BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE AND ENGINEERING

NOV 2024

DEPARTMENT: ENGINEERING AND PHYSICS

PROGRAMME BSc HONOURS DEGREE IN COMPUTER SCIENCE

COURSE CODE PH107 (3): 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) Given that $\vec{E} = \begin{bmatrix}5\\2\\3\end{bmatrix}$ and $\vec{F} = \begin{bmatrix}-2\\4\\-3\end{bmatrix}$ determine the unit vectors of $\vec{E}$ and $\vec{F}$. [4]

(b) A particle moves in a straight line and is such that its initial velocity is $(2\mathbf{i} + \mathbf{j} + 4\mathbf{k})\ ms^{-1}$. If the acceleration of the particle is $(0.1\mathbf{i} + 0.2\mathbf{j} + 0.3\mathbf{k})\ ms^{-2}$, calculate the speed of the particle after 5 seconds. [4]

(c) A car travelling at a velocity of $10\ ms^{-1}$ accelerates uniformly for 3 seconds at a rate of $1.8\ ms^{-2}$. Calculate the distance travelled during this time. [3]

(d) A object is charged to +25 *nC*. Determine the number of electrons that are needed to make the object neutral. [4]

(e) Calculate the electric potential at a distance *r* from a proton where $r = 0.552 \times 10^{-10}\ m$. [4]

(f) A 4700 μF capacitor is charged to a p.d. of 15 V. Calculate the charge acquired by the capacitor. [2]

(g) A student has available some resistors, each of resistance 100 Ω. 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) 200 Ω (2) 50 Ω (2) 40 Ω [6]

(h) A charged particle carrying twice the magnitude of the basic charge moves with velocity $\vec{v} = -6\vec{\imath} - 4\vec{\jmath} + 3\vec{k}\, ms^{-1}$ in a region where the magnetic field is $\vec{B} = 5\vec{\imath} - 10\vec{\jmath} + 2\vec{k}\, T$.

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

(i) What do you understand by capacitive reactance? [1]

(j) A resistor of resistance 1000 Ω is connected in series with a capacitor of capacitive reactance 300 Ω and a 150 V supply. Calculate the current flowing in the circuit. [4]

SECTION B

2 (a) A particle is moving in three dimensions. Its position vector is given by;

$$\boldsymbol{r} = 4\hat{x} + (5 + 2t)\hat{y} - (6 + 4t - 3t^2)\hat{z}.$$

Distances are in metres and the time t in seconds.

(i) What is the velocity vector at $= +2$? [3]
(ii) Evaluate the speed in ms^{-1} at $t = +2$. [3]
(iii) Determine the acceleration vector and its magnitude in ms^{-2} at $t = +2$. [6]

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

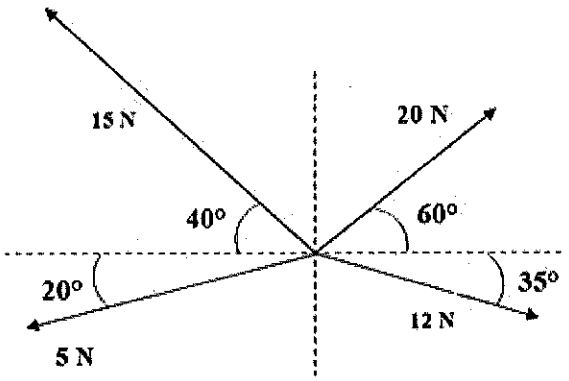

Fig. 1

3 Fig. 2 shows a system of charges located at the corners of a rectangle in vacuum. It is given that $q_1 = 8 \times 10^{-9}$ *C*, $q_2 = -2 \times 10^{-9}$ *C* and $q_3 = 4 \times 10^{-9}$ *C*.

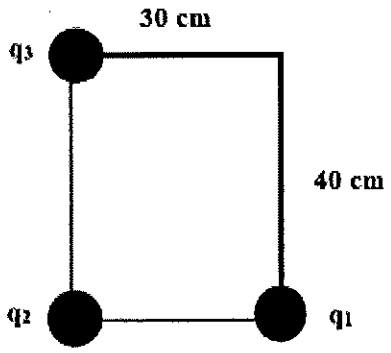

Fig. 2

(a) Calculate the electric potential at the corner where there is no charge. [18]

(b) How much work is required to move a charge of -5 *nC* from infinity to the corner where there is no charge? [2]

4 Fig. 3 shows a circuit containing two voltage sources and some resistors.

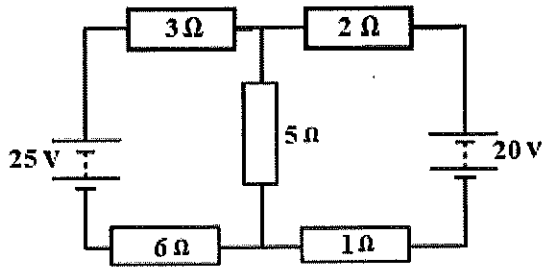

Fig. 3

(a) Use Kirchhoff's rules to determine the current passing through the 5 Ω resistor. [18]

(b) Hence calculate the potential difference across the 5 Ω resistor. [2]

5 Fig. 4 shows a network of capacitors connected to a 10 *V* battery.

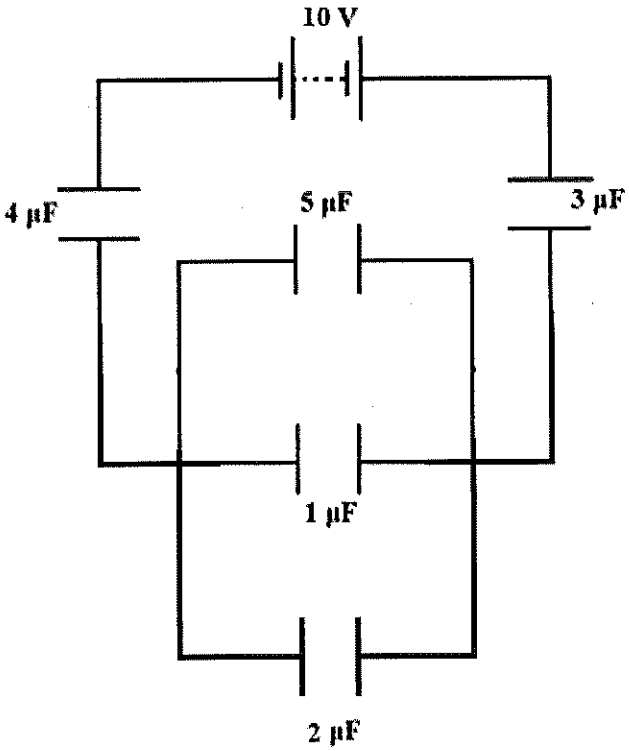

Fig. 4

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 An inductor of inductive reactance 40 Ω and a capacitor of capacitive reactance 10 Ω are connected in series with a 220 V a.c. generator.

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

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

(c) Calculate the following.

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