# Momentum

- An object with mass that is in motion has momentum

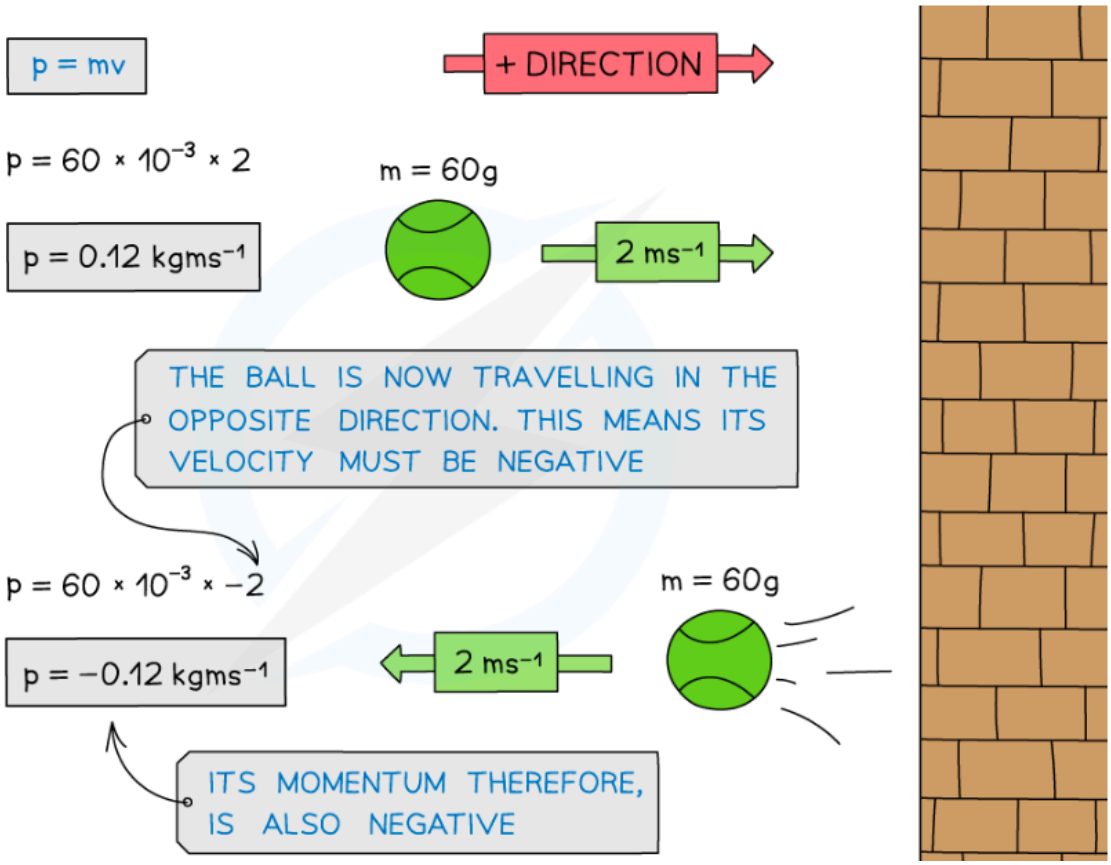
### The momentum equation

- Momentum is defined by the equation:

$$\text{momentum} = \text{mass} \times \text{velocity}$$

$$p = mv$$

- Where:
  - p= momentum, measured in kilogram metres per second (kg m/s)
  - m = mass in kilograms (kg)
  - v = velocity in metres per second (m/s)
- This means that an object at rest (i.e. $v = 0$) has no momentum
- Momentum keeps an object moving in the same direction
  - It is difficult to change the direction of an object that has a large momentum
- Velocity is a vector with both magnitude and direction
  - This means that the momentum of an object also depends on its direction of travel
  - Therefore, momentum can be either positive or negative
- If an object has positive momentum, then an object travelling in the opposite direction will have negative momentum


p = mv
+ DIRECTION
p = 60 × 10⁻³ × 2
m = 60g
p = 0.12 kgms⁻¹
2 ms⁻¹
THE BALL IS NOW TRAVELLING IN THE OPPOSITE DIRECTION. THIS MEANS ITS VELOCITY MUST BE NEGATIVE
p = 60 × 10⁻³ × −2
m = 60g
p = −0.12 kgms⁻¹
2 ms⁻¹
ITS MOMENTUM THEREFORE, IS ALSO NEGATIVE

# Conservation of momentum

- The principle of conservation of momentum states that:

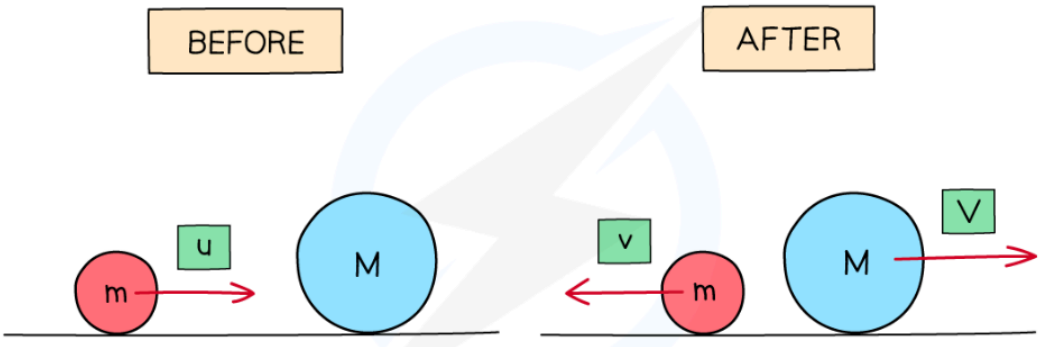
In a closed system, the total momentum before an event is equal to the total momentum after the event

- A system, in physics, is an object or group of objects
- A closed system means that no energy is transferred into or out of the system and there are no external forces acting
- The principle of conservation of momentum can also be written as:

The total momentum before a collision = The total momentum after a collision

- Since momentum is a vector quantity, a system of objects moving in opposite directions (e.g. towards each other) at the same speed will have an overall momentum of 0 since they will cancel out
    - Momentum is always conserved over time
- The diagram below shows two masses *m* with velocity *u* and *M* at rest (ie. zero velocity)

**Principle of conservation of momentum for a collision**




- Before the collision:
    - The momentum is only of mass *m* which is moving
    - If the right is taken as the positive direction, the total momentum of the system is $m \times u$
- After the collision:
    - Mass *M* also now has momentum
    - The velocity of *m* is now $-v$ (since it is now travelling to the left) and the velocity of *M* is *V*
    - The total momentum is now the momentum of *M* + momentum of *m*

# Pressure

## What is pressure?

- Pressure is defined as

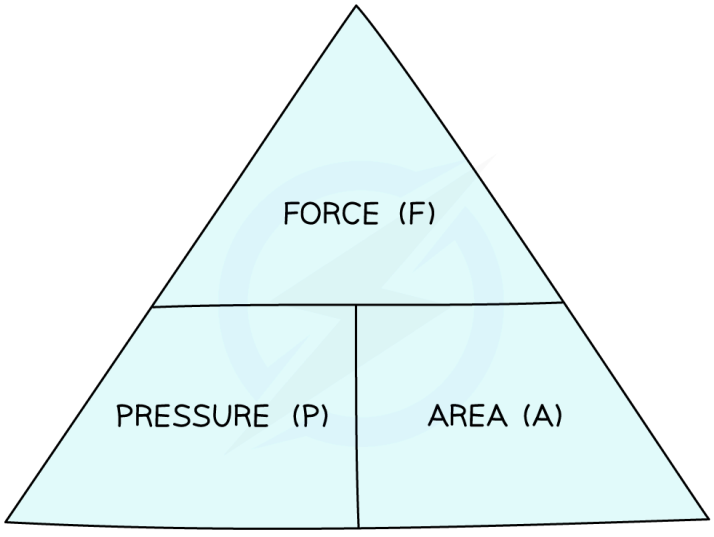
The force per unit area

- Pressure is measured in pascals (Pa)
  - 1 pascal is equivalent to 1 newton per metre squared
  - 1 Pa = 1 $N/m^2$
- It can be calculated using the following pressure equation:

$$\text{pressure} = \frac{\text{force}}{\text{area}}$$

$$p = \frac{F}{A}$$

- Where:
  - $p$ = pressure measured in pascals (Pa) or newtons per metre ($N/m^2$)
  - $F$ = force measured in newtons (N)
  - $A$ = area measured in metres squared ($m^2$)
- This equation can be rearranged with the help of a formula triangle:



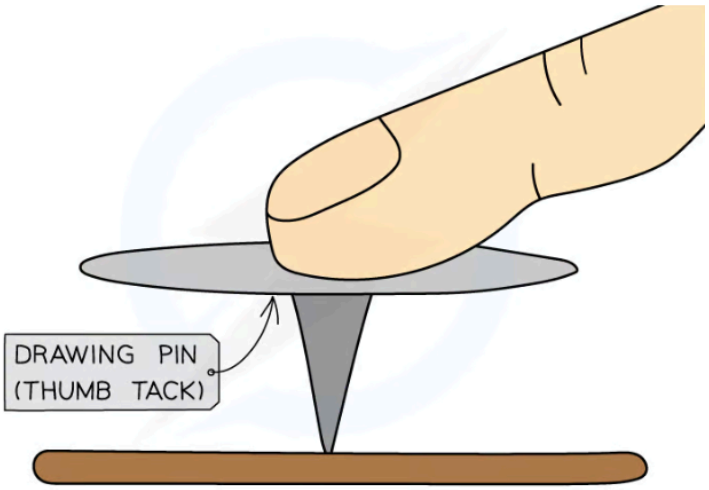
*A formula triangle can help rearrange the pressure equation*

- For more information on how to use a formula triangle refer to the revision note on speed & velocity
- This equation tells us that:
    - If a force is spread over a large area it will result in a small pressure
    - If it is spread over a small area it will result in a large pressure

## Examples of applications of pressure

- Example 1: Tractors
    - Tractors have large tyres
    - This spreads the weight (force) of the tractor over a large area
    - This reduces the pressure which prevents the heavy tractor from sinking into the mud
- Example 2: Drawing pins
- Drawing pins have sharp pointed ends with a very small area
- This concentrates the force, creating a large pressure over a small area
- This allows the drawing pin to be pushed into a wall

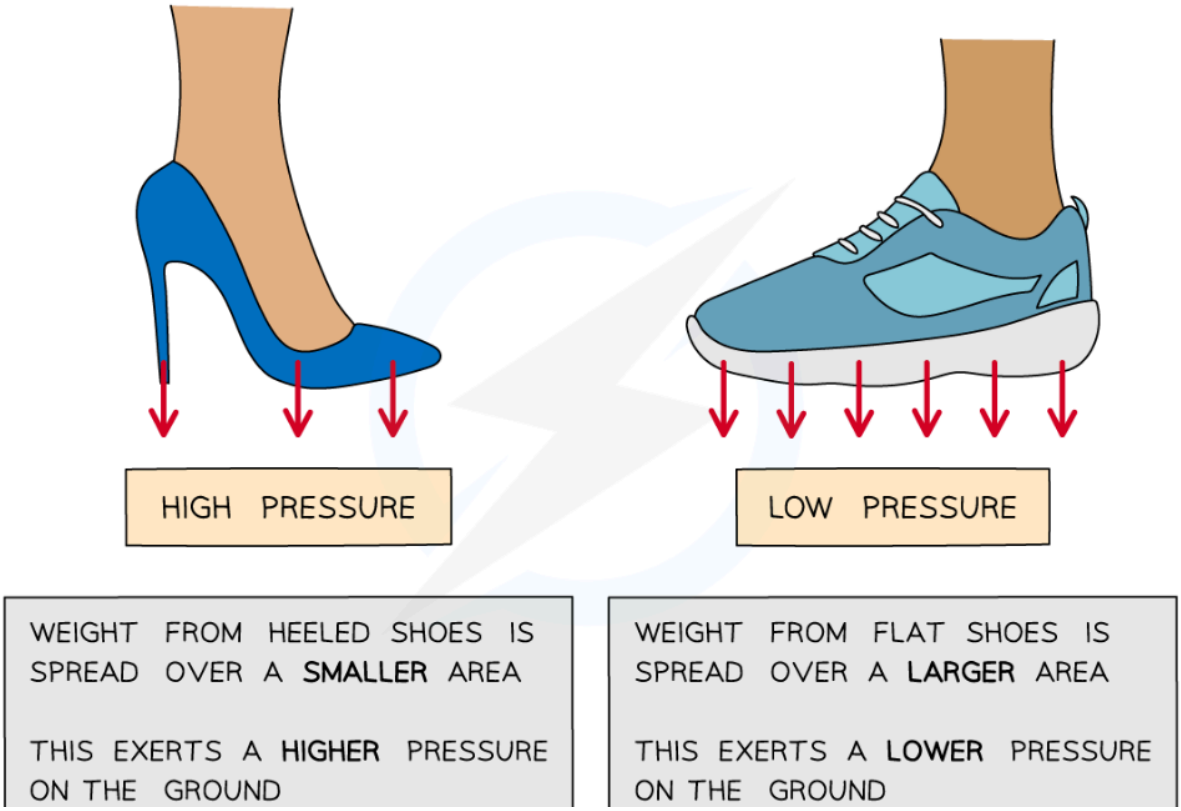
**Applying a force to a drawing pin**




- Example 3: High heels
    - High heels have small, sharp points with a small area
    - This concentrates the weight (force), creating a large pressure over a small area
    - Flat shoes have a larger area which the weight (force) is spread over resulting in a lower pressure

- This explains why high heels sink into soft surfaces more easily than flat shoes

## The effect of surface area on pressure



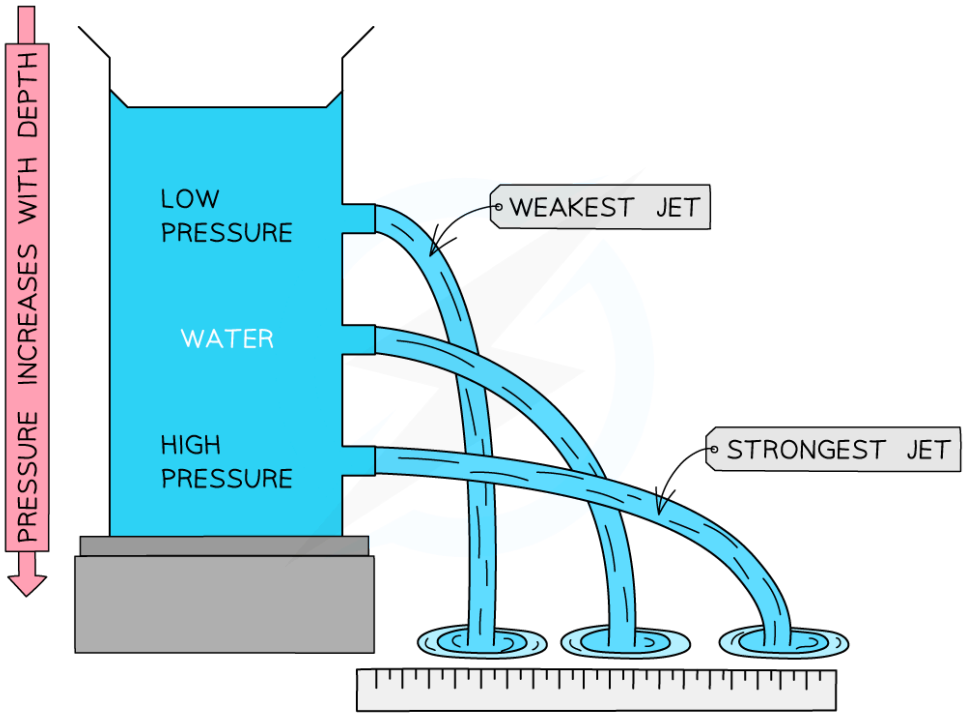
# Liquid pressure

## Factors affecting pressure in a liquid

- The pressure beneath the surface of a liquid will increase with the depth of the liquid
    - This is because the pressure in a liquid is caused by the force of the weight of the liquid above it
    - As the depth increases, there is increasingly more liquid above which causes the pressure to increase
- Pressure in a liquid also depends on the density of the liquid
    - The more dense the liquid, the greater the pressure it exerts

## Pressure in a column of water

- In a column of water, the highest pressure would be at the bottom
    - If a hole is made at the bottom of the column, the water will pour out with a large force
    - If a hole was made at the top of the column, the water will pour out with a small force
    - This is because of the difference in pressure in the column caused by the weight of the water



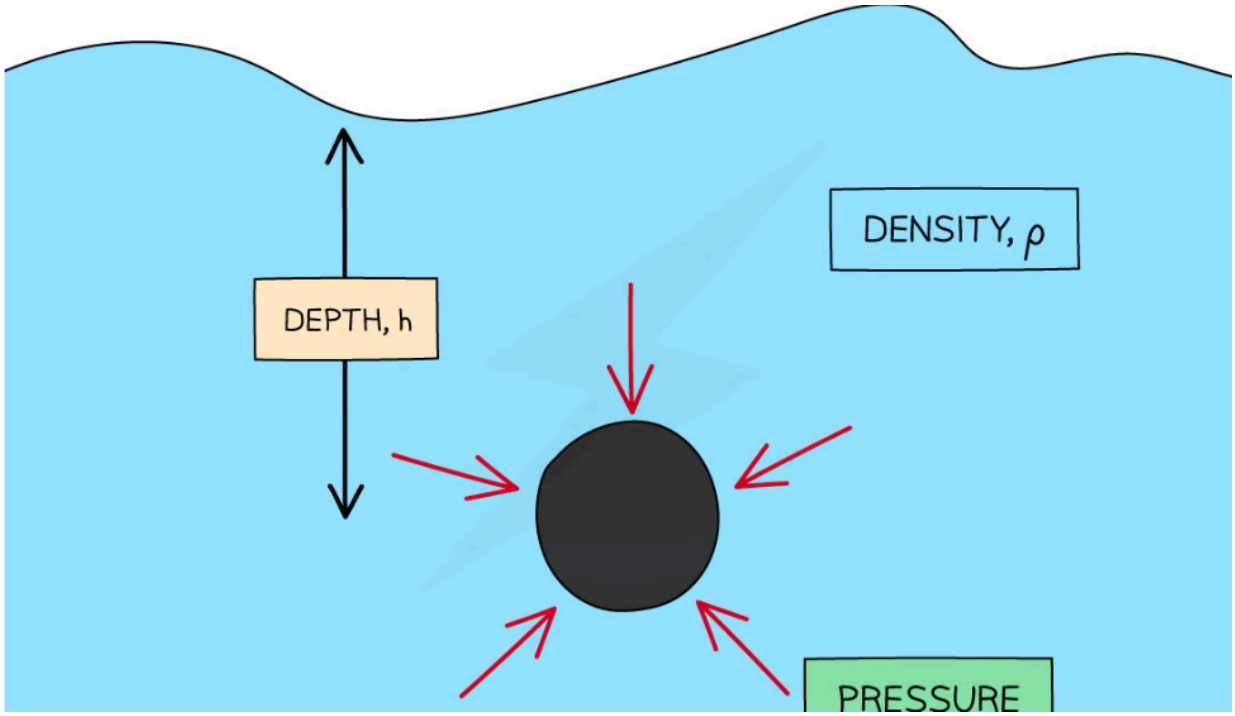
*Pressure in a column of water increases with depth, shown by the strong and weak jet of water*

- If several holes were made at the same height, the water would spurt out the same distance from each hole
    - This is because pressure at the same depth acts equally in all directions

## Calculating liquid pressure

- The pressure acting on an object in a liquid changes with depth
    - The deeper the object, the higher the pressure exerted upon it and vice versa
- The equation for the pressure difference at different depths in a liquid is given by the equation:

$$\Delta p = \rho g \Delta h$$



# Videos

https://www.youtube.com/watch?v=TpHv-sGE_Dk

https://www.youtube.com/watch?v=NzKAJWTmlwg

https://www.youtube.com/watch?v=DxKelGugDa8