BINDURA UNIVERSITY OF SCIENCE EDUCATION

DIPLOMA IN SCIENCE EDUCATION

ENGINEERING AND PHYSICS DEPARTMENT

DP002 (2): ELECTRICITY AND MAGNETISM

TIME: 3 HOURS

MAR 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)

(i). Explain in terms of electron movement what happens when a polythene rod becomes charged negatively by being rubbed with a cloth. [3]

(ii).One method of painting a car uses electrostatics. A paint spray produces paint droplets all of which are given a positive charge. The car body is given a negative charge.

1. Explain why it is important to give all the paint droplets a positive charge.[2]
2. Explain why it is important to give a car body a negative charge.[2]

(b).Calculate the current in each of the following,

(i).2C flows through a bulb in 10s [3]

(ii).2 μc flows through a light –emitting diode in 1ms. [3]

(c). What length of constantan wire of diameter 0.4mm has a resistance of 10 Ω ? Assume the resistivity of constantan is 5×10^{-7} Ω m. [6]

(d). A 3 μF capacitor is connected in series with a 6 μF capacitor. The combination is then connected in parallel with a 1 μF capacitor to a 12V battery.

(i). Draw a circuit diagram to represent this information. [2]

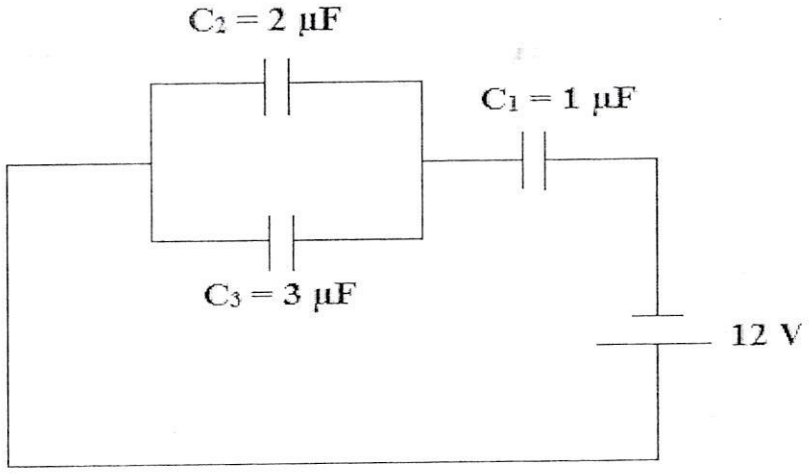

Figure 1

(b) A 10 μF capacitor is connected across the terminals of a 100 V d.c. power supply and allowed to charge fully. Calculate

(i) the charge on the capacitor, [2]

(ii) the energy stored by the capacitor. [2]

(c).A straight wire of length 50 cm and resistance 10 Ω moves sideways with velocity $15ms^{-1}$ at right angles to a uniform magnetic field of flux density 2.0×10^{-3} Tesla. Calculate the amount of current that would flow if its ends were connected by leads of negligible resistance.
[6]

(d).Draw a sketch graph to show the variation of the electric field intensity with distance x.[4]

4. (a).State Coulomb's law of electrostatics defining all the symbols in the Equation. [4]

(b) Three charges A, B and C of magnitudes 5 nC, 3 nC and 2 nC respectively are arranged at the corners of a square in vacuum as shown in **Figure 2**.

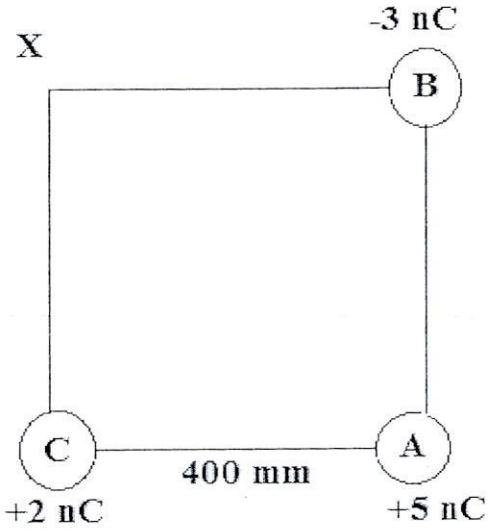

Figure 2

Calculate

(i) the electric potential at X due to the three charges. [6]

(ii) the electric field strength and its direction at X due to the three charges. [10]

5. Figure 3.1 shows the magnetic field between the two pole pieces of a large *U*-shaped magnet, with the north pole vertically above the south pole. When the strength of the magnetic field is measured along the line *AB* using a search coil, it is found to vary as shown in Figure 3.2.

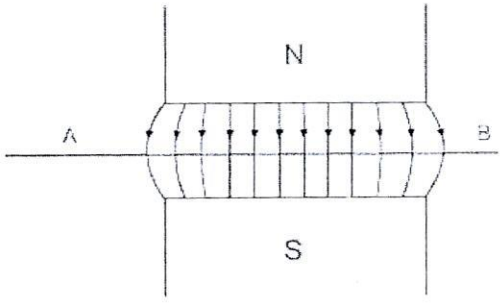

Figure 3.1

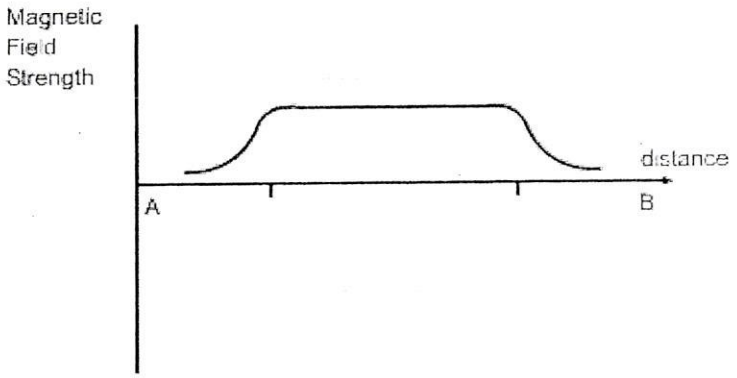

Figure 3.2

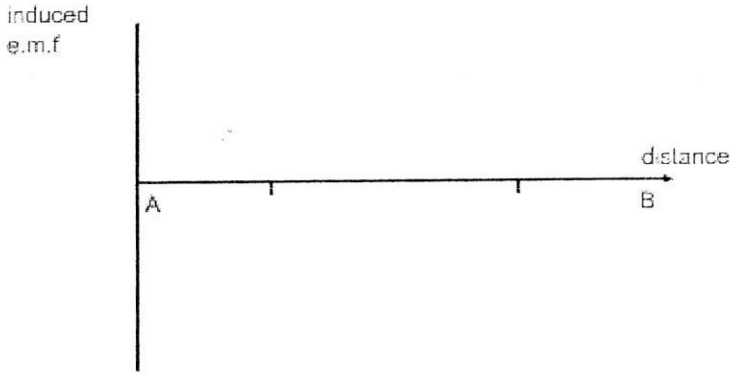

Figure 3.3

(a) Describe in words how the magnetic flux linkage in the coil changes as the coil moves from *A* to *B*. [6]

(b) State Faraday's and Lenz's law of electromagnetic induction. Why is Lenz's law, a law of conservation of energy? [4]

(c) .Redraw, Figure 3.3 and on it plot a graph to show how the e.m.f. induced in the coil varies as the coil moves from *A* to *B*. [10]

6.(a) Define the following and state their units

(i) magnetic flux.
[3]
(ii) magnetic flux density.
[3]

(b).A long vertical straight wire carries current in an upward direction. Draw a diagram to show the direction of the magnetic field around the wire. [2]

(c). An aeroplane with a wing span of 25 m is flying from East to West at a speed of 250 ms^{-1}.

(i).Calculate the potential difference between the wing tips if the vertical component of the earth's magnetic field is 4.0×10^{-5} T. [4]

(ii). Which wing tip is at a positive potential? [1]

(c).Deduce the relation between the *electric field strength* E at the surface of a conductor, the *charge density* σ and the *permittivity* ε. [6]

END OF PAPER