



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 lift moves upwards from rest with an acceleration α . A student of mass 70 kg standing in the lift exerts a force of 800 N on the floor of the lift.

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Which of the following expressions could be used to determine α ?

- ☐ **A** $70g = 70\alpha$
- ☐ **B** $800 = 70\alpha$
- ☐ **C** $800 - 70g = 70\alpha$
- ☐ **D** $70g - 800 = 70\alpha$



(Total for question = 1 mark)

Q2.

A ball of mass m is projected vertically upwards. An air resistance F acts on the ball at all times.

Which of the following equations would apply to the ball as it is travelling upwards?

- ☐ **A** $mg - F = 0$
- ☐ **B** $mg + F = 0$
- ☐ **C** $mg - F = ma$
- ☐ **D** $mg + F = ma$

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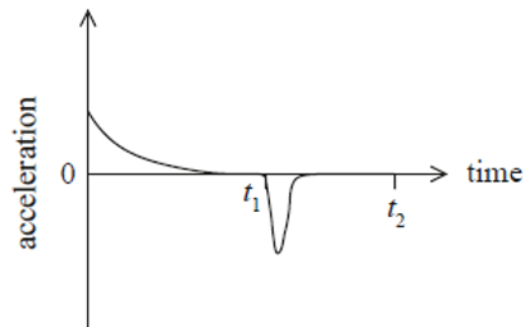
(Total for question = 1 mark)



Q3.

* A skydiver jumps from an aeroplane and accelerates until she reaches terminal velocity. At a time t_1 , she opens a parachute and a second, lower terminal velocity is reached before landing safely at time t_2 .

The acceleration-time graph for the motion of the skydiver is shown.



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Explain the shape of the graph. You should refer to the forces acting on the skydiver.

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(Total for question = 6 marks)



Q4.

The photograph shows a person riding a unicycle. The unicycle moves at a constant speed on a horizontal surface. The vertical forces R and W act as shown.



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© Martin Charles Hatch/Shutterstock

The magnitude of each force is represented by the length of the arrow on the photograph.

(a) Assess whether forces R and W are a Newton's third law pair of forces.

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(b) Explain the motion of the unicycle. Your answer should make reference to all of the forces acting on the unicycle.

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(Total for question = 5 marks)

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 ☐.

A van travels along a straight, horizontal road at a constant velocity.

Which of the following statements is correct?

- ☐ **A** The frictional force of the road on the tyres can be ignored.
- ☐ **B** The frictional force of the road on the tyres is equal to the resultant force on the van.
- ☐ **C** The frictional force of the road on the tyres is in the direction of motion of the van.
- ☐ **D** The frictional force of the road on the tyres is in the opposite direction to the motion of the van.

(Total for question = 1 mark)

Q6.

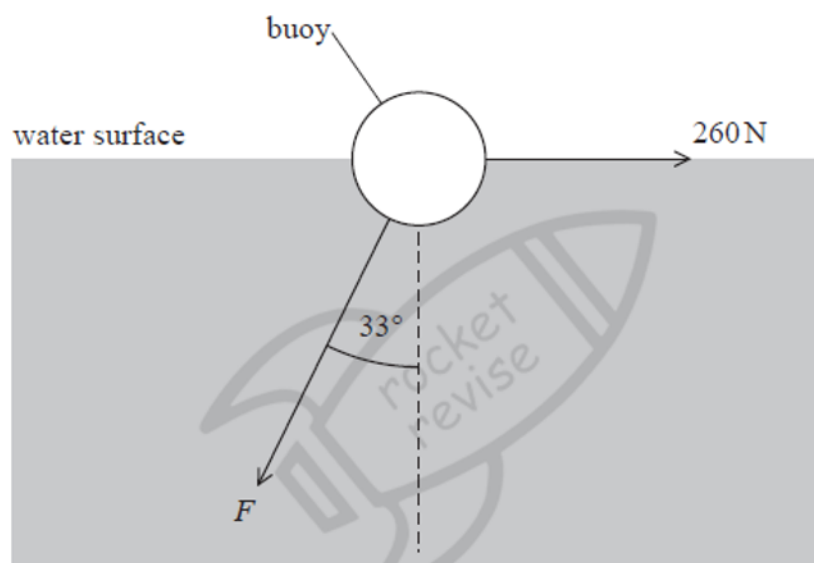
The photograph shows a floating object called a buoy. A long chain attaches the buoy to a very large mass at the bottom of the sea so that the buoy remains stationary.



(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° to the vertical as shown.

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

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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.

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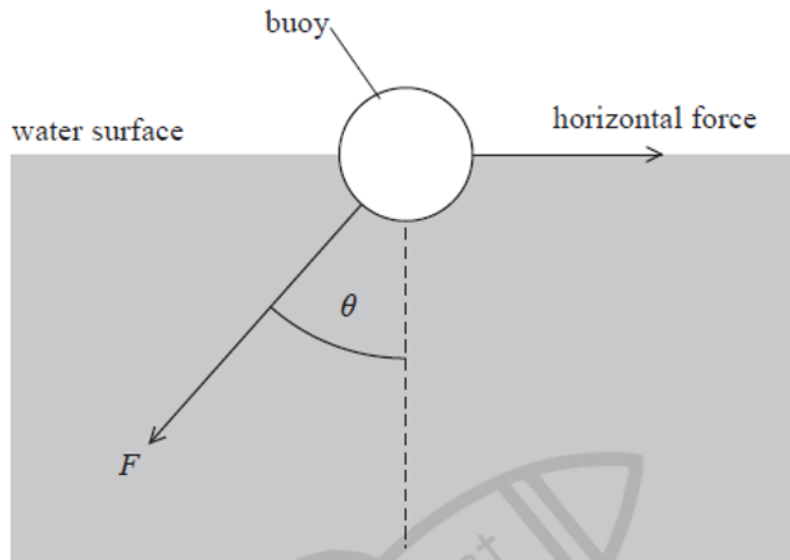
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Weight of buoy =

(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.



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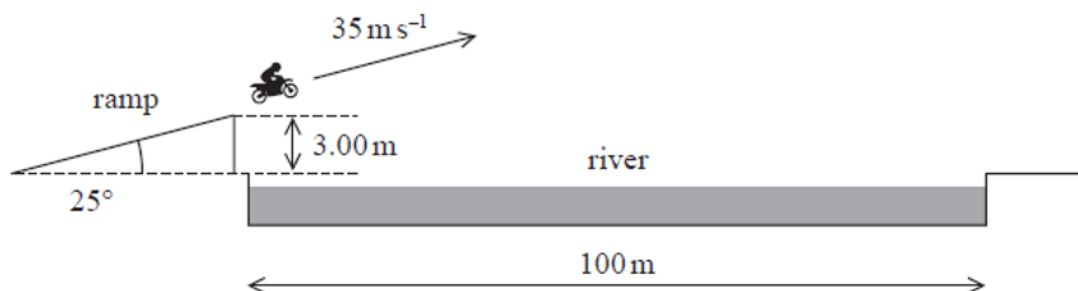
Explain how F and θ change when the horizontal force increases.

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Q7.

A stunt motorcyclist wants to jump across a river to land on the other side. The diagram shows the motorcyclist driving off a ramp at the edge of a river.



The ramp is at an angle of 25° to the horizontal and the height at the end of the ramp is 3.0 m . The width of the river is 100 m . The initial velocity of the motorcyclist is 35 m s^{-1} .

(a) Calculate the horizontal and vertical components of the motorcycle's initial velocity as it leaves the ramp.

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Horizontal component =

Vertical component =

(b) Deduce whether the rider lands on the other side of the river.

The effects of air resistance can be ignored.

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(c) Explain how air resistance would affect the jump.

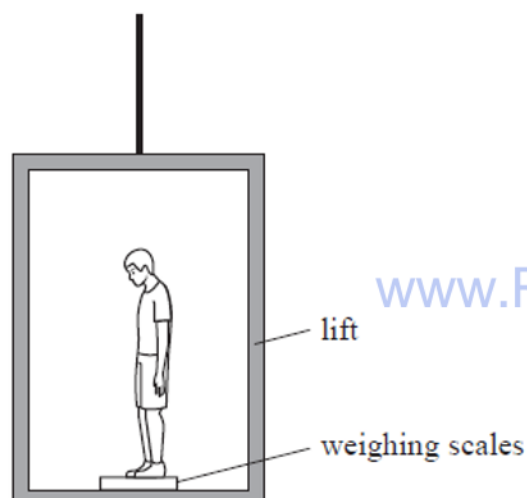
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(Total for question = 9 marks)

Q8.

* A student of weight 600 N is standing on weighing scales in a lift. The scales are calibrated to give readings in newtons.



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The lift moves upwards at constant velocity, then decelerates to rest. As the lift moves, the student looks at the readings on the scales.

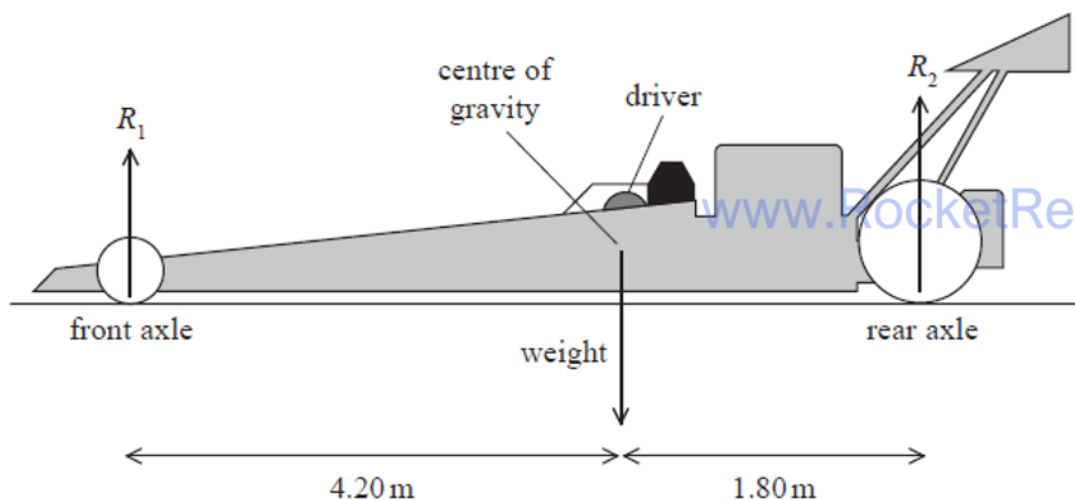
Explain the readings on the scales.



(Total for question = 6 marks)

Q9.

A dragster is a racing car designed for a very short race along a completely straight track, so must be able to accelerate at a very high rate. The dragster and driver shown below have a combined weight of $1.23 \times 10^4 \text{ N}$. The centre of gravity is 1.80 m in front of the rear axle.



The front axle of the dragster is 6.00 m from the rear axle.

(a) Calculate the reaction forces R_1 and R_2 , shown on the diagram, when the dragster is stationary and not accelerating.

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Q10.

The photograph shows a rocket. This rocket is launched vertically.



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(Source: <https://www.nasa.gov/image-feature/the-spacex-falcon-9-rocket-in-vertical-position-on-the-launch-pad>)

(a) The rocket's engines give a total upward thrust of 7.3×10^7 N.

Calculate the initial acceleration of the rocket.

mass of rocket = 5.0×10^6 kg

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Initial acceleration =

(b) Give one reason why the acceleration will increase as the rocket rises.

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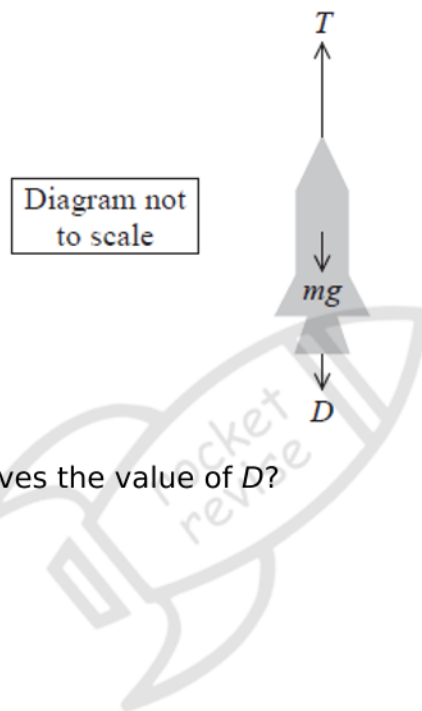
(Total for question = 4 marks)



Q11.

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 ☐.

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



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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** $D = T - m(g + a)$

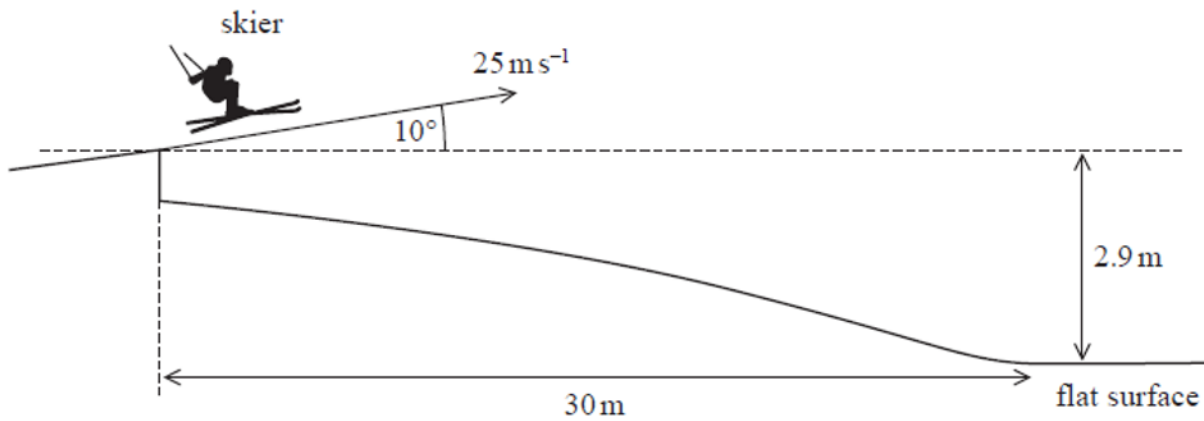
(Total for question = 1 mark)

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Q12.

A skier moving at 25 m s^{-1} skis off a ramp. The ramp is angled upwards at 10° to the horizontal, as shown.

There is a flat surface that starts 30 m from the ramp. The flat surface is 2.9 m below the ramp.



(a) Deduce whether the skier reaches the flat surface before landing. You may ignore any effects of air resistance.

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(b) Another skier travels along the horizontal surface with an initial speed of 23 m s^{-1} . She comes to rest after travelling a distance of 43 m .

Calculate the average force required to bring the skier to rest.

mass of skier = 63 kg

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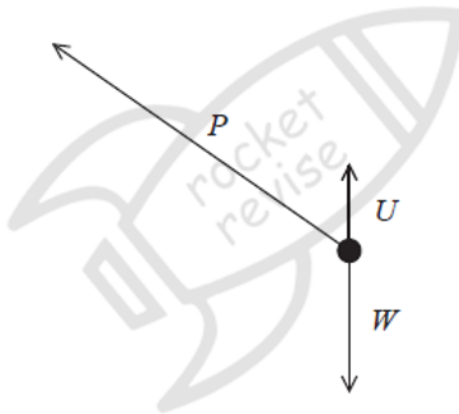
Average force =

(Total for question = 8 marks)

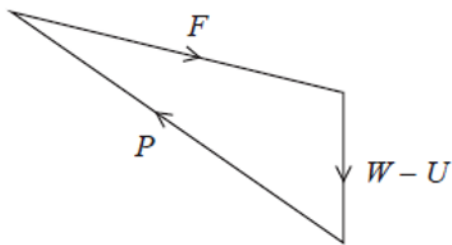
Q13.

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 ☐.

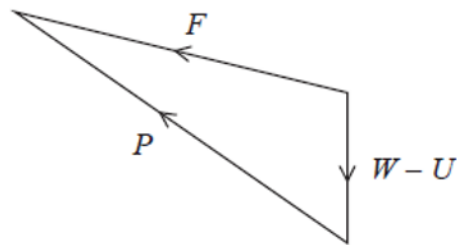
A soap bubble is being blown by the wind. The free-body force diagram shows the forces acting on the bubble. P is the force of the wind, W is the weight of the bubble and U is the upthrust acting on the bubble.



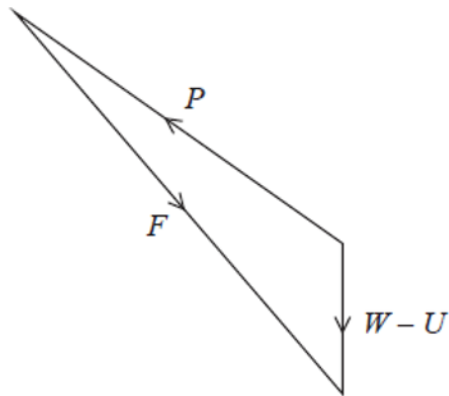
Which of the following vector diagrams shows the resultant force F acting on the bubble?



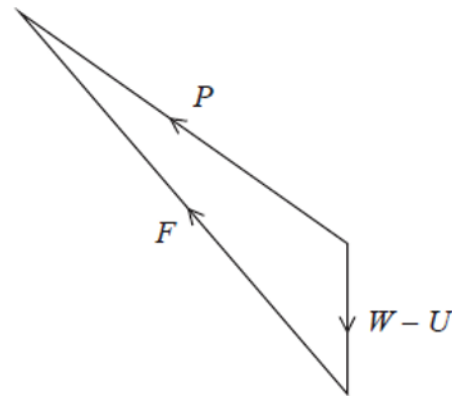
A



B



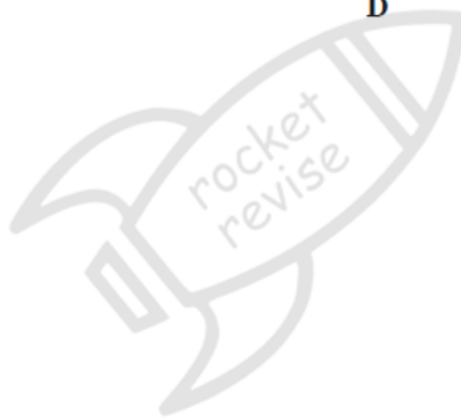
C



D

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- ☐ A
- ☐ B
- ☐ C
- ☐ D



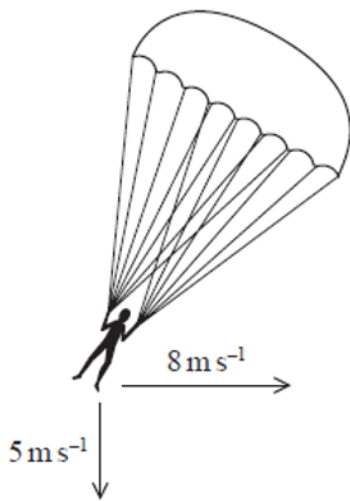
(Total for question = 1 mark)

Q14.

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Select one answer from A to D and put a cross in 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 ☐.

The diagram shows a student during a parachute jump on a windy day. The vertical component of her velocity is 5.0 m s^{-1} . The horizontal component of her velocity is 8.0 m s^{-1} . She descends at an angle θ to the vertical.



Which row of the table gives expressions for the magnitude and angle of the student's resultant velocity?

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	Magnitude / m s^{-1}	$\theta / ^\circ$
☐ A	$\sqrt{8^2 - 5^2}$	$\tan^{-1} \frac{8}{5}$
☐ B	$\sqrt{8^2 - 5^2}$	$\sin^{-1} \frac{5}{8}$
☐ C	$\sqrt{8^2 + 5^2}$	$\tan^{-1} \frac{8}{5}$
☐ D	$\sqrt{8^2 + 5^2}$	$\sin^{-1} \frac{5}{8}$

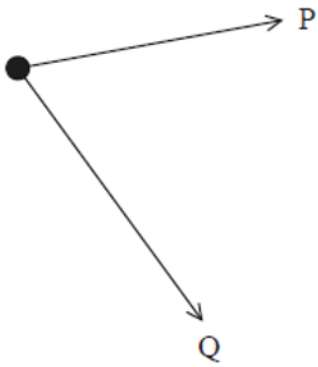
(Total for question = 1 mark)

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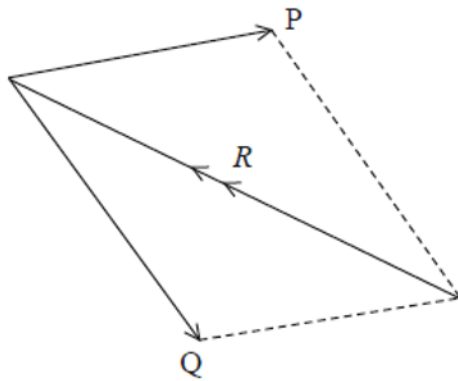
Q15.

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 ☐ .

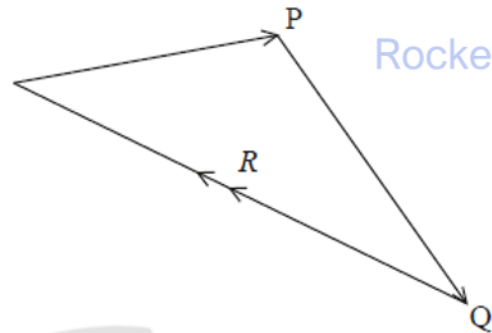
Two forces P and Q act on an object as shown.



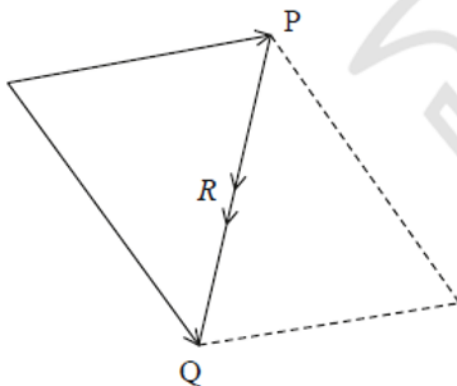
Which of the following is a correctly drawn, scaled, vector diagram for the resultant R of forces P and Q ?



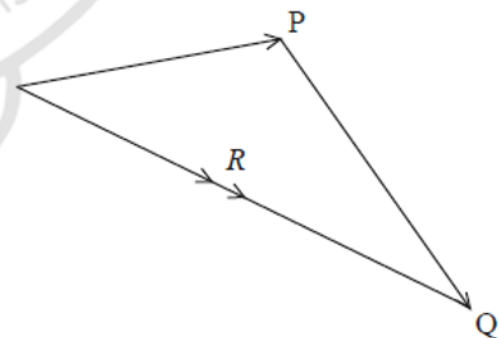
A



B



C



D

- ☐ A
- ☐ B
- ☐ C
- ☐ D

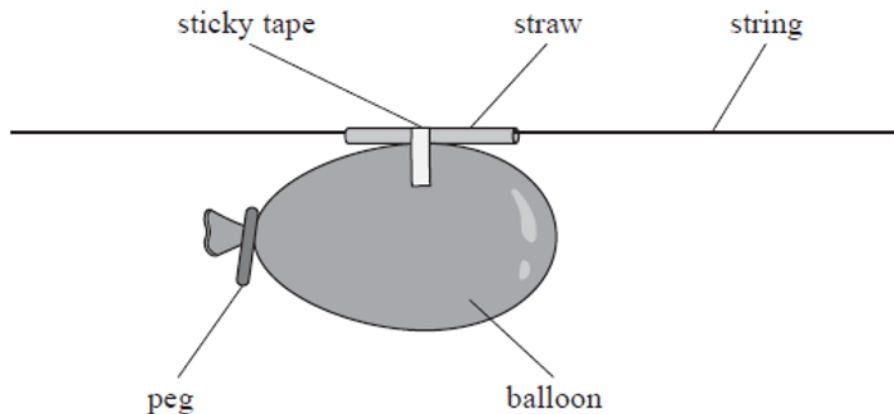
(Total for question = 1 mark)



Q16.

* A student inflates a balloon. She uses a peg to keep the balloon closed. She then attaches a straw to the balloon using sticky tape.

She passes a string through the straw and pulls the string tight, as shown.



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The student removes the peg and air leaves the balloon.

The velocity of the balloon increases from zero to a maximum.

Explain how Newton's three laws of motion apply to the motion of the balloon during this time.

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(Total for question = 6 marks)



Q17.

Select one answer from A to D and put a cross in 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 ☐.

A person is pushing a trolley at a constant velocity.

The floor exerts a force P on the person, the person exerts a force Q on the trolley.

The trolley exerts a force R on the person and the total drag force on the trolley is S .



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(Source: Andy Dossett/Alamy Stock Photo)

Which pair of forces is a Newton's Third Law pair?

- ☒ A P and R
- ☐ B Q and R
- ☐ C Q and S
- ☐ D P and S

(Total for question = 1 mark)

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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 ☐.

Two forces form a Newton's third law pair.



Which of the following statements is **not** true?

- ☐ **A** The forces act on the same object.
- ☐ **B** The forces have the same magnitude.
- ☐ **C** The forces act for the same time.
- ☐ **D** The forces are the same type of force.

(Total for question = 1 mark)

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Q19.

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 make a Newton's third law pair.

Which of the following statements is true for these forces?

- ☐ **A** They act in different directions on the same body.
- ☐ **B** They are the same type of force and act on different bodies.
- ☐ **C** They have different magnitudes and act in different directions.
- ☐ **D** They are the same type of force and have different magnitudes.

(Total for question = 1 mark)

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Q20.

According to Newton's third law, when two objects interact they exert forces on each other.

Which of the following statements is **not** a correct description of these forces?

- ☐ **A** The forces act at the same time.



- ☐ **B** The forces act in the same direction.
- ☐ **C** The forces act on different objects.
- ☐ **D** The forces have the same magnitude.

(Total for question = 1 mark)

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Q21.

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 massive star exerts a gravitational force F_{star} on a small distant planet. The planet exerts a gravitational force F_{planet} on the star.

Which row of the table is correct?

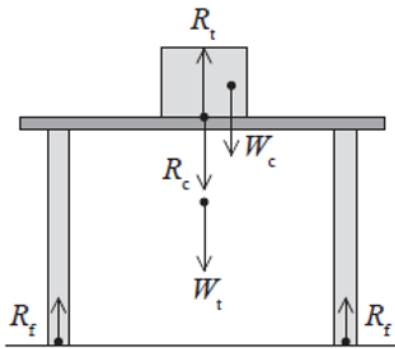
	Magnitude of forces	Direction of forces
☐ A	$F_{\text{planet}} < F_{\text{star}}$	opposite
☐ B	$F_{\text{planet}} < F_{\text{star}}$	the same
☐ C	$F_{\text{planet}} = F_{\text{star}}$	opposite
☐ D	$F_{\text{planet}} = F_{\text{star}}$	the same

(Total for question = 1 mark)

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Q22.

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 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** $R_t = W_c$

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(Total for question = 1 mark)

Q23.

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 ☐.

Once in orbit above the Earth's atmosphere, the engines on a space rocket are switched off.

Which row of the table correctly states the resulting motion of the rocket and the law explaining this motion?

	Motion of rocket	Explanation
☐ A	uniform velocity	Newton's 2 nd law
☐ B	uniform velocity	Newton's 3 rd law
☐ C	changing velocity	Newton's 2 nd law
☐ D	changing velocity	Newton's 3 rd law



(Total for question = 1 mark)

Q24.

The photograph shows an area of land where golfers can practise their golf shots. Distances are marked out along the land in front of where the golfer stands, to measure the distance travelled by the ball.

Two levels are available. If the lower level is used, the ball lands at the same height from which it was hit. If the higher level is used, this enables the ball to be hit further.



Source: www.golfnews.co.uk

(a) A ball is given an initial velocity of 33 m s^{-1} at an angle of 28° to the horizontal.

When hit from the lower level, this ball travels a horizontal distance of 92 m before landing. Use of the higher level increases the horizontal distance travelled before landing by 10 m.

Deduce whether an upper level at a height of 4.5 m would be sufficient to produce this increase. You should ignore air resistance.

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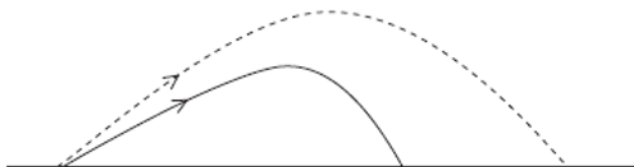
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* (b) Your answer to part (a) did not consider the effect of air resistance.

The trajectories of the motion of the golf ball with air resistance and without air resistance are shown.



Trajectory without
air resistance

Trajectory with
air resistance

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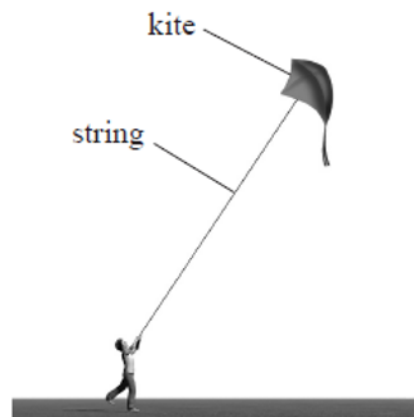
Explain the differences between the two paths.

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Q25.

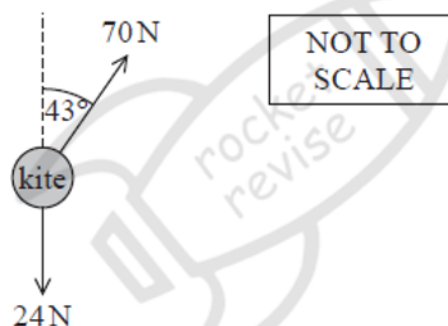
A student is flying a kite. The kite is held in equilibrium by a string as shown.



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(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.

(4)

Tension =

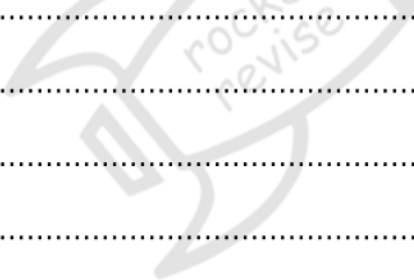
(b) The student wants to determine the tension T in the string. She attaches a mass holder to the string. The student adds known masses to the mass holder until the kite is in equilibrium and part of the string becomes horizontal, as shown.

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

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(Total for question = 9 marks)



Q26.

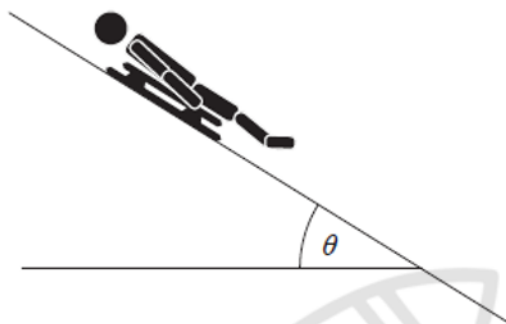
The luge is an event at the Winter Olympics. An athlete lies on a small sledge and races down an icy track, feet first.



Source: www.wtop.com

(a) An athlete accelerates down a straight section of the track as shown. The track is at an angle θ to the horizontal.

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Draw a free-body force diagram for the sledge and athlete. You should consider the relative sizes of the forces when drawing your diagram.

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(b) The mass of the athlete is one of the factors that affects her time to complete the race.

(i) Explain why the mass of the athlete has little effect on the initial acceleration.

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(ii) Explain, in terms of forces, why the athlete reaches a maximum velocity.

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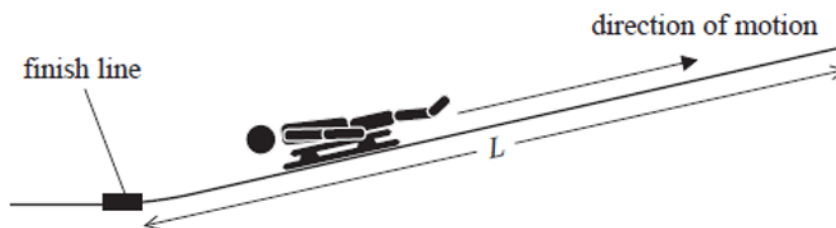
(iii) It is stated that the maximum speed is greater for athletes of greater mass.

Suggest why this is only correct up to a certain mass.

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(2)

(c) After the finish line there is a straight, uphill section of track for the sledge to decelerate in. The maximum permitted gradient of this section is 20 %.



(i) Show that a track with a gradient of 20% is at an angle to the horizontal of about 11° .

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(1)

(ii) An athlete reaches the finish line at a velocity of 33 m s^{-1} . She then applies a minimum braking force of 240 N as she moves along the uphill section of track to help her come to a stop.

Calculate the minimum uphill length of track L that should be available for braking. You should ignore all frictional forces other than those applied by the athlete.

mass of sledge and athlete = 95 kg



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$L =$

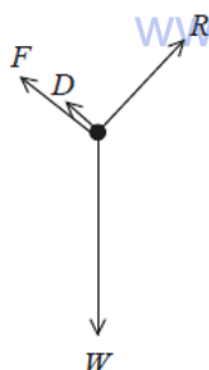
(Total for question = 18 marks)

Q27.

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 was placed at the top of a ramp and released.

The free-body force diagram for the box as it moved down the ramp at a constant velocity is shown.



D = air resistance

F = frictional force

R = normal contact force

W = weight of the box

Which two forces acting on the box have, according to Newton's third law, corresponding forces acting on the ramp?



- ☐ **A** F and D
- ☐ **B** F and R
- ☐ **C** W and D
- ☐ **D** W and R

(Total for question = 1 mark)

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Q28.

A sledge accelerates, due to gravity, from rest down a frictionless slope. Air resistance can be ignored. The slope is at an angle of 6.9° to the horizontal, as shown.



(a) Complete the free-body force diagram below for the sledge.

(2)



(b) The slope has a total length of 60 m.

(i) Show that the initial acceleration of the sledge along the slope is about 1 m s^{-2} .

(2)

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(ii) Determine the speed of the sledge at the end of the slope.

(2)

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Speed at end of slope =

(iii) Determine the time taken for the sledge to travel to the end of the slope.

(2)

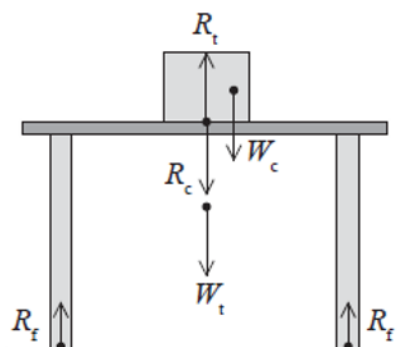
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Time taken =

(Total for question = 8 marks)

Q29.

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



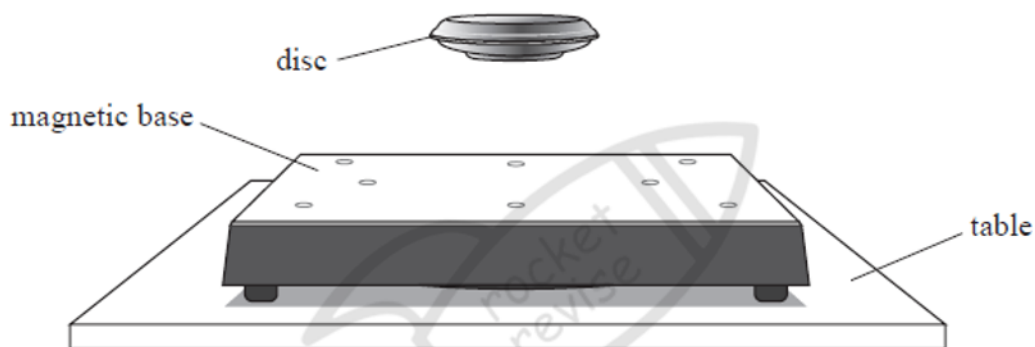
- ☐ **B** R_t
- ☐ **C** W_c
- ☐ **D** W_t

(Total for question = 1 mark)

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Q30.

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 3rd law pair.

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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.

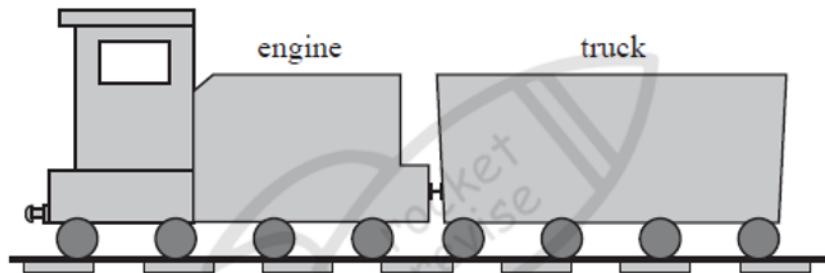


(Total for question = 4 marks)

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Q31.

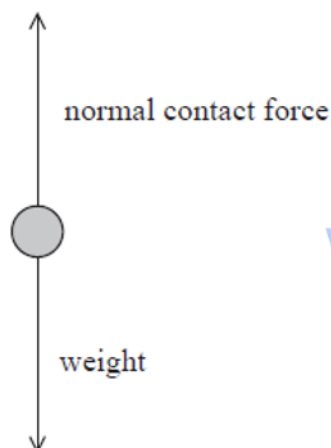
A railway engine is pushing a truck along horizontal rails at a constant velocity, as shown.



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)



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(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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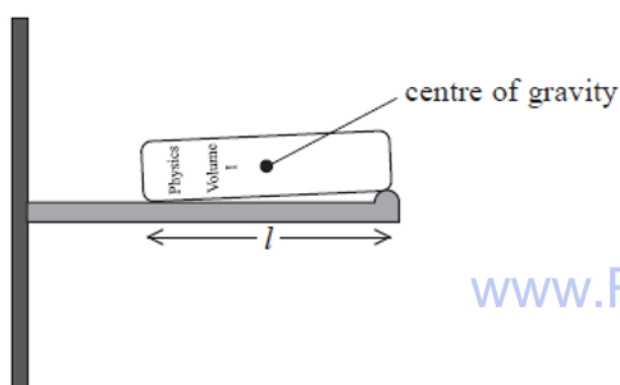
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(Total for question = 9 marks)

Q32.

A book of length l and weight W is positioned on a shelf as shown.



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(a) State what is meant by centre of gravity.

(1)

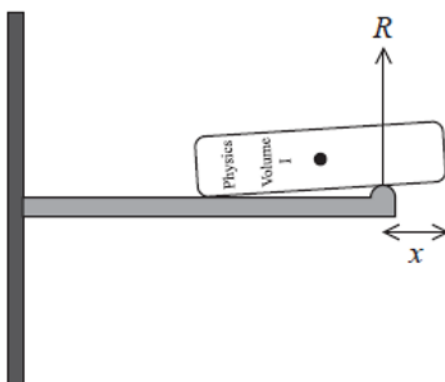
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(b) There are contact forces at the two positions where the book touches the shelf.



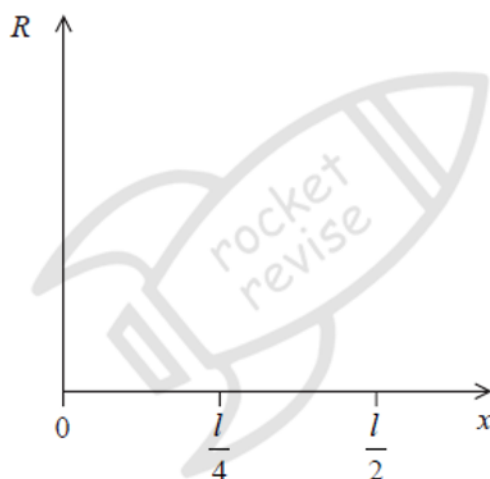
The book is moved a distance x to the right as shown.



The magnitude of the contact force R varies with x .

Sketch on the axes below the variation of R with x between 0 and $\frac{l}{2}$. You should mark the maximum value of R onto the axes.

(3)



(c) Explain why the book will not remain on the shelf if $x > \frac{l}{2}$

(2)

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Q33.

Which of the following statements describes the gravitational field strength acting on a body at a point?

- ☐ **A** gravitational force per unit length
- ☐ **B** gravitational force per unit mass
- ☐ **C** gravitational potential energy per unit length
- ☐ **D** gravitational potential energy per unit mass

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(Total for question = 1 mark)



Q34.

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 ☐.

Which of the following describes gravitational field strength?

- ☐ **A** weight per unit mass
- ☐ **B** acceleration per unit mass
- ☐ **C** gravitational potential energy per unit mass
- ☐ **D** acceleration per unit weight

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(Total for question = 1 mark)



Q35.

Select one answer from A to D and put a cross in 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 ☐.

Which row of the table contains two units that are **not** equivalent?

	Unit 1	Unit 2
☐ A	J s^{-1}	W
☐ B	kg m s^{-2}	N s
☐ C	N kg^{-1}	m s^{-2}
☐ D	Nm	J

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(Total for question = 1 mark)

