JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION (SCIENCE)

1ST YEAR 2ND SEMESTER 2013/2014 ACADEMIC YEAR

REGULAR

COURSE CODE: SPH 102

COURSE TITLE: ELECTRICITY AND MAGNETISM I

EXAM VENUE:LAB 2 **STREAM: (BSc. Science)**

DATE: 12/8/14 **EXAM SESSION: 9.00 – 11.00AM/PM**

TIME: 2 HOURS

Instructions:

1. **Answer question 1 (compulsory) in Section A and any other 2 questions in Section B .**
2. **Candidates are advised not to write on the question paper.**
3. **Candidates must hand in their answer booklets to the invigilator while in the examination room.**

SECTION A. Question 1 is **COMPULSORY**. It carries 30 marks

1. a) i) State Coulomb's law. (**2 marks)**

ii) Two point charges q_1 = +25nC and q_2 = -75nC are separated by a distance of 3.0 cm. Find the magnitude of the electric force that q_1 exerts on q_2. **(3 marks)**

b) i) Define the term *electric field*. **(2 marks)**

ii) A point charge q = -8nC is located at the origin. Find the electric field vector at the field point x = 2.0 cm, y = -2.0 cm **(6 marks)**

c) i) Distinguish between electric *potential energy* and *electric potential*. (**2 marks)**

ii) A charged particle moves in a straight line from point a to point b, a total distance of d = 0.5 m. The electric field is uniform along this line, with a magnitude E = 1.5 x 107 N/C in the direction from a to b. Determine the potential difference $V_a - V_b$. **(3 marks)**

d) i) Show that the capacitance C of a parallel-plate capacitor is given by

$$C = \varepsilon_0(A/d)$$

where ε_0 is the electric permittivity of free space, A is the area of each plate and d is the separation between the plates. **(5 marks)**

ii) The capacitor in (i) above has a capacitance of 1.0 nF. If the plates are 1.0 mm apart, what is the area of the plates? ($\varepsilon_0 = 8.854 \times 10^{-12}\ C^2/Nm^2$) **(2 marks).**

e) i) Define the term cyclotron frequency. **(1 marks)**

ii) Show that the cyclotron frequency ω is given by $\omega = qB/m$ where *q* is the magnitude of charge, *B* is the magnitude of the magnetic field and *m* is the mass. **(5 marks)**

SECTION B: Answer **ONLY TWO** questions from this section. Each question carries **20 marks.**

2. a) i) Define *electric charge* and give its units. **(3 marks)**

ii) What is the source of *electromotive force*? **(2 marks)**

b) When does the surface of a conductor remain an *equipotential* surface? **(1 mark)**

c) i) What is an electromagnetic induction**?** **(2 marks)**

ii) Explain the negative sign in the Faraday's law of electromagnetic induction. **(2 marks)**

d) i) Define the following terms:

I) Solenoid
II) Toroid **(4 marks)**

ii) Derive the expression for the magnetic field due to a solenoid and toroid. **(6 marks)**

3. i) Capacitors with capacitance C_1, C_2 and C_3 are connected in series. Derive the expression for the equivalent capacitance. **(4 marks)**

(ii) Find the equivalent capacitance in 3 (a) (i) above given that $C_1 = 2\mu F$, $C_2 = 3\mu F$ and $C_3 = 4\mu\ F$ **(2 marks).**

b) i) Show that the stored potential energy U in a capacitor is given by:

$$U = \frac{Q^2}{2C}$$

where Q is the charge and C is the capacitance. **(4 marks)**

ii) A 450 μF capacitor is charged to 295 V. A wire is connected between the plates. How many joules of thermal heat are produced as the capacitor discharges if all of the energy that was stored goes into heating the wire? **(3 marks).**

c) i) Show that the energy density μ of a parallel-plate capacitor is given by;

$$u = \frac{1}{2}\,\varepsilon_o\,E^2\,,$$

where ε_o is the electric permittivity of free space and E is the magnitude of the electric field between the plates. **(4 marks)**

(ii) The plates of a parallel-plate capacitor have an area of 2000 cm^2 and are 1.0 cm apart. The capacitor is connected to a power supply and charged to a potential difference of V = 3000 V. Find the energy density.
(ε_o = 8.854 x 10^{-12} F/m). **(3 marks)**

4. a) i) Give an expression for the magnitude of the magnetic force on a charged particle in a magnetic field, explaining all the quantities involved. **(2 marks)**

ii) A beam of protons (q = 1.6 x 10^{-19} C) moves at 3.0 x 10^5 m/s through a uniform magnetic field with magnitude 2.0 T that is directed along the positive z-axis. The velocity of each proton lies in the x-z plane at an angle of 30^o to the positive z-axis. Find the magnitude of the force on a proton. **(3 marks).**

b) i) State Faraday's law of electromagnetic induction. **(2 marks)**

ii) A coil of wire containing 500 circular loops with radius 400 cm is placed between the poles of a large electromagnetic, where the magnetic field is uniform and normal to the plane of the coil. The field decreases at a rate 0.2 T/s. What is the magnitude of the induced emf? **(4 marks)**

c) A circular coil 0.05 m in radius, with 30 turns of wire, lies in a horizontal plane. It carries a current of 5.0 A in a counter clockwise sense when viewed from above. The coil is in a uniform magnetic field directed toward the right, with magnitude 1.20 T. Find the magnitudes of:

i) Magnetic moment **(3 marks)**

ii) Torque on the coil. **(3 marks)**

iii) The coil in 4(b) rotates from its initial position to a position where its magnetic moment is parallel to the magnetic field. What is the change in potential energy? **(3 marks).**

5. a) (i) Resistors with resistances R_1, R_2 and R_3 are connected in parallel. Derive the expression or the equivalent resistance. **(3 marks)**

(ii) In figure 1, you are given that $R_1 = 2\Omega$, $R_2 = 3\Omega$, and $R_3 = 4\Omega$. Find the equivalent resistance R_E. **(3 marks)**

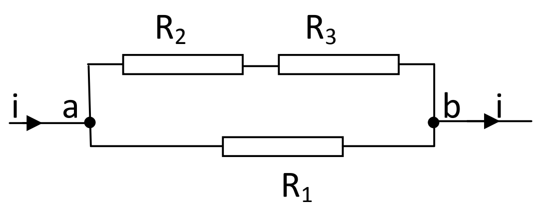
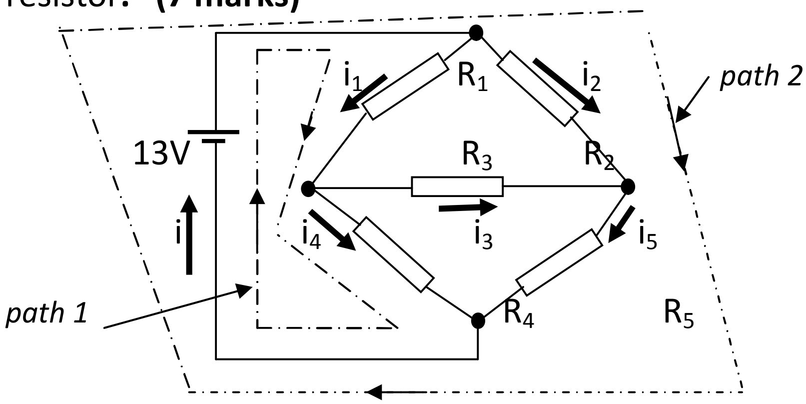


Fig. 1

b) (i) State Kirchhoff's junction rule. **(2 marks)**

ii) State Kirchhoff's loop rule. **(2 marks)**

c) i) Taking the indicated dotted paths in figure2 below, find the current in each resistor. **(7 marks)**



$R_1 = 1\Omega$, $R_2 = 1\Omega$, $R_3 = 1\Omega$

$R_4 = 1\Omega$, $R_5 = 2\Omega$

Fig. 2

ii) The electric circuit shown in figure 3 contains two batteries, each with emf and internal resistance, and four resistors. Taking the indicated path and applying the loop rule find the current in the circuit and the potential difference V_{ab}. **(3 marks)**

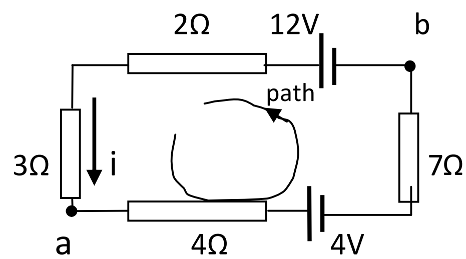


Fig. 3