



MACHAKOS UNIVERSITY

University Examinations for 2020/2021 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF EDUCATION (SCIENCE)

BACHELOR OF SCIENCE (ANALYTICAL CHEMISTRY)

BACHELOR OF SCIENCE (MATHEMATICS)

BACHELOR OF SCIENCE (TELECOMMUNICATION INFORMATION
TECHNOLOGY)

SPH 101: ELECTRICITY AND MAGNETISM 1

DATE: 12/8/2021

TIME: 8.30 a.m. – 10.30 a.m.

INSTRUCTIONS:

Answer question **ONE** which is compulsory and any other **TWO**

Take *Permittivity due free space*, $\epsilon_0 = 8.854 \times 10^{-12} \text{CN}^{-1}\text{m}^{-1}$

Charge on electron, $e = 1.6 \times 10^{-19}\text{C}$

SECTION A

Question One (Compulsory)

- (a) State four properties of electrostatic forces (4 marks)
- (b) A capacitor does not conduct direct current but seems to conduct alternating current. Explain (3 marks)

- (c) State the Ampere's law (1 marks)
- (d) A piece of plastic pipe of radius r has a uniform surface charge q . What is the electric field along its axis? Explain (2 marks)
- (e) Three capacitors C_1 , C_2 and C_3 are connected in series. Derive an expression for the net capacitance (4 marks)
- (f) The potential at a certain region is given by $V = 4x^2 - 3xy^2 + 2z^2$ volts. Determine the components of the electric field intensity, E at the point (4, -3, 2) metres (6 marks)
- (g) (i) State the Lorentz's law (1 marks)
- (ii) Charges are flowing into a plane (say this page) within a region where the magnetic field is vertically upwards. On a sketch, illustrate the direction of the lines of force due to this field. (3 marks)
- (h) Two isolated conductors of radii r_1 and r_2 are electrically connected together. Determine the ratio of their final charge densities ρ_1 and ρ_2 (4 marks)
- (i) Explain why semiconductors are said to be non-ohmic? (2 marks)

SECTION B

Answer any **TWO** questions in this section

Question 2

- (a) Show that the electric field strength E due to a dipole of magnitude q placed a distance $2a$ apart at a point x , a distance r from the line joining them is inversely proportional to r^3 , where $r \gg a$ (7 marks)
- (b) Determine the potential at point P , r metres on the axis of a uniformly charged disk of radius a , whose surface density is ρ , hence show that it behaves as a point charge when $r \gg a$ (13 marks)

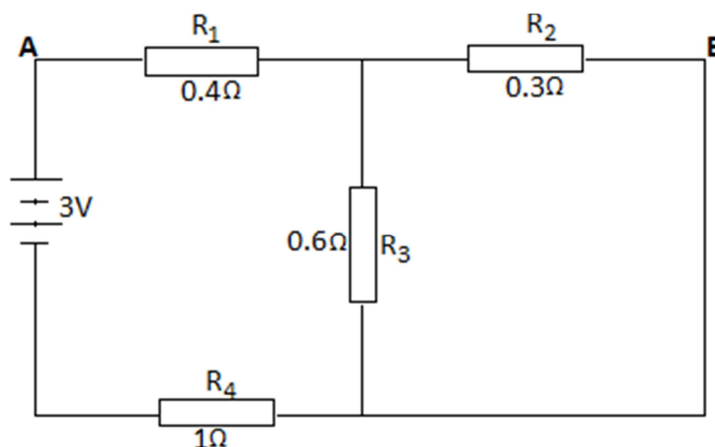
Question 3

Three charges are placed at the vertices of an equilateral triangle of sides 10 cm, such that the line joining q_1 to q_2 is parallel to the x -axis. Given that $q_1 = 1.0\mu C$, $q_2 = +3\mu C$ and $q_3 = -2\mu C$, calculate the: -

- (a) Resultant force on q_1 and its direction due to this charge distribution (6 marks)
- (b) Electric field at the point X , the centre of the configuration (9 marks)
- (c) Electric potential at X (2 marks)
- (d) Total electric potential energy due to the configuration (3 marks)

Question 4

- (a) A Singly charged carbon ion is moving at a speed of 300 km/s at right angles to a magnetic field of 0.75 T. Given that mass of carbon is 12 *amu*, where $1 \text{ amu} = 1.66 \times 10^{-27} \text{ kg}$, determine the: -
- (i) Force on the ion? (3 marks)
 - (ii) Centripetal acceleration of the ion? (4 marks)
 - (iii) Radius of the circle in which the ion moves (3 marks)
- (b) Figure 2 shows a circuit in which the emf, $\mathcal{E} = 3V$, while the resistances are $R_1 = 0.4 \Omega$, $R_2 = 0.3 \Omega$, $R_3 = 0.6 \Omega$ and $R_4 = 1 \Omega$



Determine the: -

- (i) Equivalent resistance between A and B (4 marks)
- (ii) Electric potential across R_1 (3 marks)
- (iii) Current through R_3 (3 marks)

Question 5

- (a) Describe the charging and discharging process of a capacitor (5 marks)
- (b) A circuit is connected as shown in Figure 1, where each of the capacitors has a capacitance of $5\mu\text{F}$, determine the: -

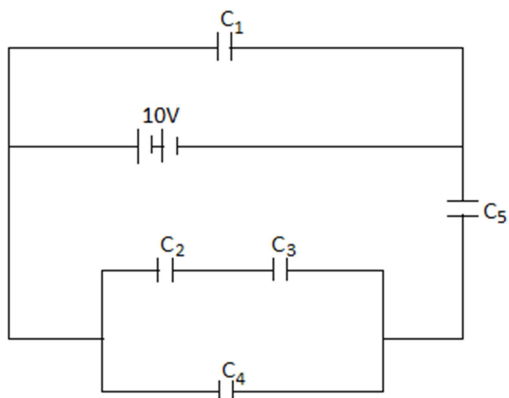


Figure 1 capacitor circuit

- (i) Total capacitance of the circuit (4 marks)
- (ii) Charge on C_1 and C_4 (5 marks)
- (iii) Total energy stored in the network when fully charged (3 marks)
- (c) Explain the effect of the presence a dielectric on the capacitance of a capacitor (4 marks)