**Question 1. [10]:**

**(a)** Determine the shortest distance from the point $(3, 7, -5)$ to the $x$-axis.

[2]

**(b)** Determine if the following points all lie on the same line: $P_1(0, -5, 5)$, $P_2(1, -2, 4)$, $P_3(3, 4, 2)$ .

[3]

**(c)** Find an equation of the largest sphere with centre $(5, 4, 9)$ that is completely contained in the first octant. (The first octant is the region of $\mathbb{R}^3$ with $x \geq 0$, $y \geq 0$ and $z \geq 0$.)

[2]

**(d)** Write an equation which represents the set of all points $(x, y, z)$ which are equidistant from $(0, 0, 2)$ and the $xy$-plane.

[3]

**Question 2. [10]:**
For this question use the vectors

$$\mathbf{a} = \mathbf{i} + \mathbf{j} - 2\mathbf{k}, \qquad \mathbf{b} = 3\mathbf{i} - 2\mathbf{j} + \mathbf{k}, \qquad \mathbf{c} = \mathbf{j} - 5\mathbf{k}$$

**(a)** Are vectors **a** and **b** orthogonal?

[2]

**(b)** Find a vector of length 4 that is orthogonal to both **a** and **b**.
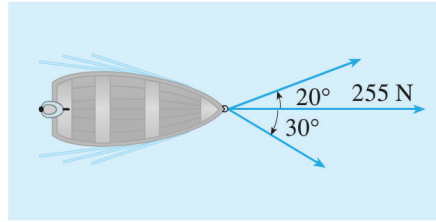
[3]

**(c)** Do **a**, **b** and **c** all lie in the same plane?

[2]

**(d)** Place the tail of each vector at $(0, 0, 0)$ and consider the triangle formed by the three terminal points. What is the area of this triangle?

[3]

$$\mathbf{a} = \mathbf{i} + \mathbf{j} - 2\mathbf{k}, \qquad \mathbf{b} = 3\mathbf{i} - 2\mathbf{j} + \mathbf{k}, \qquad \mathbf{c} = \mathbf{j} - 5\mathbf{k}$$

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**Question 3. [10]:** A boat is pulled into shore using two ropes, as shown in the figure below. If a force of 255 N is needed, find the magnitude of the force in each rope.

**Question 4. [10]:**

**(a)** Find the (i) vector, (ii) parametric and (iii) symmetric equations of the line through the points $P_1(3, -1, 1)$ and $P_2(4, 0, 2)$

**[4]**

**(b)** Find an equation of the line through $(1, 0, -1)$ that is parallel to the line $\dfrac{x - 4}{3} = \dfrac{y}{2} = z + 2$ .

**[4]**

**(c)** Determine the point at which the line $x = 2 - t$, $y = 1 + 3t$, $z = 4t$ intersects the $xz$-plane.

**[2]**

**Question 5 [10]:**

**(a)** Express the vector $\langle 2, -1, 2 \rangle$ as the sum of a vector that is orthogonal to $\mathbf{a} = \langle 1, 1, 1 \rangle$ and one that parallel to $\mathbf{a}$.

[5]

**(b)** Find the angle between a diagonal of a cube and one of its edges.

[5]