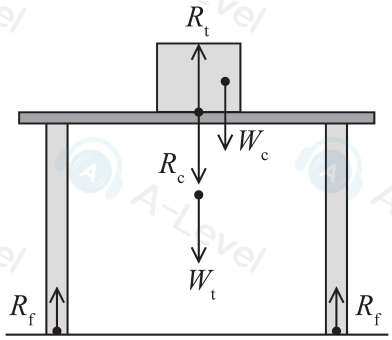
Questions 6 and 7 refer to the diagram below.

A uniform solid cube is placed on a table. The diagram shows the forces acting on the table and on the cube.



R_c = reaction force of cube on table
R_f = reaction force of floor on table
R_t = reaction force of table on cube
W_c = weight of cube
W_t = weight of table

6 The dot at the start of every arrowed line indicates the point at which the force can be considered to act.

Which of the following forces has been drawn in the wrong position?

☒ **A** R_c

☒ **B** R_t

☒ **C** W_c

☒ **D** W_t

(Total for Question 6 = 1 mark)

7 The table has four legs.

Which of the following statements is correct according to Newton's third law?

☒ **A** $4R_f = R_c + R_t$

☒ **B** $4R_f = R_c + W_t$

☒ **C** $R_c = R_t$

☒ **D** $R_t = W_c$

(Total for Question 7 = 1 mark)

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9: The driver of a car applies the brakes. The frictional force F between the tyres and the road is constant. The average power dissipated by F is 50 kW.

The car moves a distance of 13 m in a time of 2.3 s before coming to rest.

Which of the following expressions gives F in newtons?

☒ **A** $\dfrac{50 \times 10^3 \times 2.3}{13}$

☒ **B** $\dfrac{50 \times 10^3 \times 13}{2.3}$

☒ **C** $\dfrac{13}{50 \times 10^3 \times 2.3}$

☒ **D** $\dfrac{2.3}{50 \times 10^3 \times 13}$

(Total for Question 9 = 1 mark)

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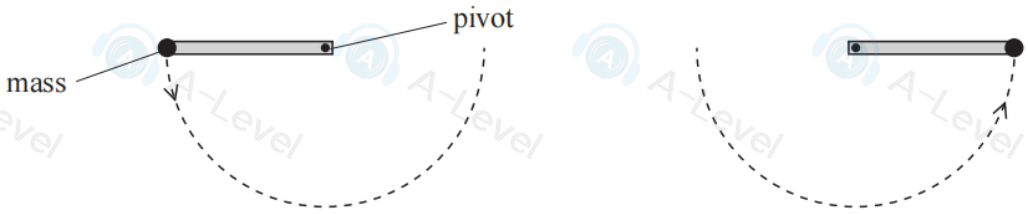
3 A physical quantity can be either a scalar or a vector.

Which row of the table is correct for acceleration and work done?

	Acceleration	Work done
☒ **A**	scalar	scalar
☒ **B**	scalar	vector
☒ **C**	vector	scalar
☒ **D**	vector	vector

(Total for Question 3 = 1 mark)

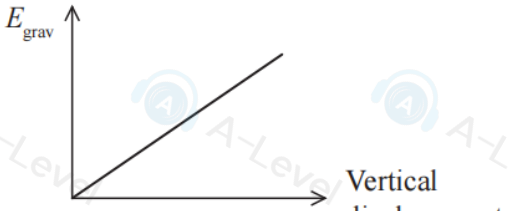
10 A mass is fixed to one end of a metre rule, which is pivoted at the other end. The mass and metre rule are held horizontally and released, as shown in the first diagram. The mass moves to its final position, as shown in the second diagram.



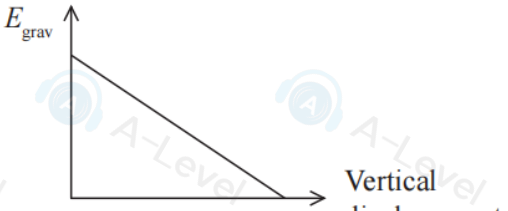
release position

final position

Which of the following is the graph of gravitational potential energy E_{grav} of the mass against vertical displacement for the motion of the mass?

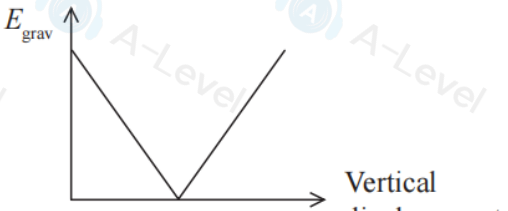


A



B

C



D

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 10 = 1 mark)

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10 The diagram shows a rocket of mass m accelerating upwards with acceleration a.
The diagram represents the forces acting on the rocket.

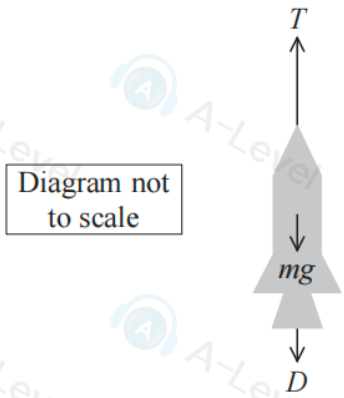


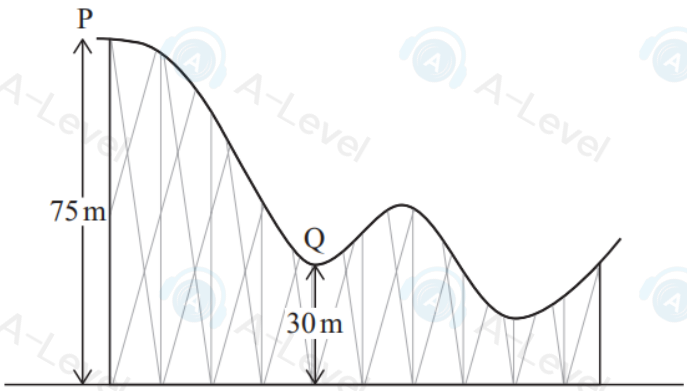
Diagram not to scale

Which of the following equations gives the value of D?

- ☒ **A** $D = T + m(g - a)$
- ☒ **B** $D = T + m(a + g)$
- ☒ **C** $D = T - m(g - a)$
- ☒ **D** $D = T - m(g + a)$

(Total for Question 10 = 1 mark)

10 The diagram shows a roller coaster. A roller coaster car stops momentarily at P before descending towards Q.



Which of the following expressions could be used to determine the velocity of the roller coaster car at Q?

A $\sqrt{79g} - \sqrt{30g}$

B $\sqrt{150g} - \sqrt{60g}$

C $\sqrt{45g}$

D $\sqrt{90g}$

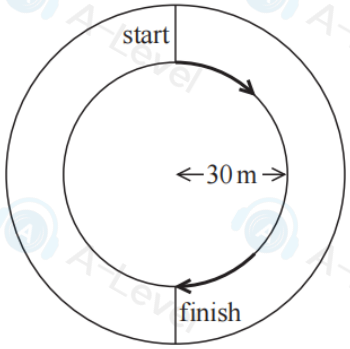
(Total for Question 10 = 1 mark)

1 Which of the following SI units is **only** used with a vector quantity?

- ☒ **A** s
- ☒ **B** m^3
- ☒ **C** ms^{-1}
- ☒ **D** ms^{-2}

(Total for Question 1 = 1 mark)

2 An athlete runs a race around half of a circular track of radius 30 m using the inside lane.

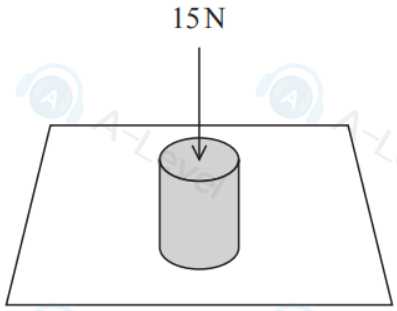


At the end of the race, what is the magnitude of the displacement of the athlete from the starting point?

- ☒ **A** 30 m
- ☒ **B** 60 m
- ☒ **C** 30π m
- ☒ **D** 60π m

(Total for Question 2 = 1 mark)

6 A solid cylinder of diameter 0.025 m is placed on a table. A force is applied to the cylinder, as shown.

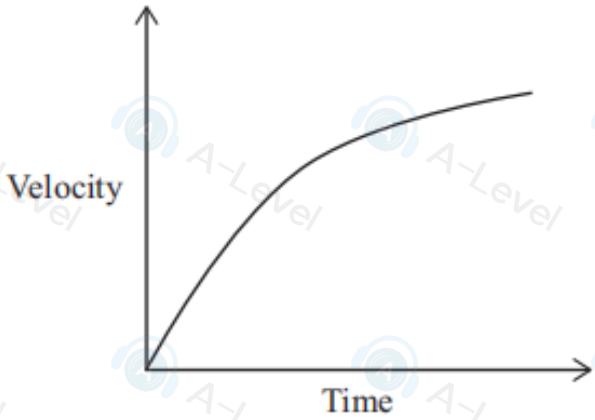


The stress in the cylinder, in pascals, can be calculated using

- ☒ **A** $\frac{15}{\pi(0.025)^2}$
- ☒ **B** $\frac{15 \times 2}{\pi(0.025)^2}$
- ☒ **C** $\frac{15 \times 4}{\pi(0.025)^2}$
- ☒ **D** $\frac{15}{2\pi(0.025)^2}$

(Total for Question 6 = 1 mark)

2 The graph shows how the velocity of an object varies with time.



Which of the following describes the motion of the object?

- ☒ **A** constant acceleration
- ☒ **B** constant displacement
- ☒ **C** decreasing acceleration
- ☒ **D** decreasing displacement

(Total for Question 2 = 1 mark)

14 A student carried out an experiment to determine the Young modulus of a sample of stainless steel in the form of a wire. The student added weights to the wire and measured the corresponding extensions.

The wire had an unstretched length of 2.6 m. The diameter of the wire was 5.6×10^{-4} m.

The student plotted a graph of weight against extension. The graph showed that the limit of proportionality was not exceeded.

(a) State what is meant by the limit of proportionality.

(1)

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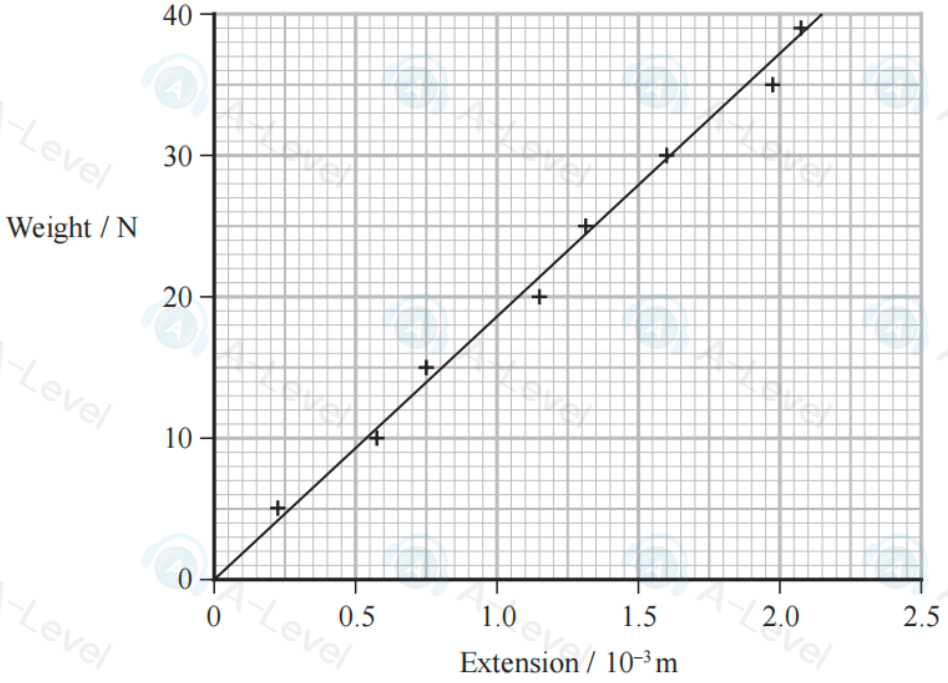
(b) The student's graph is shown below.



(i) Determine the gradient of the graph.

(2)

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Gradient = ...

(ii) Determine the Young modulus of stainless steel using your value for the gradient.

(3)

Young modulus = ...

(c) The breaking stress for this stainless steel is known to be 480 MPa.

Deduce whether it is safe for the student to increase the weight to 100.0 N.

(3)

(Total for Question 14 = 9 marks)

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18 When water vapour in the atmosphere cools it condenses, forming tiny drops of water. These drops increase in size by colliding with each other and fall back to the ground as rain.

(a) As a raindrop falls through the air it eventually reaches its terminal velocity. The upthrust on the raindrop can be considered to be negligible.

(i) Explain what is meant by the terminal velocity of the raindrop. Your answer should include a free-body force diagram for the raindrop when terminal velocity has been reached.

(4)

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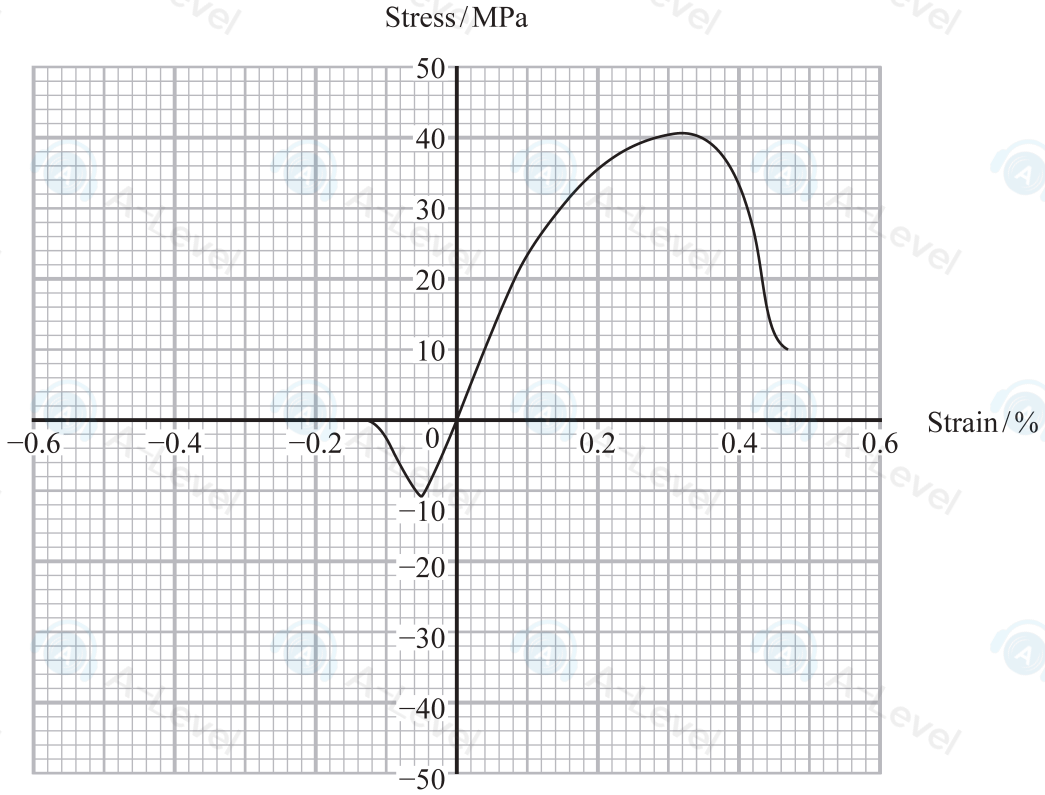
16 Concrete is a material often used for building.

A stress-strain graph for one type of concrete is shown. Positive values of strain represent compression and negative values of strain represent tension.



(a) Explain how the stress-strain graph shows that concrete is more suitable for use under compression than under tension.

(2)

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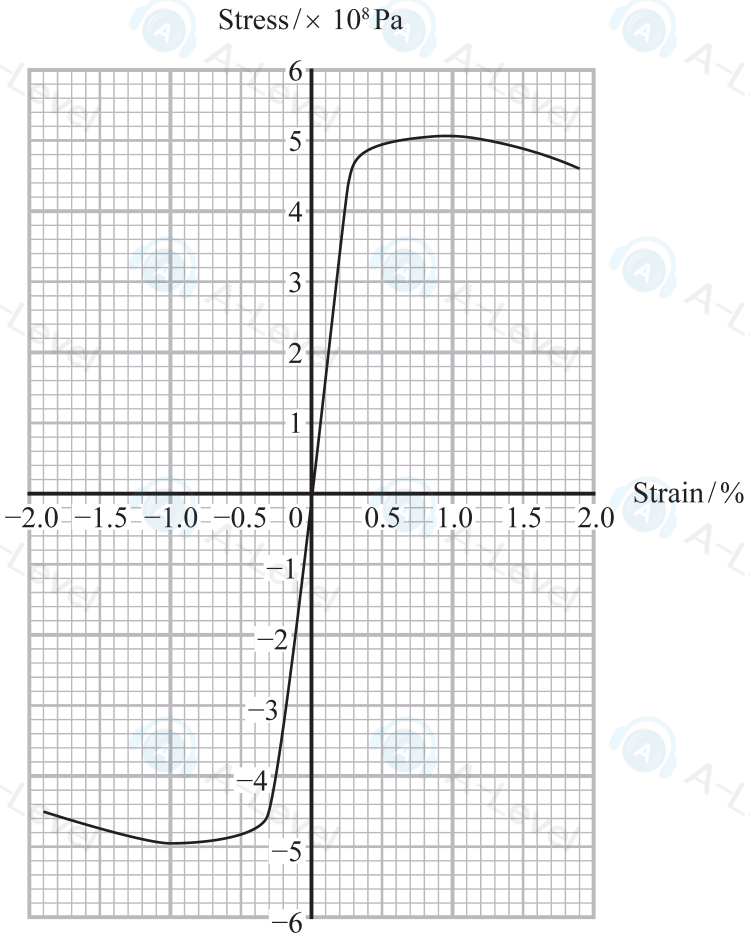
(b) Steel is a metal often used in building. The stress-strain graph for steel is shown.



A steel rod has a diameter of 45 mm.

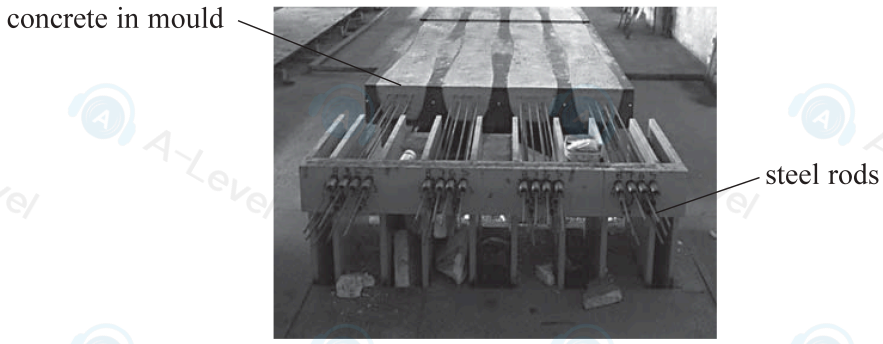
Calculate the maximum force that could be applied to the steel rod before it fractures.

(3)

Maximum force = ...

(c) To make concrete suitable for use under large forces steel rods are sometimes embedded in the concrete.

An external tensile force is applied to the steel rods. Concrete is poured into a mould around the rods. Once the concrete has set the external force is removed from the steel rods, placing the concrete in compression.



Source: www.designingbuildings.co.uk

(i) Explain how this process increases the maximum tensile force that the concrete can withstand before fracture.

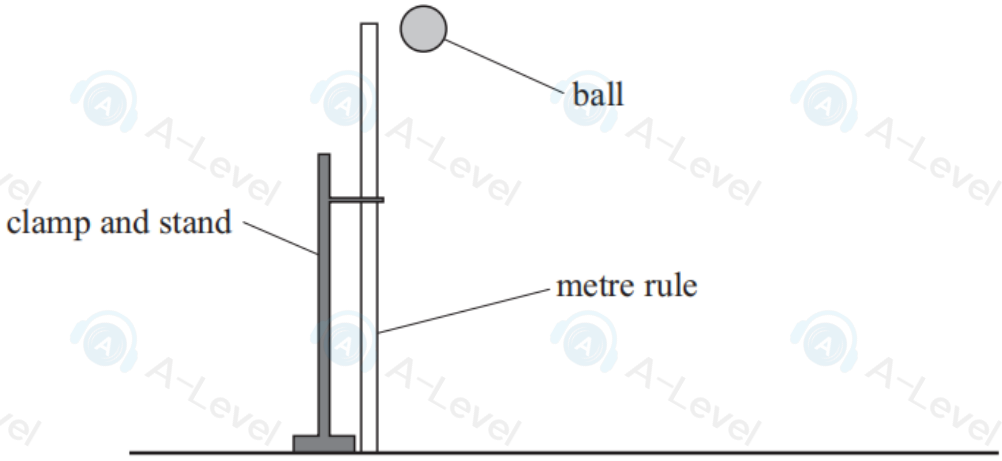
(4)

(ii) Explain why the external tensile force in the rods must not take the steel beyond its elastic limit.

(2)

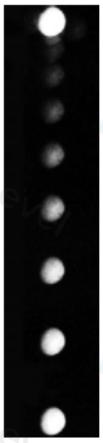
(Total for Question 16 = 11 marks)

14 A student clamped a metre rule so that it was vertical. She dropped a ball from rest near the top of the metre rule, as shown.



A strobe emits flashes of light. The time interval between flashes is constant.

The student photographed the falling ball using strobe lighting. The ball can be seen at different heights in the photograph, as shown.



(Source: © sciencephotos/Alamy Stock Photo)

For each flash of light, the student determined the distance fallen by the ball.

(a) She took one photograph using a strobe app on a mobile phone.
She took a second photograph using a laboratory strobe.

The time interval between flashes was the same for the strobe app and for the laboratory strobe. Each flash of light from the laboratory strobe has a smaller duration than each flash from the mobile phone.

Explain how the smaller duration of each flash from the laboratory strobe affected the uncertainty in the measurement of the distance fallen.

(2)

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(b) The student recorded the distances s fallen by the ball and corresponding values of the time t.

(i) Explain why a graph of s against t^2 gives a straight line.

(2)

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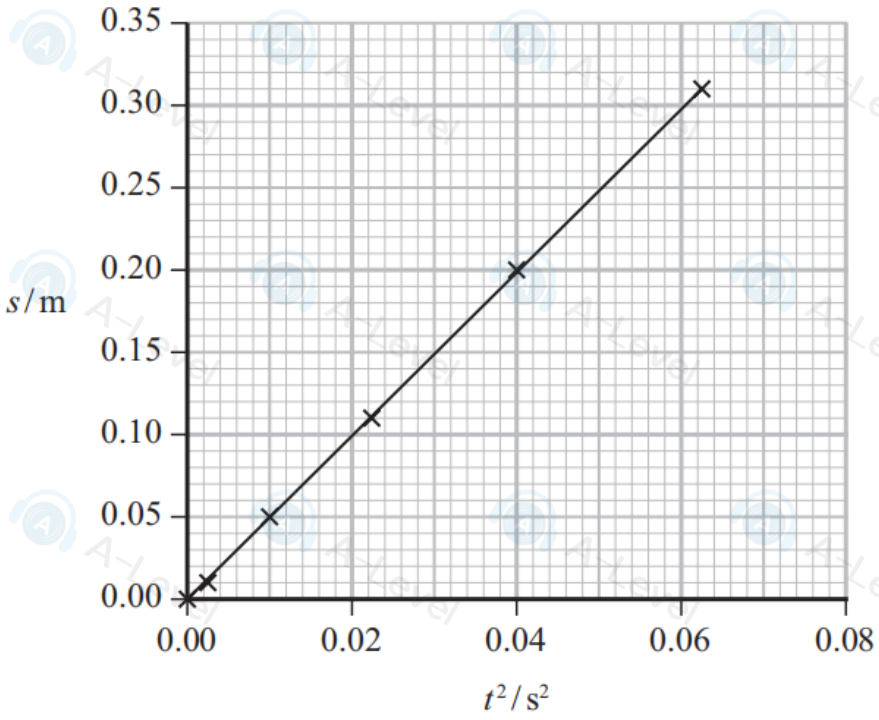
(ii) The student plotted a graph of s against t^2, as shown.



Determine the acceleration of free fall, g, using the student's graph.

(2)

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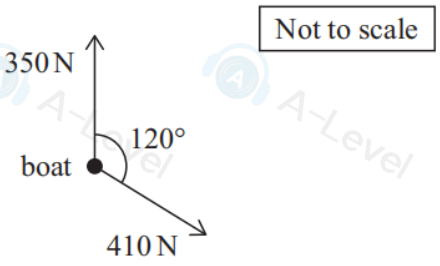
g = ...

(Total for Question 14 = 6 marks)

12 A sailing boat is moving through water.
The force of the wind on the boat is 350 N towards north.
The force of the water on the boat is 410 N at an angle of 120° from north, as shown.



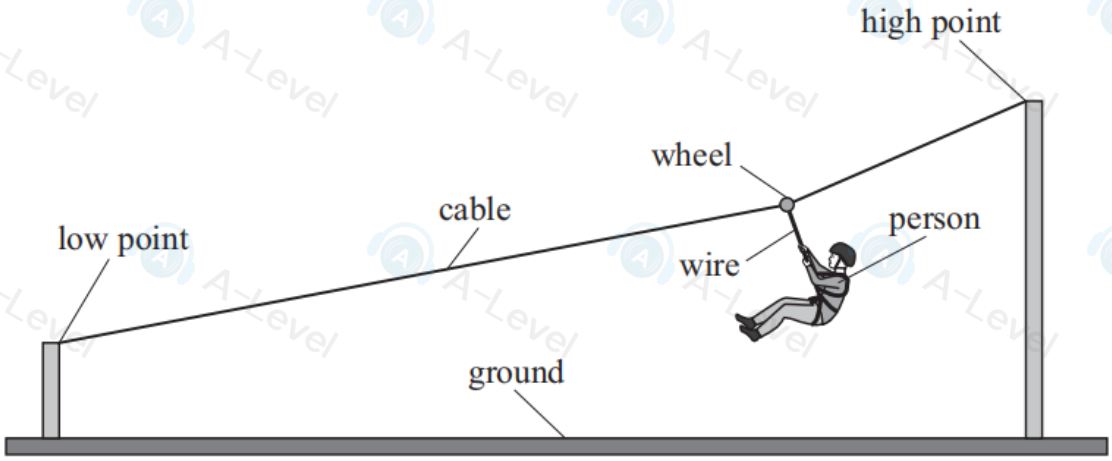
Determine the magnitude and direction of the resultant force on the boat using a scaled vector diagram.

Magnitude of resultant force = ...

Angle of resultant force from north = ...

19 A 'zip-line' consists of a cable fixed at two points, one higher than the other.

A person hangs from a wire attached to a wheel, as shown. The wheel can move along the cable. The wheel moves the person along the cable.

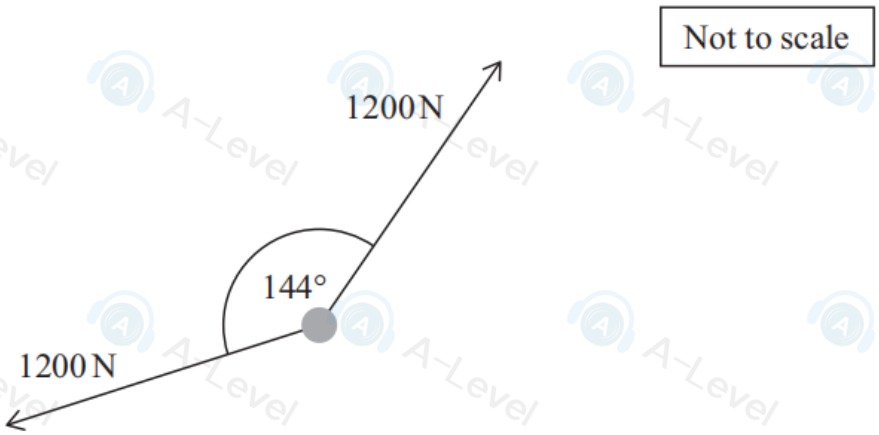


(a) In the position shown, the person is accelerating.

Complete the free-body force diagram below to show the three forces acting on the person in this position.

(3)

(b) At a particular instant, the tension in the cable is 1200 N and the angle formed by the cable at the wheel is 144°, as shown.



(i) Show, by calculation, that the force on the wheel from the cable is about 740 N.

(2)

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(ii) There is a force on the wheel from the wire of 800 N.

The angle between the force from the cable and the 800 N force from the wire is 150°.

Determine the magnitude of the resultant force on the wheel using a scaled vector diagram.

You should ignore the weight of the wheel.

(4)

Resultant force on the wheel = ...

(c) People take turns at moving along the zip-line from the high point to the low point. The people are initially at rest at the high point.

Explain why the speeds of people with different masses are always about the same when they reach the low point.

(3)

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(Total for Question 19 = 12 marks)