# A Level Physics CIE

## 3. Dynamics

CONTENTS



EXAM PAPERS PRACTICE

# 3.1 Newton's Laws of Motion

## 3.1.1 Mass & Weight

### What is Mass?

- Mass is the measure of the amount of matter in an object
- Consequently, this is the property of an object that resists change in motion
- The greater the mass of a body, the smaller the change produced by an applied force
- The SI unit for mass is the **kilogram** (kg)

Exam Tip

- Since mass is measured in **kilograms** in Physics, if it is given in grams make sure to convert to kg by dividing the value by 1000
- It is a common misconception that mass and weight are the same, but they are in fact **very different**
- Weight is the force of gravity acting upon an object
    - Weight is a vector quantity
- Mass is the amount of matter contained in the object
    - Mass is a scalar quantity

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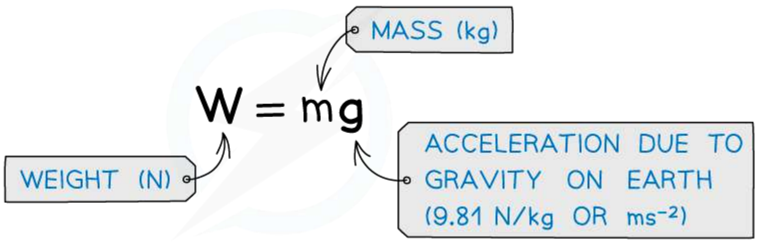
# Weight

- Weight is the effect of a gravitational field on a mass
- Since it is a force on an object due to the pull of gravity, it is measured in **newtons** (N) and is a vector quantity
- The weight of a body is equal to the product of its mass ($m$) and the acceleration of free fall ($g$)




- $g$ is the acceleration due to gravity or the gravitational field strength
- On Earth, this is **9.81 m s$^{-2}$** (or N kg$^{-1}$)

## Free Fall

- An object in free fall is falling solely under the influence of gravity
- On Earth, all free-falling objects accelerate towards Earth at a rate of **9.81 m s$^{-2}$**
- In the absence of air resistance, all bodies near the Earth fall with the same acceleration regardless of their mass

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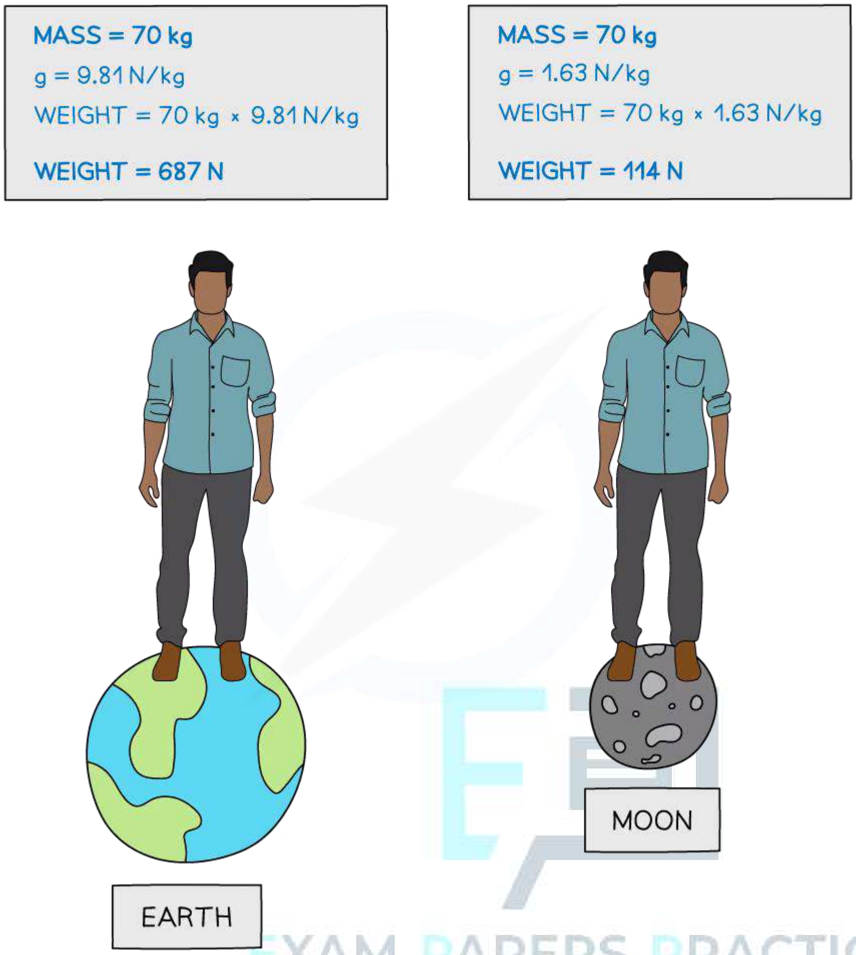
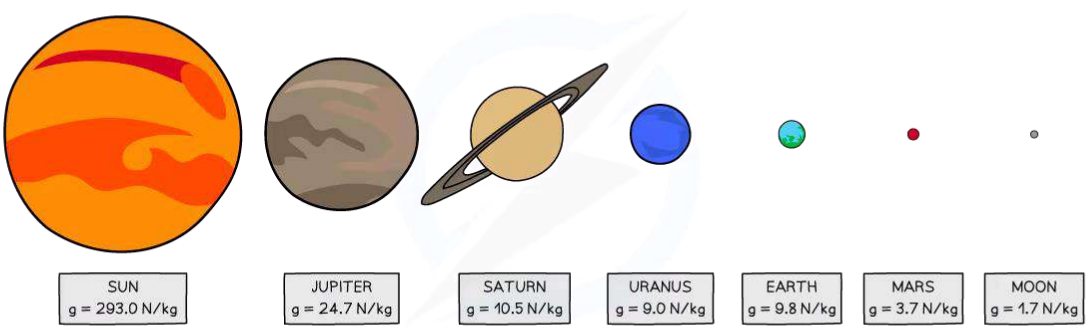
## Mass v Weight

- An object's mass always remains the same, however, its weight will differ depending on the strength of the gravitational field on different planets
- For example, the gravitational field strength on the Moon is **1.63 N kg$^{-1}$**, meaning an object's weight will be about **6 times** less than on Earth




***On the moon, your mass will stay the same but your weight will be much lower***

- Although you only need to memorise $g$ on Earth, its value on other planets in our solar system is given in the diagram below. Notice how much this varies according to the size of the planet




***Gravitational field strength of the planets in our solar system***

## Worked Example

The acceleration due to gravity on the moon is 1/6 of that on Earth. If the weight of a space probe on the moon is 491 N, calculate its mass.

STEP 1

EQUATION FOR WEIGHT

$$W = mg$$

STEP 2

REARRANGE FOR MASS m

$$m = \frac{W}{g} = \frac{491}{g}$$

STEP 3

FIND g FOR THE MOON

$$g = \frac{g_{EARTH}}{6} = \frac{9.81}{6} = 1.64\ Nkg^{-1}$$

STEP 4

SUBSTITUTE VALUE IN MASS EQUATION

$$m = \frac{491}{1.64} = 300\ kg$$

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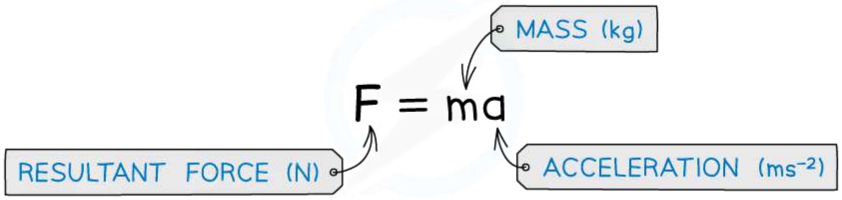
# Force & Acceleration

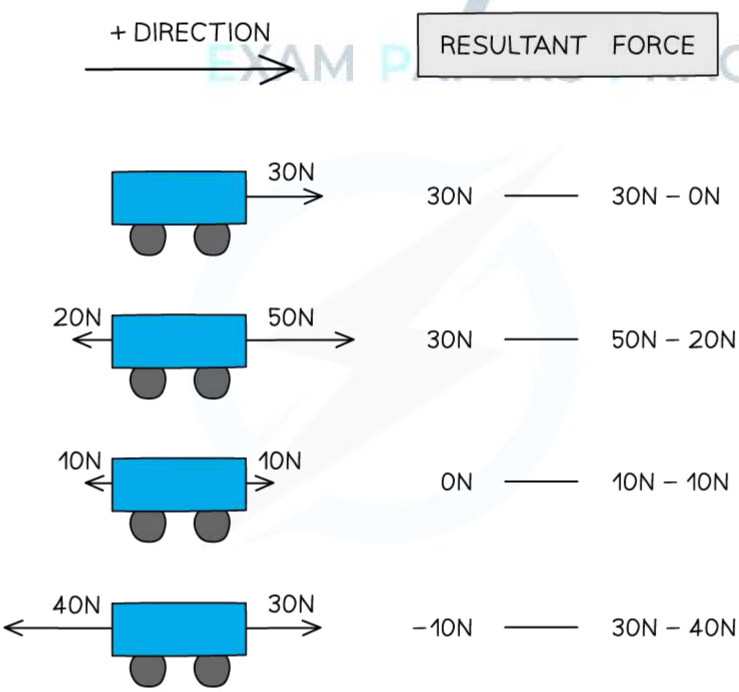
- As stated on the previous page, Newton's Second Law of Motion tells us that objects will accelerate if there is a resultant force acting upon them
- This acceleration will be in the same direction as this resultant force




***Newton's Second law equation***

## Resultant Force

- Since force is a vector, every force on a body has a magnitude and direction
- The resultant force is therefore the vector sum of all the forces acting on the body. The direction is given by either the positive or negative direction as shown in the examples below




***Resultant forces on a body***

- The resultant force could also be at an angle, in which case addition of vectors is used to find the magnitude and direction of the resultant force.
  - For more details on this, have a look at the page on "Scalars & Vectors"

## Acceleration

- Given the mass, Newton's Second Law means you can find the acceleration of an object
- Since acceleration is also a vector, it can be either positive or negative depending on the direction of the resultant force
- Negative acceleration is deceleration
- An object may continue in the same direction however with a resultant force in the opposite direction to its motion, it will slow down and eventually come to a stop

### Worked Example

A rocket produces an upward thrust of 15 MN and has a weight of 8 MN.

**A.** When in flight, the force due to air resistance is 500 kN.

What is the resultant force on the rocket?

**B.** The mass of the rocket is $0.8 \times 10^5$ kg.

Calculate the acceleration of the rocket and the direction its going in.

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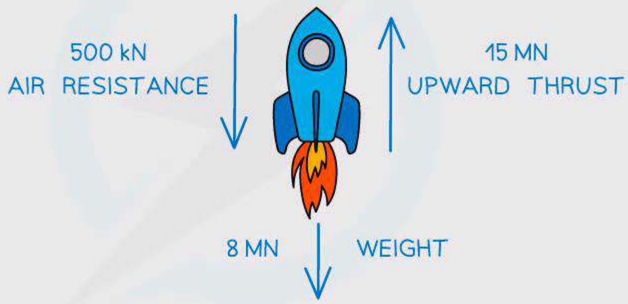
**A.** STEP 1

DRAW A DIAGRAM WITH THE FORCES IN THE RIGHT DIRECTION




STEP 2

CALCULATE THE RESULTANT FORCE ON THE ROCKET

$$F = 15\text{ MN} - (500\text{ kN} + 8\text{ MN})$$

UPWARD FORCES (15 MN) — DOWNWARD FORCES (500 kN + 8 MN)

UNIT CONVERSIONS: $1\text{ kN} = 1 \times 10^3\text{ N}$ $1\text{ MN} = 1 \times 10^6\text{ N}$

STEP 3

CONVERT ALL VALUES TO THE SAME UNITS (NEWTONS)

$$F = 15 \times 10^6\text{ N} - (500 \times 10^3\text{ N} + 8 \times 10^6\text{ N})$$

$$F = 6.5 \times 10^6\text{ N}$$

$F = 6.5$ MN UPWARDS

IN THE POSITIVE DIRECTION

**B.** STEP 1

NEWTONS SECOND LAW

$$F = ma$$

STEP 2

REARRANGE FOR ACCELERATION a

$$a = \frac{F}{m}$$

STEP 3

SUBSTITUTE IN VALUES FOR F AND m

$$a = \frac{6.5 \times 10^6\text{ N}}{0.8 \times 10^5\text{ kg}} = 81\text{ ms}^{-2}$$ UPWARDS

ACCELERATION IS ALWAYS IN THE SAME DIRECTION AS THE RESULTANT FORCE

### Exam Tip

The direction you consider positive is your choice, as long the signs of the numbers (positive or negative) are consistent with this throughout the questionIt is a general rule to consider the direction of motion the object is travelling in as positive. Therefore all vectors in the direction of motion will be positive and opposing vectors such as drag forces, are negative.

## Newton's Three Laws of Motion

- **Newton's First Law:** A body will remain at rest or move with constant velocity unless acted on by a resultant force

### Worked Example

If there are no external forces acting on the car, other than friction, and it is moving at a constant velocity, what is the value of the frictional force F?


SINCE THE CAR IS MOVING AT CONSTANT VELOCITY, THERE IS NO RESULTANT FORCE.

THIS MEANS THE DRIVING AND FRICTIONAL FORCES ARE BALANCED.

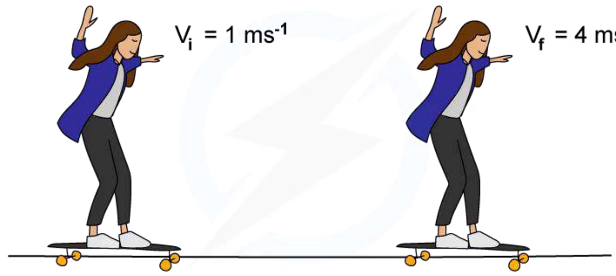
F IS ALSO EQUAL TO 6 kN

- **Newton's Second Law:** A resultant force acting on a body will cause a change in momentum in the direction of the force. The rate of change in momentum is proportional to the magnitude of the force
- This can also be written as ***F = ma***

EXAM PAPERS PRACTICE

### Worked Example

A girl is riding her skateboard down the road and increases her speed from 1 m s$^{-1}$ to 4 m s$^{-1}$ in 2.5 s.If the force driving her forward is 72 N, calculate the combined mass of the girl and the skateboard.



STEP 1

NEWTON'S SECOND LAW STATES THE RESULTANT FORCE IS EQUAL TO THE RATE OF CHANGE IN MOMENTUM

$$F = \frac{\Delta p}{\Delta t}$$

STEP 2

FIND CHANGE IN MOMENTUM $\Delta p$

$\Delta p$ = FINAL MOMENTUM − INITIAL MOMENTUM

$$\Delta p = mv_f - mv_i$$

STEP 3

SUBSTITUTE ALL VALUES INTO NEWTON'S SECOND LAW

$$72\text{ N} = \frac{m(4-1)}{2.5}$$

MASS m IS CONSTANT SO CAN BE TAKEN OUT AS FACTOR

STEP 4

REARRANGE FOR MASS m

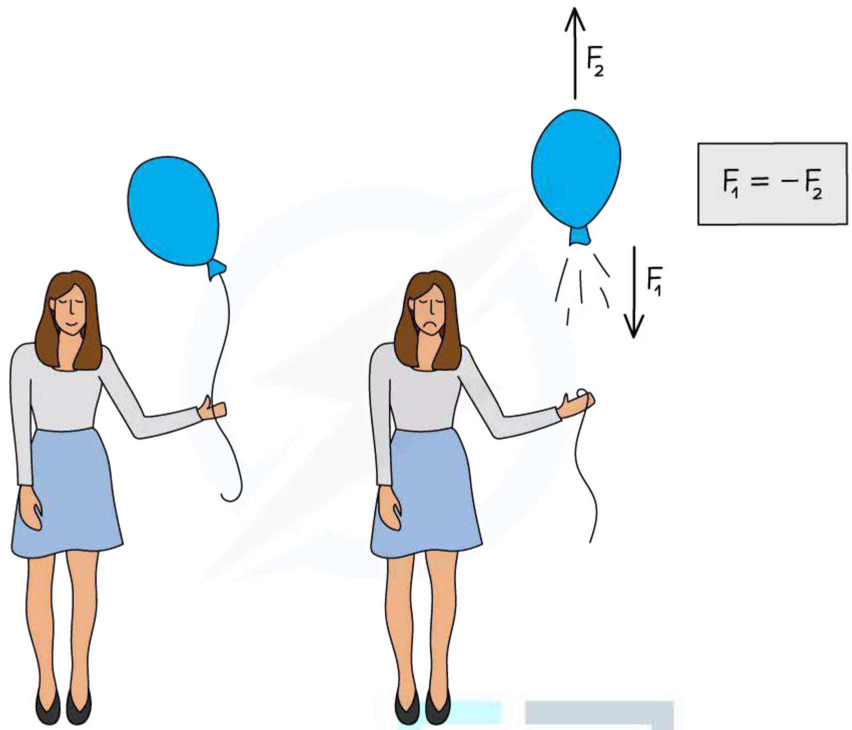
$$m = \frac{72 \times 2.5}{3} = 60\text{ kg}$$

- **Newton's Third Law:** If body **A** exerts a force on body **B,** then body **B** will exert a force on body **A** of equal magnitude but in the opposite direction
  - Newton's Third Law force pairs must act on **different** objects
  - Newton's Third Law force pairs must also be of the **same type** e.g. gravitational or frictional

EXAM PAPERS PRACTICE

## Worked Example

Using Newton's third law describe why when a balloon is untied, it travels in the opposite direction.

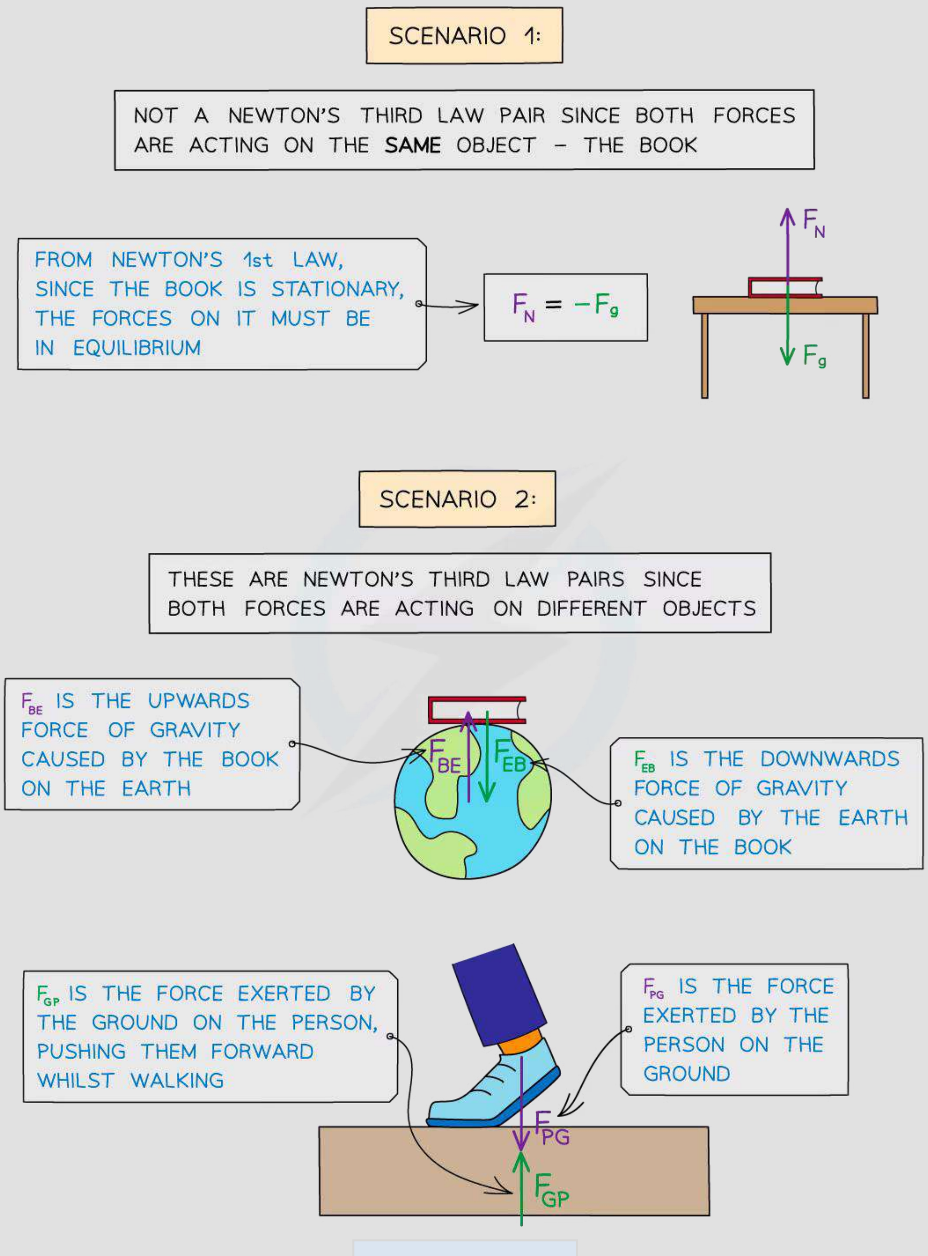



THE AIR INSIDE THE BALLOON WILL RUSH OUT WITH THE FORCE $F_1$.

THIS WILL PRODUCE AN EQUAL AND OPPOSITE FORCE ON THE BALLOON $F_2$ FORCING THE BALLOON TO MOVE THROUGH THE AIR IN THE OPPOSITE DIRECTION.

## Exam Tip

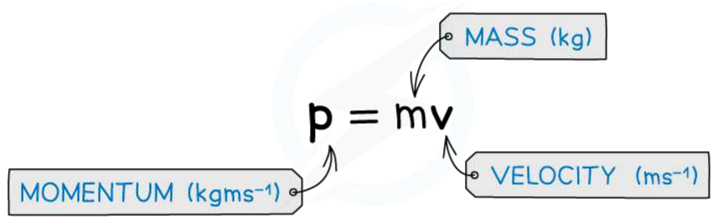
You may have heard Newton’s Third Law as: ‘For every action is an equal and opposite reaction’. However, try and avoid using this definition since it is unclear on **what** the forces are acting on and can be misleading.




***Newton’s Third Law force pairs are only those that act on different objects***

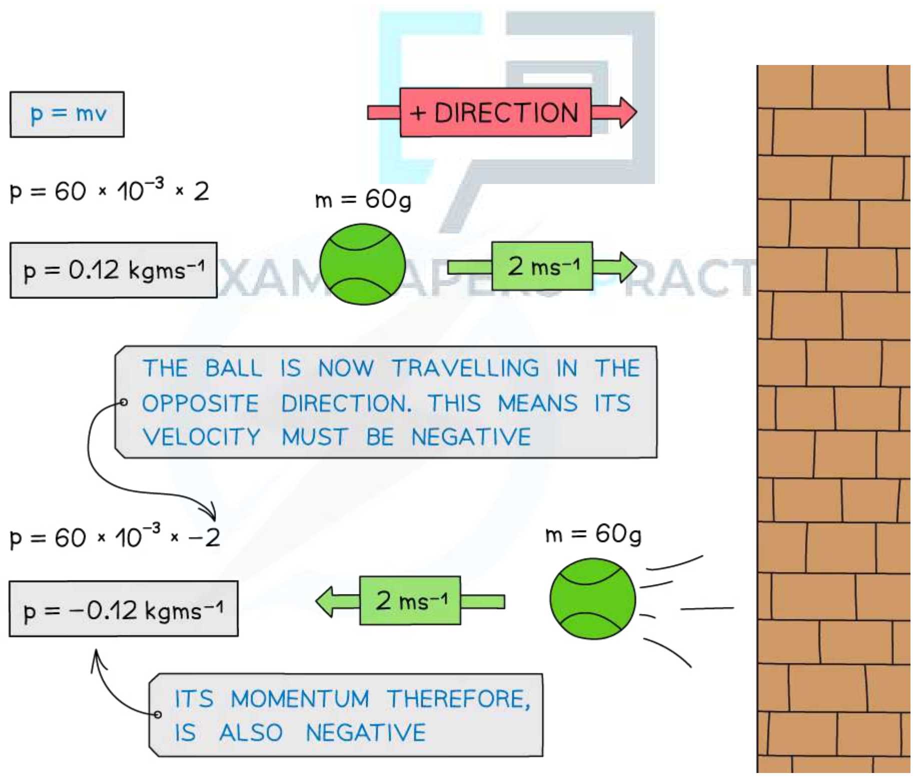
## Linear Momentum

- Linear momentum ($p$) is defined as the product of mass and velocity




***Momentum is the product of mass and velocity***

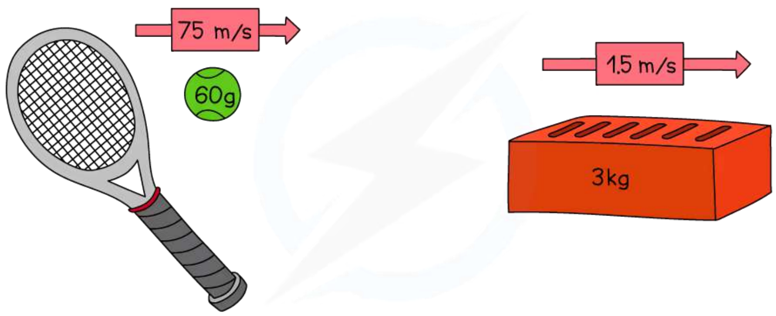
- Momentum is a vector quantity - it has both a magnitude and a direction
- This means it can have a negative or positive value
  - If an object travelling to the right has positive momentum, an object travelling to the left (in the opposite direction) has a negative momentum
- The SI unit for momentum is **kg m s$^{-1}$**




***When the ball is travelling in the opposite direction, its velocity is negative. Since momentum = mass × velocity, its momentum is also negative***

## Worked Example

Which object has the most momentum?




MOMENTUM = MASS × VELOCITY

MOMENTUM = 0.06 kg × 75 m/s
= 4.5 kg m/s

MOMENTUM = MASS × VELOCITY

MOMENTUM = 3 kg × 1.5 m/s
= 4.5 kg m/s

- Both the tennis ball and the brick have the same momentum
- Even though the brick is much heavier than the ball, the ball is travelling much faster than the brick
- This means that on impact, they would both exert a similar force (depending on the time it takes for each to come to rest)

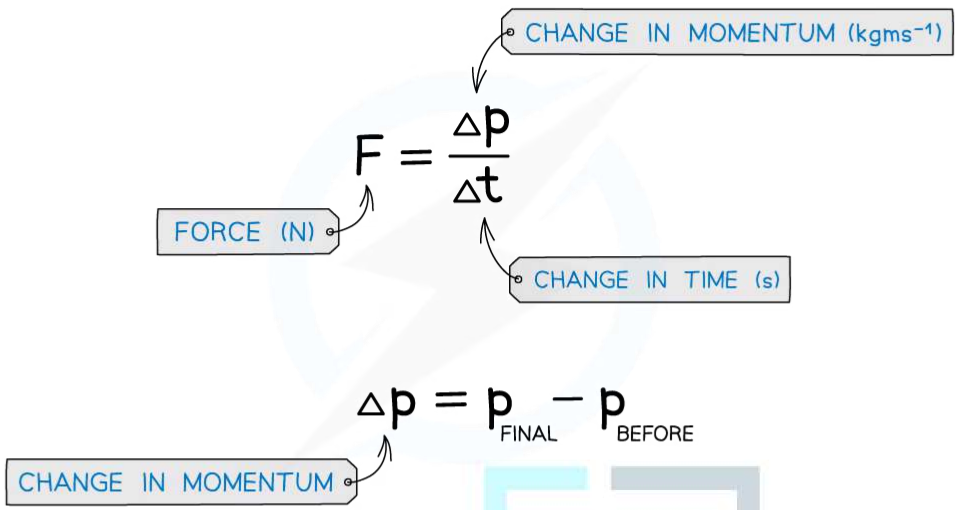
## Exam Tip

Since momentum is in **kg m s$^{-1}$**:

- If the mass is given in grams, make sure to convert to kg by dividing the value by 1000.
    - If the velocity is given in km s$^{-1}$, make sure to convert to m s$^{-1}$ by multiplying the value by 1000
- The direction you consider positive is your choice, as long the signs of the numbers (positive or negative) are consistent with this throughout the question

# Force & Momentum

- Force is defined as the **rate of change of momentum** on a body




***Force is equal to the rate of change in momentum***

- The change in momentum is defined as the final momentum minus the initial momentum:

$$p_{final} - p_{initial}$$

- Force and momentum are **vectors** so they can be either positive or negative values

**Worked Example**

A car of mass 1500 kg hits a wall at an initial velocity of 15 m s$^{-1}$.

It then rebounds off the wall at 5 m s$^{-1}$ and comes to rest after 3.0 s.

Calculate the average force experienced by the car.

STEP 1

FORCE IS EQUAL TO THE RATE OF CHANGE IN MOMENTUM

$$F = \frac{\Delta p}{\Delta t}$$

STEP 2

CHANGE IN MOMENTUM

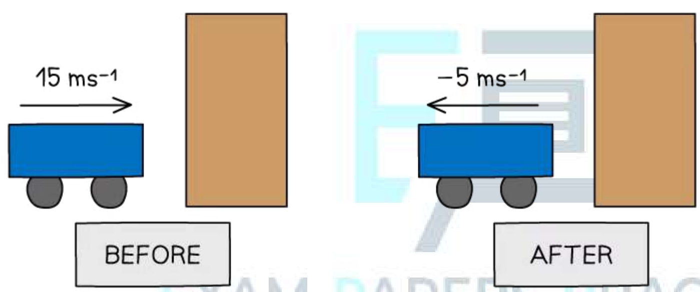
$\Delta p$ = FINAL MOMENTUM − INITIAL MOMENTUM

STEP 3

INITIAL MOMENTUM

INITIAL MOMENTUM = MASS × INITIAL VELOCITY

$$P_i = m \times v_i$$
$$= 1500 \text{ kg} \times 15 \text{ ms}^{-1}$$
$$P_i = 22500 \text{ kgms}^{-1}$$




STEP 4

FINAL MOMENTUM

FINAL MOMENTUM = MASS × FINAL VELOCITY

$$P_f = m \times v_f$$
$$= 1500 \text{ kg} \times -5 \text{ ms}^{-1}$$
$$P_f = -7500 \text{ kgms}^{-1}$$

STEP 5

CALCULATE CHANGE IN MOMENTUM $\Delta p$

$$\Delta p = -7500 - 22500 = -30000 \text{ kgms}^{-1}$$

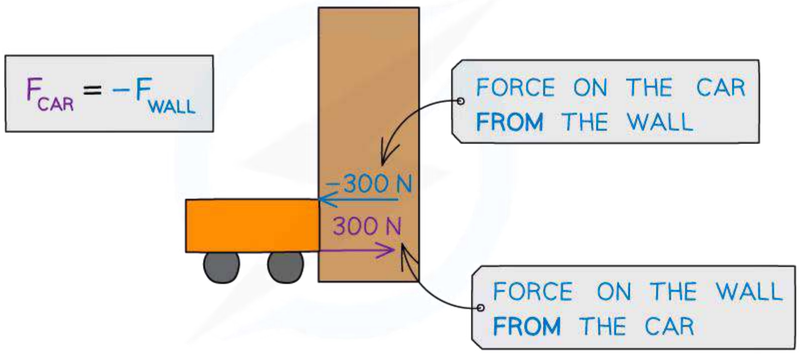
STEP 6

SUBSTITUTE THIS VALUE BACK INTO THE FORCE EQUATION

$$F = \frac{\Delta p}{\Delta t} = \frac{-30000}{3} = -10000\text{N}$$

## Direction of Forces

- The force that is equal to the rate of change of momentum is still the **resultant force**
- A force on an object will be negative if it is directed in the opposite motion to its initial velocity. This means that the force is **produced by** the object it has collided with




$F_{car} = -F_{wall}$

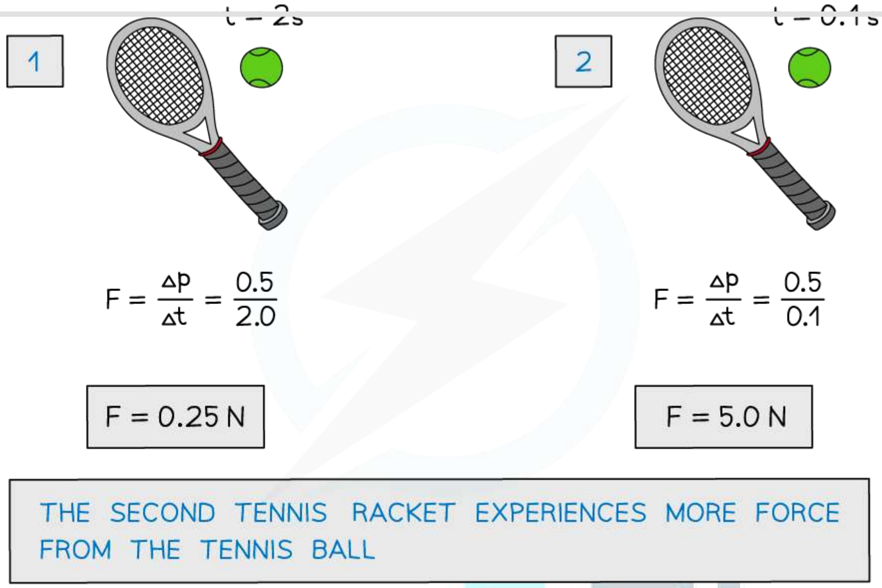
- The diagram shows a car colliding with a wall
- It is the **wall that produces** a force of −300N on the car
- Due to Newton's Third Law (see "Newton's Laws of Motion"), the car also produces a force of 300N back onto the wall

## Maths tip

- 'Rate of change' describes how one variable changes with respect to another. In maths, how fast something changes with **time** is represented as dividing by $\Delta t$ (e.g. acceleration is the rate of change in velocity)
- More specifically, $\Delta t$ is used for finite and quantifiable changes such as the difference in time between two events

## Worked Example

A tennis ball hits a racket with a change in momentum of 0.5 kg m $s^{-1}$.For the different contact times, which tennis racket experiences more force from the tennis ball?

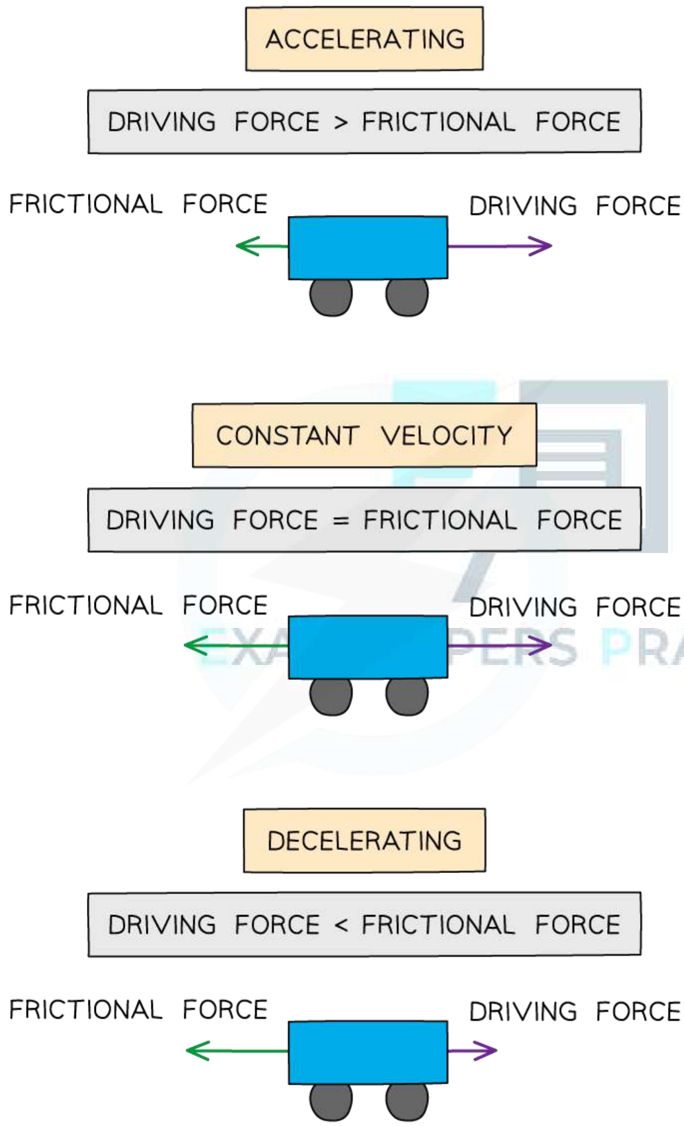



## Exam Tip

In an exam question, carefully consider what produces the force(s) acting.
Look out for words like ‘**from**’ and ‘**acting on**’ to determine this and don’t be afraid to draw a force diagram to figure out what is going on.

## Drag Forces

- Drag forces are forces acting the **opposite** direction to an object moving through a fluid (either gas or liquid)
- Examples of drag forces are **friction** and **air resistance**
- A key component of drag forces is it increases with the speed of the object. This is shown in the diagram below:




***Frictional forces on a car increase with its speed***

## Worked Example

A car of mass 800 kg has a horizontal driving force of 3 kN acting on it.Its acceleration is 2.0 m $s^{-2}$.What is the frictional force acting on the car?


STEP 1

CALCULATE THE RESULTANT FORCE FROM NEWTON'S SECOND LAW

$F = ma = 800 \times 2.0 = 1600$ N

1600 N = DRIVING FORCE – FRICTIONAL FORCE

1600 = 3000 – FRICTIONAL FORCE

STEP 2

REARRANGE FOR THE FRICTIONAL FORCE

FRICTIONAL FORCE = 3000 N – 1600 N = 1400 N

## Exam Tip

Remember to consider drag forces in your calculation for the resultant force. More details of this are in the notes “Force and acceleration”.

## Air Resistance

- Air resistance is an example of a drag force which objects experience when moving through the air
- At a walking pace, a person rarely experiences the effects of air resistance
- However, a person swimming at the same pace uses up much more energy – this is because air is 800 times less dense than water
- Air resistance depends on the **shape** of the body (object) and the **speed** it's travelling
- Since drag force increases with speed, air resistance becomes important when objects move faster

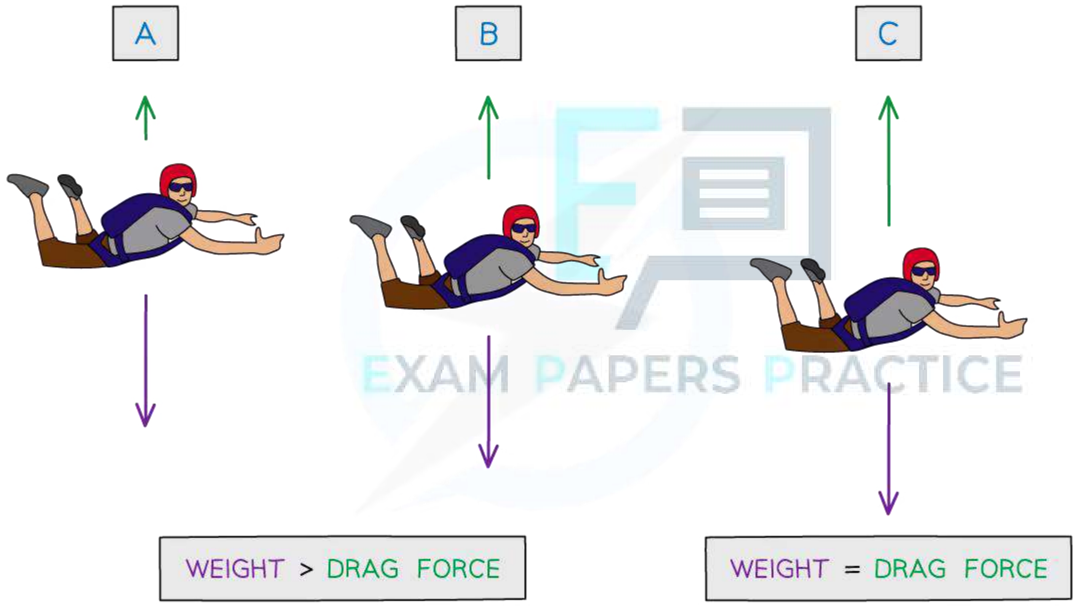
***A racing cyclist adopts a more streamline posture to reduce the effects of air resistance. The cycle, clothing and helmet are designed to allow them to go as fast as possible***

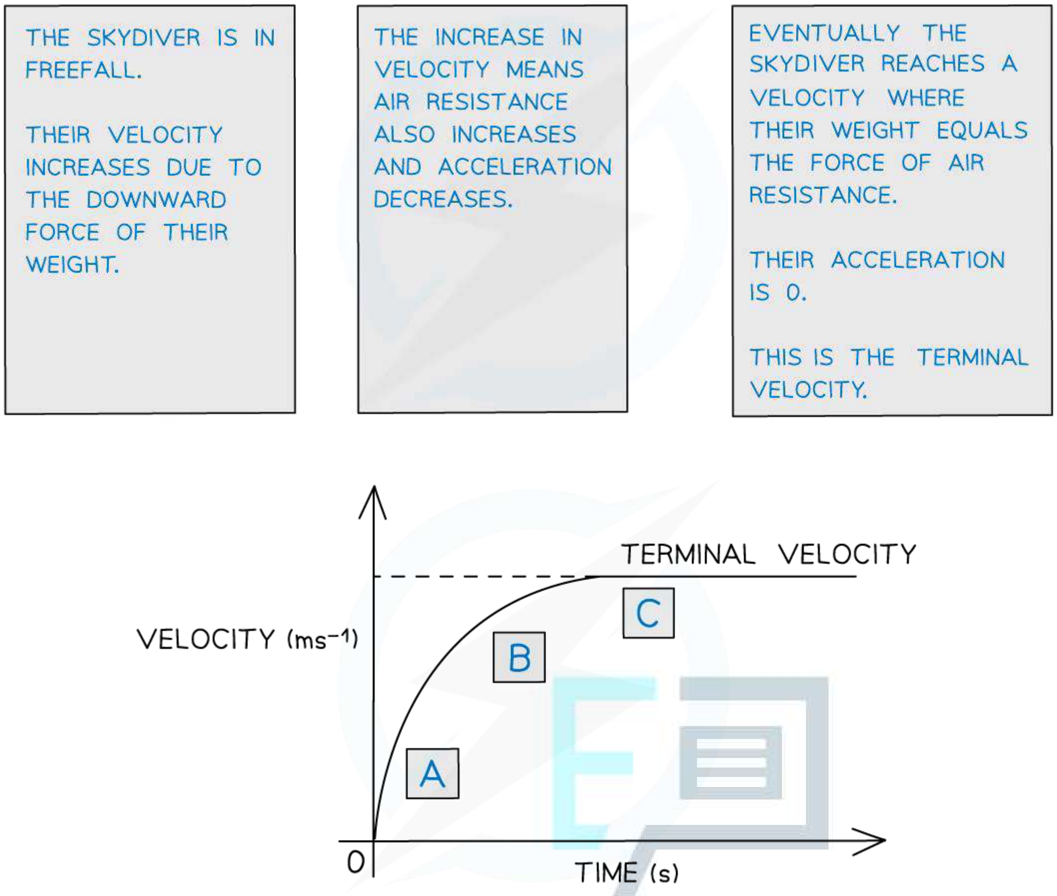
### Exam Tip

If a question considers air resistance to be '**negligible**' this means in that question, air resistance is taken to be so small it will not make a difference to the motion of the body. You can take this to mean there are no drag forces acting on the body.

## Terminal Velocity

- For a body in free fall, the only force acting is its weight and its acceleration $g$ is only due to gravity.
- The drag force increases as the body accelerates
  - This increase in velocity means the drag force also increases
- Due to Newton's Second Law, this means the resultant force and therefore acceleration decreases (recall $F = ma$)
- When the drag force is equal to the gravitational pull on the body, the body will no longer accelerate and will fall at a constant velocity
  - This the **maximum** velocity that the object can have and is called the **terminal velocity**





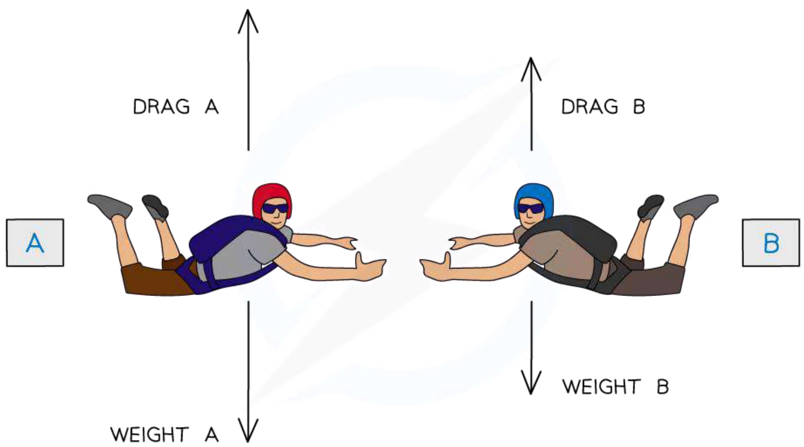

***A skydiver in freefall reaching terminal velocity***

- The graph shows how the velocity of the skydiver varies with time
- Since the acceleration is equal to the gradient of a velocity-time graph, the acceleration decreases and eventually becomes zero when terminal velocity is reached

## Worked Example

Skydivers jump out of a plane at intervals of a few seconds.

Skydivers A and B want to join up as they fall.




If A is heavier than B, who should jump first?

- Skydiver **B** should jump first since he will take longer to reach terminal velocity
- This is because skydiver **A** has a higher mass, and hence, weight
- More weight means higher acceleration and hence higher speed, therefore, **A** will reach terminal velocity faster than **B**

## Exam Tip

- Exam questions about terminal velocity tend to involve the motion of skydivers as they fall
- A common misconception is that skydivers move upwards when their parachutes are deployed – however, this is not the case, they are in fact **decelerating** to a lower terminal velocity
- What do you think this would look like on the graph above?

3.2 Linear Momentum & Conservation

3.2.1 Conservation of Momentum

## The Principle of Conservation of Momentum

- The principle of conservation of momentum is:
  - **The total momentum of a system remains constant provided no external force acts on it**

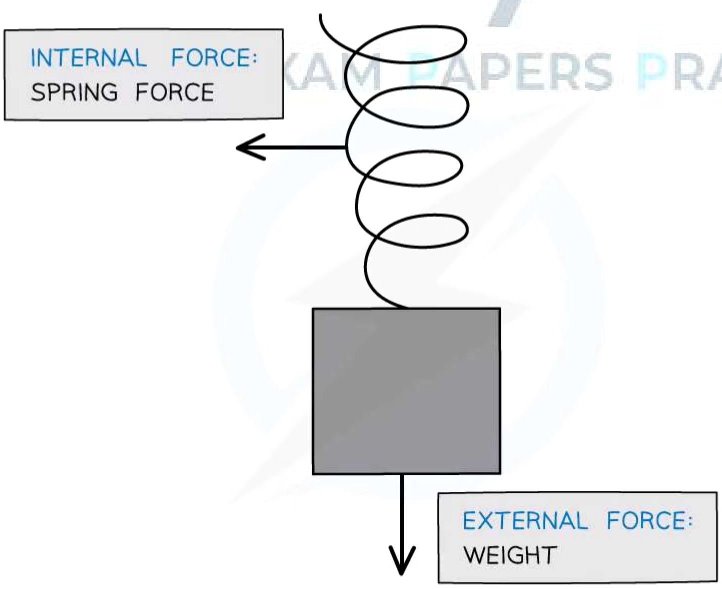
- For example if two objects collide:

  ***the total momentum before the collision = the total momentum after the collision***

- Remember momentum is a **vector** quantity. This allows oppositely-directed vectors to cancel out so the momentum of the system as a whole is zero
- Momentum is **always conserved** over time

### External and Internal Forces

- **External forces** are forces that act on a structure from outside e.g. friction and weight
- **Internal forces** are forces exchanged by the particles in the system e.g. tension in a string
- Which forces are internal or external will depend on the system itself, as shown in the diagram below:




***Internal and external forces on a mass on a spring***

- You may also come across a system with no external forces being described as a '**closed**' or '**isolated**' system

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- These all still refer to a system that is not affected by external forces
- For example, a swimmer diving from a boat:
  - The diver will move forward, and, to conserve momentum, the boat will move backwards
- This is because the momentum beforehand was zero and no external forces are present to affect the motion of the diver or the boat

EXAM PAPERS PRACTICE

## Collisions in One & Two Dimensions

### One-dimensional momentum problems

- Momentum (*p*) is equal to: ***p* = *m* × *v***
- Using the conversation of linear momentum, it is possible to calculate missing velocities and masses of components in the system. This is shown in the example below

### Worked Example

Trolley A of mass 0.80 kg collides head-on with stationary trolley B at a velocity of 3.0 $ms^{-1}$.Trolley B has twice the mass of trolley A.The trolleys stick together. Using the conservation of momentum, calculate the common velocity of both trolleys after the collision. Determine whether this is an elastic or inelastic collision.

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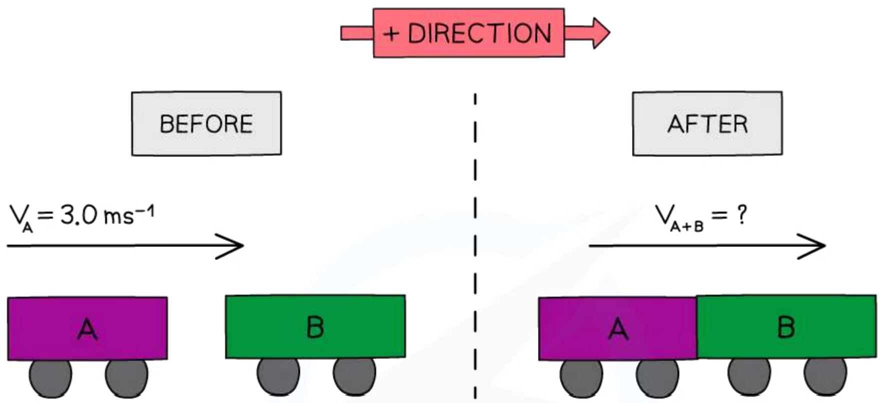



MOMENTUM BEFORE $= (M_A \times V_A) + (M_B \times V_B)$

$= (0.8\ kg \times 3.0\ ms^{-1}) + 0$

$= 2.4\ kgms^{-1}$

SINCE TROLLEY B IS STATIONARY, V = 0 THEREFORE ITS MOMENTUM IS 0

MOMENTUM AFTER $= (M_A + M_B) \times V_{A+B}$

$= (0.8\ kg + 1.60\ kg) \times V_{A+B}$

$= 2.4\ kg \times V_{A+B}$

TROLLEY B HAS TWICE THE MASS OF TROLLEY A

THE PRINCIPLE OF CONVERSATION OF MOMENTUM STATES THAT **THE TOTAL MOMENTUM OF A SYSTEM REMAINS CONSTANT PROVIDED NO EXTERNAL FORCE ACTS ON IT**

MOMENTUM BEFORE = MOMENTUM AFTER

$2.4\ kgms^{-1} = 2.4\ kg \times V_{A+B}$

$$V_{A+B} = \frac{2.4\ kgms^{-1}}{2.4\ kg}$$

REARRANGING FOR $V_{A+B}$

$V_{A+B} = 1.0\ ms^{-1}$

b) IS THIS AN ELASTIC OR INELASTIC COLLISION?

KINETIC ENERGY = $1/2\ mv^2$

KINETIC ENERGY BEFORE $= \frac{1}{2} \times M_A \times (V_A)^2 + \frac{1}{2} \times M_B \times (V_B^2)$

$= \frac{1}{2} \times 0.8 \times (3.0)^2 + 0$

$V_B = 0$

$= 3.6\ J$

KINETIC ENERGY AFTER $= \frac{1}{2} \times M_{A+B} \times (V_{A+B})^2$

$= \frac{1}{2} \times 2.4 \times (1.0)^2$

$= 1.2\ J$

THIS IS AN INELASTIC COLLISION SINCE KINETIC ENERGY IS **NOT** CONSERVED

For more help, please visit www.exampaperspractice.co.uk

- To find out whether a collision is elastic or inelastic, compare the kinetic energy before and after the collision
  - If the kinetic energy is **conserved**, it is an **elastic collision**
  - If the kinetic energy is **not conserved**, it is an **inelastic collision**

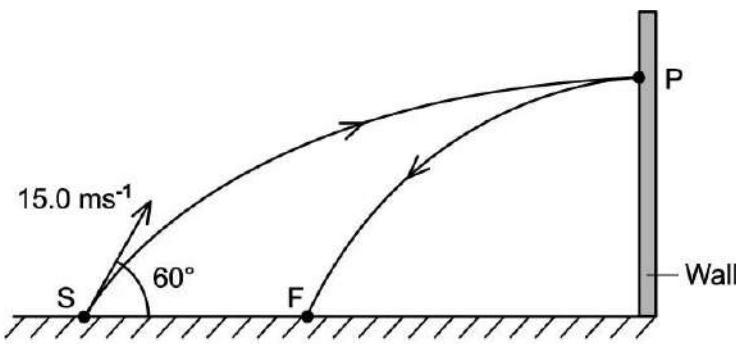
- **Elastic collisions** are commonly those where objects colliding do not stick together and then move in opposite directions
- **Inelastic collision** are where objects collide and stick together after the collision

## Two-dimensional momentum problems

- Since momentum is a vector, in 2D it can be split up into its x and y components
- Review revision notes 1.3 Scalars & Vectors on how to resolve vectors

### Worked Example

A ball is thrown at a vertical wall. The path of the ball is shown below




The ball is thrown from S with an initial velocity of 15.0 m $s^{-1}$ at 60.0° to the horizontal. The mass of the ball is 60 × $10^{-3}$ kg and rebounds at a velocity of 4.6 m $s^{-1}$.Calculate the change in momentum of the ball if it rebounds off the wall.

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STEP 1

CHANGE IN MOMENTUM EQUATION

$\Delta P = m(V_f - V_i)$

STEP 2

CALCULATE INITIAL VELOCITY

CHANGE IN MOMENTUM IS ONLY DUE TO THE HORIZONTAL VELOCITIES

$V_i = 15.0 \cos(60.0) = 7.5 \text{ ms}^{-1}$

STEP 3

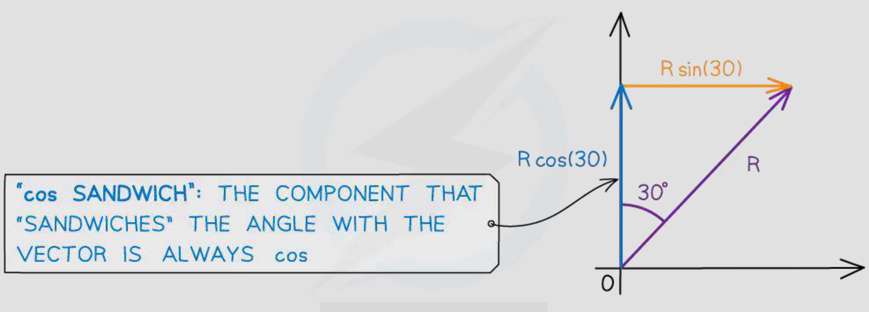
SUBSTITUTE VALUES INTO $\Delta P$ EQUATION

$\Delta P = 60 \times 10^{-3}(-4.6 - 7.5) = -0.73 \text{ Ns}$

NEGATIVE BECAUSE THE BALL IS NOW TRAVELLING IN THE OPPOSITE DIRECTION TO ITS INITIAL VELOCITY

## Exam Tip

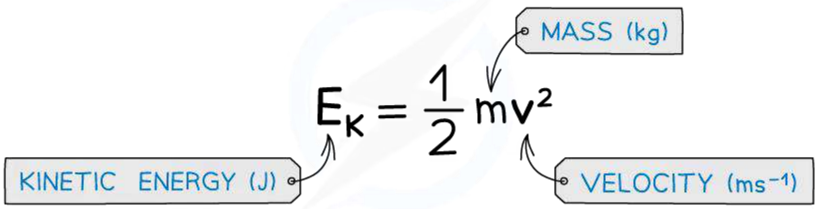
If an object is stationary or at rest, it's velocity equals **0**, therefore, the momentum and kinetic energy are also equal to 0.When a collision occurs in which two objects are stuck together, treat the final object as a single object with a mass equal to the **sum** of the two individual objects.In 2D problems, make sure you're confident resolving vectors. Here is a small trick to remember which component is cosine or sine of the angle for a vector **R:**




***Resolving vectors with sine and cosine***

## Elastic Collisions

- When two objects collide, they may spring apart retaining all of their kinetic energy. This is a perfect elastic collision
- An elastic collision is one where **kinetic energy is conserved**

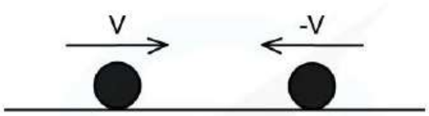



***Equation for kinetic energy***

- Since kinetic energy depends on the speed of an object, in a perfectly elastic collision (head-on approach) the relative speed of approach = the relative speed of separation

### Worked Example

Two similar spheres, each of mass $m$ and velocity $v$ are travelling towards each other. The spheres have a head-on collision. What is the total kinetic energy after the impact?




**A.** $\frac{1}{2}mv^2$ **B.** 0 **C.** $mv^2$ **D.** 2mv

ANSWER: C

IN AN ELASTIC COLLISION, KINETIC ENERGY IS CONSERVED.

THIS MEANS KINETIC ENERGY BEFORE = KINETIC ENERGY AFTER.

KINETIC ENERGY BEFORE = $\frac{1}{2}mv^2 + \frac{1}{2}mv^2 = mv^2$.

IN AN ELASTIC COLLISION, KINETIC ENERGY AFTER WILL ALSO EQUAL $mv^2$.

### Exam Tip

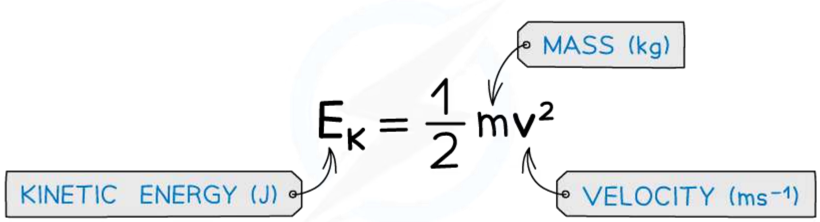
Despite velocity being a vector, kinetic energy is a scalar quantity and therefore will never include a minus sign. This is because in the kinetic energy formula, mass is scalar and the $v^2$ will always give a positive value whether its a negative or positive velocity

YOUR NOTES

EXAM PAPERS PRACTICE

## Inelastic Collisions

- Whilst the momentum of a system is always conserved in interactions between objects, kinetic energy may not always be
- An inelastic collision is one where **kinetic energy** is **not conserved**




$$E_K = \frac{1}{2}mv^2$$

***Equation for kinetic energy***

- The kinetic energy is transferred into other forms of energy such as a heat or sound
- Inelastic collisions can be when two objects collide and they crumple and deform. Their kinetic energy may also disappear completely as they come to a halt
- A perfectly inelastic collision is when two objects stick together after collision, as shown in the example below

### Worked Example

Two trolleys X and Y are of equal mass. Trolley X moves towards trolley Y which is initially stationary. After the collision, the trolleys join and move off together. Prove that this collision is inelastic.

STEP 1

COMPARE THE KINETIC ENERGY BEFORE AND AFTER THE COLLISION

KINETIC ENERGY BEFORE: $\frac{1}{2}m_x v^2 + 0$

KINETIC ENERGY AFTER: $\frac{1}{2}(m_x + m_y)v_{x+y}^2 = \frac{1}{2}(2m)v_{x+y}^2$

$m_x$ AND $m_y$ ARE EQUAL

STEP 2

CHECK IF THEY'RE EQUAL

$$\frac{1}{2}m_x v^2 + 0 \neq \frac{1}{2}(2m)v_{x+y}^2$$

STEP 3

SINCE THE KINETIC ENERGY BEFORE THE COLLISION IS NOT EQUAL TO THE KINETIC ENERGY AFTER, THIS IS AN INELASTIC COLLISION

### Exam Tip

Although kinetic energy may not always being conserved, remember **momentum will always be conserved.**

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