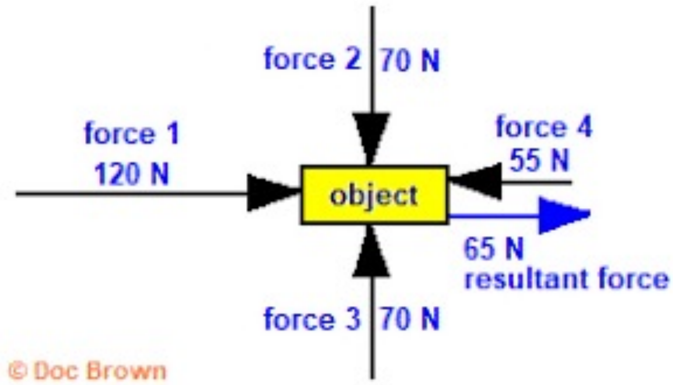
Contact & non-contact forces:

Vector:

Forces have magnitude & direction
E.g. velocity, displacement, acceleration & momentum

Represented by an arrow: length = magnitude & direction = direction of the quantity



Scalar:

Only have magnitude
E.g. speed, distance, mass, temp, time

Force types:

A push/pull on an object caused via an interaction

Contact forces: 2 objects have to touch to experience a force
E.g. air resistance, tension

Non-contact forces: objects aren't touching
E.g. magnetic force, gravitation force, electrostatic force

Interaction pair: a pair of EQUAL but OPPOSITE forces that act on 2 interacting objects

E.g. the Sun & earth are attracted to each other via a gravitational force (they both feel an equal but opposite force)

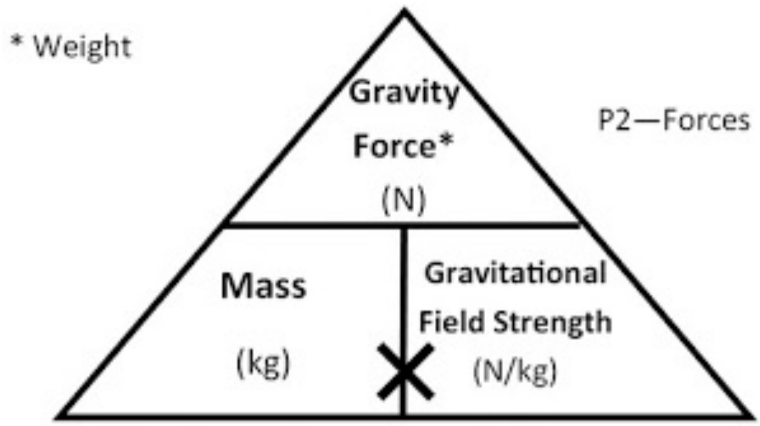
Gravitational force:

Gives everything a weight & makes everything fall towards the ground on the surface of a planet

Weight = the force acting on an object due to gravity (gravitational force)
The weight of an object changes with its location (e.g. a 1kg mass weighs 1.6 N on the moon, but on earth it weighs 9.8 N)

The force acts on the object's 'centre of mass' (the point at which the whole mass is concentrated)
In uniform objects (have the same density throughout), the 'centre of mass' is at the centre of the object

Weight is measured with a Newton-metre
Mass is NOT a force, it's measured in kg but weight is measured in N (newtons)



Mass & Weight = directly proportional

Resultant force:

The overall force acting on an object: worked out via addition & subtraction (only if the forces are parallel)

When a force moves an object through a distance, energy is transferred & work is done on the object

The thing applying the force needs chemical energy (food/fuel), it then does 'work' on the other object (by transferring energy to it)

Pushing a trolly along a rough carpet:
Work is done against frictional forces -> energy is transferred to the kinetic stores of the object (& it's thermal stores due to friction) = overall temp of the object increases

1J of work is done when 1N causes a displacement of 1m

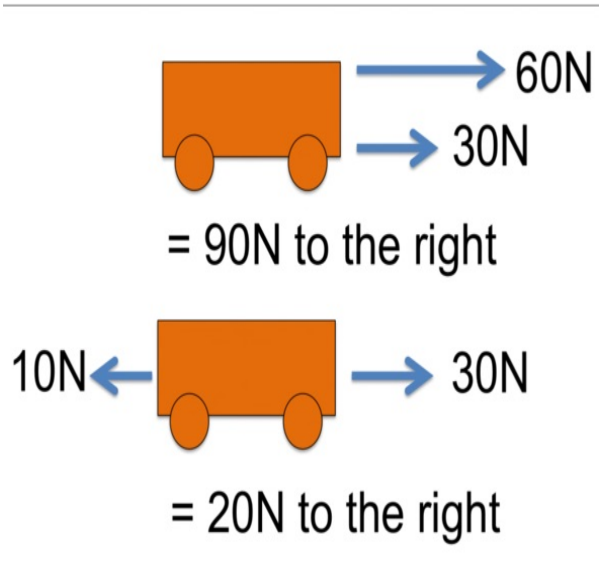
Work Done

Work done is the amount of energy transferred.
Work done = force x distance moved in the direction of the force.

$$W = \Delta E$$

$$W = F \times d$$

W = work done (J)
ΔE = energy transferred (J)
F = force (N)
d = distance moved in the direction of the force (m)



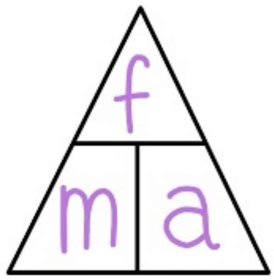
Elasticity:

Applying a force on a string = stretching, compression or bending (>2 forces act on the object) so work is done, transferring energy to the object's elastic potential energy stores

Elastic deformation = an object can revert to its original shape & length after the force is removed (ALL the energy has been transferred to the object's elastic potential energy stores)

Inelastic deformation/point of no return = object doesn't return to its original shape/length after the force has been removed

Extension is directly promotional to the force applied
Stiffer spring = higher spring constant



Limit of proportionality: the force applied no longer causes the spring to extend (a graph curves)

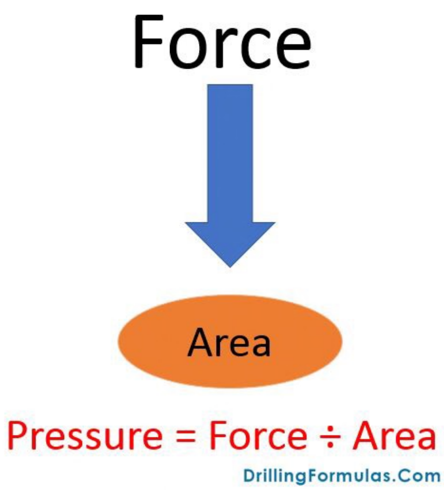
If the limit of proportionality hasn't been exceeded or to calculate the elastic potential energy of an inelastically deformed spring, use:

$$E_e = \frac{1}{2} \times k \times e^2$$

Fluid pressure:

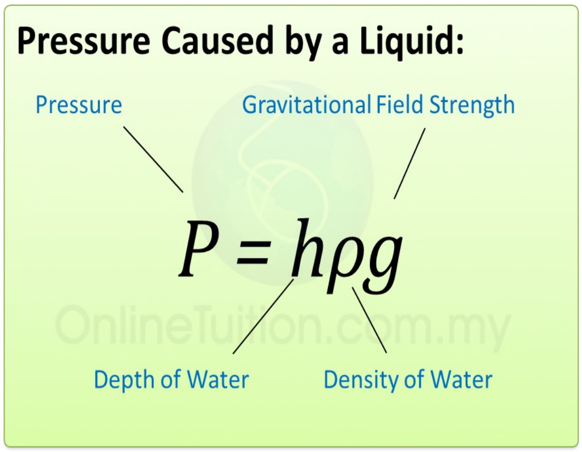
Particles in a liquid exert a force (pressure) on the container they collide with

Force is exerted at right angles to the container



Density is uniform in a liquid, more particles in an area = more collisions = a greater pressure

As depth of a liquid increases, the number of particles above that point increases = liquid pressure increases with depth



Upthrust:

When an object is submerged in a fluid, the pressure of the fluid exerts a force on it in every direction

Force at the bottom of a container = greater as with depth, pressure increases

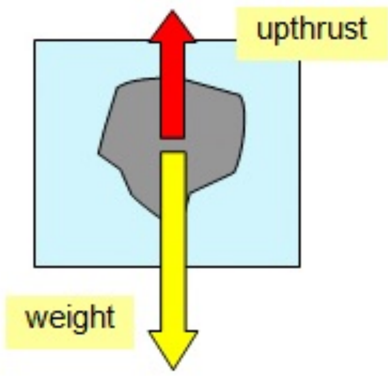
= causing upthrust

Upthrust is equal to the weight of the fluid that has been displaced by an object

If upthrust = the object's weight, forces balance & the object floats
Object's weight is more than upthrust = it sinks

An object less dense than the fluid it's placed in = weighs less than the equivalent volume of fluid
So it displaces a volume of liquid equal to its weight before being completely submerged
Then if the object's weight it equal to the upthrust, it floats
An object denser than the fluid is unable to displace enough fluid to equal its weight so it sinks

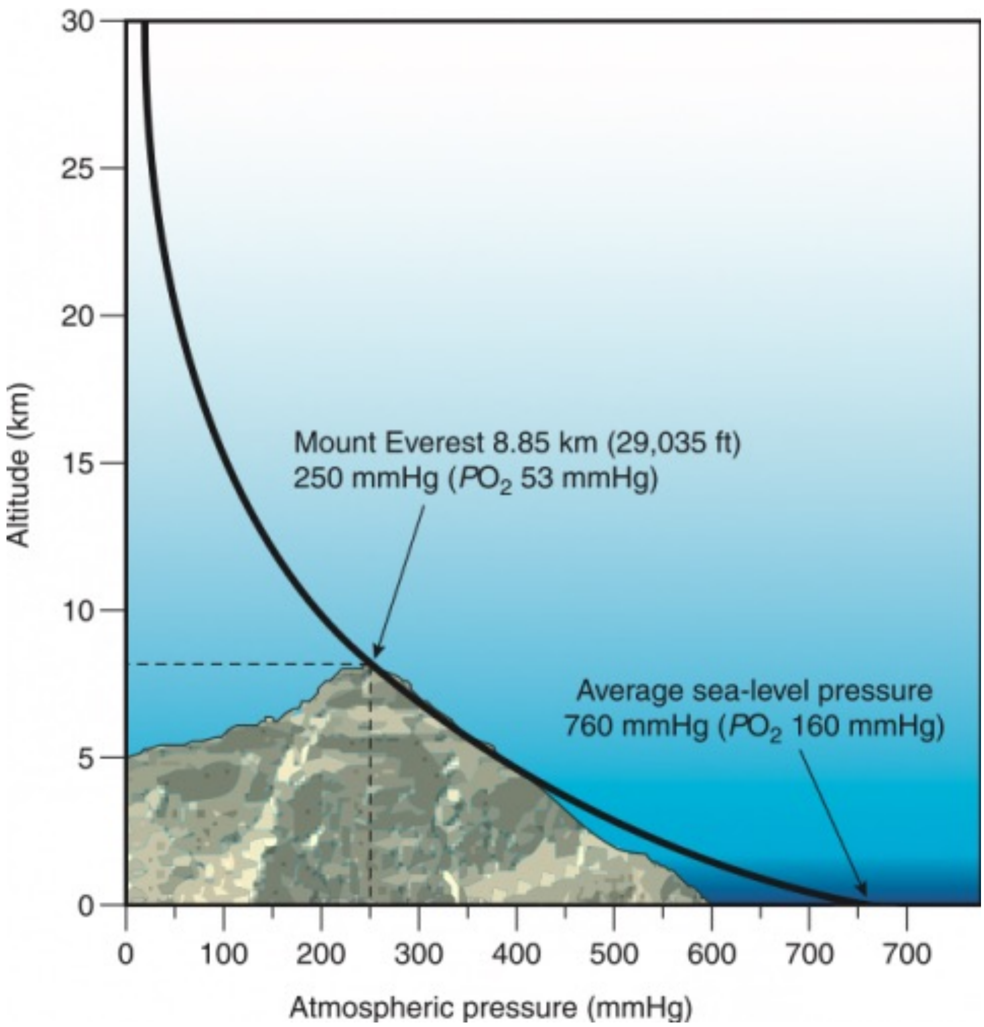
Large tanks are filled with water to increase the weight of submarines so they weigh more than the upthrust = they sink
To rise, tanks are filled with compressed air to reduce the weight so its less than upthrust



Atmospheric pressure:

As altitude increases, pressure decreases (there are LESS particles higher up so there are less collisions as the atmosphere is less dense)

AND the air above the particles is less dense = lower atmospheric pressure



Distance:

A scalar quantity: how far an object moves

Displacement:

A vector quantity: the distance & direction in a straight line from the starting -> finishing point

Speed:

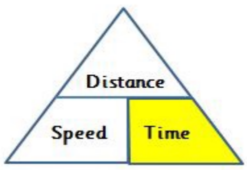
A scalar quantity: how fast your going (e.g. 30mph)

Velocity:

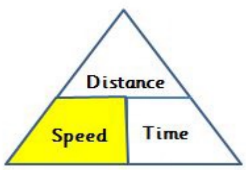
A vector quantity: speed in a given direction (e.g. 30mph north)

= objects can travel at a constant speed but changing velocity (direction)
Thus, an object going in a circle maintains a constant speed but has a changing velocity (changes direction to go in a circle)

$$\text{Distance} = \text{Speed} \times \text{Time}$$



$$\text{Time} = \frac{\text{Distance}}{\text{Speed}}$$



$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

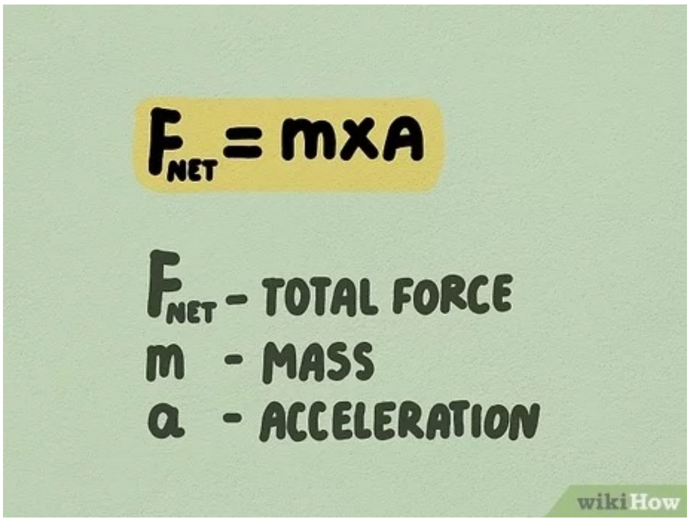
Average speeds:

Walking: 1.5 m/s
Running: 3 m/s
Cycling: 6 m/s
Cars: 25 m/s
Trains: 30 m/s
Planes: 250 m/s

Speed of objects depends on: terrain, person (activity level, age)
Speed of sound depends on: speed of wind & the medium
Speed of wind depends on: temp, atmospheric pressure & buildings

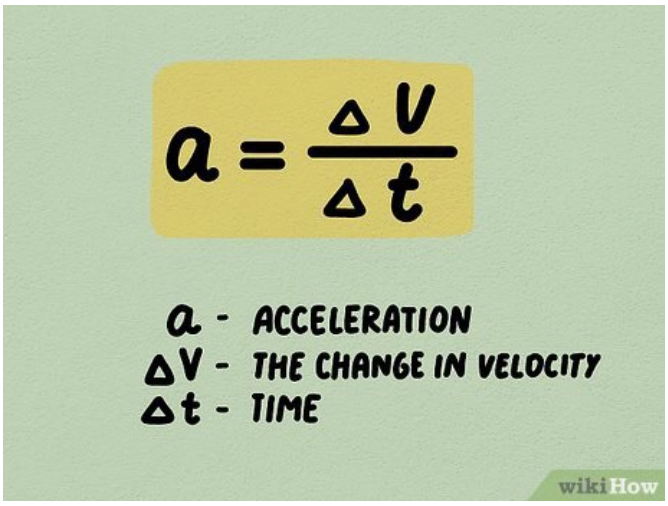
Acceleration:

A vector quantity: the change in velocity in a given time
Deceleration: negative acceleration (slowing down)



Constant/uniform acceleration:

Acceleration due to gravity is uniform for objects in free fall, roughly 9.8 m/s^2

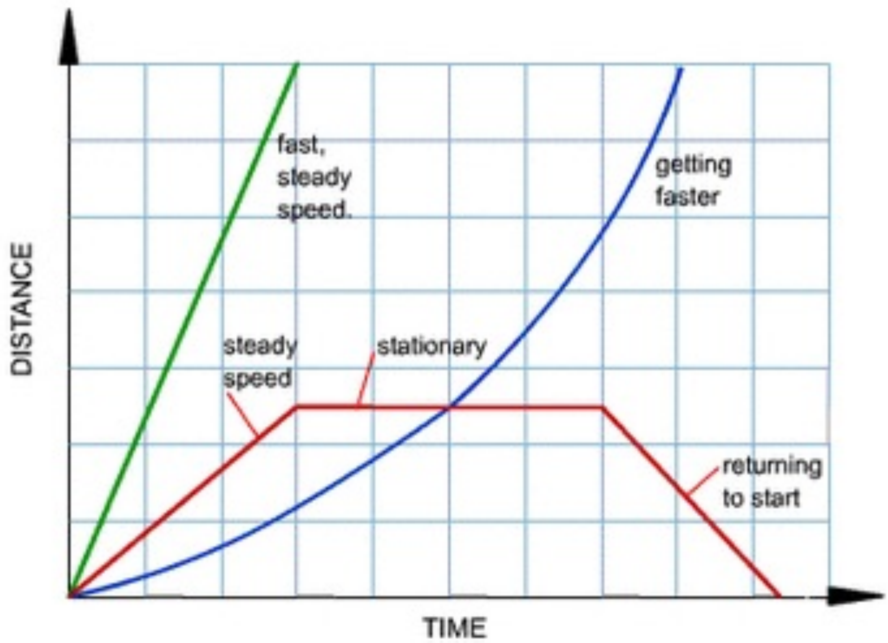


$$v^2 = u^2 + 2as$$

Distance-time graphs:

Show an object moving in a STRAIGHT line

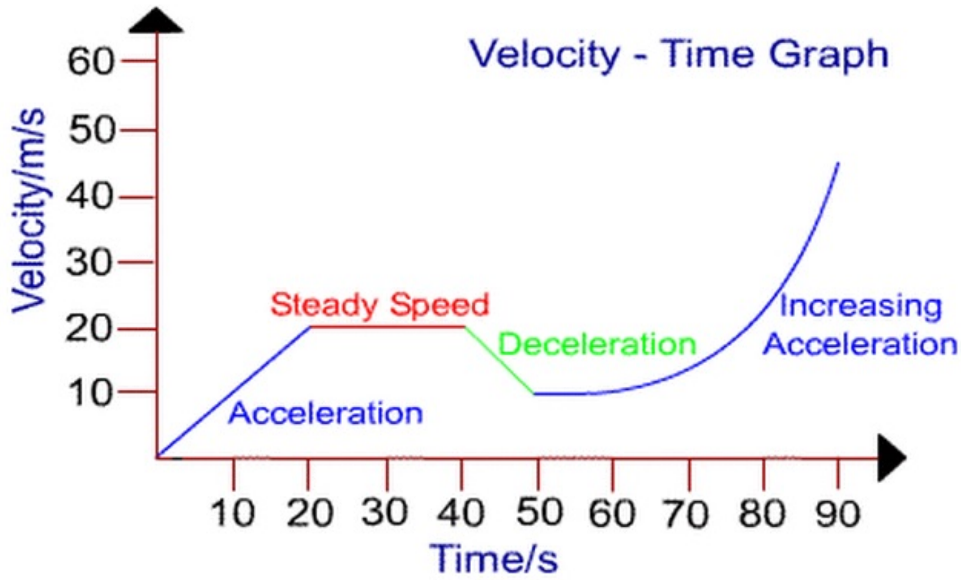
Gradient = speed (steeper = faster)
Flat sections = stationary
Straight uphill = steady speed
Curves = acceleration/deceleration (steep = speeding up, levelling off = slowing down)
Acceleration (change in speed) is calculated by finding the gradient of a tangent at a point



Velocity-time graphs:

Shows how an object's velocity changes

Gradient = acceleration (v/t)
Flat sections = steady speed
Steeper graph = greater acceleration/deceleration
Uphill = acceleration
Downhill = deceleration
Curve = changing acceleration
Area under graph = distance travelled



Terminal velocity:

Friction acts in the opposite direction of movement
Travelling at a steady speed = the driving force balances the frictional force

Drag:

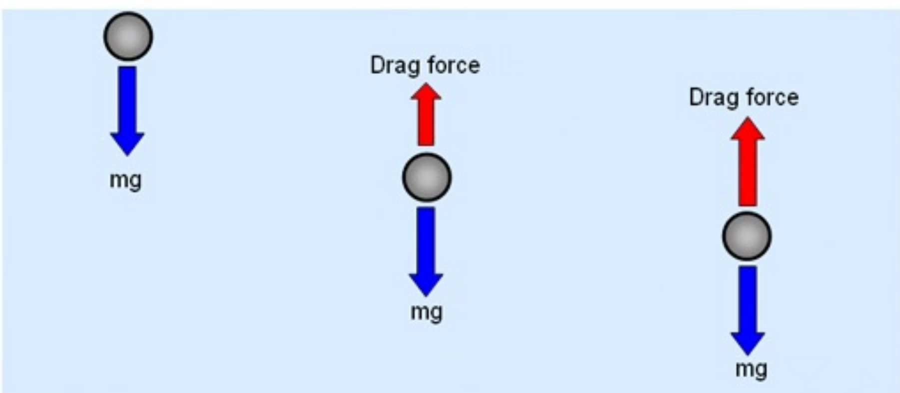
Resistance in a fluid
Reducing drag: keep the object streamlined (so fluid flows easily across it)
Frictional forces increase with speed (more friction at 70mph than at 30mph = engine has to work harder to maintain a steady speed)

Terminal velocity:

A falling object has more gravitational than frictional force = it accelerates at first
Speed increases = friction increases
Acceleration decreases

Frictional force = Accelerating force : an object has reached its max speed or TERMINAL VELOCITY

Air resistance = objects fall at different speeds so terminal velocity depends on drag vs the weight of an object
Friction depends on shape & area
With a parachute open, a skydiver reaches terminal velocity SAFELY (when hitting the ground) due to more air resistance (at 15 mph vs what would've been 130 mph!)



Body released from rest

Forces on body during acceleration

Forces on body at terminal velocity

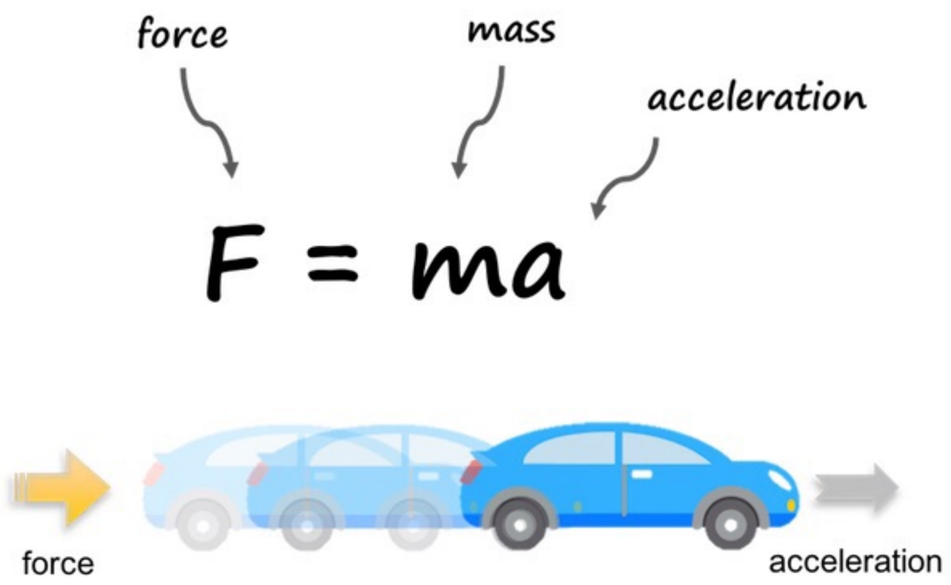
Newton's 1st law:

A resultant force of 0 = a stationary object (forces are balanced)
if it remains 0, it will move at the same velocity

A force >0 = produces an acceleration/deceleration in the direction of the force
(Shows unequal arrows on a free body diagram) via: starting, stopping, speeding up/down & changing direction

Newton's 2nd law:

The bigger resultant force on an object = the more the object accelerates
An object with a larger mass accelerates less than one with a smaller mass



Inertia:

The tendency for an object's motion to remain unchanged (Newton's 1st law explains this, until a force >0 is applied)

Inertia measures how difficult it is to change an object's velocity

Inertial mass = Force / Acceleration

Newton's 3rd law:

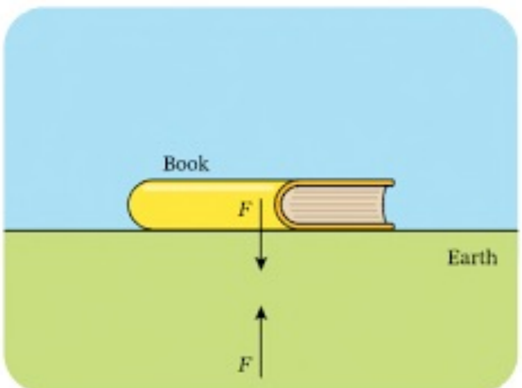
When 2 objects interact, the forces they exert on each other are OPPOSITE yet EQUAL

E.g. you push a trolley & it pushes back, you stop pushing a trolley = it stops pushing back

Equilibrium situation:

Man pushes a wall & the wall 'pushes' back (a normal contact force acts back on him), the forces are the same size

A book resting on the ground experiences a normal contact force BUT the normal contact force is acting against the weight of the book = the forces are DIFFERENT so this ISN'T Newton's 3rd law!



Stopping distances:

Emergency stop = the max force is applied to the brake's of a car to stop it in the shortest distance

Thinking distance: how far the car travels during the driver's reaction time
Affected by: speed & reaction time

Braking distance: distance taken to stop under the braking force
Affected by: speed, weather/road surface (e.g. ice & skidding), tyre condition (bald tyres = can't get rid of water so skid), condition of the brakes (worn/ faultiness)

Stopping distance = Thinking distance + Braking distance

Short stopping distance = less space is left between you and the car in front to stop safely = need speed limits

Braking:

Brake pedal is pushed -> brake pads are pressed on the wheels -> friction (as work is done) -> energy is transferred from the wheel's kinetic energy stores to it's thermal stores -> temp rises

Faster car = larger braking force = larger deceleration = skidding = unsafe

To estimate forces involved in acceleration use:

V- u squared DIAGRAM EQUATION

Speed's affect on braking distance:

As a car speeds up, thinking distance increases proportionally
But
As a car speeds up, braking distance increases faster the more you speed up (as speed doubles, kinetic energy increases 4-fold and because: W = Fs, braking distance increases 4-fold)

Reaction times:

Variations between people are caused by: tiredness, distractions, drugs & alcohol

Computer based tests: clicking the mouse when the screen changes colour

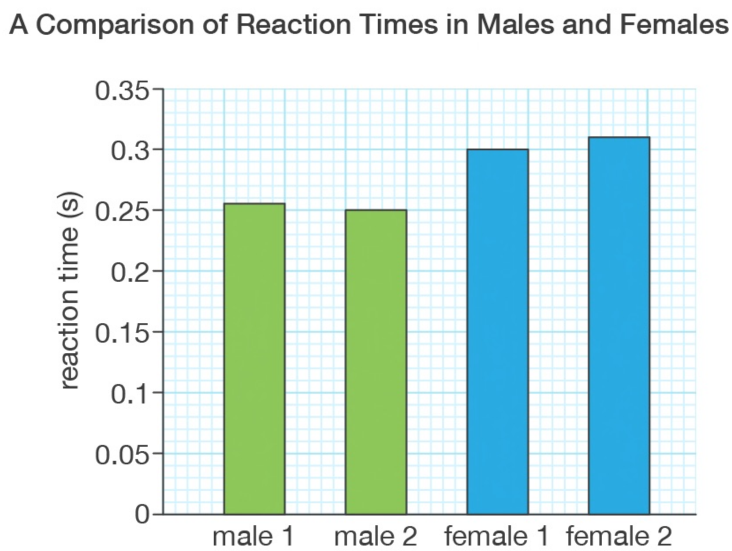
Ruler drop test:

1. Sit with arm resting on table
2. Get someone to hold a ruler between your thumb & forefinger (lined up with 0)
3. Have them randomly drop it & catch the ruler
4. Measurement on ruler where it's caught = your reaction time
5. Calculate mean reaction time after 3 drops

Control: ruler & person dropping it

Could repeat with caffeine intake or distractions & compare results

Longer distance on ruler = longer reaction time



Momentum:

A vector quantity: a measure of mass in motion

$$\overbrace{p}^{\text{momentum}} = \underbrace{m}_{\text{mass}}\,\underbrace{v}_{\text{velocity}}$$

Conservation of momentum:

Momentum before an event = Momentum after an event (in a closed system)

Events = collisions & explosions

Explosions: momentum is 0 before & cancels out to 0 after (as debris flies off in different directions)

Forces & momentum:

The force causing a change = the rate of change of momentum

$$\boxed{\text{FORCE (N)} = \frac{\text{CHANGE IN MOMENTUM (kg m/s)}}{\text{TIME TAKEN (s)}}}$$

Long change in momentum = smaller rate of change in momentum = smaller force = less severe injuries

Safety features of cars reduce change in momentum = less force = less injury:

Crumple zones: increase stopping distance
Seat belts stretch: increase time taken for person to stop
Air bags: compressing air slows person down = a more gradual hitting of the dashboard

Bike helmets: contain crushable foam = increase time taken for the head to stop in a crash = less impact on the brain

Crash mats: compressible materials increase time taken for child to stop