

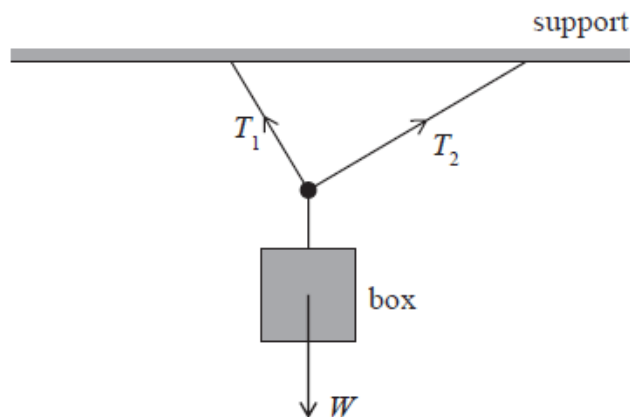
## Questions

Q1.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

A box of weight  $W$  is suspended, in equilibrium, from a support by two ropes.

The tensions in the two ropes are  $T_1$  and  $T_2$



Which of the following is a vector expression relating the forces acting on the box?

- ☐ A  $\vec{W} + \vec{T}_1 = \vec{T}_2$
- ☐ B  $\vec{W} + \vec{T}_2 = \vec{T}_1$
- ☐ C  $\vec{W} = \vec{T}_1 + \vec{T}_2$
- ☐ D  $\vec{W} + \vec{T}_1 + \vec{T}_2 = 0$

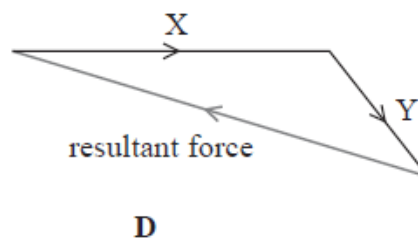
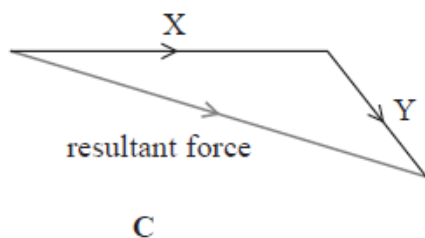
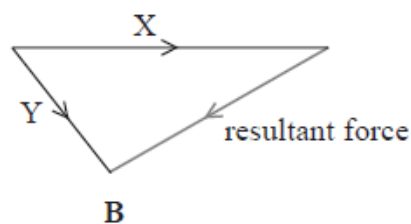
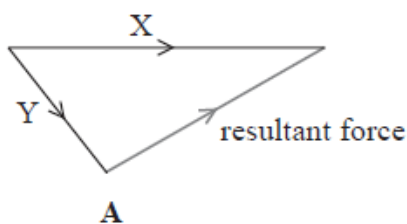
(Total for question = 1 mark)

Q2.

Answer the question with a cross in the box you think is correct . If you change your mind about an answer, put a line through the box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Two forces, X and Y, act at a point.

Which of the following vector diagrams shows the magnitude and direction of the resultant of the two forces?



☐ A

☐ B

☐ C

☐ D

(Total for question = 1 mark)

Q3.

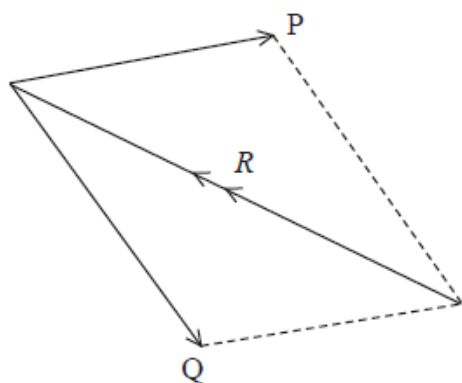
Answer the question with a cross in the box you think is correct ☐ . If you change your mind about an answer, put a line through the box ☐ and then mark your new answer with a cross ☐ .

Two forces P and Q act on an object as shown.

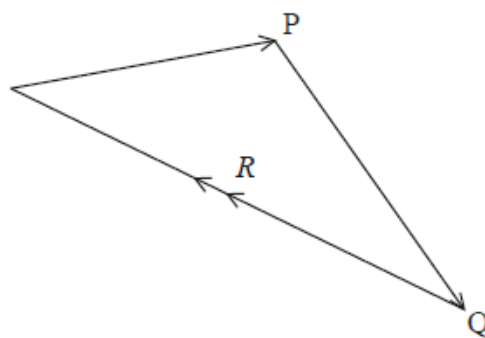


Which of the following is a correctly drawn, scaled, vector diagram for the resultant R of forces P

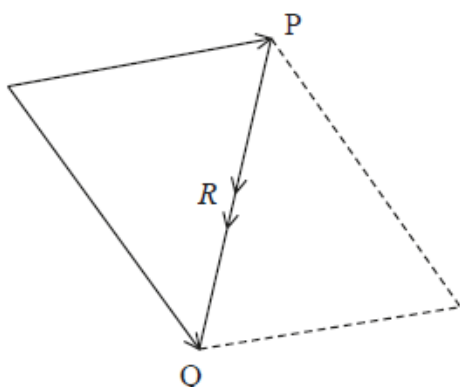
and Q?



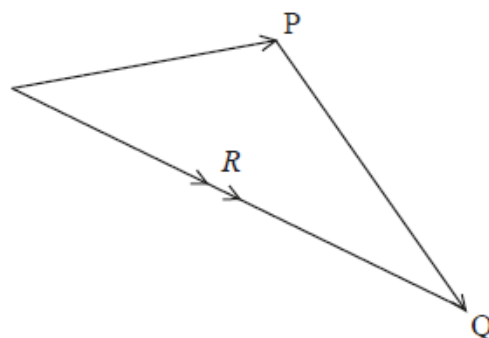
A



B



C



D

☐ A

☐ B

☐ C

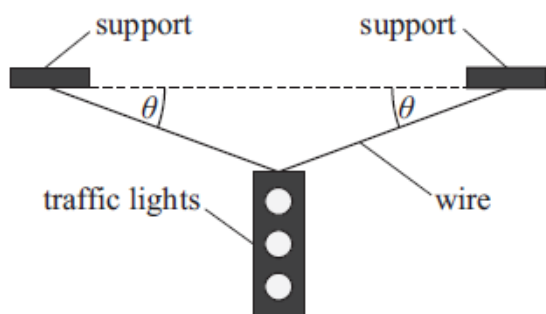
☐ D

(Total for question = 1 mark)

Q4.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Traffic lights of weight  $W$  are suspended from a wire.  
The wire is held at an angle  $\theta$  to the horizontal by two supports, as shown.



Which of the following expressions gives the tension in the wire?

☐ A  $2W \sin \theta$

☐ B  $\frac{W}{2 \sin \theta}$

☐ C  $2W \cos \theta$

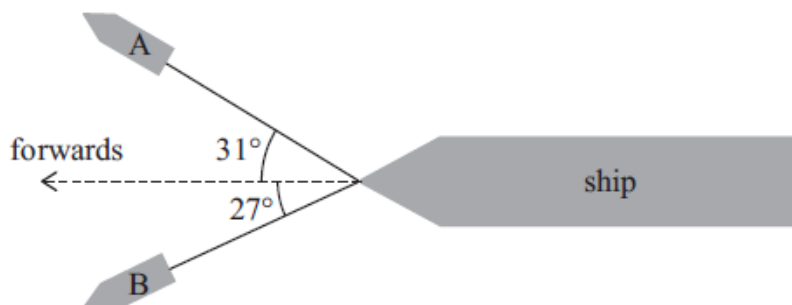
☐ D  $\frac{W}{2 \cos \theta}$

(Total for question = 1 mark)

Q5.

**Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).**

Two boats, A and B, are pulling a ship. Each boat is attached to the ship by a rope, as shown.



The force from boat A on the ship is  $F_A$ .

The force from boat B on the ship is  $F_B$ .

Which of the following expressions gives the forwards component of the total force of the boats on the ship?

☐ A  $F_A \sin (31^\circ) + F_B \cos (27^\circ)$

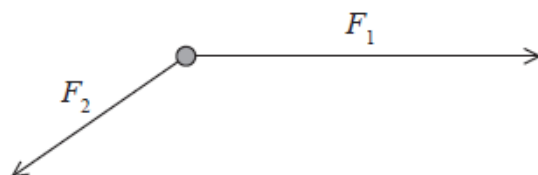
- ☐ **B**  $F_A \sin (31^\circ) + F_B \sin (27^\circ)$
- ☐ **C**  $F_A \cos (31^\circ) + F_B \cos (27^\circ)$
- ☐ **D**  $F_A \cos (31^\circ) + F_B \sin (27^\circ)$

(Total for question = 1 mark)

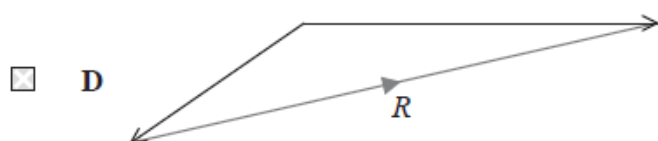
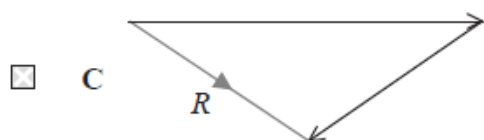
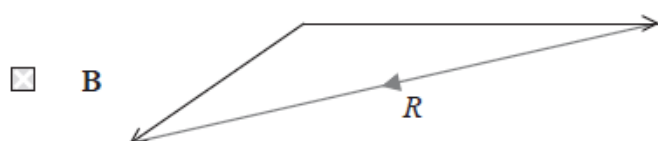
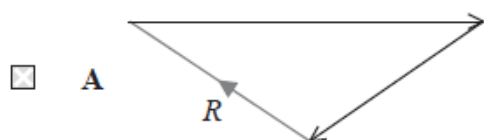
Q6.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Two forces  $F_1$  and  $F_2$  act on an object, as shown.



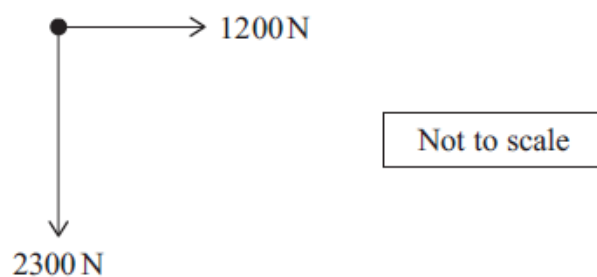
Which of the following is a correctly drawn scaled vector diagram for the resultant  $R$  of the forces  $F_1$  and  $F_2$  ?



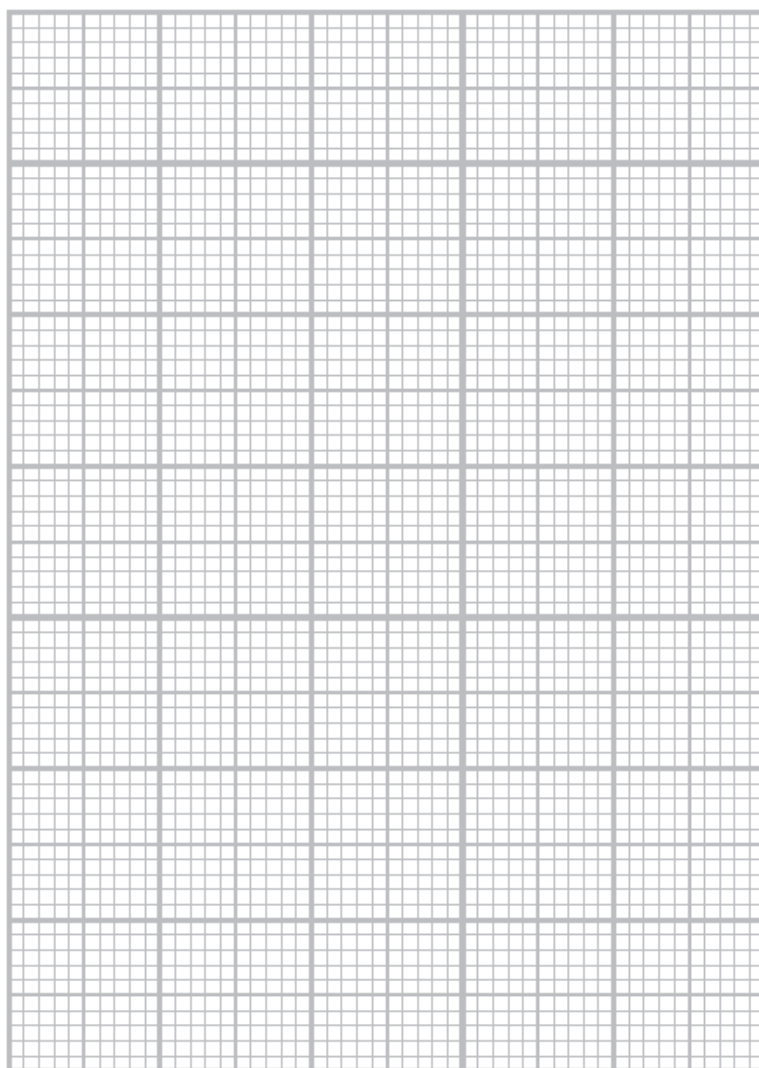
(Total for question = 1 mark)

Q7.

Two forces act on an object. The forces are perpendicular, as shown.



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



Magnitude of resultant force = ..... N

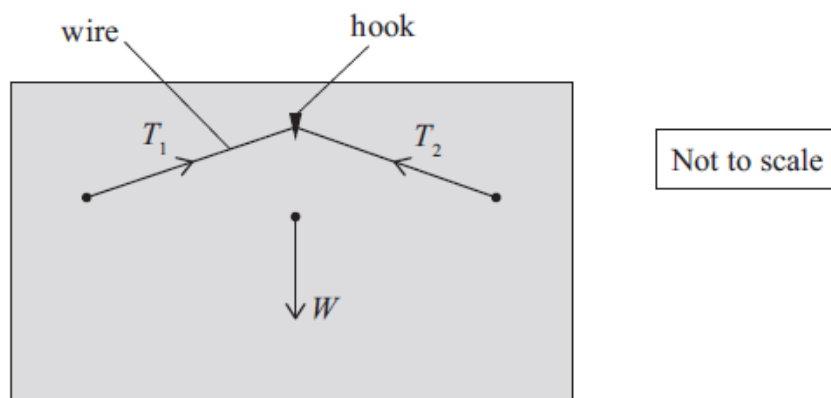
**(Total for question = 2 marks)**

Q8.

Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

A wire is used to hang a picture from a hook on a wall.

The wire exerts forces  $T_1$  and  $T_2$  on the picture. The picture has weight  $W$ , as shown.



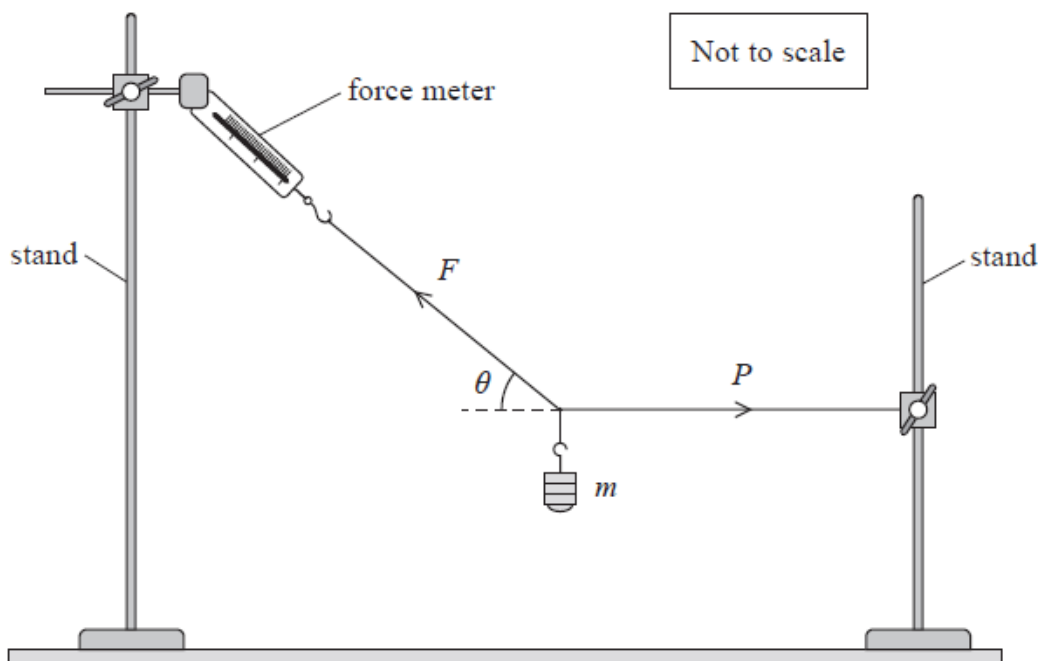
Which of the following describes the relationship between the forces when the picture is hanging on the wall?

- ☒ A  $\vec{W} = \vec{T}_1 + \vec{T}_2$
- ☒ B  $\vec{W} + \vec{T}_1 + \vec{T}_2 = 0$
- ☒ C  $\vec{W} = \vec{T}_1 - \vec{T}_2$
- ☒ D  $\vec{W} + \vec{T}_1 - \vec{T}_2 = 0$

(Total for question = 1 mark)

Q9.

A mass  $m$  is held in equilibrium by strings attached to two clamp stands. The force meter records the force  $F$  in the upper string. The force in the horizontal string is  $P$ . The angle made by the upper string to the horizontal is  $\theta$ , as shown.



(a) The force meter allows force to be measured by means of Hooke's law.

The extension of the spring inside the force meter allows the stretching force to be read from a scale.

When the force applied to stretch the spring is 15 N the extension of the spring is 8.0 cm.

Show that the stiffness of the spring is about  $2 \text{ N cm}^{-1}$ .

(2)

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(b) When  $m$  is equal to 0.55 kg, the value of  $P$  is 8.5 N.

Calculate the value of  $\theta$ , and the extension of the spring in the force meter.

(6)

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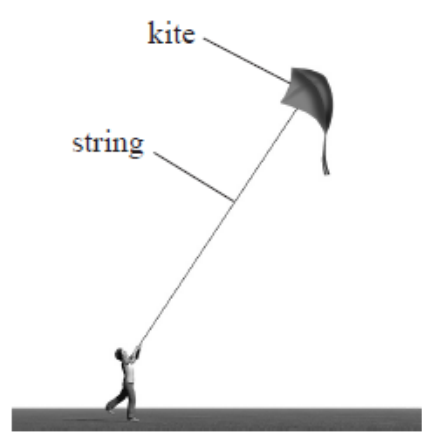
$\theta =$  .....

Extension of the spring = .....

**(Total for question = 8 marks)**

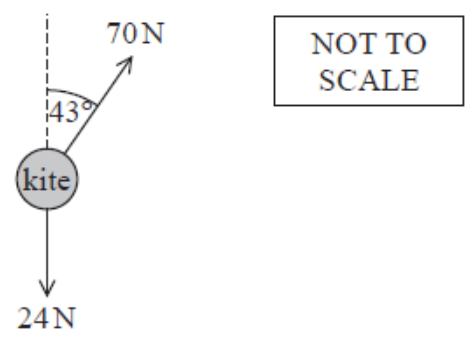
Q10.

A student is flying a kite. The kite is held in equilibrium by a string as shown.



(Source: © CAROL & MIKE WERNER/SCIENCE PHOTO LIBRARY)

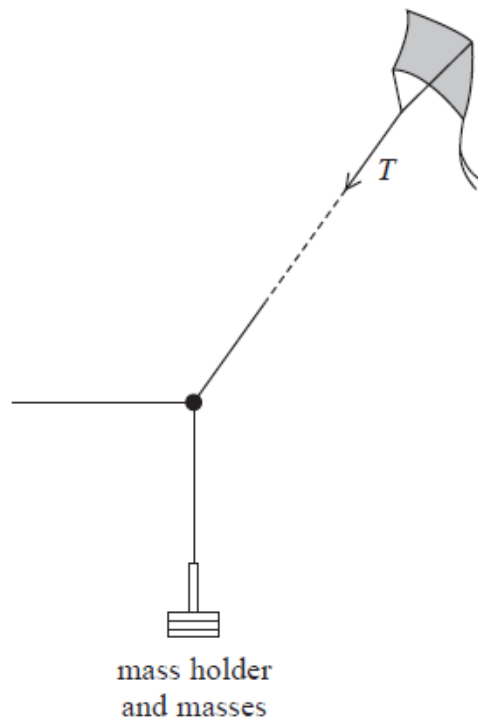
The weight of the kite is 24 N, and the wind exerts a force of 70 N at an angle of 43° to the vertical, as shown below.



(a) Determine the magnitude of the tension in the string by using a scaled vector diagram.

Tension = .....

(b) The student wants to determine the tension  $T$  in the string. She attaches a mass holder to the string. The student adds known masses to the mass holder until the kite is in equilibrium and part of the string becomes horizontal, as shown.



The student takes a photograph of the arrangement.

Describe how the student can use the photograph to determine  $T$ .

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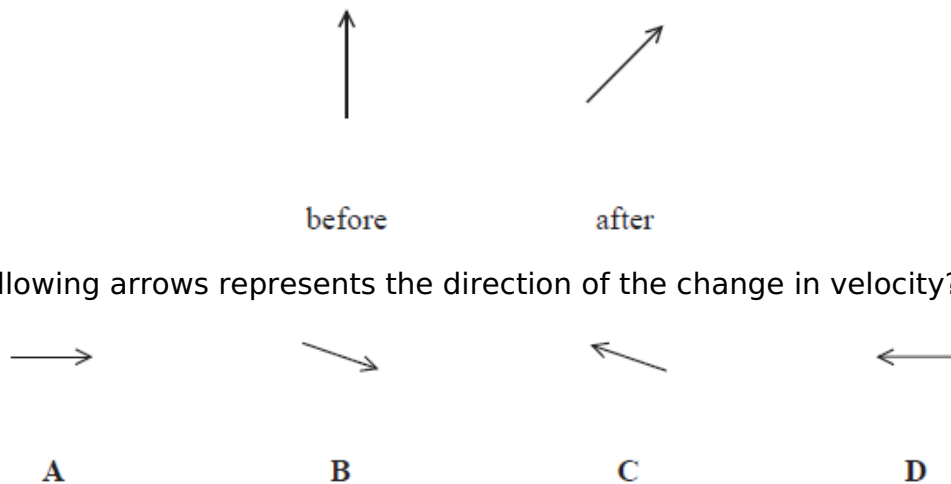
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(Total for question = 9 marks)

Q11.

The diagrams below show the velocity of an object before and after a force is applied.

The magnitude of the velocity did not change.



☐ **A**

☐ **B**

☐ **C**

☐ **D**

**(Total for question = 1 mark)**

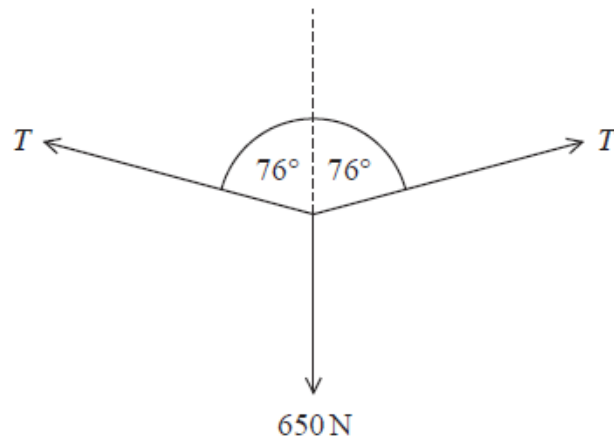
Q12.

The Tyrolean traverse is a technique for crossing a deep valley. The photograph shows a climber crossing a river using this technique. The climber moves along a rope suspended from the bank on either side of the river.



(Source: © Folio Images/Alamy Stock Photo)

(a) The free-body force diagram for the climber is shown below. The weight of the climber is 650 N.



Show that the tension  $T$  in the rope is about  $1.3 \times 10^3$  N.

(3)

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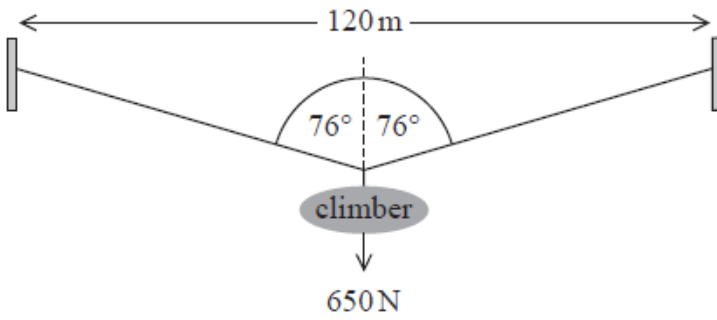
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(b) The rope has an unstretched length of 120 m as shown below.



(i) Determine the strain in the rope while it is supporting the weight of the climber.

You may ignore the weight of the rope.

(3)

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Strain = .....

(ii) The rope has a cross-sectional area of  $3.14 \times 10^{-4} \text{ m}^2$ .

Determine the Young modulus of the rope material.

(3)

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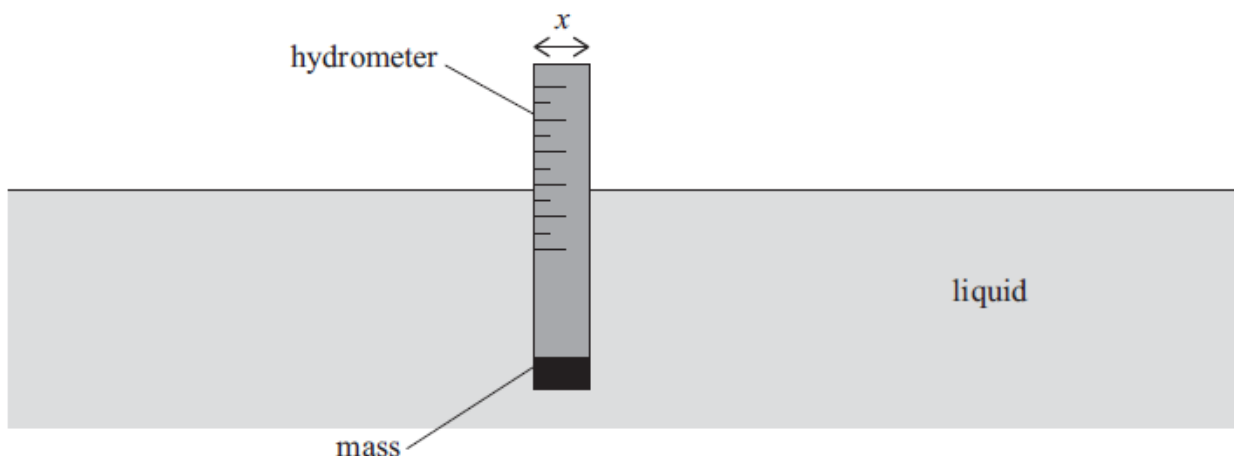
Young modulus = .....

**(Total for question = 9 marks)**

Q13.

A simple hydrometer is a cylinder with a mass at one end. The cylinder floats vertically in a liquid.

The diameter of the hydrometer is  $x$ . A scale on the side of the hydrometer shows the vertical position of the hydrometer in the liquid, as shown.



A student placed the hydrometer in a sample of pure water.

(a) Complete the free-body diagram below to show the forces acting on a hydrometer when floating in water at equilibrium.

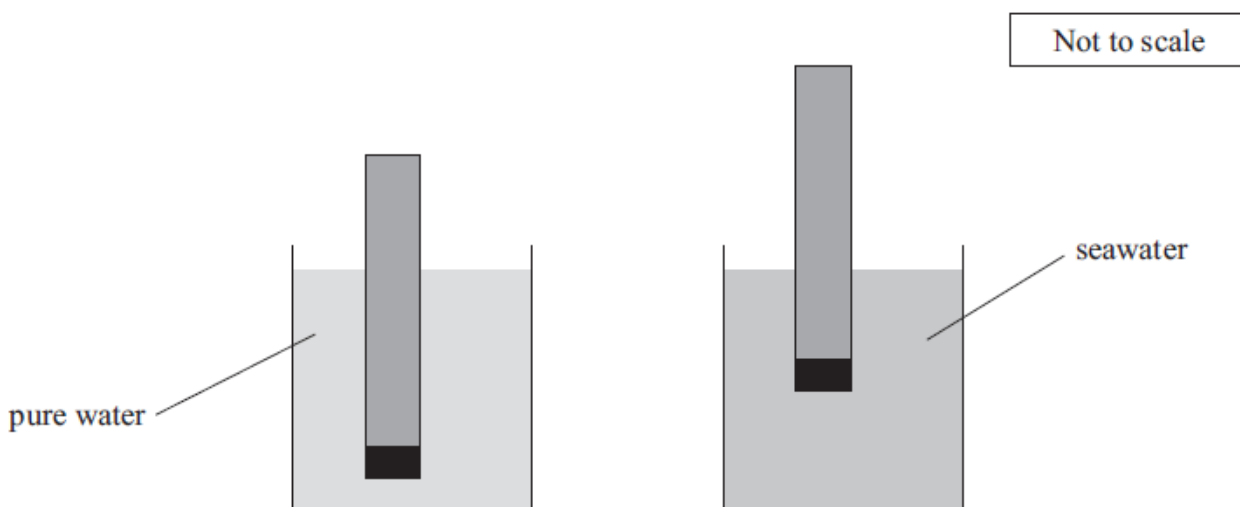
(2)



(b) The student placed the hydrometer in a sample of seawater.

Seawater is more dense than pure water.

At equilibrium, the vertical position of the hydrometer was higher in the seawater than in the pure water, as shown.



(i) Explain why the vertical position of the hydrometer was higher in the seawater than in the pure water.

(3)

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(ii) Calculate the change in the vertical position of the hydrometer when moved from pure water into seawater.

weight of hydrometer = 0.324 N

density of pure water = 997 kg m<sup>-3</sup>

density of seawater = 1025 kg m<sup>-3</sup>

$x = 1.23 \text{ cm}$

(5)

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Change in vertical position = .....

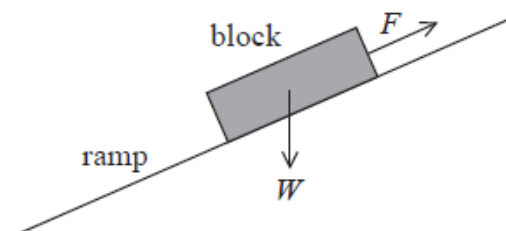
**(Total for question = 10 marks)**

Q14.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

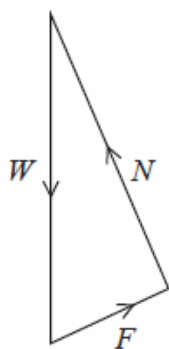
A block of wood is stationary on a frictionless ramp as shown.

The block is held in place by a string. The weight of the block is  $W$ . The force applied to the block by the string is  $F$ .

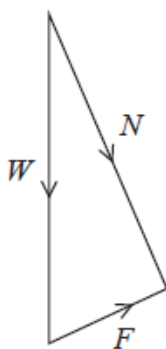


A triangle of forces can be used to determine the magnitude and direction of the normal contact force  $N$  acting on the block.

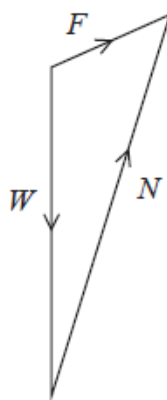
Which of the following triangles is correct?



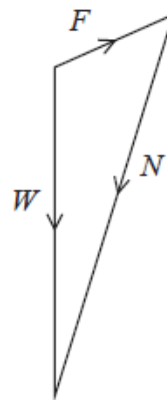
A



B



C



D

☐ A

☐ B

☐ C

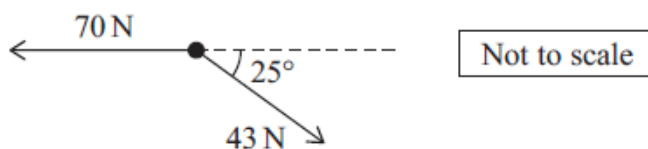
☐ D

(Total for question = 1 mark)

Q15.

A small, remotely controlled submarine is used to explore the sea.

(a) The engine of the submarine produced a horizontal force of 70 N. The drag force on the submarine was 43 N at an angle of  $25^\circ$  to the horizontal, as shown.



Determine the resultant of these two forces on the submarine by drawing a scaled vector diagram in the space below.

(5)

Magnitude of resultant force = .....

Angle of resultant force to horizontal = .....

\*(b) A crane on a ship can lift the submarine out of the sea, as shown.



(Source: adapted from © PJF Military Collection/Alamy Stock Photo)

The submarine is initially completely underwater and at rest just below the surface. A cable from the crane is attached to the submarine, so that the cable is vertical.

The crane pulls on the cable. The submarine moves vertically upwards at a constant speed until the whole submarine is out of the water.

Explain how the tension in the cable changes as the submarine moves from below the surface of the water to being completely out of the water.

You should assume the drag force on the submarine is negligible.

(6)

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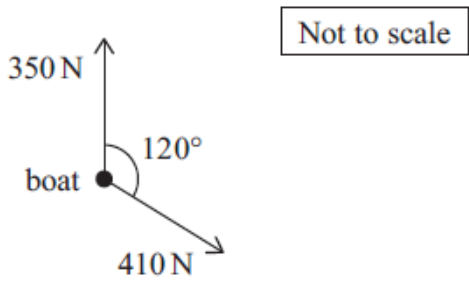
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**(Total for question = 11 marks)**

Q16.

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  $120^\circ$  from north, as shown.



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

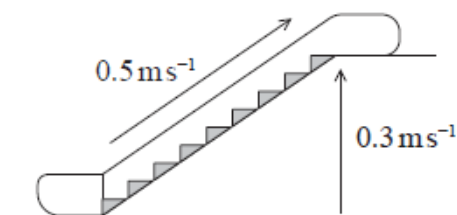
Magnitude of resultant force = .....

Angle of resultant force from north = .....

**(Total for question = 4 marks)**

Q17.

The steps on an escalator move with a speed of  $0.5 \text{ m s}^{-1}$ . The vertical component of their velocity is  $0.3 \text{ m s}^{-1}$  upwards.



Which of the following is the horizontal component of velocity for the escalator steps?

(1)

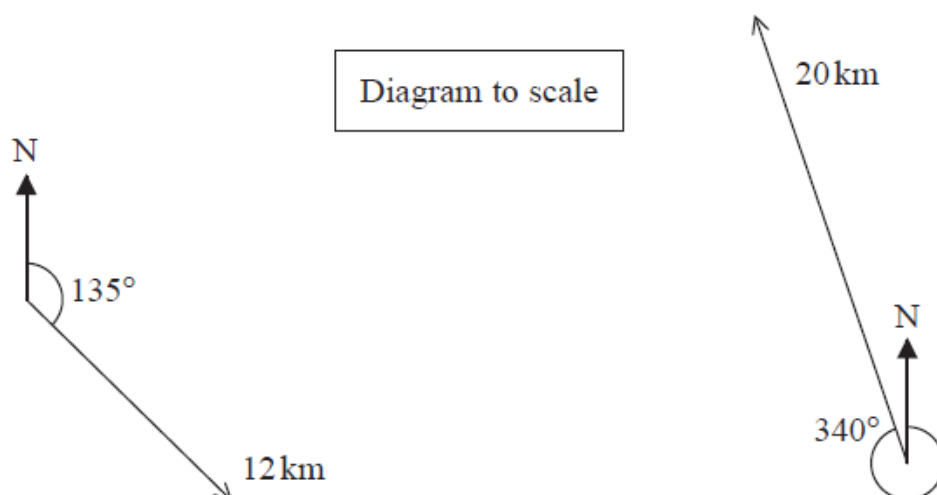
- ☐ A  $0.2 \text{ m s}^{-1}$
- ☐ B  $0.4 \text{ m s}^{-1}$
- ☐ C  $0.5 \text{ m s}^{-1}$
- ☐ D  $0.8 \text{ m s}^{-1}$

(Total for question = 1 mark)

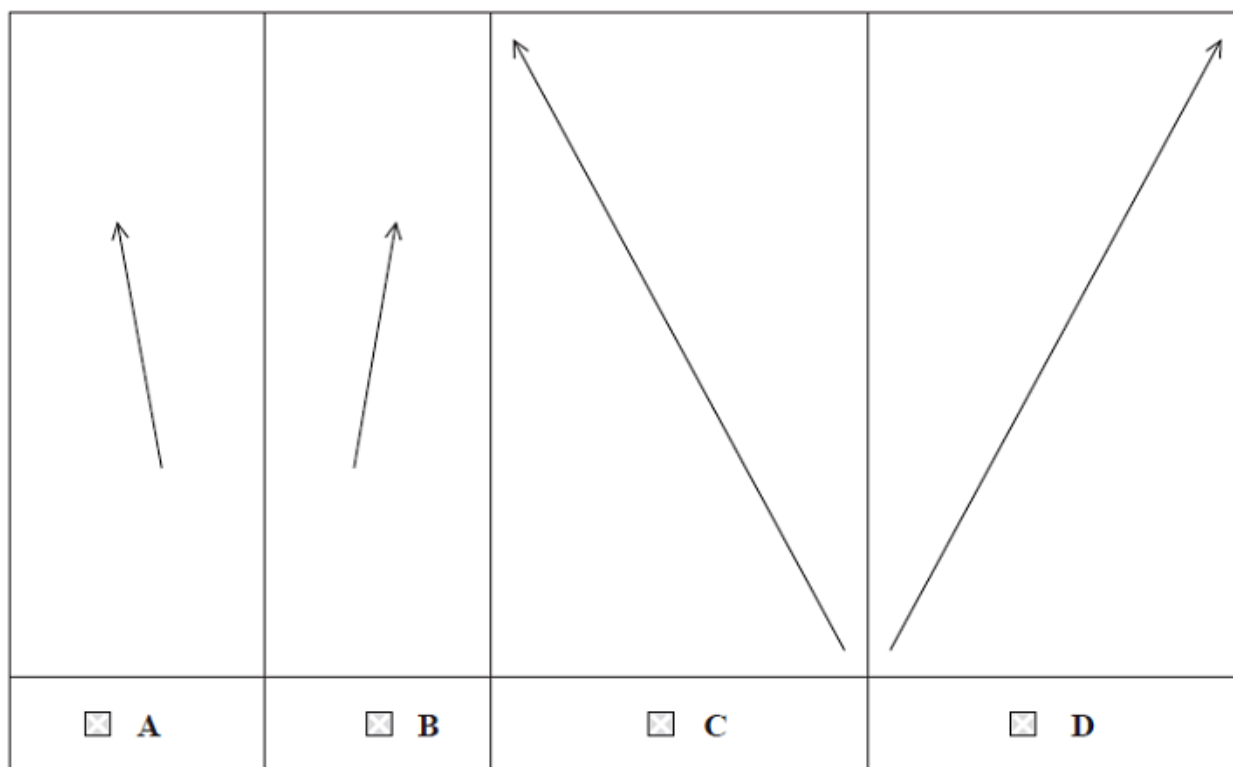
Q18.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☐ and then mark your new answer with a cross ☐.

A student walked 12 km on a bearing of  $135^\circ$  and then walked 20 km on a bearing of  $340^\circ$  as shown.



Which of the following could represent the final displacement of the student from his starting point?



**(Total for question = 1 mark)**

Q19.

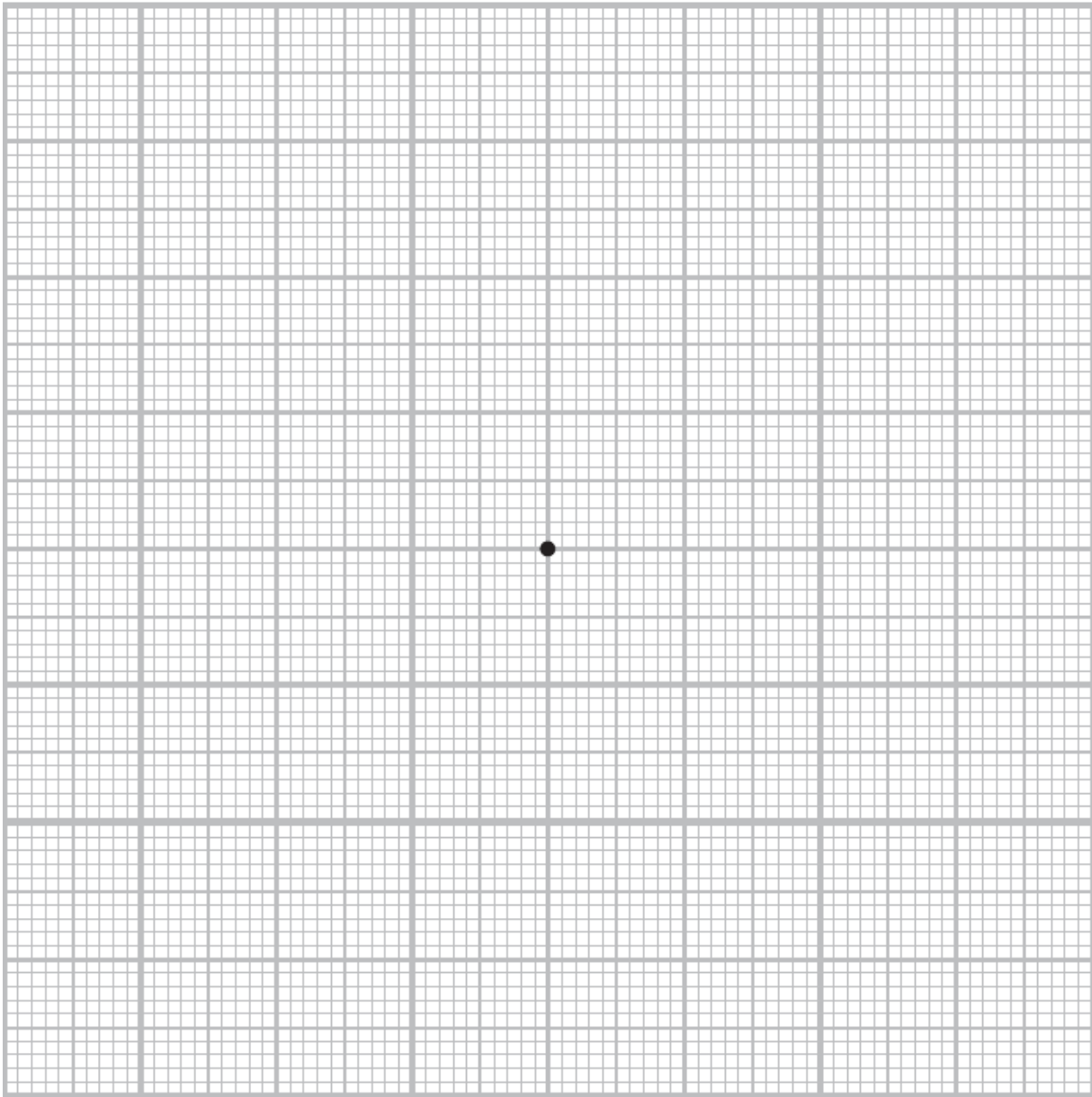
A car accelerates from rest on a horizontal road.

The engine causes a forward force  $F$  on the car of 7500 N.

The weight  $W$  of the car is 15 000 N.

The road exerts a normal contact force  $N$  on the car.

Complete the free-body force diagram for the car at the instant the acceleration begins.

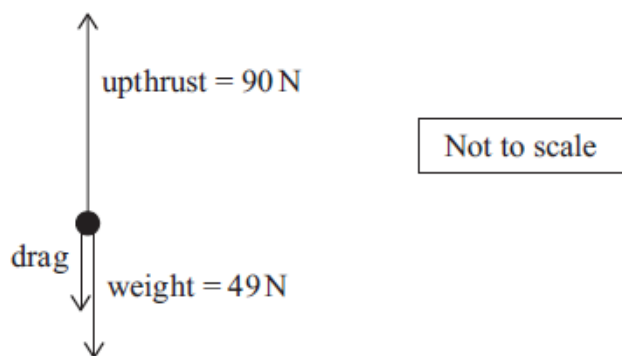


(Total for question = 2 marks)

Q20.

**Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.**

A free-body force diagram for an object moving through a fluid is shown.



The mass of the object is 5 kg.  
The object is accelerating upwards at  $4 \text{ m s}^{-2}$ .

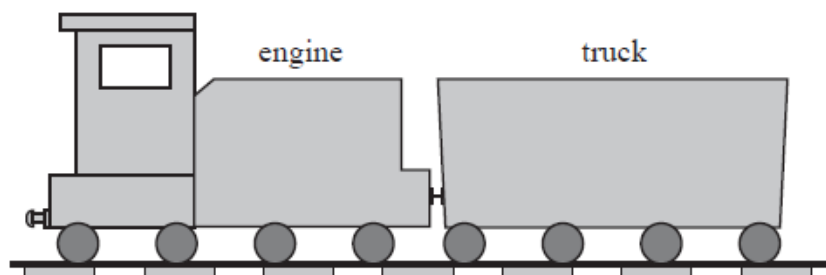
Which of the following gives the magnitude of the drag force in newtons?

- ☐ **A**  $5 \times 4$
- ☐ **B**  $90 - 49$
- ☐ **C**  $90 - 49 - (5 \times 4)$
- ☐ **D**  $90 - 49 + (5 \times 4)$

**(Total for question = 1 mark)**

Q21.

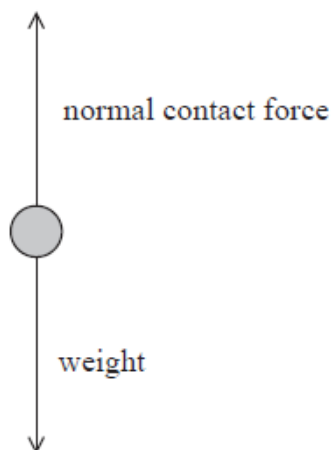
A railway engine is pushing a truck along horizontal rails at a constant velocity, as shown.



The engine exerts a forward force of  $1.2 \times 10^5 \text{ N}$  on the truck. The engine also exerts a net backwards force of  $1.5 \times 10^5 \text{ N}$  on the rails.

(a) Complete the free-body force diagram to show all the forces acting on the engine.

**(4)**



(b) A student suggests that the weight and the normal reaction force form a Newton's third law pair of forces.

Explain why the student's suggestion is **not** correct. Your answer should include reference to the features of a Newton's third law pair of forces.

(5)

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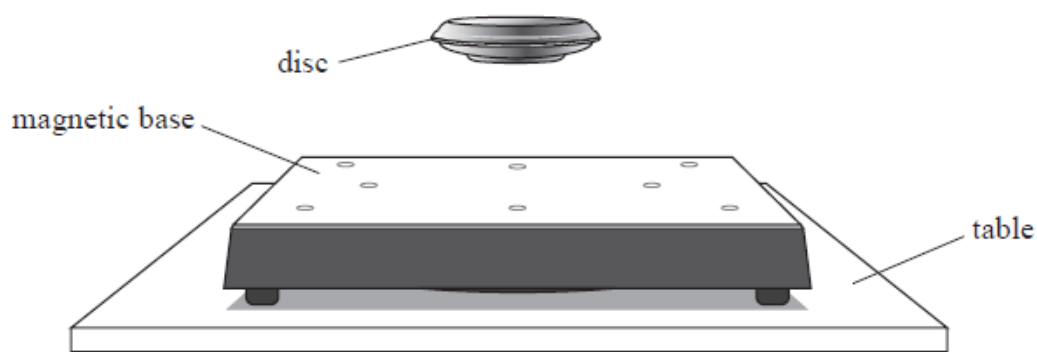
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**(Total for question = 9 marks)**

Q22.

A disc of mass  $m$  is held stationary by a force  $F$  exerted by a magnetic base, as shown.



(a) The free-body force diagram for the disc is shown below.



The two forces shown are equal in magnitude and opposite in direction.

Give two reasons why these forces are **not** a Newton's 3<sup>rd</sup> law pair.

(2)

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(b) The magnetic base has weight  $W$  and rests on a horizontal table.

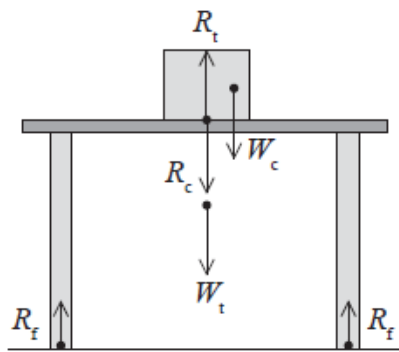
Complete the free-body force diagram below for the magnetic base.

(2)



**(Total for question = 4 marks)**

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

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?

(1)

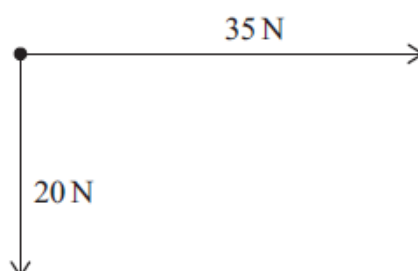
- ☐ **A**  $R_c$
- ☐ **B**  $R_t$
- ☐ **C**  $W_c$
- ☐ **D**  $W_t$

(Total for question = 1 mark)

Q24.

**Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).**

A force of 20 N and a force of 35 N act at a point. The forces act at right angles to each other, as shown.



Which of the following expressions gives the magnitude of the resultant of these forces in N?

- ☐ A  $20 + 35$
- ☐ B  $\sqrt{20 + 35}$
- ☐ C  $20^2 + 35^2$
- ☐ D  $\sqrt{(20^2 + 35^2)}$

(Total for question = 1 mark)

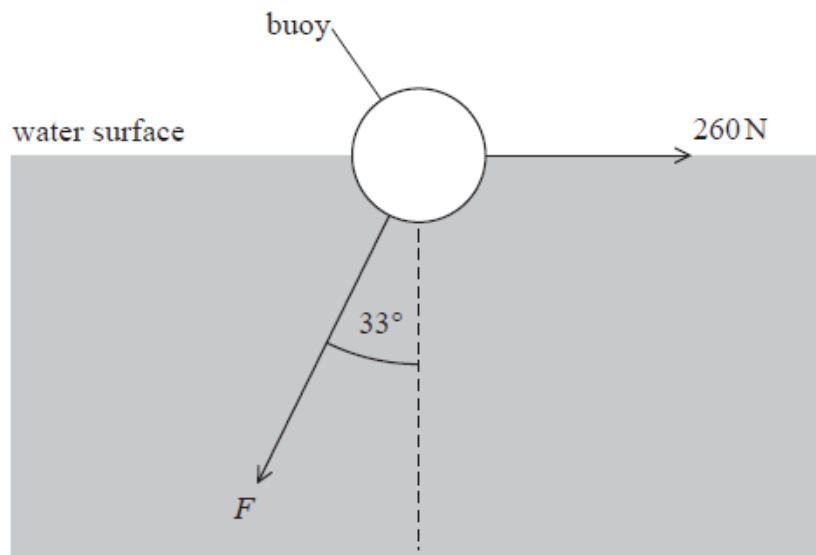
Q25.

The photograph shows a floating object called a buoy. A long chain attaches the buoy to a very large mass at the bottom of the sea so that the buoy remains stationary.



(Source: © EThamPhoto/Alamy Stock Photo)

Water flowing past the buoy causes a horizontal force of 260 N on the buoy. The chain exerts a force  $F$  on the buoy at an angle of  $33^\circ$  to the vertical as shown.



(a) (i) Show that  $F$  is about 500 N.

(2)

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(ii) The buoy floats due to the upthrust from the water.

The weight of water displaced by the buoy is 2.9 kN.

Determine the weight of the buoy.

(3)

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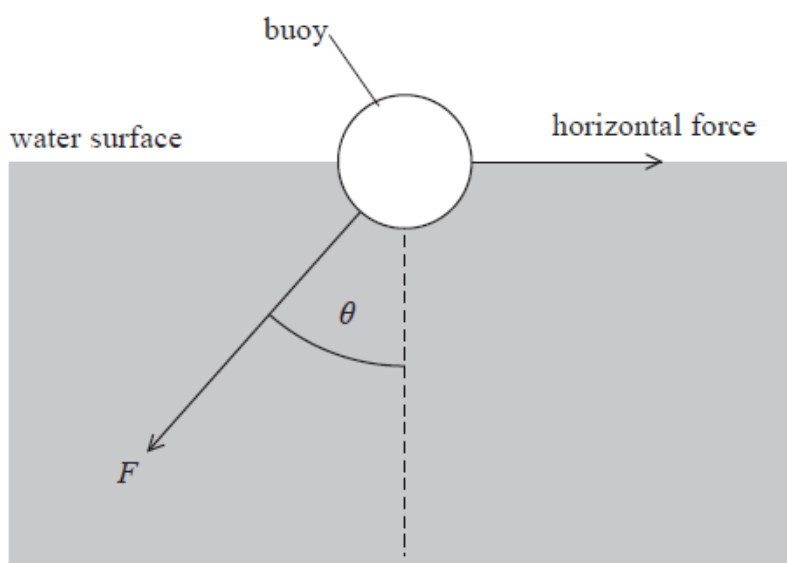
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Weight of buoy = .....

(b) The speed of the water flowing past the buoy increases, so the horizontal force increases. Assume that the weight of water displaced by the buoy does not change.



Explain how  $F$  and  $\theta$  change when the horizontal force increases.

(3)

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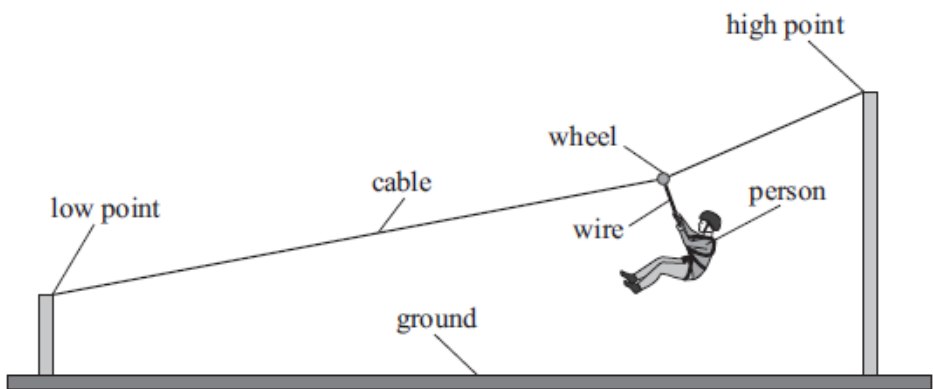
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(Total for question = 8 marks)

Q26.

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.



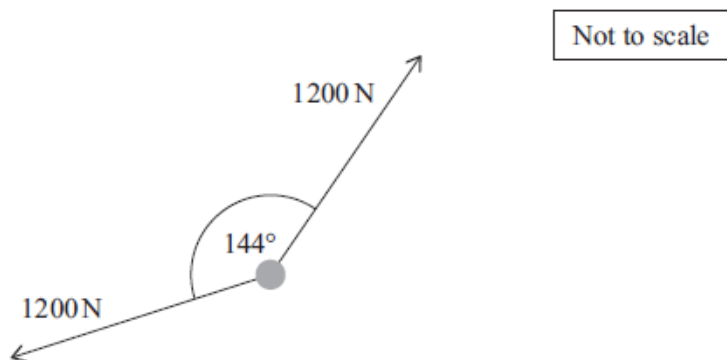
(a) In the position shown, the person is accelerating.

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  $144^\circ$ , 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  $150^\circ$ .

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 = 12 marks)**