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 gas molecule of mass *m* travelling at speed *v* strikes the side of a gas cylinder at an angle θ. The collision takes time *t*.

What is the average force acting on the side of the gas cylinder?

☒ **A** $\frac{mv}{t}$

☒ **B** $\frac{2mv}{t}$

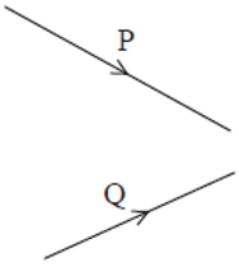
☒ **C** $\frac{mv\sin\theta}{t}$

☒ **D** $\frac{2mv\sin\theta}{t}$

(Total for question = 1 mark)

Q2.

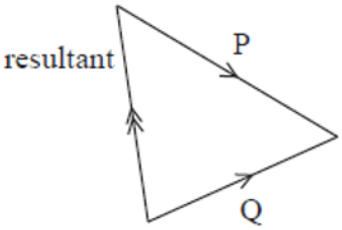
The diagram shows the momenta P and Q of two bodies about to collide.



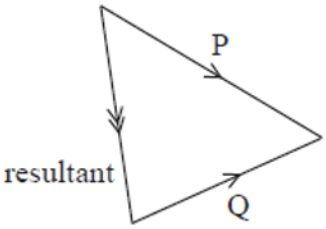
When the bodies collide they merge and move on as a single body.

Which of the following diagrams shows the resultant momentum?

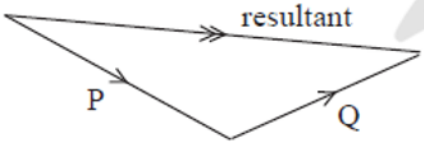
☒ **A**



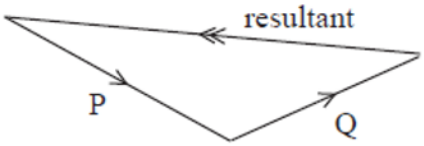
☒ **B**



☒ **C**



☒ **D**



(Total for question = 1 mark)

Q3.

The photograph shows a jumping toy.

The head is pushed down onto the base, compressing a spring. When released the spring expands and the toy jumps into the air.

A student investigated the toy.

The student placed the toy on a balance to measure the force required to compress the spring. The force was 14 N when the spring was fully compressed by 1.7 cm.

When the toy was launched it jumped to a height of 1.5 m.

(a) Show that the maximum energy stored in the compressed spring was about 0.1 J.

(2)

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(b) Initially the spring was fully compressed. As the toy was released, the head accelerated upwards on its own until the spring was uncompressed. The head then pulled the base upwards and they moved together at the same speed.

The student used the elastic potential energy stored in the spring to determine the maximum speed of the head.

The student used the gravitational potential energy gained by the whole toy to determine its initial upwards speed.

Determine whether the toy obeys the law of conservation of momentum using values of speed calculated in this way.

mass of head = 6.4 g

mass of whole toy = 7.2 g

maximum height of jump = 1.5 m

(5)

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(c) Determine whether kinetic energy was conserved as the head began to pull the base upwards.

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(Total for question = 9 marks)

Q4.

A ball of mass m travelling with velocity v strikes a wall at right angles. It bounces off the wall in the opposite direction at the same speed.

Which of the following is the impulse on the wall?

☒ **A** mv

☒ **B** $2mv$

☒ **C** $-mv$

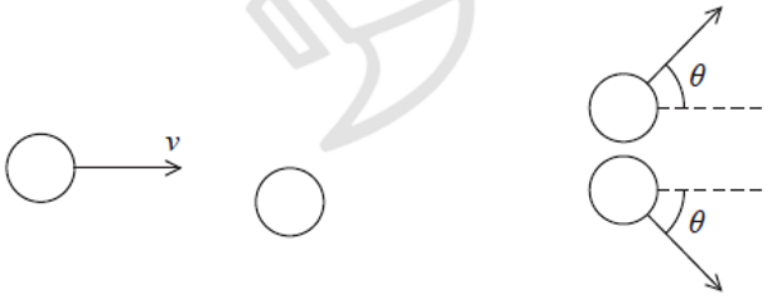
☒ **D** $-2mv$

(Total for question = 1 mark)

Q5.

A sphere travelling at speed v collides elastically with an identical sphere which is at rest.

After the collision, both spheres move off at an angle θ to the direction of travel of the first sphere, as shown. The spheres have the same speed as each other.



Before collision After collision

What is the speed of the spheres after the collision?

☒ **A** v

☒ **B** $\frac{v}{\sqrt{2}}$

☒ **C** $\frac{v}{2}$

☒ **D** $\frac{v}{4}$

(Total for question = 1 mark)

Q6.

Some asteroids pass very close to the Earth. Scientists are planning methods to deflect asteroids, to prevent them hitting the Earth.

One method would involve colliding a spacecraft into the surface of the asteroid, to change the path and speed of the asteroid. The spacecraft would remain joined to the asteroid after the collision.

(a) This collision method is modelled for a spacecraft travelling in a direction at 90° to the path of the asteroid.

Sketch a labelled vector diagram to show the momenta of the bodies before and after the collision.

(2)

(b) Show that the momentum of the spacecraft is about 10^7 N s.

mass of spacecraft = 920 kg
speed of spacecraft = 12 000 m s^{-1}

(2)

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(c) Show that this collision method causes the asteroid to change its direction through an angle of about 10^{-7} radian.

momentum of asteroid = 7.6×10^{13} N s

(2)

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(d) After the collision, the asteroid and spacecraft remain joined and move together.

Calculate the component of their velocity at 90° to the original path of the asteroid after the collision.

mass of asteroid = 2.8×10^9 kg

(2)

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Component of velocity = ...

(e) Another method would involve attaching a rocket motor to the asteroid and using the motor to apply a force to the asteroid.

In this method the force is applied at 90° to the path of the asteroid.

Deduce whether this would produce a change in momentum as great as the change produced by the collision method.

force exerted by rocket motor = 5.1×10^6 N
time for which rocket motor applies force = 6 minutes

(2)

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(Total for question = 10 marks)

Q7.

A student carried out experiments on momentum using two table hockey pucks, as shown.

The pucks each contain a small fan, so that they glide across the table on a cushion of air. The mass of the pucks can be varied by attaching small masses.

In each experiment, the student pushed one puck towards a stationary puck.

(a) In one experiment, the first puck reached a speed of 0.35 m s^{-1} after being pushed for a time of 0.28 s.

Calculate, using the idea of impulse, the average force used to accelerate the first puck.

mass of puck = 110 g

(3)

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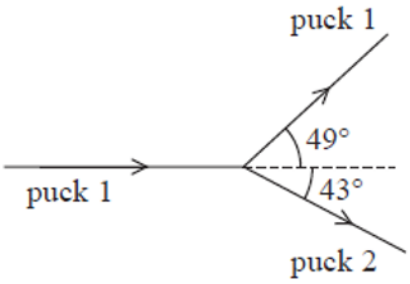
Average force = ...

(b) In another experiment, the first puck was pushed towards the stationary puck with a speed of 0.41 m s^{-1}.

The paths of the pucks before and after the collision are shown. The paths are labelled puck 1 and puck 2.



NOT to scale

(i) Calculate the speed of puck 2 after the collision.

mass of puck 1 = 110 g

mass of puck 2 = 130 g

speed of puck 1 after collision = 0.28 m s^{-1}

(4)

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Speed of puck 2 = ...

(ii) Deduce whether this was an elastic collision.

(3)

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(c) Explain the assumption made when applying the principle of conservation of momentum to collisions.

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(Total for question = 12 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 particle of mass m has kinetic energy E_k and momentum p. A second particle of mass $2m$ has kinetic energy $2E_k$.

Both particles are non-relativistic.

Which of the following is equal to the momentum of the second particle?

☒ **A** $\sqrt{2}p$

☒ **B** p

☒ **C** $2p$

☒ **D** $4p$

(Total for question = 1 mark)

Q9.

A particle of mass m has momentum p and kinetic energy E_k.
A second particle of mass $m/2$ has momentum $2p$.

What is the kinetic energy of the second particle?

☒ **A** E_k /8

☒ **B** E_k /2

☒ **C** 2 E_k

☒ **D** 8 E_k

(Total for question = 1 mark)

Q10.

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 row of the table identifies what happens to momentum and kinetic energy in an elastic collision?

		Momentum	Kinetic energy
☒	**A**	conserved	conserved
☒	**B**	conserved	not conserved
☒	**C**	not conserved	conserved
☒	**D**	not conserved	not conserved

(Total for question = 1 mark)

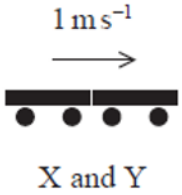
Q11.

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 ☒.

This question refers to a collision between two trolleys.

The diagram shows the momentum of two trolleys, X and Y, before a collision. The mass of each trolley is 0.25 kg.

The two trolleys join together after the collision and move on with a velocity of 1 m s^{-1} .



Which of the following is the kinetic energy of trolley X before the collision?

☒ **A** 0.5 J

☒ **B** 1 J

☒ **C** 2 J

☒ **D** 4 J

(Total for question = 1 mark)

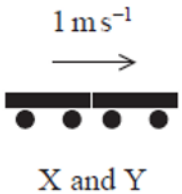
Q12.

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 ☒.

This question refers to a collision between two trolleys.

The diagram shows the momentum of two trolleys, X and Y, before a collision. The mass of each trolley is 0.25 kg.

The two trolleys join together after the collision and move on with a velocity of 1 m s^{-1} .



Which row of the table is correct for this collision?

	Momentum	Elastic or inelastic collision
☒ **A**	conserved	elastic
☒ **B**	conserved	inelastic
☒ **C**	not conserved	elastic
☒ **D**	not conserved	inelastic

(Total for question = 1 mark)

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 ☒.

An object of mass m has momentum p and kinetic energy E.

Which of the following is the mass of an object with momentum $2p$ and kinetic energy $4E$?

☒ **A** $\frac{1}{2}m$

☒ **B** m

☒ **C** $2m$

☒ **D** $4m$

(Total for question = 1 mark)

Q14.

A helicopter can hover in a fixed position as shown.

(Source: Ascent Xmedia/Getty Images)

The helicopter blades move air vertically downwards.

Explain how this enables the helicopter to maintain a constant height above the ground.

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(Total for question = 4 marks)

Q15.

A flyboard enables a person to hover at a constant height above the sea as shown. Water is constantly pumped up to the flyboard in a thick pipe. A jet of water is then forced downwards, causing an upwards force on the flyboard.

(Source: © Justin Lewis / Getty Images)

Calculate the velocity of the jet of water as it leaves the flyboard. Assume the water has negligible velocity before it leaves the flyboard.

mass of person and flyboard equipment = 175 kg
mass flow rate of water = 114 kg s^{-1}

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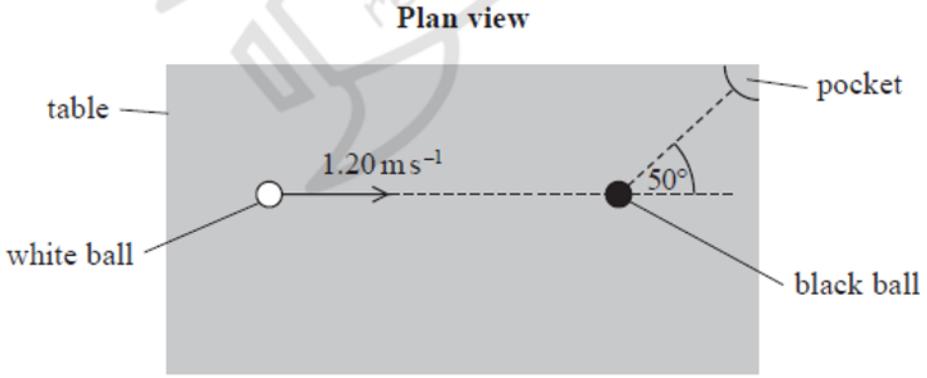
Velocity of water jet = ...

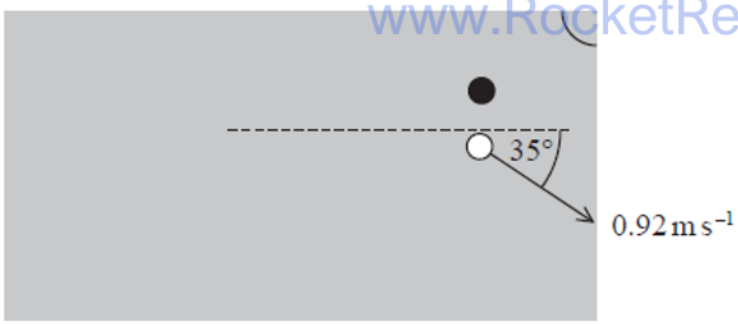
(Total for question = 3 marks)

Q16.

In a game of snooker, a white ball and a black ball of equal mass are on a horizontal table. A player hits the white ball which then moves with a velocity of 1.20 m s^{-1} before colliding with the black ball. The player hopes that the collision will knock the black ball towards the pocket at the corner of the table as shown.



After the collision, the velocity of the white ball was at 35° to its original path, as shown below.



(a) This collision was inelastic.

State what is meant by inelastic.

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(b) For this situation, a scaled vector diagram showing the velocities of the balls can be used to demonstrate the law of conservation of momentum.

Explain why.

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(c) Deduce whether the black ball moves towards the pocket. You should use a scaled vector diagram.

(5)

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(Total for question = 8 marks)

Q17.

A student used a spreadsheet to model the conservation of momentum.

(a) State the principle of conservation of momentum.

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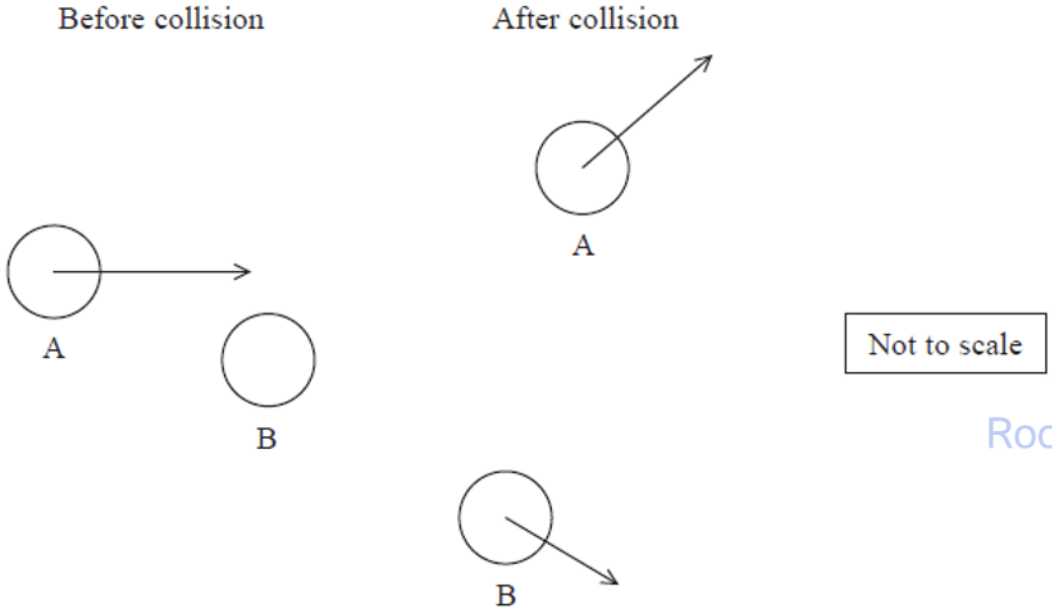
(b) The spreadsheet modelled an elastic collision between object A and object B.



The spreadsheet shows the initial values and final values when the student tested the model.

	A	B	C	D	E
1		Initial values		Final values	
2		object A	object B	object A	object B
3	mass / kg	0.85	1.70	0.85	1.70
4	magnitude of velocity / $m\,s^{-1}$	1.30	0.00	0.98	0.54
5	angle of velocity to x direction / °	0.0	0.0	54.5	–48.0
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(i) Deduce whether the values show an elastic collision.

(3)

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(ii) Deduce whether the values show the conservation of momentum.

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(Total for question = 10 marks)

Q18.

An electron has kinetic energy 7.2×10^{-16} J.

Calculate the de Broglie wavelength of the electron.

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Wavelength = ...

(Total for question = 3 marks)

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 ☒.

A car travels along a straight horizontal road. A drag force of 150 N acts for 15 s causing the speed of the car to decrease.

Which of the following is the change in momentum of the car due to the drag force?

☐ **A** 10 kg m s^{-1}

☐ **B** 1125 kg m s^{-1}

☐ **C** 2250 kg m s^{-1}

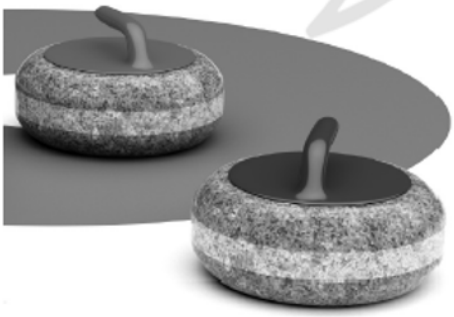
☐ **D** 16 875 kg m s^{-1}

(Total for question = 1 mark)

Q20.

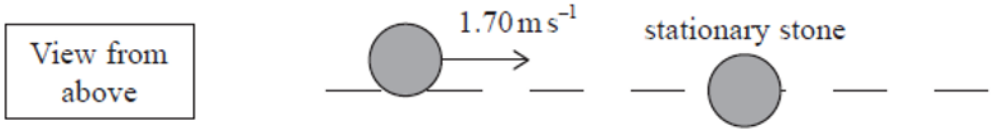
Curling is a sport played on ice. Players slide stones made of granite along the ice.

The photograph shows two of the stones. Each stone has a mass of 19.1 kg.

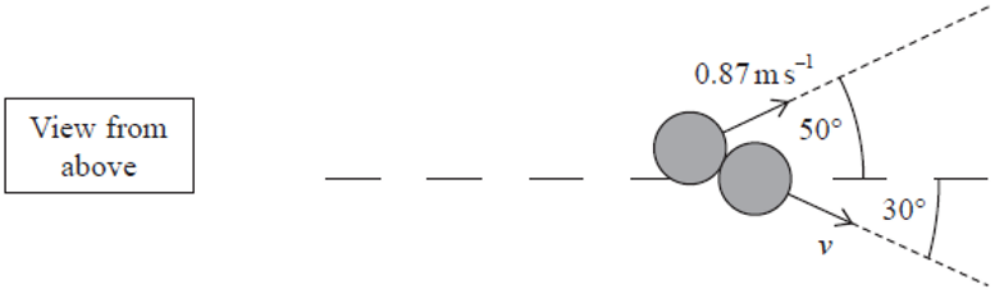


(Source: © MileA/Getty Images)

A player slides a stone at a velocity of 1.70 m s^{-1} towards a stationary stone, as shown below.



The stones collide. After the collision, both stones move off as shown below.



(a) Show that v is about 1.3 m s^{-1}.

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(b) Deduce whether the collision was elastic. Your answer should include a calculation.

(3)

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(Total for question = 7 marks)

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 ☒.

Which of the following gives the base units of impulse?

☒ **A** kg m s^{-1}

☒ **B** kg m s^{-2}

☒ **C** N m

☒ **D** N s

(Total for question = 1 mark)

Q22.

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 ball travelling at speed u towards a wall collides with the wall at right angles. The ball bounces off the wall at speed v in the opposite direction. The time for the collision is t.

Which of the following expressions gives the average force on the wall during the collision?

☒ **A** $\frac{m(u+v)}{t}$

☒ **B** $\frac{m(u+v)}{2t}$

☒ **C** $\frac{m(u-v)}{t}$

☒ **D** $\frac{m(u-v)}{2t}$

(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 ☒.

A non-relativistic particle of mass m has momentum p and kinetic energy E_k .

A second non-relativistic particle of mass $\frac{m}{2}$ has momentum $2p$.

Which of the following expressions gives the kinetic energy of the second particle?

☒ **A** $\frac{E_k}{2}$

☒ **B** E_k

☒ **C** $2E_k$

☒ **D** $8E_k$

(Total for question = 1 mark)