Scalar and Vector Quantities:

Scalar quantities:

- Mass
- Temperature
- Speed
- Energy
- Distance
- Time

Scalar quantities have only magnitude (size) but do not have a direction

Vector quantities:

- Displacement
- Weight
- Force
- Velocity
- Acceleration
- Momentum

Vector quantities have magnitude and direction

Contact and non-contact forces:

Contact force:

- Water resistance
- Air resistance
- Normal contact force

Non-contact forces:

- Gravitational field strength
- Electrostatic force
- Magnetic force

<u>Gravity and weight:</u>

$$\text{Weight (N)} = \text{Mass (kg)} \times \text{gravitational field strength (N/kg)}$$

$$\text{Weight} \underset{\text{directly proportional}}{\propto} \text{Mass}$$

You can determine the weight by using a newton meter

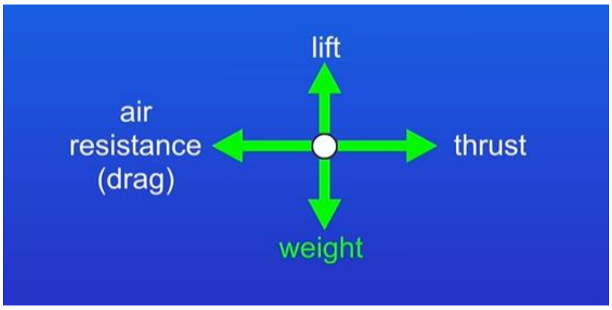
Centre of mass = Weight of an object can be thought of as acting at a single point

<u>Resultant force:</u>

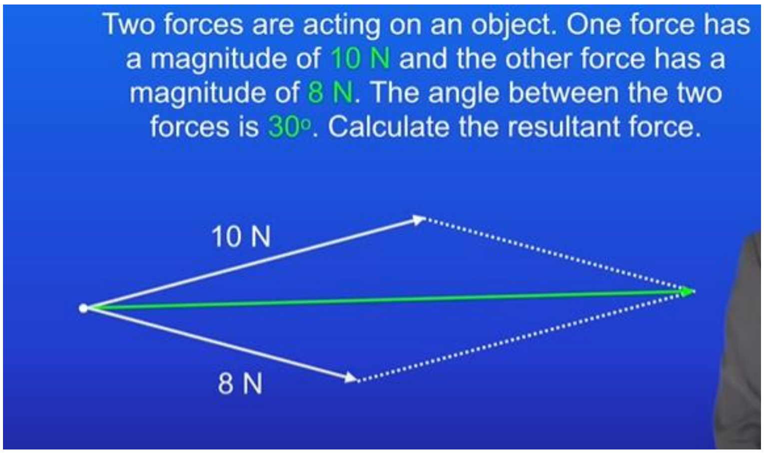
Resultant force = Overall force acting on an object

To work it out: Larger force – Smaller force

Free body diagrams:



Vector diagrams:



The magnitude of the resultant force R is given by:

$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos(\theta)}$$

Steps:

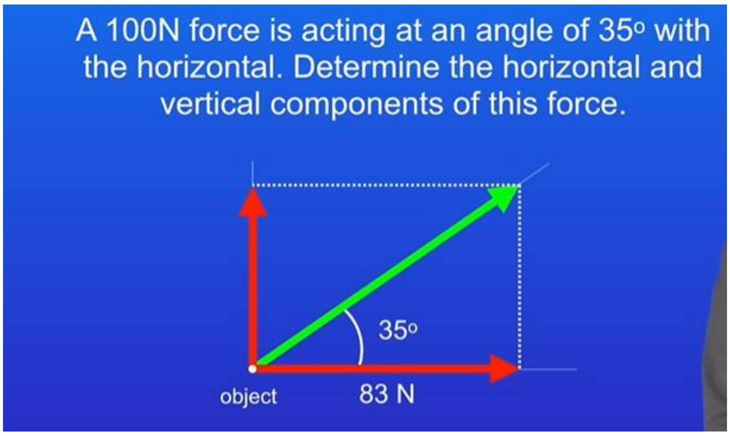
1. Solve for α_1 by taking the inverse tangent ($\tan^{-1}$) of the right-hand side:

$$\alpha_1 = \tan^{-1}\left(\frac{F_2\sin(\theta)}{F_1 + F_2\cos(\theta)}\right)$$

1. Solve for α_2 by taking the inverse tangent:

$$\alpha_2 = \tan^{-1}\left(\frac{F_1\sin(\theta)}{F_2 + F_1\cos(\theta)}\right)$$

Resolving forces:



The horizontal component is given by:

$$F_x = F\cos(\theta)$$

The vertical component is given by:

$$F_y = F\sin(\theta)$$

These should not be used unless its for checking answer

Work done and energy transfers:

Friction on an object causes the temperature to increase

$$\text{Work done (J)} = \text{Force (N)} \times \text{Distance (m)}$$

$$W\ (J) = F\ (N) \times s\ (m)$$

Work is when energy is transferred

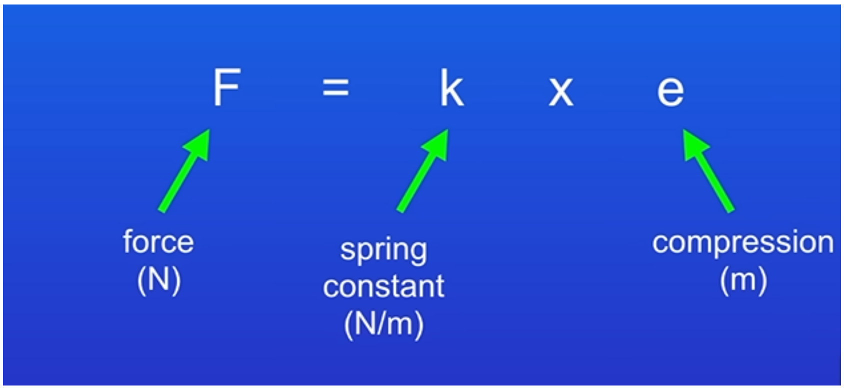
Forces and elasticity:

Elastic materials will always return to their original length if we take away the forces acting on them. This is known as elastic deformation (Hooke's law)

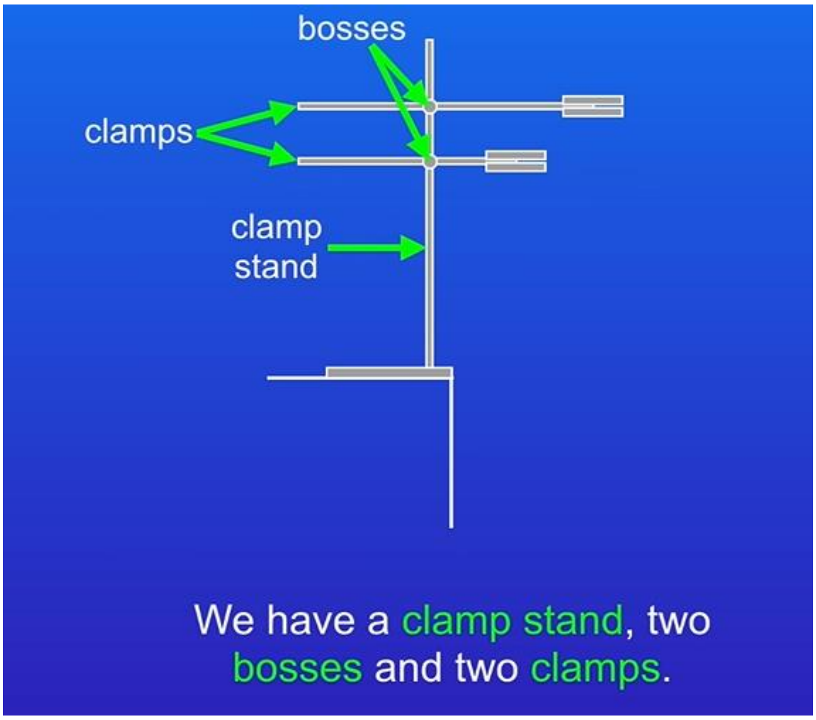
To change the objects length or shape, we have to apply more than one force

Inelastic materials do not return to their original shape after a force has been applied to them. This is called inelastic deformation

$$\underbrace{F}_{\substack{\text{force}\\ \text{(N)}}} = \underbrace{k}_{\substack{\text{spring}\\ \text{constant}\\ \text{(N/m)}}} \times \underbrace{e}_{\substack{\text{extension}\\ \text{(m)}}}$$

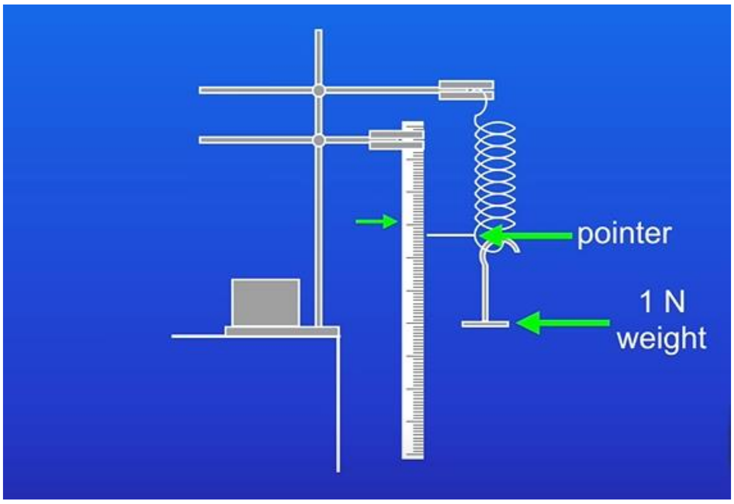


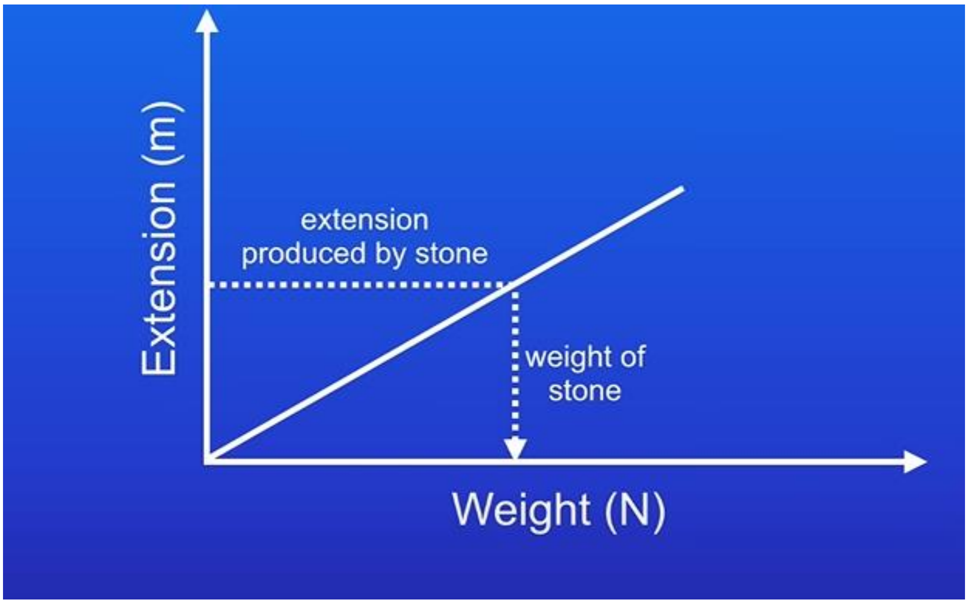
Required practical: (Forces and elasticity):

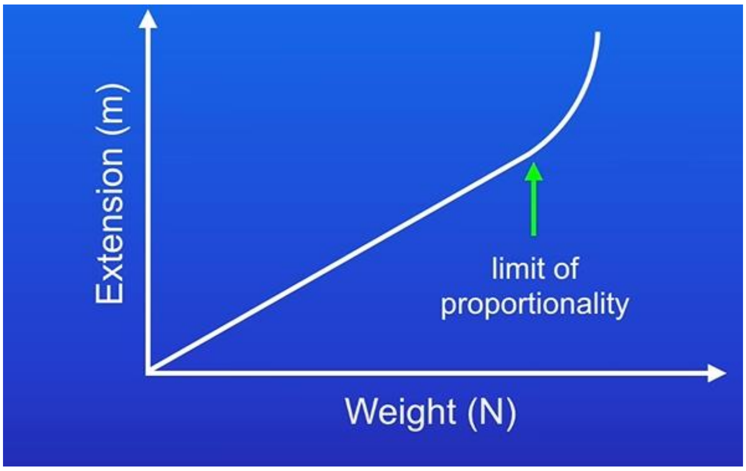


1. The equipment includes:
- Two bosses
- Two clamps
- A clamp stand
2. Place a heavy weight on the clamp stand to stop it from falling over
3. Attach a metre ruler and a spring
- The top of the spring must be at 0 on the metre ruler

4. The bottom of the spring has a wooden splint attached as a pointer which is horizontal
5. Read the position of the pointer on the metre ruler
- This is the unstretched length
6. Attach a 1N weight onto the spring
7. Read the new position of the pointer
8. Repeat step 6 several times
9. Calculate the extension by doing (new position – unstretched position)
10. Plot a graph using the results



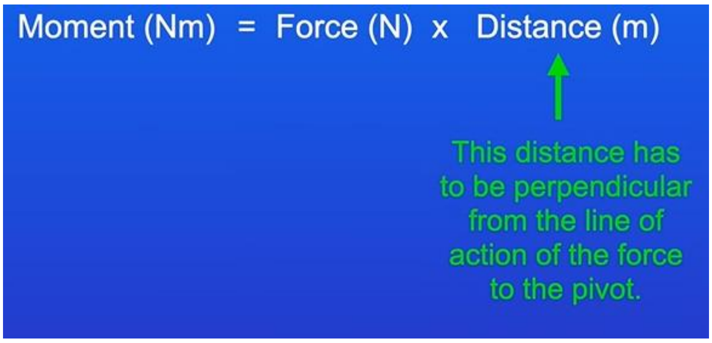


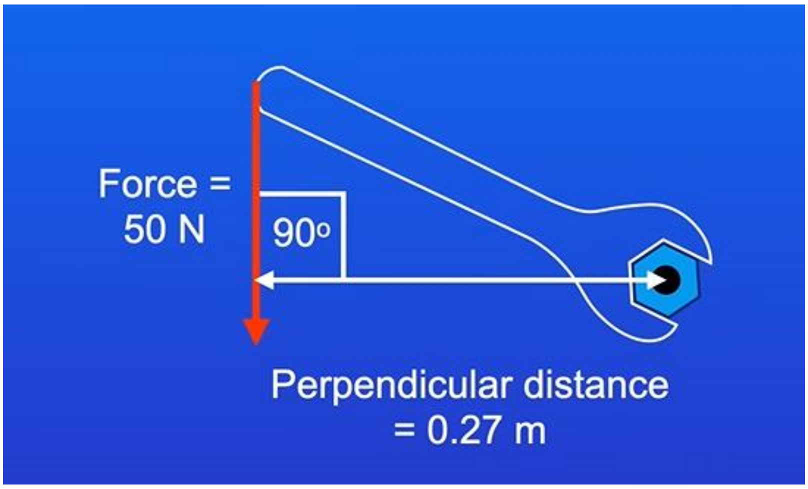


The graph begins to show a non-linear relationship because too much weight is being added causing inelastic deformation. By stretching the spring we exceed the limit of proportionality

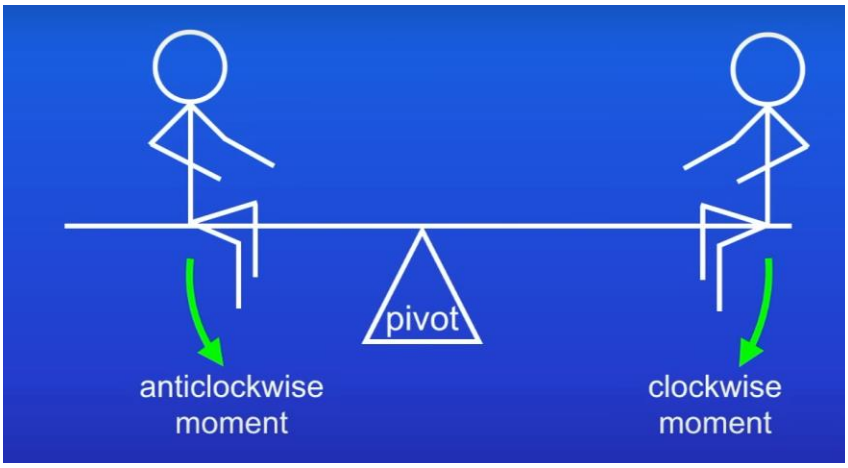
Moments:

Moment = The turning effect of a force





Balanced moments:



Balanced moments → The clockwise moment = Anti-clockwise moment

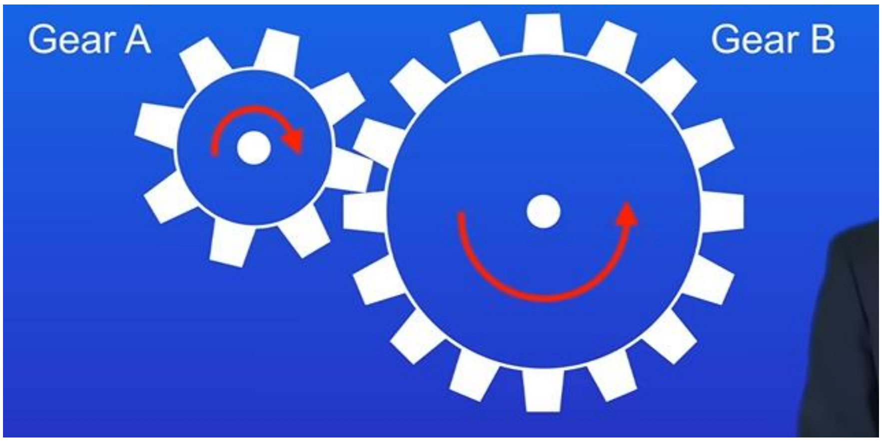
Why objects topple:

- Tilting the object causes the line of action of the weight lies outside the base of the object
- There is an unbalanced moment acting on the object which causes the object to topple

Levers and gears:

Force multiplier = Something that increases the effect of a force

Levers act as a force multiplier

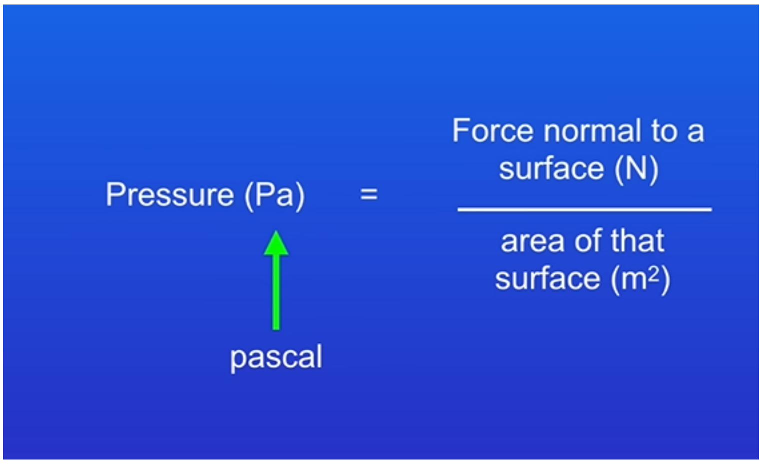


The turning effect or moment is double in gear B than in A because it has double the radius.

In gears, the moment depends on the distance from the edge of the gear to the centre

In this example, gear B has double the teeth of gear A making the work done the same because gear A has to rotate twice every once gear B rotates (inverse relationship between force and distance)

Pressure in fluids:

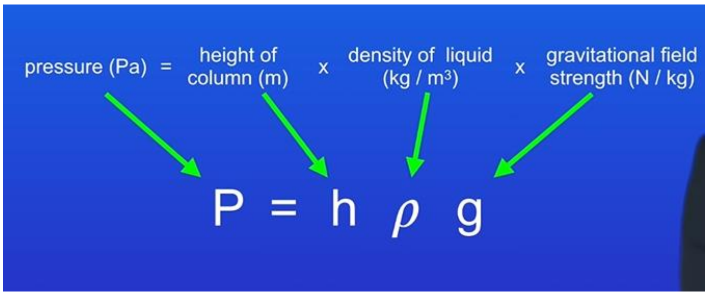


The normal is the walls of the container

Why does crisp inflate in an airplane:

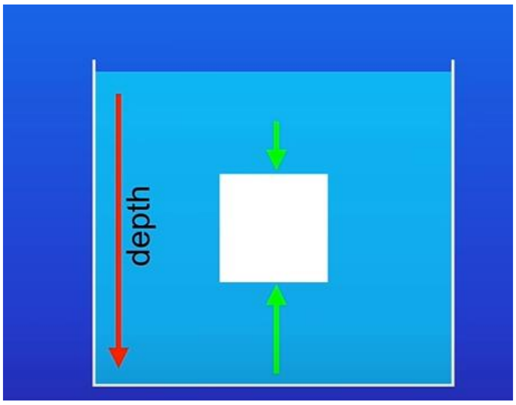
- Increase in height means there is a decrease in pressure
- Cabin pressure is lower than normal pressure so there are less particles colliding outside with the packet so it inflates

<u>Floating or sinking:</u>



Containers that contain liquids such as water usually have higher pressure at the bottom than at the top

Because there is a larger pressure at the bottom of the container, the object does not sink because of the pressure which is called upthrust



For the object to float, the upthrust must equal the object's weight

The size of the upthrust acting on the object is the same as the weight of water displaced by the object

Speed

Distance does not involve direction

Displacement tell us distance that an object moves in a straight line from start to finish (vector)

Speed (v) = Distance (s)/time

V and s are the symbols for speed and distance

Normal walking speed ~ 1.5m/s

Running speed ~ 3m/s

Cycling speed ~ 6m/s

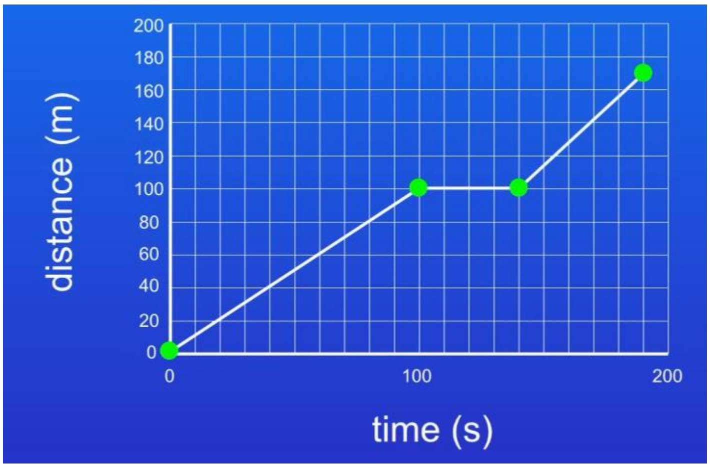
Sound – 330m/s

Velocity

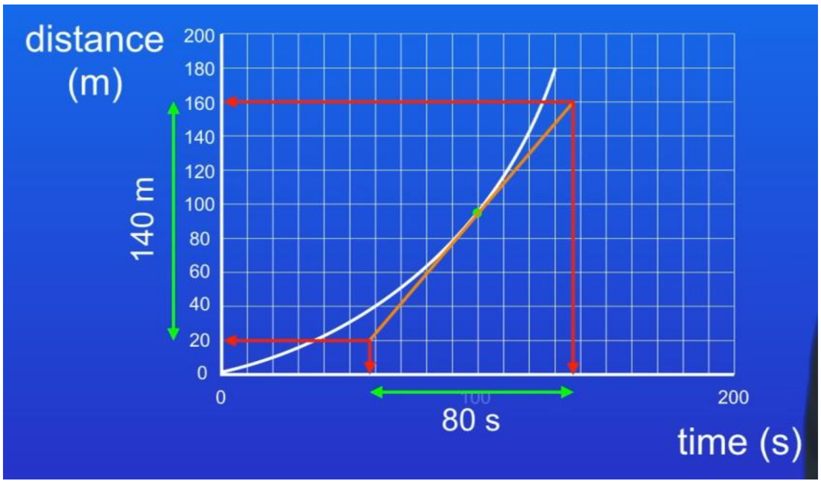
Velocity = Speed with given direction (train travels 100m/s south)

Object travelling in a circle has velocity constantly changing even when speed is constant

Distance-time graphs



Gradient of line tells us speed



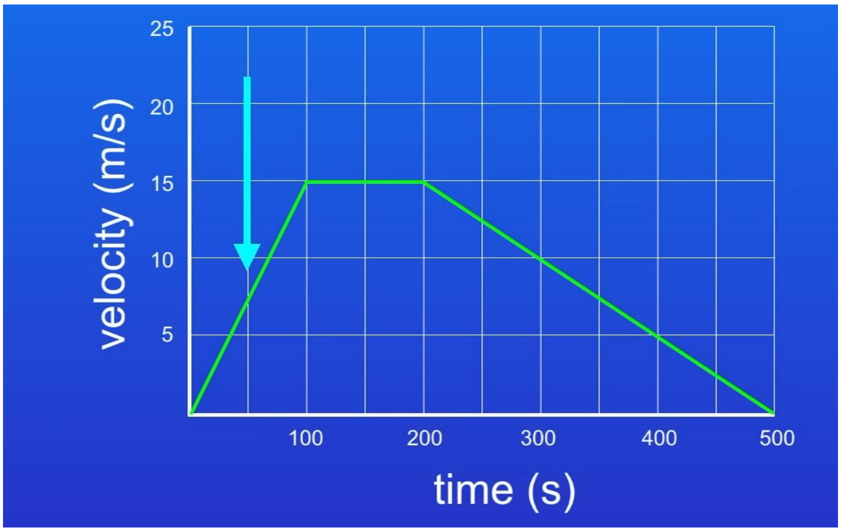
This graph tells us object is accelerating

Acceleration

Acceleration (m/s^2)= Change in velocity of object over a given time

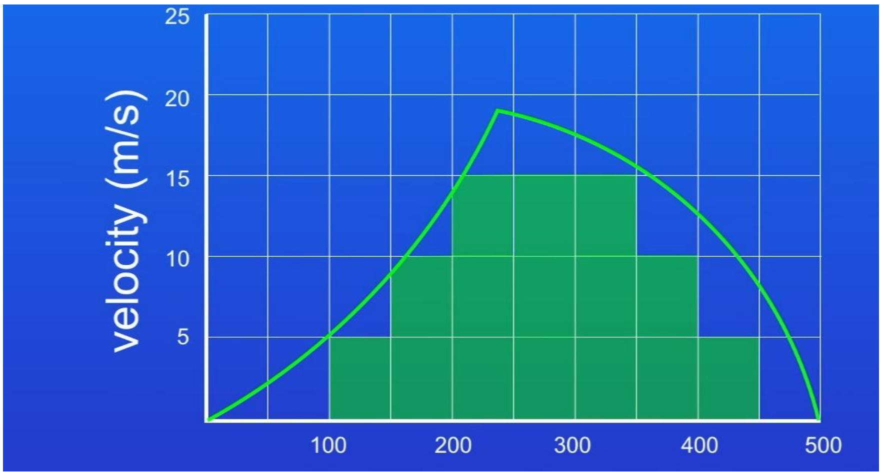
$$\text{Acceleration} = \frac{\text{Final velocity} - \text{Initial velocity}}{\text{Time}}$$

$$a = \frac{v - u}{t}$$

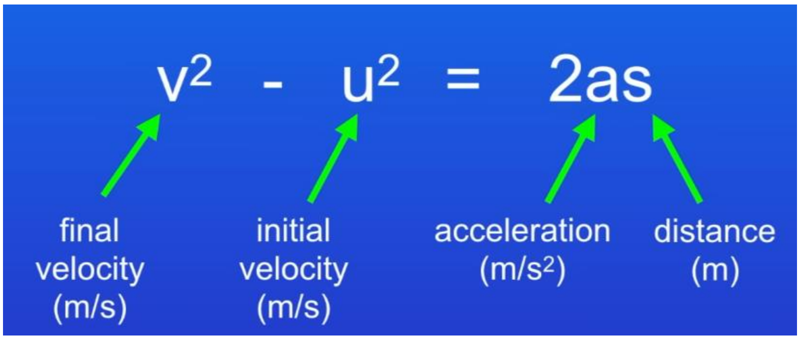


Gradient tells us acceleration

Area under graph tells us displacement



For graphs like these, count number of squares underneath graph



When object falls towards surface of earth, it initially accelerates ~9.8m/s^2

Terminal velocity = Constant velocity (no acceleration or deacceleration)

<u>Newtons law of motion</u>

First law

- If resultant force acting on stationary object = 0, then object will remain stationary or continue moving with same velocity

Resistive force = Friction with air and road

Second law

- Acceleration of object is directly proportional to force but inversely proportional to mass
- More force = More acceleration
- More mass = less acceleration

Force (N)	=	Mass (kg)	x	Acceleration (m/s^2)

Inertia = Tendency of object to stay stationary or keep moving at the same speed and in same velocity unless force is applied

Inertial mass = Measure of how difficult it is to change velocity of object (defined as ration of force needed to accelerate over the acceleration produced)

Object with larger inertial mass will need more force to produce acceleration than object with smaller inertial mass

Third law

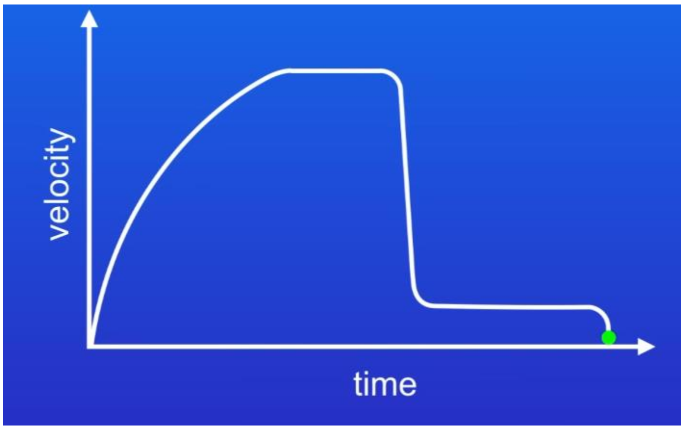
- Whenever two objects interact, the forces they exert on each other are equal (in magnitude) and opposite (in direction)

Forces acting on skydiver

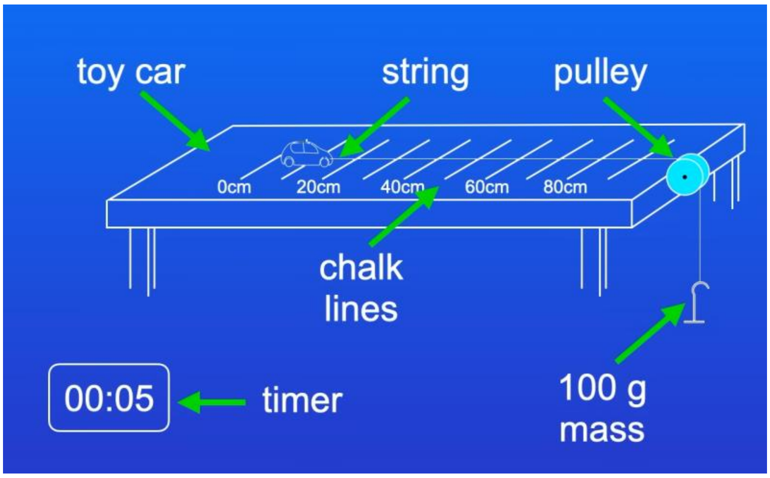
Forces on skydiver

1. When skydiver jumps out of plane, he only experiences weight (constant) → Experiences resultant force of acting downwards → Accelerate towards ground
2. As they fall, skydiver experiences friction with air molecules (drag)
3. Weight > Drag → Continues to accelerate
4. As velocity increases, drag increases and at a point, they become equal (no resultant force) → Reaches terminal velocity
5. Skydiver opens parachute
6. Surface area increases → Drag increases
7. Weight < Drag → Experiences resultant force upwards → Deceleration (velocity decreases) → Drag decreases and will be equal to weight and resultant force = 0

8. Skydiver falls with lower terminal velocity stopping him from dying



Required practical: Acceleration



1. Attach toy car to a string
2. Loop string around pulley
3. Attach a 100g mass at the other end of the pulley
4. Get a timer
5. On the desk, draw chalk lines at equal intervals (eg every 10cm)

6. Hold toy car at starting point and then let go of the car
7. Car will accelerate
8. Record time the car passes each distance marker (record on phone and play video back and record times)
9. Repeat experiment several times but decrease mass every time (80, 60, 40g)
10. When you decrease mass at the end of the string, apply a bit of mass on the car

<u>Vehicle stopping distance</u>

Stopping distance = Thinking distance + Braking distance

Greater the speed of vehicle, greater the stopping distance (assuming same braking force is applied)

Factors affecting reaction time

- Tired
- Alcohol and certain drugs
- Distractions in car (eg phone)

Factors affecting braking distance

- Wet/icy conditions reduce friction between tyres and road

- Tyre condition (new or worn)
- Condition of brakes

Forces and braking

During braking, the brake presses against wheel → Friction increased → Kinetic energy of car is converted to thermal energy in brakes → Causes temperature of brakes to increase

Momentum

If object is not moving, then it has no momentum

momentum (kg m/s)	=	mass (kg)	x	velocity (m/s)

Conservation of momentum = Total momentum before an event = total momentum after event in closed system

Change in momentum

$$\text{Force (N)} = \frac{\text{Mass (kg)} \times \text{change in velocity (m/s)}}{\text{change in time (s)}}$$

Rapid changes in momentum lead to huge forces applying and these are extremely dangerous

To reduce momentum, you can make the change in momentum over a longer time

Things which reduce momentum change:

- Airbags
- Seatbelts
- Bike helmets
- Cushioned surface
- Crashmat