BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF ENGINEERING AND SCIENCE

DEPARTMENT OF ENGINEERING AND PHYSICS

BACHELOR OF SCIENCE EDUCATION HONOURS DEGREE IN PHYSICS (HBScEdPh)/ BACHELOR OF SCIENCE HONOURS DEGREE IN ENVIRONMENTAL PHYSICS AND ENERGY SOURCES (HBScEPES)

PH103/HPH121: ELECTRICITY AND MAGNETISM

DURATION: 3 HOURS JAN 2025 TOTAL MARKS: 100

INSTRUCTIONS TO CANDIDATES
Answer **ALL** parts of Section A and any **THREE** questions from Section B.
Section A carries 40 marks and Section B carries 60 marks.

Electronic charge, q = 1.6 x 10^{-19} C
Permittivity of free space, ε_0 = 8.85 x 10^{-12} F m^{-1}
Permeability of free space, $\mu_0 = 4\pi x 10^{-7}$ H m^{-1}
Mass of electron, m_e = 9.11 x 10^{-31} kg
Mass of proton, m_p = 1.67 x 10^{-27} kg
Avogadro constant, N_A = 6.02 x 10^{23} mol^{-1}
Universal Gravitation Constant, G = 6.67 x 10^{-11} N m^2 kg^{-2}
Acceleration due to gravity, g = 9.81 m s^{-2}

SECTION A

1. (a) Distinguish between conductors and insulators. Give two examples of each. [6]

(b) If an electric field exists to the right, in which direction will a negative charge move if placed in the field? [2]

(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 length of the wire. [3]

(d) Calculate the Coulomb force between two point charges $q_1 = +12nC$ and $q_2 = -18nC$ at a separation distance of 30 cm. State with a reason whether this force is attractive or repulsive? [5]

(e) A 15 cm diameter circular loop of wire is placed in a 0.50 T magnetic field.
(i) When the plane of the loop is perpendicular to the field lines, what is the magnetic flux through the loop? [3]

(ii) The plane of the loop is rotated until it makes a 35 ^{0} angle with the

field lines. What is the angle θ in the equation $\Phi_B = BA\cos\theta$ for this situation? [2]

(f) A series LCR circuit with L = 2 H, C = 2 μF and R = 20 Ω is driven by an ac source of maximum emf, 100 V and of variable frequency. Find the resonance frequency ω_0, the phase ϕ and maximum current I_{max} when the ac source angular frequency is 400 rads^{-1}. [10]

(g) Three $20\mu C$ charges are placed on the corners of a square of side 2m. Calculate:

(i) the potential V at the fourth, unoccupied corner of the square. [3]

(ii) the work needed to bring the fourth positive charge of $20\mu C$ from infinity and place it on the fourth corner of the square. [3]

(h) Given that 1kJ is required to carry a 10C charge from one point to the other, what is the potential difference between these two points? [3]

SECTION B

2. (a) State Kirchhoff's junction and loop rules. [4]

(b) Use Kirchhoff's junction and loop rules to find the currents flowing through each resistor in Figure 2.1, indicating their directions on a diagram. [10]

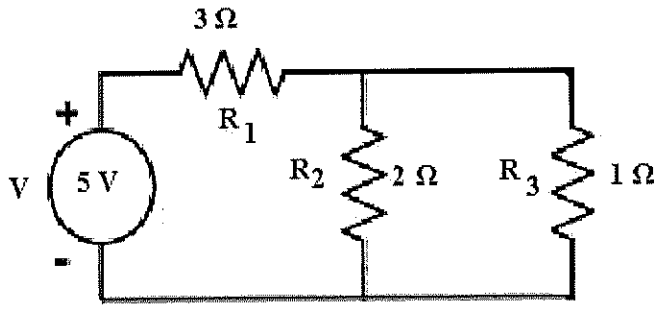

Figure 2.1. Electric circuit.

(c) Calculate the power delivered to each resistor in Figure 2.1. [6]

3. (a) Explain the similarities and differences between electric forces and gravitational forces. [6]

(b) A $90pF$ capacitor is connected to a 12V battery and charged to 12V. How many electrons are transferred from one plate to another? [4]

(c) Four 2 μF capacitors are connected as shown in Figure 3.1.

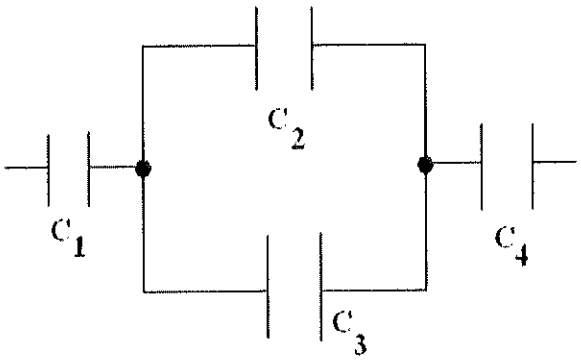

Figure 3.1. Electric circuit.

Calculate the total capacitance. [10]

4. (a) State *Faraday's law* of electromagnetic induction. [2]

(b) A flat circular coil has 200 turns of wire each of radius 10 cm. A uniform magnetic field B exists in a direction perpendicular to the plane of the coil. The magnetic field is decreasing at the rate of 10^{-2} T s^{-1}. Calculate the emf induced in the coil and the induced current if the resistance of the coil is 0.1Ω. [5]

(c) A solenoid is 70 cm long with 1000 turns per metre and carries a current of 10 A. What is the magnitude of the *magnetic field* through the centre of this solenoid? [3]

(d) Use *Ampere's law* to derive a formula for the magnitude of the magnetic field set up by a current *I* in a long straight wire. [4]

(e) Briefly, describe the two basic principles which govern the operation of transformers. [6]

5. (a) Define electric flux. [2]

(b) State Gauss' law in words and in its mathematical form. [5]

(c) Consider a uniform electric field oriented in the x-direction. Find the electric flux through each surface of a cube with edges L oriented as shown in Fig. 5.1, and the net flux. [13]

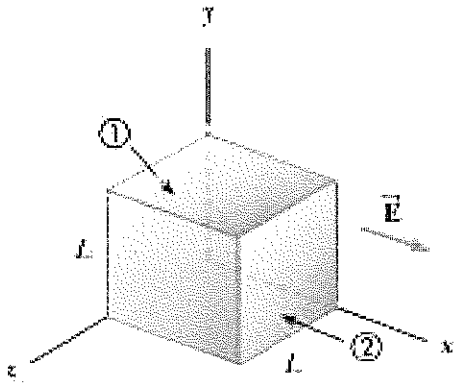

Figure 5.1. Electric flux through a cube.

6. Consider three point charges at the corners of a triangle, as shown in Figure 6.1, where $q_1 = 6.00\,nC$, $q_2 = -2.00\,nC$ and $q_3 = 5.00nC$.

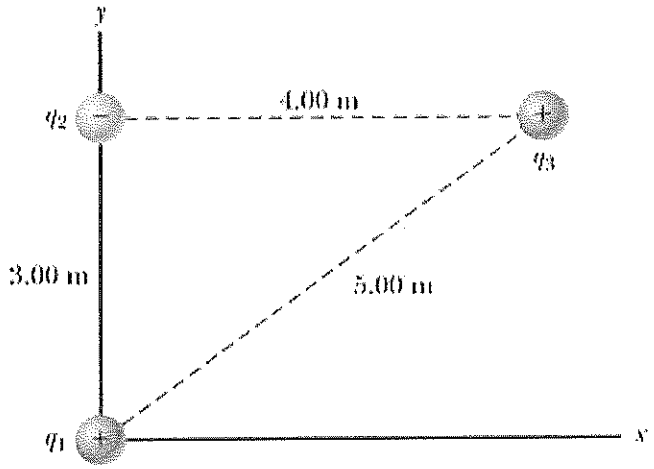

Figure 6.1. Three point charges.

(a) Find the components of the force $\vec{F}_{23}$ exerted by q_2 on q_3. [5]

(b) Find the components of the force $\vec{F}_{13}$ exerted by q_1 on q_3. [5]

(c) Find the resultant force on q_3, in terms of components and also in terms of magnitude and direction. [10]

END OF EXAMINATION