1.3 Vectors & Scalars

Question Paper

Course	DP IB Physics
Section	1. Measurement & Uncertainties
Topic	1.3 Vectors & Scalars
Difficulty	Hard

Time allowed: 70

Score: /53

Percentage: /100

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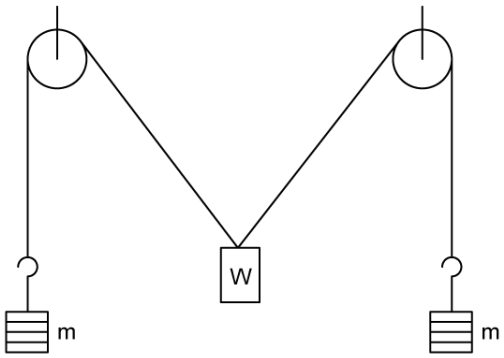
Question 1a

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.



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

[2]

[2 marks]

Question 1b

The mass of the load *W* is *M*.

(b)
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]

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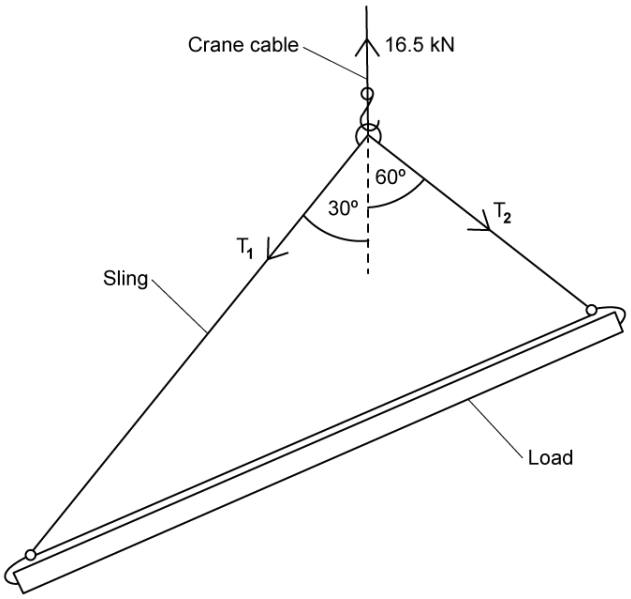
Question 1c

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



(c)

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

[4]

[4 marks]

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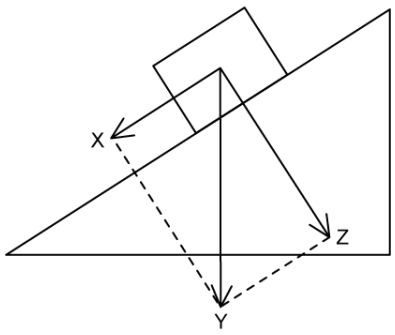
Question 1d

A crate rests on an inclined plane.



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

[3]

[3 marks]

Question 2a

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.

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

[3]

[3 marks]

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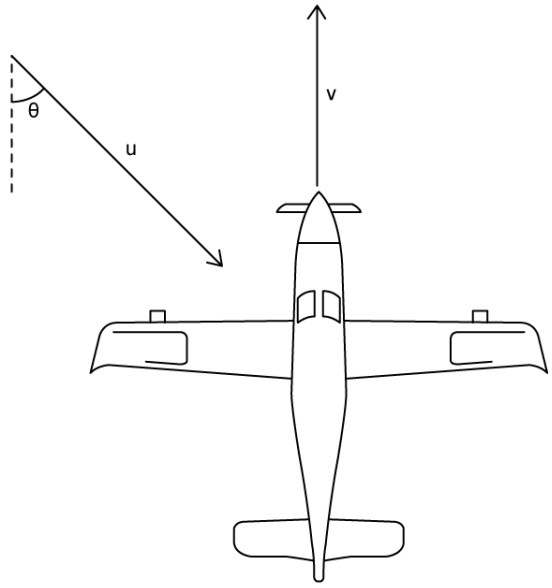
Question 2b

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.

(b)
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]

[2 marks]

Question 2c

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.

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

[3]

[3 marks]

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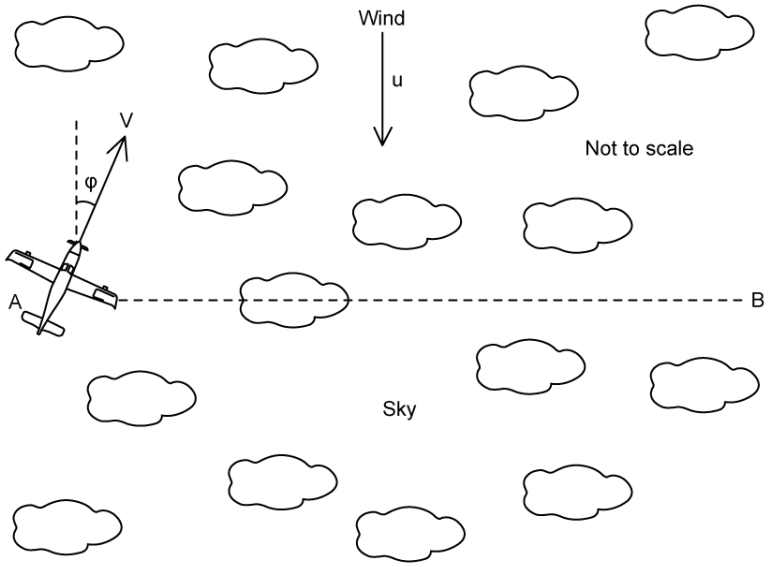
Question 2d

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.

(d)
Construct a scale drawing to determine φ.

[3]

[3 marks]

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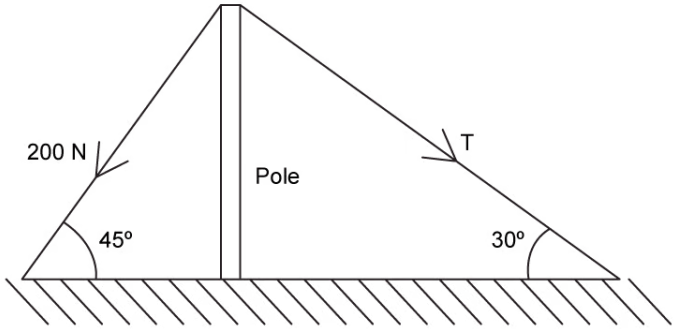
Question 3a

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



(a)

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

[4]

[4 marks]

Question 3b

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.

(b)

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

[3]

[3 marks]

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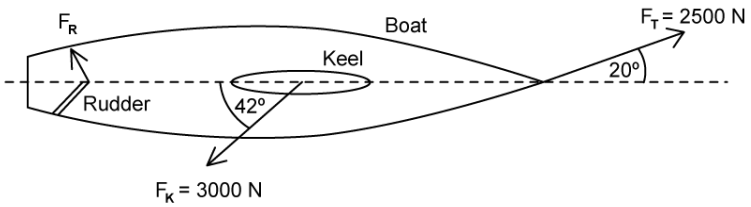
Question 3c

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.



(c)

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]

[4 marks]

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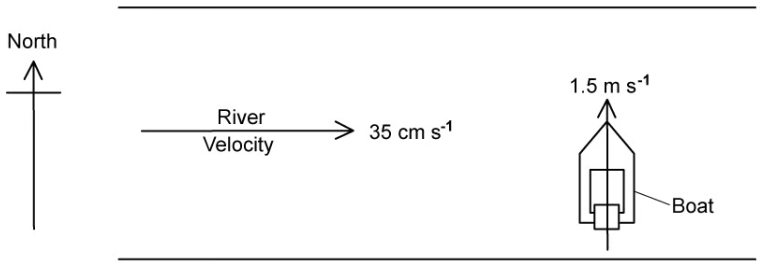
Question 3d

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}.



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

[4]

[4 marks]

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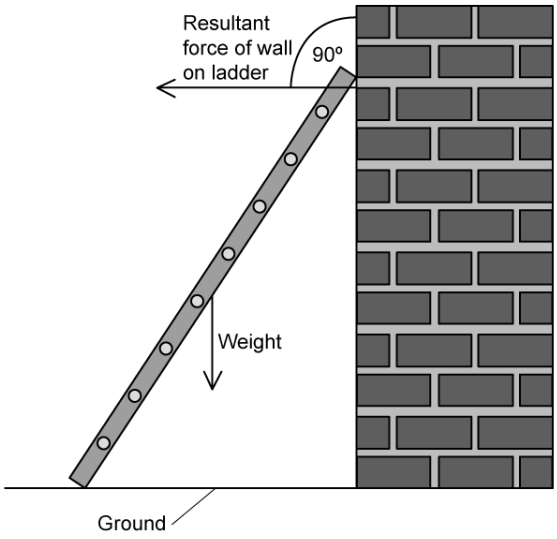
Question 4a

A ladder rests against a vertical wall as shown.



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

[2]

[2 marks]

Question 4b

(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.

[2]

[2 marks]

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Question 4c

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

(c)
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]

[3 marks]

Question 4d

The ladder weighs 125 N.

(d)
Calculate the magnitude of vector G.

[2]

[2 marks]

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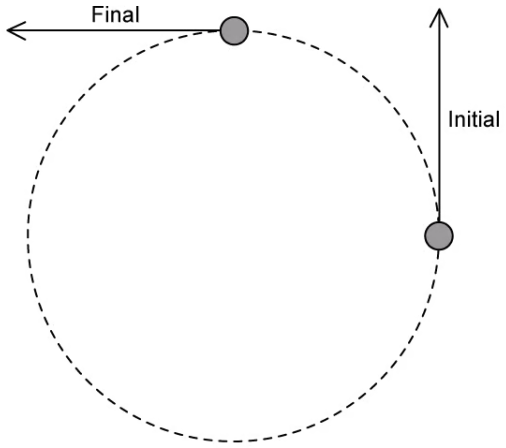
Question 5a

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



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

[2]

[2 marks]

Question 5b

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

[2]

[2 marks]

Question 5c

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

[2]

[2 marks]

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