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How to use this knowledge organiser:

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PHYSICS FORCES and MOTION 1 (combined) Paper 2:KS4

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- Scalar, vector and speed
- Velocity and acceleration
- Forces
- Resultant forces
- Resolving vectors (H)
- Newton's first law
- Newton's second law
- F=ma practical
- Newton's third law
- Momentum (H)
- Momentum calculations (H)

Key Words

Key Word	Definition
Acceleration	The rate of change of velocity. It can be calculated from the gradient of a velocity-time graph.
Conservation of momentum (higher only)	The total momentum of a system before an event is always equal to the total momentum of the system after the event.
Contact forces	A force that occurs when objects are physically touching.
Displacement	A measure of how far an object moves in a given direction. It is the straight line between the starting and finishing points and is a vector quantity.
Distance	A measure of how far an object moves, that does not depend on direction and is therefore a scalar quantity.
Equilibrium	An object is in equilibrium if the resultant force and resultant moment are both equal to zero.
Forces	A push or pull that an object experiences due to the interaction with another object. Force is a vector quantity.

Misconceptions

Speed is not the same as velocity.

Velocity is speed with a direction.

If an object is accelerating it is not necessarily speeding up.

If an object is changing direction its velocity is changing so it is accelerating.

Objects at rest (not moving) still have forces acting on them.

A force is not needed to keep an object moving at a constant speed. Newton's 1st law – motion is unchanged until a force acts.

Key questions

What is the difference between speed and velocity?

What is a resultant force?

What are Newton's laws of motion?

How can the effect of force on acceleration be investigated?

What is conservation of momentum? (H)

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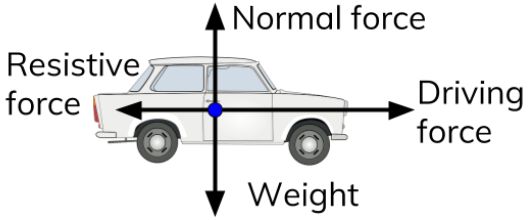
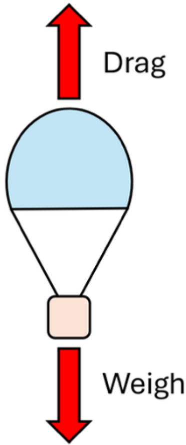
Keywords

Inertia (higher only)	The tendency of an object to remain in its same state of uniform motion or rest.
Inertial mass (higher only)	A measure of how hard it is to change an object's velocity. It is defined as the ratio of force over acceleration.
Newtonmeter	A calibrated spring-balance used to measure weight.
Newton's first law	If a stationary object's resultant force is zero, the object will remain stationary. If a moving object's resultant force is zero, the object will continue to move at the same speed, and in the same direction.
Newton's second law	An object's acceleration is directly proportional to the force applied to it, and inversely proportional to its mass.
Newton's third law	The forces that two objects exert on each other when they interact are equal and opposite.
Non-contact forces	A force that occurs when objects are physically separated.
Resolution of forces (higher only)	All forces can be resolved into two perpendicular components that have the same effect as the single force.
Resultant force	The single force that can replace all the individual forces acting on an object and have the same effect.

Contact and non-contact forces

Forces either push or pull on an object. This is as a result of its interaction with another object.





Forces are categorised into two groups:.

Contact forces	Non-contact forces
The objects are physically touching	The objects are physically separated
Examples: friction, air resistance, tension, normal contact force	Examples: gravitational force, electrostatic force and magnetic force

Forces are another example of a vector quantity and so they can also be represented by an arrow.

Resultant force

A resultant force is a single force which replaces several other forces. It has the same effect acting on the object as the combination of the other forces it has replaced. The forces acting on this object are represented in a free body diagram. The arrows are relative to the magnitude and direction of the force.

The car is being pushed to the left by a force of 30N. It is also being pushed to the right by a force of 50N. The resultant force is: 50N – 30N = 20N
The 20N resultant force is pushing to the right, so the car will move right.

When a resultant force is not zero, an object will change speed (accelerate or decelerate) or change direction (or both), we say the forces are unbalanced.

When an object is stationary, there are still forces acting upon it. In this case, the resultant force is 30N – 30N = 0N.
The forces are in equilibrium and are balanced (cancel each other out).
When forces are balanced, an object will either remain stationary or if it is moving, it will continue to move at a constant speed.

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Keywords

Scalar quantities	Quantities that only have a magnitude (size), not a direction. Speed, distance, time, energy.
Speed	A scalar quantity that is a measure of the rate of increase of distance.
Vector quantities	Quantities that have both a magnitude and direction. They are represented by an arrow, with the length representing the magnitude and the arrowhead representing the direction. Velocity, acceleration, momentum, displacement, force.
Velocity	A vector quantity that is a measure of the rate of change of displacement. It is the speed in a given direction.
Weight	The force acting on an object due to gravity. It is equal to the product of the object's mass and the gravitational field strength at its location.
Work done	Work is done on an object when a force causes it to move through a distance. It is directly proportional to the distance travelled and the magnitude of the force in the direction of motion.

Speed

Speed: how fast an object moves (usually changing constantly, it does not involve direction = SCALAR QUANTITY) Walking/running/cycling speed depends on many factors including: age, terrain, fitness and distance travelled. Speed of sound & wind also vary.

$$s = v \times t$$

Distance travelled (m) = speed (m/s) x time (s)

Activity	Typical value
Walking	1.5 m/s
Running	3 m/s
Cycling	6 m/s
Car	13-30 m/s (29-67mph)
Aircraft	250 m/s
Sound in air	330 m/s

Velocity and acceleration

Velocity and acceleration are both vector quantities. Velocity is the speed of an object in a given direction.

Acceleration is the rate of change of velocity.

$$a = \frac{\Delta v}{t} \qquad \text{Acceleration (m/s}^2\text{)} = \frac{\text{change in velocity (m/s)}}{\text{time (s)}}$$

Changes in velocity due to acceleration can be calculated using the equation below. This equation of motion can be applied to any moving object which is travelling in a straight line with a uniform acceleration.

$$v^2 - u^2 = 2as$$

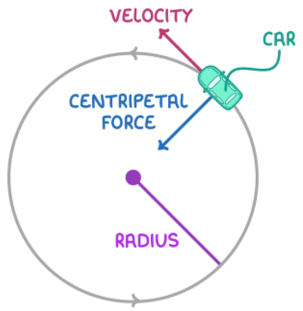
Final velocity^2 (m/s) – initial velocity^2 (m/s) = 2 × acceleration (m/s^2) × displacement (m)

Circular motion (higher only)

An object in **uniform circular motion** has a constant **speed** However, it is **continuously changing direction.** Since velocity is the speed in a given direction, it, therefore, has a **constantly changing velocity**. The object therefore must be **accelerating** (because acceleration is defined as the rate of change of velocity). This acceleration is called the **centripetal acceleration** and is **perpendicular** to the direction of the linear speed (centripetal means it acts **towards the centre** of the circular path).

Centripetal force and acceleration are always directed towards the centre of the circle.

The centripetal acceleration is caused by a **centripetal force** of constant magnitude that also acts **perpendicular** to the direction of motion (towards the centre). For an object in orbit the centripetal force is gravity, for a car turning a corner it is provided by friction.



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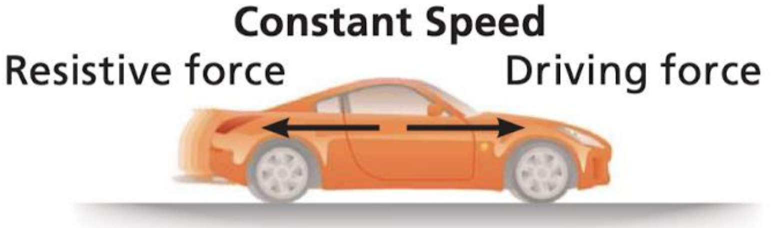
Newton's first law of motion

Newton's first law: an object will remain in the same state of motion unless acted on by an external force. When the resultant force acting on an object is zero:

- if the object is stationary, it remains stationary
- if the object is moving, it continues to move at the same speed and in the same direction, i.e. at constant velocity.

The velocity of an object will only change if there is a resultant force acting on it. For a car travelling at a steady speed, the driving force is balanced by the resistive forces.



Inertia (higher only)

The tendency for objects to continue in the same state of motion is called inertia.

Newton's second law of motion

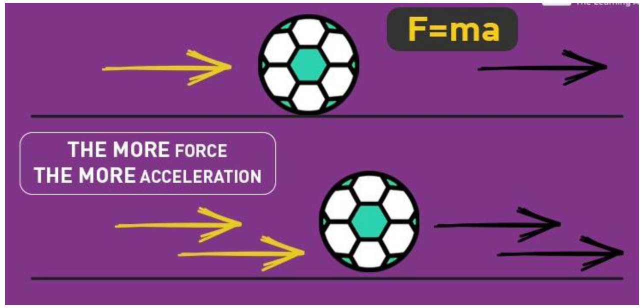
Newton's second law: the acceleration of an object is proportional to the resultant force acting on the object and inversely proportional to the mass of the object, i.e.

- if the resultant force is doubled, the acceleration will be doubled
- if the mass is doubled, the acceleration will be halved.

This law can be summarised with the equation:

F = m x a

Force (N) = mass (kg) x acceleration (m/s^2)



Inertial mass (higher only)

Mass is a measure of inertia. It describes how difficult it is to change the velocity of an object. This inertial mass is given by the ratio of force over acceleration

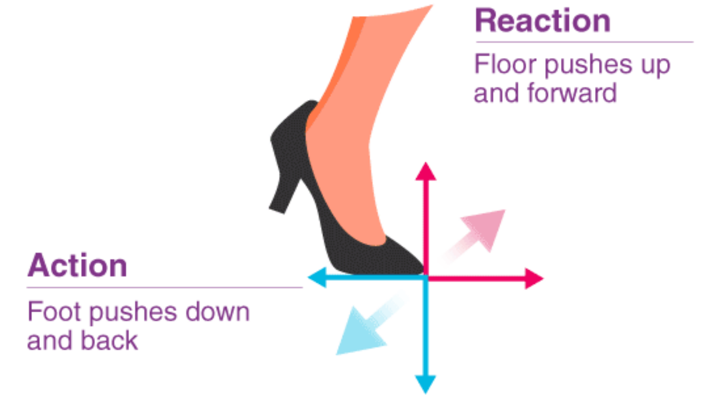
$$m = \frac{F}{a}$$

The larger the mass, the bigger the force needed to change the velocity.

Newton's third law of motion

Newton's third law: Whenever two objects interact, the forces they exert on each other are equal and opposite.

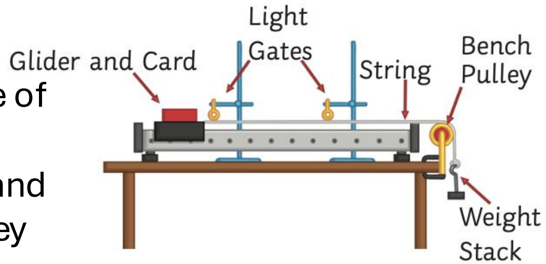
It is often stated as: for every action there is an equal and opposite reaction. This means that whenever one object exerts a force on another, the other object exerts a force back. This reaction force is of the same type and is equal in size, but opposite in direction.



FORCES and MOTION 1

F = ma practical

Investigate the effect of varying the force on the acceleration of an object of constant mass



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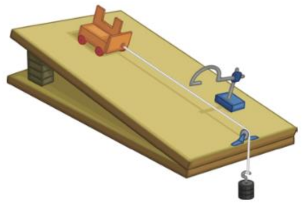

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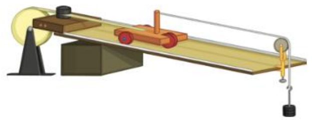


1. Clamp a pulley onto the edge of the desk
2. Attach a string to the trolley and place the string over the pulley
3. Attach a mass holder to the string
4. place a slotted mass on the mass holder
5. Use *W* = *mg* to calculate the force
6. Use light gates and data logger to measure acceleration
7. Repeat for different numbers of slotted masses

The unused masses should be kept on the trolley to keep the mass of the system constant

Friction should be kept to a minimum by using a frictionless trolley, air track or low ramp.

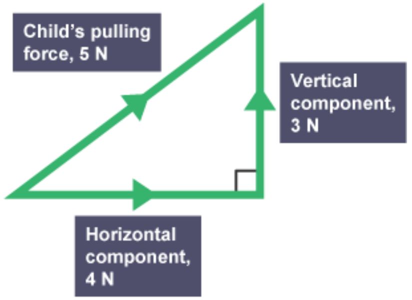
Alternative method to vary force is to vary the height of the runway using wooden blocks. Force is directly proportional to acceleration

To investigate the effect of varying mass on the acceleration use the equipment above but keep the force on the mass hanger constant and vary the mass on top of the trolley. Mass is inversely proportional to acceleration

Resolving vectors (higher only)

A scale vector diagram can be used to calculate resultant forces that are not acting directly opposite of one another, on a straight line.

To resolve vectors by scale drawing means carefully producing a scale drawing with all lengths and angles correct. This should be done using a sharp pencil, ruler and protractor. Follow these steps:



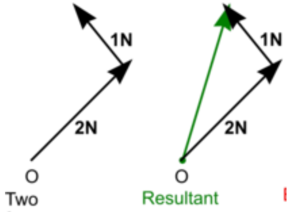
1. Choose a scale which fits to the page. For example, if resolving a resultant force of 100 N, use 1 cm = 10 N so that the resultant drawing is around 10 cm high
2. Clearly mark the starting point and a line to represent either the vertical or horizontal direction. This will depend on the angle given in the question, for example if the direction is '30° east of north' then start with a vertical line representing north
3. Carefully measure the angle and start by drawing the resultant vector including the direction
4. Draw a triangle using two of the sides of this rectangle and measure them to calculate their magnitude according to the scale

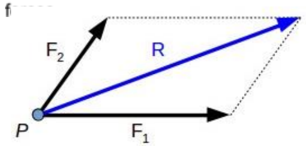
Combining vectors to find a resultant force

There are two methods that can be used to combine vectors using a scale diagram: the **triangle method** and the **parallelogram method**

To combine vectors using the triangle method:

1. link the vectors head-to-tail
2. the resultant vector is formed by connecting the tail of the first vector to the head of the second vector





To combine vectors using the parallelogram method:

1. link the vectors tail-to-tail
2. complete the resulting parallelogram
3. the resultant vector is the diagonal of the parallelogram

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Keywords

Momentum (higher only)	A property of any moving object, calculated as the product of mass and velocity. Measured in kg m/s.
System	Systems involve an object or objects and their interactions. They can be very simple (e.g. a falling object) or very complicated (e.g. our whole galaxy).
Closed system	A system where objects are not thought to be affected by external forces or other objects outside the system. We only think about the objects inside the system, which means the quantities momentum and energy are conserved.
Conservation	Simply means 'keeping the same.' To add detail, conservation of a quantity means that the total amount of it is the same before and after an event. In any closed system, the total amount of energy and momentum before and after an event is equal.

Momentum (higher only)

Momentum is a property that any moving object has. It is defined as the product of mass and velocity of the object, so if the velocity is 0 m/s (stationary), the momentum is also 0. Since momentum is calculated using velocity, which has a direction, momentum is a vector quantity. Just like with velocity, you can show the momenta (the plural of momentum) of objects moving in opposite directions by using a + sign for one of them and a – sign for the other.

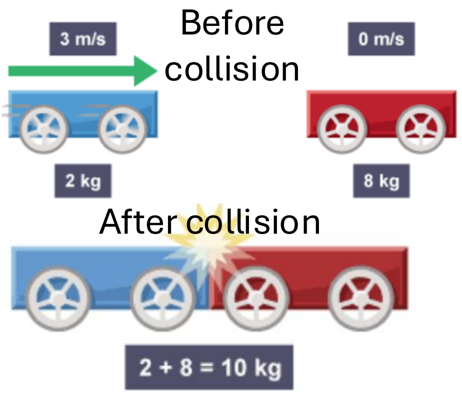
$p = m \times v$

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

Conservation of momentum (higher only)

Momentum is a property that is conserved in closed systems. This means **the total momentum before an event is exactly equal to the total momentum after the event**. This is called conservation of momentum. You can see conservation of momentum in action when objects collide (like snooker balls or cars in a crash) or when something stationary separates (e.g. firing a bullet from a gun or jumping off a stationary skateboard – it also explains why you should be very careful when jumping from a small boat onto the bank).

Conservation of momentum in collisions.



You can use the principle of conservation of momentum to calculate the velocity of the combined trolleys after the collision. **First calculate the momentum of both trolleys before the collision:**

2 kg trolley = 2 × 3 = 6 kg m/s and 8 kg trolley = 8 × 0 = 0 kg m/s

Total momentum before collision = 6 + 0 = 6 kg m/s

Total momentum (*p*) after collision = 6 kg m/s (because momentum is conserved)

Mass (*m*) after collision = 10 kg

Next, rearrange to find v: p = m x v so 6 = 10 x v $v = \frac{6}{10}$ v = 0.6 m/s

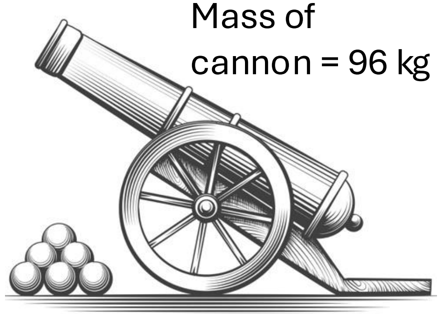
Conservation of momentum in explosions

Calculate the velocity of the cannon immediately after firing. Total momentum of cannon and cannon ball before = 0 kg m/s (because neither object is moving). Total momentum of cannon and cannon ball after collision = 0 kg m/s (because momentum is conserved)

Momentum of cannon ball after firing = 4.0 × 120 = 480 kg m/s

Momentum of cannon after firing = -480 kg m/s (because it recoils in the opposite direction).

Rearrange to find v: p = m x v so -480 = 96 x v $v = \frac{-480}{96}$ v = -5 m/s



Mass of cannon = 96 kg

Cannon ball = 4 kg fired at 120 m/s

Note that the forward velocity of the cannon ball was given a positive value. The negative value for the cannon's velocity shows that it moved in the opposite direction.

PHYSICS WAVES 1

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- Properties of waves and wave types
- Wave structure and time period equation
- Wave speed calculations
- Speed of sound
- Wave required practical

Key Words

Key Word	Definition
Amplitude	The maximum displacement of a wave from its undisturbed (equilibrium) position.
Frequency	The number of waves passing a given point in a second, in hertz (Hz).
Hertz	The unit of frequency.
Period	The time it takes for one complete wave to pass a given point, in seconds (s).
Wave speed	The speed at which energy is transferred through the medium. It is equal to the wave's wavelength multiplied by frequency, in m/s
Wavelength	The distance from a point on one wave to the same point on the adjacent wave (ie. peak to peak or trough to trough), in metres.

Misconceptions

Waves do not carry/move material / matter, they transfer energy.

High amplitude waves do not travel faster than small amplitude waves in the same medium.

All waves do not travel the same way. They all transfer energy but the oscillation direction differs.

Frequency is not connected to loudness. Frequency determines the pitch of a sound and amplitude determines the volume (loudness) which measures energy transferred.

Key questions

What is the difference between transverse and longitudinal waves?

How can the speed of waves in water be measured?

How can the speed of sound in air be measured?

How can you prove waves transfer energy but not matter?

What is the wavelength / amplitude / frequency of a wave?

Physics WAVES 1

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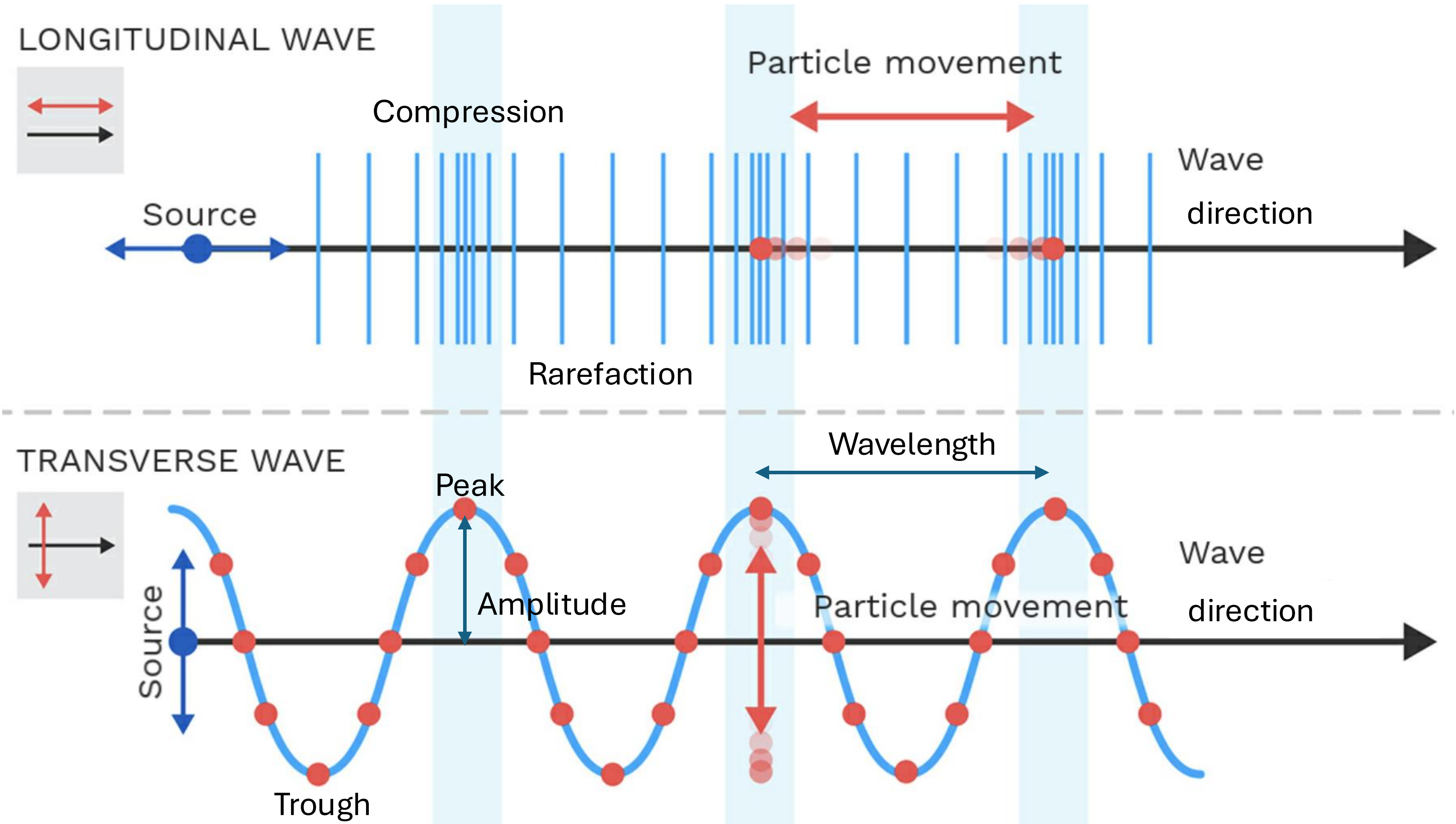
Types of wave

Longitudinal waves	Waves with oscillations that are parallel to the direction of travel/ energy transfer.
Transverse waves	Waves with oscillations that are perpendicular to the direction of travel/ energy transfer.
Compression	A region in a longitudinal wave where the particles are closest together.
Rarefaction	A region in a longitudinal wave where the particles are furthest apart.
Medium	The substance a wave is travelling through.
Oscillation	A repeated movement back and forth/side to side, also called vibration.



Transverse waves: oscillations are perpendicular to the direction of energy transfer. Examples: ripples on water, electromagnetic waves.

T

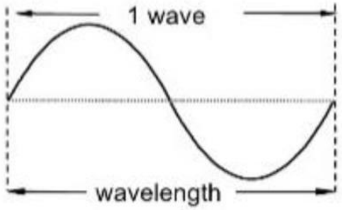
Longitudinal waves: oscillations are para**ll**el to the direction of energy transfer. Examples: sound, ultrasound.

||

Only energy moves from place, not the medium. We can observe this by watching a ball/toy duck floating on water. If a wave is generated the ball will only oscillate up and down. It will NOT move in the direction of energy. Sound waves travelling through air do not leave a vacuum.

Properties of waves and equations

Amplitude: height of wave from middle.
Wavelength: horizontal length of one wave.
Frequency: how many whole waves pass each second. Measured in hertz (Hz). 1 Hz means 1 wave per second.
Period: time for one whole wave to pass.



$T = \frac{1}{f}$

$$\text{Time period (s)} = \frac{1}{\text{frequency (Hz)}}$$

$$v = f\lambda$$

Wave speed (m/s) = frequency (Hz) x wavelength (m)

Physics

WAVES 1

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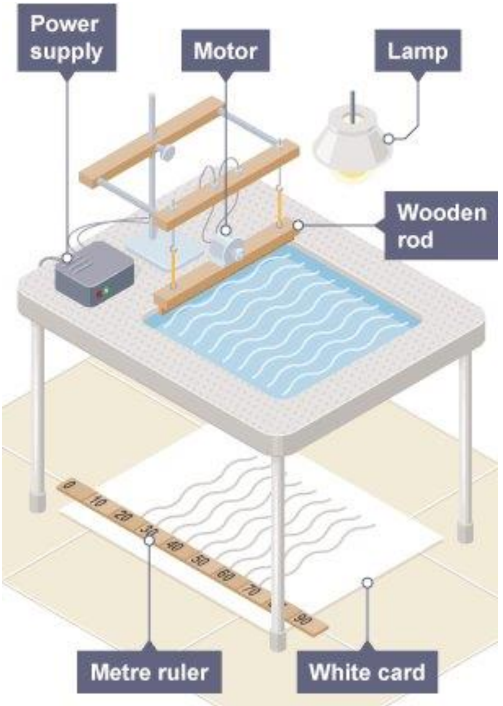
Measuring the speed of water waves – required practical

Use the speed equation: wave speed = wavelength x frequency

Equipment:



Find wavelength of wave:
Measure length of 10 waves using ruler.
Divide measured length by 10 to get 1 wavelength.

Find frequency of the wave using one of the methods below:

1. Counting number of waves in 10 seconds then divide by 10.
2. Using signal generator and strobe, read off frequency from the signal generator - Match motor speed to strobe frequency (wave shadow will appear stationary)

Alternative method:
1. Measure the distance travelled by a wave with a ruler.
2. In 10 seconds using a stopwatch
3. Distance / Time = Speed

To improve the accuracy:
For wavelength measure across a number of waves (e.g. 10 of them) and then divide the distance (in m) by the number of waves.
For frequency measure across a longer time period (e.g. 60 s) and then divide the number of waves by the time

Measuring speed of waves in a solid – required practical

Use the speed equation: wave speed = wavelength x frequency

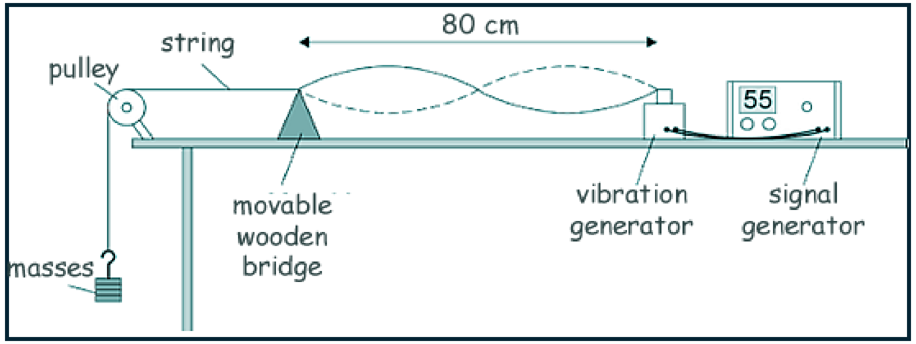


Diagram shows 1 wavelength (2 half waves)

As frequency increase bridge will need moving to the right to keep 1 wavelength

Find wavelength of wave:
Move wooden bridge to create a standing wave (wave appears stationary)
Count number of half wavelengths on string and measure total length with ruler
Find length of 1 half wave (total length ÷ number of half waves, then x2 to find one wavelength

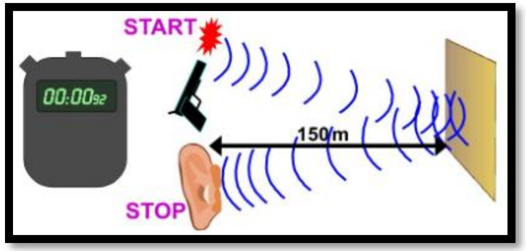
Find frequency of the wave:
Record from signal generator for your measured wavelength

Change frequency and repeat

To test effect of string tension, add/remove masses from string

Measuring the speed of sound

Use the speed equation: $\text{Speed} = \frac{\text{Distance}}{\text{Time}}$



1. Measure the distance the sound travels using trundle wheel/tape measure. (Distance to wall and back).
2. Time how long it takes for the echo to return with stopwatch.
3. Divide the distance by the time.

To reduce errors, repeat multiple times, remove anomalies and calculate a mean or use 2 microphones connected to a data logger with a digital timer

PHYSICS Forces and Motion 2 (combined)

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Paper 2:KS4

Gravity (W=mg)	Uniform acceleration	Velocity-time graphs	Terminal velocity	Distance-time graphs	Stopping distance	Factors affecting braking	Springs and Ee	Hooke's law

Key Words

Key Word	Definition
Acceleration	The rate of change of velocity. Can be calculated from the gradient of a v-t graph.
Braking Distance	The distance a vehicle travels under the braking force.
Centre of Mass	The single point through which the weight of the object can be said to act.
Elastic Deformation	Non-permanent deformation which allows the object to return to its original shape when the deforming forces are removed.
Elastic Limit	The force beyond which an object will no longer deform elastically.
Limit of Proportionality	The point beyond which the extension of an elastic object is no longer directly proportional to the force applied to it.
Newtonmeter	A calibrated spring-balance used to measure weight.

Misconceptions

Weight is not the same as mass

Weight is a force due to gravity, mass measures the matter an object is made from

Acceleration is not the same as velocity

Acceleration is the rate of change of velocity, velocity is distance covered over time

A positive acceleration does not mean getting faster

Acceleration is a vector, a +/- shows direction the number = size of acceleration

Elastic potential energy is not only stored in stretched elastic objects

Ee is stored when stretched or compressed

Key questions

What is the relationship between mass and weight?

What are the features of distance-time and velocity-time graphs?

What are the factors that affect thinking and braking distance?

What is stopping distance?

What is the relationship between force and extension? How can it be investigated?

Physics Forces and Motion 2

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Key words

Key Word	Definition
Inelastic Deformation	Permanent deformation - the object will no longer return to its original shape when the deforming forces are removed.
Spring Constant	A measure of a spring's stiffness.
Stopping Distance	The sum of the thinking and braking distances.
Thinking Distance	The distance a vehicle travels during the driver's reaction time. Typical human reaction times are in the range of 0.2-0.9 seconds.
Weight	The force acting on an object due to gravity.

Weight, mass, gravity

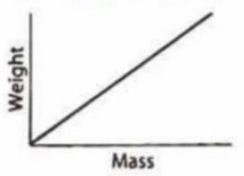
Weight (N) = mass (kg) x gravitational field strength (N/kg)

$W = m \times g$

Weight is directly proportional to mass ($W \propto m$)

- Doubling mass = double weight

Gravitational field on Earth = 9.8 N/kg



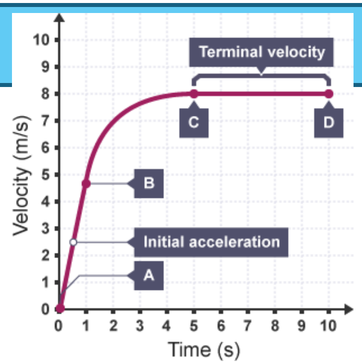
Acceleration

$v^2 - u^2 = 2as$ v = final velocity (m/s), u = initial velocity (m/s), a = acceleration (m/s^2), s = displacement (m)

Applies to uniform (constant) acceleration

Near Earth's surface any object falling freely under gravity has an acceleration of about 9.8 N/kg

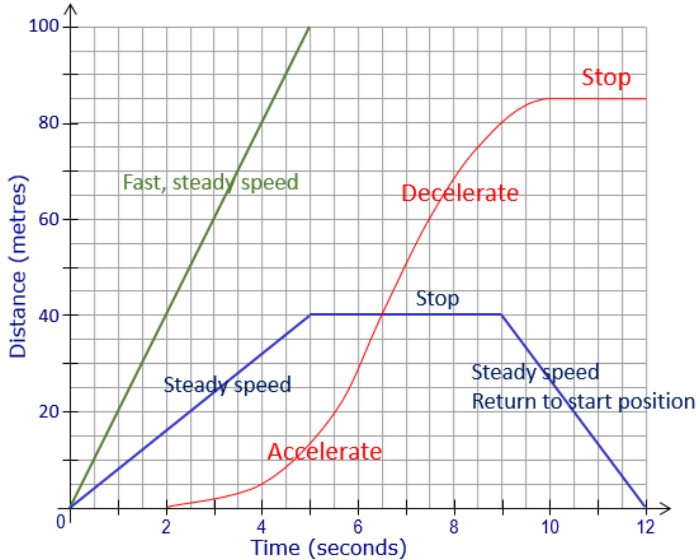
Terminal velocity



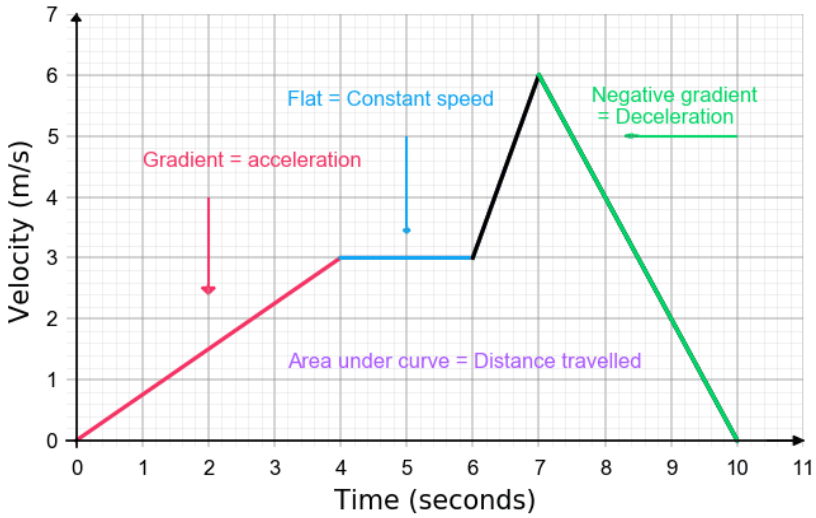
Objects falling through a fluid (including air):

- Accelerate because of gravity (A-B)
- Resistance force increases as it gets faster (B-C)
- Eventually, resistance force balances gravity = zero resultant force
- Object stops accelerating and falls at constant velocity (called terminal velocity) (C-D)

Distance-time graph features



Velocity-time graph features



Physics Forces and Motion 2

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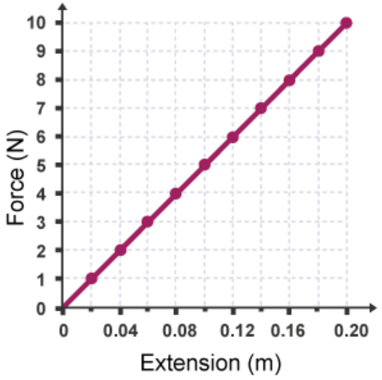
Factors affecting stopping distance

Thinking distance	Braking distance
Alcohol increases reaction times increasing thinking distance	Wet or icy roads reduce friction between the tyres and road increasing braking distance.
Distractions increase reaction times increasing thinking distance	Worn tyres and brakes reduce friction between the tyres and road increasing braking distance.
Increased speed increases the distance travelled during their reaction time increasing thinking distance	Increased speed increases the force needed to stop the car increasing braking distance.
Tiredness increases reaction times increasing thinking distance	Larger mass means larger force needed to decelerate the vehicle, causing increasing breaking distance.
Stimulants decrease reaction times decreasing thinking distance	Loose road surface reduce friction between the tyres and road increasing braking distance.

- Force applied to brakes → work done by friction between brakes and wheel → decreases kinetic energy of vehicle and increases thermal energy (temperature) of brakes
- Greater speed needs greater braking force to stop vehicle in certain distance
- Greater braking force → greater deceleration of vehicle
- Large decelerations may lead to brakes overheating and/or loss of control (skidding)

Springs and elastic potential energy

Force applied to a spring is directly proportional to the extension ($F \propto e$) if limit of proportionality is not exceeded



Force (N) = spring constant (N/m) x extension (m) $F = k \times e$
(works for compression or extension)

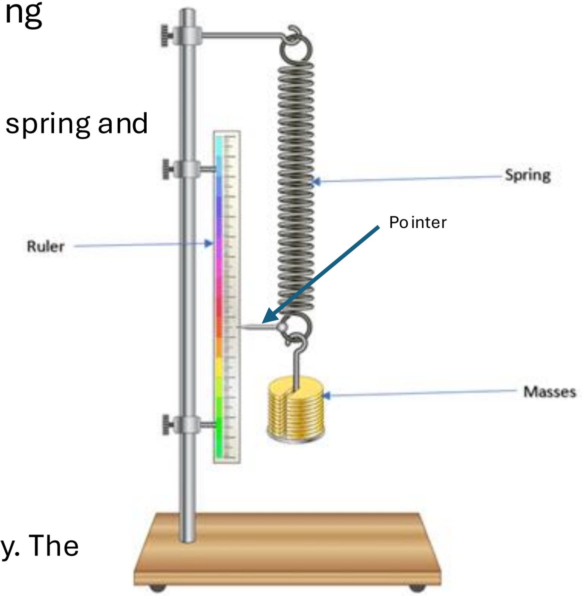
Spring constant = gradient of the graph →

Gradient = $\frac{Change\ in\ y}{change\ in\ x}$

Elastic potential energy (J) = 0.5 x spring constant (N/m) x extension^2 (m)
Area under graph = elastic potential energy stored (up to limit of proportionality)

Hooke's law – required practical

Investigate relationship between force and extension for a spring



1. Set up the equipment as shown in the diagram.
2. Ensure 0cm on the ruler is level with the bottom of the unstretched spring and the ruler is vertical.
3. Add a 100 g mass to the spring.
4. Read the extension of the spring from the ruler using the pointer
5. Add 200g to the spring. Measure the new extension using the ruler.
6. Repeat steps 2-5 for masses of 300g, 400g, 500g, 600g.
7. Calculate the weight of each mass using **W = m x g**
8. Plot a graph of extension against force.

Safety considerations

1. Wear safety goggles. The spring could snap and damage eyes
2. Place a cushion under the masses and keep your feet out of the way. The masses could fall and hurt feet or damage the floor.

PHYSICS

WAVES 2 combined

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Paper 2:KS4

- Waves recap
- Electromagnetic waves – non ionising
- Electromagnetic waves - ionising
- Infrared radiation
- Refraction

Key Words

Key Word	Definition
Angle of Incidence	The angle between the incident ray and normal.
Angle of refraction	The angle between the refracted ray and normal.
Colour	Colour is determined by frequency and wavelength.
Electromagnetic Waves	Transverse waves that transfer energy from the source of the waves, to an absorber. They form a continuous spectrum of different frequencies and all travel at the same speed in a vacuum.
Ionising Radiation	Radiation that can cause the mutation of genes and cause cancer.
Normal	The normal is an imaginary reference line that is constructed perpendicular to a boundary at the point that the wave intercepts it.
Refraction	When a wave changes direction as it crosses a boundary.

Misconceptions

Light waves and radio waves are the same thing. They are both EM waves.

Different colours of light are not different types of waves. They are all EM waves just with different wavelengths.

The speed of light can change. Depends on the density of the material.

In refraction, the characteristics of the wave do not change. Frequency stays the same, only wavelength changes, changing the speed.

Key questions

What is ionising radiation and how is it damaging?

What is refraction?

What is the electromagnetic spectrum?

How does surface effect the amount of IR emitted/absorbed?

(HT) How are radio waves produced?

Physics WAVES 2 combined

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Paper 2:KS4

Electromagnetic spectrum

Radio Waves	Used for television and radio signals.	Cause alternating current in receiver circuits and can bend over the top of hills
Microwaves	Used for satellite communications and for cooking food.	Cause water molecules to vibrate more when absorbed (get hotter) & can pass through ionosphere to get to and from satellites
Infrared (IR)	Used for cooking food, electrical heaters and infrared imaging.	Given off by hot objects & make something hot when absorbed
Visible Light	The only type our eyes can detect. Used for fibre optic communications.	Go through glass fibres
Ultraviolet (UV)	Used in energy efficient lamps and for sun tanning.	Skin turns brown to try and protect flesh from the UV
X-rays	Used to take medical X-ray scans.	Pass through flesh, not bone & destroy cells e.g. cancer cells
Gamma rays	Used to sterilise medical equipment and in cancer treatment.	

Changes in atoms/nuclei of atoms can result in EM waves being generated/absorbed:

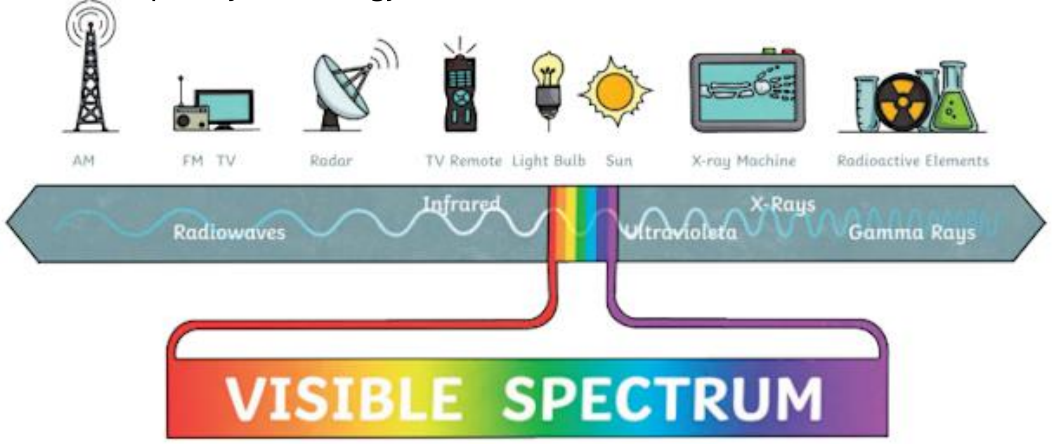
- Electrons moving between energy levels can generate waves, e.g. infrared waves, visible light, ultraviolet waves and X-rays.
- Changes in the nucleus of an atom can generate waves, e.g. an unstable nucleus can give out excess energy as gamma rays.

Each group contains a range of frequencies.

- red light has the lowest frequencies of visible light
- violet light has the highest frequencies of visible light

Longest wavelength
Lowest frequency and energy

Shortest wavelength
Highest frequency and energy

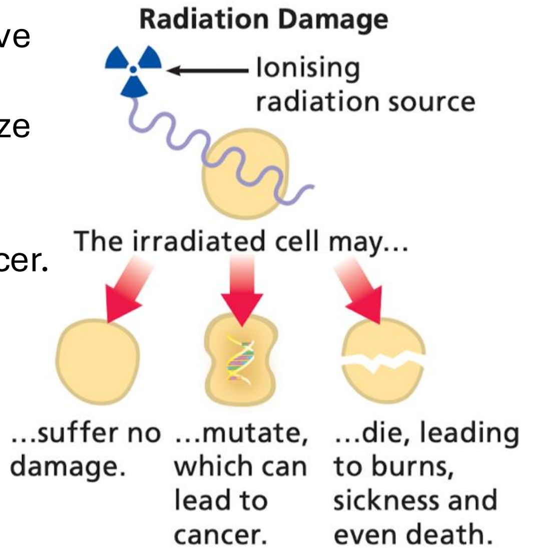


Dangers of EM waves

Ultraviolet waves, X-rays and gamma rays can have hazardous effects on human body tissue. The effects depend on the type of radiation and the size of the dose.

- Ultraviolet waves can cause skin to age prematurely and increase the risk of skin cancer.
- X-rays and gamma rays are ionising radiation that can cause the mutation of genes and cancer.

Radiation dose (in sieverts) is a measure of the risk of harm resulting from an exposure of the body to the radiation. 1000 millisieverts (mSv) = 1 sievert (Sv)



Radiation Damage

Ionising radiation source

The irradiated cell may…

…suffer no damage.

…mutate, which can lead to cancer.

…die, leading to burns, sickness and even death.

Physics WAVES 2 combined

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Paper 2:KS4

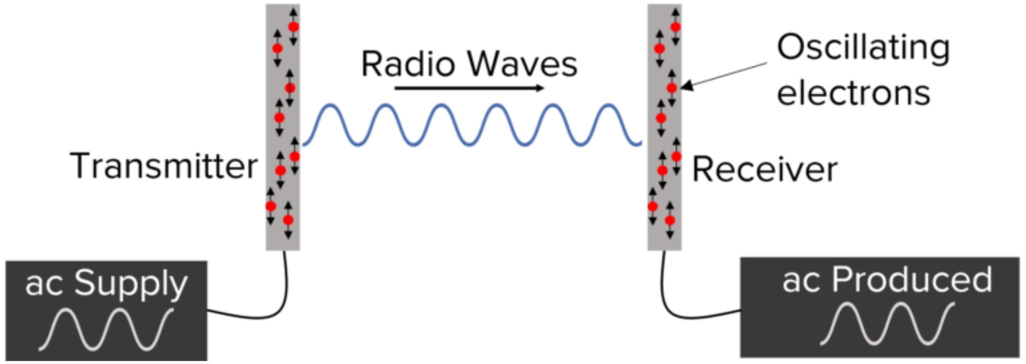
Properties of EM waves

Absorb	Take waves in
Transmit	Pass waves through
Refract	Bend waves so they change direction (due to the difference in velocity of the waves in different substances)
Reflect	Bounce waves back

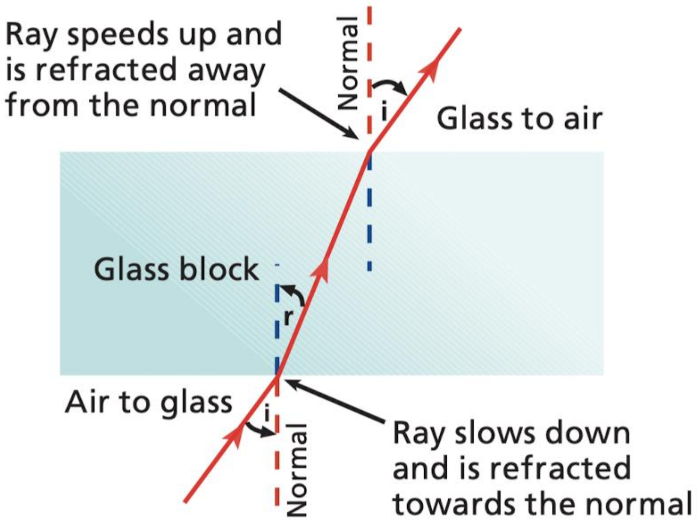
Different substances do each of the above in ways that vary with wavelength.

Radio waves (higher tier)

Radio waves can be produced by oscillations of electrons in electrical circuits (transmitters). When they are absorbed, they create an alternating current with the same frequency as the radio wave itself, so radio waves can themselves induce oscillations in an electrical circuit (a receiver).



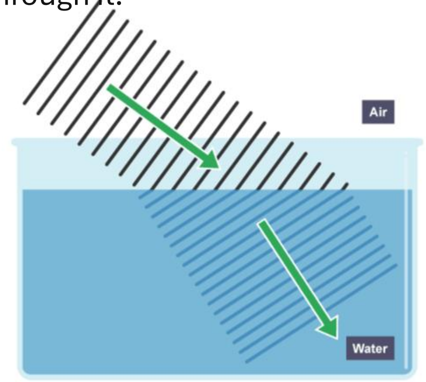
Refraction


Refraction of Light Ray Through a Glass Block

Different materials have different densities. Light waves may change direction at the boundary (refract) between two transparent materials.
Less dense to more dense ray bends towards normal, more dense to less dense ray bends away from normal.

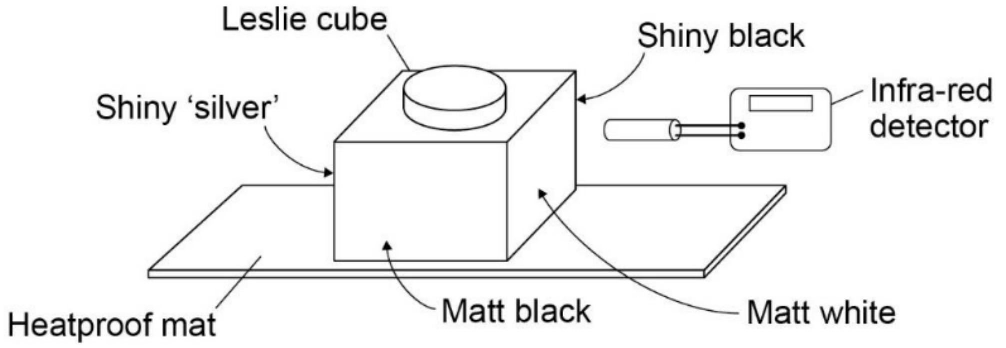
(HT) The density of a material affects the speed that a wave will be transmitted through it.

The denser the material, the more slowly light travels through it. If a wave slows down, its wavelength will decrease. The effect of this can be shown using wave front diagram.



IR Radiation and absorption

1. Fill Leslie cube with boiling water.
2. Use IR detector to measure the amount of infrared radiated from each surface.
3. Make sure that the detector is the same distance from each surface.
4. Should find: matt radiates more than shiny & black (dark) radiates more than white (light).



PHYSICS

MAGNETISM and ELECTROMAGNETISM (combine

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Paper 2:KS4

- Magnetism
- Magnetic fields
- Magnetism in wires
- Motor effect (HT)
- Fleming’s left-hand rule (HT)

Key Words

Key Word	Definition
Attraction	Opposite poles will experience a force of attraction, meaning they will experience a force towards each other. The force between a magnet and magnetic material is always one of attraction.
Electromagnet	A solenoid with an iron core.
Induced magnet	A material that becomes a magnet when it is placed in an existing magnetic field but loses its magnetism quickly once it is removed. Induced magnetism always produces attractive forces.
Permanent magnet	A magnet that produces its own magnetic field.
Repulsion	Like-poles will experience a force of repulsion, meaning they will experience forces in opposite directions.
Solenoid	A wire wrapped into the shape of a coil, that has a strong and uniform magnetic field inside of it. The solenoid’s magnetic field strength can be increased by adding an iron core.

Misconceptions

Larger magnets are not always stronger than smaller magnets (also depends on material)

All metals are not magnetic – iron, cobalt and nickel are magnetic elements, materials containing these can be magnetic e.g. steel

In a magnet, the field lines do not only exist outside the magnet

There is not a magnetic north pole at geographic north, it is a magnetic south that attracts the north pole in the compass to show geographic north

Key questions

What is a magnetic field?

What materials are magnetic?

How can the strength of a magnetic field around a wire be increased/ reversed?

(HT) How can the direction a motor will turn be identified?

(HT) What is the motor effect?

Physics MAGNETISM and ELECTROMAGNETISM (combine

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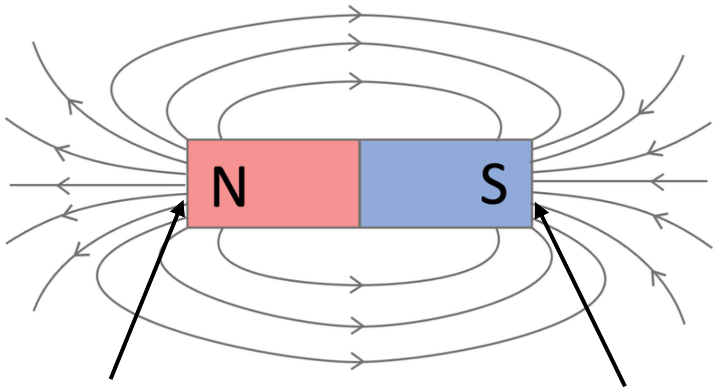
Paper 2:KS4

Key words

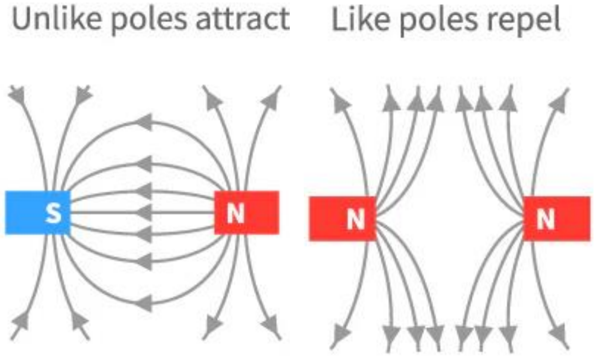
Key word	Definition
Current carrying wires	When current flows through a wire, a magnetic field is generated around it. The strength of the field is dependent on the magnitude of the current and the distance from the wire.
Magnetic compass	A device containing a small bar magnet that points in the direction of the Earth's magnetic field.
Magnetic field lines	Lines representing the strength and direction of a magnetic field. The field line direction at any point is in the direction that a force would act on another north pole if placed at that point.
Magnetic field	The region around a magnet in which another magnet or magnetic material will experience a force.
Magnetic materials	Iron, steel, cobalt and nickel.
Magnetic poles	The regions of a magnet where the magnetic forces are at their strongest.

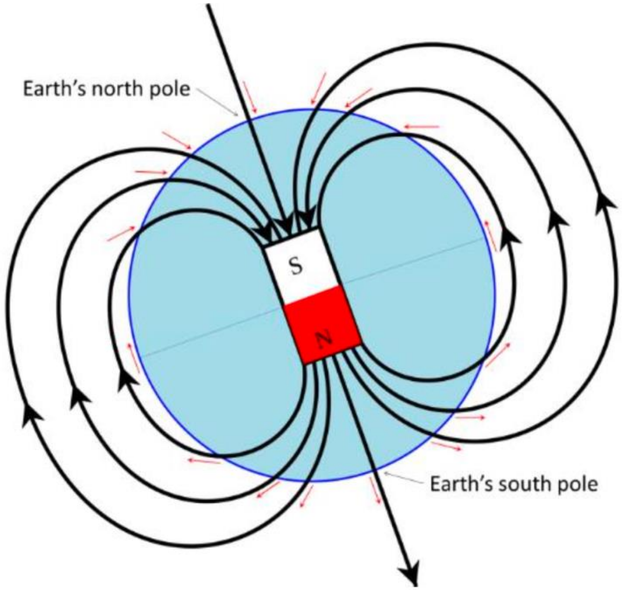
Magnetic fields

Magnetic field: region around a magnet where a force acts on another magnet or magnetic material.
The magnetic materials are: iron, steel, cobalt and nickel.
Force between a magnet and a magnetic material is always only attraction.
Strength of magnetic field depends on the distance from the magnet (stronger at shorter distances)
Field is strongest at the magnet's poles.
Direction of magnetic field at any point is given by the direction of the force that would act on another north pole placed at that point.
Direction of magnetic field lines is from the north (seeking) pole of a magnet to the south (seeking) pole of the magnet.



Lines closer together = stronger field





A magnetic compass contains a small bar magnet.
The Earth has a magnetic field.
The compass needle points in the direction of the Earth's magnetic field.
This is evidence for the core of the Earth being magnetic.

Electromagnetism

When current flows through a conducting wire → magnetic field around the wire.

Shape of magnetic field is series of concentric circles in a plane, perpendicular to the wire.

Direction of field lines depends on direction of current.

Strength of field depends on current through the wire and the distance from the wire.

Shaping wire into a solenoid increases strength of field created because the coils create a dense region of magnetic field (more coils → denser → stronger field)

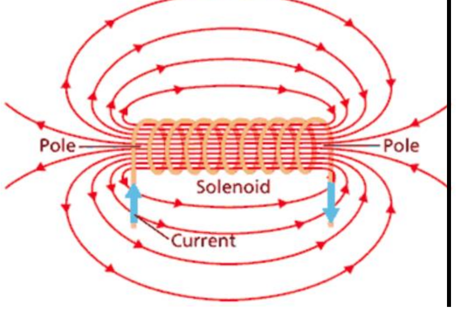
Magnetic field inside a solenoid is **strong** and **uniform**.

The magnetic field around a solenoid has a similar shape to that of a bar magnet.

Adding an iron core increases the magnetic field strength of a solenoid.

An electromagnet is a solenoid with an iron core.

Right-hand can be used to find poles – curl fingers aligned with current (+→-) and thumb points to north

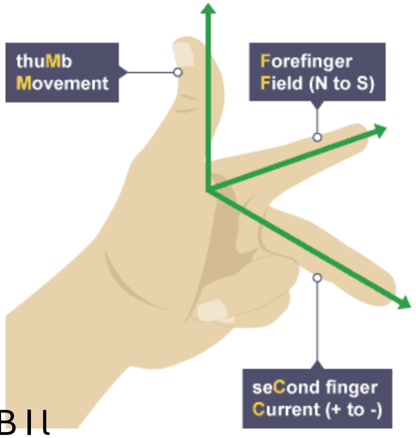


Fleming's left-hand rule (HT only)

Place a conductor carrying a current in a magnetic field → magnet producing the field and the conductor exert a force on each other. Called the motor effect.

Reverse current or field direction → direction of force reversed.

Direction of force found using Flemming's Left Hand Rule:



For a conductor at right angles to a magnetic field and carrying a current: $F = B\,I\,l$

Force (N) = magnetic field strength (T) x current (A) x length of wire (m)

T = teslas

Motors (HT only)

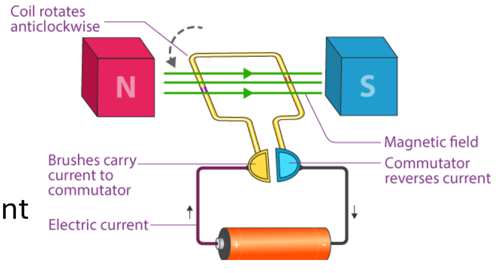
A coil of wire carrying a current in a magnetic field tends to rotate.

Explanation: current → magnetises coil → magnetic field around coil → interacts with field it is in → fields repel → coil rotates

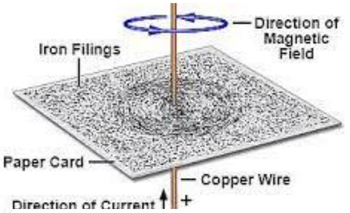
This is the basis of an electric motor.

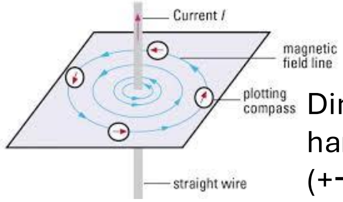
The force on a conductor in a magnetic field causes the rotation of the coil in an electric motor.

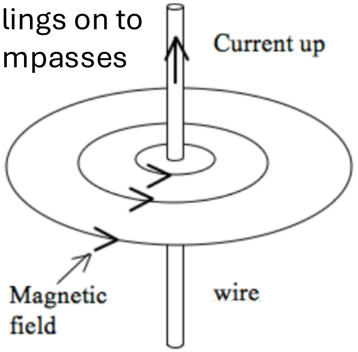
Split ring commutator used to reverse the current every half turn and keep the motor spinning

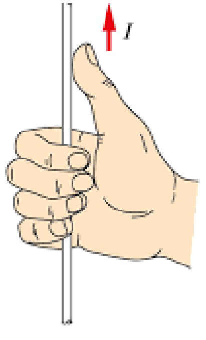


Field can be seen by sprinkling iron filings on to card and tapping/ placing plotting compasses









Direction of field can be found using right-hand – thumb points in direction of current (+→-), curl of fingers shows direction of field

Key words (HT only)

Key word	Definition
Electric motor	A current-carrying coil of wire in a magnetic field. The two sides of the coil that are perpendicular to the magnetic field experience forces in opposite directions, causing rotation.
Fleming's left-hand rule	A rule used to determine the orientation of the force (thumb), current (second finger) and magnetic field (first finger) when a current-carrying wire is placed in a magnetic field (motor effect).
Motor effect	When a current-carrying wire is placed in a magnetic field, a force will be experienced between the wire and the magnet responsible for the field.

Physics Working scientifically terms Paper 2:KS4

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Working scientifically term	Definition	Example/how to improve
Accurate / accuracy	Result that is close to the true value	Improve method, reduce random errors, use higher resolution equipment Measure across multiple waves and divide to find wavelength of one, time for 10 seconds and divide when finding frequency
Valid result	Test only the effect of the independent variable on dependent variable	Use control variables - keep everything else the same between what you are testing
Random error	Results vary in unpredictable ways	Reduced by making more measurements, ignoring anomalies (results that don't fit pattern) and calculating a mean
Systematic error	Results differing from the true value by a consistent amount each time	Reading above/below eye line on measuring cylinder the same each time
Zero error (specific type of systematic error)	Equipment that should read 0 but doesn't	Newton meter / stop watch - zero before using or read error value and add to finial measure if it is a negative and subtract if it is a positive
Precise	Results that cluster closely	Small amount of variation between repeats (must have repeated values to identify), uncertainty value will be small
Uncertainty	How far above (+) or below (-) mean the results are	Difference (between highest and lowest result) ÷ 2 Given as ±, add uncertainty value to mean to find highest result, subtract for lowest
Resolution	Smallest measurement that equipment can make	12.1°C = resolution of 0.1°C Higher resolution equipment will give more accurate result
Repeatable	Repeats under same condition by same investigator give similar pattern	Repeat investigation
Reproducible	Similar results are obtained by different investigators with different equipment	Ask someone else to repeat investigation