CHUKA UNIVERSITY

UNIVERSITY EXAMINATIONS

SECOND YEARS EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE (PHYSICS, MATHS,COMPUTER SCIENCE) AND BACHELOR OF EDUCATION (SCIENCE)

PHYS 241: ELECTRICITY AND MAGNETISM 1

STREAMS: BSC(PHYS, MATH, COMP SC, APPLIED COMP SC, BED(ARTS)

TIME: 2 HOURS

DAY/DATE: THURSDAY 06/12/2018 **11.30 A.M – 1.30 P.M**

INSTRUCTIONS

Answer Question ONE and ANY Other TWO Questions.

Important information: $\mu_o = 4\pi \times 10^{-7}$ H/m), $\varepsilon_o = 8.854 \times 10^{-12}$ F.m^{-1}, electron mass = 9×10^{-31} kg, electron/proton charge = 1.6×10^{-19} C

Question One (30 marks)

(a) A current of 3.18 mA flows through a conductor of electricity in 4 minutes. Calculate the amount of charge flowing through the conductor during this time. (3marks)

(b) Four charges, $q_1 = 3.79$ μC, $q_2 = 4.21$ μC, $q_3 = 9.17$ μC and $q_4 = 17.13$ μC are placed as shown in figure 1.1. If the distance between q_1 and q_2 is 30 cm, that between q_1 and q_3 is 20 cm while that between q_1 and q_4 is 40 cm. Calculate the electrostatic force experienced by q_1 due to q_2, q_3 and q_4 (3marks)

Figure 1.1. Four charges placed at four corners of a parallelogram.

(c) A current carrying wire loop and solenoid were design by a first year student in Chuka University. Sketch the wire loop and solenoid showing the magnetic flux configuration. (3marks).

(d) Two positive point charges were placed close to each other as shown in figure 1.2. Sketch the electric field due to these point charges. (2marks)

Figure 1.2. Two positive point charges.

(e) A charge of 60 μC is flowing through a magnetic field of 1.5 Teslas at a velocity of 300 m/s. Calculate the magnetic force experience by the charge? (3marks)

(f) The potential difference between two points along a conductor of electricity is 4.67V. What is its resistance if the current flowing through the conductor is 0.683 A? (3marks).

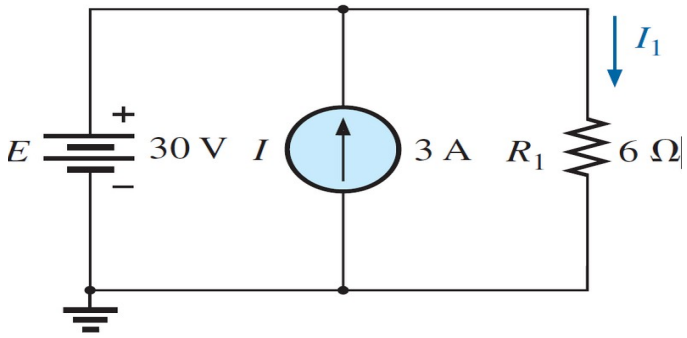
(g) Mains electricity is generated at the power station by a technique known as electromagnetic induction. State three factors that determined the magnitude of induce emf in the coil. (3marks)

(h) Two point charges, q_1 = 53 μC and q_2 = 103 μC are separated by a distance of 19 cm as shown in figure 1.3. Calculate the total electric field at point P, 17 cm from q_2. (3marks)

Figure 1.3. Two point charges separated by a distance of 19 cm

(i) Three capacitors of 3.45 μF, 2.63 μF and 6.79 μF were connected in series within an electric circuit. What is the total resulting capacitance? (3marks)

(j) Using the superposition theorem, determine the current I_1 for the network in figure 1.4.



(4marks)

Figure 1.4. Two-source network to be analyzed using the superposition theorem

Question two (20 marks)

(a) Using Biot-Savart law, show that the expression for magnetic flux due to a long wire at a single point, a distance x from the wire is given by;

$$B = \frac{\mu_0 I}{2\pi x}$$

where B is the magnetic flux, x is the distance from the wire at which magnetic field is to be determined while μ_o is the permeability of free space (10marks)

(b) A step up transformer has 100 and 100000 primary and secondary turns respectively. If the

input voltage is 240 V.

(i) What will be the output voltage? (3marks)

(ii) Describe four ways to minimize power wastage in this transformer. (4marks)

(c) A 250 μF capacitor was charged to a voltage of 12 V. determined the energy stored in this capacitor (3marks)

Question three (20 marks)

(a) Two parallel wires carry currents of 8 A and 2A in the same direction as shown in figure 3.1.

(i) What is the magnitude of the magnetic field midway between the wires? (6marks)

(ii) What is the direction of the net magnetic field? (1mark)

(iii) Where between the two wires is the magnetic field zero? (5marks)

(iv) How much magnetic force is experience by wire 2 due to the current in wire 1? (2marks)

Figure 3.1. Two parallel wire carrying currents of different magnitude.

(b) The electrical circuit in figure 3.2 was used to study Thévenin theorem. It has resistors and a voltage source.

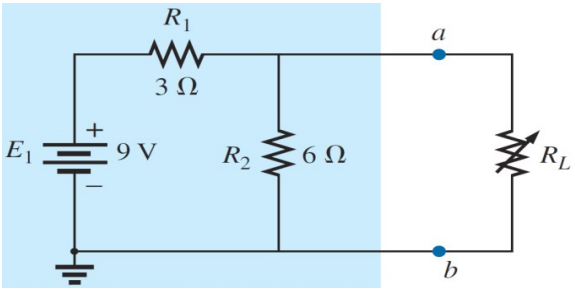


Figure 3.2. Volatge source connected to the resistor network.

Calculate Thévenin equivalent circuit for the network in the shaded area of the network in figure 3.2. (5marks)

Question four (20 marks)

(a) A simple potentiometer with three terminals can be designed with two resistors and used as a voltage divider in a circuit as shown in figure 4.1. A is input, B is output and C is the ground.

Figure 4.1. Two resistors connected to form a potentiometer for pd measurement.

Calculate the fixed voltages that can be obtained from its output terminal and how to connect them to the required electrical component (4marks)

(b) An electron moving in a circular orbit in an atom at a speed of 3×10^7 m/s experienced a magnetic field of 6×10^{-4} T perpendicular to it.

(i) What is the radius of the circular orbit (2marks)

(ii) What is the frequency of the electron? (2marks)

(iii) Calculate the energy of the electron in keV. (1 eV = 1.6×10^{-19} J) (2marks)

(c) A group of three equal charges, **Q** are placed at the corners of an equilateral triangle of side **a**. Show that the resultant force on the charge at the top of the apex of the triangle is given by;

$$F = \frac{Q^2\sqrt{3}}{4\pi\varepsilon_0 a^2}$$

(10marks)

where **Q** is the charge placed at each apex of the triangle, **a** is the length of the side of the triangle.

Question five (20 marks)

(a) Consider the arrangement of resistors shown in figure 5.1;

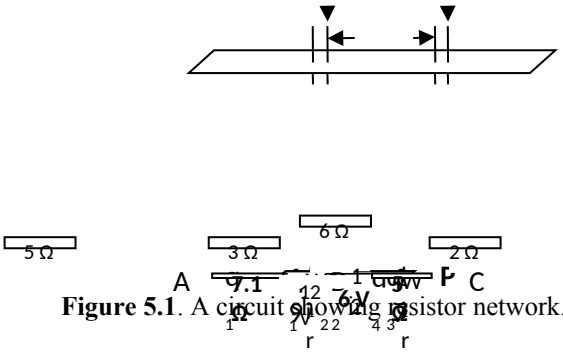


Figure 5.1. A circuit showing resistor network.

Determine the

(i) equivalent resistance in the circuit (3marks)

(ii) current flowing in the circuit (2marks)

(iii) current flowing through the 6 Ω resistor (3marks)

(b) What's the force on a 0.5C charge moving at velocity v = (2i+5j+10k) ms^{-1} in a magnetic field B = (8i+3j+5k) x 10^{-4} Teslas. (2marks)

(c) A particle of mass m is rotating as it describes a circular path of radius R and experiencing magnetic field of magnitude B. If the particle has a charge q, show that the period of rotation T is given by; $$T = \frac{2\pi m}{qB}$$ (3marks)

(d) Figure 5.2 shows a current source connected to a voltage source through a network of resistors. Using the superposition theorem, determine the current through resistor R_2 for the network. (7marks)

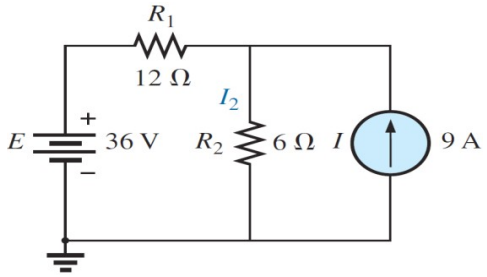


Figure 5.2. Current source connected to the resistor network and the voltage source.
