



STEM SMART Single Maths 4 - Vectors

Manipulating Vectors in 2D

Pre-Uni Maths for Sciences I1.2

Subject & topics: Maths | Geometry | Vectors

Stage & difficulty: A Level P1

Two vectors \underline{p} and \underline{q} are given by $\underline{p} = \begin{pmatrix} 4 \\ 3 \end{pmatrix}$ and $\underline{q} = \begin{pmatrix} 2 \\ -1 \end{pmatrix}$.

Part A

Magnitude of \underline{p}

Find the magnitude of \underline{p} .

Part B

Magnitude of \underline{q}

Find the magnitude of \underline{q} . Give your answer to 3 sf.

Part C

Angle of \underline{p}

Find the angle that \underline{p} makes with the x -axis. Give your answer to 3 sf.

Part D

$\underline{p} + \underline{q}$

Find the vector $\underline{p} + \underline{q}$ in column vector form and give its magnitude. Give your answer to 3 sf.

Part E

$\underline{p} - \underline{q}$

Find the column vector form of $\underline{p} - \underline{q}$ and give the angle this vector makes with the x -axis. Give your answer to 3 sf.



Vectors: Positions and Problems 1ii

Subject & topics: Maths Stage & difficulty: A Level P1

It is given that $\underline{a} = 3\underline{i} + 4\underline{j}$, $\underline{b} = -5\underline{i} + 2\underline{j}$, $\underline{c} = 7\underline{i} - 3\underline{j}$ and $\underline{d} = 3\underline{a} - 2\underline{b} + \underline{c}$.

Part A
Vector \underline{d}

Write down vector \underline{d} in terms of \underline{i} and \underline{j} .

$\underline{d} =$ $\underline{i} +$ \underline{j}

Part B
Magnitude of \underline{d}

Find the magnitude of \underline{d} . Give your answer to 3 significant figures.

Part C
Direction of \underline{d}

Find the direction of vector \underline{d} , relative to \underline{i} . If the direction is anticlockwise from \underline{i} give a positive angle, if it is clockwise from \underline{i} give a negative angle. Give your answer in degrees to 3 significant figures.

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Vectors: Positions and Problems 3ii

Subject & topics: Maths **Stage & difficulty:** A Level P1

These questions will help you practise vector additions.

Part A**Finding the resultant**

Find the resultant of $\begin{pmatrix} 8 \\ -1 \end{pmatrix}$ and $\begin{pmatrix} -2 \\ -5 \end{pmatrix}$.

What is the magnitude of the resultant? Give your answer in surd form.

Part B**Direction of the resultant**

What angle does the resultant make with the x -axis? If it is anticlockwise from the axis, give it as a positive angle, if it is clockwise, give it as a negative angle.

Part C

Vector sum 1

You are given that $\underline{p} + \underline{q} = \begin{pmatrix} -1 \\ 3 \end{pmatrix}$.

Write the following as a single column vector:

$$\left[\begin{pmatrix} 3 \\ 7 \end{pmatrix} + \underline{p} \right] + \underline{q}$$

What is its magnitude? Give your answer in an exact form.

Part D

Vector sum 2

As before, taking $\underline{p} + \underline{q} = \begin{pmatrix} -1 \\ 3 \end{pmatrix}$, find the resultant as a column vector to

$$-4(\underline{q} + \underline{p}).$$

What is its magnitude?

Adapted from UCLES, OCR GCSE Maths, A502/02, June 2015, question 12

Question deck:

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Position of Boat

Pre-Uni Maths for Sciences I1.1

Subject & topics: Maths | Geometry | Vectors **Stage & difficulty:** GCSE P2, A Level P1

A boat sails 4.00 km at a bearing of 210°.

Part A

Displacement south

Find how far south of its starting point its final position is.

Part B

Displacement west

Find how far west of its starting point its final position is.

Created for isaacphysics.org by Julia Riley.

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Vectors: Positions and Problems 2ii

Subject & topics: Maths **Stage & difficulty:** A Level P1

Figure 1 shows a ship **S** being pulled by two tug-boats.

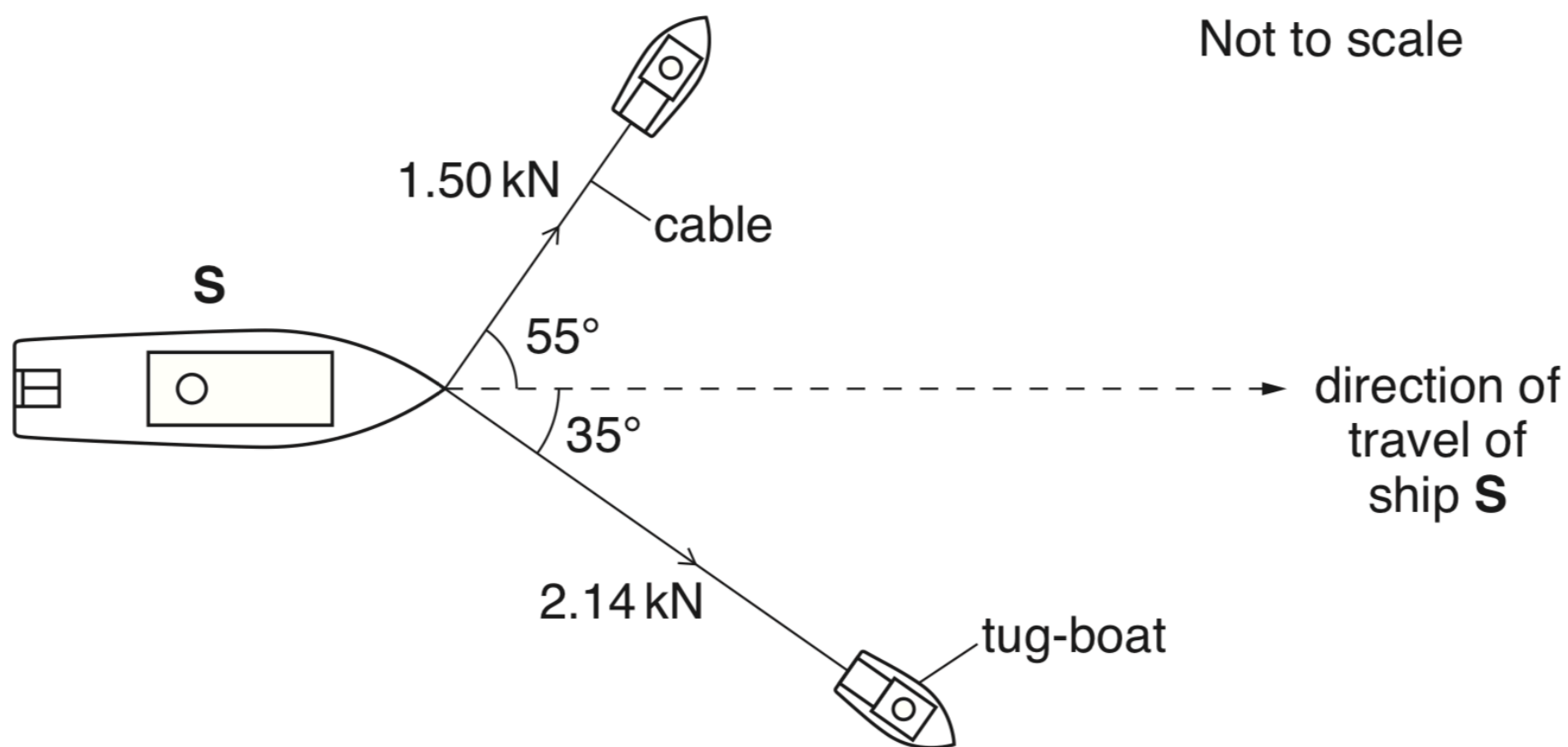


Figure 1: The ship **S** is being pulled by two tug-boats.

The ship is travelling at a constant velocity. The tensions in the cables and the angles made by these cables to the direction in which the ship travels are shown in **Figure 1**.

Part A

Vector triangle

Draw a vector triangle of the forces on the boat due to the tug-boats. What angle does the resultant force make to the direction of travel of the ship?

Part B

Magnitude of the resultant force

Determine the magnitude of the resultant force provided by the two cables. Give your answer to 3 significant figures.

Part C

Drag force on the ship

State the magnitude of the drag force acting on the ship, correct to 3 significant figures.

Part D

Direction of drag force

What is the direction of the drag force and explain your answer?

- ☐ It is in the same direction as the resultant force due to the tug boats.
- ☐ It is in the same direction as the top tug-boat.
- ☐ It is in the opposite direction as the top tug-boat.
- ☐ It is in the opposite direction to the bottom tug-boat.
- ☐ It is in the same direction as the bottom tug-boat.
- ☐ It is directly opposite to the resultant force due to the tug boats.

Modified with permission from UCLES, A-level, June 2010, OCR Physics A, Question 4 part C.



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Vectors: Position, Distance and Problems 1i

Subject & topics: Maths

Stage & difficulty: A Level P1

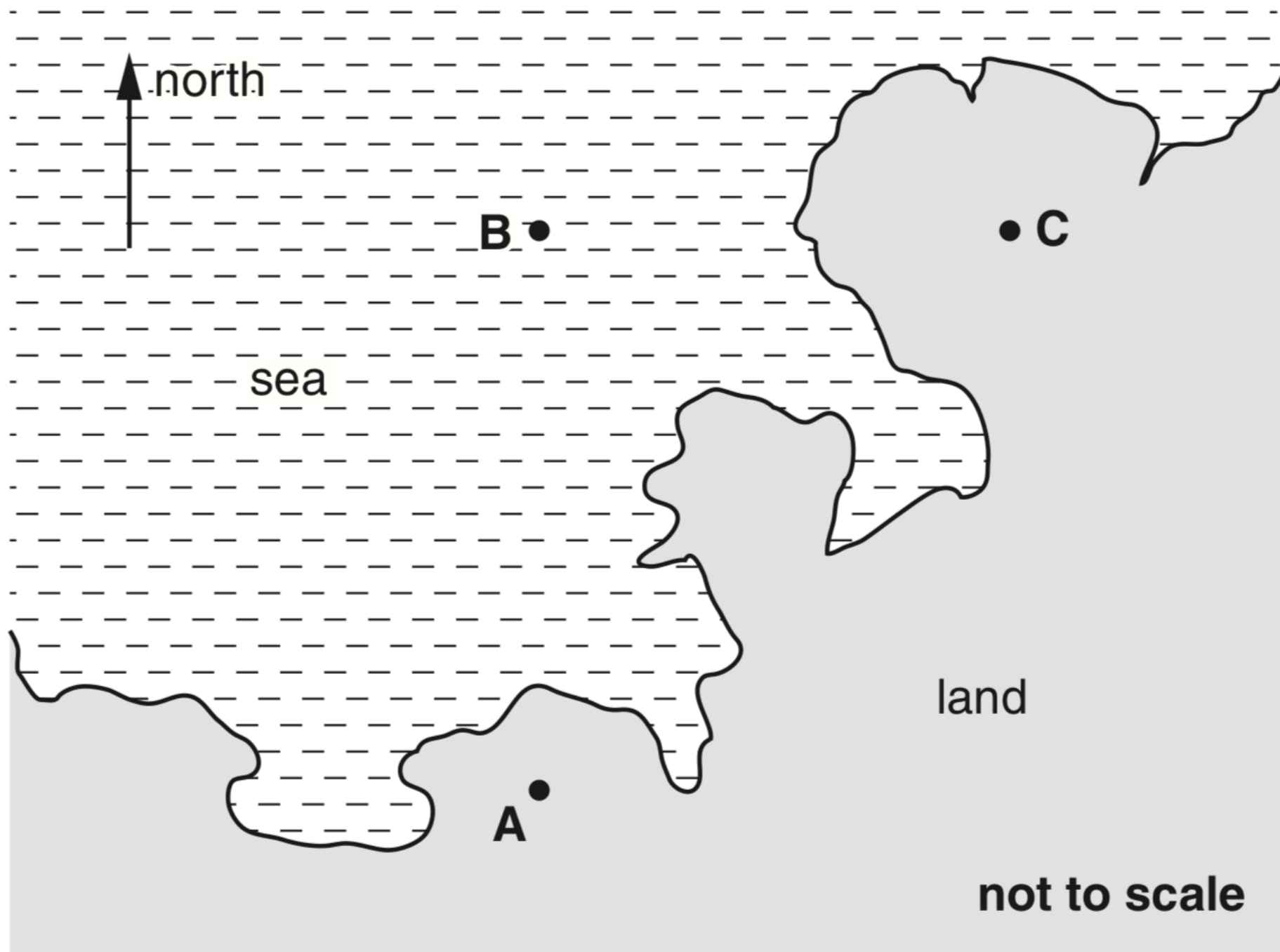


Figure 1: Map of a coastline showing A and C on land, and B in the sea.

An aircraft flies due north from A for a distance of 360 km (3.6×10^5 m) to point B. Its average speed between A and B is 170 m s^{-1} . At B the aircraft is forced to change course and flies due east for a distance of 100 km to arrive at C.

Part A

Journey time

Calculate the time of the journey from A to B.

Part B

A vector triangle

Draw a labelled displacement triangle to represent the aircraft's journey.

Which of the diagrams below is correct?

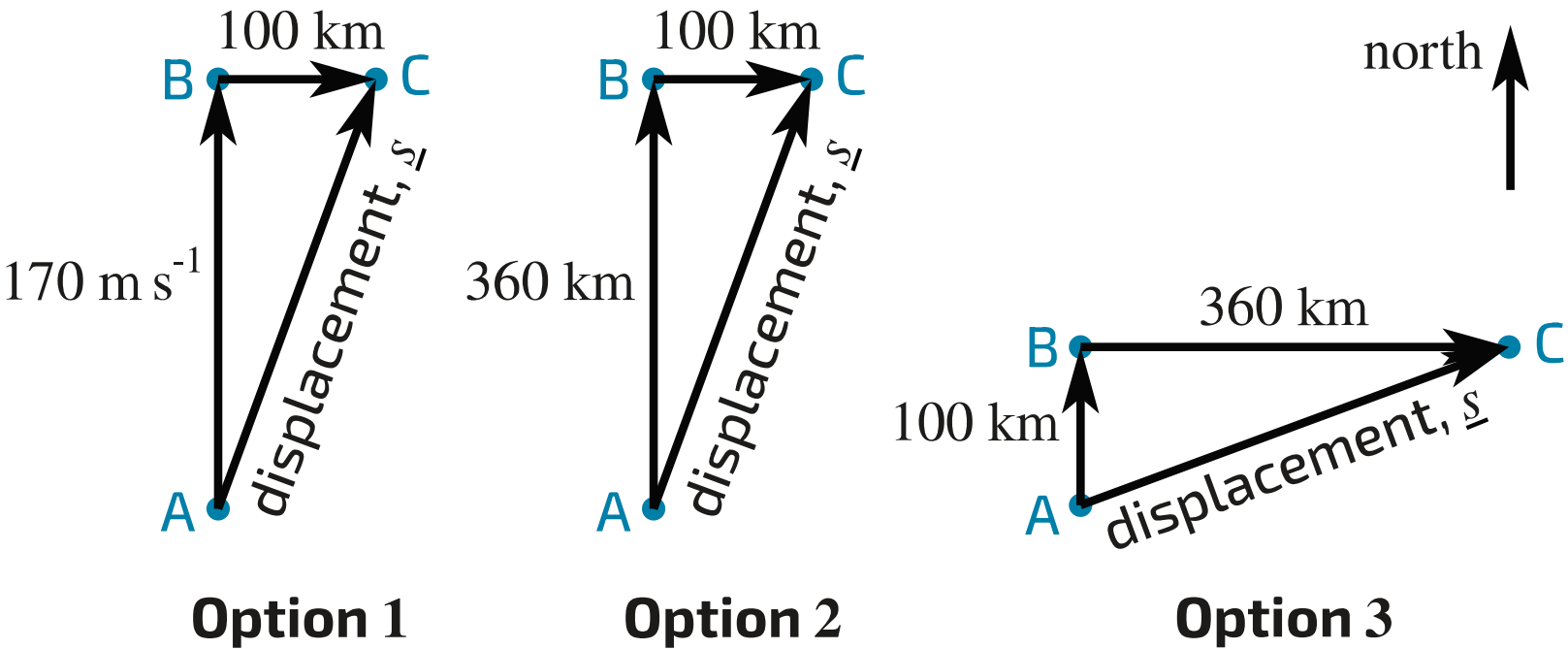


Figure 2: Possible displacement vector diagrams for the aeroplane as it travels from A to B to C.

- ☐ Option 1
- ☐ Option 2
- ☐ Option 3

Part C

Distance A to C

Use the displacement triangle to determine the magnitude of the displacement in km of the aircraft at C from A.

Part D

Bearing

Find the bearing of C from A. Give your answer in degrees.

Modified with permission from UCLES, OCR Physics A, June 2009, Question 1 part B.

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Vectors: Position, Distance and Problems 2i

Subject & topics: Maths **Stage & difficulty:** A Level P1

A man drives his friend to a station, **A**, to catch a train. When the man and his friend arrive at station **A**, the train is ready to leave and the friend cannot catch the train.

The man knows the train goes to another station **D** on a journey which can be modelled as a straight line. The train travels at an average speed of 30 mph and arrives at station **D** 22 minutes after leaving station **A**.

The man knows a road route from station **A** to station **D** that can be modelled as three straight roads, going via road junctions, **B** and **C**, such that

$$\overrightarrow{AB} = 4\mathbf{i} + 3\mathbf{j} \quad \overrightarrow{BC} = 2\mathbf{j}, \quad \overrightarrow{CD} = -4\mathbf{i} + 6\mathbf{j}$$

where the numbers are distances in miles.

The man can drive with an average road speed of 45 mph. Can the man drive his friend from station **A** to station **D** in time for his friend to catch the train from station **D**? Show clearly how you arrive at your answer.

How many minutes spare does the friend have or by how many minutes has he missed it by? If he missed the train, give a negative number of minutes.

Written for Isaac Physics by Sally Waugh

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Ferry and Current

Subject & topics: Maths | Geometry | Vectors **Stage & difficulty:** A Level P2, Further A P1

A ferry is to cross the Sound of Islay from Port Askaig on Islay to Feolin on Jura which is 0.950 km due east of Port Askaig. The tidal current in the Sound of Islay is strong and the water is flowing at 3.50 m s^{-1} in a northerly direction. The ferry travels at a speed of 5.00 m s^{-1} relative to the water.

Part A

Which direction?

In what direction should the ferry set out? Give your answer as a bearing.

Part B

How long to cross

How long, in seconds, will the ferry take to make the crossing?



Vectors: Position, Distance and Problems 3i

Subject & topics: Maths Stage & difficulty: A Level P1

Four points A, B, C and D are such that $\overrightarrow{AB} = \begin{pmatrix} 5 \\ 3 \end{pmatrix}$, $\overrightarrow{BC} = \begin{pmatrix} 4 \\ -2 \end{pmatrix}$ and $\overrightarrow{CD} = \begin{pmatrix} m \\ m \end{pmatrix}$. \overrightarrow{AD} is parallel to the x -axis.

Part A
Vector \overrightarrow{AD}

Find the vector \overrightarrow{AD} .

Give the x component of \overrightarrow{AD} :

Give the y component of \overrightarrow{AD} :

Part B
Magnitude of \overrightarrow{BC}

What is the magnitude of vector \overrightarrow{BC} ?

Part C

Direction of \overrightarrow{BC}

Find the direction of the vector \overrightarrow{BC} relative to the x -axis. If vector is above the x -axis, give a positive angle, if it is below the x -axis, give a negative angle. This corresponds to anticlockwise being positive.

Modified with permission from UCLES, OCR GCSE Maths A, A502/02, November 2011, question 12.

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The Harbour Entrance

Subject & topics: Physics | Mechanics | Kinematics **Stage & difficulty:** A Level C3

The entrance to a harbour is a channel of length a which runs between two sandbanks a distance b apart. The banks and the channel can be assumed to be rectangular. On this particular day, there is a current of constant speed v flowing from one sandbank to the other. A yacht travelling at a constant speed relative to the water of u wants to enter the harbour.

Find the least value of u needed for the yacht to safely enter the harbour.

The following symbols may be useful: a , b , u , v

Used with permission from UCLES, A Level Further Maths, Syllabus C, June 1989, Special Paper, Question 7.
