LONDON SCIENCE COLLEGE

Name:

Date:

# MOMENTUM
# TEST 3

# AS-Level

Mark

Grade

## PHYSICS

For this paper you must have:

- Ruler
- Pencil and Rubber
- Scientific calculator, which you are expected to use when appropriate

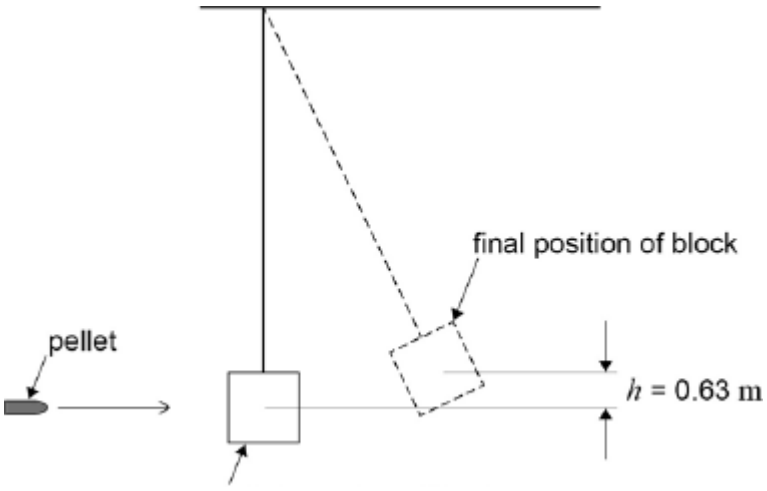
## Instructions

- Answer all questions
- Answer questions in the space provided
- All working must be shown

## Information

- The marks for the questions are shown in brackets

**1** 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 $s^{-1}$

**(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.

**(4)**

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

**(2)**

**(Total 10 marks)**

**2** 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)**

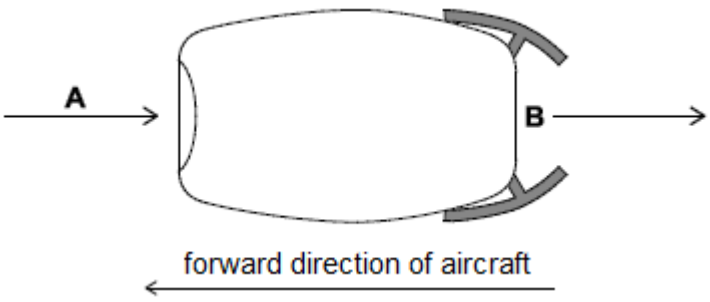
**3** A firework rocket is fired vertically into the air and explodes at its highest point. What are the changes to the total kinetic energy of the rocket and the total momentum of the rocket as a result of the explosion?

| | **total kinetic energy of rocket** | **total momentum of rocket** | |
|---|---|---|---|
| **A** | unchanged | unchanged | ⬭ |
| **B** | unchanged | increased | ⬭ |
| **C** | increased | unchanged | ⬭ |
| **D** | increased | increased | ⬭ |

**(Total 1 mark)**

**4** **Figure 1** shows a jet engine.

**Figure 1**




Air enters the engine at **A** and is heated before leaving **B** at a much higher speed.

(a) State what happens to the momentum of the air as it passes through the engine.

_____

_____

**(1)**

(b) Explain, using appropriate laws of motion, why the air exerts a force on the engine in the forward direction.

_____

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**(3)**

(c) In one second a mass of 210 kg of air enters at **A**. The speed of this mass of air increases by 570 m $s^{-1}$ as it passes through the engine.

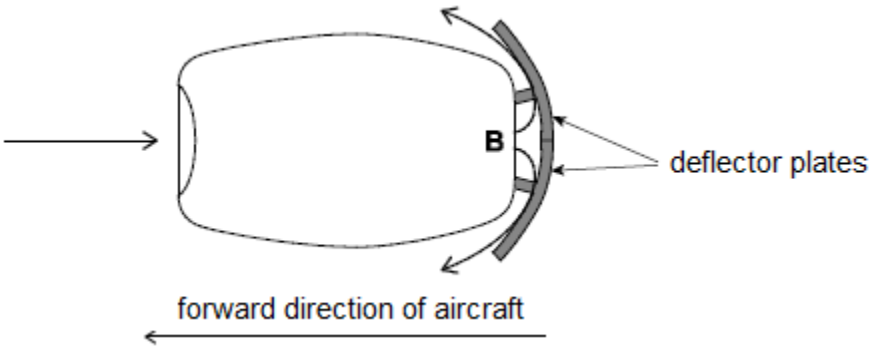
Calculate the force that the air exerts on the engine.

force = _____ N

**(1)**

(d) When an aircraft lands, its jet engines exert a decelerating force on the aircraft by making use of deflector plates. These cause the air leaving the engines to be deflected at an angle to the direction the aircraft is travelling as shown in **Figure 2**.

**Figure 2**




The speed of the air leaving **B** is the same as the speed of the deflected air.

Explain why the momentum of the air changes.

_____

_____

_____

_____

_____

**(2)**

(e) The total horizontal decelerating force exerted on the deflector plates of the jet engines is 190 kN.

Calculate the deceleration of the aircraft when it has a mass of $7.0 \times 10^4$ kg.

deceleration = _____ m $s^{-2}$

**(1)**

(f) The aircraft lands on the runway travelling at a speed of 68 m $s^{-1}$ with the deflector plates acting.

Calculate the distance the aircraft travels along the runway until it comes to rest. You may assume that the decelerating force acting on the jet engines remains constant.

distance = _____ m

**(2)**

(g) Suggest why in practice the decelerating force provided by the deflector plates may not remain constant.

_____

_____

_____

_____

_____

_____

_____

**(2)**

**(Total 12 marks)**

**5** What is represented by the area under a force–displacement graph?

**A** rate of change of kinetic energy ⬭

**B** change in momentum ⬭

**C** work done ⬭

**D** acceleration ⬭

**(Total 1 mark)**

**6** In a test a 500 kg car travelling at 10 m $s^{-1}$ hits a wall. The front 0.30 m of the car crumples as the car is brought to rest.

What is the average force on the car during the impact?

**A** 830 N ⬭

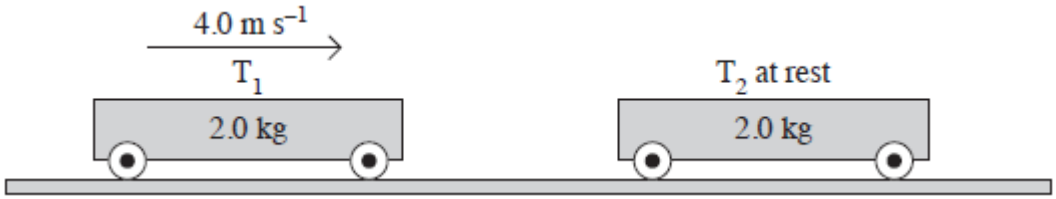
**B** 7500 N ⬭

**C** 8300 N ⬭

**D** 83 000 N ⬭

**(Total 1 mark)**

**7** 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 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 m $s^{-1}$.

**B** $T_1$ will rebound from $T_2$ at 4.0 m $s^{-1}$.

**C** $T_1$ and $T_2$ will both move at 2.8 m $s^{-1}$.

**D** $T_1$ and $T_2$ will both move at 1.4 m $s^{-1}$.

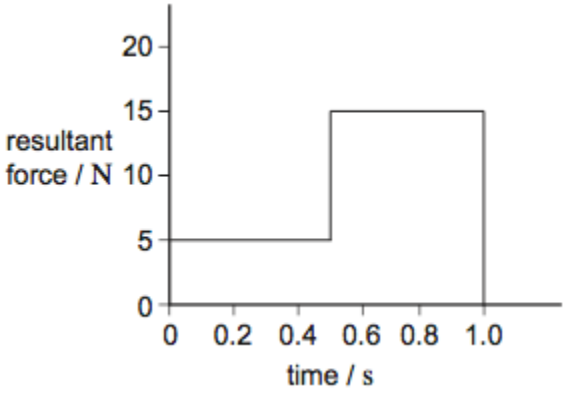
**(Total 1 mark)**

**8** Which line, **A** to **D**, in the table correctly shows what is conserved in an elastic collision?

| | Mass | Momentum | Kinetic energy | Total energy |
|---|---|---|---|---|
| **A** | conserved | not conserved | conserved | conserved |
| **B** | not conserved | conserved | conserved | not conserved |
| **C** | conserved | conserved | not conserved | conserved |
| **D** | conserved | conserved | conserved | conserved |

**(Total 1 mark)**

**9** The graph shows how the resultant force applied to an object of mass 2.0 kg, initially at rest, varies with time.




What is the speed of the object after 1.0 s?

**A** 2.5 m $s^{-1}$

**B** 5.0 m $s^{-1}$

**C** 7.5 m $s^{-1}$

**D** 10 m $s^{-1}$

**(Total 1 mark)**

**10** The diagram shows a cue striking a stationary snooker ball of mass 140 g. The contact time of the cue with the ball is 12 ms. The ball leaves the cue with a velocity $v$ of 0.40 m $s^{-1}$


(a) Show that there is an impulse of about $6 \times 10^{-2}$ N s when the cue is in contact with the snooker ball.

**(2)**

(b) Calculate the average force exerted by the cue on the snooker ball when they are in contact.

average force _____ N

**(2)**

**(Total 4 marks)**

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

**A** work

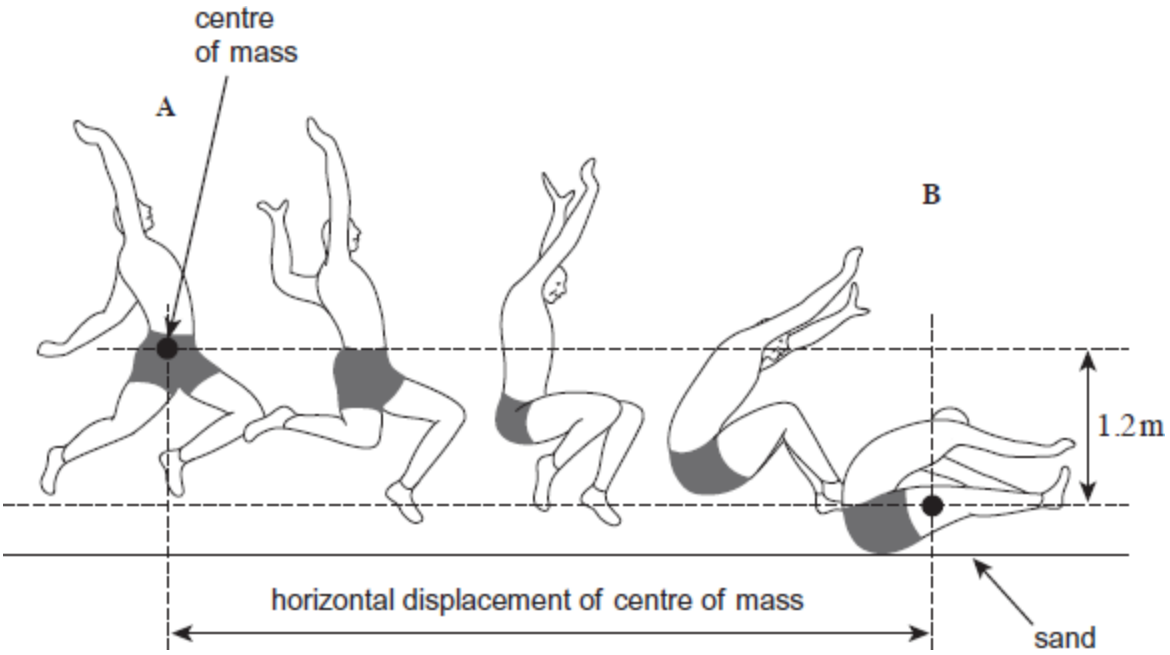
**B** energy

**C** acceleration

**D** weight

**(Total 1 mark)**

**12** The motion of a long jumper during a jump is similar to that of a projectile moving under gravity. The figure below shows the path of an athlete above the ground during a long jump from half-way through the jump at position **A**, to position **B** at which contact is made with sand on the ground. The athlete is travelling horizontally at **A**.




(a) During this part of the jump, the centre of mass of the athlete falls 1.2 m.

(i) Calculate the time between positions **A** and **B**.

time _____ s

**(3)**

(ii) The athlete is moving horizontally at **A** with a velocity of 8.5 m $s^{-1}$. Assume there is noair resistance. Calculate the horizontal displacement of the centre of mass from **A** to **B**.

horizontal displacement _____ m

**(2)**

(b) (i) The athlete in the image above slides horizontally through the sand a distance of 0.35 m before stopping.

Calculate the time taken for the athlete to stop. Assume the horizontal component of the resistive force from the sand is constant.

time _____ s

**(2)**

(ii) The athlete has a mass of 75 kg. Calculate the horizontal component of the resistive force from the sand.

horizontal component of resistive force _____ N

**(3)**

**(Total 10 marks)**

**13** A golf club strikes a stationary golf ball of mass $4.8 \times 10^{-2}$ kg and the ball leaves the club with a speed of 95 m $s^{-1}$. If the average force exerted on the ball is 7800 N, how long are the ball and club in contact?

**A** $5.8 \times 10^{-4}$ s

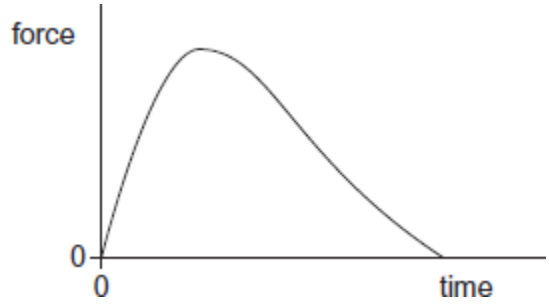
**B** $1.2 \times 10^{-2}$ s

**C** 0.51 s

**D** 0.58 s

**(Total 1 mark)**

**14** The graph shows how the force acting on a rocket varies with time.




Which one of the following is represented by the area under the graph?

**A** distance travelled

**B** gain in kinetic energy

**C** change in velocity

**D** change in momentum

**(Total 1 mark)**

**15** Water of density 1000 kg $m^{-3}$ flows out of a garden hose of cross-sectional area $7.2 \times 10^{-4}$ $m^2$ at a rate of $2.0 \times 10^{-4}$ $m^3$ per second. How much momentum is carried by the water leaving the hose per second?

**A** $5.6 \times 10^{-5}$ N s

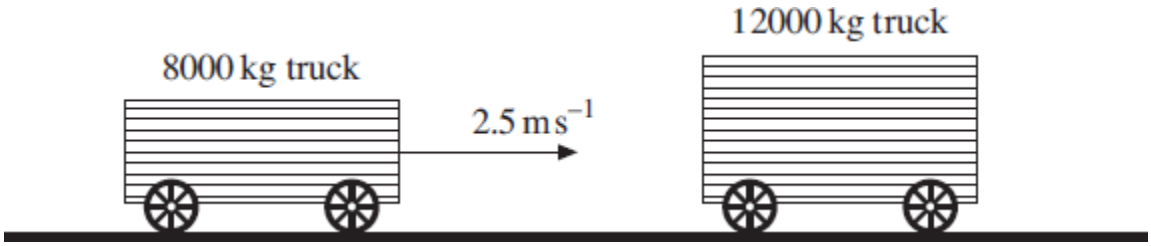
**B** $5.6 \times 10^{-2}$ N s

**C** 0.20 N s

**D** 0.72 N s

**(Total 1 mark)**

**16** A railway truck of mass 8000 kg travels along a level track at a velocity of 2.5 $ms^{-1}$ and collides with a stationary truck of mass 12000 kg. The two trucks move together at the same velocity after the collision.




What is the change in momentum of the 8000 kg truck due to the impact?

**A** 8000 N s

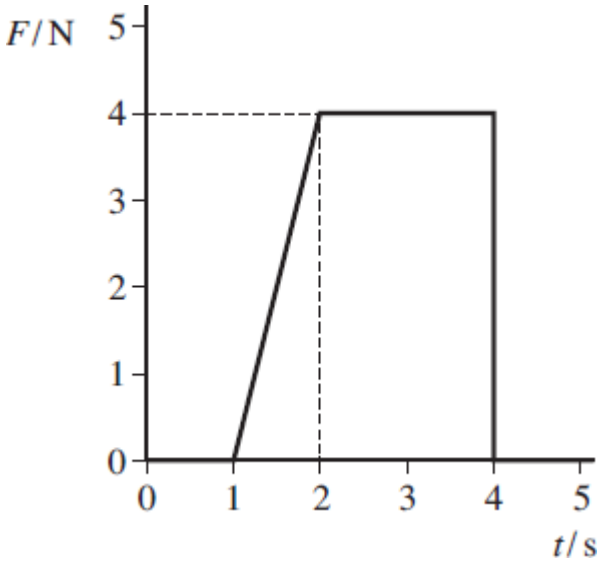
**B** 12000 N s

**C** 20000 N s

**D** 25000 N s

**(Total 1 mark)**

**17** The graph shows how the resultant force, *F*, acting on a body varies with time, *t*.




What is the change in momentum of the body over the 5 s period?

**A** 2N s

**B** 8N s

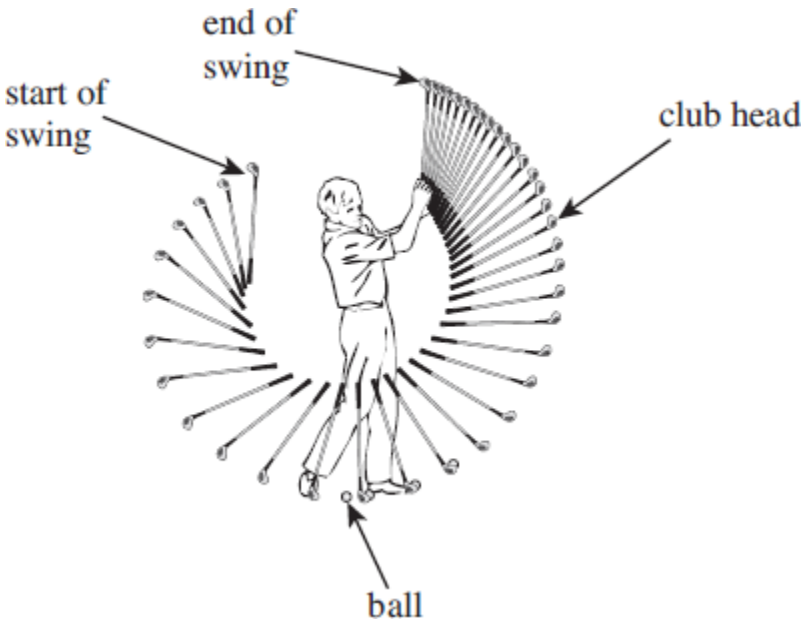
**C** 10N s

**D** 12N s

**(Total 1 mark)**

**18** When hitting golf balls long distances, golfers *follow through* with the swing. Doing this increases the time for which the club head is in contact with the ball.

The figure below is a stroboscopic photograph of a golf swing. The images were taken at equal time intervals.




(a) Sketch, on the axes below, how the speed of the club head varies with time over the whole swing.


**(2)**

(b) Explain in terms of the impulse acting on the ball the advantage to the golfer of following through with the swing.

_____

_____

_____

_____

**(2)**

(c) The club head is in contact with the ball for a time of 180 μs. The mass of the club head is 0.17 kg and that of the ball is 0.045 kg. At the moment of contact the ball is at rest and the club head is moving with a speed of 35 $ms^{-1}$. The ball moves off with an initial speed of 58 $ms^{-1}$.

(i) Calculate the average force acting on the ball while the club head is in contact with it.

average force on ball _____ N

**(2)**

(ii) Deduce the average force acting on the club head due to its collision with the ball.

average force on club head _____ N

**(1)**

(iii) Explain why it is not possible to transfer all the kinetic energy of the club head to the ball.

_____

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_____

_____

_____

_____

**(2)**

**(Total 9 marks)**

**19** A rail truck X travels along a level track and collides with a stationary truck Y. The two trucks move together at the same velocity after the collision.


Which line, **A** to **D**, in the table states how the total momentum and the total kinetic energy of the trucks change as a result of the impact.

| | **total momentum** | **total kinetic energy** |
|---|---|---|
| **A** | unchanged | unchanged |
| **B** | unchanged | decreases |
| **C** | decreases | decreases |
| **D** | decreases | unchanged |

**(Total 1 mark)**