BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE EDUCATION

DEPARTMENT OF MATHEMATICS AND SCIENCE EDUCATION

PHE107: PHYSICS FOR COMPUTER SCIENCE

TIME: 3 HOURS

AUG 2024

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, $\varepsilon_o = 8.85 \times 10^{-12}\ Fm^{-1}$
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

QUESTION 1

(a) Calculate the angle between the vectors $\vec{r} = (2,2,5)$ and $\vec{s} = (-2,-4,1)$. [4]

(b) Distinguish between a dot product and a cross product of vectors? [2]

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

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

(e) An object moves at 5 ms^{-1} around a circular path of radius 15 m. Determine the centripetal force. [3]

(f) Calculate the magnitude of the electric field at a point 2×10^{-7} m from a proton. [3]

(g) A 120 μF capacitor is charged to a p.d. of 10 V. Calculate the charge acquired by the capacitor. [2]

(h) 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 (3) 40 Ω [6]

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

i. Calculate the magnitude of the magnetic force $\vec{F}$ on this particle. [5]

ii. Verify that $\vec{F}$ is centripetal in nature. [3]

(j) What do you understand by inductive reactance? [1]

(k) A resistor of resistance 30Ω is connected in series with an inductor of inductive reactance 15 Ω and a 240 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;

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

Distances are in metres and the time t in seconds.

(i) What is the velocity vector at $t = +5$? [3]

(ii) Evaluate the speed in ms^{-1} at $t = +5$. [3]

(iii) Determine the acceleration vector and its magnitude in ms^{-2} at $t = +5$. [6]

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

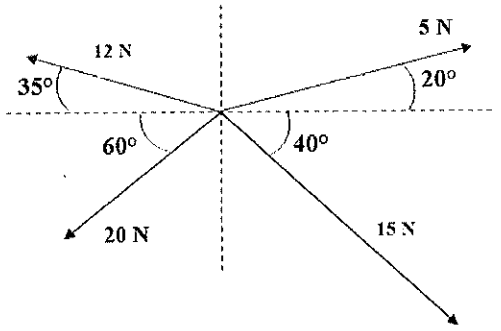

Figure 1

3 Figure 2 shows a system of charges located at the corners of a rectangle in vacuum. It is given that $q_1 = 6.00\times10^{-9}$ C, $q_2 = -2.00\times10^{-9}$ C and $q_3 = 5.00\times10^{-9}$ C.

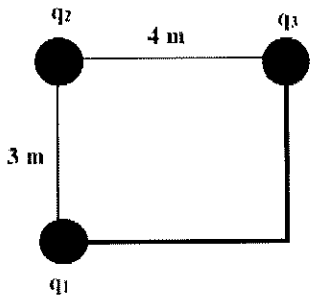

Figure 2

Calculate the electric potential at the corner where there is no charge. [20]

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

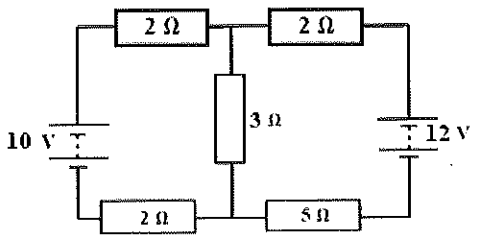

Figure 3

(a) Use Kirchhoff's rules to determine the current passing through the 3 Ω resistor. [18]

(b) Hence calculate the potential difference across the 3 Ω resistor. [2]

5 Figure 4 shows a network of capacitors connected to a 60 *V* battery.

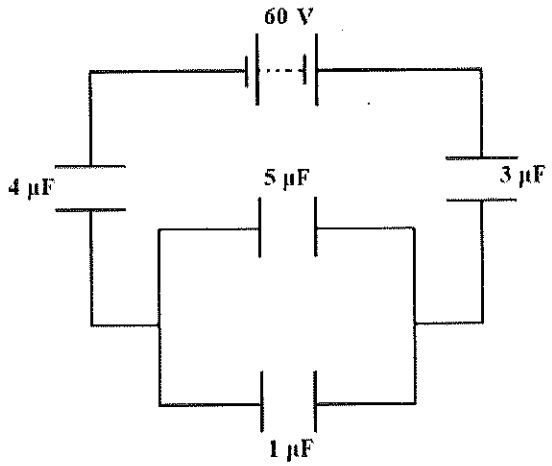

Figure 4

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]

END OF EXAMINATION