface charge density rcm^{-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 u = 2 x $106ms^{-1}$ 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 $450Vm^{-1}$:

(i) Determine the vertical displacement from the initial horizontal position that the electron undergoes within the plates **(5 marks)**

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

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 = $1.7 \times 10^{-8}\Omega m$. Find:

(i) the current **(3 marks)**

(ii) the electric field **(2 marks)**

b) Derive on 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 ε_1 has an emf of 15V and internal resistance of 2Ω; and the cell ε_2 has emf of 4V and internal resistance of 1Ω; and the cell ε_3 has emf of 4V and internal resistance of 1 Ω. In the circuit $R_1 = 4\Omega$, $R_2 = 3\Omega$ and R3 = 2Ω. Determine the current i_1, i_2, and i_3 **(7 marks)**

d) Two capacitors C1 = 0.1μF and C2 = 0.25μF are connected in series to a 12V 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 parallel wires are 3cm apart. They carry currents I = 3A and I_2 = 5A in opposite directions, as shown in figure 3. I, is out of the paper while I_2 is into the paper.

(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 either wire. **(3 marks)**

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

b) An electron with kinetic energy of 10^3Ev moves perpendicular to the lines of a uniform $\vec{B} = 10^{-3} T$

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

(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 = 106J ms^{-1} in the field $\vec{B} = 0.052\,\hat{j}$ T what is the force on the electron **(4 marks)**