**PH 110** **GROUP:** C **ASSIGNMENT:** ONE **DUE DATE:** 16th February 2024

## QUESTION ONE

(i) The radius of a solid sphere is measured to be (6.50 ± 0.20) cm, and its mass is measured to be (3.85 ± 0.02) kg. Determine the density of the sphere in $kg/m^3$ and the uncertainty in the density.

(ii) How many significant figures are in the following numbers? (a) 78.9 ± 0.2 (b) $3.788 \times 10^9$ (c) $2.26 \times 10^{-6}$ (d) 0.0053 (e) 9 500

(iii) Determine the following
(a) 3.41 x 2.2 (b) 0.03 x 0.134 (c) 3.41 + 2.2 (d) 0.03 + 0.123

## QUESTION TWO

(i) The speed of sound $v$ might plausibly depend on the pressure $P$, the density $\rho$ , and the volume $V$ of the gas. Use dimensional analysis to determine the exponents x, y and z in the formula:
$v = Cp^x \rho^y V^z$
where $C$ is a dimensionless constant. Hence write down the relationship between the said quantities based on the derived exponents.

(ii) A Copperbelt University railways engineering student, uses dimensional analysis to find the distance over which a signal can be seen clearly in foggy conditions. The student assumes that the distance $d$ depends on the frequency $f$ of the signal, the density $\rho$ of the fog, and intensity of light $I$ (power/area) from the signal with $k$ as a constant. Show that
$d = k\left(\frac{1}{f}\right)\left(\sqrt[3]{\frac{I}{\rho}}\right)$

## QUESTION THREE

(i) A furlong is 220 yards, a mile is 1760 yards or 1609 meters, and a fortnight is 14 days. In 1991, the Zambian athlete, Samuel Matete won an Olympic gold medal, in Zurich, Switzerland, when he represented Zambia in the 400 m hurdles. His average speed was 8.5 meters per second. Express his speed in

(a) kilometer per minute

(b) mile per hour

(c) furlong per fortnight

(ii) You find yourself pacing, in a deep thought about a physics problem. First you walk 12 meters due east. Then, you walk 6 meters due north. Then you doze off and find yourself 50 meters from your starting point and 30° north of east. How far did you walk while you dozed?

(iii) Find the magnitude and angle of the resultant of the following displacement vectors:

**A** = 5.0 m at E $37^0$ N

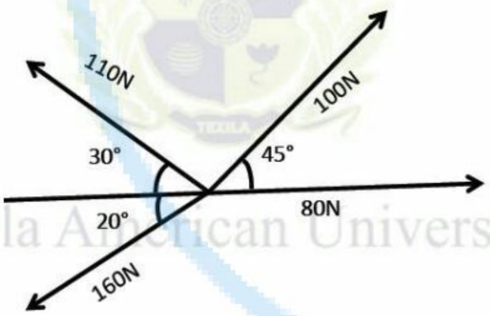
**B** = 6.0 m at W $45^0$ N

**C** = 4.0 m at W $30^0$ S

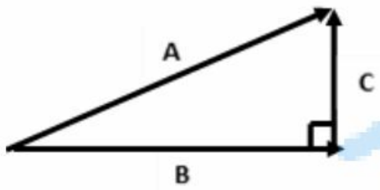
**D** = 3.0 m at E $60^0$ S

**QUESTION FOUR**

(i) Find the magnitude and direction of the resultant of the three vectors below




(ii) In the diagram below are three vectors **A**, **B** and **C**. If $\boldsymbol{A} = 2\hat{\imath} + \hat{\jmath} + 3\hat{k}$ and $\boldsymbol{B} = \hat{\imath} + 2\hat{\jmath} + 5\hat{k}$.




Determine

(i) angle between **A** and **B**
(ii) magnitude of **C**
(iii) vector **C**
(iv) **A.C**
(v) **A X B**

# Assignment

## # Question One

$$\text{Density} = \frac{m}{v} \quad , \text{where } v = \tfrac{4}{3}\pi r^3$$

$$= \frac{m}{\tfrac{4}{3}\pi r^3}$$

$$\cancel{100} \; 6.5\,\cancel{cm} \times \frac{1m}{100\,\cancel{cm}} = 0.065\,m$$

~~Density = 0.00~~

$$\text{Density} = \frac{3.85}{\tfrac{4}{3}\pi (0.065)^3}$$

$$= \frac{3.85}{0.001150}$$

$$\text{Density} = 3346.8\ kg/m^3$$

# Now to find the uncertainity

$$\frac{\Delta D}{D} = \frac{\Delta m}{m} + \frac{\Delta r}{r}$$

$$\frac{\Delta D}{3346.8} = \frac{0.02}{3.85} + \frac{0.2}{6.5}$$

$$\frac{\Delta D}{3346.8} = 0.035964$$

$$\Delta D = 120.36\ kg/m^3$$

∴ Density with its uncertainity

$D = (3546.8 \pm 120.86)\ kg/m^3$

(ii) (a) $78.9 \pm 0.2$ -> 3 s.f

(b) $3.788 \times 10^9$ -> 4 s.f

(c) $2.26 \times 10^{-6}$ -> 3 s.f

(d) 0.0053 -> 2 s.f

(e) 9500 -> 2 s.f

(iii)

(i) # With multiplication & Division round off your answer to the same number of significant figures as the number with the least significant figures used (least precise).

# With (+) and (−) your answer should have the same decimal places as the numbe with the least decimal places used.

(a) $3.41 \times 2.2 = 7.502 = \underline{7.5}$

(b) $0.03 \times 0.134 = 0.00402 = \underline{0.004}$

(c) $3.41 + 2.2 = 5.61 = \underline{5.6}$

d $0.03 + 0.123 = 0.153 = \underline{0.15}$

Questrom 2

$$v = C p^x \rho^y V^z$$

$$LT^{-1} = (ML^{-1}T^{-2})^x (ML^{-3})^y (L^3)^z$$

$$LT^{-1} = M^x L^{-x} T^{-2x} M^y L^{-3y} L^{3z}$$

$$LT^{-1} = M^{x+y} L^{-x-3y+3z} T^{-2x}$$

$$M^0 L T^{-1} = M^{x+y} L^{-x-3y+3z} T^{-2x}$$

| | |
|---|---|
| $T^{-1} = T^{-2x}$ | $M^0 = M^{x+y}$ |
| $-1 = -2x$ | $0 = x+y$ |
| $\frac{-1}{-2} = \frac{-2x}{-2}$ | $x = -y$ |
| | $y = -x$ |
| $x = \frac{1}{2}$ | $y = -\frac{1}{2}$ |

$$L = L^{-x-3y+3z}$$

$$1 = -x - 3y + 3z$$

$$1 = -\frac{1}{2} - 3\left(-\frac{1}{2}\right) + 3z$$

$$1 = -\frac{1}{2} + \frac{3}{2} + 3z$$

$$1 = 1 + 3z$$

$$3z = 0$$

$$z = 0$$

$$v = C P^{x} \rho^{y} V^{z}$$

$$v = C P^{\frac{1}{2}} \rho^{-\frac{1}{2}} V^{0}$$

$$v = C\sqrt{\frac{P}{\rho}}$$

# The equation implies that the velocity does not depend on the volume

$$d \propto f \rho I$$

$$d = k f^{x} \rho^{y} I^{z}$$

$$L = (T^{-1})^{x} (M L^{-3})^{y} (M T^{-3})^{z}$$

$$L = T^{-x} M^{y} L^{-3y} M^{z} T^{-3z}$$

$$L = T^{-x-3z} M^{y+z} L^{-3y}$$

$$M^0 T^0 L = T^{-x-3z} M^{y+z} L^{-3y}$$

$$L = L^{-3y}$$
$$1 = -3y$$
$$y = -\frac{1}{3}$$

$$M^0 = M^{y+z}$$
$$0 = y + z$$
$$-y = z$$
$$z = -\left(-\frac{1}{3}\right)$$
$$z = \frac{1}{3}$$

$$T^0 = T^{-x-3z}$$
$$0 = -x - 3z$$
~~or~~
$$x = -3\left(\frac{1}{3}\right)$$
$$x = -1$$

$$\therefore \quad d = k f^x \rho^y I^z$$
$$d = k f^{-1} \rho^{-\frac{1}{3}} I^{\frac{1}{3}}$$
$$d = k \frac{1}{f} \frac{I^{\frac{1}{3}}}{\rho^{\frac{1}{3}}}$$
$$d = k \frac{1}{f}\left(\sqrt[3]{\frac{I}{\rho}}\right)$$

# Question 3

8. 5 metrs per second

8.5 m/s

(a) $$\frac{8.5\cancel{m}}{\cancel{s}} \times \frac{1km}{1000\cancel{m}} \times \frac{60\cancel{s}}{1min} = \underline{0.51 \ km/min}$$

(b) $$\frac{8.5\cancel{m}}{s} \times \frac{1 \ mile}{1609\cancel{m}} \times \frac{3600\cancel{s}}{1hour} = 19.018 \ mile/hour$$

$$= \underline{19 \ mile/hour}$$

(c) $$\frac{8.5\cancel{m}}{s} \times \frac{1 \ \cancel{mile}}{1609\cancel{m}} * \frac{1760 \ \cancel{yards}}{1 \ \cancel{mile}} \times \frac{1 \ furlong}{220\cancel{yards}} \times \cancel{3600s} = \underline{0.0422[illegible]}$$

$$\frac{0.042262 \ furlong}{s} \times \frac{3600s}{1hour} \times \frac{24 \ hour}{1 \ day} \times \frac{14 \ days}{1 \ fortnight}$$

$$= \underline{51120.45 \ furlong/fortnight}$$

7 data given

$\vec{\Delta} = 50m, 30° NE$

$\vec{A} = 12m$ East $(0°)$

$\vec{B} = 6m$ North $(90°)$

Solution

Here vector $\vec{\Delta}$ is the resultant vector showing the total movement. And the summation of x and y components make a vector that describes the full movent. So the vector required is $\vec{C}$ which we dont know

i.e $\vec{\Delta} = \vec{A} + \vec{B} + \vec{C}$

$$\Delta = \vec{A}_x + \vec{A}_y + \vec{B}_x + \vec{B}_y + \vec{C}_x + \vec{C}_y$$

$$= 12\cos 0°\hat{i} + 12\sin 0°\hat{j} + 6\cos 90°\hat{i} + 6\sin 90°\hat{j} + \vec{C}\cos\theta + C\sin\theta$$

so since $C = C_x + C_y$ we now write

$$C = \vec{\Delta} - (\vec{A} + \vec{B}), \quad \vec{\Delta} = \Delta_x + \Delta_y$$

$$C = (50\cos 30°\hat{i} + 50\sin 30°\hat{j}) - (\vec{A} + \vec{B})$$

$$C = [50\cos 30° - (12\cos 0° + 6\cos 90°)]\hat{i} + \cancel{[50\sin 30° -}$$

$$+ [50\sin 30° - (12\sin 0° + 6\sin 90°)\hat{j}]$$

$$= \cancel{50}.$$

$$= \cancel{43.30127019\hat{i} - 12\hat{i}}$$

$$(43.30127019 - 12)\hat{i} + (25 - 6)\hat{j}$$

$$= 31.30127019\hat{i} + 19\hat{j}$$

$$= 31.3\hat{i} + 19\hat{j}$$

the the magnitude of C will be

$$C = \sqrt{31.30127019^2 + 19^2}$$

$$= 36.61651971m$$

$$= 36.62m$$

and the direction is

$$\tan\theta = \frac{C_y}{C_x}$$

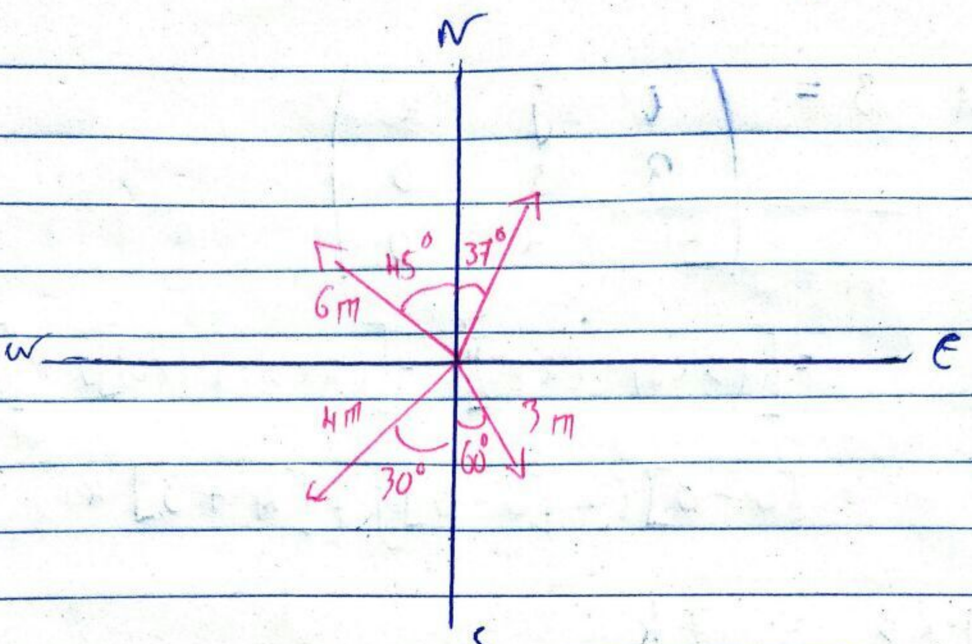
$$= \frac{19m}{31.30127019m}$$

$$\theta = 31.25792331^{\circ}$$

$$= \underline{\underline{31.3^{\circ}}}$$

∴ The distance moved while not paying attention was 36.62m at and angle of 31.3° in the first quadrant.

Q.10




| | x-comp | y-comp |
|---|---|---|
| A | $5\cos 53^\circ$ | $5\sin 53^\circ$ |
| B | $6\cos 135^\circ$ | $6\sin 135^\circ$ |
| C | $4\cos 240^\circ$ | $4\sin 240^\circ$ |
| D | $3\cos 330^\circ$ | $3\sin 330^\circ$ |
| R | $-0.642$ | $3.27$ |

$$|R| = \sqrt{x^2 + y^2}$$

$$= \sqrt{(-0.642)^2 + (3.27)^2}$$

$$\underline{|R| = 3.33\,m}$$

$$\theta = \tan^{-1}\left(\frac{y}{x}\right)$$

$$\theta = \tan^{-1}\left(\frac{3.27}{0.642}\right)$$

$$\theta = 78.9^\circ$$

$$\theta = 180 - 78.9^\circ$$

$$\underline{\theta = 101.1^\circ}$$

# Question 4

# Component Method

| | x-comp | y-comp |
|---|---|---|
| A | $80 \cos 0^\circ$ | $80 \sin 0^\circ$ |
| B | $100 \cos 45^\circ$ | $100 \sin 45^\circ$ |
| C | $110 \cos 150^\circ$ | $110 \sin 150^\circ$ |
| D | $160 \cos 200$ | $160 \sin 200$ |
| R | $-94.9029$ | $70.987$ |

$$|R| = \sqrt{x^2 + y^2}$$

$$= \sqrt{(94.9029)^2 + (70.987)^2}$$

$$= \sqrt{14045.714}$$

$$|R| = 118.5\,N$$

$$\theta = \tan^{-1}\left(\frac{y}{x}\right)$$

$$\theta = \tan^{-1}\left(\frac{70.987}{94.9029}\right)$$

$$\theta = 36^\circ$$

$$\theta = 180^\circ - 36^\circ$$

$$\theta = 144^\circ$$

$\therefore$ The resultant vector of magnitude 118.5N lies in the direction $144^\circ$ from the (+) x-axis.

Question Four

(ii) $A = 2i + j + 3k \qquad B = i + 2j + 5k$

$$Q = \cos^{-1}\left(\frac{A \cdot B}{|A|\,|B|}\right)$$

$A \cdot B = (2i + j + 3k) \cdot (i + 2j + 5k)$

$= 2 + 2 + 15$

$A \cdot B = 19$

$|A| = \sqrt{(2)^2 + (1)^2 + (3)^2}$

$|A| = \sqrt{14}$

$|B| = \sqrt{(1)^2 + (2)^2 + (5)^2}$

$|B| = \sqrt{30}$

$$\therefore\ Q = \cos^{-1}\left(\frac{A \cdot B}{|A|\,|B|}\right)$$

$$Q = \cos^{-1}\left(\frac{19}{\sqrt{14} \cdot \sqrt{30}}\right)$$

$Q = 22^0$

(ii) # To find magnitude of C we just use ba pythagoras

$$C^2 = B^2 - A^2$$

where $A = |A| = \sqrt{14}$

$B = |B| = \sqrt{30}$

$$C^2 = (\sqrt{30})^2 - (\sqrt{14})^2$$

$$C^2 = 30 - 14$$

$$C = \sqrt{16}$$

$$C = 4 \text{ units}$$

(iii) Since vector C is going perpendicularly upwards the it makes $90^\circ$ with both the $x$ and $y$ axis and $0^\circ$ with the $z$-axis

$\cos\alpha = \frac{i}{|c|}$ $\cos\beta = \frac{j}{|c|}$ $\cos\gamma = \frac{k}{|c|}$

$\overline{\cos 90^\circ} = \frac{i}{4}$ $\overline{\cos 90^\circ} = \frac{j}{4}$ $\overline{\cos 0^\circ} = \frac{z}{4}$

$i = 0$ $j = 0$ $z = 4$

$\therefore 0i + 0j + 4k$

$C = 4k$

(iv) $A.C = (2i + j + 3k)(4k)$

$= \underline{12}$

(v) $A \times B = \begin{pmatrix} i & j & K \\ 2 & 1 & 3 \\ 1 & 2 & 5 \end{pmatrix}$

$= [(1\times5) - (2\times3)]i - [(2\times5) - (1\times3)]j + [(2\times2) - (1\times1)]k$

$= [5 - 6]i - [10 - 3]j + [4 - 1]k$

$A \times B \; -i - 7j + 3k$