IB · DP · Physics

3 hours 15 questions

Structured Questions

1.3 Vectors & Scalars

1.3.1 Vector & Scalar Quantities / 1.3.2 Combining & Resolving Vectors / 1.3.3 Solving Vector Problems

Easy (5 questions)	/46
Medium (5 questions)	/54
Hard (5 questions)	/53
Total Marks	**/153**

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Easy Questions

1 (a) State the definition of a vector quantity.

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(2 marks)

(b) A list of vector quantities and their SI unit is given.

Quantity	SI unit
Acceleration	
	K
Mass	

Complete the information missing from the table.

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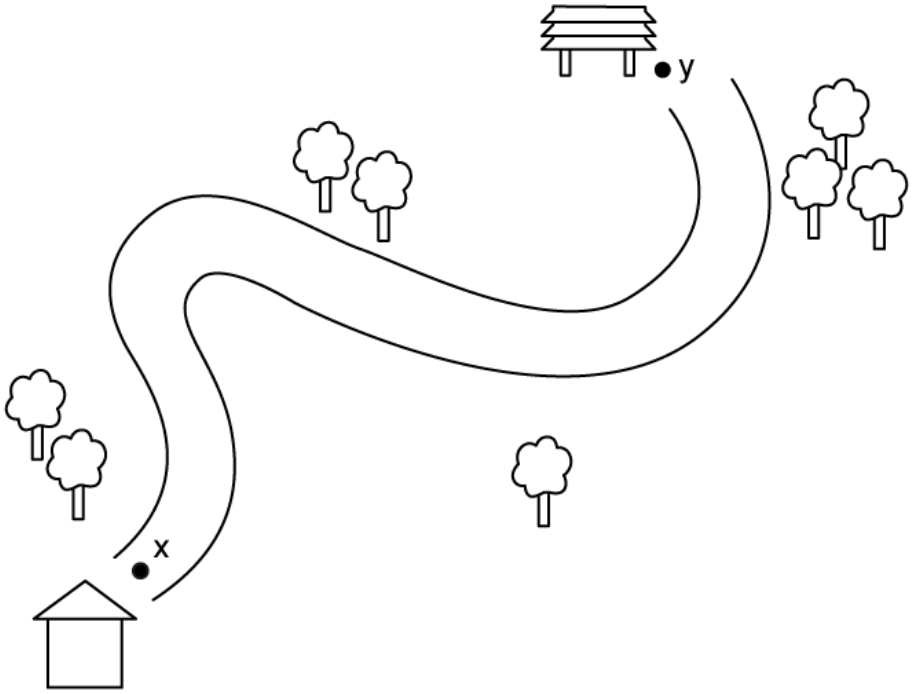
(3 marks)

(c) Lindsay cycles along a path every day, from her front garden at X to a bench by the nearby lake at Y.



(i) Sketch a line on the image that would indicate the distance travelled by Lindsay between X and Y. Label this distance *d*.

[2]

(ii) State whether the distance travelled *d* by Lindsay is greater than, equal to, or less than her displacement between X and Y.

[1]

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(3 marks)

(d) Lindsay cycles along the same path back home, from Y to X. The total distance logged by her smartwatch is 2.4 km. State and explain what the total displacement for her journey is.

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(2 marks)

2 (a) Describe what happens to the magnitude of a vector when it is

(i) multiplied by an integer greater than 1.

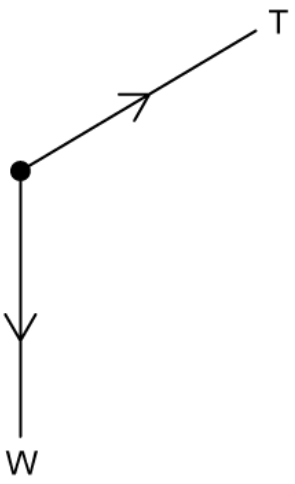
[1]

(ii) multiplied by a negative number.

[1]

(2 marks)

(b) An incomplete free body force diagram for a painting hanging by special wires in equilibrium is shown.



Three forces act on the painting.

(i) Complete the free body force diagram by sketching the additional force vector required for equilibrium.

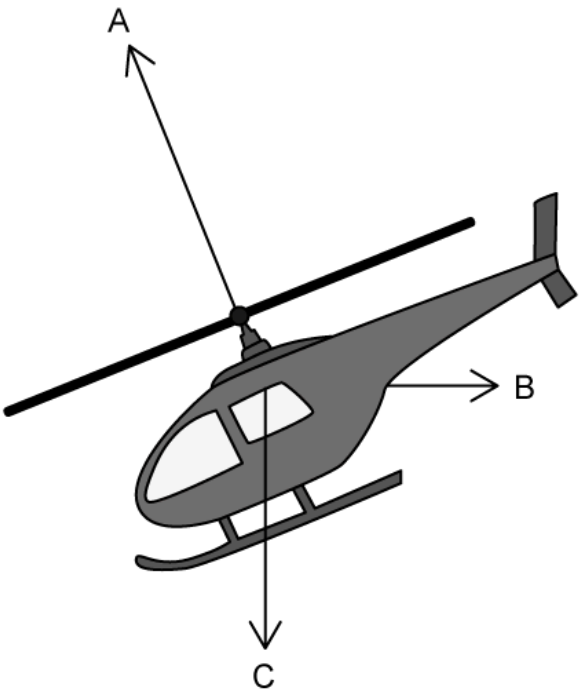
[2]

(ii) State the name of the force you have drawn.

[1]

(3 marks)

(c) A helicopter is moving horizontally through the air. Three forces act on the helicopter, A, B and C.



State the name of each of the three forces A, B and C.

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(3 marks)

(d) State and explain the direction of horizontal motion for the helicopter shown in part (c).

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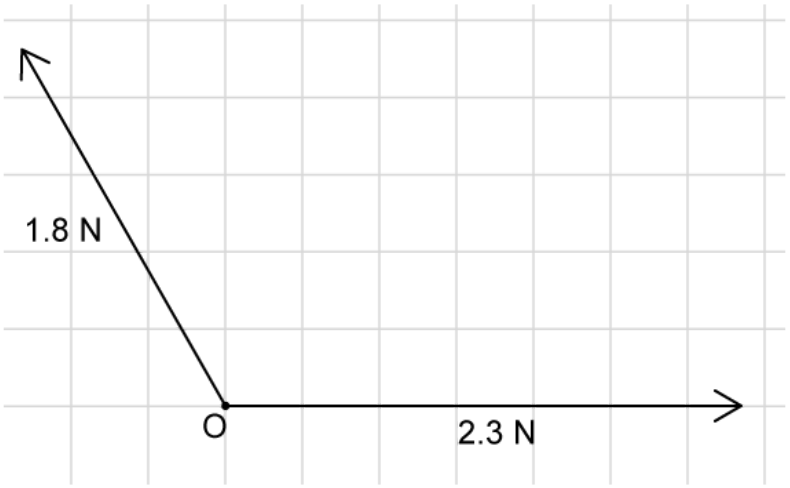
(2 marks)

3 (a) Two vectors act on an object at O. The length of each square on the grid is 1 cm.



Determine the scale used to draw the diagram, including an appropriate unit.

(3 marks)

(b) Complete the scale drawing by drawing an appropriate parallelogram on the grid in part (a) to show the resultant force on the object at O.

(2 marks)

(c) Hence, by measuring the resultant vector drawn in part (b), determine the amount of force it represents.

(2 marks)

(d) The 1.8 N force now acts vertically upwards, such that the two forces acting on the object at O are perpendicular. Calculate the magnitude of the new resultant force acting on the object at O.

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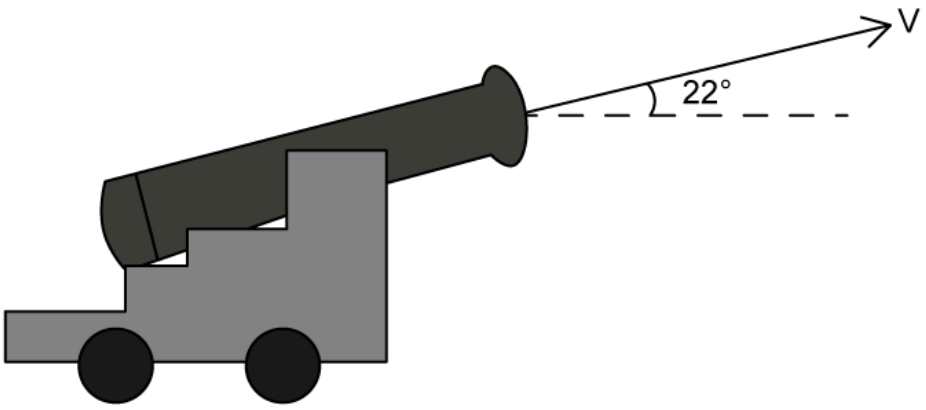
(2 marks)

4 (a) A small cannon is designed to fire projectiles at an angle of 22° to the horizontal with an initial velocity *v*.



Calculate the vertical component of velocity if its initial velocity $v = 10\ m\ s^{-1}$.

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(2 marks)

(b) State the direction of the horizontal component of velocity.

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(1 mark)

(c) State and explain why the horizontal component of velocity stays constant in the absence of air resistance.

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(2 marks)

(d) The vertical component of the projectile's velocity decreases to zero.

(i) State the point along the projectile's journey at which its vertical component of velocity is zero.

[1]

(ii) Explain why the projectile's vertical component of velocity decreases to zero.

[2]

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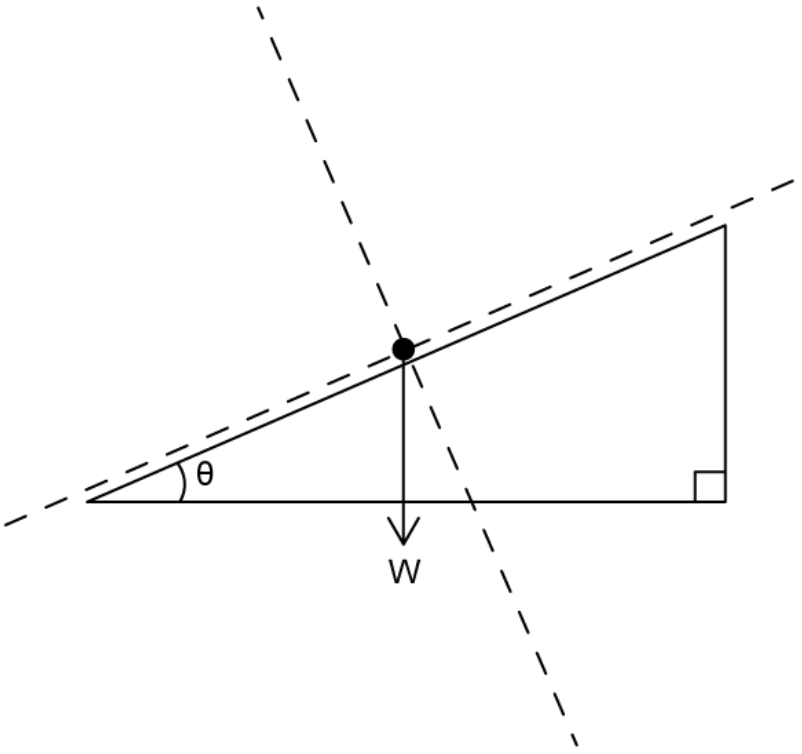
(3 marks)

5 (a) An object of weight *W* is at rest on an inclined plane.



Using an appropriate parallelogram, draw the components of the weight *W* along the axes shown.

(3 marks)

(b) Write an expression for the magnitude of the component of weight acting parallel to the slope.

(1 mark)

(c) Draw the normal reaction force on the object in part (a) and label it *R*.

(2 marks)

(d) Identify the third force acting on the object and describe its direction with respect to the slope.

(3 marks)

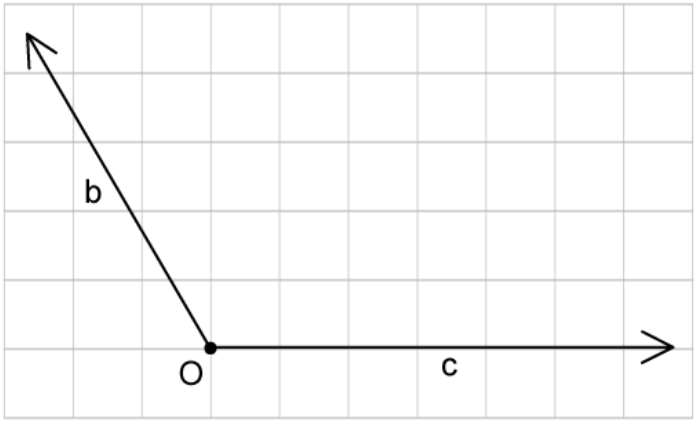
Medium Questions

1 (a) Complete the table by stating whether the quantity is a vector or a scalar and by giving the full name of its unit.

Quantity	Vector or Scalar	Unit
Momentum		
Weight		
Kinetic Energy		
Power		

(4 marks)

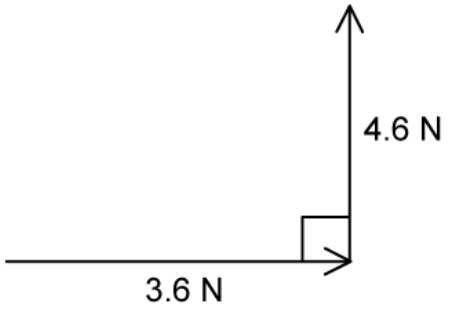
(b) The diagram shows two forces ***b*** and ***c*** acting on an object at **O**.



Draw a force triangle diagram to show the resultant force and state the value of this resultant force in terms of ***b*** and ***c***

(3 marks)

(c) The diagram shows two different forces with magnitudes 4.6 N and 3.6 N perpendicular to each other acting on an object.



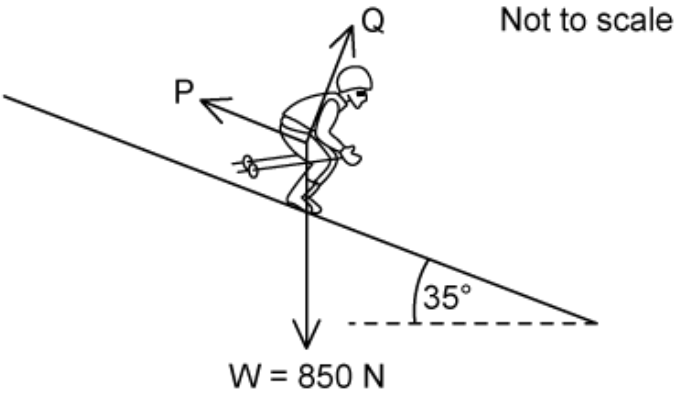
Calculate the magnitude of this resultant force.

(2 marks)

(d) Calculate the angle to the horizontal at which the resultant force acts.

(2 marks)

2 (a) The diagram shows a skier travelling at constant speed down a slope of 35°



The force labelled **P** is parallel to the slope. The force labelled **Q** is perpendicular to the slope. Assume that there is no friction between the skis and the snow.

Draw the force triangle and identify the forces labelled **P** and **Q**.

(4 marks)

(b) Calculate the magnitude of force **Q**.

(2 marks)

(c) Calculate the magnitude of the force **P**.

(2 marks)

(d) Draw a new force diagram and calculate the new resultant force down the slope on the skier.

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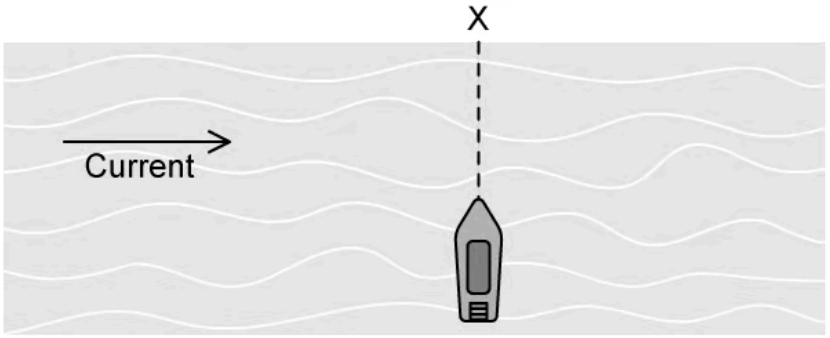
(2 marks)

3 (a) A man wants to cross a river in a motorboat. The speed of the motorboat in still water is 7.0 ms^{-1}. The river is 32 m wide. There is a current in the river whose speed with respect to the shore is 5.0 ms^{-1}.



Draw a vector triangle to show the velocities of the motorboat in still water, the current and the resultant velocity of the motorboat.

(2 marks)

(b) Calculate the resultant speed of the motorboat.

(2 marks)

(c) The man aims his boat at point X.

Determine the distance from X further down the river at which he reaches the shore.

(2 marks)

(d) A woman in an identical boat leaves from the same spot as the man but wants to land at point X.

Determine the direction in which she must turn her boat to do this.

(4 marks)

4 (a) A cyclist cycles 15.0 km due east, followed by 23.0 km due north and then another 7.0 km east.

Draw a vector diagram to represent the cyclist's journey.

(3 marks)

(b) Calculate the resultant displacement travelled by the cyclist:

(3 marks)

(c) Calculate the angle from where the cyclist started to due north of the cyclist final destination.

(3 marks)

(d) The cyclist wants to return home.

What angle clockwise from north must he take to go home directly?

(3 marks)

5 (a) State whether impulse is a scalar or vector quantity and explain why.

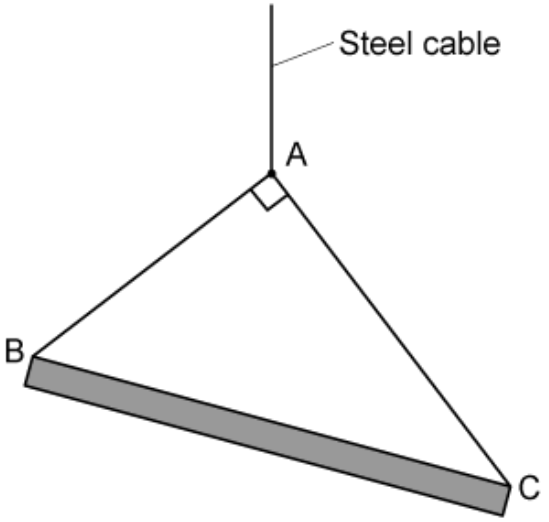
(3 marks)

(b) Electric charge can either be stated positive or negative.

State whether electric charge is a scalar or vector quantity and explain why.

(3 marks)

(c) The diagram shows a uniform beam supported by two light cables, **AB** and **AC**, which are attached to a single steel cable from a crane. The beam is stationary and in equilibrium.



Draw the vector triangle for this situation labelling the tension in both cables and the weight of the beam.

(3 marks)

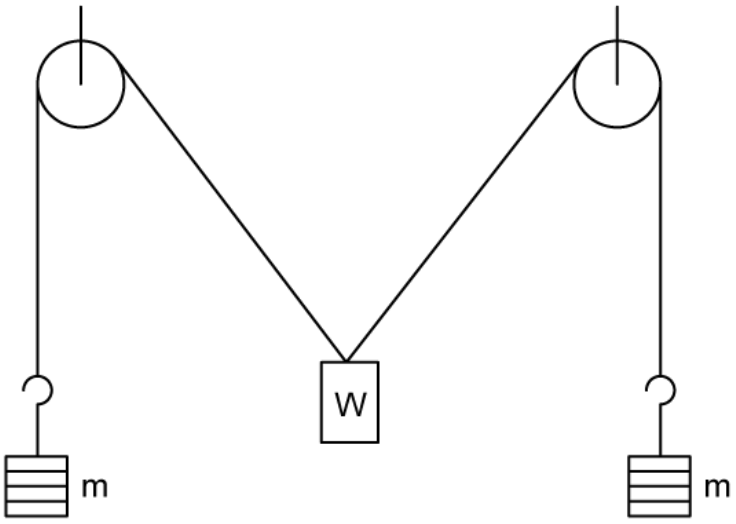
(d) The tension in the cable **AB** is 9 N and the tension in the cable **AC** is 12 N.

Calculate the resultant force required in the beam **BC** to keep the system in equilibrium.

(2 marks)

Hard Questions

1 (a) A load *W* is supported by two strings kept in tension by equal masses *m* hung from their free ends, with each string passing over a smooth pulley.



Draw a free body force diagram for the load *W*, expressing tensional forces in terms of each mass *m*.

(2 marks)

(b) The mass of the load *W* is *M*.

Determine an expression for

(i) *m* in terms of *W*, *g* and the angle to the vertical θ

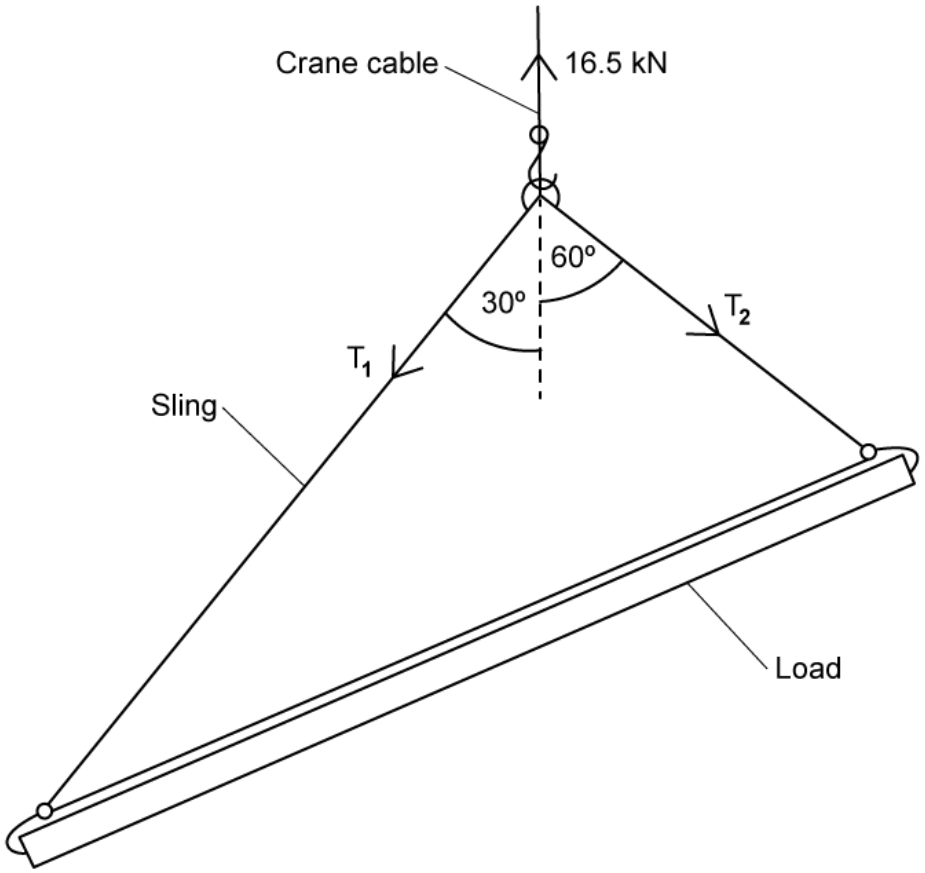
[2]

(ii) *M* in terms of *m* and the angle to the vertical θ.

[1]

(3 marks)

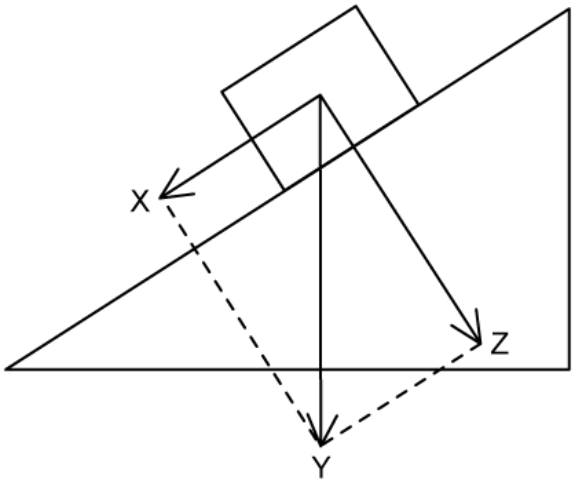
(c) A crane hook is held in equilibrium by three forces of magnitude 16.5 kN, T_1 and T_2.



Construct a diagram, including an appropriate scale, to determine the magnitude of T_1 and T_2.

(4 marks)

(d) A crate rests on an inclined plane.



Explain the effects on vectors X, Y and Z if the angle of inclination increases.

(3 marks)

2 (a) A plane flying across the Lake District sets off from base camp to Lake Windermere, 28 km away, in a direction of 20.0° north of east.

After dropping off supplies it flies to Lake Coniston, which is 19 km at 30.0° west of north from Lake Windermere.

By constructing a scale drawing, determine the distance from Lake Coniston to base camp.

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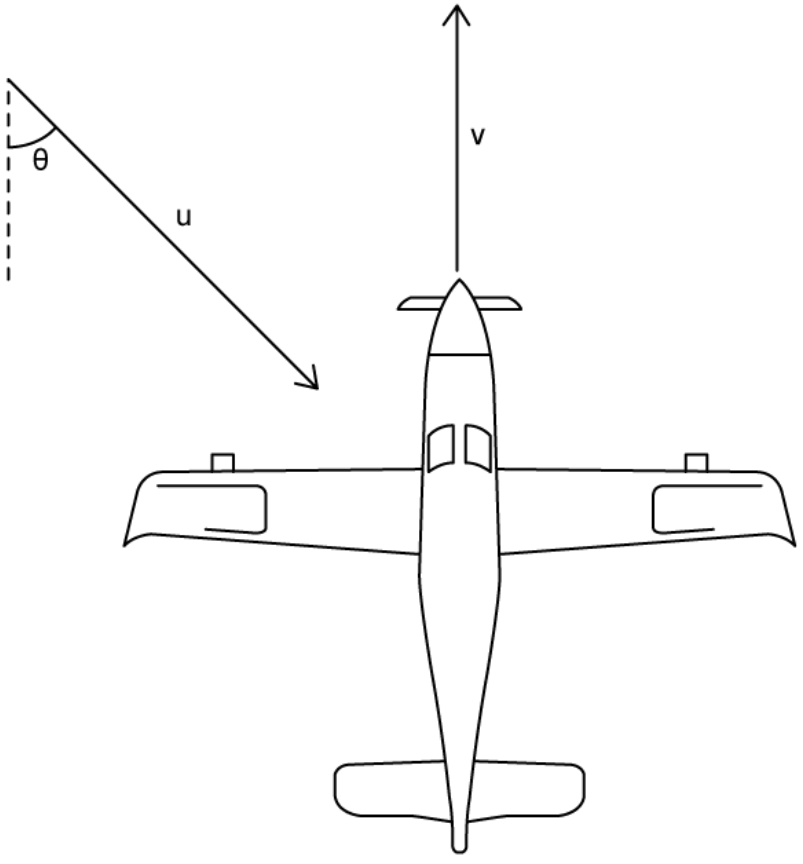
(3 marks)

(b) The plane now flies due north with a speed *v.* It moves through air that is stationary relative to it.



Suddenly, the plane enters a region where the wind is blowing with a speed u from a direction of θ anticlockwise from south.

Determine an expression for the time taken t for the plane to fly a distance D due north of its current position in this windy region.

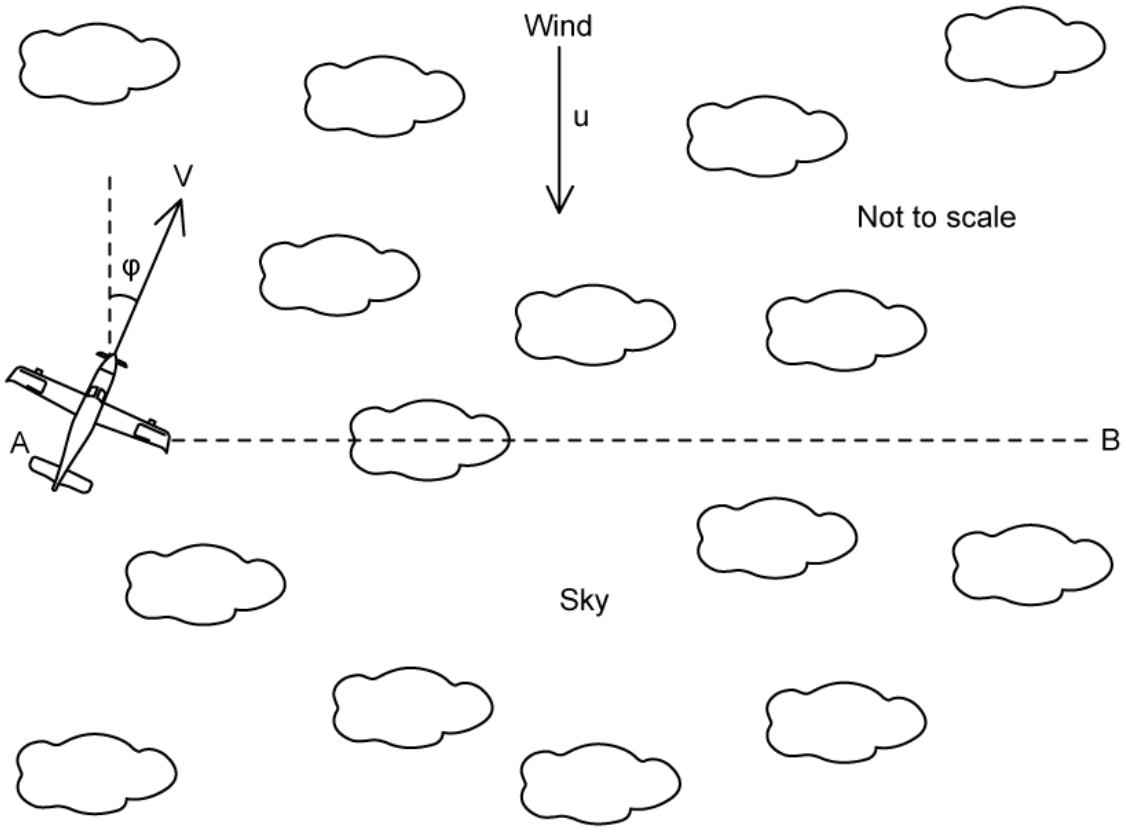
(2 marks)

(c) In still air, the plane travels 180 km every 30 minutes. In the windy region described in part (c), the aircraft takes an extra 4 minutes to travel the same distance, when the wind blows at an angle 53° anticlockwise from south.

Assuming the orientation of the plane does not change, calculate the speed of the wind u in km h^{-1}.

(3 marks)

(d) The wind now blows due south with the same speed as in part (c). The plane continues to travel at the same speed in this windy region.

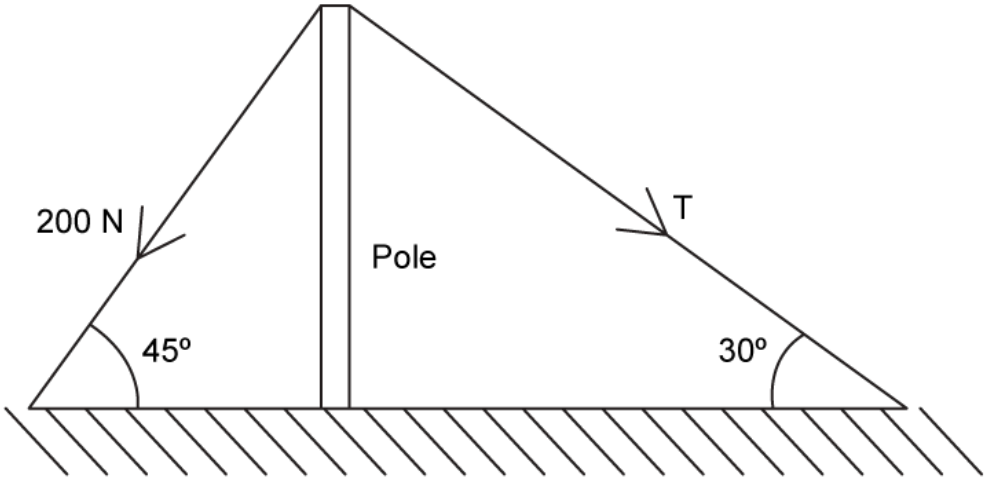


The pilot wishes to cross the sky along the straight line AB. In order to do so, they must turn the plane at an angle φ clockwise from north.

Construct a scale drawing to determine φ.

(3 marks)

3 (a) Two taut, light ropes keep a pole vertically upright by applying two tension forces, one of magnitude 200 N and one of magnitude *T*.



Construct a scale diagram to determine the weight of the pole *W* and the magnitude of *T*.

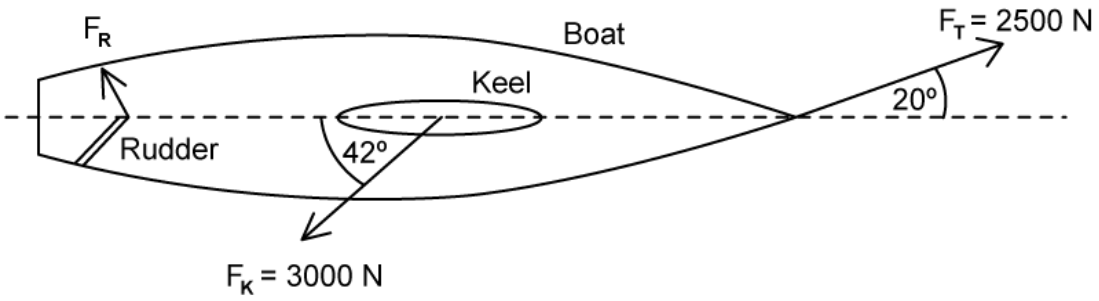
(4 marks)

(b) A canoeist can paddle at a speed of 3.8 m s^{-1} in still water. But, she encounters an opposing current, moving at a speed of 1.5 m s^{-1} at 30° to her original direction of travel.

Construct a scale diagram to determine the magnitude of the canoeist's resultant velocity.

(3 marks)

(c) The boat shown is being towed at a constant velocity by a towing rope, which exerts a tension force F_T = 2500 N. There are two resistive forces indicated – the force of the water on the keel F_K and the force of the water on the rudder, F_R.



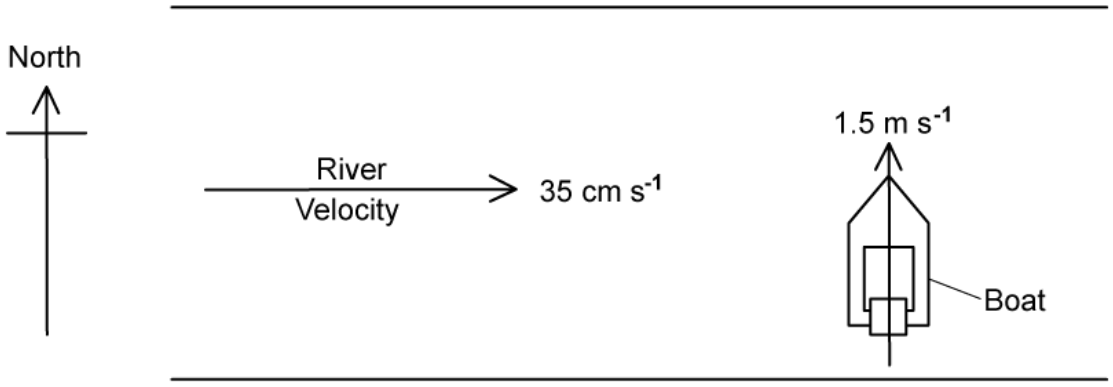
By calculation, or by constructing a diagram, determine the magnitude of F_R.

You may wish to use the result:

$$\tan\theta = \frac{\sin\theta}{\cos\theta}$$

(4 marks)

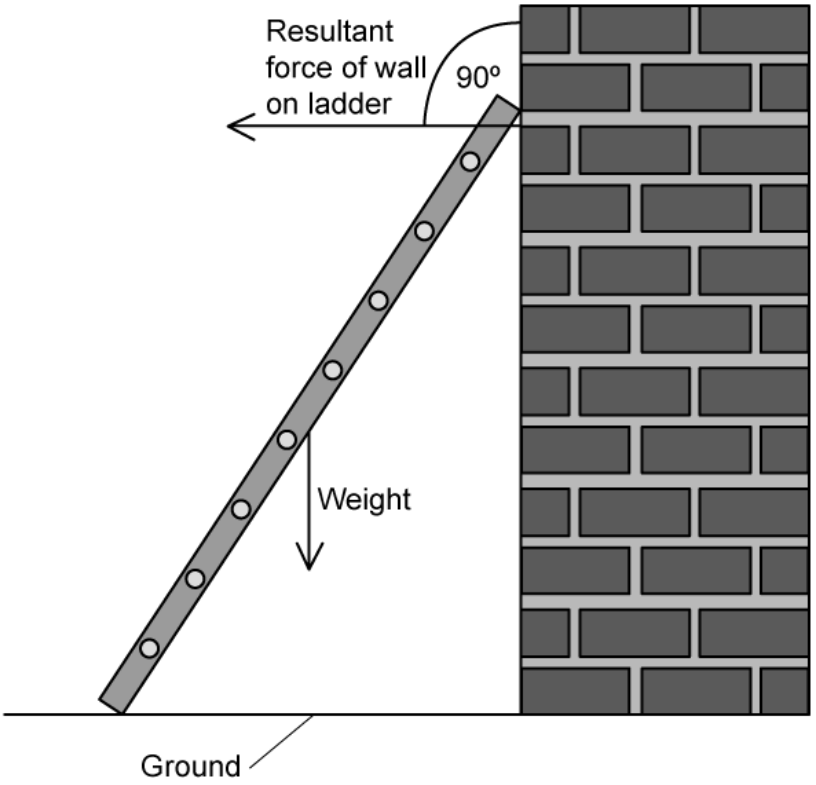
(d) Another boat wishes to cross a river. The river flows from west to east at a constant velocity of 35 cm s^{-1} and the boat leaves the south bank, due north, at 1.5 m s^{-1}.



Construct a scale diagram to determine the resultant velocity of the boat.

(4 marks)

4 (a) A ladder rests against a vertical wall as shown.



Explain how the image shows that there is no coefficient of static friction between the ladder and the wall.

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(2 marks)

(b) Draw a vector on the image to show the direction of the resultant force from the ground exerted on the ladder. Label this vector G.

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(2 marks)

(c) G acts at an angle of 62° to the ground.

Show that the coefficient of static friction between the ladder and the ground at the point of slipping is 0.53.

You may wish to use the result:

$$\tan\theta = \frac{\sin\theta}{\cos\theta}$$

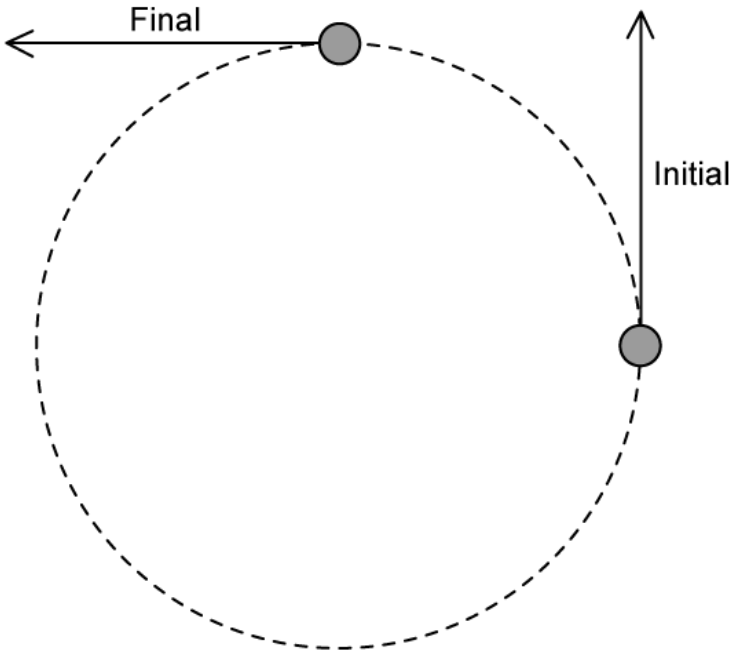
(3 marks)

(d) The ladder weighs 125 N.

Calculate the magnitude of vector G.

(2 marks)

5 (a) The linear velocity *v* of a particle moving in a circle is tangential to its orbit.



Find, using a suitably labelled sketch, the vector representing the particle's change in velocity.

(2 marks)

(b) Find, using a suitably labelled sketch, the vector representing the particle's instantaneous change in velocity.

(2 marks)

(c) Use your answer to part (b) to deduce a property of the particle's acceleration.

(2 marks)