Write your name, centre number and candidate number in the boxes below.

Surname	Other names

Centre number | | | | | |

Candidate number | | | | |

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Momentum and impulse

Time allowed: 1 hour

Subject code **0625**

Physics

Paper 4 (Extended)

You must have: a ruler marked in centimetres and millimetres, a protractor, compasses, a pen, an HB pencil and an eraser.

Total marks

/ 64

Instructions

- Answer every question in the space provided on this paper.
- Write in black or dark blue ink. Pencil may be used for diagrams and graphs.
- Fill in your name, centre number and candidate number above.
- Show your working: a correct method can earn marks even if the answer is wrong.

Information

- This paper has 9 questions worth 64 marks in total.
- The marks for each question or part are shown in brackets, for example [3].

Advice

- Read every question through once before you write anything.
- Use the marks in brackets to judge how long to spend on each part.
- If you finish early, go back and check your working.

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Print at 100% (Actual size) so diagrams keep their real measurements.

1 A cricket ball is travelling at a speed of 25 m / s horizontally through the air. The mass of the ball is 0.14 kg.

A player catches the ball and the ball comes to rest.

(a) Calculate the change in momentum of the ball during the catch.

change in momentum = ... [2]

(b) The player's hands are in contact with the moving ball for 9.7 ms.

Calculate the horizontal force exerted by her hands to bring the ball to rest.

force = ... [3]

[Total: 5]

Momentum and impulse Click for more variations

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1(a)	(–) 3.5 kgm / s	**A2**
	(Δp =) $m(\Delta)u$ **OR** $m\{v - u\}$ **OR** 0.14 × {25 (– 0)}	C1
1(b)	360 N	**A3**
	0.0097 (s) **OR** 9.7×10^{-3} (s) **OR** 3.6×10^{n}	C1
	(F =) (Δ)p / t **OR** 3.5 / 0.0097	C1

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2 Fig. 2.1 shows a golfer about to hit a golf ball with a golf club. The initial momentum of the golf ball is zero.



Fig. 2.1

(a) Define momentum.

..... [1]

(b) The golf club is in contact with the ball for 5.0×10^{-4} s. The velocity of the golf ball as it leaves the golf club is 41 m/s. The golf ball has a mass of 0.046 kg.

(i) Calculate the impulse on the golf ball.

impulse = ... [2]

(ii) Calculate the force applied to the ball by the golf club.

force = ... [2]

[Total: 5]

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2(a)	(momentum is) mass × velocity	**B1**
2(b)(i)	1.9 N s **OR** 1.9 kg m / s	**A2**
	impulse = $F\Delta t$ = $\Delta\{mv\}$**OR** (impulse =$F\Delta t$ =) $\Delta\{mv\}$ **OR** (impulse =) 0.046 × 41	C1
2(b)(ii)	3800 N	**A2**
	F=Δp / Δt **OR** (F=) Δp / (Δ)t **OR** (F=) Δ(mv) / (Δ)t **OR** (F =) impulse / (Δ)t **OR** 1.9 / 0.0005 **OR** 3.8 × 10^{N} N	C1

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3 Fig. 3.1 shows a collision at very slow speed between two cars travelling along a straight road.

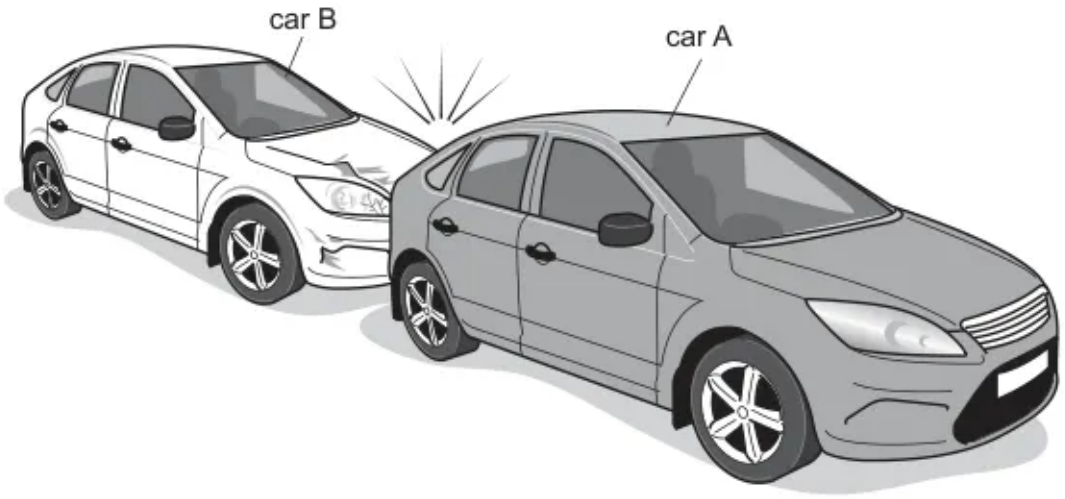


Fig. 3.1

Car B, of mass 800 kg, is moving at 2.0 m/s and collides with car A, of mass 1000 kg, which is stationary. After the collision, both cars travel in the same direction as the initial direction of car B.

(a) After the collision, car A moves at 1.3 m/s.

Show that the speed of car B after the collision is approximately 0.4 m/s.

[3]

(b) **(i)** Calculate the impulse exerted by car A on car B.

impulse = ... [2]

(ii) State the impulse exerted by car B on car A.

impulse = ... [1]

[Total: 6]

Momentum and impulse Click for more variations

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3(a)	momentum before collision = momentum after collision	B1
	(initial momentum (*p*) =) 800 × 2 OR 1600 (kg m / s)	B1
	(v =) (1600 – 1300) / 800 OR 300 / 800 OR 0.38 (m / s)	B1
3(b)(i)	(impulse =) change in momentum	C1
	1300 Ns	A1
3(b)(ii)	same value as **(b)(i)** OR 1300 (Ns)	B1

4 Trolley A and trolley B are on a horizontal, frictionless bench. Trolley A moves to the right with a constant velocity u = 0.44 m / s. Trolley B is stationary.

Fig. 2.1 shows trolley A before it collides with trolley B.

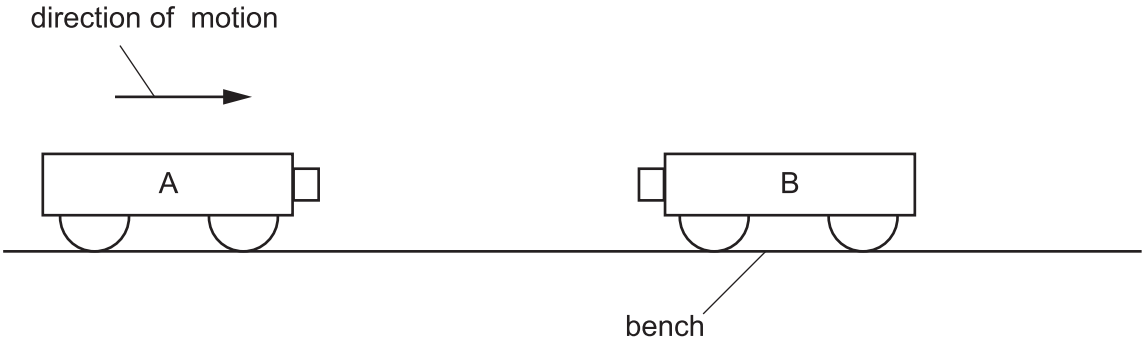


Fig. 2.1 (not drawn to scale)

(a) State the momentum of trolley B before the collision. Explain your answer.

statement .....

explanation .....

.....

[1]

(b) After the collision, the two trolleys are joined together and travel with a constant velocity v = 0.18 m / s to the right. The mass of trolley A is 0.75 kg.

Calculate the mass of trolley B.

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mass of trolley B = ... [3]

(c) (i) The trolleys move onto a rough surface which exerts a constant force F on the trolleys and brings them to rest in 2.6 s.

Calculate F.

F = ... [2]

(ii) A different rough surface exerts a smaller resistive force on the trolleys. State how this affects the time taken to bring the trolleys to rest. Explain your answer.

statement .....

explanation .....

.....

[1]

[Total: 7]

Momentum and impulse Click for more variations

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4(a)	(statement momentum is) zero / 0 **AND** (explanation) momentum is mass × velocity **OR** the velocity (of B) is zero	**B1**
4(b)	1.1 kg	**A3**
	Conservation of momentum **OR** momentum after (collision) = momentum before (collision) **OR** {0.75 × 0.44} = {0.75 + m} × 0.18	C1
	momentum before collision = 0.75 × 0.44 (+ m ×0 = 0.33) **OR** momentum after collision = (0.75 + m) × 0.18	C1
4(c)(i)	0.13 N	**A2**
	$(F =) \Delta p \div (\Delta)t$ **OR** (0.75 + 1.1) × 0.18 ÷ 2.6 **OR** (F =) 0.33 ÷ 2.6 $(F =)\{0.75 + \mathbf{2(b)}\} \times 0.18 \div 2.6$	C1
4(c)(ii)	(time taken) **I**ncreases **AND** use of $F(\Delta)t = \Delta\{mv\}$ **OR** $F \propto 1 / (\Delta)t$ **OR** same momentum change required	**B1**

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5 **(a)** Define momentum.

..... [1]

(b) Fig. 3.1 shows two toy trains, A and B, on a track.

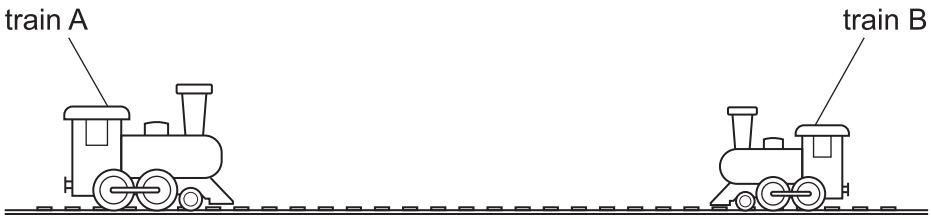


Fig. 3.1

The mass of train A is 0.45 kg and the mass of train B is 0.21 kg. The trains do **not** have motors.

Train A travels towards train B and they collide.

Immediately before the collision:

- the velocity of train A is 0.34 m / s to the right
- the velocity of train B is 0.12 m / s to the left.

The trains stick together when they collide.

Calculate the velocity of the trains immediately after the collision.

velocity = ...

direction .....

[4]

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(c) A different train is travelling with a momentum of 0.26 kg m / s.

The train slows down and stops after 2.1 s.

Calculate the average force acting on the train during this time.

average force = ... [2]

[Total: 7]

Momentum and impulse Click for more variations

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5(a)	(momentum =) mass × velocity **OR** (p =) mv	**B1**
5(b)	(velocity =) 0.19 m / s **AND** (direction) to the right	**A4**
	(momentum before collision) = {0.45 × 0.34} – {0.21 × 0.12} **OR** 0.1278	C1
	(momentum after collision) = 0.66 × v	C1
	momentum before collision = momentum after collision **OR** {0.45 × 0.34} – {0.21 × 0.12} = 0.66 × v **OR** 0.153 – 0.0252 = 0.66 × v	C1
5(c)	(–) 0.12 N	**A2**
	$F\Delta t = \Delta\{mv\}$ **OR** (F =) $\Delta p \div (\Delta)t$ **OR** (F =) $\Delta\{mv\} \div (\Delta)t$ **OR** (F =) 0.26 ÷ 2.1	C1

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6 Fig. 2.1 shows two cars, A and B, before they collide.

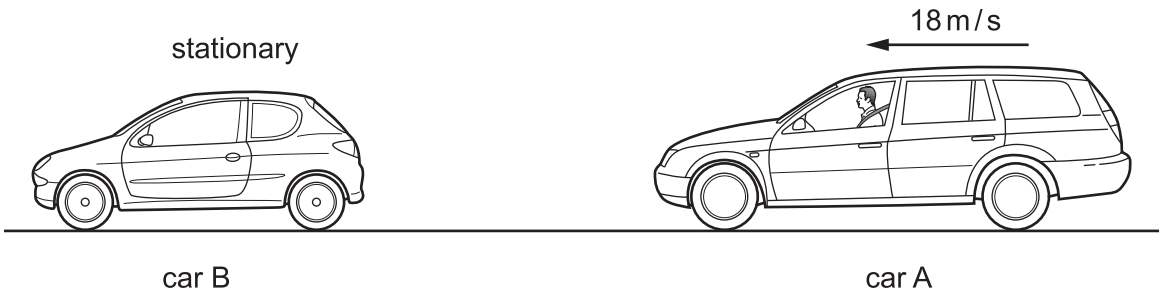


Fig. 2.1

Car B, of mass 1200 kg, is stationary. Car A, of mass 2000 kg, is travelling towards car B at 18 m / s.

(a) Calculate the momentum of car A.

momentum = ... [2]

(b) The cars collide and car B experiences an impulse. Car A continues to move in the same direction, with a momentum of 21 000 kg m / s.

(i) Calculate the momentum of car B immediately after the collision.

momentum = ... [1]

(ii) Determine the average impulse experienced by car B during the collision.

impulse = ... [1]

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(iii) The cars are in contact for 0.20 s.

Calculate the average resultant force experienced by car B during the collision.

force = ... [2]

(c) A modern car is designed so that, during a collision, the front section of the car is crushed and the time of contact increases.

Explain the benefit of increasing the time of contact for the people in the car.

.....

.....

.....

..... [2]

[Total: 8]

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6(a)	(*p* =)*mv* **or** 2000 × 18 36 000 kg m/s (**or** N s)	**C1** **A1**
6(b)(i)	15 000 kg m/s (**or** N s)	**B1**
6(b)(ii)	15 000 kg m/s (**or** N s) (e.c.f.**(i)**)	**B1**
6(b)(iii)	(*F* =)*p* ÷ *t* **or** *mv* ÷ *t* **or** 15 000 ÷ 0.20 (e.c.f.**(i)**/**(ii)**) 75 000 N	**C1** **A1**
6(c)	(increased time causes) decreased rate of: change of momentum/acceleration/deceleration/impulse ÷ time smaller forces on people/less injury	**B1** **B1**

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7 Fig. 2.1 shows two railway trucks on a track.



Fig. 2.1

Truck A of mass 6000 kg is moving at 5.0 m / s. It is approaching truck B of mass 5000 kg, which is stationary.

(a) Calculate the momentum of truck A.

momentum = ... [2]

(b) The trucks collide, their buffers compress and then they bounce off each other, remaining undamaged.

After the collision, truck B has a momentum of 27 000 kg m / s.

(i) Determine the impulse applied to truck B.

impulse = ... [2]

(ii) The trucks are in contact for 0.60 s.

Calculate the average force on truck B.

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force = ... [2]

(iii) Calculate the final speed of truck A.

speed = ... [3]

[Total: 9]

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7(a)	momentum = mv	**C1**
	(=) 30 000 kg m / s OR N s	**A1**
7(b)(i)	impulse same as momentum change	**C1**
	27 000 kg m / s OR N s	**A1**
7(b)(ii)	F= impulse(mom ch) / t in any form OR impulse(mom ch) / t	**C1**
	(F=27 000 / 0.6 =) 45 000 N	**A1**
7(b)(iii)	momentum loss truck A same as momentum gain truck B / impulse	**C1**
	(final mom truck A=) candidate's **(a)** – candidate's **(b)(i)**	**C1**
	(v= 3000/6000 =) 0.50 m/s	**A1**
		Total: 9

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8 **(a)** Underline the pair of quantities which must be multiplied together to calculate *impulse*.

force and mass	force and velocity	mass and time
time and velocity	weight and velocity	force and time

[1]

(b) Fig. 3.1 shows a collision between two blocks A and B on a smooth, horizontal surface.



Fig. 3.1

Before the collision, block A, of mass 2.4 kg, is moving at 3.0 m/s. Block B, of mass 1.2 kg, is at rest.

After the collision, blocks A and B stick together and move with velocity *v*.

(i) Calculate

1. the momentum of block A before the collision,

momentum = ...[2]

2. the velocity *v*,

velocity = ...[2]

3. the impulse experienced by block B during the collision.

impulse = ...[2]

(ii) Suggest why the total kinetic energy of blocks A and B after the collision is less than the kinetic energy of block A before the collision.

.....

.....[1]

[Total: 8]

Momentum and impulse Click for more variations

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8(a)	'force and time'	**B1**
8(b)(i)1.	(momentum =) mv	**C1**
	(momentum = 2.4 × 3 =) 7.2 kg m / s OR Ns	**A1**
8(b)(i)2.	$(m_A + m_B)v = m_A$ x 3 OR momentum conserved	**C1**
	(v = 7.2 / 3.6 =) 2.0 m / s	**A1**
8(b)(i)3.	(impulse / Ft =) m(v – u)	**C1**
	(impulse / Ft = 1.2 × (2–0) =) 2.4 kg m / s OR N s	**A1**
8(b)(ii)	thermal/sound energy (produced at collision/lost)	**B1**
	Total:	**8**

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9 **(a)** State the word equation that defines *momentum*.

.....[1]

(b) A metal block A, travelling in a straight line at 4.0 m/s on a smooth surface, collides with a second metal block B which is at rest. Fig. 2.1 shows the two metal blocks A and B before and after the collision.

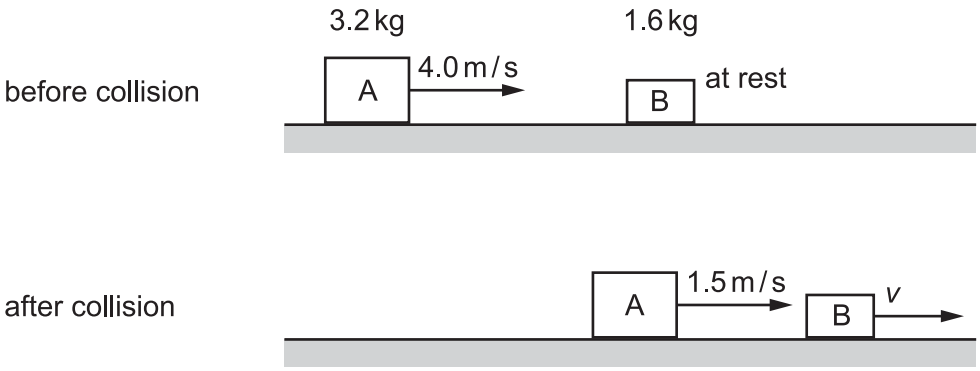


Fig. 2.1

The mass of A is 3.2 kg. The mass of B is 1.6 kg.
After the collision, the velocity of A is 1.5 m/s.

Calculate

(i) the momentum of A before the collision,

momentum = ...[2]

(ii) the velocity *v* of B after the collision.

v = ...[3]

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(c) In the collision that occurred in **(b)**, block A and block B are in contact for 0.050 s.

Calculate the average force that is exerted on B during the collision.

average force = ...[2]

(d) After the collision in **(b)**, the total kinetic energy of the two blocks is less than the kinetic energy of block A before the collision.

Suggest **one** reason for this.

.....

.....[1]

[Total: 9]

Momentum and impulse Click for more variations

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9(a)	(momentum =)mass × velocity	**B1**
9(b)(i)	(p =)3.2 × 4.0	**C1**
	13 kg m / s	**A1**
9(b)(ii)	momentum conserved	**C1**
	12.8 – (3.2 × 1.5) OR 12.8 – 4.8 OR 8.0 OR 8.0 ÷ 1.6	**C1**
	5.0 m / s	**A1**
9(c)	(F =) $\frac{\Delta p}{\Delta t}$ **or** 8.0 ÷ 0.050	**C1**
	160 N	**A1**
9(d)	internal energy (of blocks) increase OR thermal energy/sound energy (lost/produced at collision)	**B1**
	Total:	**9**

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