

1

Which of the following is a scalar quantity?

- A** kinetic energy ☐
- B** momentum ☐
- C** force ☐
- D** acceleration ☐

(Total 1 mark)

2

Which of the following is a scalar quantity?

- A** velocity ☐
- B** kinetic energy ☐
- C** force ☐
- D** momentum ☐

(Total 1 mark)

3

Two forces of 6 N and 10 N act at a point. Which of the following could **not** be the magnitude of the result?

- A** 16 N ☐
- B** 8 N ☐
- C** 5 N ☐
- D** 3 N ☐

(Total 1 mark)

4

Which is a scalar quantity?

- | | | |
|----------|----------|-----------------------|
| A | momentum | ☐ |
| B | weight | ☐ |
| C | power | ☐ |
| D | moment | ☐ |

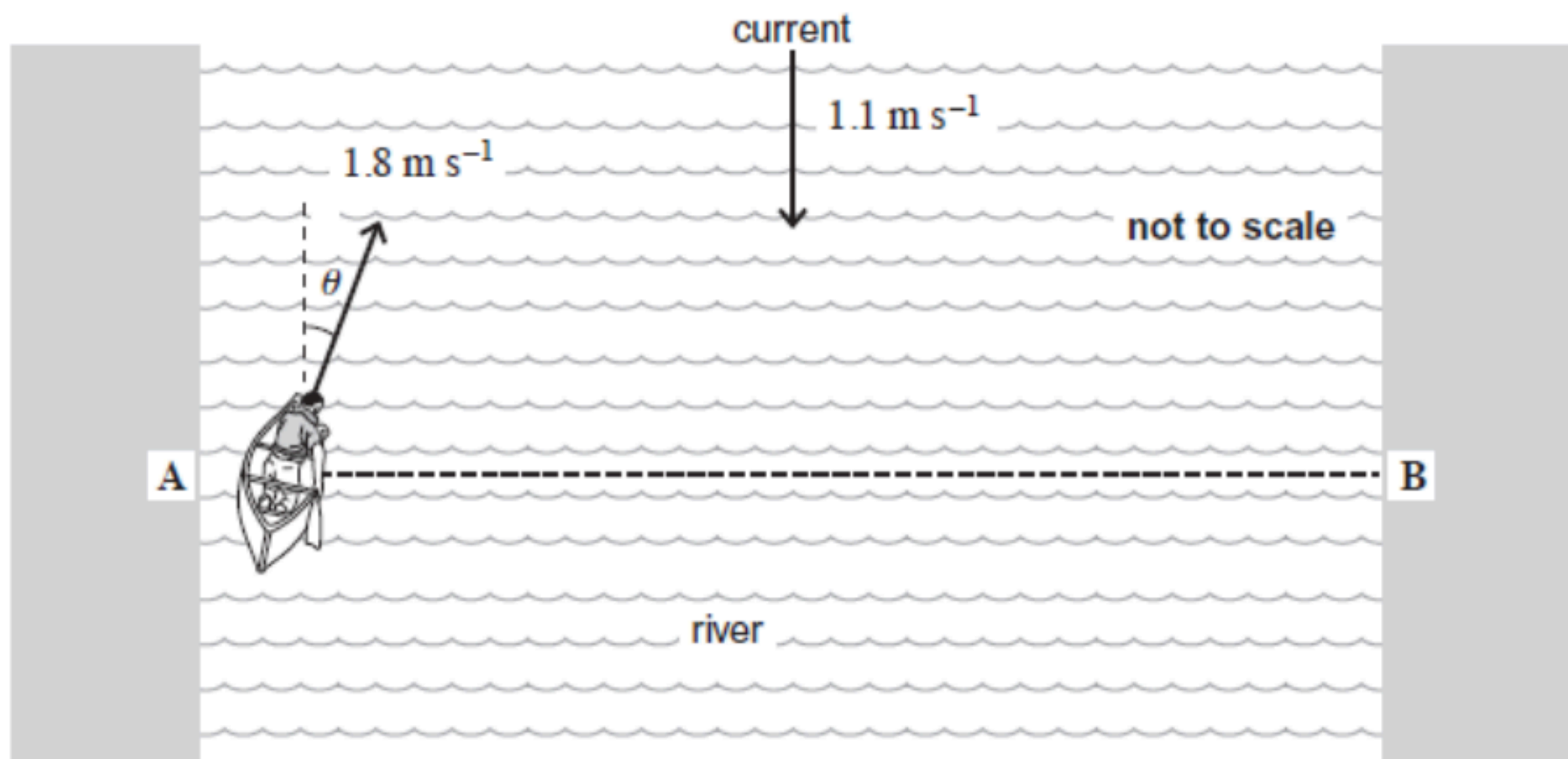
(Total 1 mark)

5

A canoeist wishes to cross a river in a straight line between two points labelled **A** and **B** as shown in the diagram below.

The canoeist can paddle the canoe at a speed of 1.8 m s^{-1} in still water.

The current in the river has a speed of 1.1 m s^{-1} .



To cross from **A** to **B** the canoeist has to paddle at an angle θ to the direction of the current, as shown above.

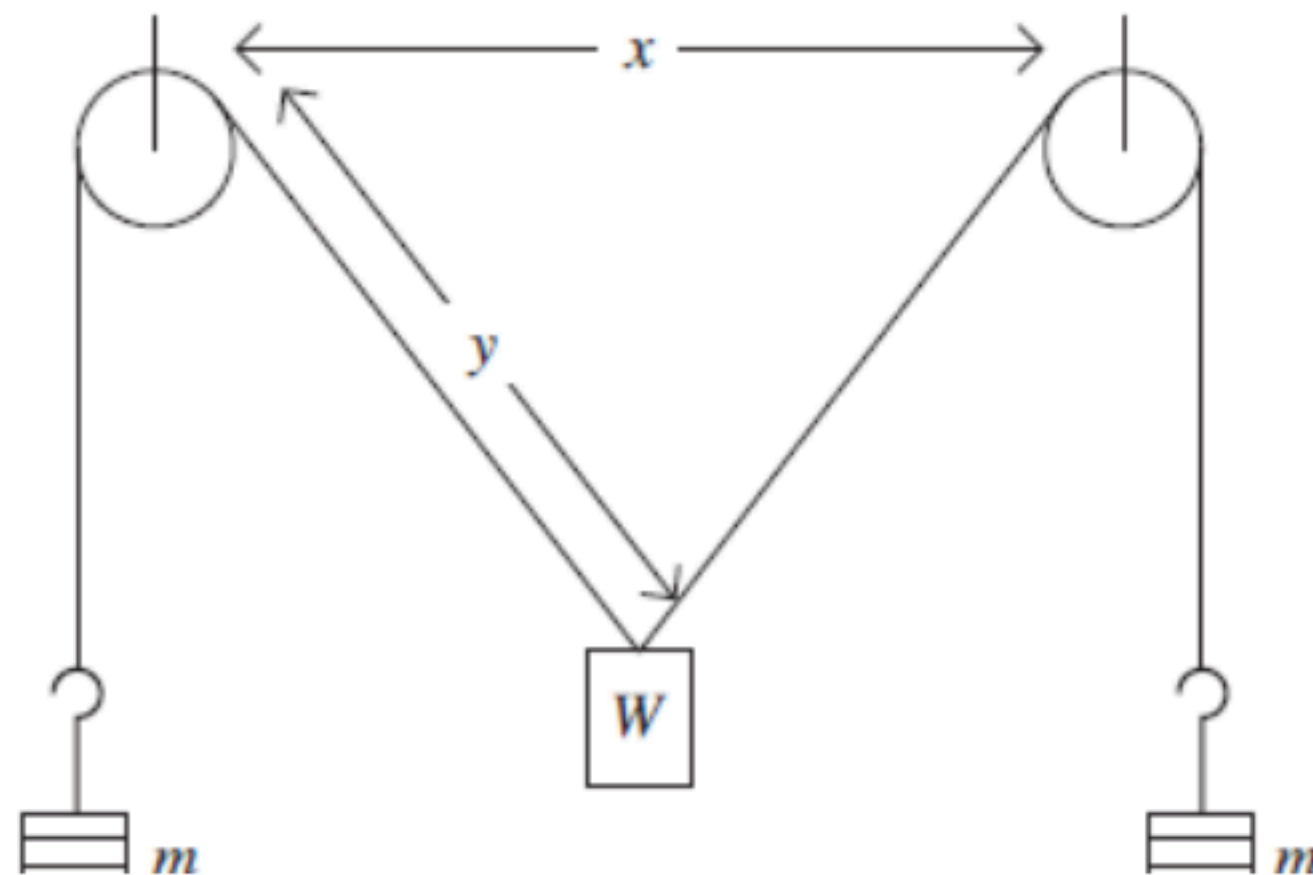
Determine θ using a scale drawing.

angle θ _____ degrees

(Total 3 marks)

- 6** In an experiment an unknown load, of weight, W , was supported by two strings kept in tension by equal masses, m , hung from their free ends, with each string passing over a frictionless pulley. The arrangement was symmetrical and is shown in **Figure 1**.

Figure 1

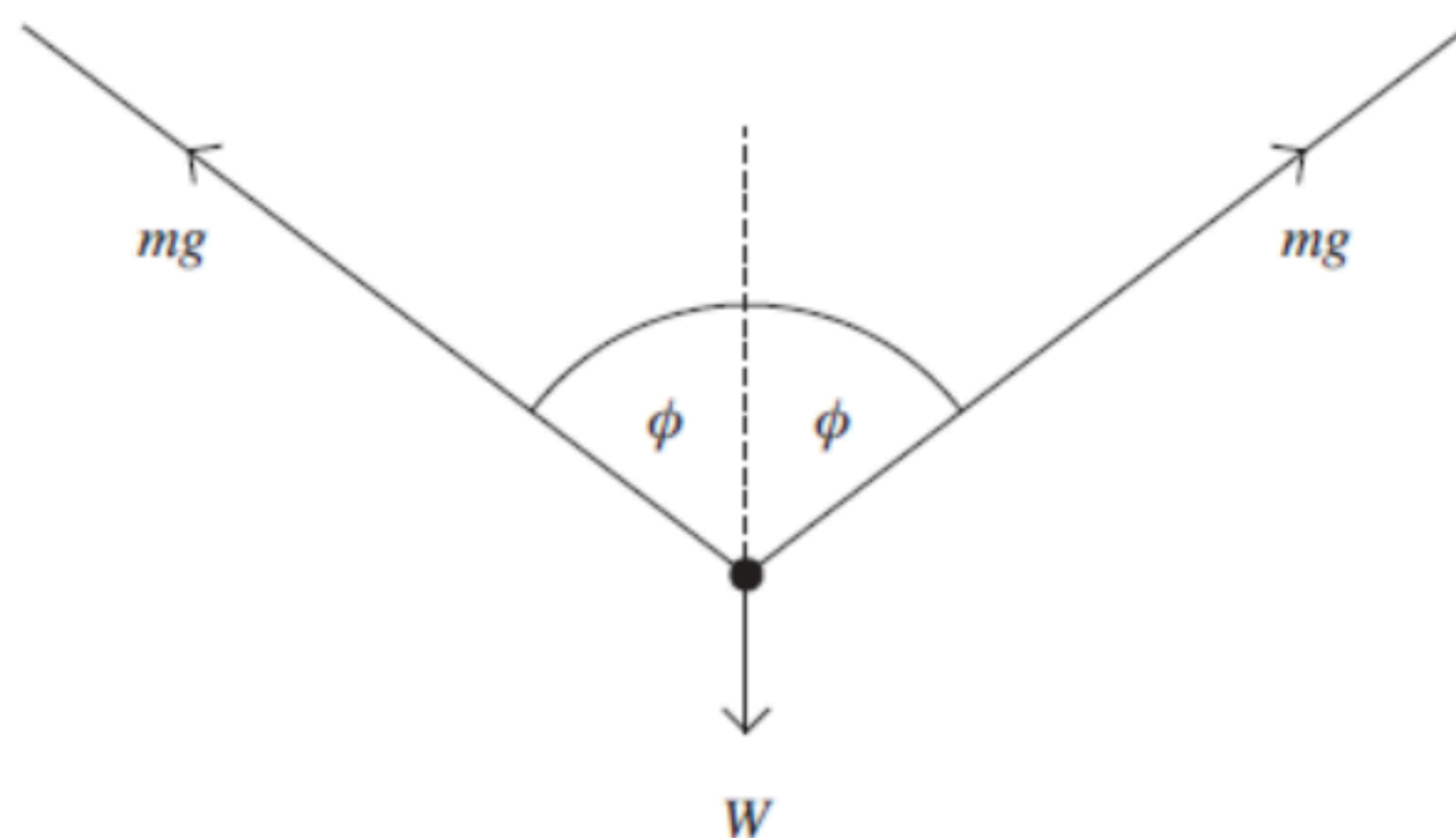


The distance x was kept constant throughout the experiment. The length y was measured for different values of m .

The distance between the strings at the pulleys, $x = 0.500\text{m}$

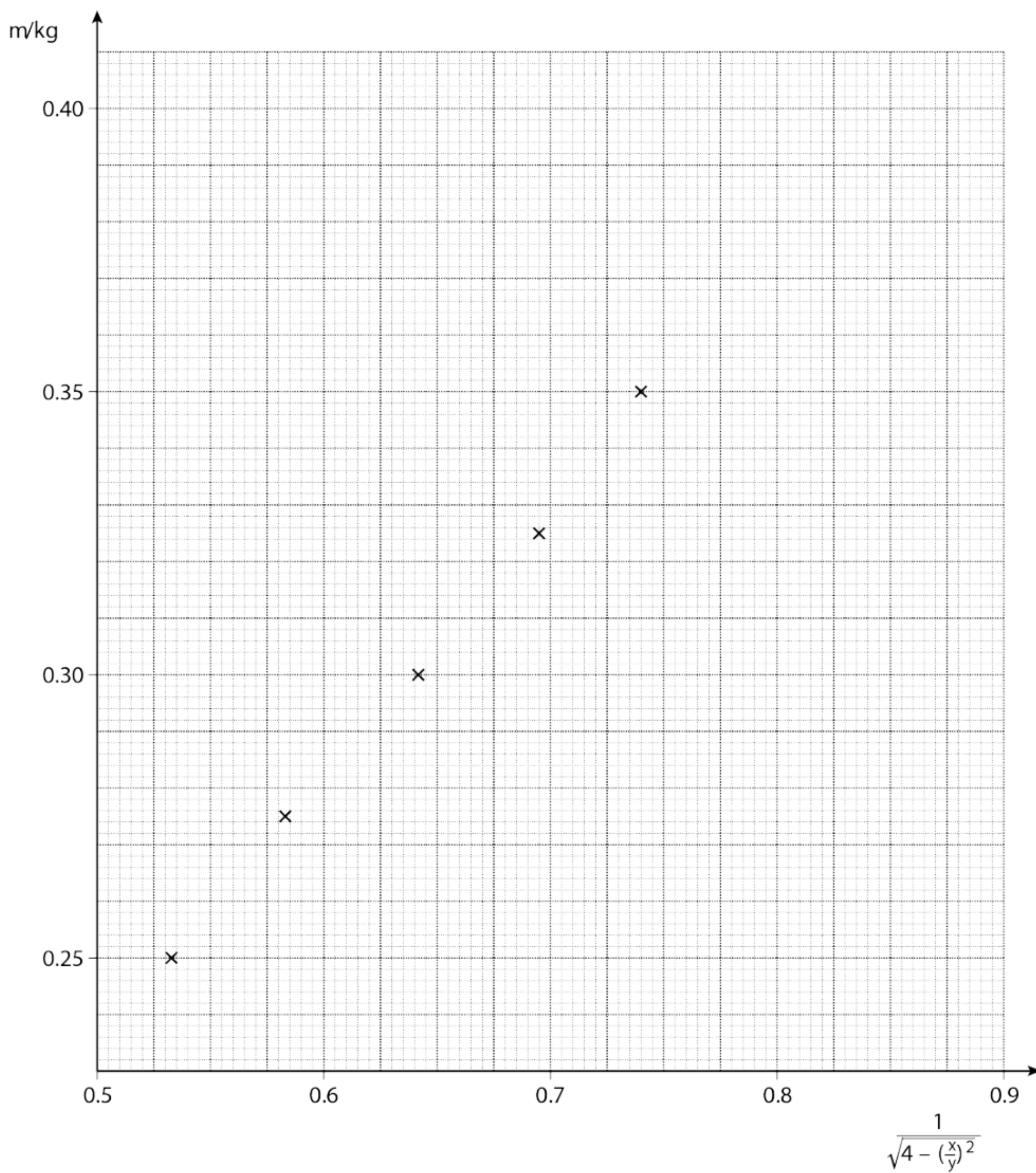
- (a) **Figure 2** shows the three forces acting through the point at which the strings are attached to the load. The weight of the load is W and the tension in each string is mg , where g is gravitational field strength.

Figure 2



- (i) By resolving the forces vertically show that $m = \frac{W}{2g \cos \phi}$
where ϕ is the angle between each string and the vertical.

(ii) Draw the line of best fit through the points plotted on the graph.



(1)

- (b) (i) Determine the gradient of your graph.

(3)

- (ii) The equation for the straight line is $m = \frac{W}{g} \times \frac{1}{\sqrt{4 - \left(\frac{x}{y}\right)^2}}$

Given that $g = 9.81 \text{ N kg}^{-1}$, determine a value for W .

(2)

- (c) When m was 0.300 kg, y was 0.400 m.

Calculate the percentage uncertainty in $\left(\frac{x}{y}\right)^2$ for $m = 0.300 \text{ kg}$.

(3)

- (d) (i) Explain the term *systematic error*.

(1)

- (ii) In practice, there may be a systematic error in this experiment because of friction in the pulleys.

When the measurements were taken, increasing values of m were used. State and explain how friction in the pulleys would have affected the measured values of y .

(2)

(Total 13 marks)

7

- (a) (i) State **two** vector quantities.

vector quantity 1 _____

vector quantity 2 _____

- (ii) State **two** scalar quantities.

scalar quantity 1 _____

scalar quantity 2 _____

(2)

- (b) The helicopter shown in **Figure 1a** is moving horizontally through still air. The lift force from the helicopter's blades is labelled **A**.

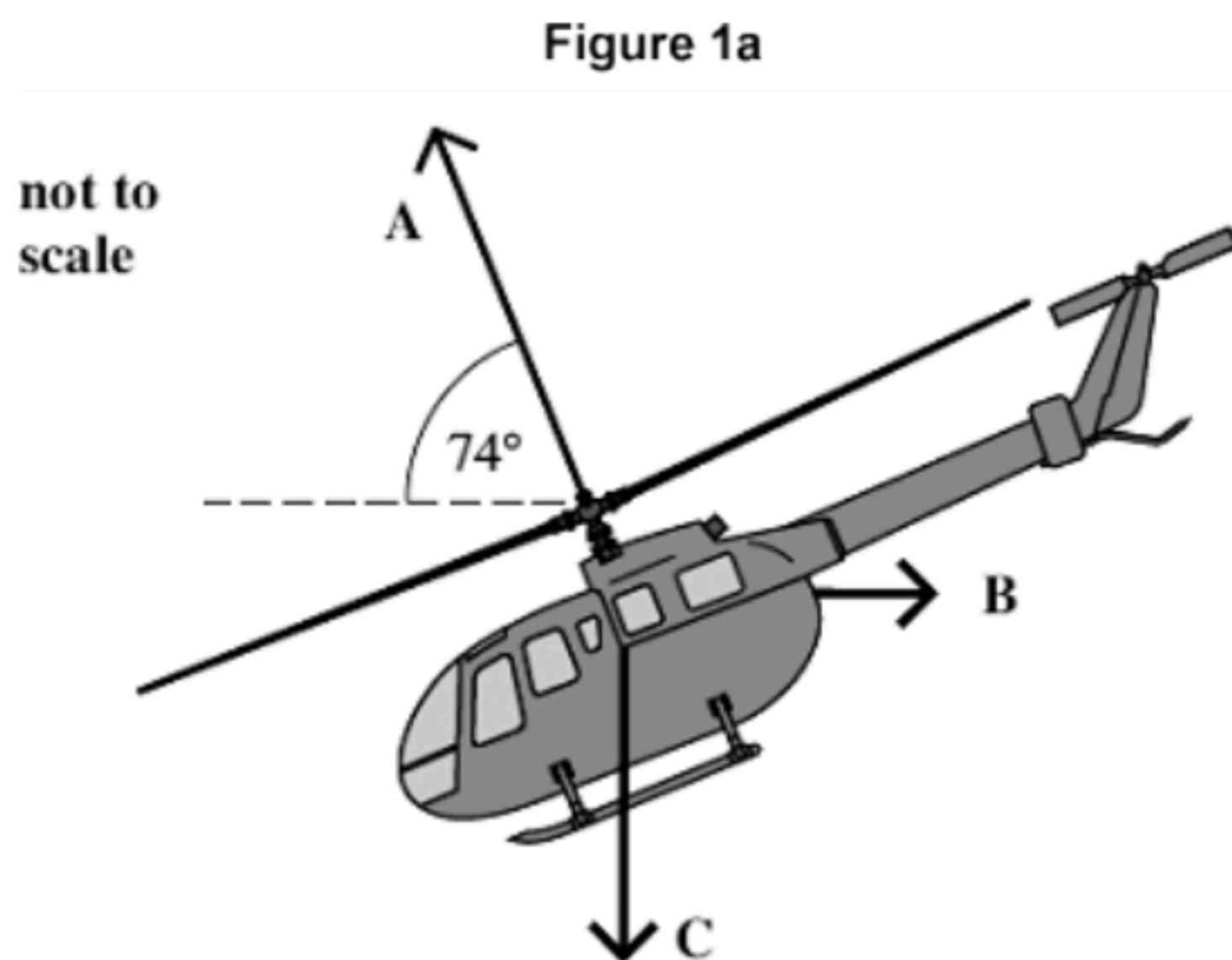
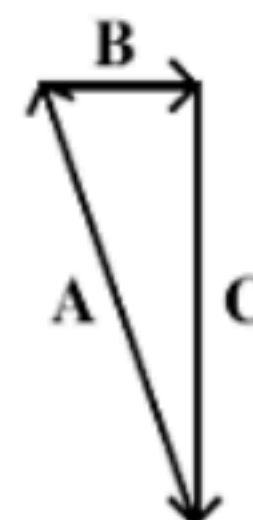


Figure 1b



- (i) Name the two forces **B** and **C** that also act on the helicopter.

B _____

C _____

(2)

- (ii) The force vectors are also shown arranged as a triangle in **Figure 1b**.

State and explain how **Figure 1b** shows that the helicopter is moving at a constant velocity.

(2)

- (c) The lift force, **A**, is 9.5 kN and acts at an angle of 74° to the horizontal.

Calculate the weight of the helicopter. Give your answer to an appropriate number of significant figures.

answer = _____ N

8

Figure 1 shows car **A** being towed at a steady speed up a slope which is inclined at 5.0° to the horizontal. Assume that the resistive forces acting on car **A** are negligible.

Figure 1

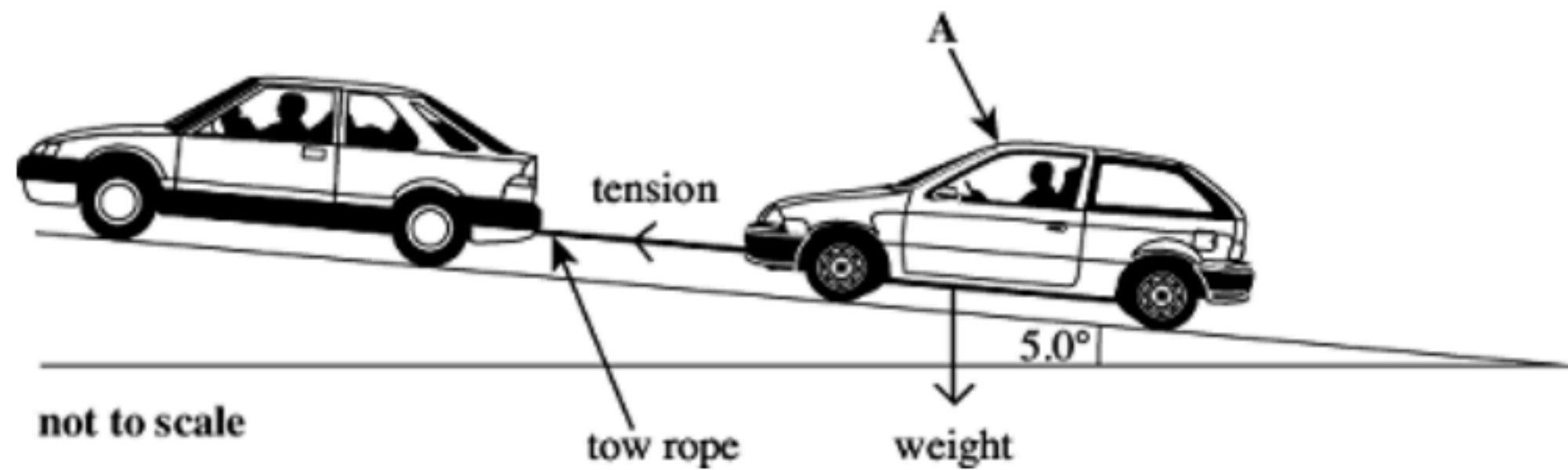
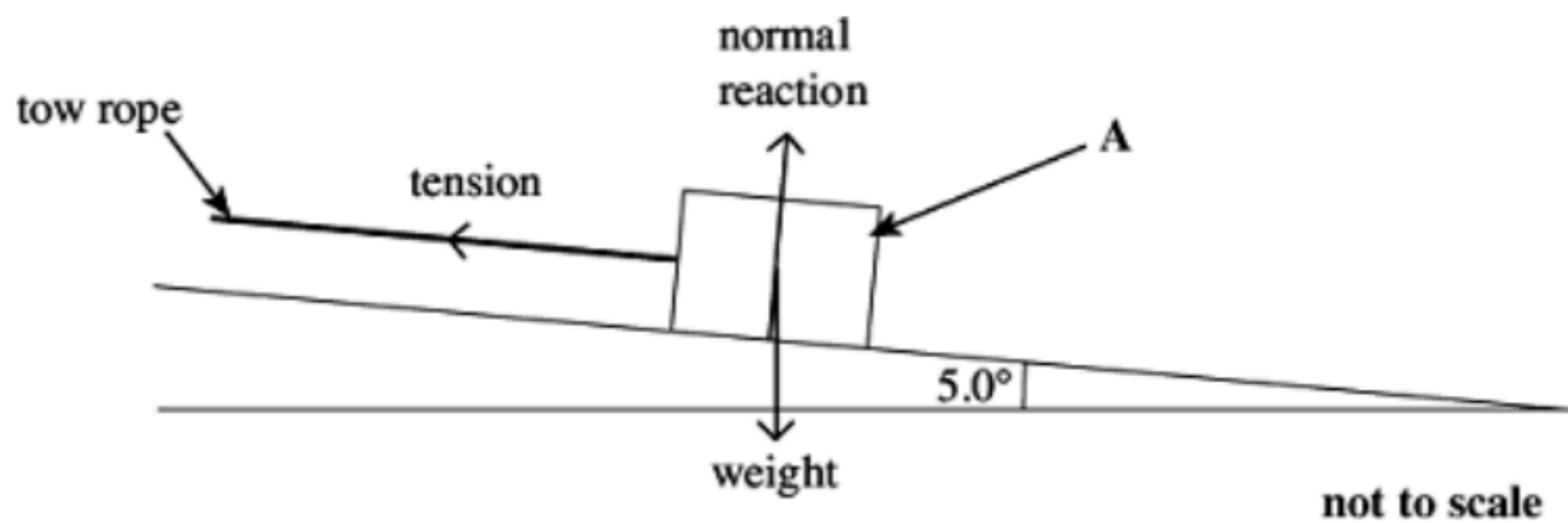


Figure 2 represents a simplified version of the forces acting on car **A** at the instant shown in **Figure 1**.

Figure 2



- (a) (i) Car **A** has a mass of 970 kg. Show that the component of its weight that acts parallel to the slope is approximately 830 N.

- (ii) Calculate the energy stored in the tow rope as car **A** is towed up the slope at a steady speed. The tow rope obeys Hooke's law and has a stiffness of $2.5 \times 10^4 \text{ Nm}^{-1}$.

energy stored _____ J

(4)

- (b) The tow rope is attached to a fixing point on car **A** using a metal hook. During the ascent of the slope the fixing point snaps and the metal hook becomes detached from car **A**. The metal hook gains speed due to the energy stored in the rope. State and explain how the speed gained by the hook would have changed if the rope used had a stiffness greater than $2.5 \times 10^4 \text{ Nm}^{-1}$.

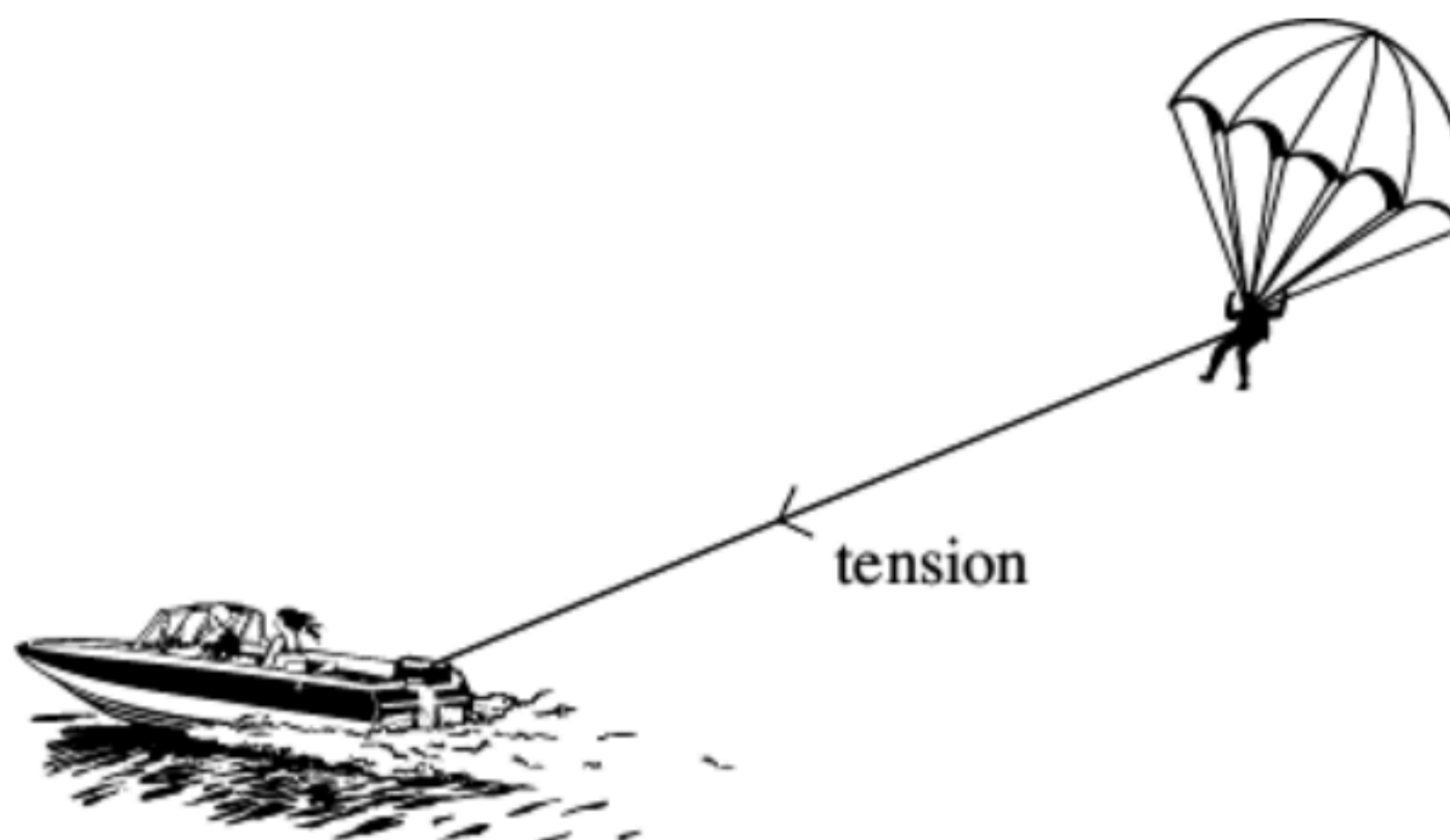
(3)

(Total 9 marks)

9

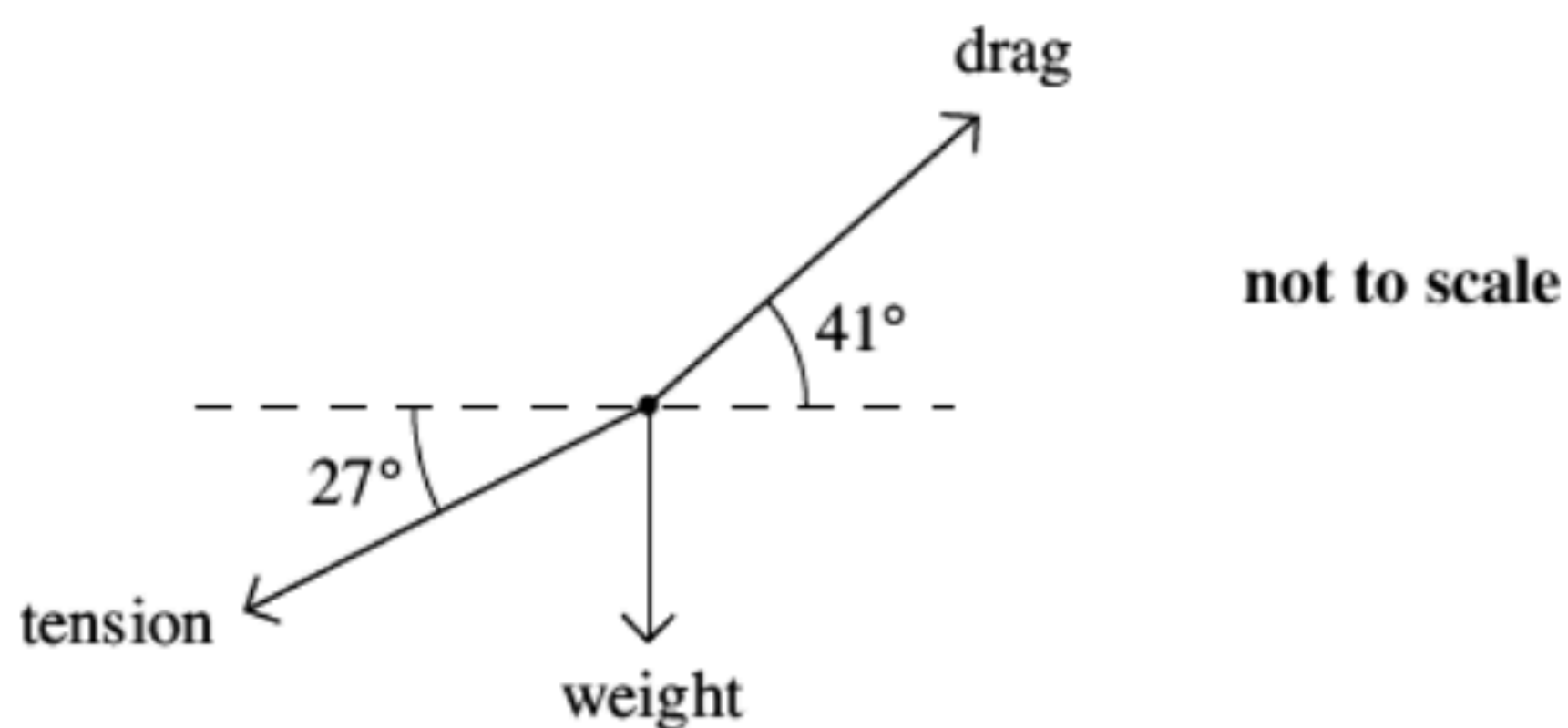
Figure 1 shows a parascender being towed at a constant velocity.

Figure 1



The forces acting on the parascender are shown in the free-body diagram in **Figure 2**.

Figure 2



The rope towing the parascender makes an angle of 27° with the horizontal and has a tension of 2.2 kN. The drag force of 2.6 kN acts at an angle of 41° to the horizontal. Calculate the weight of the parascender.

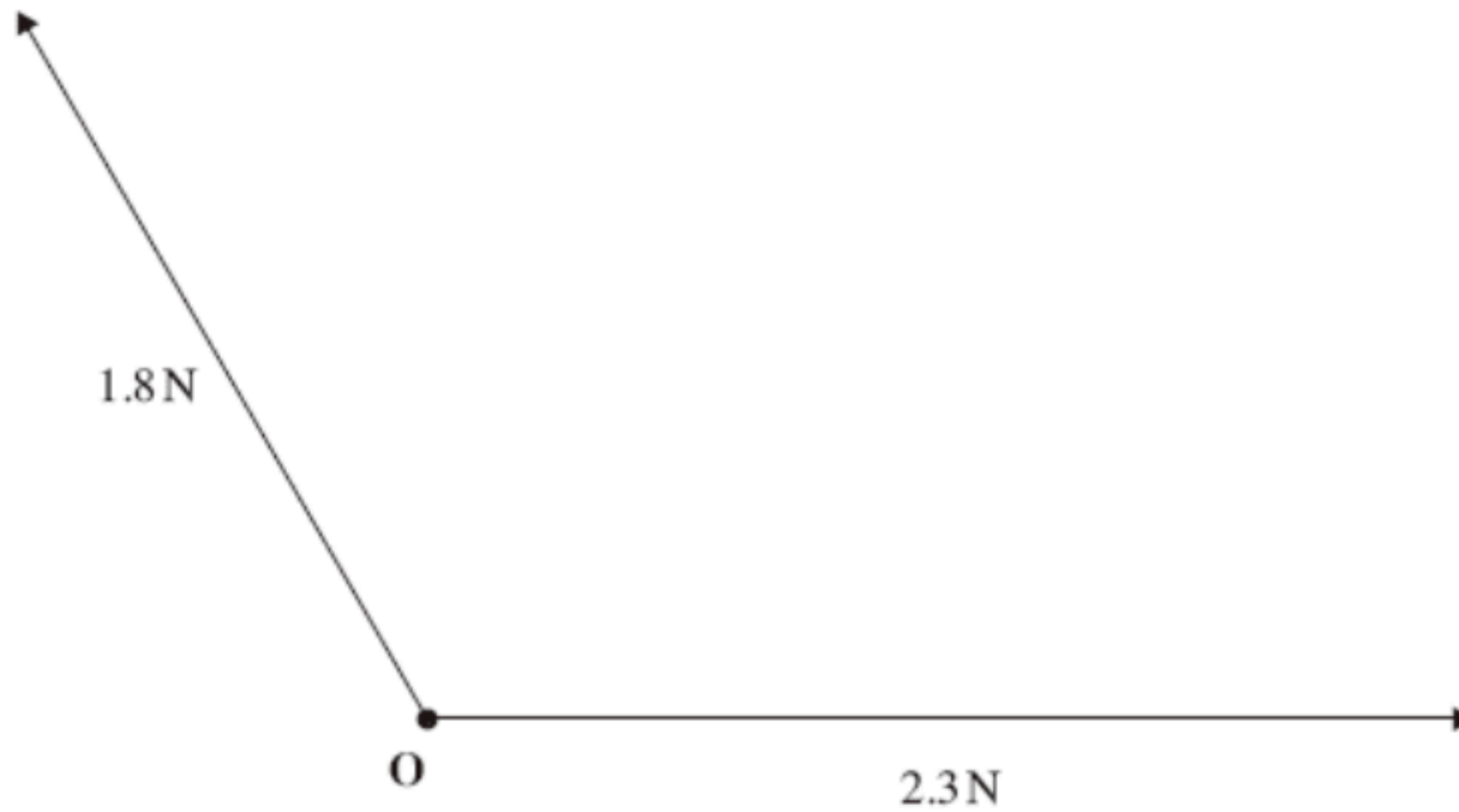
weight _____ N
(Total 3 marks)

10

(a) What is meant by a scalar quantity?

(1)

- (b) The figure below shows two forces acting on an object at **O**. The forces have been drawn to scale.



- (i) State the scale used in the figure above

(1)

- (ii) Complete the scale drawing, the figure above, to determine the magnitude of the resultant force.

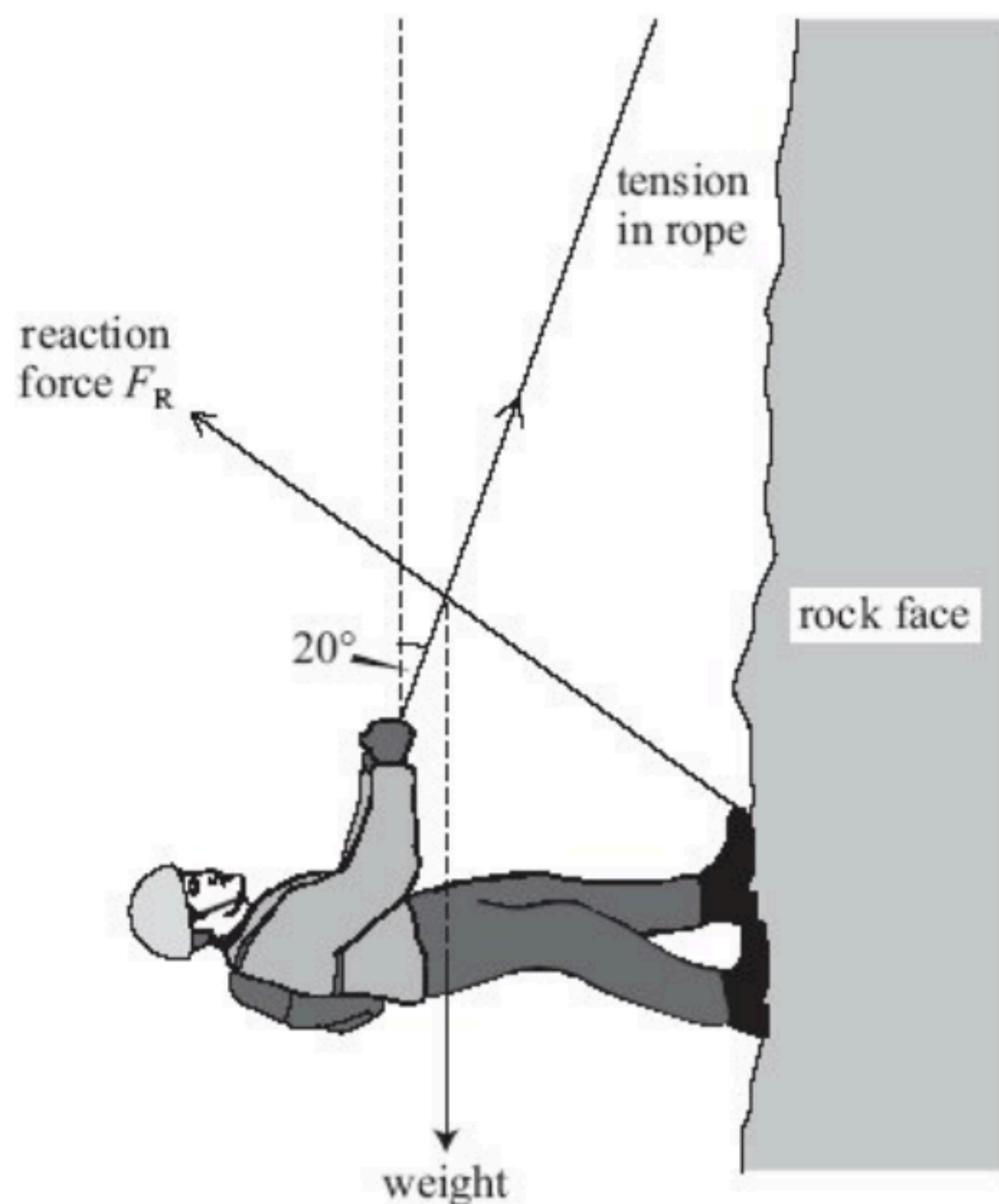
magnitude of resultant force _____ N

(3)

(Total 5 marks)

11

The diagram below shows a rock climber abseiling down a rock face. At the instant shown the climber is stationary and in equilibrium. The forces acting on the climber are shown in the diagram below.



The tension in the rope is 610 N and it acts at 20° to the vertical.
The weight of the climber is 590 N.

Calculate the vertical component of the reaction force, F_R , between the feet of the climber and the rock.

vertical component _____ N
(Total 3 marks)

12

In the leisure pursuit called parascending a person attached to a parachute is towed by a towrope attached to a motor boat as shown in **Figure 1**.

Figure 1

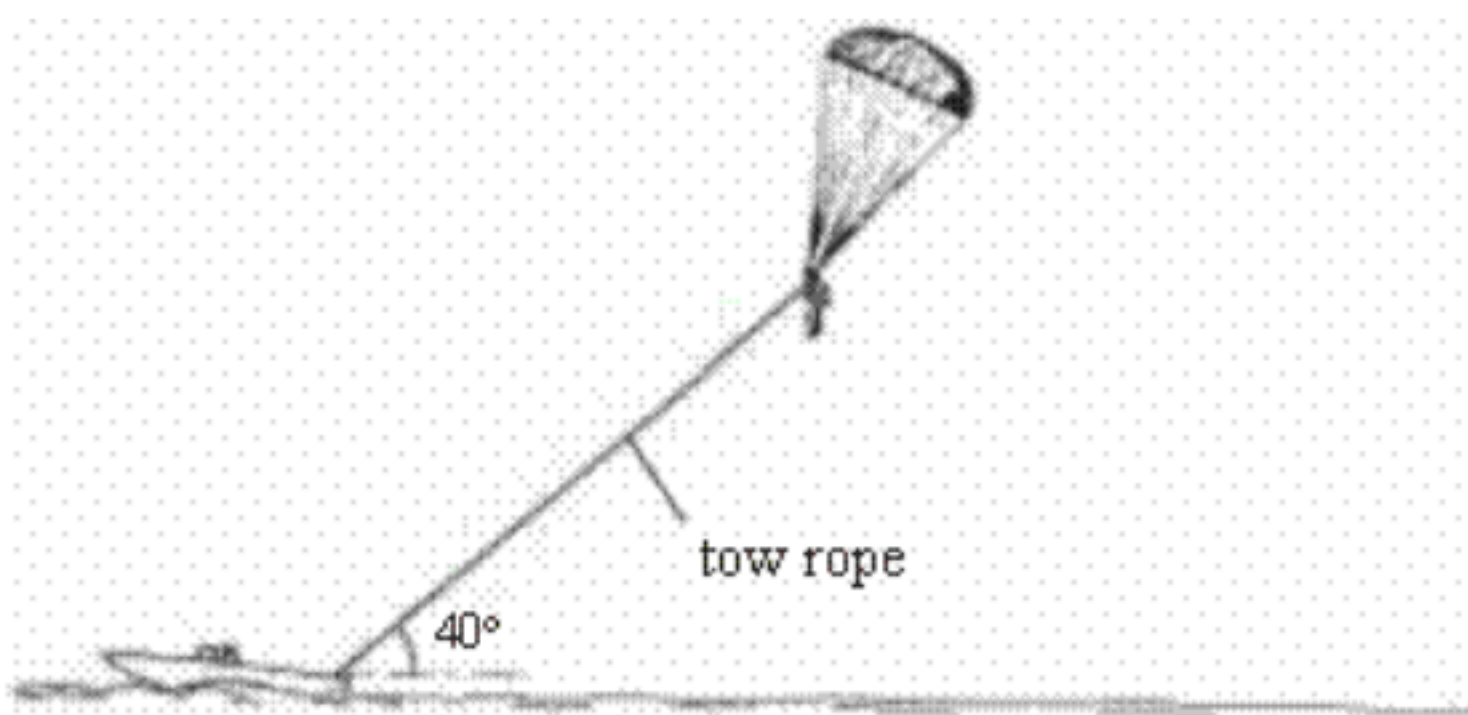


Figure 2

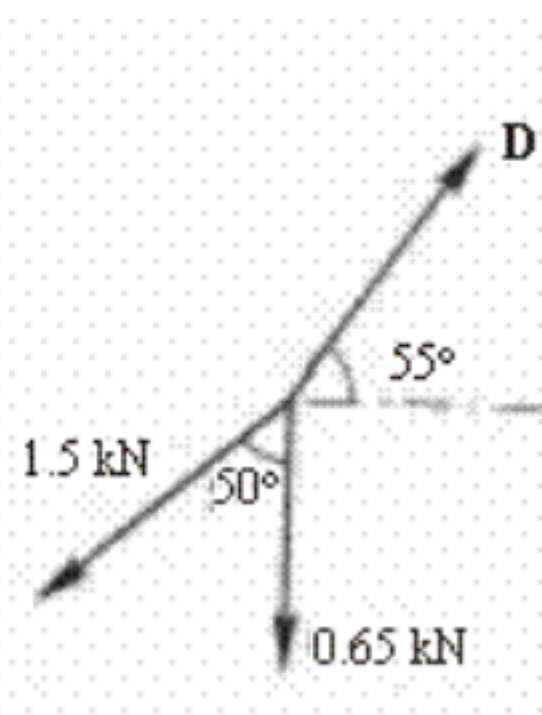


Figure 2 shows the directions of the forces acting on a person of weight 0.65 kN when being towed horizontally at a constant speed of 8.5 m s^{-1} .

The tension in the tow rope is 1.5 kN and D is resultant force exerted by the parachute on the parascender.

- (a) (i) State why the resultant force on the parascender must be zero.

- (ii) Calculate the magnitude of D .

magnitude of _____ kN

(4)

- (b) (i) Calculate the horizontal resistance to motion of the boat produced by the tow rope.

resistance _____ kN

- (ii) The horizontal resistance to the motion of the boat produced by the water is 1200 N . Calculate the total power developed by the boat.

power _____

(5)

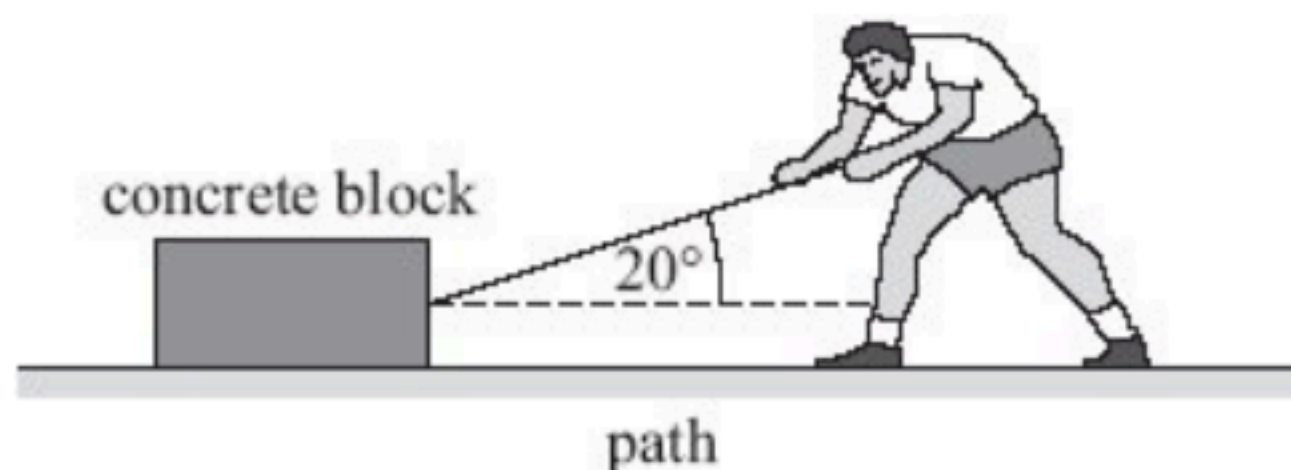
- (c) State and explain the initial effect on the boat if the tow rope were to break.

(2)

(Total 11 marks)

13

The diagram below shows a man participating in a 'strong man' competition. The event requires the man to haul a concrete block along a horizontal path for a distance of 15 m. The frictional force between the block and the path is 2800 N.



- (a) The rope is inclined at an angle of 20° to the horizontal.
Calculate the minimum force that the man must exert on the rope to move the block.

force _____ N

(1)

- (b) Calculate the minimum work that the man has to do to complete the event.

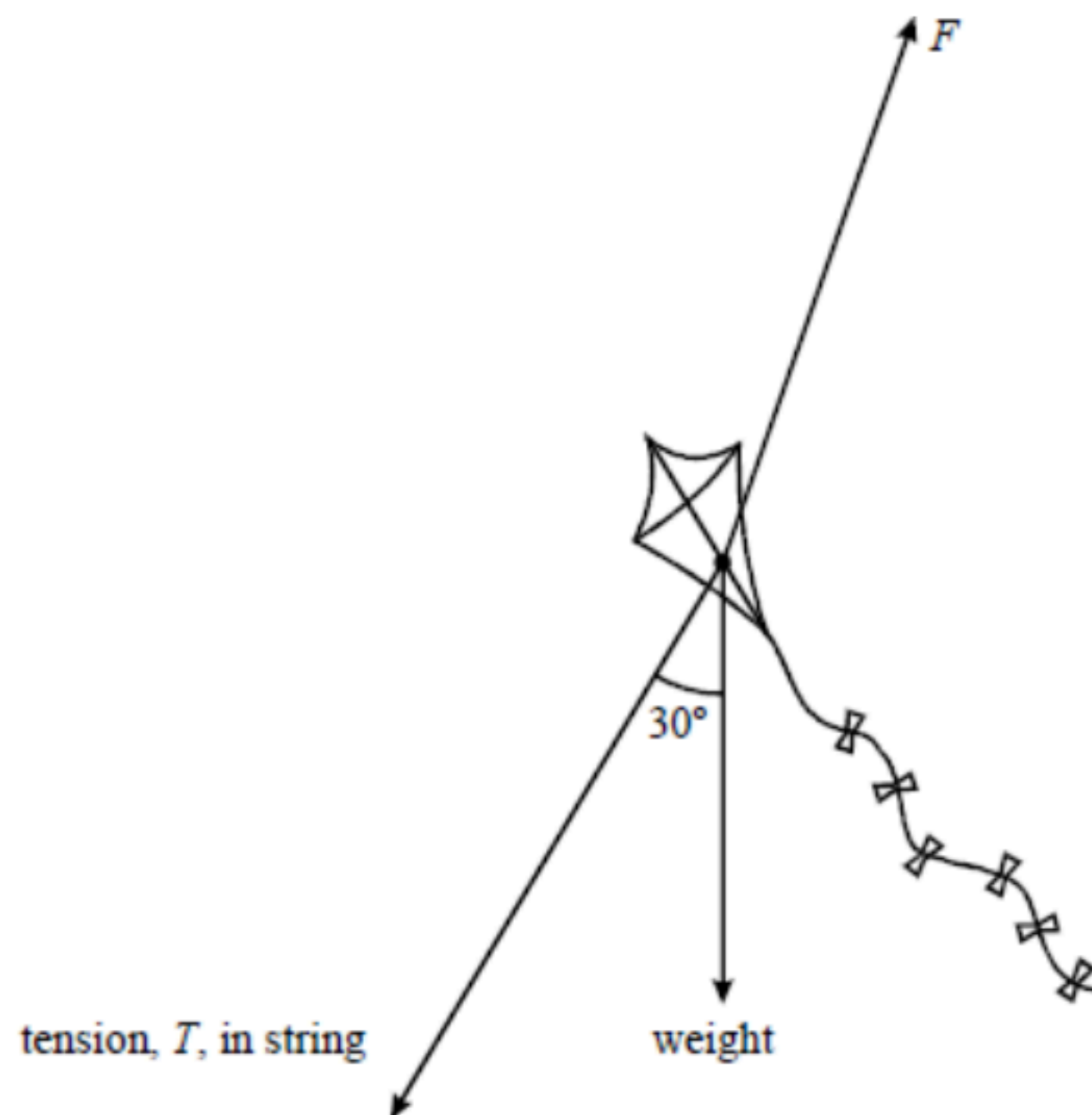
work done _____ J

(1)

(Total 2 marks)

14

The diagram shows the forces acting on a stationary kite. The force F is the force that the air exerts on the kite.



- (a) Show on the diagram how force F can be resolved into horizontal and vertical components.

(2)

- (b) The magnitude of the tension, T , is 25 N.

Calculate

- (i) the horizontal component of the tension,

- (ii) the vertical component of the tension.

(2)

- (c) (i) Calculate the magnitude of the vertical component of F when the weight of the kite is 2.5 N.

- (ii) State the magnitude of the horizontal component of F .

- (iii) Hence calculate the magnitude of F .

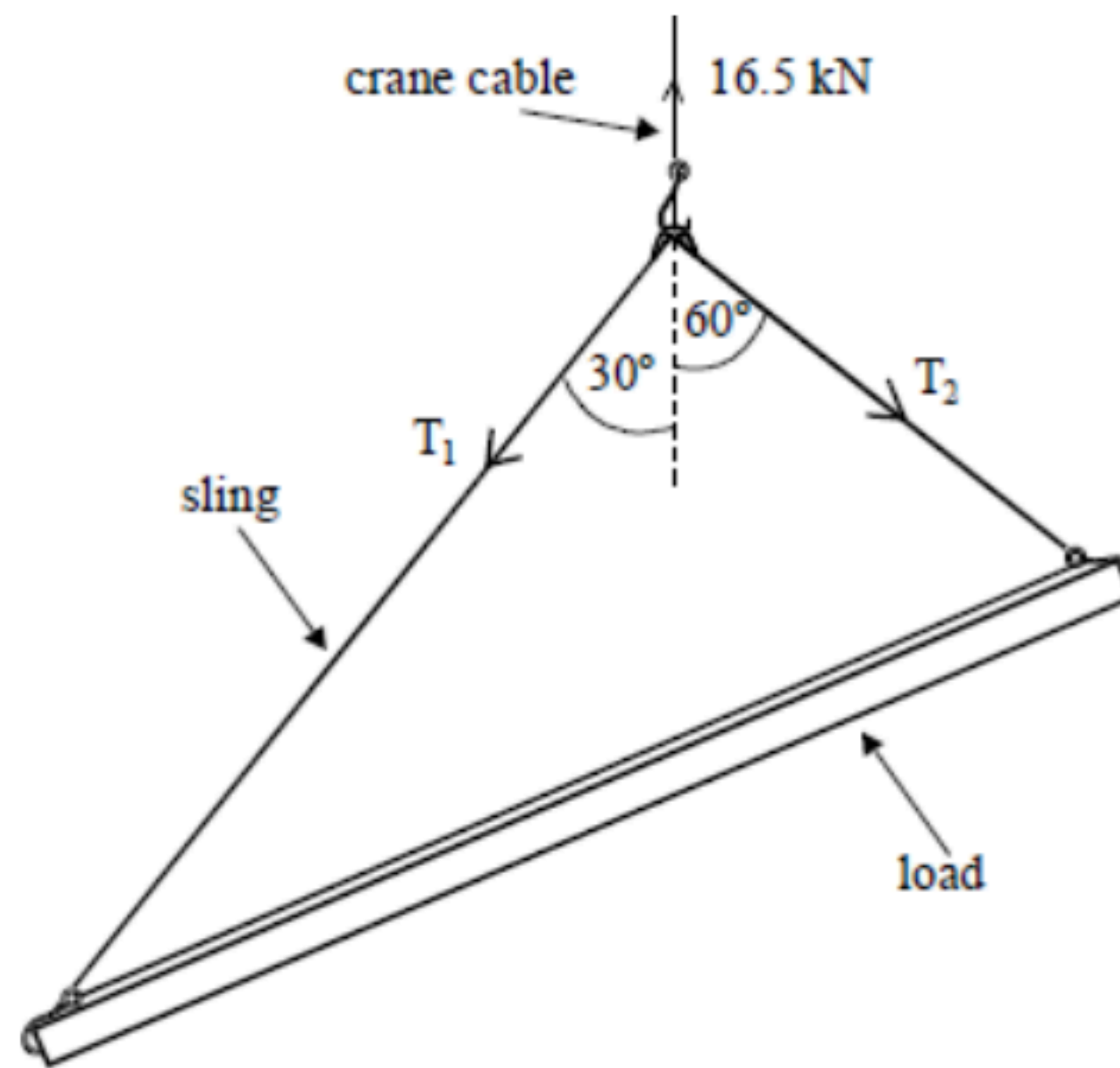
(4)

15

- (a) State the condition necessary for the equilibrium of three coplanar forces acting at a point.

(1)

- (b) The diagram shows a crane hook in equilibrium under the action of a vertical force of 16.5 kN in the crane cable and tension forces T_1 and T_2 in the sling.



Find the tension forces T_1 and T_2 acting in the sling. You may **either** calculate these forces **or** find them by scale drawing. In either case you should show your method clearly.

$$T_1 = \underline{\hspace{2cm}}$$

$$T_2 = \underline{\hspace{2cm}}$$

(4)

(Total 5 marks)

Mark schemes

1	A			[1]
2	B			[1]
3	D			[1]
4	C			[1]
5	Right-angled triangle, nose-to-tail with arrows			
		M1		
	Appropriate scale (fills half the space minimum)			
		A1		
	52 ± 1 (degrees)			
	1 mark for 52.3° by calculation			
		B1		
				[3]
6	(a) (i) $W = 2mg \cos \phi \quad \therefore m = W/(2g \cos \phi) \checkmark$ <i>The question says <u>show that</u>, so the candidates must write down both steps.</i>		1	
	(ii) Well drawn straight line of best fit. $\checkmark$ <i>The line should follow the trend of the points with an even scatter of points on either side of the line.</i>		1	
	(b) (i) Triangle drawn with smallest side at least 8 cm in length. $\checkmark$ Correct readings taken from the line for the triangle $\checkmark$ Gradient in the range 0.45 to 0.49 (0.445 to 0.494) quoted to 2 or 3 significant figures $\checkmark$ <i>The size of the triangle can be identified from readings taken from the line.</i> <i>The third mark is independent of the other two: error carried forward for incorrect readings (or for a poor line of best fit) which give a gradient out of range is not allowed.</i>		3	

- (ii) Candidate's answer for gradient in (b)(i) correctly multiplied by g (expected answer 4.6)✓

N ✓

No s.f. penalty.

The second mark is for the unit and can be awarded if the numerical answer is incorrect.

2

- (c) $\delta x\% = 0.2$ and $\delta y\% = 0.5$ ✓

$$\delta(x/y)\% = \delta x\% + \delta y\% = 0.2 + 0.5 = 0.7 \checkmark$$

$$\text{Use of } \delta(x/y)^2\% = 2 \times \delta(x/y)(\%) \checkmark$$

Final answer is $(\pm) 1.4 (\%)$ which automatically gains all three marks

Otherwise

Accept only 1 s.f. for 1st and/or 2nd marks.

The third mark is for the method, not the final answer

3

- (d) (i) Systematic errors in measurements are errors which show a pattern or a bias or a trend ✓

Some acceptable alternatives

- **A systematic error** is one which deviates by a fixed amount from the true value of a measurement
- An error which has the same value in all readings
- A difference between the true value of a quantity and the indicated value caused by a fault in the measuring device
- Accept a good example of systematic error.

1

- (ii) y would be larger✓

because angle θ would be smaller

or

because friction would be opposing the increasing weight of m ✓

2

[13]

7

- (a) (i) two from: velocity, acceleration, force etc ✓

1

- (ii) two from: speed, distance, mass etc ✓

1

- (b) (i) B: drag / air resistance ✓

C: weight ✓

2

- (ii) closed triangle (of vectors) ✓

so forces are in **equilibrium** / **resultant force is zero** / **forces balance**
(so moving at constant velocity) ✓

(c) $W = 9500 \sin 74$ ✓
 $= 9100$ ✓ (9132)
2 sf ✓

3

[9]

8

(a) (i) uses trigonometry ($mg \sin 5$ or $mg \cos 85$ seen)

B1

829.3 / 828.5 (N) at least 3 sf

B1

2

(ii) tension = 830 (N)

C1

$E = \frac{1}{2} F \Delta L$ **and** $F = k \Delta L$ identified / or combined to $E = \frac{1}{2} (F^2 / k)$

C1

correct sub condone power 10 error

C1

13.8 (J) range 13.9 to 13.7

A1

4

(b) lower speed

B1

less extension

B1

less energy stored (in rope)

B1

3

[9]

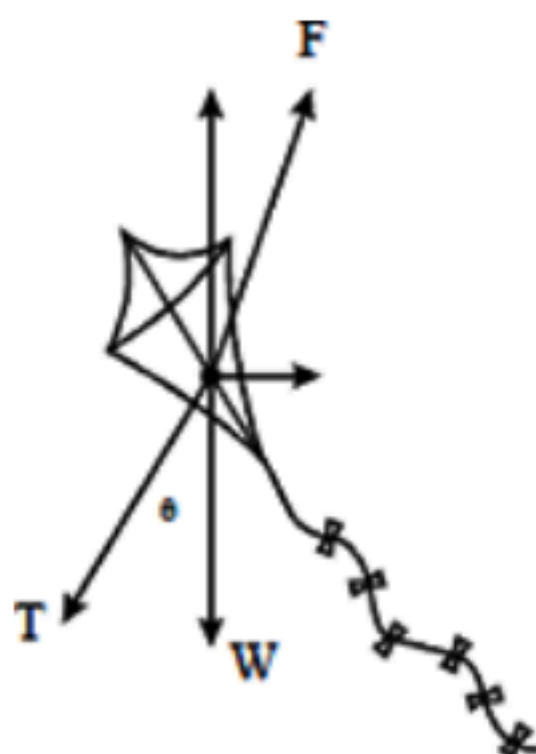
9	statement that forces up = forces down/correctly resolved vertical component of either drag or tension		
		C1	
	$2600 \sin 41 = W + 2200 \sin 27$ seen (or equivalent kN)		
		C1	
	$1705.8 = W + 998.8$ (condone power 10 error)		
	707/710 (N)		
		A1	3
			[3]

10	(a) (has magnitude but) no direction/has only magnitude		
		B1	1
	(b) (i) 1N: 3.9 or 4 cm/1 cm: 0.25 or 0.26 N		
		B1	1
	(ii) completes parallelogram correctly/or 'nose to tail'		
		M1	
	measures/draw correct diagonal		
		M1	
	2.1 ± 0.1 N		
		A1	3
			[5]

11	vertical component of rope = $610 \times \cos(20)$ or 573(N)	C1		[3]
	610 cos 20 seen in an equation			
	(vertical component of resultant) = $590 - 573$ or their F_v	C1		
	16.8 or 17(N) cao	A1		
12	(a) (i) velocity is constant (1)			[11]
	no acceleration (1)			
	(ii) $1.5 \sin 50 = D \cos 55$ (1)			
	2.0 kN (1)		4	
	(b) (i) 1.15 kN (1)			
	(ii) total resistance to motion = $1200 + 1150$ N (1)			
	use of power = Fv (1)			
	20 (1)			
	kW (1)		5	
	(c) boat now has resultant force of 1200 N acting on it (1)			
	boat will accelerate (until resistance of water = 2350 N) (1)		2	
13	(a) $2800/\cos 20 = 3000$ (2980)N (1)	B1	1	
	(b) 42000J (1)	B1	1	[2]

14

(a)



components at right angles (1)
 vertical component in line with the weight (1)
 vertical components to start from the •)

2

(b) (i) (horizontal component) = $25 \sin \theta = 12$ (or 13) N (12.5) (1)
 (± 0.5 N if scale drawing)

(ii) (vertical component) = $25 \cos \theta = 22$ N (21.7) (1)
 (± 0.5 N if scale drawing)

2

(c) (i) vertical component of $F = 21.7 + 2.5 = 24$ N (24.2)
 [or 25 (24.5)] (1) (allow C.E. from (b))

(ii) horizontal component of $F = 12$ (or 13) N (1) (12.5) (allow C.E. from (b))

(iii) $F = \sqrt{12.5^2 + 24.2^2}$ (1) (allow C.E. from parts (i) and (ii))
 $= 27$ N (27.2) [or 28 (28.2)] (1) (26 N to 29 N if scale drawing)

[if θ measured on diagram and $F \cos \theta$ used, (1) (1) (same tolerance)]

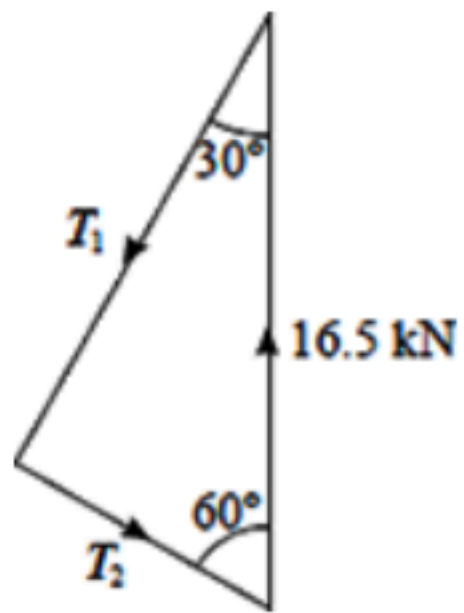
4

[8]**15**

(a) resultant force = zero
 (or the forces can be represented in magnitude and direction by the three sides of a triangle taken in order) (1)

(1)

(b)



scale drawing:

sensible scale used and stated **(1)**

arrows shown correctly **(1)**

one length measurement correctly stated **(1)**

both scale conversions correct to give $T_1 = 14 \text{ kN}$, $T_2 = 8 \text{ kN}$ **(1)**

[or by calculation: $T_1 = 16.5 \sin 60$ **(1)** 14.3 kN **(1)**

$$T_2 = 16.5 \cos 60 \text{ **(1)** } 8.3 \text{ kN **(1)**}$$

[or by resolving forces vertically and horizontally:

$$T_1 \sin 30 = T_2 \sin 60 \text{ **(1)**}$$

$$T_1 \cos 30 + T_2 \cos 60 = 16.5 \text{ (kN) **(1)**}$$

gives $T_1 = 14.3 \text{ kN}$ **(1)** and $T_2 = 8.3 \text{ kN}$ **(1)**

(4)

[5]