Delta Physics

Select a topic of your Choice

5 minutes – Individual

Momentum and Impulse

What happens when moving objects meet?



Higher Physics

PART 1

Momentum

A tennis ball and a lorry both move at 1 m s^{-1}. Which is harder to stop, and why?

By the end of this part…

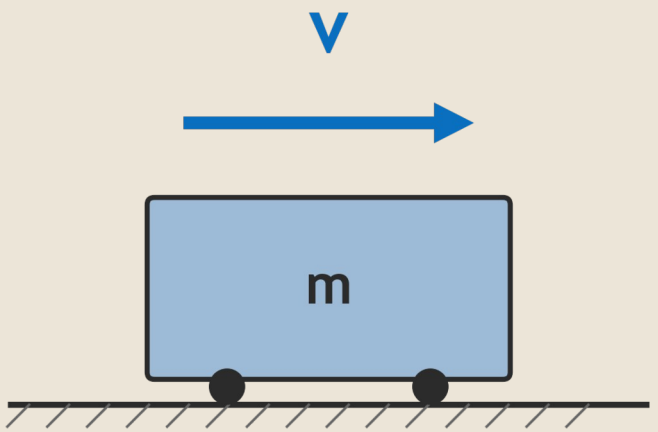


1. I can **calculate momentum** using **p = mv**
2. I can explain why **momentum** is a **vector**
3. I can **rearrange p = mv** to find a **mass** or a **velocity**

Momentum

$$p = mv$$

p	m	v
momentum ($kg\ m\ s^{-1}$)	mass (kg)	velocity ($m\ s^{-1}$)



p = mv

Momentum Is a Vector

Choose a direction

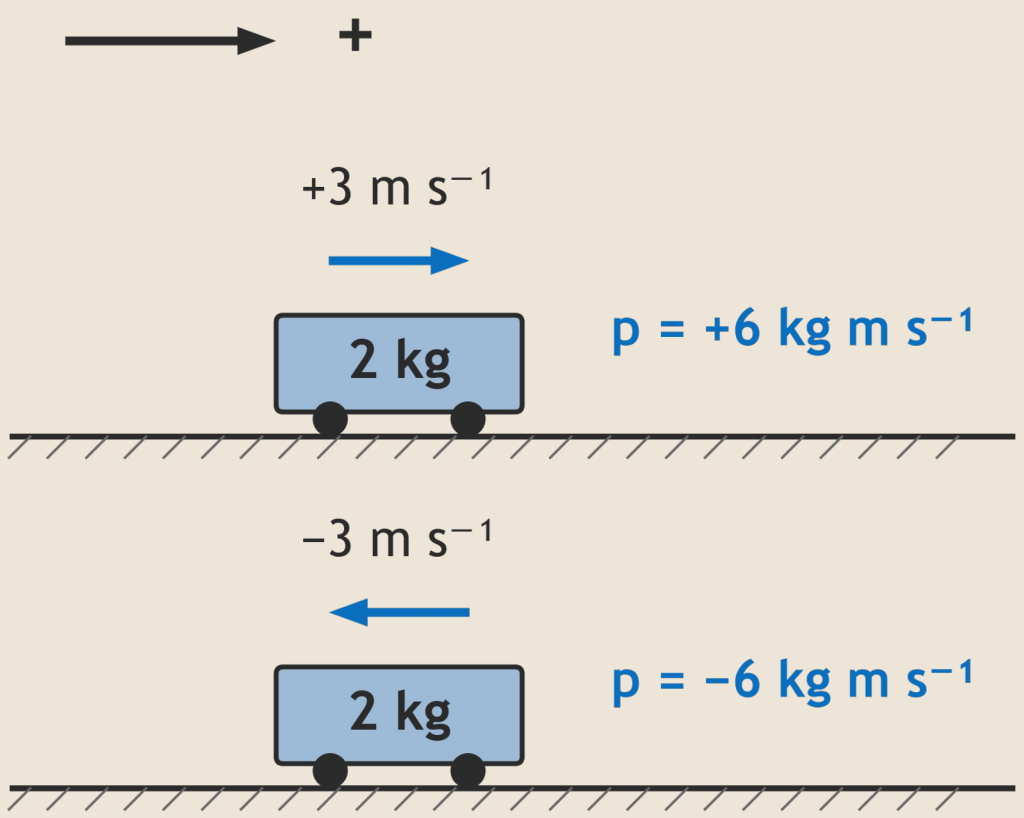
one way is positive

The other way

the velocity and momentum are negative

Unit

kg m s^{-1}



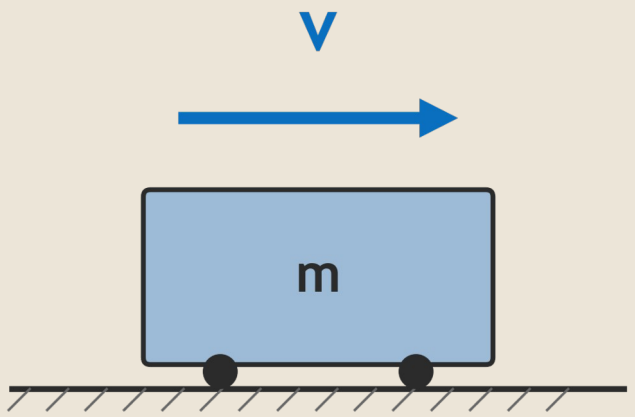
Worked Example 1: Momentum

A 1200 kg car travels at 25 m s^{-1}. **Calculate** the car's **momentum.** **3**

$p = mv$ **(1)**

$p = 1200 \times 25$ **(1)**

$p = 3.0 \times 10^4$ kg m s^{-1} **(1)**



p = mv

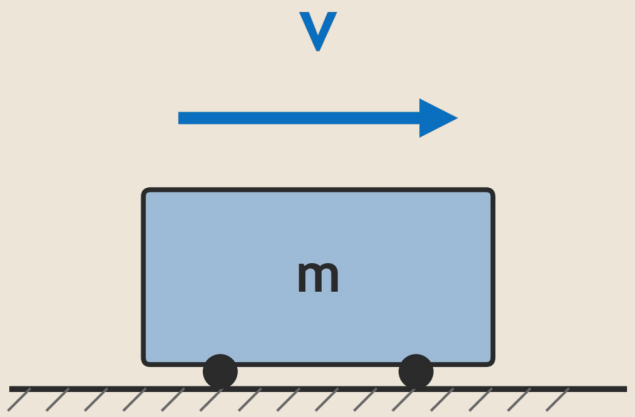
Worked Example 2: Finding the Velocity

A 0.16 kg ball has a **momentum** of 4.0 kg m s^{-1}. **Calculate** the ball's **speed**. **3**

$p = mv$ **(1)**

$4.0 = 0.16 \times v$ **(1)**

$v = 25$ m s^{-1} **(1)**



p = mv

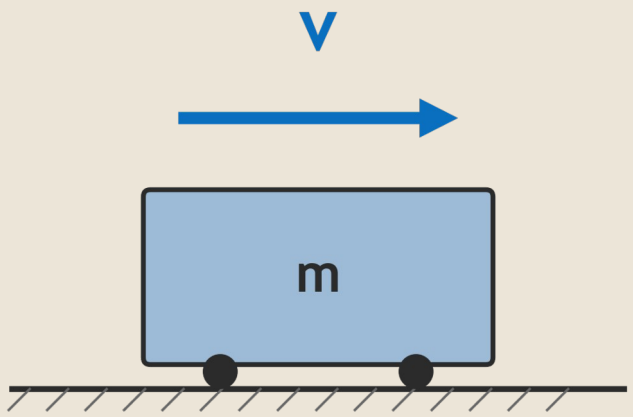
Worked Example 3: Finding the Mass

A trolley moving at 0.50 m s^{-1} has a **momentum** of 0.60 kg m s^{-1}. **Calculate** its **mass.** **3**

$p = mv$ **(1)**

$0.60 = m \times 0.50$ **(1)**

$m = 1.2$ kg **(1)**



p = mv

Your Turn

1. A 65 kg runner moves **left** at 8.0 m s^{-1} (right is positive). **Calculate** the **momentum**.

2. A 0.060 kg ball has a **momentum** of 1.8 kg m s^{-1}. **Calculate** its **speed**.

3. A cyclist and bike at 6.0 m s^{-1} have a **momentum** of 480 kg m s^{-1}. **Calculate** their **mass**.

−520 kg m s^{-1}

30 m s^{-1}

80 kg

2023 Paper 1 Q3. The momentum of an object of mass 4 kg is 20 kg m s^{-1}. The kinetic energy of the object is



A 10 J

B 50 J

C 100 J

D 400 J

E 800 J

Answer B: $v = 20 \div 4 = 5$ m s^{-1}, so $E_k = \frac{1}{2} \times 4 \times 5^2 = 50$ J

Look back — by the end of this part…



1. I can **calculate momentum** using **p = mv**
2. I can explain why **momentum** is a **vector**
3. I can **rearrange p = mv** to find a **mass** or a **velocity**

Delta Physics

Our Dynamic Universe

Motion — equations and graphs

5 minutes – Individual

PART 2

Collisions and Explosions

Two trolleys spring apart from rest. Where does their momentum come from?

By the end of this part…



1. I can **state** the **law of conservation of momentum**
2. I can **calculate** a **velocity** after a **collision**
3. I can **calculate** a **velocity** after an **explosion**

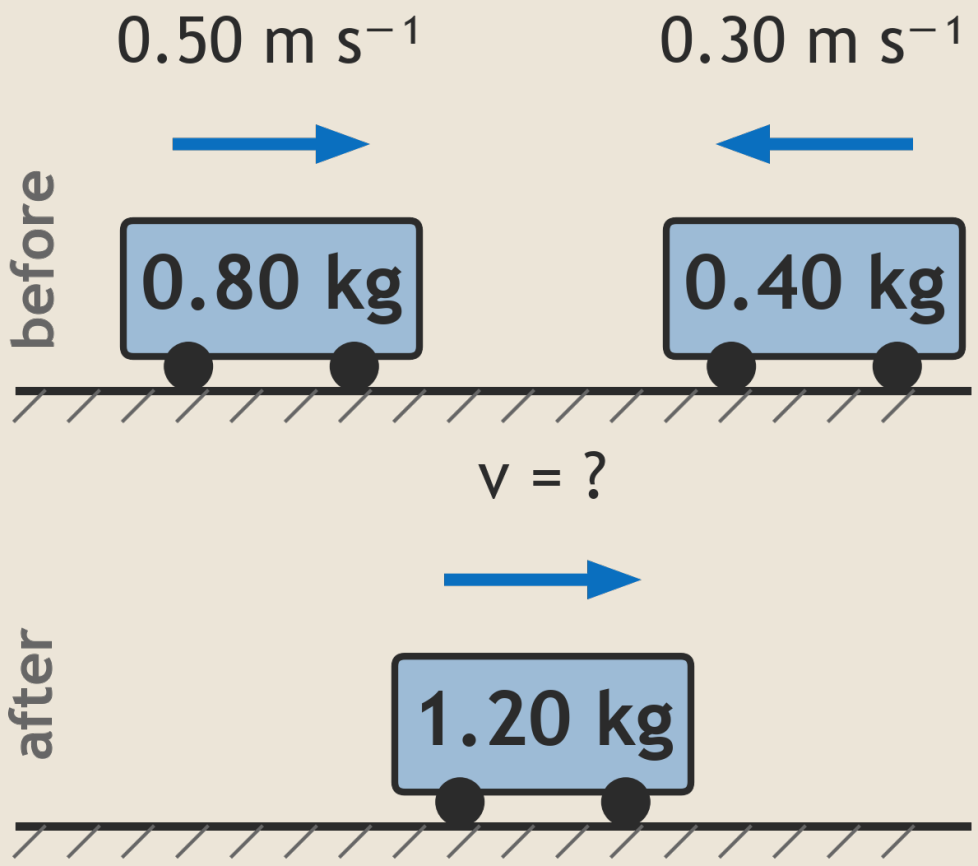
Conservation of Momentum

The law

The **total momentum before** a collision **equals** the **total momentum after**, in the **absence of external forces.**

Explosions

obey it too: total momentum before is 0



Conservation of Momentum: the Equation

$$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$$

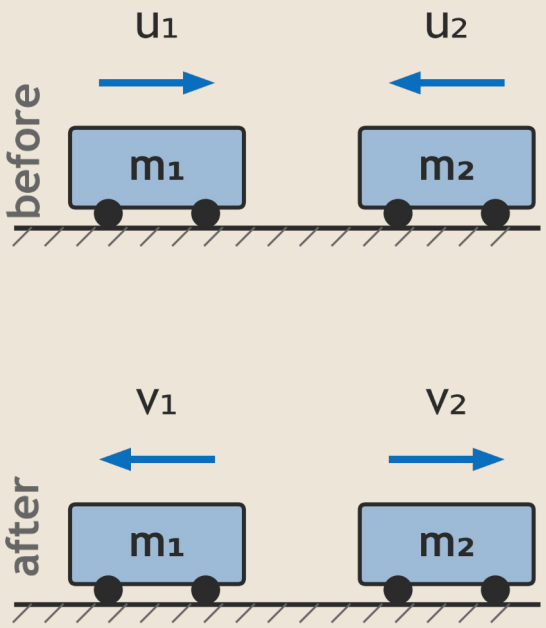
m_1, m_2 masses (kg)

u_1, u_2 velocities before (m s^{-1})

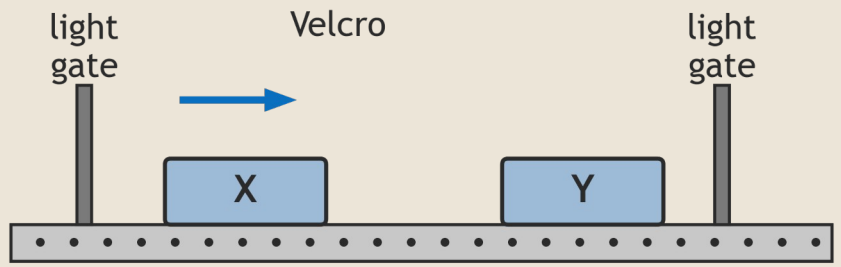
v_1, v_2 velocities after (m s^{-1})

Stick $v_1 = v_2 = v$

Explosion $u_1 = u_2 = 0$



Demo: Collide and Stick



air track: Y starts at rest

Predict the **speed** after X **sticks** to an equal, stationary Y.

Quantity	Reading
masses (kg)	
u of X (m s^{-1})	
v together (m s^{-1})	
total p before, after	

Half X's speed.

Worked Example 1: Collide and Stick

Two trolleys **collide** and **stick** together, as shown. **3**

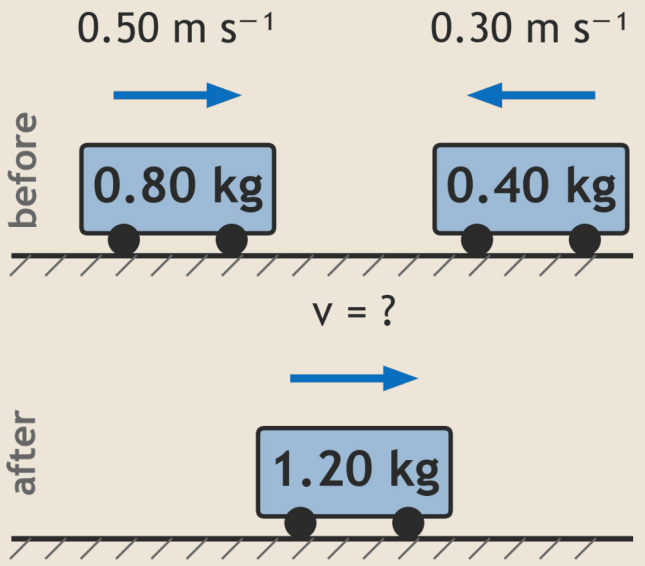
Calculate their **velocity** after the collision.

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ **(1)**

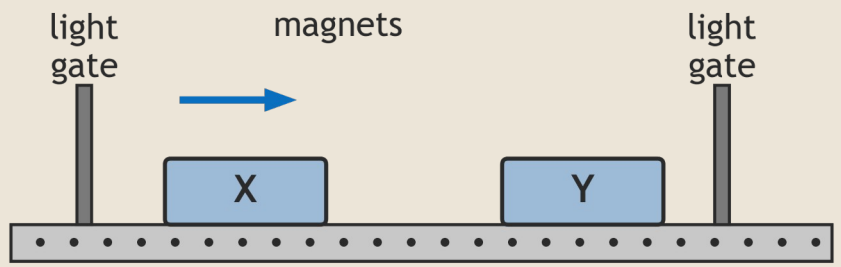
$(0.80 \times 0.50) + (0.40 \times -0.30) = 1.20v$ **(1)**

$v = 0.23 \text{ m s}^{-1}$ **(1)**

(0.23 m s^{-1} to the right)



Demo: Collide and Split



air track: Y starts at rest

Predict: X hits an equal, **stationary** Y and they **split**. What does X do?

Quantity	Reading
masses (kg)	
u of X (m s^{-1})	
v of X, v of Y (m s^{-1})	
total p before, after	

X stops; Y moves off at X's speed.

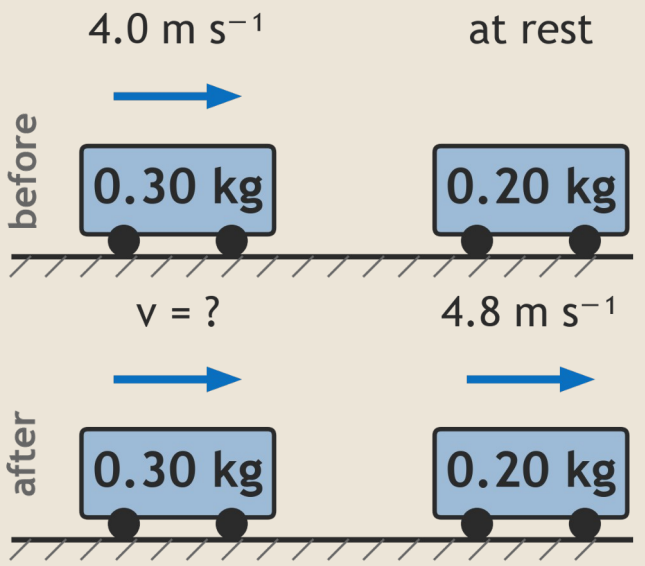
Worked Example 2: Collide and Split

A trolley hits a **stationary** trolley, as shown. **Calculate** the **velocity** of the 0.30 kg trolley after. **3**

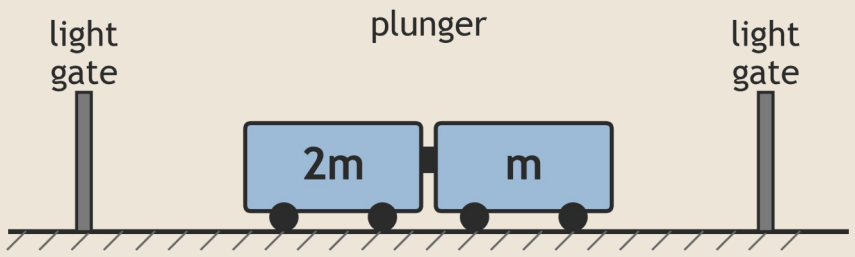
$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ **(1)**

$0.30 \times 4.0 = 0.30v_1 + 0.20 \times 4.8$ **(1)**

$v_1 = 0.80 \text{ m s}^{-1}$ **(1)**



Demo: Explosion



bench: both trolleys start at rest

Predict: one trolley has **twice the mass**. How fast does it move off?

Quantity	Reading
masses (kg)	
speeds (m s^{-1})	
momenta (kg m s^{-1})	
total momentum after	

Half the speed, the other way.

Worked Example 3: An Explosion

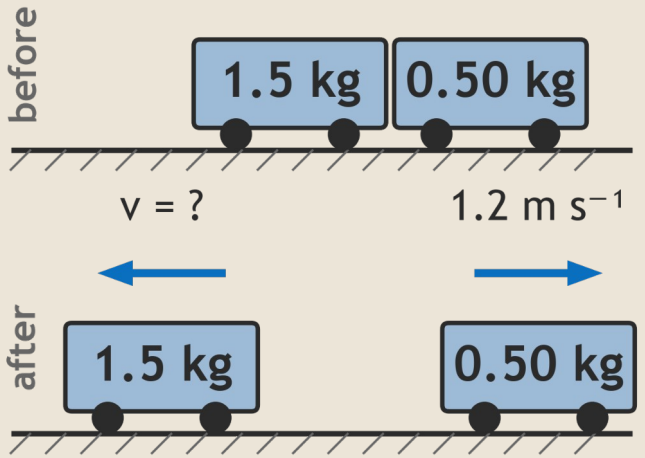
Two trolleys at **rest** are pushed apart by a spring, as shown. **Calculate** the **velocity** of the 1.5 kg trolley. **3**

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ **(1)**

$0 = 1.5v_1 + (0.50 \times 1.2)$ **(1)**

$v_1 = -0.40 \text{ m s}^{-1}$ **(1)**

(0.40 m s^{-1} to the left)



Your Turn



1. A 3.0 kg trolley at 2.0 m s^{-1} **sticks** to a **stationary** 1.0 kg trolley. **Calculate** their **velocity**.

   1.5 m s^{-1}

2. A 0.40 kg puck at 3.0 m s^{-1} knocks a 0.60 kg puck **at rest** to 1.6 m s^{-1}. **Calculate** its own **velocity**.

   0.60 m s^{-1}

3. A 40 kg skater pushes off a 60 kg skater from **rest** at 3.0 m s^{-1}. **Calculate** the other's **velocity**.

   −2.0 m s^{-1}

2024 Paper 1 Q6. The velocity of the trolleys immediately after the collision is

A 0.50 m s^{-1}

B 1.3 m s^{-1}

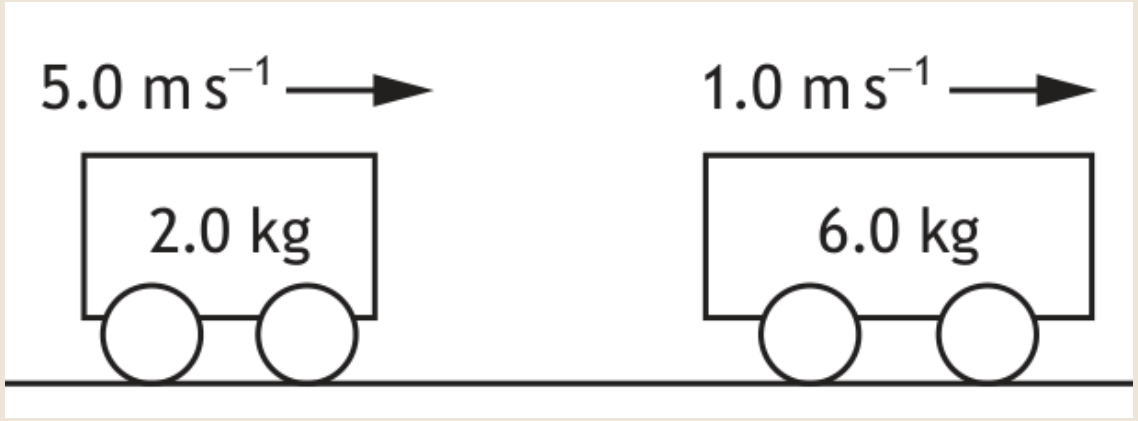
C 2.0 m s^{-1}

D 2.7 m s^{-1}

E 8.0 m s^{-1}

Answer C: (2.0 × 5.0) + (6.0 × 1.0) = 8.0v, so 2.0 m s^{-1}

Two trolleys move along a level bench as shown. The trolleys collide and stick together. They continue to move along the bench.



2020 Paper 1 Q7. The recoil speed of the nail gun immediately after firing is

A $0.005\ m\ s^{-1}$

B $0.05\ m\ s^{-1}$

C $0.12\ m\ s^{-1}$

D $1.2\ m\ s^{-1}$

E $120\ m\ s^{-1}$

Answer C: $0.0040 \times 150 = 5.0v$, so $0.12\ m\ s^{-1}$

A nail gun of mass 5.0 kg fires a nail of mass 4.0 g.
The nail gun and nail are initially at rest.
The speed of the nail immediately after firing is $150\ m\ s^{-1}$.

Look back — by the end of this part…



1. I can **state** the **law of conservation of momentum**
2. I can **calculate** a **velocity** after a **collision**
3. I can **calculate** a **velocity** after an **explosion**

Delta Physics

Select a topic of your Choice

5 minutes – Individual

PART 3

Elastic and Inelastic

Momentum is always conserved in a collision. Is kinetic energy?

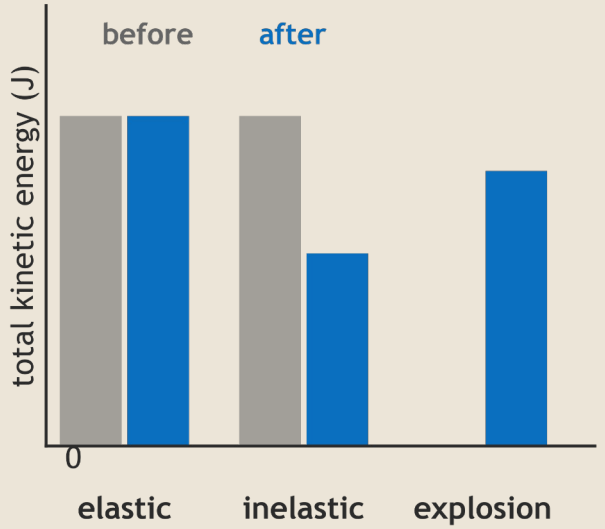
By the end of this part…



1. I can **calculate** the **total kinetic energy** before and after an interaction
2. I can **decide** whether a collision is **elastic** or **inelastic**
3. I can **explain** what happens to **kinetic energy** in an **explosion**

What Is Conserved?

	Momentum	Total E_k	Total energy
Elastic	yes	yes	yes
Inelastic	yes	no (less)	yes
Explosion	yes	no (more)	yes



Worked Example: Inelastic or Not?

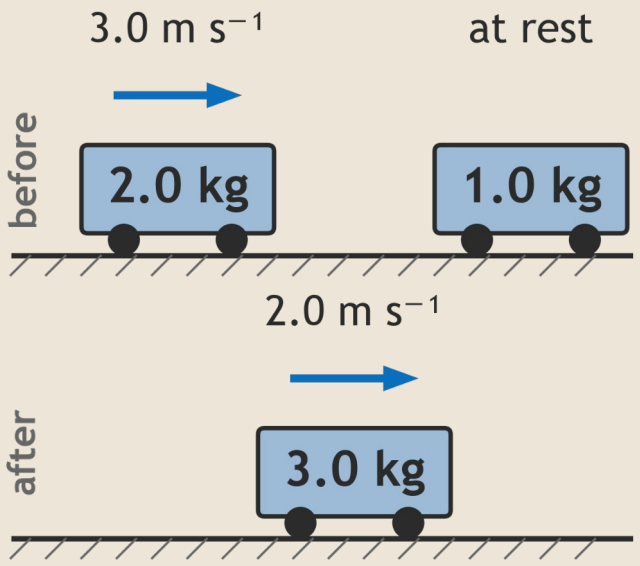
A 2.0 kg trolley at 3.0 m s^{-1} hits a **stationary** 1.0 kg one. **3**
They **stick** at 2.0 m s^{-1}. **Show** it is **inelastic**.

$E_k = \frac{1}{2}mv^2$ **(1)**

(before: $0.5 \times 2.0 \times 3.0^2 = 9.0$ J)

after: $0.5 \times 3.0 \times 2.0^2 = 6.0$ J **(1)**

E_k before is greater than E_k after **(1)**



Past Paper: 2020 Paper 2 Q3(c)

The collision between the ball and the lens is inelastic. **Explain** what is meant by an inelastic collision.

Kinetic energy is greater before (the collision) than after. (1)

Not accepted: 'E_k before not equal to E_k after'; 'E_k is not conserved'.

Past Paper: 2018 Section 2 Q3(c)

A collision between two vehicles on an air track is being investigated. **Explain** how the student would determine whether the collision was elastic or inelastic.

Calculate the total kinetic energy before and (total kinetic energy) after. (1)

If E_k before is equal to E_k after, the collision is elastic. If E_k before is greater than E_k after, the collision is inelastic. (1)

Your Turn



1. A 4.0 kg trolley at 2.0 m s^{-1} **sticks** to a **stationary** 4.0 kg one. **Calculate** the E_k **lost**.

   4.0 J

2. A 1.0 kg ball at 6.0 m s^{-1} stops on hitting a 1.0 kg ball **at rest**. **Show** whether it is **elastic**.

   Elastic: 18 J both

3. Two 2.0 kg trolleys **at rest** spring apart at 1.5 m s^{-1} each. **Calculate** the **kinetic energy** gained.

   4.5 J

2019 Paper 1 Q6. A student makes the following statements about an elastic collision.



I Total momentum is conserved.

II Total kinetic energy is conserved.

III Total energy is conserved.

A I only B II only C I and II D I and III E I, II, III

Answer E: all three are conserved in an elastic collision

2026 Paper 1 Q4. Which row gives the total kinetic energy (J) of the trolleys immediately before and immediately after the collision?

A 7.5 and 7.5

B 23 and 38

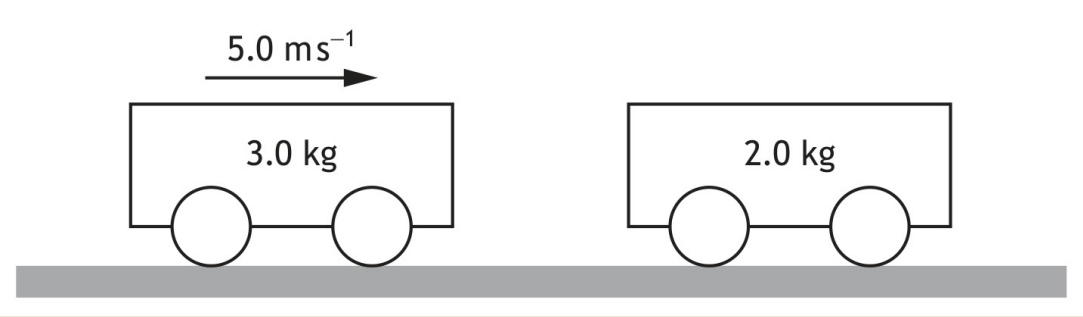
C 38 and 23

D 38 and 29

E 75 and 45

Answer C: 37.5 J before, 22.5 J after

A 3.0 kg trolley at 5.0 m s^{-1} hits a stationary 2.0 kg trolley. After the collision the trolleys stick together. Friction is negligible.



Look back — by the end of this part…



1. I can **calculate** the **total kinetic energy** before and after an interaction
2. I can **decide** whether a collision is **elastic** or **inelastic**
3. I can **explain** what happens to **kinetic energy** in an **explosion**

Delta Physics

Our Dynamic Universe

Forces, energy, and power

5 minutes – Individual

PART 4

Impulse

Why does a foam ball protect the circuit inside it?

By the end of this part…

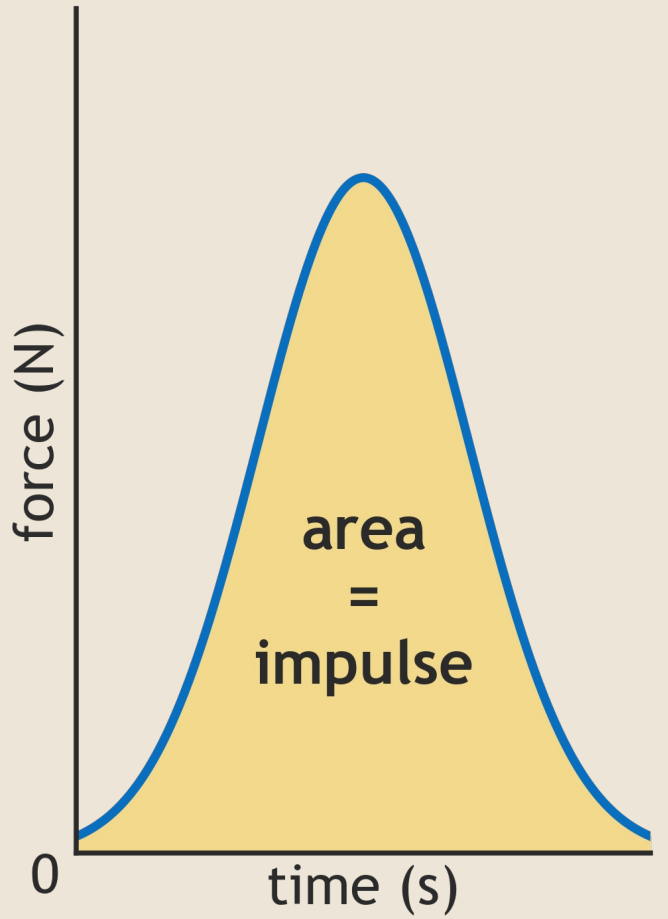


1. I can **calculate impulse** using **Ft = mv – mu**
2. I can find the **impulse** from the **area under a force-time graph**
3. I can find the **average force** or the **contact time** from a force-time graph
4. I can **explain** why a **longer contact time** means a **smaller force**

Impulse

$$Ft = mv - mu$$

F average force (N)
t time of contact (s)
m mass (kg)
v final velocity (m s^{-1})
u initial velocity (m s^{-1})
Ft impulse (N s)



Impulse Is the Area

Impulse

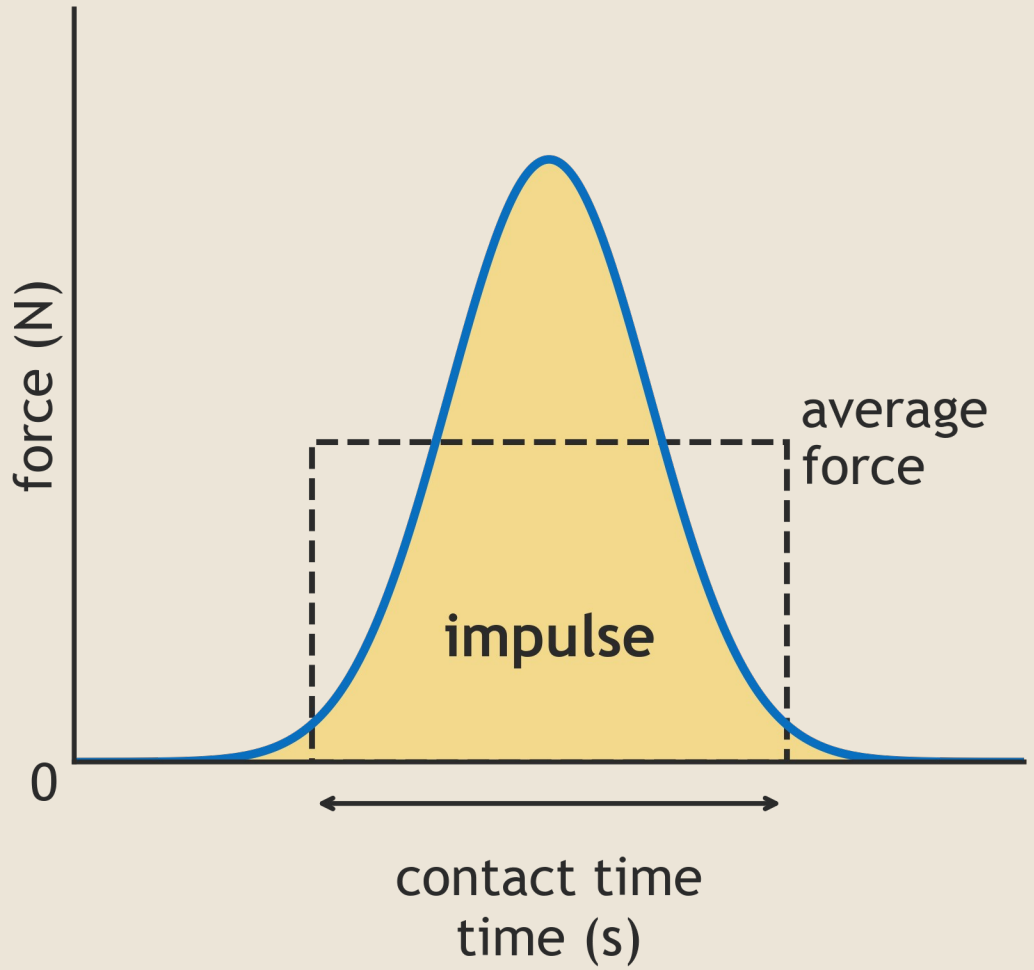
the area under a force-time graph

Change in momentum

equals the impulse

Average force

the steady force with the same area



Newton's Third Law in a Collision

Equal and opposite

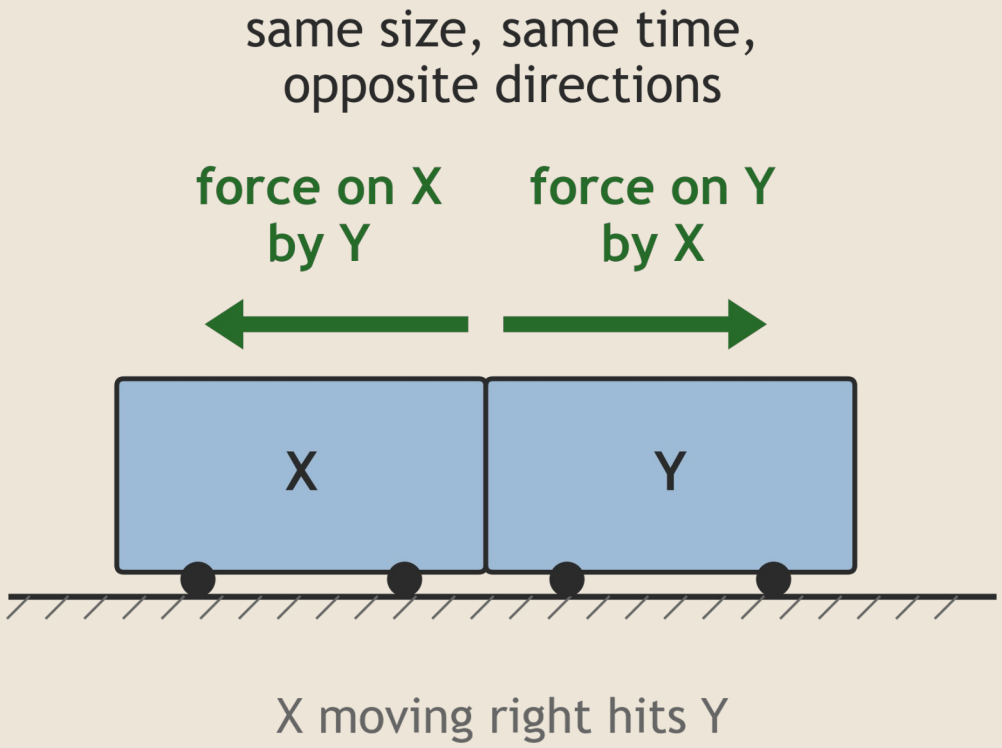
force on Y by X, force on X by Y

Same contact time

so equal and opposite impulses

So

X loses the momentum Y gains



X moving right hits Y

Longer Contact, Smaller Force

Same impulse

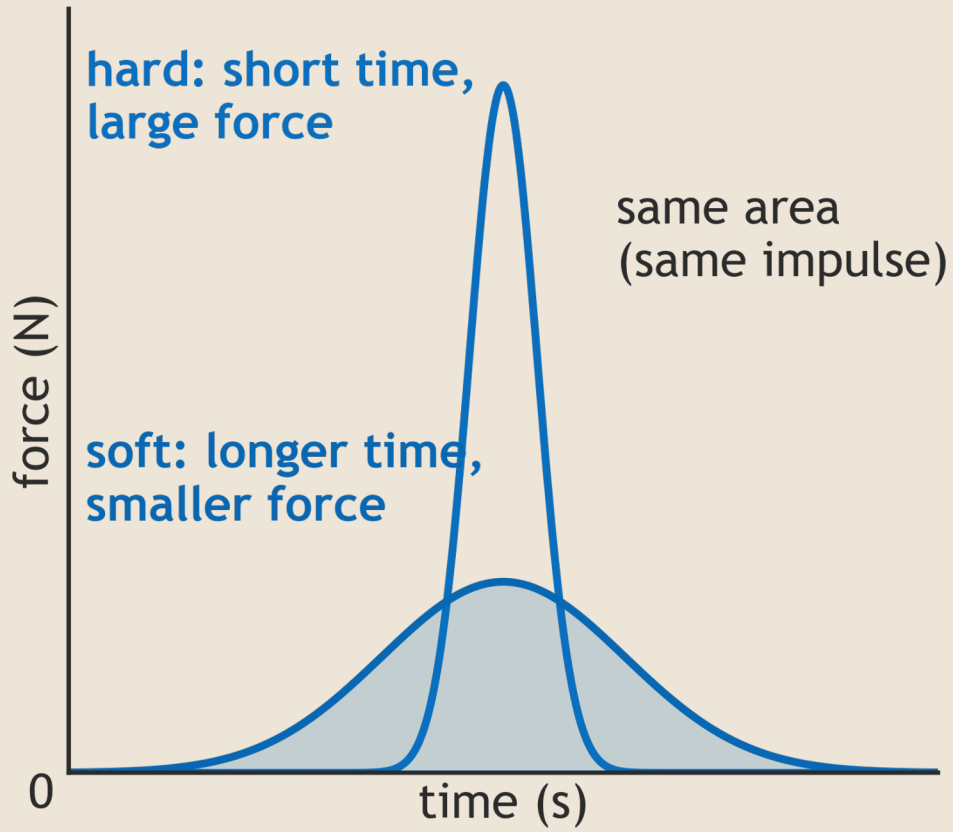
the same area

Longer contact time

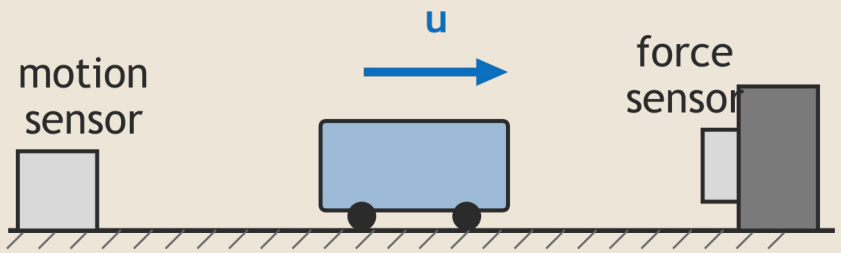
a smaller average force

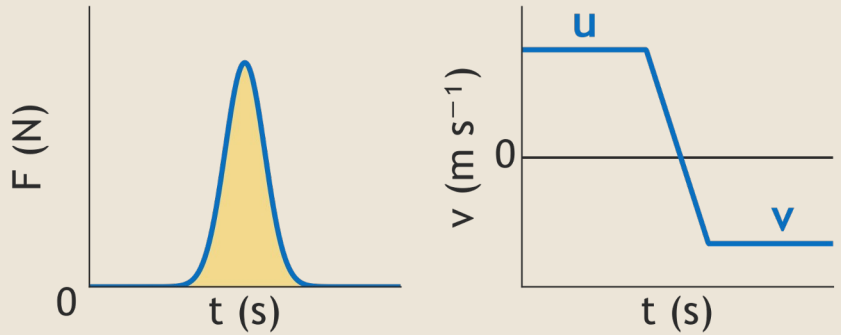
Exam sketch

a bell or a triangle



Demo: Measuring Impulse





Predict: how will the **area under F-t** compare with **mv – mu**?

Quantity	Reading
m (kg)	
u, v (m s^{-1})	
mv – mu (kg m s^{-1})	
area under F-t (N s)	

Equal: the impulse is Δp.

Worked Example 1: Impulse from a Graph

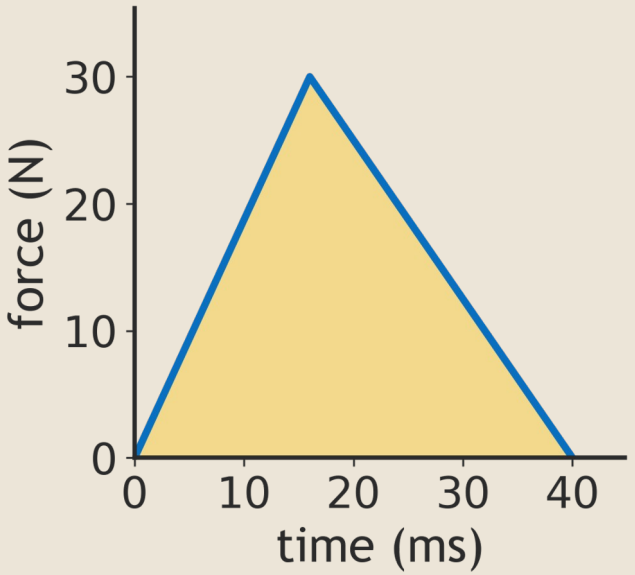
The graph shows the **force on a trolley** during a collision. **3**

Determine the **impulse** on the trolley.

impulse = area under graph **(1)**

impulse = ½ × 0.040 × 30 **(1)**

impulse = 0.60 N s **(1)**



Worked Example 2: Bouncing Back

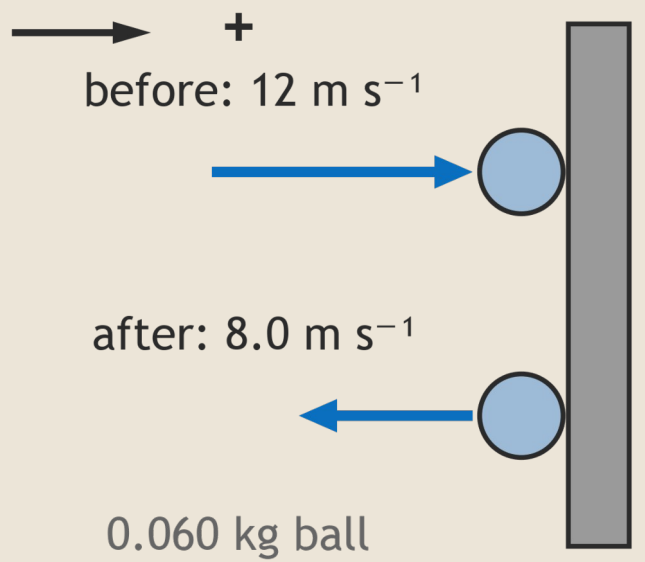
A 0.060 kg ball hits a wall at 12 m s^{-1} and **rebounds** at 8.0 m s^{-1} in 0.015 s. **Calculate** the **average force.** **3**

$Ft = mv - mu$ **(1)**

$F \times 0.015 = 0.060(-8.0) - 0.060(12)$ **(1)**

$F = -80$ N **(1)**

(80 N, away from the wall)



Worked Example 3: Speed After a Hit

A 0.045 kg golf ball is **at rest**. The graph shows the club's force on it. **Calculate** its **final speed**. **3**

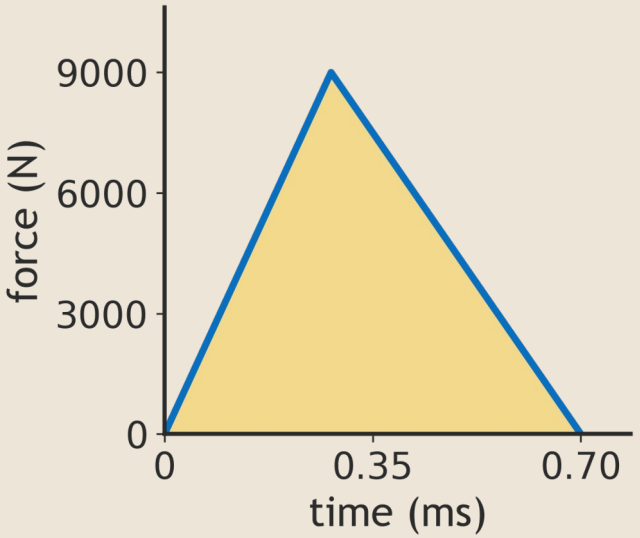
impulse = area under graph

$Ft = mv - mu$ **(1)**

impulse = $\frac{1}{2} \times 0.70 \times 10^{-3} \times 9000$

$3.15 = 0.045v - 0$ **(1)**

$v = 70\ \text{m s}^{-1}$ **(1)**



Your Turn



1. A force rises steadily from 0 to 36 N and back to 0 in 50 ms. **Determine** the **impulse**.

0.90 N s

2. A 0.057 kg ball lands at 6.0 m s^{-1} and **rebounds** at 4.0 m s^{-1} in 0.020 s. **Calculate** the **average force**.

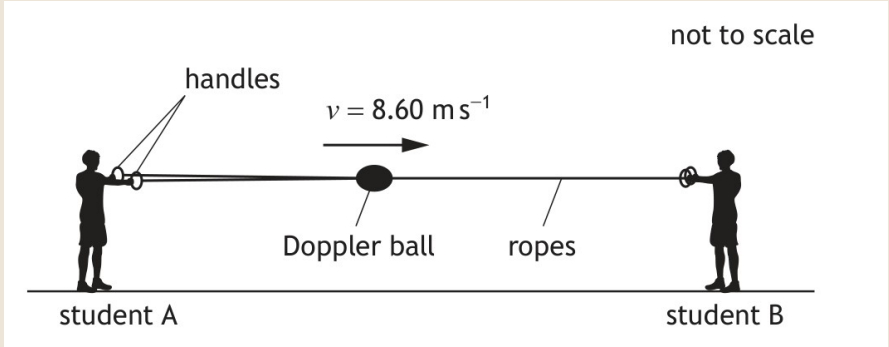
29 N

3. A 0.50 kg trolley is **at rest**. A push rises steadily to 6.0 N and back to 0 in 0.40 s. **Calculate** its **speed**.

2.4 m s^{-1}

Past Paper: 2024 Paper 2 Q1(b)(ii)

The foam Doppler ball collides with the handles at the end of the ropes held by student B and comes to rest. **Explain** how the foam ball protects the circuit board during the collision.



(The foam) increases the time of contact (with the handles) (1)

The force (on the circuit board) is less (1)

2026 Paper 1 Q6. The magnitude of the average force applied to the car during this time is

A 1.1×10^4 N

B 2.1×10^4 N

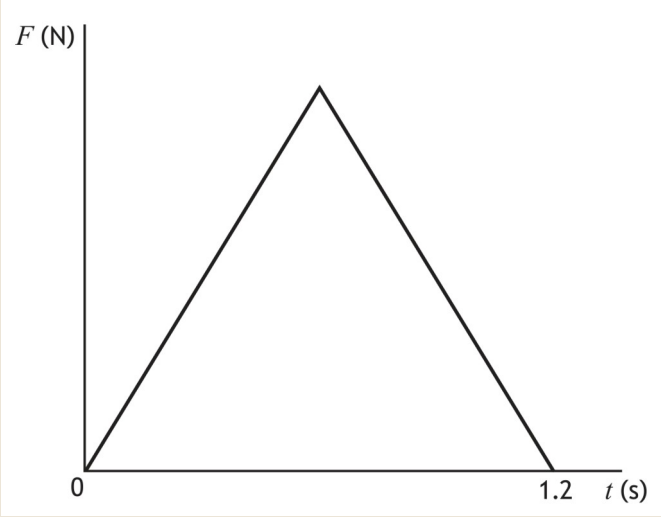
C 2.5×10^4 N

D 4.2×10^4 N

E 5.0×10^4 N

Answer B: $(1400 \times 18) \div 1.2 = 2.1 \times 10^4$ N

A car of mass 1400 kg is travelling at a speed of 18 m s^{-1}. A force is now applied to the car bringing it to rest.



2025 Paper 1 Q6. The mean force exerted by the ball on the ground during the collision is

A 0.146 N

B 0.811 N

C 0.645 N

D 1.44 N

E 8.03 N

Answer E: $0.164 \times (3.96 + 4.85) \div 0.180 = 8.03$ N

Ball of mass 0.164 kg, dropped from rest.
Speed just before it hits the ground: 4.85 m s^{-1}.
In contact with the ground for 0.180 s.
Speed immediately after it rebounds: 3.96 m s^{-1}.

2025 Paper 1 Q7. Clay X is softer than clay Y (same shape, same mass). Both fall from the same height and stop when they hit the ground.



I Sample X comes to rest in less time than sample Y.
II The mean force exerted by the ground on sample X is less than the mean force exerted by the ground on sample Y.
III The change in momentum of sample X is less than the change in momentum of sample Y.

A I only B II only C I and II D I and III E II and III

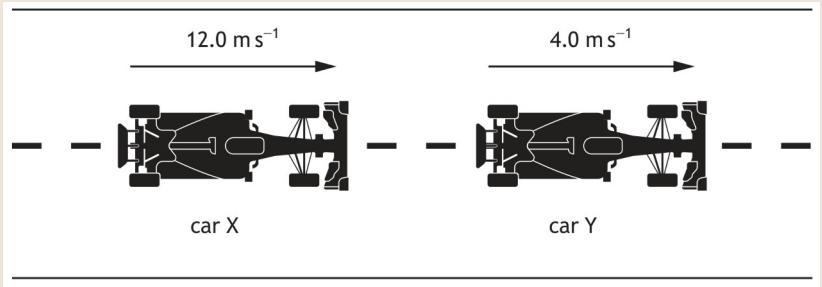
Answer B: softer: longer time, smaller force; same Δp

Look back — by the end of this part…

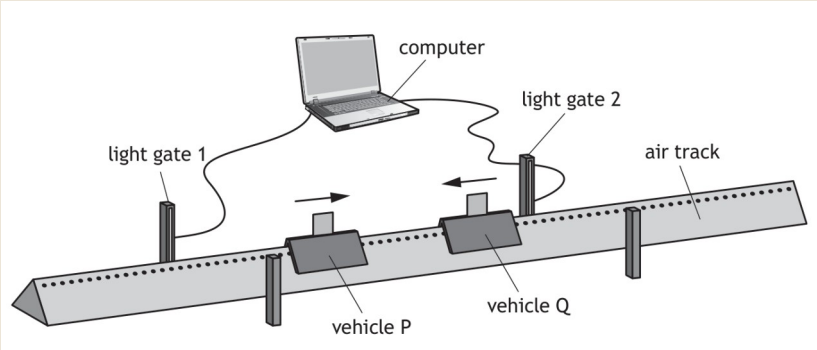


1. I can **calculate impulse** using **Ft = mv – mu**
2. I can find the **impulse** from the **area under a force-time graph**
3. I can find the **average force** or the **contact time** from a force-time graph
4. I can **explain** why a **longer contact time** means a **smaller force**

Momentum and Impulse in the Exam



2023 Paper 2 Q3



2025 Paper 2 Q2

Past papers

Kept back: 2018 S2 Q3(a)(b), 2022 P2 Q3(c), specimen P2 Q2.

Course specification — 1 of 4

- Use of the principle of conservation of momentum and an appropriate relationship to solve problems involving the momentum, mass and velocity of objects interacting in one dimension.
- Knowledge of energy interactions involving the total kinetic energy of systems of objects undergoing inelastic collisions, elastic collisions, and explosions.

Course specification — 2 of 4

- Use of an appropriate relationship to solve problems involving the total kinetic energy of systems of interacting objects.
- Use of Newton's third law to explain the motion of objects involved in interactions.
- Interpretation of force-time graphs involving interacting objects.

Course specification — 3 of 4

- Knowledge that the impulse of a force is equal to the area under a force-time graph and is equal to the change in momentum of an object involved in the interaction.
- Use of data from a force-time graph to solve problems involving the impulse of a force, the average force and its duration.

Course specification — 4 of 4

- Use of an appropriate relationship to solve problems involving mass, change in velocity, average force, and duration of the force for an object involved in an interaction.

Credits (1 of 3)

2023 Paper 1 Q3: © Qualifications Scotland (SQA). Higher Physics 2023, Paper 1, Question 3.

2024 Paper 1 Q6: © Qualifications Scotland (SQA). Higher Physics 2024, Paper 1, Question 6.

2020 Paper 1 Q7: © Qualifications Scotland (SQA). Higher Physics 2020, Paper 1, Question 7.

Past Paper: 2020 Paper 2 Q3(c): © Qualifications Scotland (SQA). Higher Physics 2020, Paper 2, Question 3(c).

Past Paper: 2018 Section 2 Q3(c): © Qualifications Scotland (SQA). Higher Physics 2018, Section 2, Question 3(c).

2019 Paper 1 Q6: © Qualifications Scotland (SQA). Higher Physics 2019, Paper 1, Question 6.

2026 Paper 1 Q4: © Qualifications Scotland (SQA). Higher Physics 2026, Paper 1, Question 4.

Past Paper: 2024 Paper 2 Q1(b)(ii): © Qualifications Scotland (SQA). Higher Physics 2024, Paper 2, Question 1(b)(ii).

Credits (2 of 3)

2026 Paper 1 Q6: © Qualifications Scotland (SQA). Higher Physics 2026, Paper 1, Question 6.

2025 Paper 1 Q6: © Qualifications Scotland (SQA). Higher Physics 2025, Paper 1, Question 6.

2025 Paper 1 Q7: © Qualifications Scotland (SQA). Higher Physics 2025, Paper 1, Question 7.

Momentum and Impulse in the Exam: © Qualifications Scotland (SQA). Higher Physics 2023 Paper 2 Q3; 2025 Paper 2 Q2.

Course specification — 1 of 4: © Qualifications Scotland (SQA). Higher Physics Course Specification v4.1 (September 2026), pp.7-8

Course specification — 2 of 4: © Qualifications Scotland (SQA). Higher Physics Course Specification v4.1 (September 2026), pp.7-8

Course specification — 3 of 4: © Qualifications Scotland (SQA). Higher Physics Course Specification v4.1 (September 2026), pp.7-8

Credits (3 of 3)

Course specification — 4 of 4: © Qualifications Scotland (SQA). Higher Physics Course Specification v4.1 (September 2026), pp.7-8

R Stewart - October 2026