BINDURA UNIVERSITY OF SCIENCE EDUCATION

DIPLOMA IN SCIENCE EDUCATION

PHYSICS AND MATHEMATICS DEPARTMENT

PH010/DP002: ELECTRICITY AND MAGNETISM

TIME: 3 HOURS

OCT 2023

INSTRUCTIONS

Answer **question one** in Section A and **any three** questions from Section B. Section A carries 40 marks and each question in Section B carries 20 marks.

Physical constants

Electronic charge, $e = 1.6 \times 10^{-19}$ C
Boltzmann's constant, $k = 1.38 \times 10^{-23}$ JK^{-1}
Mass of an electron, $m_e = 9.11 \times 10^{-31}$kg
Permittivity of free space, $\varepsilon_o = 8.85 \times 10^{-12}$ $C^2N^{-1}m^{-2}$
Velocity of light in vacuum, $c = 3.00 \times 10^8$ ms^{-1}
Acceleration due to gravity, $g = 9.81$ ms^{-2}

SECTION A

1 (a) The p.d. across 2 m of a wire is 5 V when the current in it is 100 mA. Find the diameter of the wire if its resistivity is 1×10^{-6} Ω m. [6]

(b) Define an ohmic conductor. [3]

(c) Draw the I-V characteristics of each of the following devices:

(i) Filament lamp [2]
(ii) Silicon diode. [2]

(d) An electric lamp is rated at 60 W, 240 V. Calculate the filament resistance when the lamp is operating normally. [4]

(e) The diagram in **Fig 1.1** shows some resistors connected together.

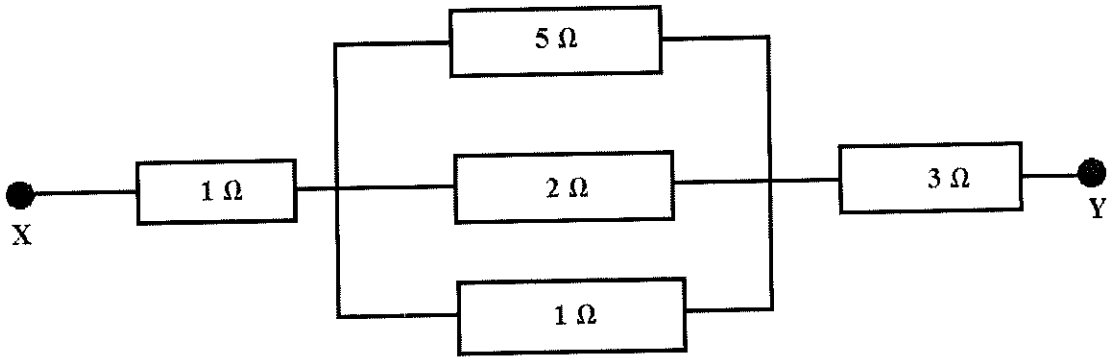


Fig 1.1

If a battery of e.m.f 6 V is connected across the points X and Y, how much current would flow between the points? [5]

(f). A resistor has a p.d of 40 V when the current flowing in it is 120mA. Calculate the p.d. when the current is 600mA. [6]

(g). Describe the important properties of electric charge. [4]

(h).The four wires shown in Figure 1.2 all carry the same current from point A to point B through the same magnetic field. Rank the wires with justification according to the magnitude of the magnetic force exerted on them, from greatest to least. [8]

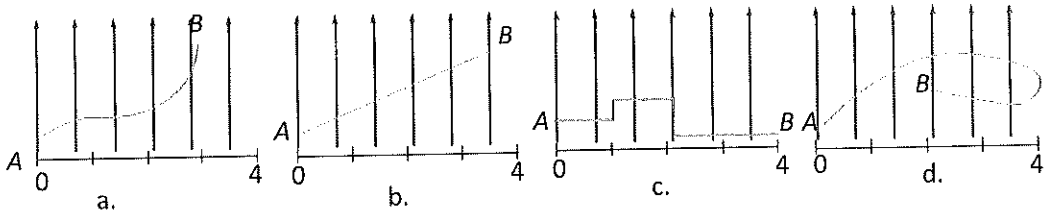
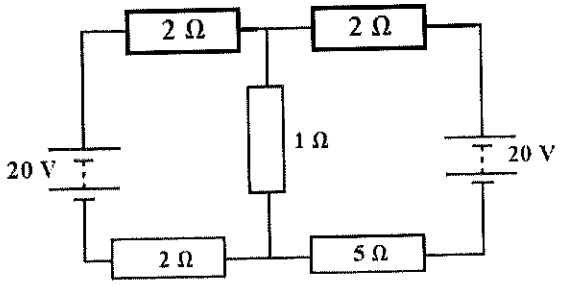


Figure 1.2: Question 1. h

SECTION B

2.a. Figure 2.1 is an illustration of the application of Kirchoff's laws. Use Kirchhoff's rules to determine the current passing through each resistor and the potential difference across it. [14]



b. With aid of a diagram, show that the total resistance (R_T) for two different resistors that are [6]

connected in parallel is given by equation (2.1).

$$R_T = \frac{R_1 R_2}{R_1 + R_2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.1)$$

3.a. Figure 3.1 shows a network of capacitors connected to a 200 V battery.

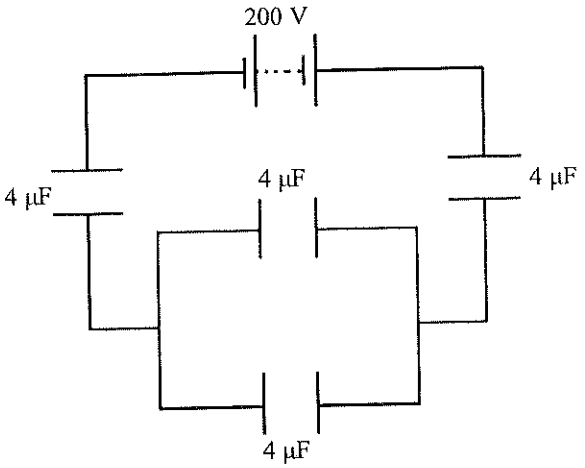


Figure 3.1: Question 3.b.

Calculate

i. The equivalent capacitance of the capacitors [6]

ii. The charge on each capacitor [4]

iii. The potential difference across each capacitor [4]

b. With the aid of a clearly labelled circuit diagram, show that the effective capacitance (C_{ef}) of three capacitors arranged in parallel is given by equation (3.1) [6]

$$C_{ef} = C_1 + C_2 + C_3 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.1)$$

where the symbols have their usual meanings.

4.a. Write down the mathematical statement of Coulomb's law of electrostatics defining all the symbols used. [5]

b. Two ions A and B are separated by 0.72 mm in vacuum. A has a charge of $+3.2\times10^{-19}$ C and B has a charge of -1.6×10^{-19} C . Calculate the force exerted by A on B. [4]

c. Three point charges Q_1, Q_2 and Q_3 respectively of 1 μC, -2 μC and 3 μC are fixed at the positions shown in Figure 4.1. The charges are in vacuum. [11]

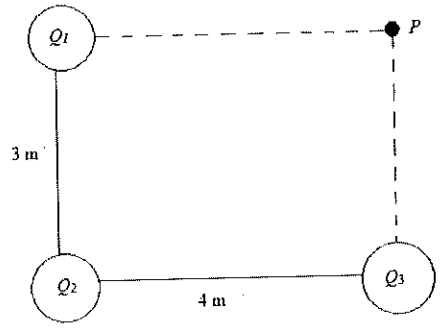
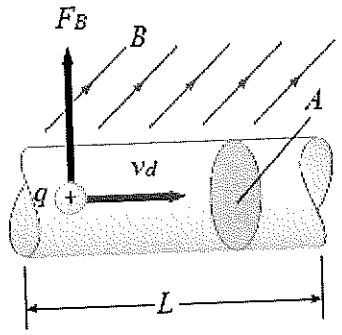


Figure 4.1: Question 4.b.

Calculate the potential at point P at the corner of the rectangle.

5.a. Consider a straight segment of wire of length L and cross-sectional area A, carrying a current [8]



I in a uniform magnetic field B.

Show that the total magnetic force $F_B = ILB$.

b. The north-pole end of a bar magnet is held near a positively charged piece of plastic. Is the plastic attracted, repelled, or unaffected by the magnet? [4]

c. A wire carries a current of 10 A in a direction that makes an angle of 30° with the direction of the magnetic field of strength 0.3 T. Find the magnitude of the force on a 5 m long of the wire. [4]

d. An electron moves at a velocity of 2.4×10^7 ms^{-1} perpendicular to a magnetic field of strength 4.5×10^{-2} T. Calculate the size of the force on the electron. [4]

6. For the circuit shown in Figure 6.1, calculate the current through the 12 Ω resistor. [20]

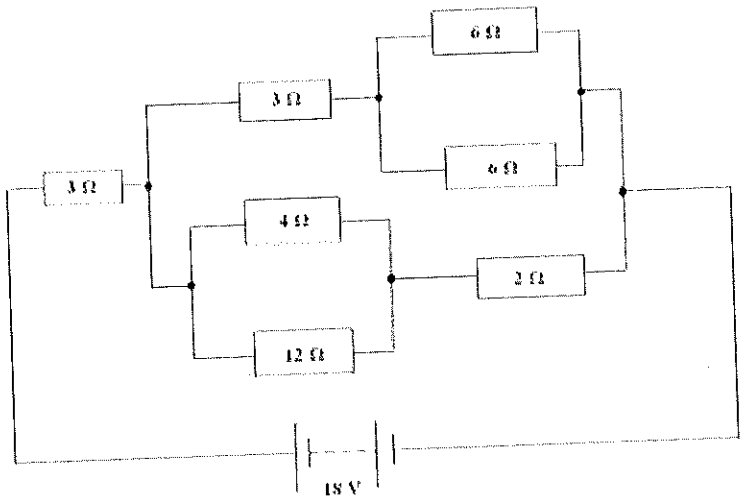


Figure 6.1: Question 6

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