

- 7 Points $A(2, 2, 5)$, $B(1, -1, -4)$, $C(3, 3, 10)$ and $D(8, 6, 3)$ are the vertices of a pyramid with a triangular base.

$$\vec{OA} = \begin{pmatrix} 2 \\ 2 \\ 5 \end{pmatrix} \quad \vec{OB} = \begin{pmatrix} 1 \\ -1 \\ -4 \end{pmatrix} \quad \vec{OC} = \begin{pmatrix} 3 \\ 3 \\ 10 \end{pmatrix}$$

- (i) Calculate the lengths AB and AC , and the angle BAC . [4]

- (ii) Show that $\vec{AD}$ is perpendicular to both $\vec{AB}$ and $\vec{AC}$. [3]

- (iii) Calculate the volume of the pyramid $ABCD$. [3]

[The volume of the pyramid is $V = \frac{1}{3} \times \text{base area} \times \text{perpendicular height}$]

$$i) \quad \vec{AB} = \vec{OB} - \vec{OA} = \begin{pmatrix} -1 \\ -3 \\ -9 \end{pmatrix} \quad \text{So then } AB = \sqrt{1^2 + 3^2 + 9^2} = \sqrt{91}$$

$$\vec{AC} = \vec{OC} - \vec{OA} = \begin{pmatrix} 1 \\ 1 \\ 5 \end{pmatrix} \quad \text{So then } AC = \sqrt{1^2 + 1^2 + 5^2} = \sqrt{27} = 3\sqrt{3}$$

$$\vec{AB} \cdot \vec{AC} = (-1) \times 1 + (-3) \times 1 + (-9) \times 5 = -47$$

$$\vec{AB} \cdot \vec{AD} = (-1) \times (-2) + (-3) \times (-2) + (-9) \times (-5) = 47$$

$$\cos \theta = \frac{\vec{AB} \cdot \vec{AC}}{AB \cdot AC} = \frac{-47}{\sqrt{91} \cdot 3\sqrt{3}}$$

$$\theta = 171^\circ$$

ii)



$$\text{Area} = \frac{1}{2} \times \sqrt{91} \times 3\sqrt{3} = 3\sqrt{273}$$

$$\text{Vol} = \frac{1}{3} \times 3\sqrt{273} \times h = 9 \times 3.3$$

$$h = \sqrt{6^2 + 6^2 + 2^2} = \sqrt{56} = 2\sqrt{14}$$

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**Janet Crawshaw, Keith Gordon, Kathryn
Scott**

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