

**Q1.** Which one of the following has the same unit as the rate of change of momentum?

- A** work
- B** energy
- C** acceleration
- D** weight

(Total 1 mark)

**Q2.** The nucleus of a radioactive isotope  $X$  is at rest and decays by emitting an  $\alpha$  particle so that a new nuclide  $Y$  is formed.

Which one of the following statements about the decay is correct?

- A** The momentum of  $Y$  is equal and opposite to the momentum of the  $\alpha$  particle.
- B** The momentum of  $Y$  is equal to the momentum of  $X$ .
- C** The kinetic energy of  $Y$  is equal to the kinetic energy of the  $\alpha$  particle.
- D** The total kinetic energy is the same before and after the decay.

(Total 1 mark)

**Q3.** Trolley  $T_1$ , of mass 2.0 kg, collides on a horizontal surface with trolley  $T_2$ , which is also of mass 2.0 kg. The collision is elastic. Before the collision  $T_1$  was moving at  $4.0 \text{ m s}^{-1}$  and  $T_2$  was at rest.



Which one of the following statements is correct?

Immediately after the collision

- A**  $T_1$  is at rest and  $T_2$  moves at  $4.0 \text{ m s}^{-1}$ .

- B  $T_1$  will rebound from  $T_2$  at  $4.0 \text{ m s}^{-1}$ .
- C  $T_1$  and  $T_2$  will both move at  $2.8 \text{ m s}^{-1}$ .
- D  $T_1$  and  $T_2$  will both move at  $1.4 \text{ m s}^{-1}$ .

(Total 1 mark)

Q4.(a) Explain what is meant by a **thermal** neutron.

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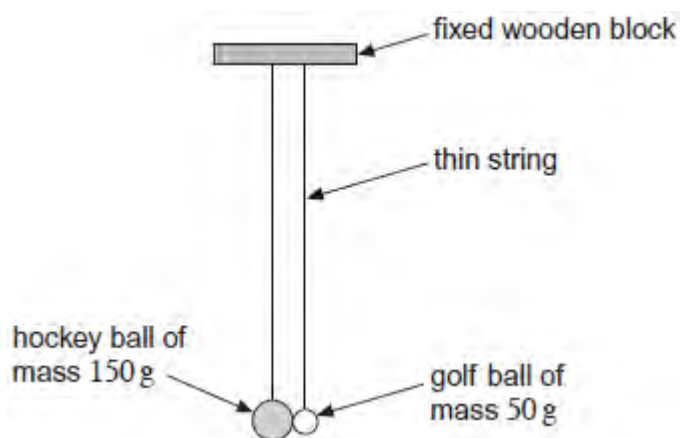
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(2)

(b) A student sets up the arrangement, shown in the diagram below, to demonstrate the principle of moderation in a nuclear reactor.



A golf ball of mass 50 g is initially hanging vertically and just touching a hockey ball of mass 150 g. The golf ball is pulled up to the side and released. It has a speed of  $1.3 \text{ m s}^{-1}$  when it collides head-on with the hockey ball. After the collision the balls move in opposite directions with equal speeds of  $0.65 \text{ m s}^{-1}$ .

- (i) Calculate the height above its initial position from which the golf ball is released. Assume that there is no air resistance.

height ..... m

(2)

- (ii) Show that momentum is conserved in the collision and that the collision is perfectly elastic.

(4)

- (iii) Calculate the percentage of the kinetic energy of the golf ball transferred to the hockey ball during the collision.

percentage transferred ..... %

(2)

- (iv) Explain how this demonstration relates to the moderation process in a reactor and state **one** way in which the collisions in a reactor differ from the collision in the demonstration.

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(2)

- (v) Name the substance used as the moderator in a pressurised water reactor (PWR).

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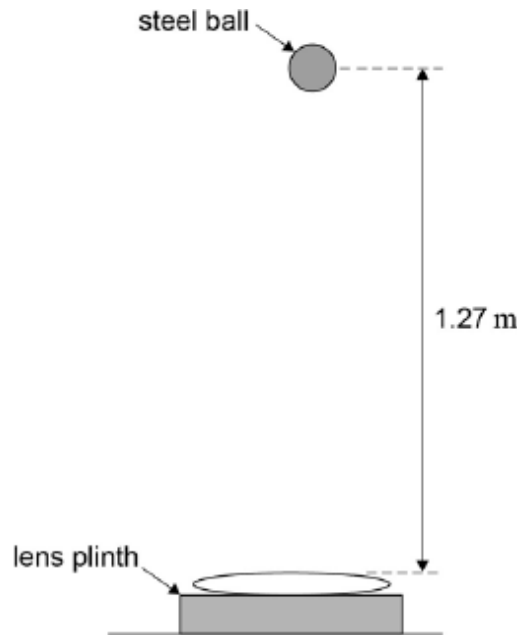
(1)

(Total 13 marks)

**Q5.** Spectacle lenses can be tested by dropping a small steel ball onto the lens, as shown in the figure below, and then checking the lens for damage.

A test requires the following specifications:

- diameter of ball = 16 mm
- mass of ball = 16 g
- height of drop = 1.27 m



- (a) Calculate the density of the steel used for the ball.

density = .....kg m<sup>-3</sup>

(3)

- (b) In a test the ball bounced back to a height of 0.85 m.

Calculate the speed of the ball just before impact.

$$\text{speed} = \dots\dots\dots \text{m s}^{-1} \quad (2)$$

- (c) Calculate the speed of the ball just after impact.

$$\text{speed} = m \dots\dots\dots \text{m s}^{-1} \quad (2)$$

- (d) Calculate the change in momentum of the ball due to the impact.

$$\text{momentum} = m \dots\dots\dots \text{kg m s}^{-1} \quad (2)$$

- (e) The time of contact was 40 ms. Calculate the average force of the ball on the lens during the impact.

$$\text{average force} = \dots\dots\dots \text{N} \quad (2)$$

- (f) Explain, with reference to momentum, why the test should also specify the material of the plinth the lens sits on.

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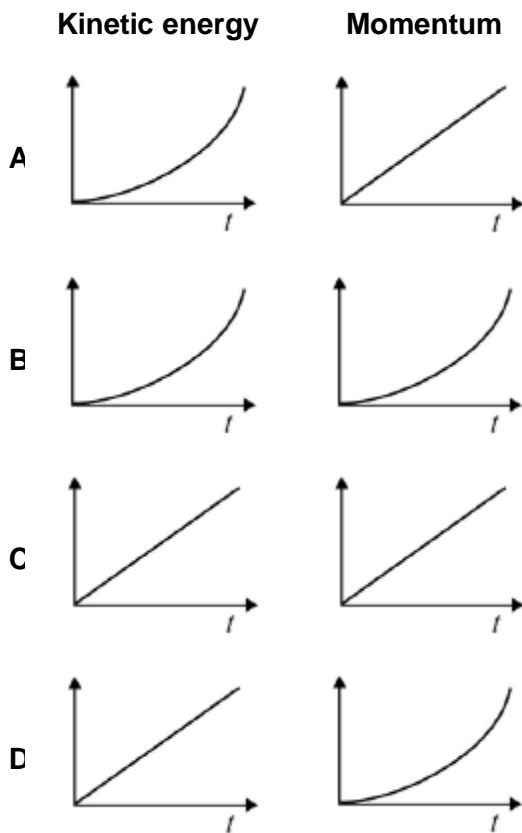
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(2)  
(Total 13 marks)

**Q6.** An object is accelerated from rest by a constant force  $F$  for a time  $t$ . Which graphs represent the variation of time with the change in the kinetic energy and the change in momentum of the object?



A

B

C

D

(Total 1 mark)

**Q7.** A body falls freely, with negligible air resistance. What quantity of the body is its rate of change of momentum?

A mass

B power

C kinetic energy

D weight

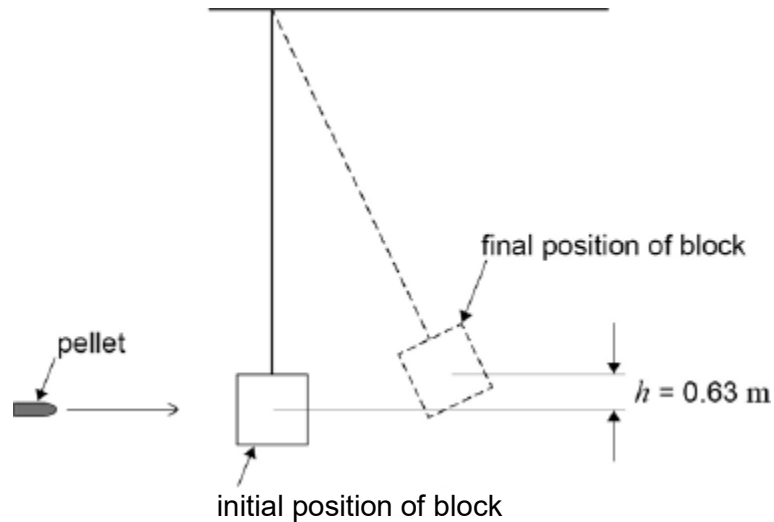
(Total 1 mark)

**Q8.** A firework rocket is fired vertically into the air and explodes at its highest point. What are the changes to the total kinetic energy of the rocket and the total momentum of the rocket as a result of the explosion?

	total kinetic energy of rocket	total momentum of rocket	
A	unchanged	unchanged	<input type="checkbox"/>
B	unchanged	increased	<input type="checkbox"/>
C	increased	unchanged	<input type="checkbox"/>
D	increased	increased	<input type="checkbox"/>

(Total 1 mark)

**Q9.** The speed of an air rifle pellet is measured by firing it into a wooden block suspended from a rigid support. The wooden block can swing freely at the end of a light inextensible string as shown in the figure below.



A pellet of mass 8.80 g strikes a stationary wooden block and is completely embedded in it. The centre of mass of the block rises by 0.63 m. The wooden block has a mass of 450 g.

- (a) Determine the speed of the pellet when it strikes the wooden block.

speed = ..... m s<sup>-1</sup>

(4)

- (b) The wooden block is replaced by a steel block of the same mass. The experiment is repeated with the steel block and an identical pellet. The pellet rebounds after striking the block.

Discuss how the height the steel block reaches compares with the height of 0.63 m reached by the wooden block. In your answer compare the energy and momentum changes that occur in the two experiments.

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**(4)**

- (c) Discuss which experiment is likely to give the more accurate value for the velocity of the pellet.

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**(2)**

**(Total 10 marks)**