BINDURA UNIVERSITY OF SCIENCE EDUCATION

JAN 2025

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT: ENGINEERING AND PHYSICS

PROGRAMME BSc HONOURS DEGREE IN COMPUTER SCIENCE / BSc EDUCATION HONOURS DEGREE IN COMPUTER SCIENCE

COURSE CODE PH107 (1): PHYSICS FOR COMPUTER SCIENCE

DURATION: 3 HOURS TOTAL MARKS: 100

INSTRUCTIONS TO CANDIDATES

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, $\varepsilon_o = 8.85 \times 10^{-12}\ Fm^{-1}$
Permeability of free space, $\mu_o = 4\pi \times 10^{-7}\ Hm^{-1}$
Velocity of light in vacuum, $c = 3.00 \times 10^{8}\ ms^{-1}$
Universal Gravitational Constant, $G = 6.7 \times 10^{-11}\ Nm^2kg^{-2}$
Acceleration due to gravity, $g = 9.81\ ms^{-2}$
Electric potential at infinity, $V_\infty = 0$

SECTION A

1 (a) Find the angle between the vectors $\vec{M} = (3, 2, -4)$ and $\vec{N} = (-1, -5, 0)$. [4]

(b) What is the difference between a dot product and a cross product of vectors? [2]

(c) Calculate the cross product of the vectors $\vec{R} = (0, -3, 2)$ and $\vec{S} = (-4, 5, 1)$. [5]

(d) Verify that the cross product calculated in (c) is orthogonal to both $\vec{R}$ and $\vec{S}$. [2]

(e) An object moves at 10 ms^{-1} around a circular path of radius 20 m. Determine the centripetal force. [3]

(f) Calculate the magnitude of the electric field at a point $5 \times 10^{-7}\ m$ from a proton. [3]

(g) A 470 μF capacitor is charged to a p.d. of 20 V. Calculate the charge acquired by the capacitor. [2]

(h) Suppose that you have some resistors, each of resistance 1 KΩ. Draw circuit diagrams, one in each case, to show how a number of these resistors may be connected to produce a combined resistance of;

(1) 2 KΩ (2) 0.5 KΩ (3) 0.4 KΩ [6]

(i) A charged particle carrying 4 times the magnitude of the electron has a velocity $\vec{v} = 3\vec{\imath} - 2\vec{\jmath} + 2\vec{k}\ ms^{-1}$ in a region where the magnetic field is $\vec{B} = 4\vec{\imath} + 3\vec{\jmath} + \vec{k}\ T$.

(1) Find the magnitude of the magnetic force $\vec{F}$ on this particle. [5]
(2) Verify that $\vec{F}$ is a centripetal force. [3]

(j) Define inductive reactance? [1]

(k) A resistor of resistance 100 Ω is connected in series with an inductor of inductive reactance 150 Ω and a 5 V supply. Calculate the circuit current. [4]

SECTION B

2 (a) Vectors $\vec{P}$ and $\vec{Q}$ are given by: $\vec{P} = (1, -5, 2)$ and $\vec{Q} = (4, 0, -2)$ determine the unit vectors of $\vec{P}$ and $\vec{Q}$ leaving your answer in exact form. [4]

(b) A particle has an initial velocity of (2i - 4j-3k) ms^{-1} and an acceleration of (0.4i + 0.3j+ 2k) ms^{-2}. Calculate

(i) the speed of the particle after 2 seconds. [5]

(ii) the distance travelled in the 2 seconds. [3]

(c) Calculate the resultant and direction of the forces given in Fig. 1. [8]

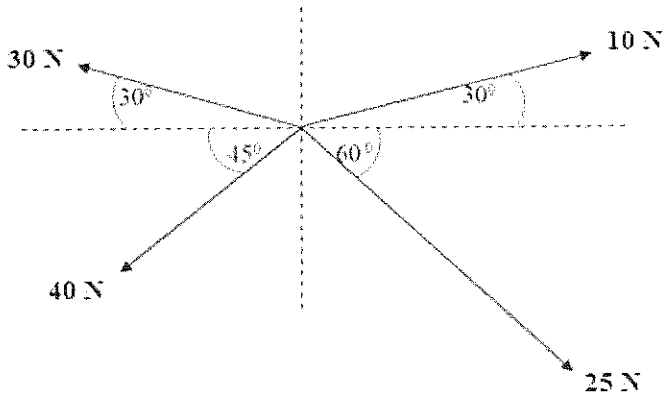

Fig. 1

3 Three point charges Q_1, Q_2 and Q_3 respectively of magnitudes 1 μC, 2 μC and 3 μC are fixed at the positions shown in Fig 2. The charges are in vacuum.

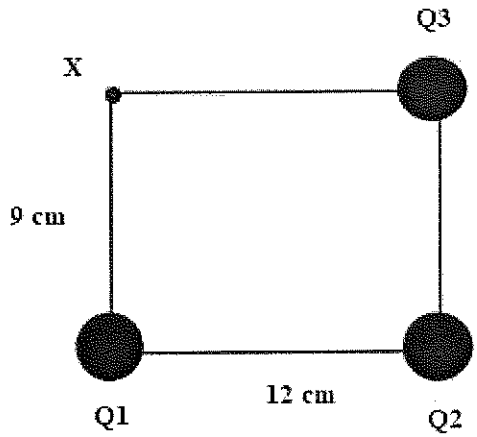

Fig. 2

(a) Calculate the electric potential at point X due to the three charges. [18]

(b) How much work is required to move a charge of -5 μC from infinity to point X? [2]

4 (a) Sate Kirchhoff's voltage and current laws and explain the fundamental physical principles upon which each of the laws is based. [4]

(b) Fig. 3 shows a network containing two voltage sources and five resistors.

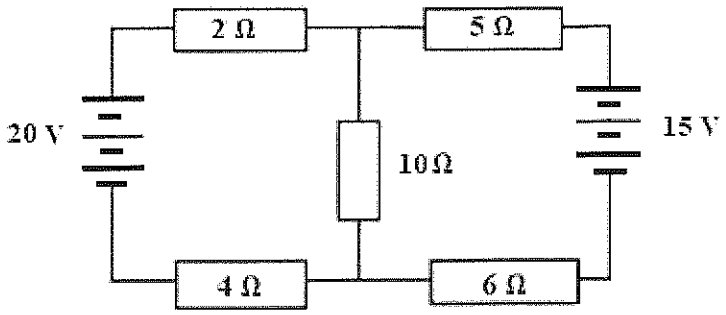

Fig. 3

(i) Use Kirchhoff's rules to determine the current through the 10 Ω resistor. [14]

(ii) Hence calculate the potential difference across the 10 Ω resistor. [2]

5 Fig. 4 shows a network of capacitors connected to a voltage source.

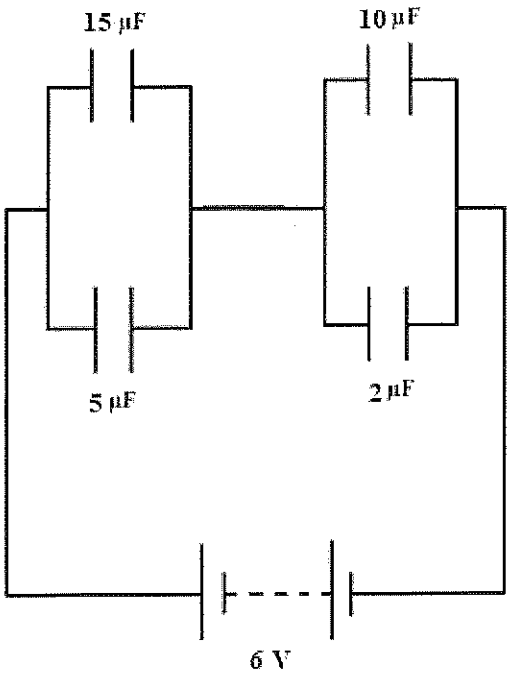

Fig. 4

Calculate

(a) the equivalent capacitance of the capacitors. [5]
(b) the charge on each capacitor. [5]
(c) the potential difference across each capacitor. [5]
(d) the energy stored in each capacitor. [5]

6 A resistor of resistance 100 Ω and an inductor of inductive reactance 150 Ω are connected in series with a 60 V a.c. generator.

(a) Draw a circuit diagram showing how the components are connected. [5]

(b) Draw the phasor diagram for V_R and V_L. [4]

(c) Calculate the following.

(i) impedance [3]
(ii) total current [2]
(iii) potential drop across the resistor [2]
(iv) potential drop across the inductor [2]
(v) the phase angle [2]