



MACHAKOS UNIVERSITY

University Examinations 2017/2018

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

AUGUST SEMESTER EXAMINATION FOR
BACHELOR OF EDUCATION (SCIENCE)

SPH 101: ELECTRICITY AND MAGNETISM 1

DATE: 14/11/2017

TIME: 2:00 – 4:00 PM

INSTRUCTIONS:

Answer question **ONE** which is compulsory and any other **TWO**. Laws should be stated and their mathematical meaning given. The following constants may be useful $\mu_0 = 12.56 \times 10^{-7}$
 $\epsilon_0 = 8.85 \times 10^{-12}$, $G = 6.67 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$, mass of a proton, $m_p = 1.67 \times 10^{-27} \text{ kg}$, mass of an electron $m_e = 9.1 \times 10^{-31} \text{ kg}$, Charge $q = 1.6 \times 10^{-19} \text{ C}$

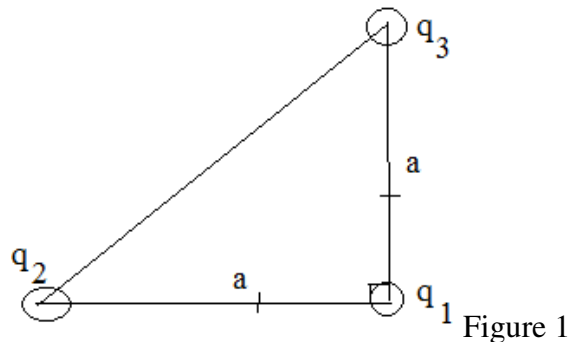
QUESTION ONE (COMPULSORY) (30 MARKS)

- a) Explain characteristics of a conductor in electrostatic equilibrium (4 marks)
- b) A parallel plate capacitor has plates of dimensions 4 cm by 20 cm separated by a 2.0 mm thickness paper. If the dielectric constant is 2.7, Find its capacitance. (4 marks)
- c) State three findings of Charles Coulomb (1736-1836) regarding Coulomb's law of electrostatic force between charged particles. (3 marks)
- d) Derive the expression for
 - i) Gravitational Potential Energy between a big body of mass M and a small body of mass m at a distance r . (3 marks)
 - ii) Electric Potential Energy between a big body fixed in space of charge Q and a small charge q at a distance r (3 marks)
- e) Sketch a diagram showing a circuit that can be used to charge a capacitor (2 marks)

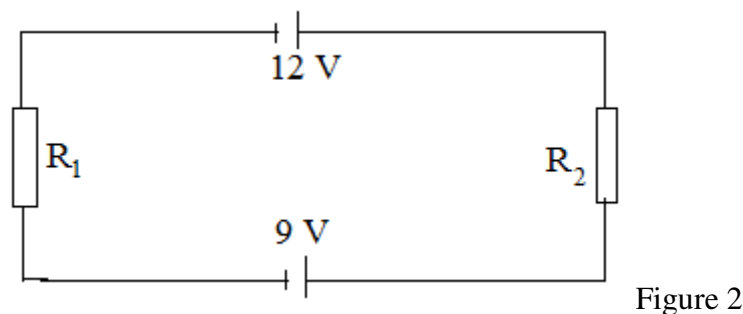
- f) State on application of a capacitor (2 marks)
- g) Give two importance of a dielectric in a capacitor (2 marks)
- h) A $200\mu\text{F}$ capacitor is made of two parallel plates of area 120cm^2 . The plates are separated by a dielectric of thickness $8.0 \times 10^{-6}\text{m}$. Find dielectric constant. (4 marks)
- i) A parallel plate capacitor has an area $A = 2 \times 10^{-4}\text{m}^2$ and a capacitance of 2.5 F . Find the plate separation distance (d). (3 marks)

QUESTION TWO (20 MARKS)

- a) Consider three point charges located at the corners of a right triangle as shown in Figure 1. Where $q_1 = 4\mu\text{C}$, $q_3 = 6\mu\text{C}$, $q_2 = -2\mu\text{C}$ and $a = 6\text{ cm}$. Find resultant force exerted on q_3 . (8 marks)



- b) Two batteries are connected in series to two resistors as shown in Figure 2, $R_1 = 10\Omega$ and $R_2 = 4\Omega$. Using Kirchhoff's voltage rule find magnitude of current in the circuit (5 marks)



- c) i) State Kirchhoff's voltage rule (2 marks)
- ii) In the circuit shown in Figure 3, resistances and Emf of the battery are indicated. Calculate current through the battery. (5 marks)

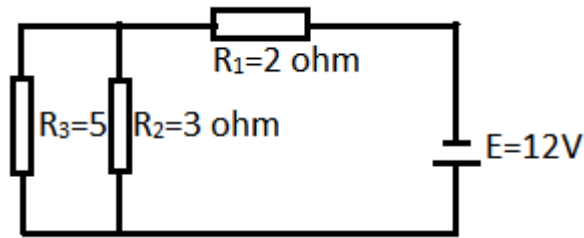


Figure 3

QUESTION THREE (20 MARKS)

- a) Two identical charged spheres, each of charge $50.4 \times 10^{-8} \text{ C}$ hang in equilibrium as shown Figure 4. The length of each string is 20 cm and the displacement angle ϕ is 5° . Find their masses. (10 marks)

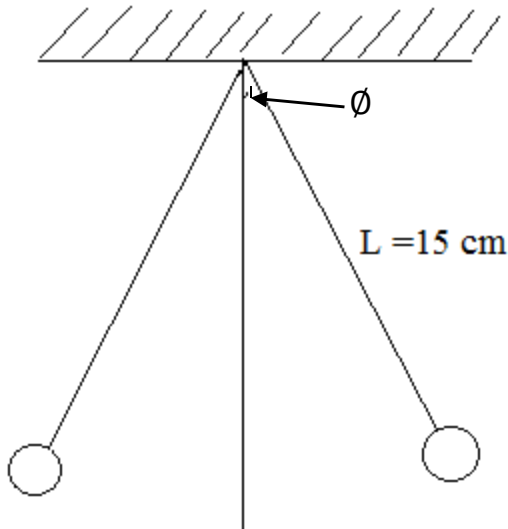


Figure 4

- b) A charge $q_1 = 4 \mu\text{C}$ is located at origin and $q_2 = 6 \mu\text{C}$ is located at $(x, y) = (0, 0.4)$ metres. Find
- the resultant electric field (6 marks)
 - its direction and (2 marks)
 - its magnitude (2 marks)

QUESTION FOUR (20 MARKS)

- a) An uncharged capacitor and resistor are connected in series to a battery. If emf of the battery is 12 V and Capacitor is $6 \mu F$ and $R = 8 \times 10^6 \Omega$. Find the i) time constant of the circuit, ii) the maximum charge on the capacitor, iii) the maximum current in the circuit and iv) the charge and current as a function of time 8 marks
- b) The e.m.fs and resistances of a circuit are given as $\mathcal{E}_1 = 6 V$, $\mathcal{E}_2 = 3 V$, $R_1 = 2\Omega$, $R_2 = 3\Omega$, $R_3 = 0.5 \Omega$ Figure 4. Find current in each of the resistors by application of Kirchhoff's current rule. 12 marks

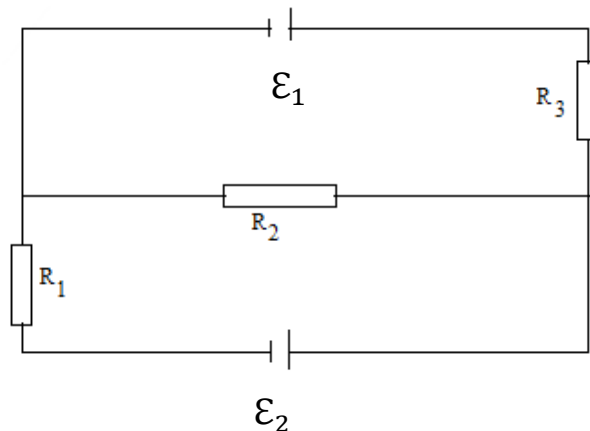


Figure 5

QUESTION FIVE (20 MARKS)

- a) The electric force between an electron and proton in a hydrogen atom is $4.6 \times 10^{-6} \text{ N}$. Find
- i) the distance between them (4 marks)
 - ii) Gravitational force between them (4 marks)
 - iii) comment on the answer i) and ii) above (2 marks)
- b) During a capacitor charging process, the charge and current at time t is given by $q(t) = Q(1 - e^{-t/RC})$ and $I(t) = \frac{\mathcal{E}}{R} e^{-t/RC}$ respectively. Derive the two expressions. (10 marks)