MACHAKOS UNIVERSITY

University Examinations 2021/2022

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR SUPPLEMENTARY/SPECIAL EXAMINATION FOR

BACHELOR OF EDUCATION (SCIENCE)

BACHELOR OF EDUCATION (SPECIAL NEEDS)

BACHELOR OF SCIENCE IN MATHEMATICS

BACHELOR OF SCIENCE IN ANALYTICAL CHEMISTRY

BACHELOR OF SCIENCE IN TELECOMMUNICATION AND INFORMATION TECHNOLOGY

SPH 101: ELECTRICITY AND MAGNETISM I

DATE: 15/03/2022 **TIME: 11:00-1:00PM**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Answer question ONE and any TWO questions.
- Question one carries 30 marks, all other questions carry 20 marks each

QUESTION 1 (30 MARKS)

(a) Describe any two simple experiments that demonstrate the existence of electrostatic forces.

(2 marks)

(b) Explain why it is safe to stay inside an automobile during a lightning storm. (2 marks)

(c) The electron and proton of a hydrogen atom are separated (on average) by a distance of approximately $5.3*10^{-11}$ m. find the magnitudes of the electric force and the gravitational force between the two particles. ($|e| = 1.60*10^{-19}\,C$ and $m_e = 9.11*10^{-31}\,kg$, $m_p = 1.67*10^{-27}\,kg$)

(3 marks)

(d) State and explain the rules for drawing electric field lines. (3 marks)

(e) Describe the process of charging a conductor by induction. (5 marks)

(f) Electrical devices are often rated with a voltage and a current. Batteries, however, are only rated with voltage. Explain. (2 marks)

(g) An electric heater is operated by applying a potential difference of 50V to a nichrome wire of total resistance 8Ω. Determine the current by the wire and the power rating of the heater.

(3 marks)

(h) If a metal object receives a positive charge, does its mass increase, decrease, or stay the same What happens to its mass if the object receives a negative charge? (2 marks)

(i) A spherical Gaussian surface surrounds a point charge q. Describe what happens to the total flux through the surface if:

i. The charge is tripled, (1 mark)

ii. The radius of the sphere is doubled, (1 mark)

iii. The surface is changed to a cube, and (1 mark)

iv. The charge is moved to another location inside the surface. (1 mark)

(j) A parallel plate capacitor has an area of $2\,cm^2$ and a plate separation of $1\,mm$. Find its capacitance. (2 marks)

(k) An electric wire in the wall of a building carries a dc current of 25 A vertically upward. Determine the magnetic field due to this current at a point p, 10 cm due north of the wire. ($\mu_0 = 4\pi*10^{-7}$ T.m/A). (3 marks)

QUESTION 2 (20 MARKS)

(a) Consider three point charges located at right angles as shown in figure 2.1. Where, $q_1 = q_3 = 5.0\mu C, q_2 = -2.0\mu C,$ *and* $a = 0.1m.$ Find the resultant force exerted on q_3.

(5 marks)

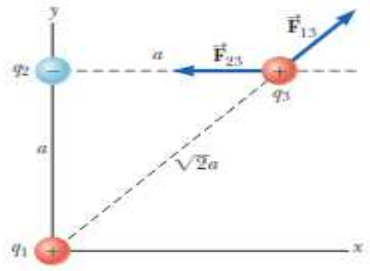

Figure 2.1

(b) Three-point charges lie along the $x-axis$ as shown in figure 2.2. The positive charges $q_1 = 15.0\mu C$ is at $x = 2.0m, q_2 = 6.0\mu C$ is at the origin and the net force acting on q_3 is zero. What is the $x-coordinate$ of q_3 ? (5 marks)

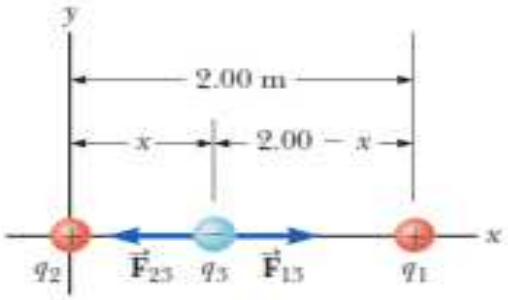

Figure 2.2.

(c) Describe the procedure to evaluate the electric field at a point, P due to a continuous charge distribution. (5 marks)

(d) Two parallel straight wires 10.0 cm apart carry currents in opposite directions as shown in Figure 2.3. Current $I_1 = 5.0\,\text{A}$ is out of the page, and $I_2 = 7.0\,\text{A}$ is into the page. Determine the magnitude and direction of the magnetic field halfway between the two wires.

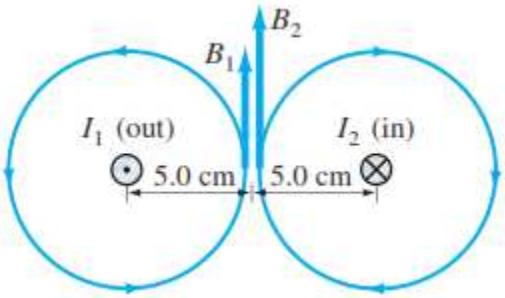

Figure 2.3. (5 marks)

QUESTION 3 (20 MARKS)

(a) A water droplet of mass $3.0*10^{-12}$ Kg is located in the air near the ground during a stormy day. An atmospheric electric field of magnitude $6.0*10^{3}$ N/C points vertically downward in the vicinity of the water droplet. The droplet remains suspended at rest in the air. Determine the electric charge of the droplet. (4 marks)

(b) An $\alpha - particle$ has a mass $m = 6.64 * 10^{-27}$ Kg and charge $q = +2e = 3.2 * 10^{-19}$ C. Compare the magnitude of the electric repulsion between two $\alpha - particles$ with that of gravitational attraction between them. (4 marks)

(c) A wire carrying a steady dc current, $I = 30$ A has a length $l = 12$ cm between the pole faces of a magnet. The wire is at an angle $\theta = 60^0$ to the field. The magnetic field is approximately uniform at $0.90T$. Determine the magnitude and direction of the force on the wire. (ignore the field beyond the pol pieces). (3 marks)

(d) An electron travels at $1.5 * 10^7$ m/s in a plane perpendicular to a uniform 0.010 T magnetic field. Describe its path quantitatively. (Ignore gravity, $m_e = 9.1 * 10^{-31} kg, q = 1.6 * 10^{-19}$ C) (4 marks)

(e) Two-point charges are located on the $x - axis$ of a coordinate system: $q_1 = 1.0$ nC is at $x = +2.0$ cm, and $q_2 = -3.0$ nC is at $x = +4.0$ cm. determine the total electric force exerted by q_1 and q_2 on a charge $q_3 = 5.0$ nC at $x = 0$. (5 marks)

QUESTION 4 (20 MARKS)

(a) Explain why the picture on a television screen become distorted when a magnet is brought near the screen. (3 marks)

(b) A coil consisting of 100 circular loops with radius 0.6 m carries a 5.0-A current. (i) Find the magnetic field at a point along the axis of the coil, 0.8 m from the center. (ii) Along the axis, at what distance from the center of the coil is the field magnitude $\frac{1}{8}$ as great as it is at the center? (5 marks)

(c) A circular coil 0.05 m in radius, with 30 turns of wire, lies in a horizontal plane. It carries a counterclockwise (as viewed from above) current of 5.0 A. the coil is in a uniform 1.20-T magnetic field directed toward the right. Find the magnitudes of the magnetic moment and the torque on the coil. (5 marks)

(d) Figure 4.1 shows a "bridge" circuit. Find the current in each resistor and the equivalent resistance of the network of five resistors (7 marks)

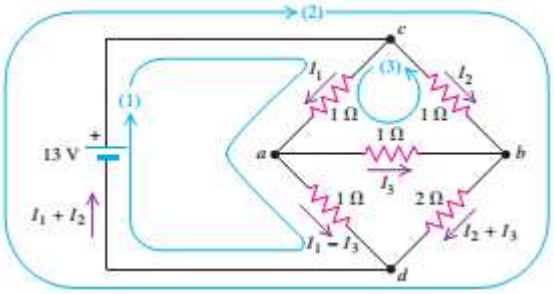

Figure 4.1

QUESTION 5 (20 MARKS)

(a) Compare and contrast the electric field lines and the electric field in a region of space**.**

(4 marks)

(b) Charge $q_1 = 7 * 10^{-6} C$ is at the origin, and charge $q_2 = -5 * 10^{-6} C$ is on the $x - axis$, 0.3 m from the origin. Determine the magnitude of the electric field at point P which has coordinates on the y-axis 0.4 m from the origin. (5 marks)

(c) Find the equivalent resistance of the network in Figure 5.1 and the current in each resistor. The source of emf has negligible internal resistance. (5 marks)

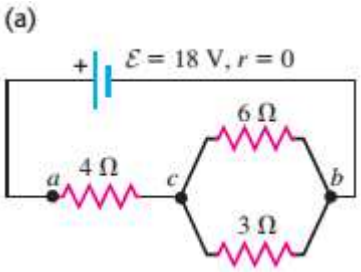

Figure 5.1

(d) A $65.0\,\Omega$ resistor is connected to the terminals of a battery whose emf is 12.0 V and whose internal resistance is $0.5\,\Omega$, as shown in figure 5.2.

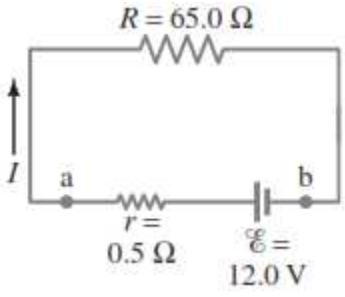

Figure 5.2.

Calculate: (i) the current in the circuit, (2 marks)

(ii) the terminal voltage of the battery, $V_{ab,}$ and (1 mark)

(iii) the power dissipated in the resistor R and in the battery's internal resistance, r.

(3 marks)