



eClassroom

A-LEVEL MATHEMATICS • MECHANICS 1

Momentum and Impulse

Worksheet

Pearson Edexcel International A Level (WME01) & A Level (9MA0) • Calculator and statistical tables allowed: take $g = 9.8 \text{ m s}^{-2}$ and give answers to 2 or 3 s.f.

Free Momentum and Impulse worksheet for A-Level and International A-Level Maths, with full worked solutions



Tap a section to jump straight to it

By the end of this worksheet you can: find momentum and impulse • use impulse = $mv - mu$ and $I = Ft$ • apply conservation of momentum • handle directions and reversals • *Stretch:* algebraic masses and speeds, conditions on direction, and motion before and after a collision.

Which questions are for me?

CORE The methods every A-level student must secure. Start here.

STRETCH Signs and directions, impulses that are equal and opposite, and what happens before and after.

Every section has both, clearly labelled. Questions get harder as you go, and every skill in Sections A to D is needed in Section E.

Track your progress

Section	B	C	D	E
Core marks	23	10	13	17
Stretch marks	16	14	17	10
My score				

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Name

Class

Date



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A**Worked examples & Your turn**

Read each example carefully. Cover it up, then answer the question beside it using the same method.

CORE*Secure the method***Worked example A1: momentum**

Find the momentum of a 3 kg ball moving at 4 ms^{-1}

Momentum = mv , in Ns

12Ns

Your turn A1

Find the momentum of a 0.25 kg ball moving at 18 ms^{-1}

Worked example A2: impulse

A 2 kg particle speeds up from 3 ms^{-1} to 8 ms^{-1} in the same direction. Find the impulse.

Impulse = $mv - mu$

$$2(8) - 2(3)$$

10Ns

Your turn A2

A 0.5 kg particle slows from 6 ms^{-1} to 2 ms^{-1} in the same direction. Find the magnitude of the impulse.

Worked example A3: a reversal

A 0.4 kg ball hits a wall at 5 ms^{-1} and rebounds at 3 ms^{-1} . Find the magnitude of the impulse.

Away from the wall is positive: $u = -5$, $v = 3$

$$0.4(3 - (-5))$$

3.2Ns

Your turn A3

A 0.2 kg ball hits a wall at 10 ms^{-1} and rebounds at 4 ms^{-1} . Find the magnitude of the impulse.



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STRETCH

Worked example A4: particles that join

A 2 kg particle at 6 m s^{-1} hits a 4 kg particle at rest, and they join. Find their speed.

Momentum before = momentum after

$$2(6) = 6v$$

$$2 \text{ m s}^{-1}$$

Your turn A4

A 3 kg particle at 5 m s^{-1} hits a 2 kg particle at rest, and they join. Find their speed.

Worked example A5: opposite directions

A (2 kg) moves right at 5 m s^{-1} and B (3 kg) moves left at 2 m s^{-1} . After they collide, A moves left at 1 m s^{-1} . Find B's velocity.

Right is positive

$$10 - 6 = -2 + 3v$$

$$2 \text{ m s}^{-1} \text{ right}$$

Your turn A5

A (4 kg) moves right at 3 m s^{-1} and B (1 kg) moves left at 6 m s^{-1} . After they collide, B moves right at 2 m s^{-1} . Find A's velocity.

Worked example A6: force and time

A force of 40 N acts for 0.15 s on a 0.5 kg puck at rest. Find its speed.

$$I = Ft, \text{ then } I = mv - mu$$

$$I = 6; 6 = 0.5v$$

$$12 \text{ m s}^{-1}$$

Your turn A6

A force of 25 N acts for 0.2 s on a 0.4 kg puck at rest. Find its speed.

Worked example A7: pushing apart

Skaters of mass 50 kg and 70 kg push apart from rest. The 50 kg skater moves at 2.1 m s^{-1} . Find the other's speed.

Total momentum stays 0

$$50(2.1) = 70v$$

$$1.5 \text{ m s}^{-1}$$

Your turn A7

Trolleys of mass 3 kg and 1.2 kg spring apart from rest. The 3 kg trolley moves at 0.8 m s^{-1} . Find the other's speed.



B**Fluency**

Each question is a designed sequence. From one part to the next, ask yourself: what changed, and what did it do to the answer?

CORE*Secure the method*

B1 A 0.6 kg ball moves at 5 m s^{-1}

- | | |
|--|---|
| (a) Find its momentum | (b) Find the impulse to speed it up to 9 m s^{-1} |
| (c) Find the impulse to send it back at 4 m s^{-1} | (d) That impulse lasts 0.02 s: find the average force |

[4 marks]

B2 A (4 kg) at 6 m s^{-1} catches B (2 kg) at 3 m s^{-1} , moving the same way.

- | | |
|--|------------------------------------|
| (a) Find the total momentum | (b) If they join, find their speed |
| (c) If A then moves at 4 m s^{-1} , find B's speed | (d) Find the impulse on B then |

[4 marks]

B3 A (3 kg) moves right at 4 m s^{-1} and B (2 kg) moves left at 5 m s^{-1}

- | | |
|---|---------------------------------------|
| (a) Find the total momentum | (b) If they join, find their velocity |
| (c) If A rebounds at 2 m s^{-1} , find B's velocity | (d) Find the impulse on A then |

[4 marks]

B4 A 0.15 kg ball arrives at a bat at 20 m s^{-1} and leaves in the opposite direction at 30 m s^{-1}

- | | |
|----------------------------------|--|
| (a) Find the impulse on the ball | (b) Contact lasts 0.005 s: find the average force |
| (c) Find the impulse on the bat | (d) Find the impulse if it left at 20 m s^{-1} |

[4 marks]



CORE

continued: pushing apart and unknowns

- B5** A person of mass 60 kg jumps horizontally off the back of a boat of mass 80 kg, which was at rest, with speed 2.5 m s^{-1}
- (a) Find the speed of the boat.
 - (b) Find the magnitude of the impulse on the boat.
 - (c) State the total momentum afterwards. [3 marks]
- B6** P (2 kg) at 6 m s^{-1} hits Q (m kg) at rest. Afterwards P moves at 2 m s^{-1} and Q at 4 m s^{-1} , both in P 's original direction.
- (a) Find the momentum lost by P
 - (b) Find m
 - (c) Find the impulse on Q
 - (d) If P had stopped, find Q 's speed
- [4 marks]

STRETCH

- B7** P (mass m) at $4u$ meets Q (mass $2m$) moving at u towards it. Afterwards P moves back at speed u
- (a) Find Q 's velocity
 - (b) Find the impulse on P
 - (c) Find the impulse on Q
 - (d) Has Q changed direction?
- [4 marks]
- B8** P (2 kg) at 5 m s^{-1} hits Q (4 kg) at rest. Afterwards P has velocity $v \text{ m s}^{-1}$ and Q has velocity $w \text{ m s}^{-1}$
- (a) Find w in terms of v
 - (b) Find w if P stops
 - (c) Show $w > 2.5$ if P reverses
 - (d) Using $w \geq v$, find the greatest v
- [4 marks]
- B9** A 0.5 kg puck at 4 m s^{-1} hits a 1.5 kg puck at rest and they join. They then slide on a rough floor with $\mu = 0.1$
- (a) Find the common speed
 - (b) Find the friction
 - (c) Find the deceleration
 - (d) Find the distance to stop
- [4 marks]
- B10** A 0.1 kg ball is dropped from 1.25 m onto a floor and rebounds to 0.8 m
- (a) Find its speed before impact
 - (b) Find its speed after impact
 - (c) Find the impulse from the floor
 - (d) Find it if the ball does not rebound
- [4 marks]



C**Reasoning**

Show your working and explain your thinking. A correct answer without a reason does not score full marks.

CORE*Secure the method*

- C1** Asked for the speed of Q after a collision, Ama gives -2 ms^{-1}
Explain her error. [2 marks]
- C2** A 0.5 kg particle changes speed from 2 to 6 ms^{-1} in the same direction. Ben writes the impulse as $0.5g(6 - 2)$
Explain his error, and find the impulse. [2 marks]
- C3** A (2 kg) at 4 ms^{-1} and B (3 kg) at 2 ms^{-1} move towards each other and join. Cal writes $8 + 6 = 5v$
Explain his error, and find the velocity. [3 marks]
- C4** A string between two particles becomes taut. Dee gives the particles different speeds just afterwards.
Explain her error. [3 marks]

STRETCH

- C5** A 2 kg particle speeds up from 3 to 7 ms^{-1} in the same direction. Eli writes the impulse as $2(7 + 3)$
Explain his error, and find the impulse. [3 marks]
- C6** A 1 kg ball hits a 4 kg ball. Faye says the lighter ball receives the larger impulse.
Explain why she is wrong. [3 marks]
- C7** A ball hits a fixed wall and rebounds. Gus writes “momentum before = momentum after” for the ball.
Explain his error. [3 marks]
- C8** Two particles collide; while they are in contact, A exerts a force F on B for time t
- (a) Use Newton’s third law to show that the impulses on A and B are equal and opposite. (3)
- (b) Hence show that momentum is conserved in the collision. (2)
- [5 marks]



D**Problem solving**

You decide the method. Read the whole question first, and show every step.

CORE

Secure the method

- D1** Particles A and B , of masses $2m$ and m , move towards each other along the same straight line on a smooth horizontal surface with speeds $3u$ and $2u$, as shown. They collide directly, and the direction of motion of each particle is reversed. After the collision A has speed u



- (a) Find the speed of B after the collision.

(2)

- (b) Find the magnitude of the impulse on A

(1)

[3 marks]

- D2** Particle A of mass km moves at $4u$ and catches particle B of mass $2m$, moving at u in the same direction on a smooth surface. After the collision A moves at $2u$ in the same direction, and the impulse on B has magnitude $3mu$



- (a) Find the speed of B after the collision.

(2)

- (b) Find the value of k

(2)

[4 marks]

- D3** Two skaters, A of mass 60 kg and B of mass 45 kg , stand at rest on smooth ice and push apart. Immediately afterwards, A moves at 1.5 ms^{-1} . Find the speed of B , and the magnitude of the impulse that each skater exerts on the other.



[3 marks]

- D4** A bullet of mass 0.02 kg moving horizontally at 400 ms^{-1} embeds itself in a block of mass 1.98 kg at rest on a smooth horizontal surface.

- (a) Find the speed of the block and bullet immediately afterwards.

(2)

- (b) Find the magnitude of the impulse on the block.

(1)

[3 marks]



STRETCH

- D5** A ball of mass 0.2 kg is dropped from rest from a height of 2.5 m onto horizontal ground and rebounds to a height of 1.6 m . The ball moves freely under gravity.

(a) Find the magnitude of the impulse exerted on the ball by the ground.

(3)

(b) The ball is in contact with the ground for 0.04 s . Find the magnitude of the average force on it.

(1)

[4 marks]

- D6** A puck of mass 0.5 kg rests on horizontal ice. It is struck by a horizontal impulse of magnitude 3 N s and then slides in a straight line. The coefficient of friction between the puck and the ice is 0.05

Find the distance the puck slides before it comes to rest.

[4 marks]

- D7** A particle P of mass m moving at $5u$ collides directly with a particle Q of mass $3m$ at rest on a smooth surface. After the collision P moves back along its original path with speed u



(a) Find the speed of Q after the collision.

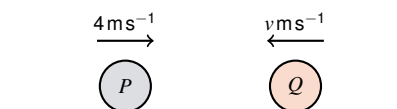
(2)

(b) Find the magnitude of the impulse on P , in terms of m and u

(2)

[4 marks]

- D8** Particle P of mass 3 kg moves at 4 ms^{-1} towards particle Q of mass 2 kg , which moves towards P at $v\text{ ms}^{-1}$. They collide and join.



(a) Find the range of values of v for which the combined particle moves in P 's original direction.

(3)

(b) Given that $v = 9$, find the speed and direction of the combined particle.

(2)

[5 marks]



E**Exam practice**

Full-size exam questions in the style of WME01. Write your answers in the spaces, and show every step.

CORE

Exam questions for everyone

E1 A bullet of mass 0.05 kg is fired horizontally at 300 ms^{-1} into a block of mass 2.95 kg that is at rest on a rough horizontal floor. The bullet embeds itself in the block, and the block and bullet then slide together along the floor. The coefficient of friction between the block and the floor is 0.4 . The bullet and block are modelled as particles, and the impact is modelled as instantaneous.

(a) Find the speed of the block and bullet immediately after the impact.

(2)

(b) Find the magnitude of the impulse exerted on the block by the bullet, stating the units of your answer.

(2)

(c) Find the distance the block slides before it comes to rest.

(3)

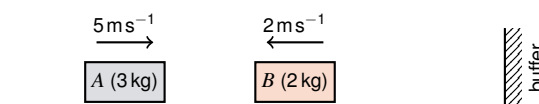
(d) State one modelling assumption, other than those given, that you have made about the impact or about the motion afterwards.

(1)

(Total for Question E1 is 8 marks)



- E2** Two trolleys, A of mass 3 kg and B of mass 2 kg , move towards each other along a straight horizontal track with speeds 5 ms^{-1} and 2 ms^{-1} . They collide directly. Immediately after the collision A moves at 1 ms^{-1} in its original direction. The track is smooth and horizontal, and the trolleys are modelled as particles moving along the same straight line.



- (a) Find the speed and direction of B immediately after the collision.

(3)

- (b) Find the magnitude of the impulse exerted on A in the collision.

(2)

B then hits a fixed buffer at the end of the track and rebounds with speed 3 ms^{-1}

- (c) Find the magnitude of the impulse exerted on B by the buffer.

(2)

- (d) Explain why A and B will collide again, stating the direction in which each is moving.

(2)

(Total for Question E2 is 9 marks)



STRETCH

E3 A cart of mass 400 kg moves along a straight horizontal track at 3 m s^{-1} . A sack of mass 100 kg is dropped vertically into the cart from a hopper above the track, and the sack immediately moves with the cart. The cart and sack are modelled as particles, and the track is horizontal.

(a) Find the speed of the cart immediately after the sack lands in it.

(2)

(b) Find the magnitude of the horizontal impulse exerted on the sack by the cart.

(2)

The cart then brakes uniformly and comes to rest in a distance of 12 m

(c) Find the magnitude of the braking force.

(3)

(d) Find the time taken to stop.

(1)

(e) Explain why the vertical momentum of the sack is not conserved when it lands in the cart, although the horizontal momentum of the cart and sack together is conserved.

(2)

(Total for Question E3 is 10 marks)

Want more exam practice? The **Exam Questions by Topic** booklets have 10 more full exam questions on Mechanics 1 Chapter 6, Momentum and Impulse, with a full mark scheme.

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