Vectors and Scalars AS Revision Pack

Name:

Class:

Date:

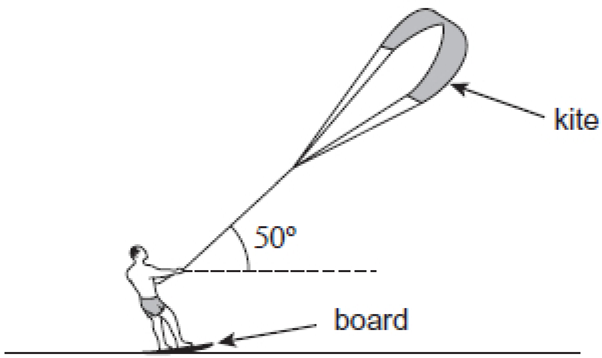
Time: **196 minutes**

Marks: **165 marks**

Comments:

1 **Figure 1** shows a kite boarder holding a line that is attached to a kite.

Figure 1



The wind blows the kite and the kite boarder moves at a constant speed across a level water surface. The tension in the line is 720 N and the line makes an angle of 50° to the horizontal.

(a) (i) Calculate the vertical component of the tension in the line.

vertical component of tension ____________________ N

(2)

(ii) The kite boarder has a mass of 58 kg.

Calculate the normal reaction of the board on the kite boarder.

normal reaction ____________________ N

(2)

(iii) Suggest how the answer to part **(a)(ii)** compares with the upthrust of the water on the board.

Consider the board to have negligible mass.

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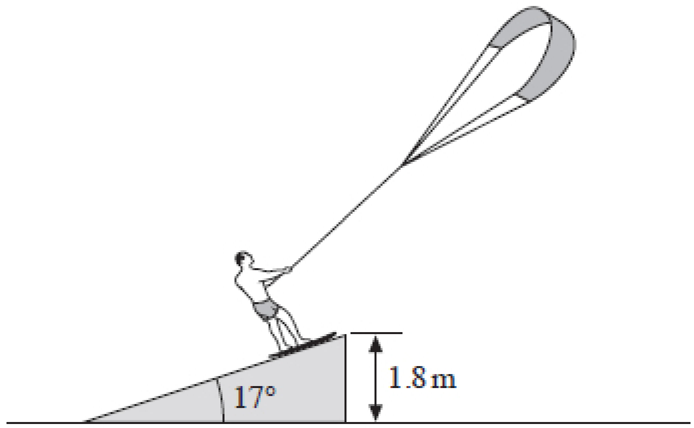
(2)

(b) **Figure 2** shows the kite boarder about to perform a jump using a ramp.

Figure 2



The end of the ramp is 1.8 m above the water surface. The kite boarder leaves the ramp at a velocity of 12 m s^{-1} and at an angle of 17° to the horizontal. The kite boarder lets go of the line at the instant he leaves the ramp.

Calculate the speed with which the kite boarder enters the water.

Assume that the kite boarder is a point mass and ignore the effects of air resistance.

speed ____________________ m s^{-1}

(4)

(Total 10 marks)

2 (a) Indicate with ticks (✓) in the table below which of the quantities are vectors and which are scalars.

	Velocity	**Speed**	**Distance**	**Displacement**
vector				
scalar				

(2)

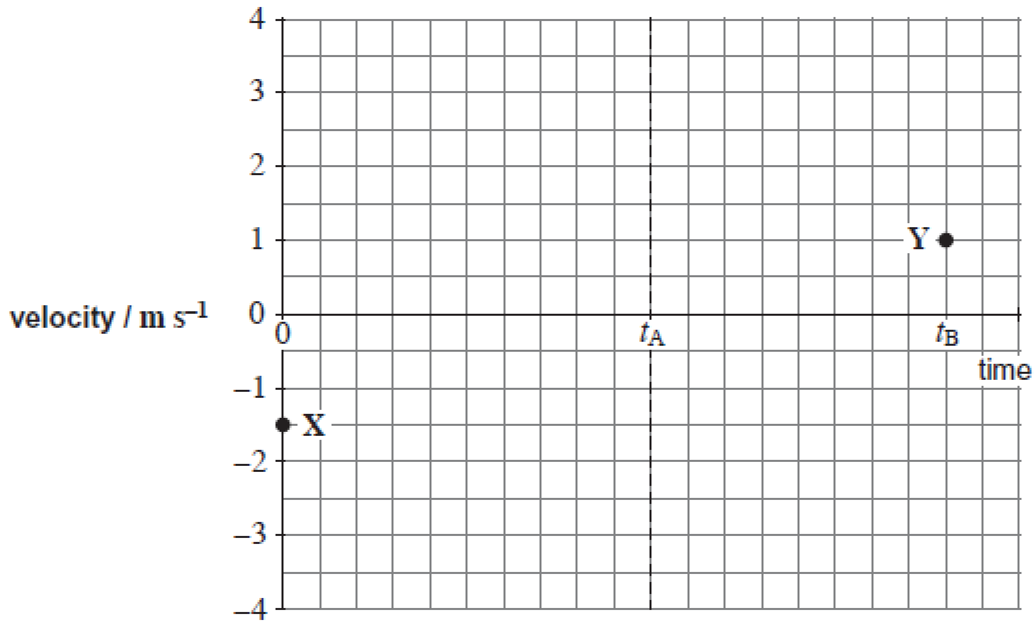
(b) A tennis ball is thrown vertically downwards and bounces on the ground. The ball leaves the hand with an initial speed of 1.5 m s^{-1} at a height of 0.65 m above the ground. The ball rebounds and is caught when travelling upwards with a speed of 1.0 m s^{-1}.

Assume that air resistance is negligible.

(i) Show that the speed of the ball is about 4 m s^{-1} just before it strikes the ground.

(3)

(ii) The ball is released at time t = 0. It hits the ground at time t_A and is caught at time t_B. On the graph, sketch a velocity−time graph for the vertical motion of the tennis ball from when it leaves the hand to when it returns. The initial velocity **X** and final velocity **Y** are marked.



(3)

(c) In a game of tennis, a ball is hit horizontally at a height of 1.2 m and travels a horizontal distance of 5.0 m before reaching the ground. The ball is at rest when hit.

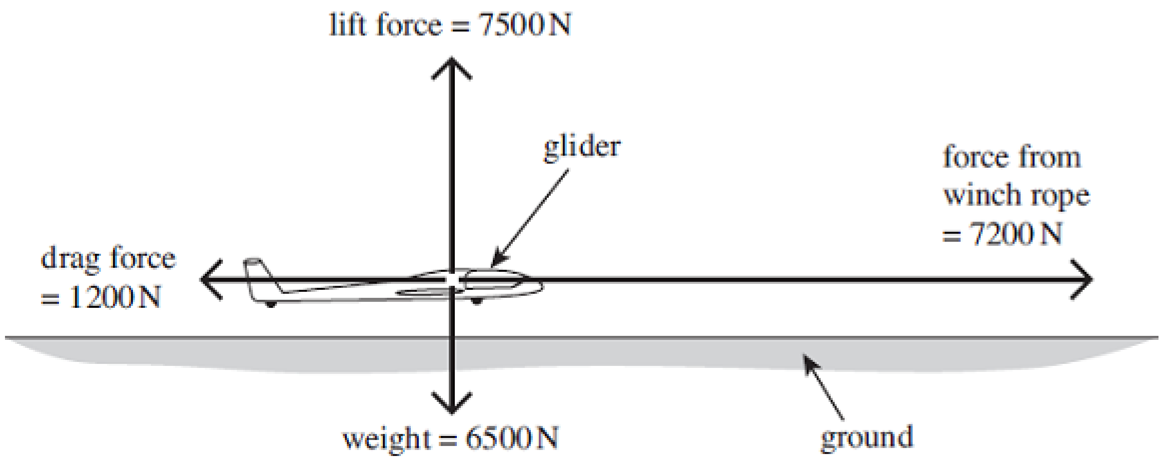
Calculate the initial horizontal velocity given to the ball when it was hit.

horizontal velocity = ____________________ m s^{-1}

(3)

(Total 11 marks)

3 Gliders can be launched with a winch situated on the ground. The winch pulls a rope that is attached to the glider. The diagram below shows the forces acting on the glider at one instant during the launch.



(a) The combined weight of the glider and pilot is 6500 N.

(i) Show that the magnitude of the resultant force acting on the glider is about 6100 N.

(2)

(ii) Calculate the angle between this resultant force and the horizontal.

angle ____________________ degrees

(2)

(iii) Calculate the resultant acceleration of the glider in the diagram above.

resultant acceleration ____________________ m s^{-2}

(2)

(b) The glider climbs a vertical distance of 600 m in 55 s. The average power input to the winch motor during the launch is 320 kW.

(i) Calculate the gain in gravitational potential energy (gpe) of the glider.

gain in gpe ____________________ J

(2)

(ii) Calculate the percentage efficiency of the winch system used to launch the glider. Assume the kinetic energy of the glider after the launch is negligible.

efficiency ____________________ %

(3)

(Total 11 marks)

4 (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 1a

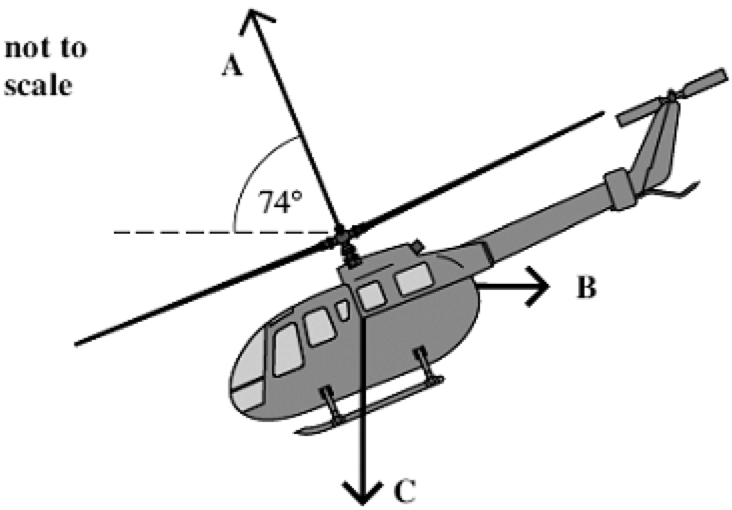
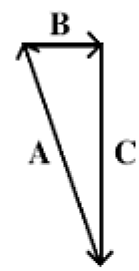


Figure 1b



(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.

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(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

(3)

(Total 9 marks)

5 **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

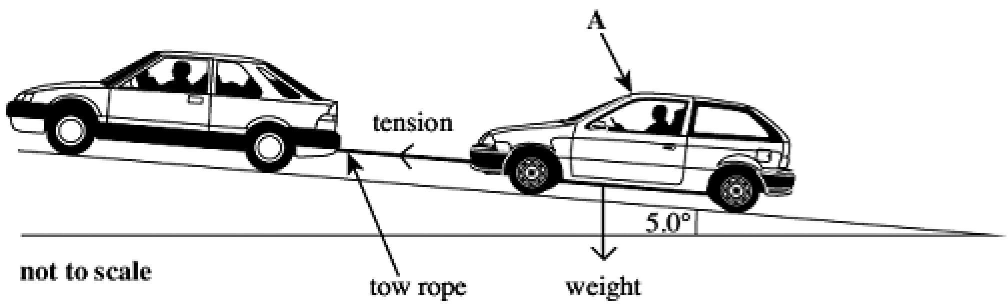
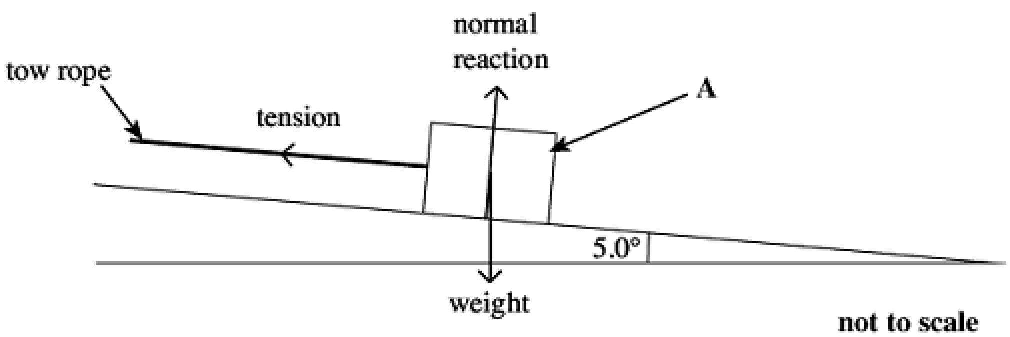


Figure 2 represents a simplified version of the forces acting on car **A** at the instant shown in **Figure 1**.

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.

(2)

(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 2.5×10^{4} 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 2.5×10^{4} Nm^{-1}.

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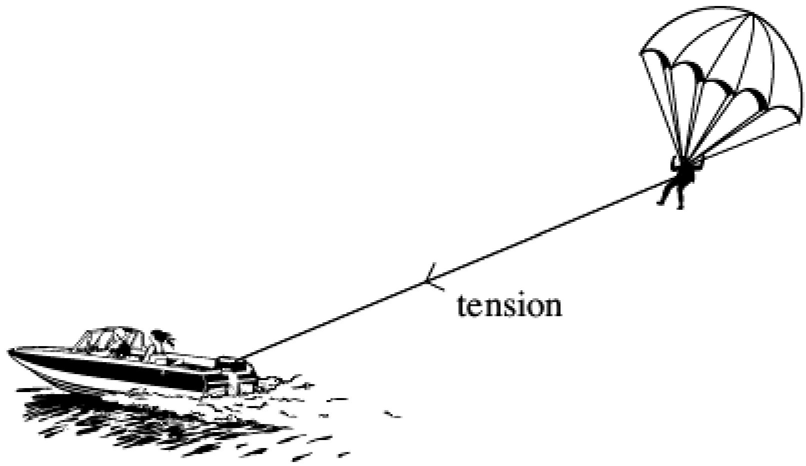
(3)

(Total 9 marks)

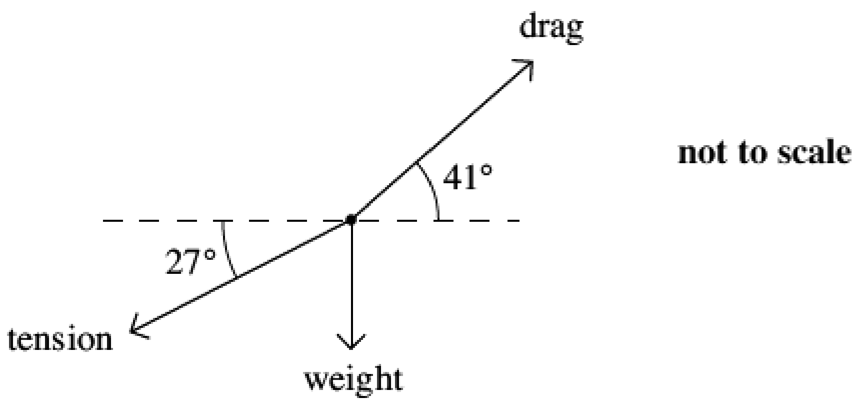
6 **Figure 1** shows a parascender being towed at a constant velocity.

Figure 1



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

Figure 2



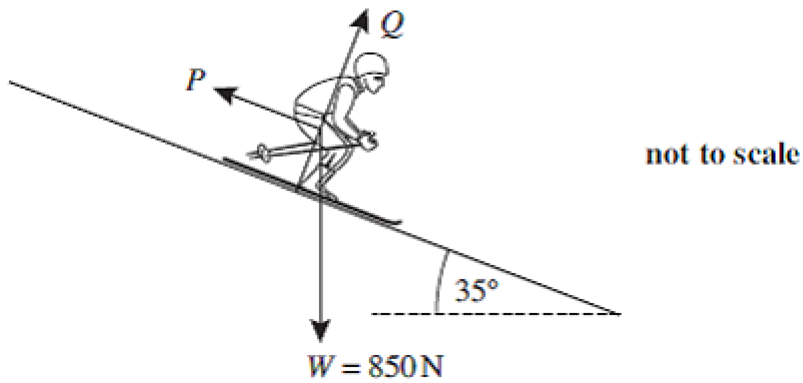
The rope towing the parascender makes an angle of 27° with the horizontal and has a tension of 2.2 kN. The drag force of 2.6 kN acts at an angle of 41° to the horizontal. Calculate the weight of the parascender.

weight ______________________ N

(Total 3 marks)

7 (a) **Figure 1** 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.

Figure 1



(i) Identify the forces labelled **P** and **Q**.

P ____

____

Q ____

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(2)

(ii) State the condition necessary for the skier to be travelling at a constant velocity.

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____

(1)

(b) **Figure 2** shows an arrow representing the weight, W, of the skier. The arrow has been drawn to scale.

Figure 2

scale 1 cm: 100 N

By drawing the forces **P** and **Q** onto **Figure 2**, complete the scale diagram and determine the magnitude of the force **P**.

magnitude of force **P** ______________________ N

(4)

(c) (i) The skier moves onto level snow. Initially the magnitude of force **P** remains constant. The mass of the skier is 87 kg.
Calculate the initial deceleration of the skier.

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deceleration ______________________ ms^{-2}

(2)

(ii) State and explain what would happen to the deceleration as the skier continues along the level snow.

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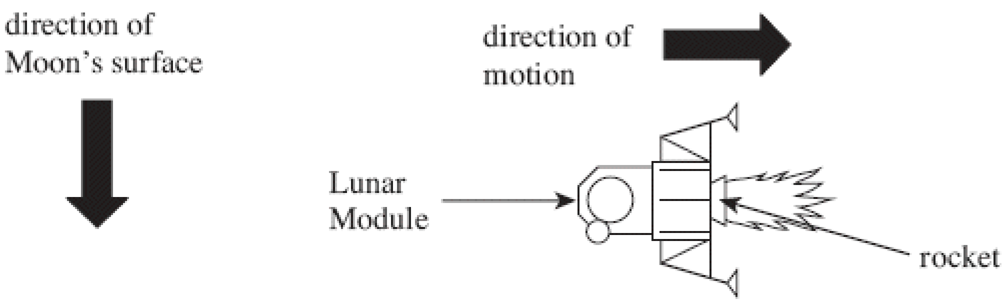
(2)

(Total 11 marks)

8 In the 1969 Moon landing, the Lunar Module separated from the Command Module above the surface of the Moon when it was travelling at a horizontal speed of 2040 m ss^{-1}.
In order to descend to the Moon's surface the Lunar Module needed to reduce its speed using its rocket as shown in **Figure 1**.

Figure 1



(a) (i) The average thrust from the rocket was 30 kN and the mass of the Lunar Module was 15100 kg. Calculate the horizontal deceleration of the Lunar Module.

answer = ______________________ m s^{-2}

(2)

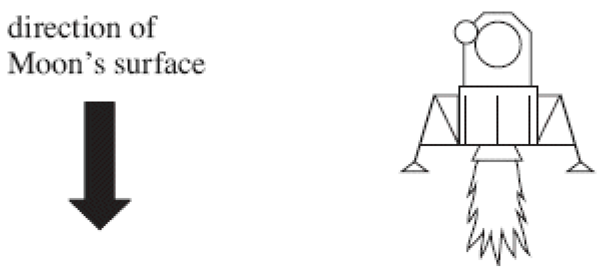
(ii) Calculate the time for the Lunar Module to slow to the required horizontal velocity of 150 m s^{-1}. Assume the mass remained constant.

answer = ______________________ s

(2)

(b) The rocket was then used to control the velocity of descent so that the Lunar Module descended vertically with a constant velocity as shown in **Figure 2**. Due to the use of fuel during the previous deceleration, the mass of the Lunar Module had fallen by 53%.

Figure 2



acceleration due to gravity near the Moon's surface = 1.61 m s^{-2}

(i) Draw force vectors on **Figure 2** to show the forces acting on the Lunar Module at this time. Label the vectors.

(2)

(ii) Calculate the thrust force needed to maintain a constant vertical downwards velocity.

answer = ______________________ N

(2)

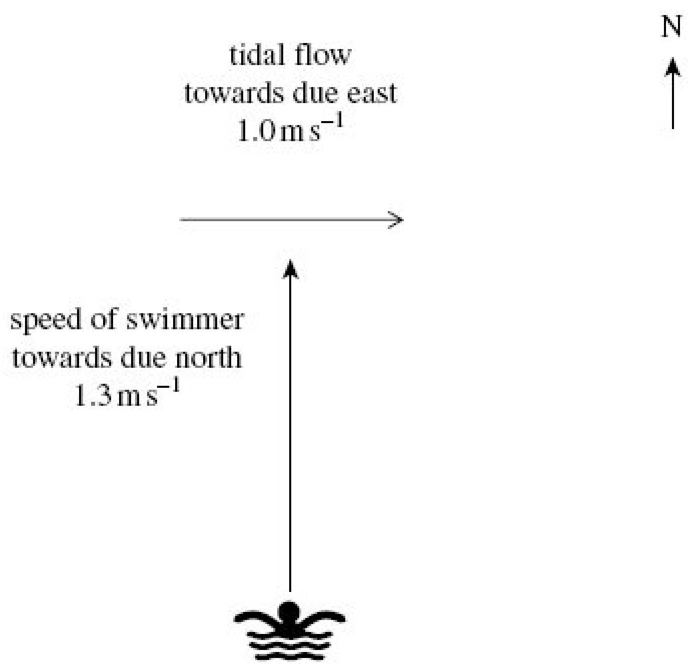
(c) When the Lunar Module was 1.2 m from the lunar surface, the rocket was switched off. At this point the vertical velocity was 0.80 m s^{-1}. Calculate the vertical velocity at which the Lunar Module reached the lunar surface.

answer = ______________________ m s^{-1}

(2)

(Total 10 marks)

9 The diagram below shows a long-distance swimmer swimming due north at 1.3 m s^{-1} in a tide that flows at 1.0 m s^{-1} due east.



(a) Calculate the magnitude of the resultant velocity of the swimmer.

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___

___

magnitude of resultant velocity ____________________ m s^{-1}

(2)

(b) Calculate the angle the resultant velocity of the swimmer makes with due north.

angle ____________________ degrees

(2)

(Total 4 marks)

10 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

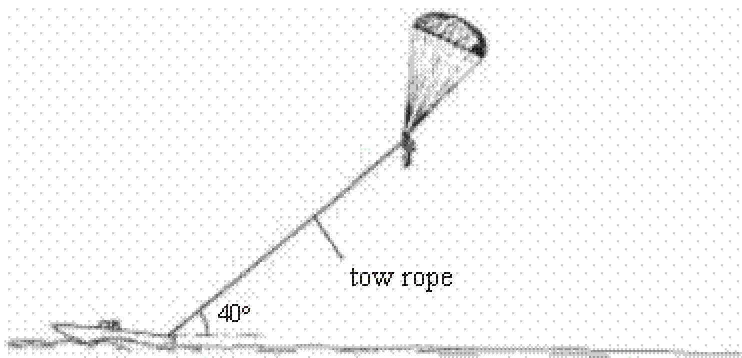

Figure 2

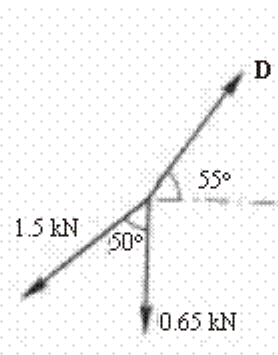

Figure 2 shows the directions of the forces acting on a person of weight 0.65 kN when being towed horizontally at a constant speed of 8.5 m s^{-1}.

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.

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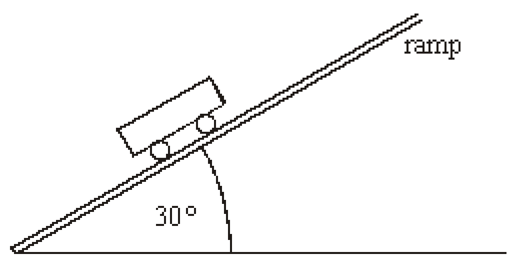
(2)

(Total 11 marks)

11 A fairground ride ends with the car moving up a ramp at a slope of 30° to the horizontal as shown in the figure below.



(a) The car and its passengers have a total weight of 7.2×10^3 N. Show that the component of the weight parallel to the ramp is 3.6×10^3 N.

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(1)

(b) Calculate the deceleration of the car assuming the only force causing the car to decelerate is that calculated in part (a).

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(2)

(c) The car enters at the bottom of the ramp at 18 m s^{-1}. Calculate the minimum length of the ramp for the car to stop before it reaches the end. The length of the car should be neglected.

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(2)

(d) Explain why the stopping distance is, in practice, shorter than the value calculated in part (c).

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(2)

(Total 7 marks)

12 (a) State the difference between vector and scalar quantities.

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(1)

(b) State **one** example of a vector quantity (other than force) and **one** example of a scalar quantity.

vector quantity ___

scalar quantity ___

(2)

(c) A 12.0 N force and a 8.0 N force act on a body of mass 6.5 kg at the same time. For this body, calculate

(i) the maximum resultant acceleration that it could experience,

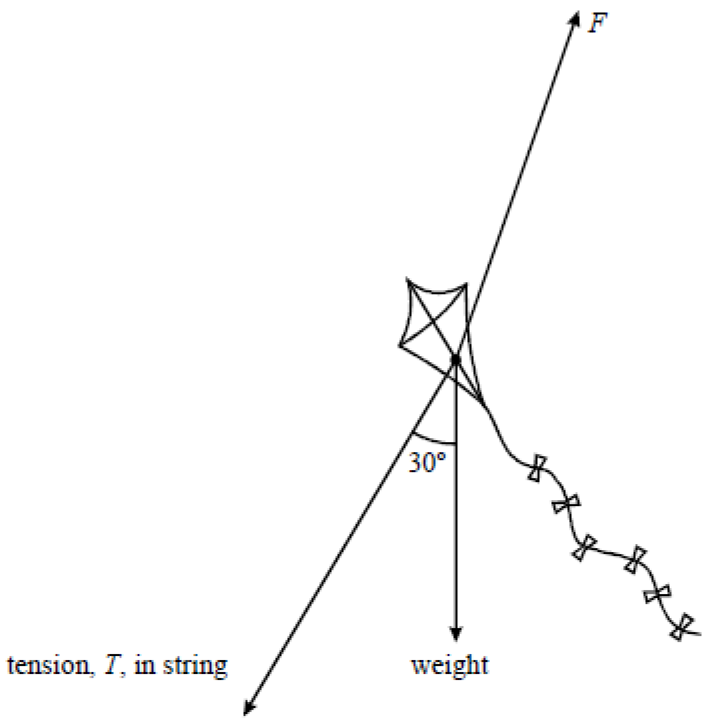
___

___

(ii) the minimum resultant acceleration that it could experience.

(4)
(Total 7 marks)

13 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.

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

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(iii) Hence calculate the magnitude of F.

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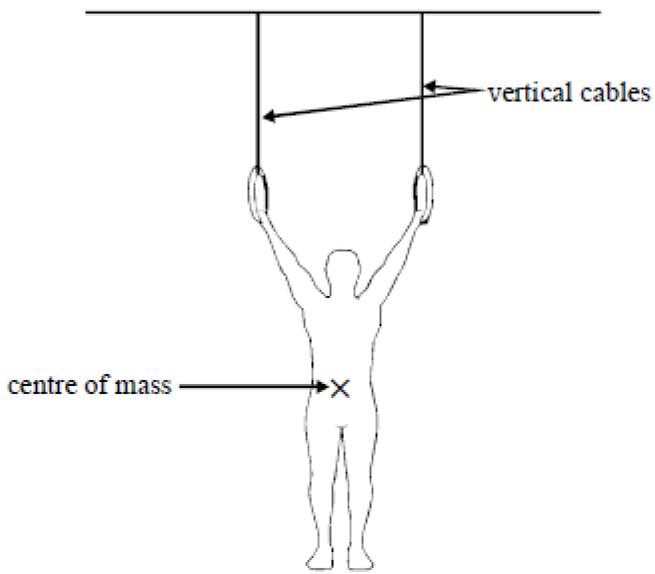
(4)

(Total 8 marks)

14 The diagram shows a gymnast of weight 720 N hanging centrally from two rings, each attached to cables which hang vertically.



(a) State the tension in each cable.

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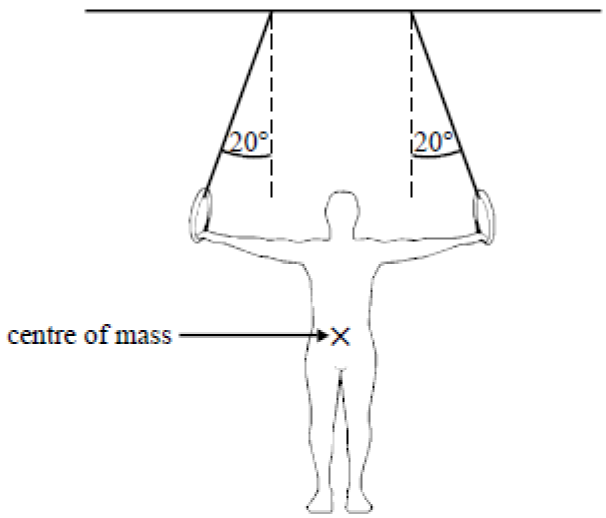
(1)

(b) The diagram shows the gymnast after he has raised his body so that his centre of mass moves through a vertical distance of 0.60 m.



Calculate

(i) the increase in gravitational potential energy of the gymnast,

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___

(ii) the tension in each cable.

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(3)

(c) The gymnast now raises his legs so that they become horizontal, without raising the rest of his body. State and explain whether his gravitational potential energy is changed by this manoeuvre.

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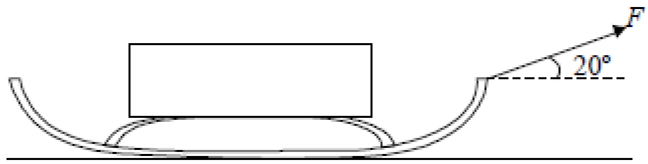
(2)
(Total 6 marks)

15 A heavy sledge is pulled across snowfields. The diagram shows the direction of the force F exerted on the sledge. Once the sledge is moving, the average horizontal force needed to keep it moving at a steady speed over level ground is 300 N.



(a) Calculate the force F needed to produce a horizontal component of 300 N on the sledge.

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(1)

(b) (i) Explain why the work done in pulling the sledge **cannot** be calculated by multiplying F by the distance the sledge is pulled.

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(ii) Calculate the work done in pulling the sledge a distance of 8.0 km over level ground.

____

____

(iii) Calculate the average power used to pull the sledge 8.0 km in 5.0 hours.

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(6)

(c) The same average power is maintained when pulling the sledge uphill. Explain **in terms of energy transformations** why it would take longer than 5.0 hours to cover 8.0 km uphill.

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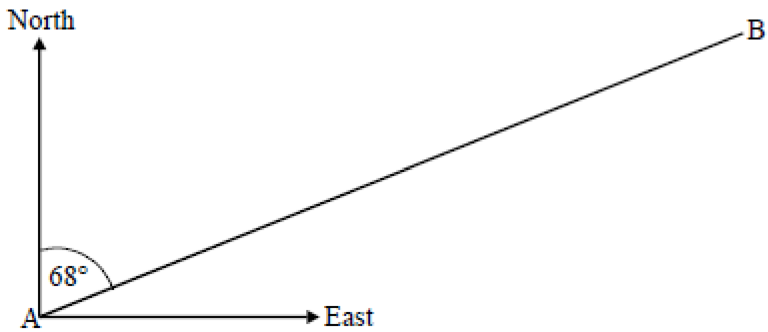
(3)
(Total 10 marks)

16 A microlight is a small aircraft powered by a petrol engine. The diagram represents the flight path, AB, of a microlight on a short horizontal training flight.



(a) On its outward journey, the wind velocity is 7.5 m s^{-1} due North and the resultant velocity of the microlight is 20 m s^{-1} in a direction 68° East of North, so that it travels along AB.

(i) Show that for the aircraft to travel along AB at 20 m s^{-1} it should be pointed due East.

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(ii) The driving force of the aircraft engine is 2.0×10^3 N. Calculate the work done by the engine if the aircraft travels 10 km on its outward journey.

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(iii) Calculate the output power of the aircraft engine for the outward journey.

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(6)

(b) After flying 10km, the aircraft turns round and returns along the same flight path at a resultant velocity of 14 m s^{-1}. Assuming that the turn-round time is negligible, calculate the average speed for the complete journey.

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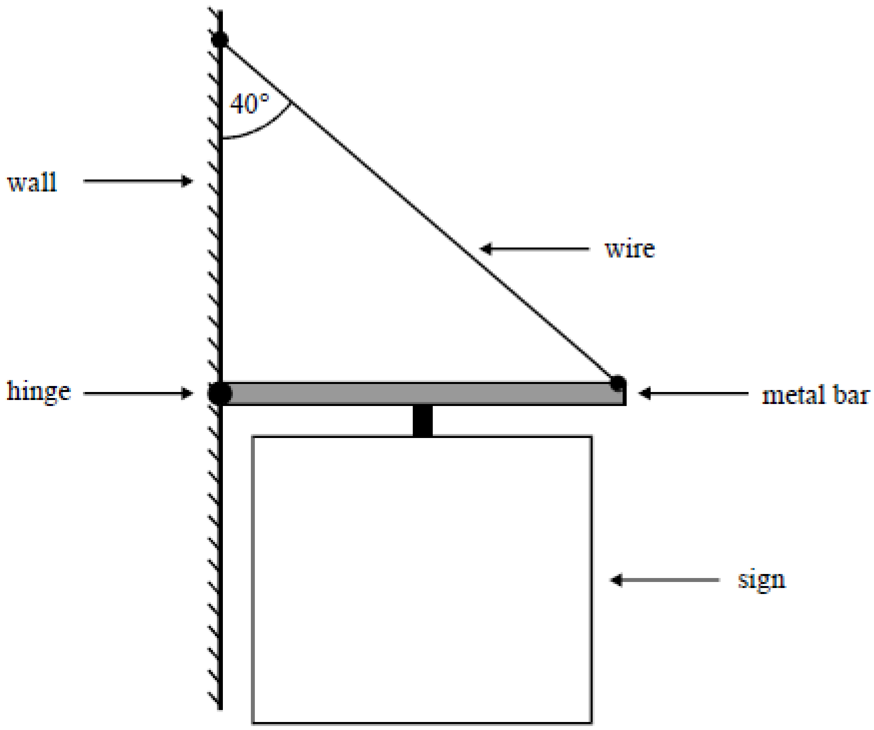
(2)

(Total 8 marks)

17 A public house sign is fixed to a vertical wall as shown in the diagram.



A uniform metal bar 0.75 m long is fixed to the wall by a hinged joint that allows free movement in the vertical plane only. The wire is fixed to the wall directly above the hinge and to the free end of the horizontal metal bar. The wire makes an angle of 40° with the wall.
A single support holds the sign and is mounted at the mid point of the metal bar so that the weight of the sign acts through that point.

(a) (i) Draw on the diagram three arrows showing the forces acting on the metal bar, given that the system is in equilibrium. Label the arrows A, B and C.

(ii) State the origin of the forces.

A ____

B ____

C ____

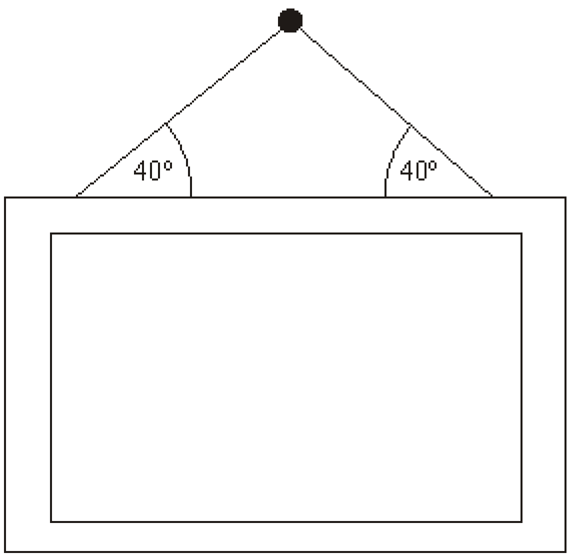
(5)

(b) The combined mass of the metal bar and sign is 12 kg and the mass of the wire is negligible. By taking moments about the hinged end of the bar, or otherwise, calculate the tension in the wire.

(4)

(Total 9 marks)

18 The figure below shows a heavy mirror hanging symmetrically from a nail fixed to a wall. It is supported by a strong cord attached at two points on its top edge.



(a) Draw and clearly label **three** arrows on the figure above to show the forces acting **on** the mirror in the vertical plane.

(3)

(b) The tension in the cord is 39 N and the angle that each end of the cord makes with the horizontal is 40°. Calculate the vertical component of the tension in the cord and hence the weight of the mirror.

vertical component of the tension ____________________

weight of the mirror ______________________________

(3)

(Total 6 marks)

19 **Figure 1** shows an arrow about to be released from a bow.

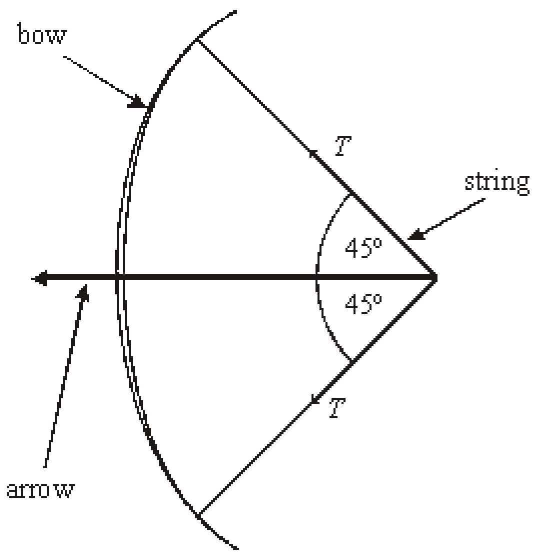


Figure 1

When the arrow is released the initial forward force on it is 25 N.

(a) Find, by means of a calculation or scale drawing, the initial tension, *T*, in the string of the bow.

tension ____________________

(2)

(b) The graph in **Figure 2** shows the variation of *F* with *d*, where *F* is the force on the arrow and *d* is the distance the string is pulled back.

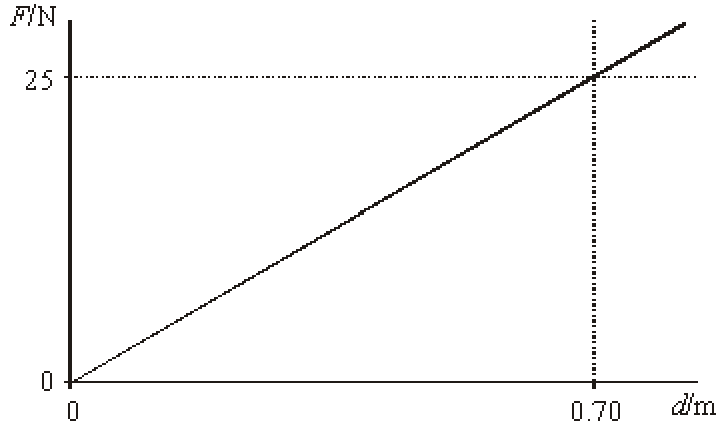


Figure 2

Calculate the initial energy stored in the bow as the arrow is about to be released.

energy ____________________

(2)

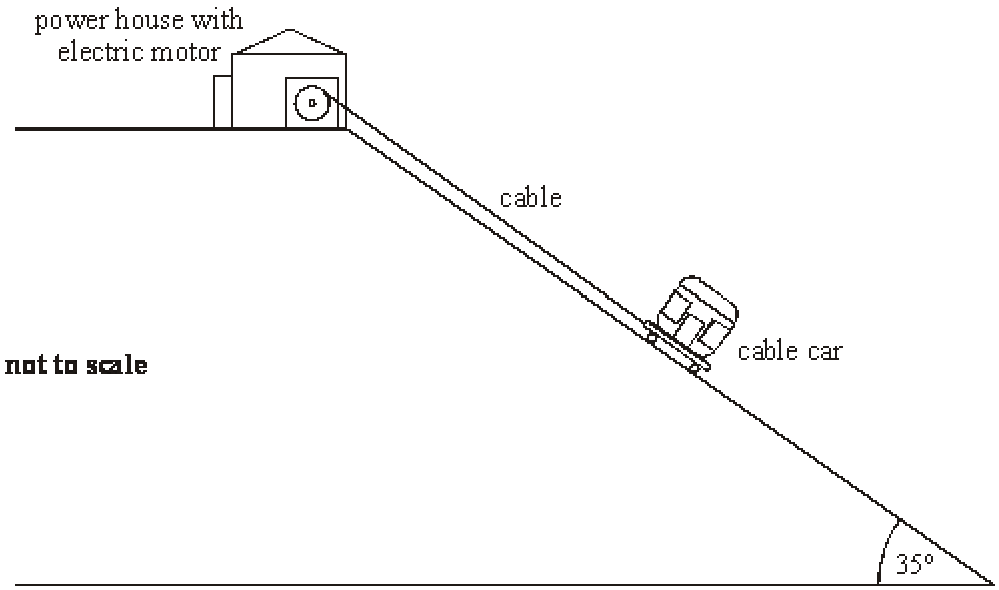
(c) Calculate the energy stored in the bow when the string is pulled back a distance of 0.60 m.

energy ____________________

(2)

(Total 6 marks)

20 The figure below shows a cable car being pulled up a 35° slope of length 120 m.



The cable car has a weight of 1.5×10^4 N. The total frictional force resisting motion is 3.0×10^3 N.

the gravitational field strength, g = 9.8 N kg^{-1}

(a) (i) Show that the component of the weight of the cable car parallel to the slope is 8600 N.

(1)

(ii) Calculate the tension in the cable when the cable car is moving at a constant speed up the slope.

tension ____________________

(1)

(b) The cable snaps when the cable car is at rest at the top of the slope. The frictional force remains constant at 3.0×10^3 N.

Calculate:

(i) the acceleration of the cable car down the slope;

acceleration ____________________

(3)

(ii) the speed of the cable car when it reaches the bottom of the slope;

speed ____________________

(2)

(iii) the time taken for the cable car to reach the bottom of the slope.

time taken ____________________

(2)

(Total 9 marks)

Mark schemes

1 (a) (i) 720 sin 50° or 720 cos 40°
550 (552) (N)

2

(ii) 58 × 9.81 or 569 seen
19 (N)

Allow 569-(their (a)(i) for 2 marks

2

(iii) Upthrust is same as normal reaction (or same as their (a)(ii)
Newton's 2nd or 3rd Law or Archimedes' Principle reason given

2

(b) u_h = 12 cos 17° or 11.5 (m s^{-1}) seen
u_v = 12 sin 17° or 3.5 (m s^{-1}) seen
Use of $v^2 = u^2 + 2as$ with either 3.5 or 1.8 or v_v = 6.9 (m s^{-1})
13.4 (m s^{-1})

OR

Initial KE = 0.5 × 58 × 12^2 or 4176 (J) seen
ΔGPE = 58 × 9.81 × 1.8 or 1024 (J) seen
or v = √(2 × 9.81 × 1.8) or 5.9 (m s^{-1}) seen
Final KE = 5200 (J) or v = √(2.KE/m)
13.4 (m s^{-1})

Allow valid suvat arguments that use time of flight

4

[10]

2 (a) Velocity and speed correct ✓
Distance and displacement correct ✓

	velocity	speed	distance	displacement
vector	✓			✓
scalar		✓	✓	

2

(b) (i) $v^2 = u^2 + 2as$

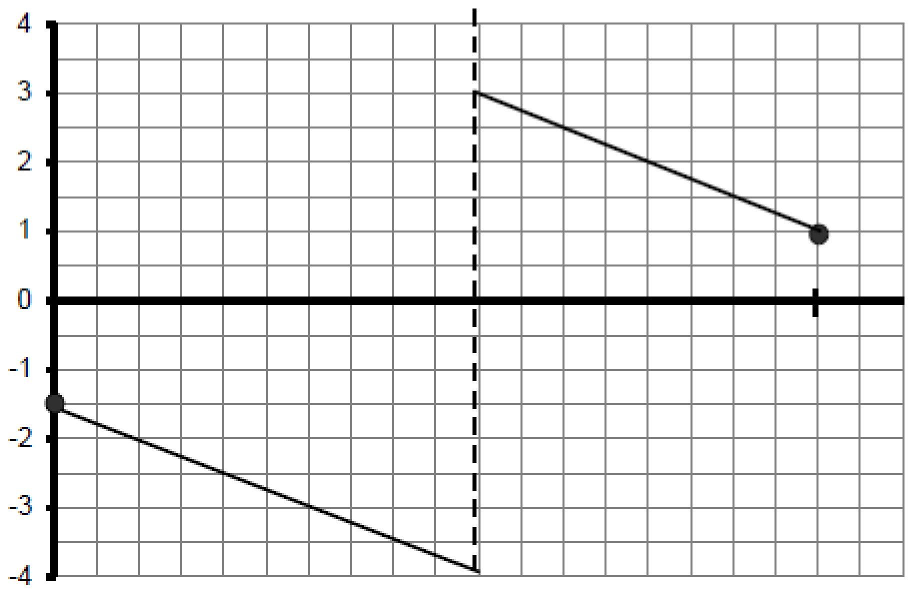
$v = \sqrt{u^2 + 2as}$ ✓ $v = \sqrt{1.5^2 + 2 \times 9.81 \times 0.65}$ ✓

= (−)3.9 (m s^{-1}) ✓two or more sig fig needed (− 3.87337 m s^{-1})

1st mark for equation rearranged to make v the subject (note sq' root may be implied by a later calculation) penalise the use of g = 10 m s^2 only on this question
2nd mark for substituting numbers into any valid equation
3rd mark for answer
Alt' approach is gainKE = lossPE
missing out u gives zero marks
answer only gains one mark [Note it is possible to achieve the correct answer by a wrong calculation]

3

(ii) **velocity / ms^{-1}**



first line descends from X to the dotted line at t_A or up to one division sooner ✓ (allow line to curve)

first line is straight and descends from X to v = −4 (m s^{-1}) ✓(allow tolerance one division)
second line has same gradient as the first, straight and descends to v = 1(m s^{-1}) ✓(tolerance ½ division)
a steep line may join the two straight lines but its width must be less than 2 divisions

3

(c) $s = ut + 1/2at^2$

$t = \sqrt{\frac{2s}{a}}$ OR correct substitution seen into either equation $t = \sqrt{\frac{2 \times 1.2}{9.81}}$ ✓

= 0.49 (s) ✓ (0.4946 s)

working must be shown for the first mark but not the subsequent marks

$v = s / t$

= 5.0 / 0.49 = 10 (m s^{-1}) ✓ (10.2 m s^{-1}) (allow CE from their time)

[note it is possible to achieve the correct answer by a wrong calculation]

3

[11]

3 (a) (i) 1000(N) AND 6000(N) seen

Independent marks

OR

$F = \sqrt{(1000)^2 + (6000)^2}$ ✓ allow incorrect values seen

= **6083** (N) (= 6100) ✓ More than 2 sf seen

Allow full credit for appropriate scale drawing

Ignore rounding errors in 3rd sig fig.

2

(ii) tanϴ = 1000 / 6000 or correct use of sin or cos ✓

ϴ = 9.5 (9.46°) ✓

Allow range 9.4 − 10.4

Use of cos yields 10.4

Allow use of 6100

Some working required for 2 marks.

Max 1 mark for correct calculation of vertical angle (range 79.6 − 80.6) some working must be seen

2

(iii) ($m = W/g =$) 6500 / 9.81 (= 662.6 kg) ✓

($a = F / m$ = 6083 / 662.6)

= 9.2 (ms^{-2}) ✓ (9.180)

Use of weight rather than mass gets zero

Correct answer on its own gets 2 marks

Penalise use of g=10 in this question part only (max 1)

2

(b) (i) = 6500 × 600 ✓ (662.6 × 9.81 × 600)

= 3 900 000 ✓ (J)

Look out for W x g x h which gives 39000000 (gets zero)

Correct answer on its own gets 2 marks

Do not allow use of 1/2 mv² (= 39 000)

2

(ii) (E= Pt =) 320 000 ×; 55 (= 17 600 k J)
OR P= 1(b)(i) / 55 (7.09 × 10^4) ✓
3.9 / 17.6 OR 70.9 / 320 OR = 0.22(16) ✓ ecf from first line

Some valid working required for 3 marks

conversion to a percentage (= 22 %) ✓

Look out for physics error: Power / time (320/55) then use of inverted efficiency equation yielding correct answer
Do not allow percentages >= 100% for third mark

3

[11]

4 (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) ✓

2

(c) *W* = 9500 sin 74 ✓

= 9100 ✓ (9132)

2 sf ✓

3

[9]

5 (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

$E = ½ F\Delta L$ **and** $F = k\,\Delta L$ identified / or combined to $E = ½ (F^2/k)$

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]

6 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]

7 (a) (i) air resistance/drag

B1

(normal) reaction (of the ground on the skier)

B1

2

(ii) no resultant force (in any direction)/forces in equilibrium

B1

1

(b) any closed triangle with *W* as a complete side

M1

closed triangle with correct lengths or angles even if *P* and *Q* are reserved

A1

correct triangle by eye

A1

force correct 490 ± 20 N

B1

4

(c) (i) appropriate force/87 **ecf**

C1

5.4 to 5.9 ms^{-2} **cao**

A1

2

(ii) deceleration would decrease

B1

resistance forces increase with speed/are proportional to speed^2/

resultant force gets smaller as speed gets less

B1

2

[11]

8 (a) (i) $\left(a = \frac{F}{m}\right) = \frac{(-)30(000)}{15100}$ **(1)** = (–)2.0 (= 1.99 m s^{-2}) **(1)**

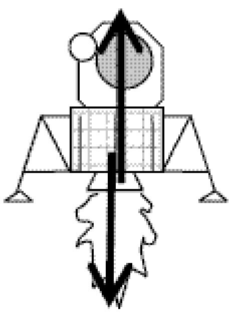
2

(ii) ($v = u + at$) $t = \frac{v - u}{a}$ or substitution **(1)**

$= \left(\frac{150 - 20401}{-1.99}\right)$ = 950 (s) **(1)** ecf from (i)

2

(b) (i)



opposing vertical arrows of roughly equal length **or** labelled weight/mg/gravity/W **and** thrust/reaction/R/F/TF/engine force/rocket force/motor force/motive force/driving force **(1)**

correctly labelled
+ arrows vertical
+ not more than 2 mm apart
+ roughly central
+ weight arrow originates within rectangular section and thrust originates within rectangular section or on jet outlet **(1)**

2

(ii) new mass = 15100 × 0.47 = 7097 (kg) **(1)**

(F = mg = 7097 × 16(1)) = 11000 (= 11426 N) **(1)**

2

(c) ($v^2 = u^2 + 2as$ $v = \sqrt{0.80^2 + 2 \times 1.61 \times 1.2)}$ correct u, a and s clearly identified **(1)**

= 2.1 (= 2.122 m s^{-1}) **(1)**

2

[10]

9 (a) $\sqrt{(1.3^2 + 1.0^2)}$

C1

1.6/1.64 (m s^{-1})

A1

2

(b) angle = $\tan^{-1}$ (1.0/1.3)

C1

N38°E/N37.6°E

A1

2

[4]

10 (a) (i) velocity is constant **(1)**

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

[11]

11 (a) component (parallel to ramp) = $7.2 \times 10^3 \times \sin 30$ **(1)** (= 3.6×10^3 N)

1

(b) mass = $\frac{7.2 \times 10^3}{9.81}$ = 734 (kg) **(1)**

$a = \frac{3600}{734}$ = 4.9(1) m s^{-2} **(1)**

2

(c) (use of $v^2 = u^2 + 2as$ gives) $0 = 18^2 - (2 \times 4.9 \times s)$ **(1)**
$s = 33(.1)$ m **(1)**
(allow C.E. for value of a from (b))

2

(d) frictional forces are acting **(1)**
increasing resultant force [or opposing motion] **(1)**
hence higher deceleration [or car stops quicker] **(1)**
energy is lost as thermal energy/heat **(1)** □

Max 2

[7]

12 (a) vector quantities have direction (as well as magnitude) and scalar quantities do not **(1)**

1

(b) vector: e.g. velocity, acceleration, momentum **(1)**
scalar: e.g. mass, temperature, energy **(1)**

2

(c) (i) addition of forces (12 + 8) **(1)**
(use of $F = ma$ gives) $a = \frac{(12+8)}{6.5} = 3.1 \text{ m s}^{-2}$ **(1)** (3.08 m s^{-2})

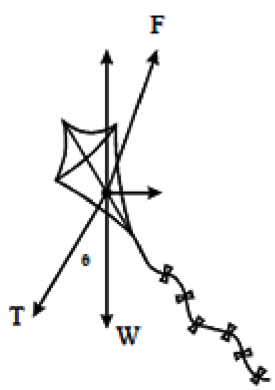
(ii) subtraction of forces (12 – 8) **(1)**

$a = \frac{(12-8)}{6.5} = 0.62 \text{ m s}^{-2}$ **(1)** (0.615 m s^{-2})

4

[7]

13 (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 θ = 12 (or 13) N (12.5) **(1)**
(± 0.5N if scale drawing)

(ii) (vertical component) = 25 cos θ = 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 cosθ used, (1) (1) (same tolerance)]

4

[8]

14 (a) 360 N **(1)**

(1)

(b) (i) ($E_p = mgh$ gives) E_p = 720 × 0.6 = 4.3 × 10^2 J **(1)**

(ii) T cos 20° **(1)** = 360 (N)
T = 380 N **(1)**
(allow e.c.f from (a))

(3)

(c) (potential energy) changes **(1)**
centre of mass/gravity moves upwards **(1)**

The Quality of Written Communication marks were awarded primarily for the quality of answers to this part

(2)

[6]

15 (a) F cos 20 = 300 gives F = 319 N **(1)**

(1)

(b) (i) work done = force × distance moved <u>in direction of force</u> **(1)**
F is not in the direction of motion **(1)**

(ii) work done = force × distance = 300 × 8000 = 2.4 × 10^6 J

(iii) power = $\frac{\text{work done}}{\text{time taken}}$ **(1)**

= $\frac{2.4}{5.0 \times (60 \times 60)} \times 10^6$ **(1)** (allow e.c.f. for work done in (ii))

= 133 W **(1)** (allow e.c.f. for incorrect time conversion)

(6)

(c) on the level, work is done only against friction **(1)**
uphill, more work must be done to <u>increase in potential energy</u> **(1)**
sensible conclusion drawn

(e.g. increased work at constant power requires longer time) **(1)**

(3)

[10]

16 (a) (i) component velocity North = 20 cos68° **(1)**
= 7.5 m s^{-1}
which is supplied by wind **(1)**
by triangle of velocities [or by components] (aircraft must point East) **(1)**

alternative (a)(i)
triangle or parallelogram of velocities **(1)**
find angle between aircraft component and wind using sine and cosine formulae – prove 90° **(1)** **(1)**

(ii) work done = $Fs\cos\theta$ [or force × distance moved in direction of force or $2.0 \times 10^3 \times 10 \times 10^3 \cos 22°$] **(1)**
= $1.8(5) \times 10^7$ J **(1)**

(iii) power = $\dfrac{\text{work done}}{\text{time taken}} = 1.8(5) \times 10^7 \div \left(\dfrac{10000}{20}\right)$ **(1)**

= 3.6×10^4 W **(1)**

alternative (iii)
power = force × velocity component East = $2.0 \times 10^3 \times 20\cos 22°$ **(1)**
= 3.6×10^4 W **(1)**

(max 6)

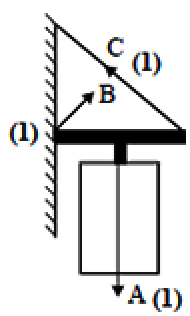
(b) return time = $\left(\dfrac{10000}{14}\right)$ = 714 s ∴ total time = 1214 s **(1)**

average speed = $\left(\dfrac{20000}{1214}\right)$ = 16[16.5] m s^{-1} **(1)**

(2)

[8]

17 (a) (i)

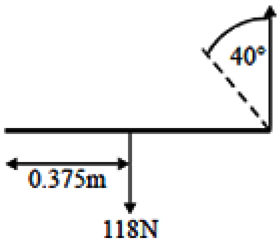


n.b. B must make an appreciable angle with wall and bar

(ii) A weight of sign and bar (accept gravity) **(1)**
B reaction of wall **(1)**
C tension in wire **(1)**

max 5

(b)



use of *mg* **(1)**

clockwise moments 118 × 0.375 **(1)**

= anticlockwise moments (*T*cos40° **(1)**) × 0.750 (1)

T = 77 N **(1)**

max 4

[9]

18 (a) two tension arrows, directions correct, on cord

B1

weight arrow, starting from centre of mirror, acting downwards

B1

two arrows labelled tension or T **+** one arrow labelled weight, W or mg (not gravity) **and** *no other arrows*

B1

3

(b) vert comp = *T* sin 40 (39 sin 40) = 25(.1) N

C1**,** A1

weight = 50 (–1 or –2) N

B1

3

allow e.c.f. from (b)

or *graphical method:* 25 ± 2 N, 50 ± 5 N

A1**,** A1

*(**s.f. error** if not 2 s.f.)*

max 2

[6]

19 (a) (2) T cos 45 = 25 or T cos 45 = 12.5
(or equations with sin 45) **or**
T = 25 cos 45 adequate scale (minimum 10 mm = 5 N)

C1

T = 17.7(18 N) 17 – 18 N

A1
2

(b) energy = ½ $F\,\Delta L$ or (25 × 0.7) seen or ½ $k\Delta L^2$ and $F = k\Delta L$

C1

8.75 (J) (condone omission or incorrect unit here)

A1
2

(c) 0.73 × their (b) 6.4(3) if correct

B1

J (allow in (b) or (c) (condone N m)
no mark if incorrect unit in (b) or (c)
condone if correct in (b) but omitted (c) or vice versa

B1
2

[6]

20 (a) (i) 1.5×10^4 sin 35 or 1.5×10^4 cos 55 seen = 8603.65
(to 4 sf minimum-no up)

B1
1

(ii) 11 600 N or 12 000 N

B1
1

(b) (i) any 2 from the following for C marks

accelerating force = 5600 N

C1

mass of cable car = 1530 kg (or 15 000/9.8 seen)

C1

F = ma

3.7 m s^{-2} (cnao)

A1

3

(ii) $v^2 = u^2 + 2as$

C1

30 (29.6) m s^{-1} (ecf for acceleration $\sqrt{240 \times acc}$)

A1

2

(iii) any equation of uniformly accelerated motion that includes *t*

C1

8.1 s (ecf for *v* or *a)*
(correct substitution leading to answer = their *v/a* or 240/their *v)*

A1

2

[9]