**BINDURA UNIVERSITY OF SCIENCE EDUCATION**
**PHYSICS AND MATHEMATICS DEPARTMENT**
**PH010/DP002: ELECTRICITY AND MAGNETISM** JUN 2024
**DURATION: THREE HOURS**

Answer **ALL** parts of Section A and any **THREE** questions from Section B. Section A carries 40 marks and Section B carries 60 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, $\varepsilon_o = 8.85 \times 10^{-12}$ Fm$^{-1}$

Electric potential at infinity, $V_\infty = 0$ — Permeability of free space, $\mu_o = 4\pi \times 10^{-7}$ Hm$^{-1}$

1.a. Discuss the properties of electric charge [6]

b. State the difference(s) between an electric conductor and an insulator. [4]

c. The labelled points in Figure 1.1 are on a series of equipotential surfaces associated with an electric field. Rank (from greatest to least) the work done by the electric field on a positively charged particle that moves from *A* to *B*; from *B* to *C*; from *C* to *D*; from *D* to *E*. [8]

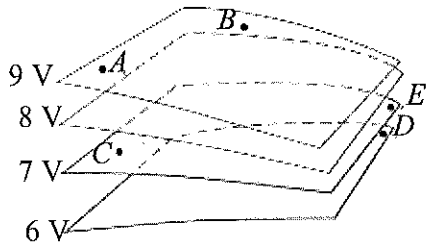
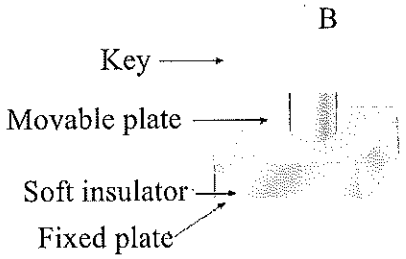



Figure 1.1: Question 1.c.

d. Many computer keyboard buttons are constructed of capacitors, as shown in Figure 1.2. When [4]




a key is pushed down, the soft insulator between the movable plate and the fixed plate is compressed. When the key is pressed, the capacitance (a) increases, (b) decreases, or (c) changes in a way that we cannot determine because the complicated electric circuit connected to the keyboard button may cause a change in *V*.

e. Consider three capacitors having capacitances of 3.0 μF, 6.0 μF, and 12 μF. Find their [4]

equivalent capacitance when they are connected in parallel.

f. i. Calculate the resistance of a plastic cylinder that is 10.0 cm long, has a cross-sectional area of $2.00\times10^{-4}$ $m^2$ and resistivity of $3.0\times10^{10}$ $\Omega m$ [4]

ii. Use the calculated resistance to explain the uses of plastic in the electricity industry [2]

g. A battery has an emf of 12.0 V and an internal resistance of 0.04 Ω. Its terminals are connected to a load resistance of 4.00 Ω. Calculate the power delivered to the load resistor. [6]

h. What is the maximum work that a constant magnetic field ($B$) can perform on a charge ($q$) moving through the field with velocity ($v$)? [2]

## SECTION B

2 In the circuit diagram in Figure 1.4, find the value of the currents $I_1$, $I_2$ and $I_3$ and comment on the values obtained. [20]

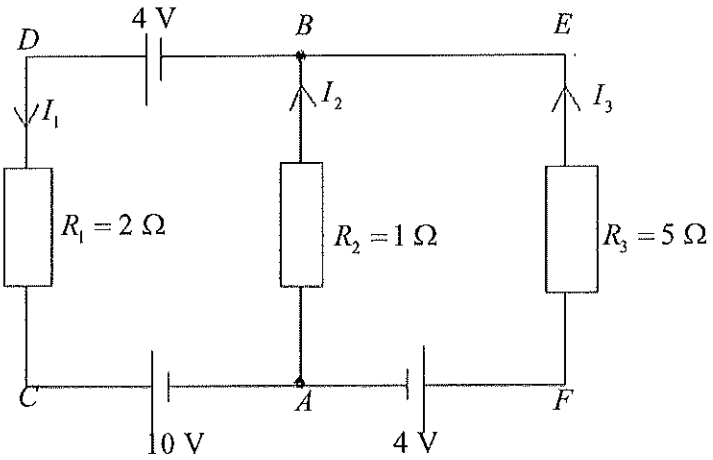



Figure 1.3: Question 2.

3.(a).An electron in a television picture tube moves toward the front of the tube with a speed of $8.0\times10^6$ $ms^{-1}$ along the $x$ axis as shown in Figure 1.4. Surrounding the neck of the tube are coils of wire that create a magnetic field of magnitude 0.025 T, directed at an angle of 60° to the $x$ axis and lying in the $xy$ plane. Calculate the magnetic force on and acceleration of the electron.[10]

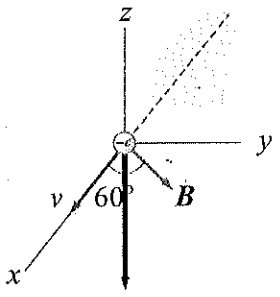



Figure 1.4 Question 3.a.

(b).Discuss the important differences between electric and magnetic forces.[6]

(c).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]

4. (a) **Fig 1.5** shows a network of capacitors connected to a voltage source.

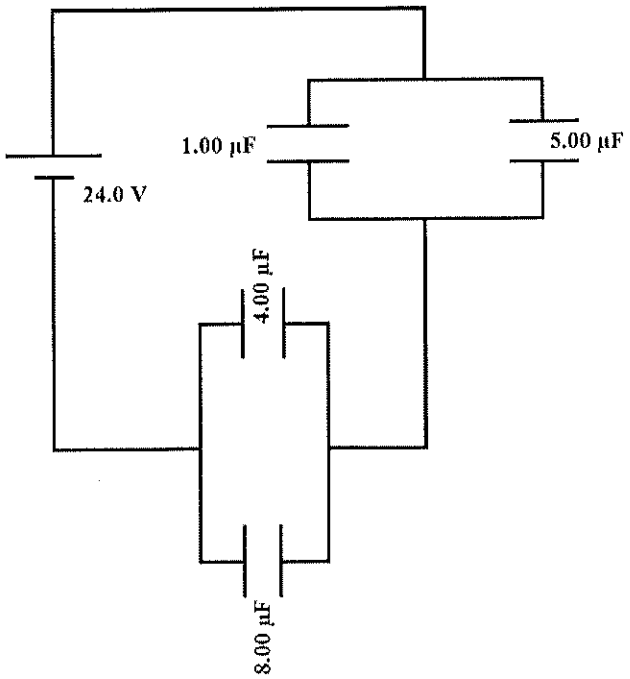



**Fig 1.5**

Calculate

(i) the equivalent capacitance of the capacitors. [4]

(ii) the potential difference across each capacitor. [4]

(iii) the charge on each capacitor. [4]

(b) **Fig 1.6** shows an electric circuit. A voltmeter and an ammeter are to be connected in the circuit so as to measure the potential difference across component R as well as the current though it.

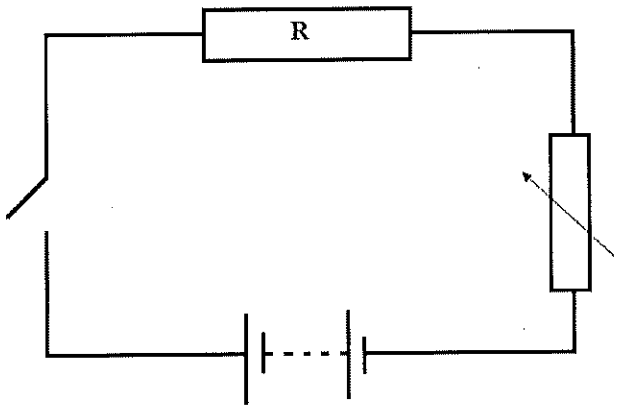



**Fig 1.6**

(i) Redraw the circuit and include the voltmeter **V** and ammeter **A** in their appropriate positions. [2]

(ii) Describe in detail how you would use the circuit to determine the size of the component R. [6]

5. (a) (i) By reference to Coulomb's law in electrostatics and Newton's law of gravitation, explain what is meant by an inverse square law field [3]

(ii) Define *electric potential* and distinguish it clearly from *electric potential energy.* [2]

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

(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]

(d) Write down an expression for F, the force on a long straight conductor of length L, carrying current I at an angle $\theta$ to a uniform magnetic field of flux density B. [2]

(e) **Fig 1.6** shows a conductor that is carrying current I in a magnetic field of flux density B.

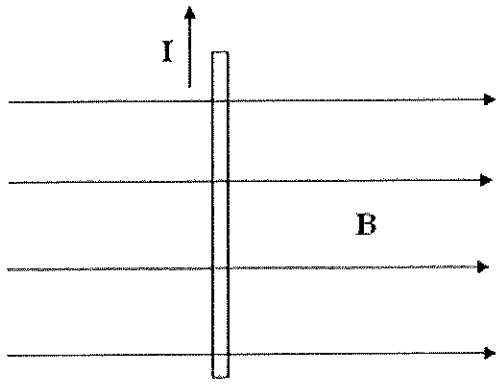



**Fig 1.6**

Determine the direction of motion of the conductor stating clearly what rule you used. [3]

6.a. Figure 1.7 shows two positively charged particles fixed in place on an $x$ axis. The ch are $q_1 = 1.60 \times 10^{-19}$ C and $q_2 = 3.20 \times 10^{-19}$ C, and the particle separation is $R = 0.02$ m third particle with charge $q_3 = -3.20 \times 10^{-19}$ C and is at a distance $3/4R$ from particle 1.

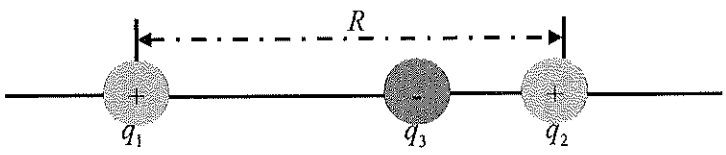



Figure 1.7: Question 2. a.

What is the net electrostatic force on particle $\left(\vec{F}_{1,\text{net}}\right)$ 1 due to particles 2 and 3?. [10]

b. A battery has an emf of 12.0 V and an internal resistance of $0.05\ \Omega$. Its terminals are connected to a load resistance of $3\ \Omega$.

c. Find the current in the circuit and the terminal voltage of the battery. [6]

d. Calculate the power delivered by the battery. [4]

**END OF EXAMINATION**