

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 ☐.

Which of the following is an SI unit for momentum?

☐ **A** kg m s^{-1}

☐ **B** J m^{-1}

☐ **C** m s^{-2}

☐ **D** N s^{-1}

(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 ☒ 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)

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 (☐).

A student uses a wooden bat to hit a stationary ball of mass m .

As the bat hits the ball, the momentum of the bat decreases by Δp .

The ball then moves with velocity v .

The student then uses the bat to hit a stationary ball of mass $3m$.

The momentum of the bat decreases by $2\Delta p$.

Which of the following expressions gives the velocity of the ball of mass $3m$ after being hit?

☐ **A** $\frac{1}{6}v$

☐ **B** $\frac{2}{3}v$

☐ **C** $\frac{3}{2}v$

☐ **D** $6v$

(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 (☐).

Two objects, R and S, are falling vertically and accelerating due to gravity.
Air resistance is negligible.

R has mass m and S has mass $2m$.

Initially, each object has momentum p .

After time t object R has momentum $2p$.

Which of the following gives the momentum of object S after time t ?

- ☐ **A** $2p$
- ☐ **B** $3p$
- ☐ **C** $4p$
- ☐ **D** $5p$

(Total for question = 1 mark)

Q5.

Trolleys X and Y of masses m and $3m$ respectively are travelling at the same speed towards each other. The trolleys collide and move off together.



Which of the following statements is correct?

- ☐ **A** The force of X on Y during the collision is greater than the force of Y on X.
- ☐ **B** The force of X on Y during the collision is less than the force of Y on X.
- ☐ **C** The speed of X after the collision is greater than v .
- ☐ **D** The speed of X after the collision is less than v .

(Total for question = 1 mark)

Q6.

An air track is a straight tube with holes along its length. Air forced through the holes lifts the gliders, preventing friction between the gliders and the air track.

A teacher uses an air track and two gliders, A and B, to demonstrate the principle of conservation of linear momentum.

Glider A and B move towards each other and then collide.

(a) State how Newton's third law applies to the gliders during the collision.

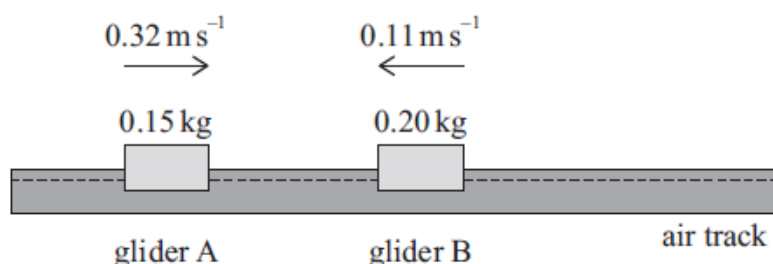
(1)

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(b) Gliders A and B have different masses and move at different velocities before the collision, as shown.



The gliders stick together in the collision.

A student predicts that the gliders will move to the left after the collision.

Deduce whether the prediction is correct.

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(Total for question = 4 marks)

Q7.

An aluminium sphere collides head-on with a stationary steel sphere. The two spheres move off separately after the collision.

(a) State the principle of conservation of momentum.

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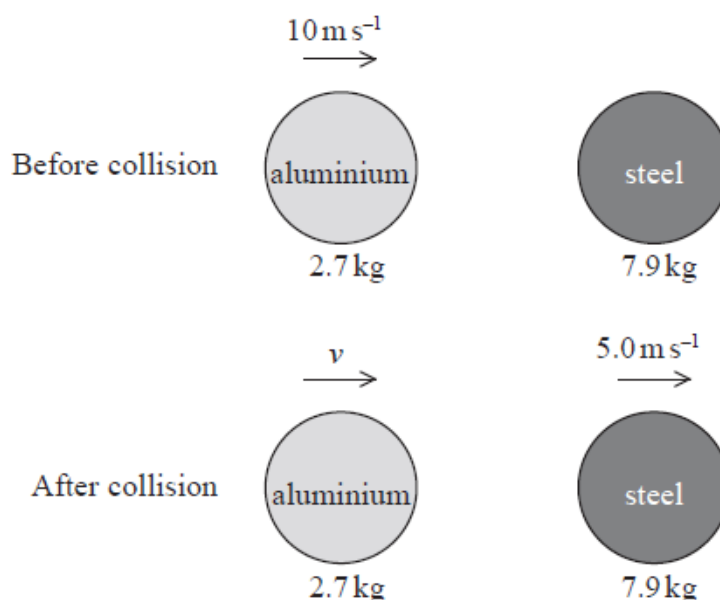
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(b) The aluminium sphere has an initial velocity of 10.0 m s^{-1} . Immediately after the collision the velocity of the steel sphere is 5.0 m s^{-1} .



Calculate the velocity v of the aluminium sphere immediately after the collision.

mass of aluminium sphere = 2.7 kg

mass of steel sphere = 7.9 kg

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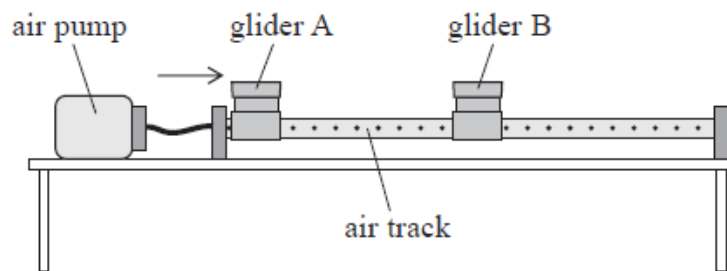
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$v =$

Q8.

A teacher demonstrated the principle of conservation of linear momentum using two gliders, A and B, and an air track. A has the same mass as B.

A and B were initially stationary, then A was pushed gently towards B as shown.



(a) State the principle of conservation of linear momentum.

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(b) A magnet was attached to each glider. The gliders collided and stuck together.

A data logger and sensor were used to record the velocity of A. The velocity recorded after the collision was half the velocity recorded before the collision.

(i) Deduce whether these results show that the law of conservation of linear momentum is obeyed.

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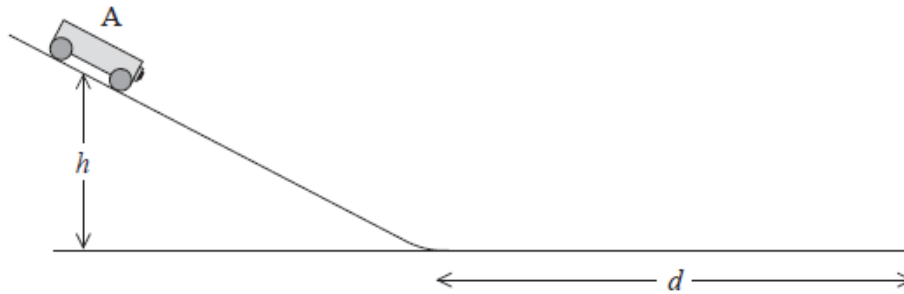
(ii) Explain why the force of attraction between the two magnets did not affect this demonstration.

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(Total for question = 6 marks)

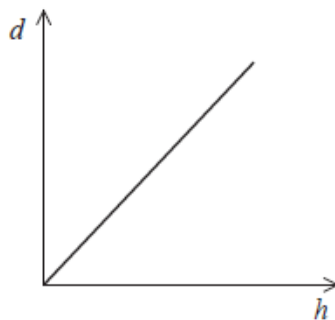
Q9.

A student set up the apparatus shown.



(a) When released from a height h , trolley A ran down the slope and then continued to move horizontally. On the horizontal part of the track a frictional force F brought the trolley to rest over a short distance d . The trolley has a mass m . The student measured d for a range of heights h .

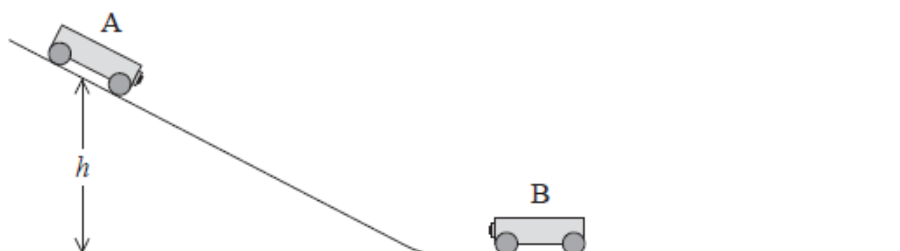
The student plotted the following graph of d against h .



Derive an expression for the gradient of the graph, in terms of F , m and g .

(2)

(b) In a second experiment, an identical trolley B was placed at rest at the bottom of the slope. When trolley A was released as before, it rolled down and collided with trolley B. After the collision the two trolleys joined together and moved off to the right with a velocity v .



The student predicted that, provided friction was ignored, $v = \sqrt{\frac{gh}{2}}$.

Assess whether the student was correct.

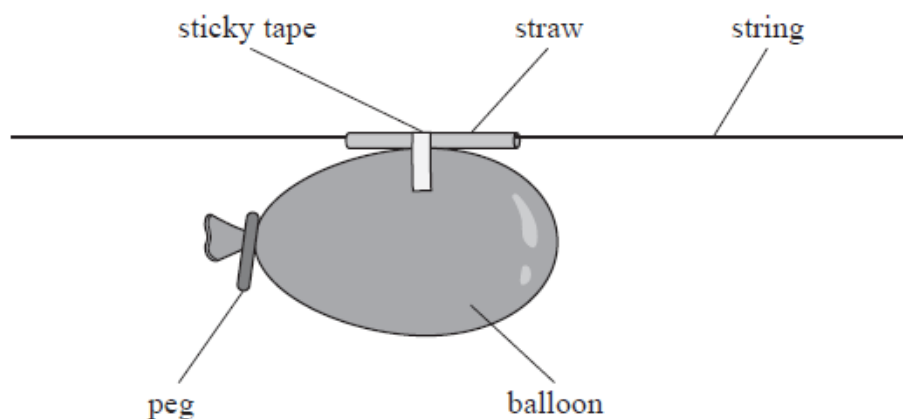
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(Total for question = 6 marks)

Q10.

* 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.



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)

Q11.

Speed skating on ice is an Olympic sport. Collisions between skaters sometimes occur.

(a) State the principle of conservation of momentum.

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(b) Two speed skaters are skating as shown.



(Source: © sportpoint/Shutterstock)

Initially, skater B is directly behind skater A. Skater B is moving faster and collides with skater A.

During the collision, skater B locks his arms around skater A so that they move forward together with a speed of 6.2 m s^{-1} .

Deduce whether momentum is conserved in this collision.

initial speed of skater A = 5.5 m s^{-1}

mass of skater A = 65 kg

initial speed of skater B = 7.5 m s^{-1}

mass of skater B = 60 kg

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(c) The kinetic energy of the two skaters after the collision is much less than their combined kinetic energy before the collision, so the collision is inelastic.

Explain the decrease in kinetic energy in this collision.

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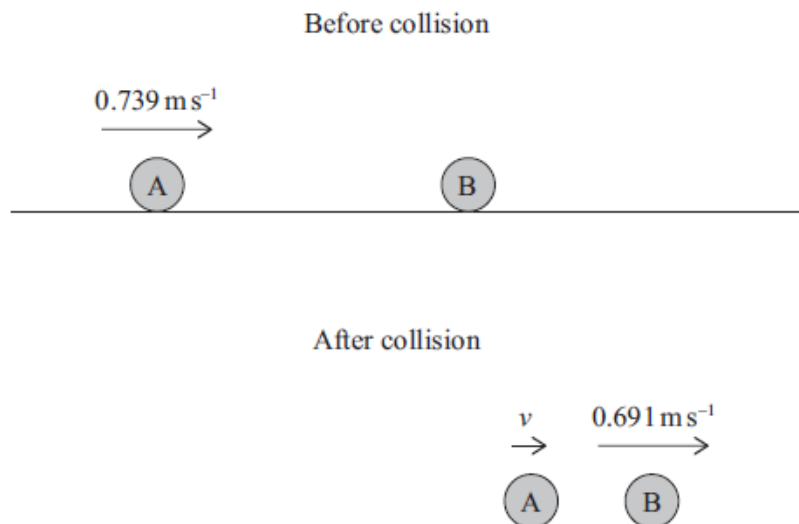
(Total for question = 7 marks)

Q12.

Two identical balls, A and B, collide. Ball B is initially at rest. After the collision, ball B moves off in the same direction as ball A.

The mass of each ball is 0.165 kg.

The initial velocity of ball A is 0.739 m s^{-1} . After the collision, the velocity of ball B is 0.691 m s^{-1} , as shown.



(a) Show that the velocity of ball A immediately after the collision is about 0.05 m s^{-1} .

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(b) Before the collision, the kinetic energy of ball A is 4.5×10^{-2} J, and the kinetic energy of ball B is zero.

Determine the decrease in total kinetic energy during the collision.

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Decrease in total kinetic energy = ... J

(c) During the collision there is a resultant force on ball B from ball A.

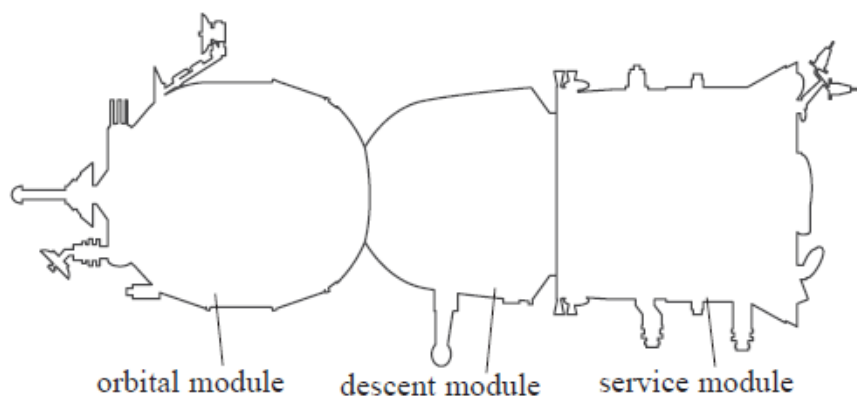
Explain, in terms of Newton's laws, why ball A decelerates during the collision.

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(Total for question = 7 marks)

Q13.

A spaceship is used to take astronauts and equipment to the International Space Station. The spaceship consists of an orbital module, a descent module and a service module, as shown.

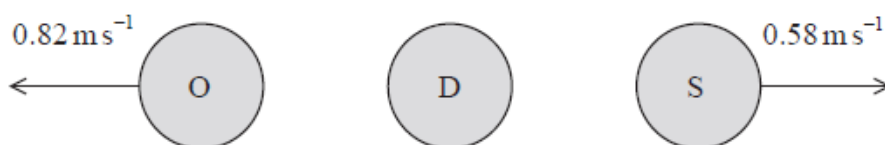


(Source: © NASA)

The astronauts return to Earth in the descent module.

Before entering the Earth's atmosphere, the modules separate.

The orbital module (O) and service module (S) move away from the descent module (D) in opposite directions, as shown below.



(a) Determine the velocity v of the descent module after separation.

You should only consider momentum along a horizontal line through the centres of the three modules.

mass of O = 1350 kg

mass of D = 2950 kg

mass of S = 2100 kg

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Magnitude of v = ... Direction of v =

(b) The velocity of the descent module can be changed using a rocket motor. The rocket motor ejects hot gases at high velocity.

(i) Explain why the velocity of the descent module changes when the rocket motor is used.

Your answer should refer to Newton's laws of motion.

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(ii) When the rocket motor is operating, the velocity of the descent module changes by 0.58 m s^{-1} during a time of 5.0 seconds.

mass of descent module = 2950 kg

Calculate the average force exerted on the hot gas during this time.

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Average force = ...

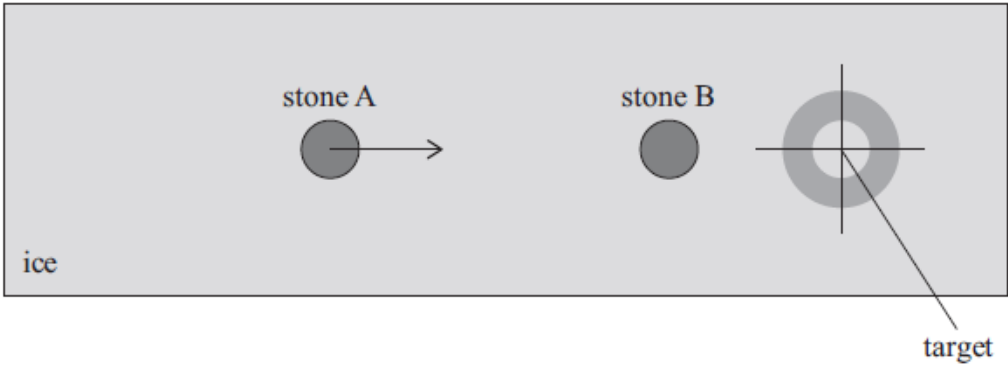
(Total for question = 10 marks)

Q14.

In a game called ‘curling’, players slide circular ‘stones’ across ice towards a target.

In one game, stone A moves towards the target, and stone B is stationary. Stone A is about to collide with stone B, as shown.

View from above



(a) During the collision, there is a resultant force on stone A and a resultant force on stone B in the opposite direction. These forces have the same magnitude and act for the same time.

Explain how Newton's second law predicts that momentum is conserved when stone A collides with stone B.

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(b) Before the collision, stone A had a kinetic energy of 3.8 J. Stone B was stationary.

After the collision, stone B moved with a speed of 0.45 m s^{-1} .

Stone A will slide past the target if the momentum of stone A after the collision is greater than 5.5 kg m s^{-1} .

Deduce whether stone A will slide past the target.

mass of stone A = 18 kg
mass of stone B = 17 kg

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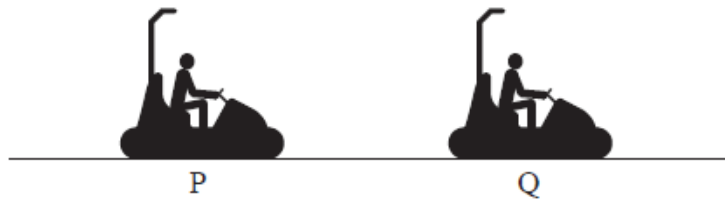
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(Total for question = 7 marks)

Q15.

The diagram shows two bumper cars, P and Q, at an amusement park.



Q was stationary. P was moving at a speed of 2.10 m s^{-1} towards Q.

P collided with Q. After the collision, P and Q moved off in the same direction. P moved with a speed of 1.15 m s^{-1} . Q moved with a speed of 1.57 m s^{-1} .

(a) (i) Show that the total mass of Q was about 150 kg.

total mass of P = 250 kg

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(ii) State **one** assumption you made in your calculation in (a)(i).

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(iii) The collision lasted a total time of 1.35 s.

Calculate the average horizontal force on Q during the collision.

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Average horizontal force = ...

(b) Explain why P decelerates during the collision. Your answer should make reference to Newton's laws of motion.

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(Total for question = 10 marks)

Q16.

The photograph shows a fireboat used to put out fires on ships at sea. A pump, fixed to the boat, pumps water from the sea. The seawater is projected at high speed out of a pipe connected to the pump.



(Source: © Konrad Zelazowski/age fotostock/Superstock)

(a) The mass of seawater pumped each second is 300 kg. The pipe has a diameter of 10.0 cm.
density of seawater = 1030 kg m^{-3}

(i) Show that the speed at which the seawater is projected from the pipe is about 37 m s^{-1} .

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(ii) Determine the rate at which the momentum of the seawater is changed by the pump.
You may assume that the seawater is initially stationary.

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Rate of change of momentum = ...

(b) Projecting water from the pipe causes a force to be exerted on the pump.

Explain the direction of the force on the pump.

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(c) Initially the pump is turned off and the fireboat moves forwards through the water at a constant speed. The boat's engine provides a constant forward force.

When the pump is turned on, water is projected forwards and the fireboat slows to a lower constant speed.

Explain why the boat now has a lower constant speed.
Your answer should refer to all the horizontal forces on the boat.

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(Total for question = 11 marks)

Q17.

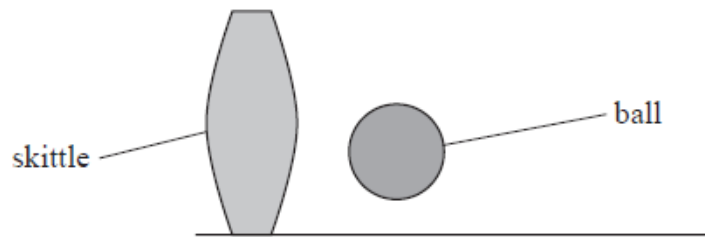
A skittle is a wooden object that can stand upright on one end.

In a game of Skittles, a ball is thrown at some skittles to knock them over, as shown.

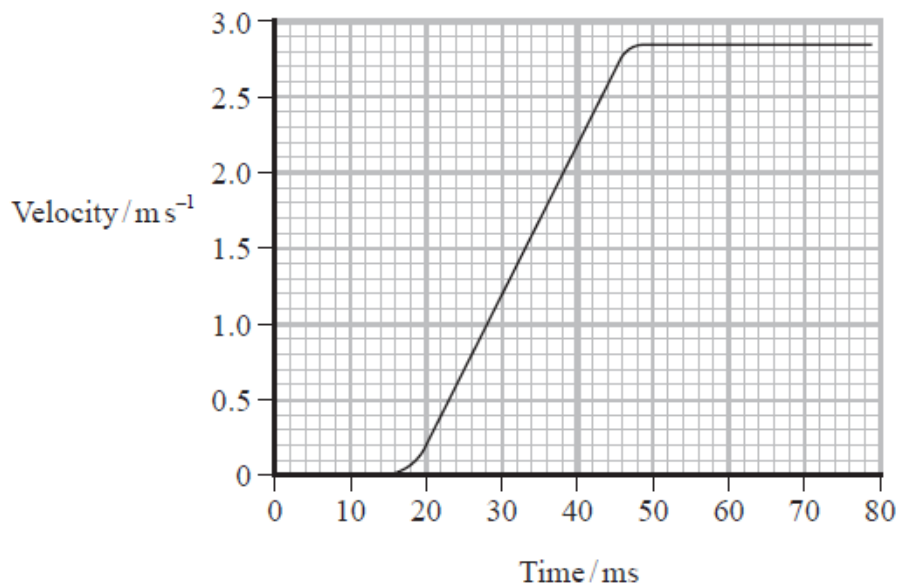


(Source: © CMBiles/Getty Images)

The diagram below shows the ball just before it collides with a skittle.



(a) The graph shows how the velocity of the skittle varies with time. The time shown on the graph starts just before the ball hits the skittle.



Determine the average acceleration of the skittle during the collision.

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Average acceleration = ...

*(b) Explain how Newton's second and third laws of motion apply to the ball and the skittle during the collision.

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(c) The ball is thrown again, and collides with another stationary skittle.

During the collision the horizontal velocity of the ball changes from 7.2 m s^{-1} to 1.6 m s^{-1} .

The horizontal velocity of the skittle immediately after the collision is 3.1 m s^{-1} in the same direction as the ball.

Determine the mass of the ball.

mass of skittle = 1.4 kg

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Mass of ball = ...

(Total for question = 12 marks)

