PEARSON EDEXCEL A-LEVEL PHYSICS · 9PH0

PHYSICS



EXAM QUESTION PACK

TOPIC 6: FURTHER MECHANICS

IMPULSE AND COLLISIONS IN 2D

SCORE	PERCENTAGE
/140	%

STEMUP

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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 are the base units for impulse?

☒ **A** kg m s^{-1}

☒ **B** kg m s^{-2}

☒ **C** N m

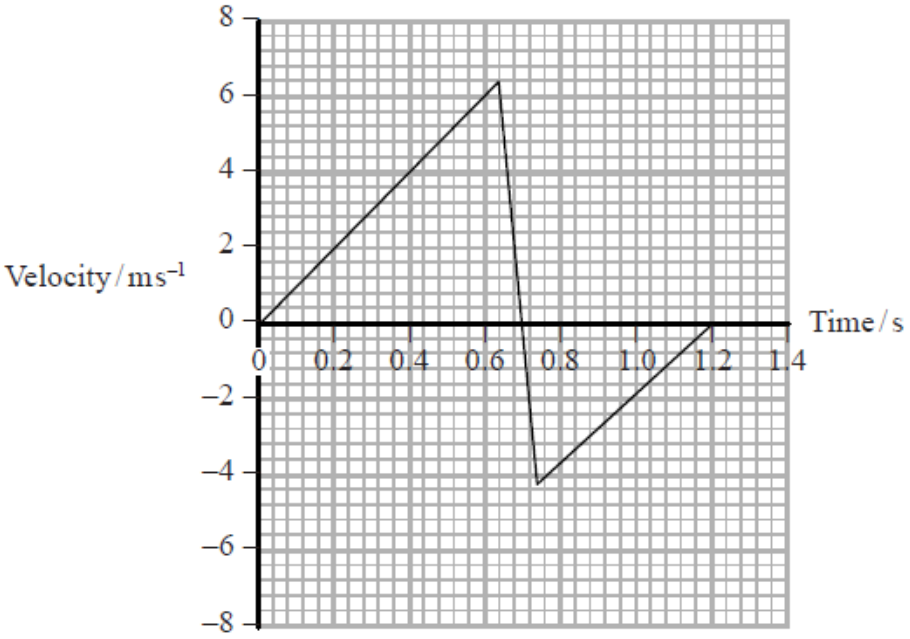
☒ **D** N s

(Total for question = 1 mark)

Q2.

A stationary ball is released from a height of 2.0 m onto a hard surface.

The simplified velocity-time graph shows the motion of the ball as it falls and bounces back to its maximum height.



(a) Calculate the maximum height reached by the ball after bouncing.

(2)

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Maximum height = ...

(b) Calculate the decrease in kinetic energy of the ball as it bounces.

mass of ball = 60 g

(2)

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Decrease in kinetic energy = ...

(c) Calculate the resultant force on the ball when it is in contact with the ground.

(3)

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Resultant force = ...

(d) The ball is replaced with one that is softer. It is released from a height of 2.0 m onto the same surface as before. A velocity-time graph is drawn to show the motion of the new ball.

Describe the similarities and differences between the two graphs.

(3)

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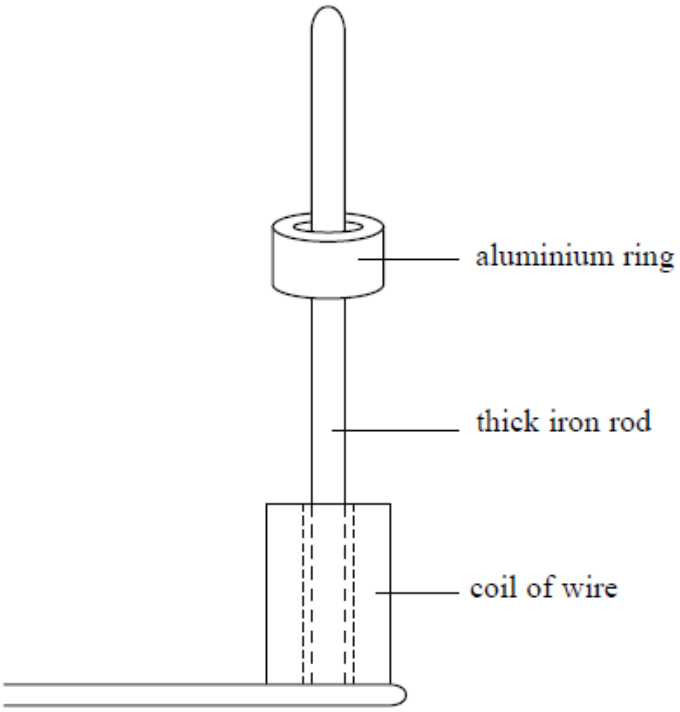
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(Total for question = 10 marks)

Q3.

A coil of wire is placed around the lower end of an iron rod. The coil is supplied with an alternating current.

A thick aluminium ring is placed around the iron rod above the coil. The coil remains in the position shown.



The current is switched off and the aluminium ring comes to rest on top of the coil.
The supply to the coil is changed and a direct current (dc) is switched on. An upwards force *F* acts on the ring for 0.05 s accelerating it to a final speed, *v*. The ring then moves freely through a height of 30 cm.

Mean diameter of ring = 4.8 cm
Mass of ring = 0.019 kg
Magnetic field strength = 0.032 T

(i) Use conservation of energy to calculate the speed *v* of the ring after 0.05 s.

(2)

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v = ...

(ii) Use the idea of impulse to calculate the magnitude of the mean force F acting on the ring and hence the mean current I in the ring.

(6)

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F = ...

I = ...

(Total for question = 8 marks)

Q4.

A footballer kicks a football from the penalty spot. A graph of force on the ball against time is drawn.

The area under the force-time graph represents

☒ **A** acceleration

☒ **B** change in kinetic energy

☒ **C** change in momentum

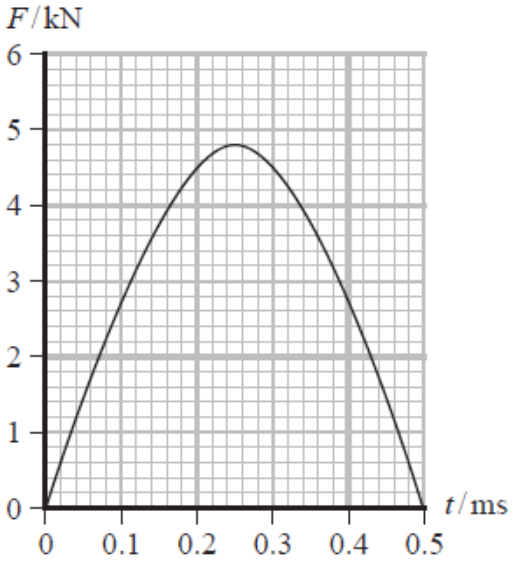
☒ **D** displacement

(Total for question = 1 mark)

Q5.

In the game of golf a stationary ball is hit by a club. One of the aims of the game is to land the ball on a patch of ground called the green.

The graph shows how the force *F* exerted by the club on the ball varies with time *t* as the ball is hit.



State why the area under the graph represents impulse.

(1)

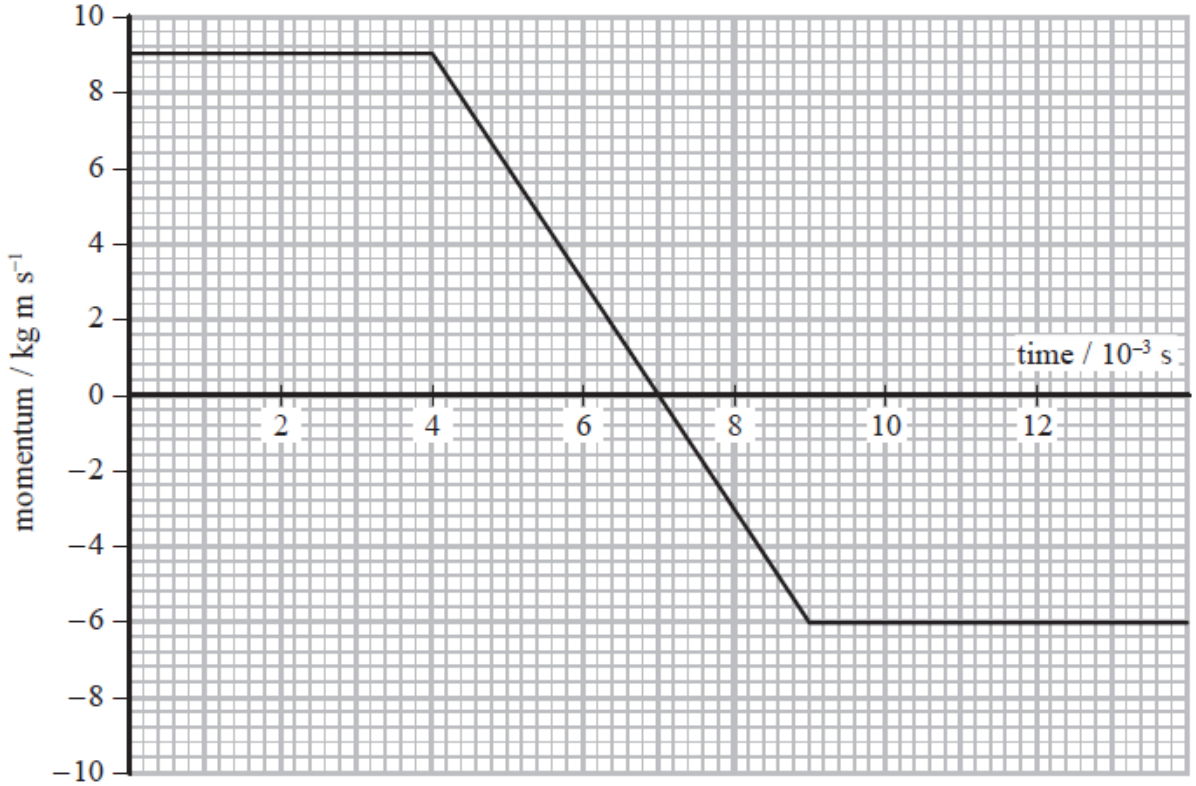
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(Total for question = 1 mark)

Q6.

A football is kicked horizontally to hit a wall. Its momentum just before it hits the wall is 9.0 kg m s^{-1}.
It rebounds horizontally from the wall with a momentum of −6.0 kg m s^{-1}. The graph shows how the momentum of the football varies during the impact with the wall.



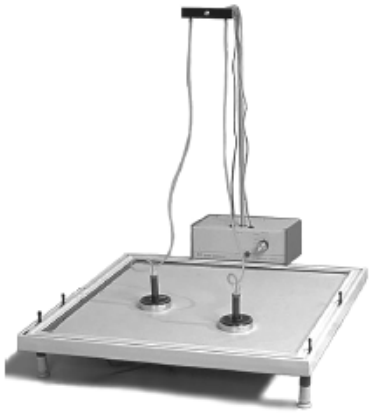
The force exerted by the wall on the football is

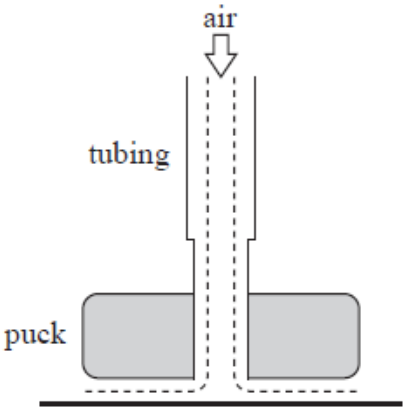
- **A** 3.0 N
- **B** 15 N
- **C** 600 N
- **D** 3000 N

(Total for question = 1 mark)

Q7.

A teacher is demonstrating the principle of conservation of momentum using a flat glass surface and air pucks. Lightweight tubing supplies compressed air to the pucks which is forced out from the bottom of the pucks. This means that the pucks move with very little friction across the glass surface.





(a) Explain, using ideas about molecular movement, how the puck is able to hover a small distance above the glass surface.

(4)

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*(b) Applying Newton's 2nd and 3rd laws of motion to the collision between two pucks leads to the conclusion that momentum is conserved.

Justify this statement.

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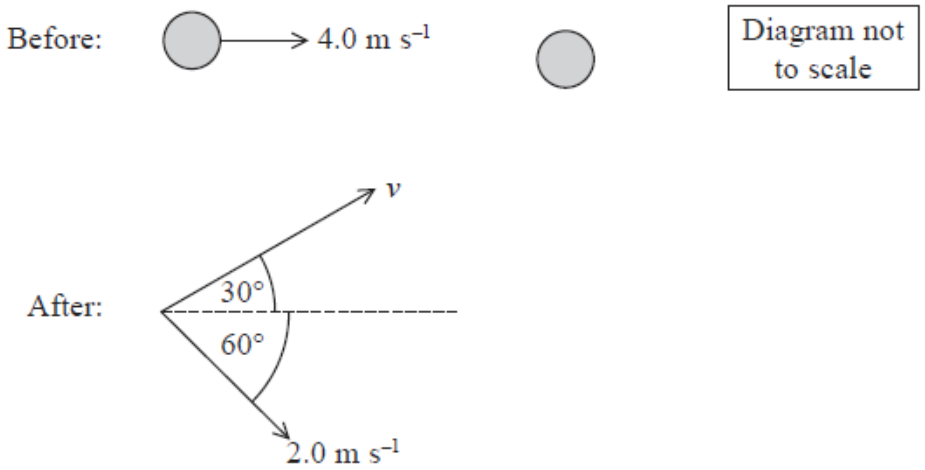
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(c) The teacher uses two identical pucks to investigate collisions. In one collision, one puck moves with a velocity of 4.0 m s^{-1} and collides with a second puck that is stationary. After the collision, the first puck has a velocity v at an angle of 30° to its original direction, and the second puck moves off with a velocity of 2.0 m s^{-1} at an angle of 60° to the original direction.



(i) Show that the magnitude of the velocity v of the first puck after the collision is about 3.5 m s^{-1}.

(3)

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(ii) Use the data to determine if the collision is elastic or inelastic.

(3)

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(Total for question = 16 marks)

Q8.

Which of the following is a possible unit for rate of change of momentum?

☒ **A** kg m s^{-1}

☒ **B** kg m s^{-2}

☒ **C** N s

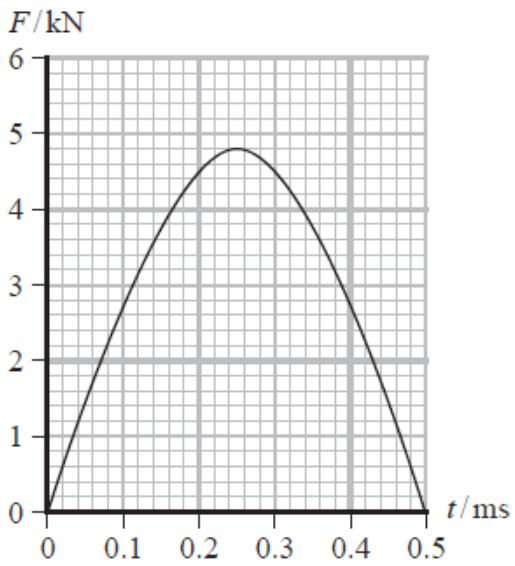
☒ **D** N s^{-1}

(Total for question = 1 mark)

Q9.

In the game of golf a stationary ball is hit by a club. One of the aims of the game is to land the ball on a patch of ground called the green.

The graph shows how the force *F* exerted by the club on the ball varies with time *t* as the ball is hit.



(i) Show that the velocity of the ball is about 30 m s^{-1} immediately after it is hit by the club.

mass of ball = 0.046 kg

(3)

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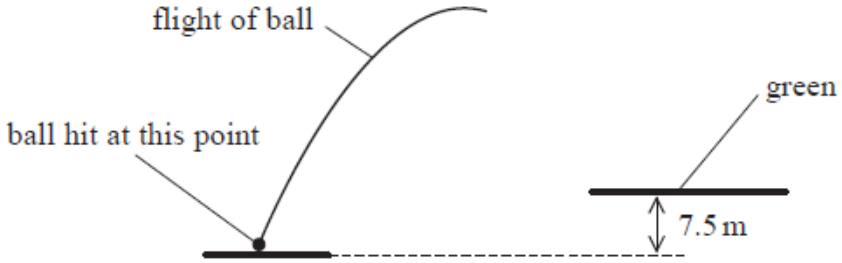
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(ii) The ball has a time of flight of 3.5 s before landing. The green is a vertical distance of 7.5 m above the point at which the ball was hit, as shown. The green is about seventy metres away from where the ball is hit.



Deduce whether, if air resistance is ignored, the ball could land on the green after a flight time of 3.5 s.

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(Total for question = 8 marks)

Q1.

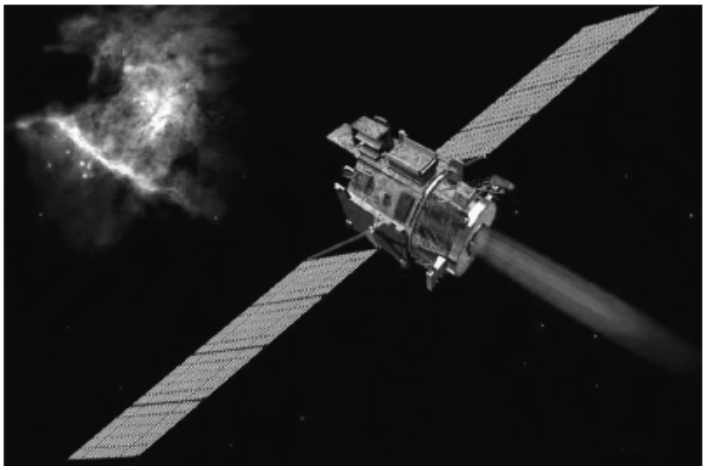
A bullet is fired into a block of wood. Select the line of the table that applies to this situation.

	Collision	Kinetic energy	Momentum
☐ A	elastic	conserved	conserved
☐ B	inelastic	not conserved	conserved
☐ C	elastic	conserved	not conserved
☐ D	inelastic	not conserved	not conserved

(Total for question = 1 mark)

Q2.

* The photograph shows a probe moving in space.



Whilst moving, empty fuel tanks can be ejected by means of an explosion. This has the effect of increasing the speed of the probe.

Discuss whether conservation of momentum and conservation of energy apply in this situation and why the speed of the probe increases.

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(Total for question = 6 marks)

Q3.

A series of experiments was carried out in the 1970s to investigate the structure of protons using the linac at Stanford, USA.

An electron leaves the accelerator with a momentum of 20 GeV / c.

(i) Explain, with reference to base units, why GeV / c can be used as a unit of momentum.

(2)

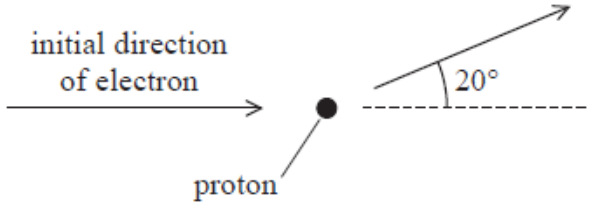
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(ii) An electron with initial momentum 20 GeV / c collides with a stationary proton. After the collision the electron is deflected by an angle of 20° as shown and its momentum is 9.1 GeV / c. The momentum of the proton after the collision is 11.9 GeV / c.



Deduce whether the law of conservation of momentum is obeyed.

(3)

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(iii) The collisions between electrons and the protons in these experiments are sometimes inelastic.

State what is meant by an inelastic collision.

(1)

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(Total for question = 6 marks)

Q4.

A 'Gauss gun' can be made from five ball bearings of equal mass and two magnets, as shown.



Pairs of ball bearings are placed to the right of two strong magnets. A single ball bearing is released from the left, as shown. The ball bearing is attracted to, and collides with, the first magnet. This and all subsequent collisions can be assumed to be elastic.

Explain what happens to make the last ball bearing on the right subsequently move off with a large velocity.

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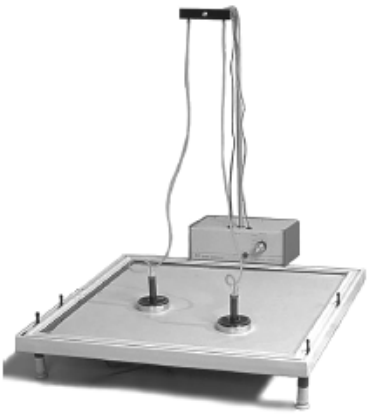
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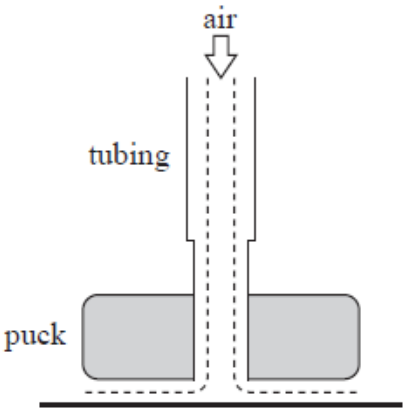
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(Total for question = 3 marks)

Q5.

A teacher is demonstrating the principle of conservation of momentum using a flat glass surface and air pucks. Lightweight tubing supplies compressed air to the pucks which is forced out from the bottom of the pucks. This means that the pucks move with very little friction across the glass surface.





(a) Explain, using ideas about molecular movement, how the puck is able to hover a small distance above the glass surface.

(4)

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*(b) Applying Newton's 2nd and 3rd laws of motion to the collision between two pucks leads to the conclusion that momentum is conserved.

Justify this statement.

(6)

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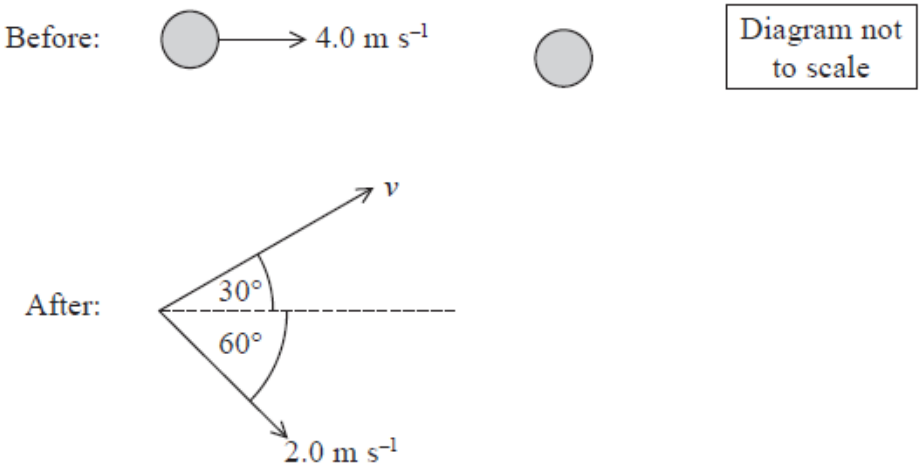
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(c) The teacher uses two identical pucks to investigate collisions. In one collision, one puck moves with a velocity of 4.0 m s^{-1} and collides with a second puck that is stationary.
After the collision, the first puck has a velocity *v* at an angle of 30° to its original direction, and the second puck moves off with a velocity of 2.0 m s^{-1} at an angle of 60° to the original direction.



(i) Show that the magnitude of the velocity v of the first puck after the collision is about 3.5 m s^{-1}.

(3)

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(ii) Use the data to determine if the collision is elastic or inelastic.

(3)

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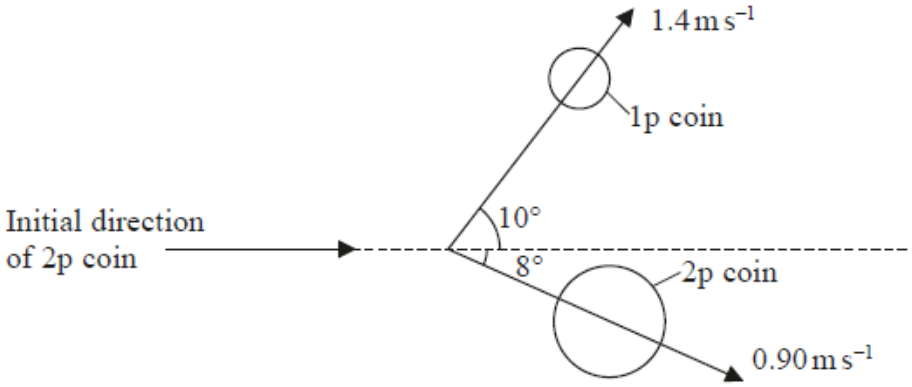
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(Total for question = 16 marks)

Q6.

A student carried out an experiment with coins.

She arranged a collision between a 2p coin and a stationary 1p coin. She noted the directions in which the coins moved after the collision and determined their velocities.



(i) Show that the velocity of the 2p coin just before the collision was about 2 m s^{-1}.

mass of 2p coin = 7.1 g

mass of 1p coin = 3.6 g

(4)

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(ii) Show that the collision was inelastic.

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(Total for question = 6 marks)

Q1.

At the beginning of the 20th century, Rutherford carried out large-angle alpha particle scattering experiments using gold ($^{197}_{79}$Au) foil.

The vast majority of the alpha particles went straight through the foil whilst a few were deflected straight back.

Rutherford also carried out the experiment with aluminium ($^{27}_{13}$Al) foil.
The aluminium foil had the same thickness as the gold foil and the alpha particles had the same initial kinetic energy.

The following observations were made.

Observation 1:
The fraction of alpha particles scattered at any particular angle for aluminium foil was always much less than for gold foil.

Observation 2:
The alpha particles scattered from aluminium foil had less kinetic energy than the alpha particles scattered from gold foil.

Explain how these observations can be used to deduce how an aluminium nucleus compares to a gold nucleus.

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(Total for question = 4 marks)

Q2.

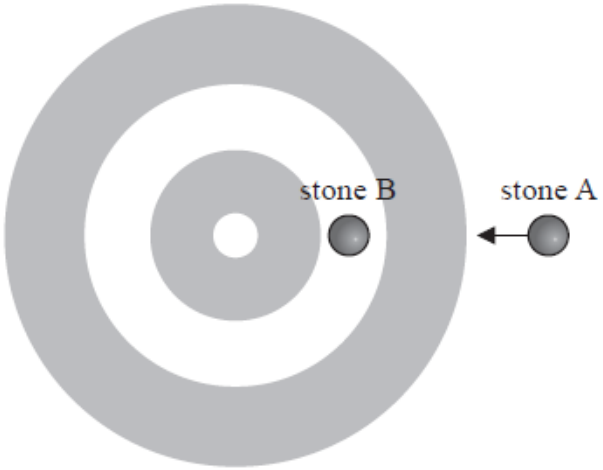
In the sport of curling, two teams of 'curlers' take turns sliding polished granite stones across an

ice surface towards a circular target marked on the ice.



commons.wikimedia.org

* Stone B is stationary. Stone A travels towards the target and makes a direct hit on stone B as shown. Both stones have mass *m*.



The collision is elastic. Just before the collision stone A has a velocity *v*. After the collision stone B moves off with velocity *v*.

Discuss how the relevant conservation laws apply to this collision.

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(Total for question = 6 marks)

Q3.

Which of the following statements is always true for an inelastic collision?

☒ **A** Both momentum and kinetic energy are conserved.

☒ **B** Neither momentum nor kinetic energy is conserved.

☒ **C** Kinetic energy is not conserved.

☒ **D** Momentum is not conserved.

(Total for question = 1 mark)

Q4.

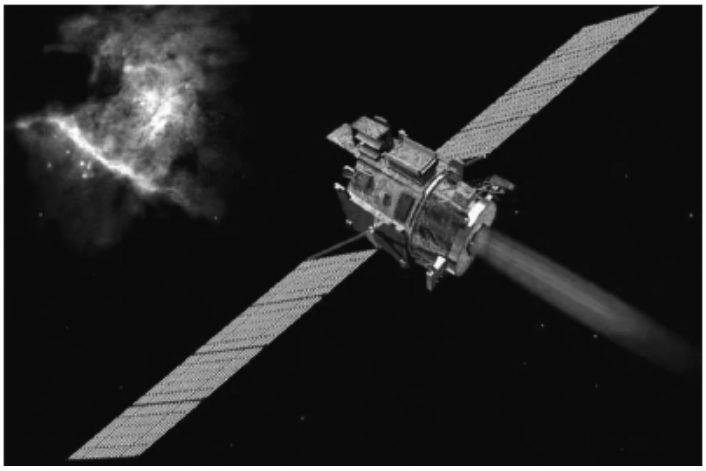
A bullet is fired into a block of wood. Select the line of the table that applies to this situation.

	Collision	Kinetic energy	Momentum
☒ **A**	elastic	conserved	conserved
☒ **B**	inelastic	not conserved	conserved
☒ **C**	elastic	conserved	not conserved
☒ **D**	inelastic	not conserved	not conserved

(Total for question = 1 mark)

Q5.

* The photograph shows a probe moving in space.



Whilst moving, empty fuel tanks can be ejected by means of an explosion. This has the effect of increasing the speed of the probe.

Discuss whether conservation of momentum and conservation of energy apply in this situation and why the speed of the probe increases.

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(Total for question = 6 marks)

Q6.

Select the row of the table which correctly identifies the quantities conserved in an inelastic collision.

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

(Total for question = 1 mark)

Q7.

A series of experiments was carried out in the 1970s to investigate the structure of protons using the linac at Stanford, USA.

An electron leaves the accelerator with a momentum of 20 GeV / c.

(i) Explain, with reference to base units, why GeV / c can be used as a unit of momentum.

(2)

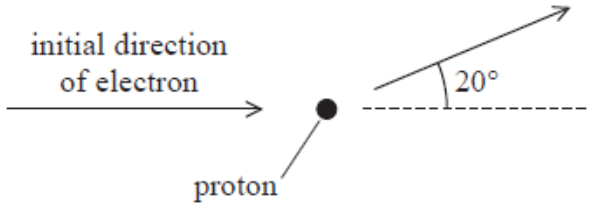
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(ii) An electron with initial momentum 20 GeV / c collides with a stationary proton. After the collision the electron is deflected by an angle of 20° as shown and its momentum is 9.1 GeV / c. The momentum of the proton after the collision is 11.9 GeV / c.



Deduce whether the law of conservation of momentum is obeyed.

(3)

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(iii) The collisions between electrons and the protons in these experiments are sometimes inelastic.

State what is meant by an inelastic collision.

(1)

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(Total for question = 6 marks)

Q8.

A 'Gauss gun' can be made from five ball bearings of equal mass and two magnets, as shown.



Pairs of ball bearings are placed to the right of two strong magnets. A single ball bearing is released from the left, as shown. The ball bearing is attracted to, and collides with, the first magnet. This and all subsequent collisions can be assumed to be elastic.

Explain what happens to make the last ball bearing on the right subsequently move off with a large velocity.

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(Total for question = 3 marks)

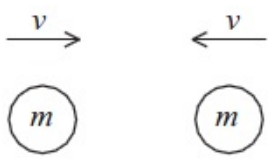
Q9. Select the row in the table that correctly identifies what happens in an inelastic collision.

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

(Total for Question = 1 mark)

Q10.

Two identical spheres of mass m are both travelling with a speed v towards each other.



The spheres collide head-on.

Which of the following statements **must** be true after the collision?

☒ **A** total momentum = $2mv$

☒ **B** total momentum = 0

☒ **C** total kinetic energy = mv^2

☒ **D** total kinetic energy = 0

(Total for question = 1 mark)

Q1.

(a) State what is meant by the de Broglie wavelength.

(2)

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(b) An electron is accelerated from rest, in a vacuum, through a potential difference of 500 V.

(i) Show that the final momentum of the electron is about 1×10^{-23} N s.

(3)

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(ii) Calculate the de Broglie wavelength for this electron.

(2)

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de Broglie wavelength = ...

(Total for question = 7 marks)

Q2.

The discovery of the Higgs particle was an important contribution to our understanding of particle physics.

(a) Describe the standard model for subatomic particles. You should identify the fundamental particles and the composition of the particles we can observe.

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(b) The mass of the Higgs particle is 2.2×10^{-25} kg.

Calculate this mass in GeV/c^2.

(3)

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Mass = ... GeV/c^2

(c) The Higgs particle was discovered using the Large Hadron Collider (LHC) in 2012. Two beams of very high energy protons, moving in opposite directions, were made to collide.

(i) Explain the need for such high energy collisions.

(3)

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(ii) The beams of protons are contained within a ring of superconducting magnets.

Calculate the momentum of a proton in a beam.

(3)

magnetic field strength = 8.3 T
circumference of the ring = 27 km

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Momentum = ...

(iii) State the total momentum of the products of the collision between the two beams of protons.

(1)

Total momentum = ...

(d) A student used the equation $E_k = \frac{p^2}{2m}$ to predict the energy of a proton in the beam, using the momentum calculated in (c)(ii), but found the energy was far higher than 7 TeV.

Explain why.

(2)

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(Total for question = 17 marks)

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 ☒.

The velocity v of a non-relativistic particle can be expressed in terms of combinations of the following quantities: kinetic energy E_k, momentum p and mass m.

Which of the following expressions is correct?

☒ **A** $v = \frac{p^2}{m}$

☒ **B** $v = \sqrt{\frac{2E_k}{m}}$

☒ **C** $v = \frac{E_k}{2p}$

☒ **D** $v = \frac{2E_k}{pm}$

(Total for question = 1 mark)