

P5 Moments, levers and gears

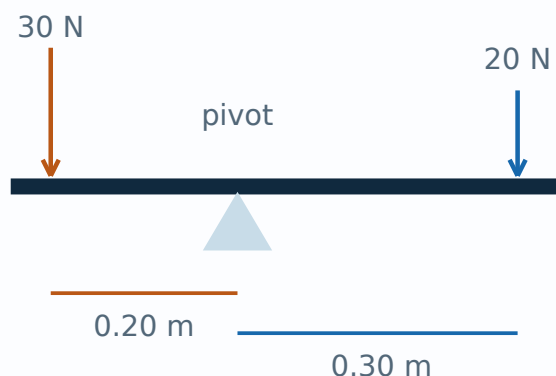
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Use alongside the shared topic notes. Foundation + Higher content.

Calculate a turning effect

$$M = F d$$

Moment M is in N m . Force F is in N . Distance d is the **perpendicular** distance in metres from the pivot to the force's line of action.



A balanced object has equal total clockwise and anticlockwise moments. Here $30 \times 0.20 = 20 \times 0.30 = 6 \text{ N m}$.

Use a lever



Longer effort arm: less force needed

The effort moves through a greater distance

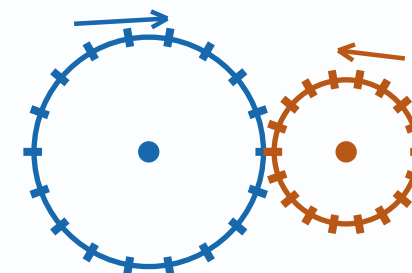
A lever transmits the turning effect of a force. Moving the effort farther from the pivot increases its moment for the same force.

A smaller effort can balance a larger load when the effort's perpendicular distance is larger.

Example: a 120 N load acts 0.10 m from a pivot. At 0.60 m on the other side, an effort of 20 N balances it.

Take care: the distance along a tilted lever is not always the perpendicular distance required.

Transmit rotation with gears



larger gear

smaller gear

Meshed gears rotate in opposite directions

Teeth transfer force between meshed gears. Adjacent gears rotate in opposite directions.

A small driving gear turning a larger gear gives slower output rotation and a larger turning effect. Reversing this arrangement gives faster output with a smaller turning effect.

Gears and levers transfer energy; they do not create it. A greater force or moment comes with a change in distance moved or rotational speed.

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P5 Fluid and atmospheric pressure

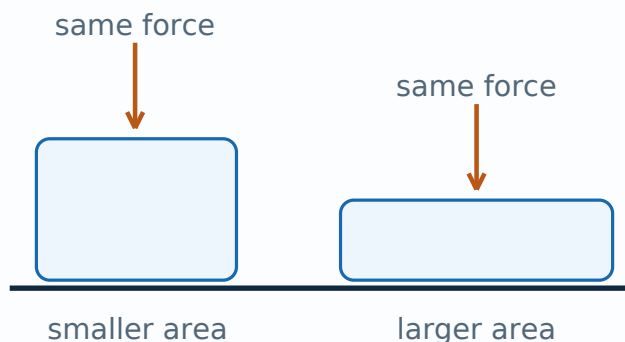
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Use alongside the shared topic notes. Foundation + Higher content.

Pressure is force per area

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

Pressure p is in pascals (Pa), force F in newtons (N), and area A in square metres (m^2). One pascal is one newton per square metre.



Pressure depends on force per unit area

For the same normal force, a smaller area gives a larger pressure. Convert area carefully: $1 \text{ cm}^2 = 10^{-4} \text{ m}^2$.

Liquids and gases are fluids

A fluid can flow: it may be a liquid or a gas. Fluid pressure causes a force **normal** to a surface, meaning at right angles to it.

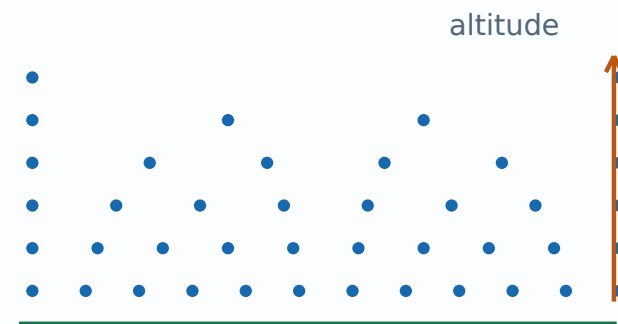
Example: a fluid exerts a 240 N normal force on 0.060 m^2 .

$$p = \frac{240}{0.060}$$

Pressure = **4000 Pa**. Rearrange as $F = pA$ to calculate the normal force on a known area.

Pressure is a scalar; force has direction. Draw force arrows perpendicular to each surface, including curved surfaces.

Why air pressure falls



Air becomes less dense as altitude rises

Air molecules collide with surfaces and produce atmospheric pressure. Earth's atmosphere is thin compared with Earth's radius.

At higher altitude there is less air above the surface, so the weight of the air above is smaller. The atmosphere is also less dense.

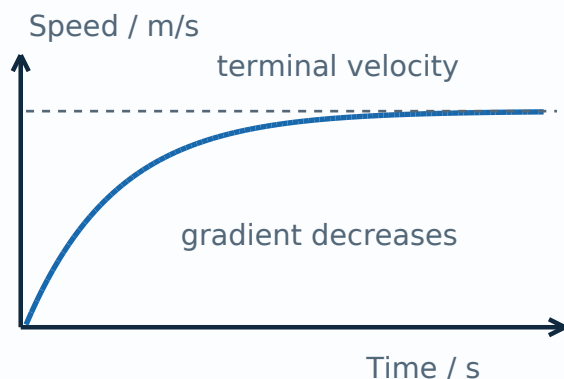
Atmospheric pressure therefore decreases with increasing altitude. Do not say gravity becomes zero: the explanation is the smaller weight of air above.

P5 Terminal velocity and stopping graphs

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Use alongside the shared topic notes. Foundation + Higher content.

Explain a terminal-speed curve

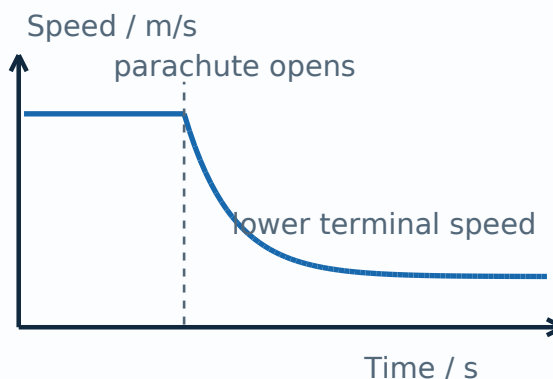


Just after release, weight exceeds drag, so the falling object accelerates. As speed rises, drag increases.

The resultant downward force gets smaller, so acceleration decreases: the speed-time curve becomes less steep.

At terminal velocity, drag balances weight. Resultant force and acceleration are zero, and speed is constant. Balanced forces do not mean the object has stopped.

Interpret a parachute graph

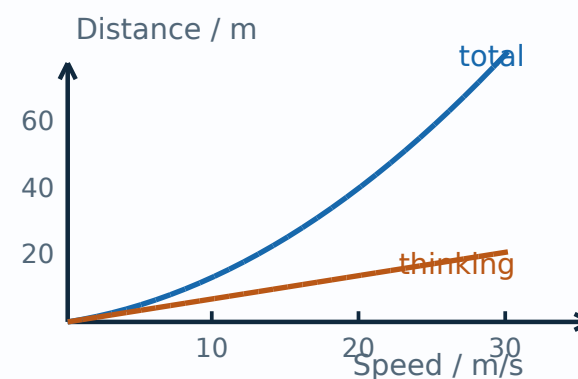


Opening a parachute increases drag. Initially drag exceeds weight, so the resultant force is upward and the falling person slows down.

As speed decreases, drag decreases. Eventually drag again balances weight and the person falls at a lower terminal velocity.

A downward-moving person can have an upward resultant force: the force changes the velocity; it need not point in the motion's direction.

Estimate stopping distances



Stopping distance = thinking distance + braking distance. Read the total at the stated speed; subtract one part from the total to find the other.

Use a graph's scale and units to estimate between plotted values. The illustrative model here gives about 41 m at 20 m/s.

At the same speed, compare vehicle curves directly. Wet roads, worn tyres, poor brakes and greater load can increase braking distance; tiredness can increase thinking distance.

P5 Liquid pressure and upthrust

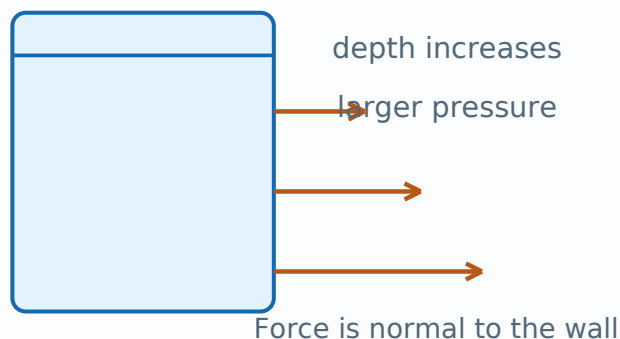
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Use alongside the shared topic notes. Higher-tier material is kept on this separate page.

Pressure grows with depth

$$p = h \rho g$$

h is depth in m, ρ is liquid density in kg/m^3 and g is gravitational field strength in N/kg . This gives pressure due to the liquid column in Pa.



Greater depth means a taller liquid column above; greater density means more mass in that column. Both increase the pressure.

Calculate pressure changes

Example: water has density 1000 kg/m^3 and $g = 9.8 \text{ N/kg}$. Find the increase in pressure from 2 m to 5 m depth.

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

$\Delta h = 3 \text{ m}$, so $\Delta p = 3 \times 1000 \times 9.8 = \mathbf{29\,400 \text{ Pa}}$.

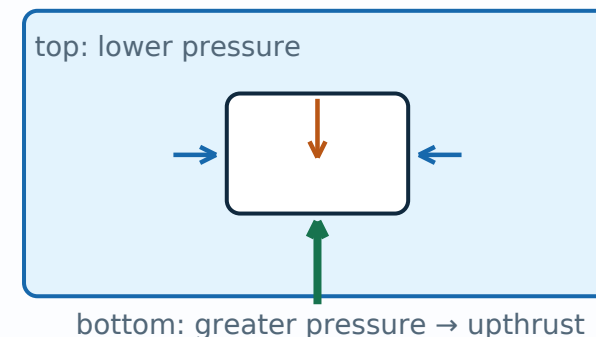
Use the change in depth for a pressure difference. The same atmospheric pressure acts at the surface and cancels in the comparison.

For total pressure at depth in an open liquid, add atmospheric pressure if the question asks for it.

Check: twice the depth gives twice the pressure due to the liquid, if density and g stay constant.

Explain floating and sinking

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Pressure is greater on the bottom surface than the top. This difference produces a resultant upward force called **upthrust**.

An object rises if upthrust exceeds weight and sinks if weight exceeds upthrust. It floats at rest when the forces balance.

For a freely floating object, the displaced liquid's weight equals the object's weight. Average density helps predict whether an object can float.

P5 Momentum calculations and safety

Separate Physics extras | AQA 8463 | HIGHER ONLY

Use alongside the shared topic notes. Higher-tier material is kept on this separate page.

Conserve total momentum

Shared foundation: momentum $p = mv$, measured in kg m/s. In a closed system, total momentum before equals total momentum after an event.



Before: $(2 \times 3) + (1 \times 0) = 6$ kg m/s. After the trolleys join: $3v = 6$, so $v = \mathbf{2 \text{ m/s}}$.

Choose a positive direction. A velocity in the opposite direction is negative. Include every object in the system.

Force changes momentum

$$F = \frac{m \Delta v}{\Delta t}$$

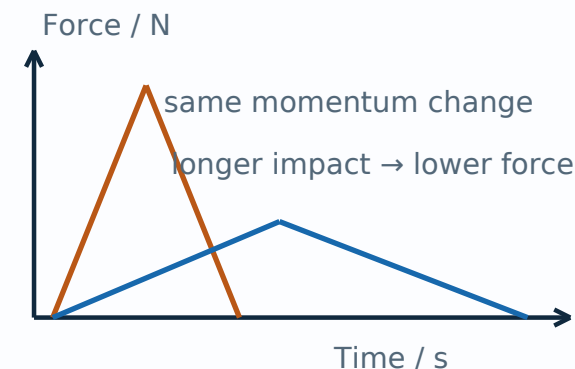
The average resultant force equals change in momentum divided by time. For constant mass, $\Delta v = \text{final velocity} - \text{initial velocity}$.

Example: a 0.15 kg ball changes from +20 m/s to -10 m/s in 0.050 s.

$\Delta v = -30$ m/s. $F = 0.15 \times (-30) \div 0.050 = \mathbf{-90 \text{ N}}$. The force is opposite the chosen positive direction.

A rebound can give a larger momentum change than stopping. Use signed velocities before calculating the change.

Explain safety features



For the same momentum change, increasing the stopping time reduces the average force.

Airbags, seat belts, crash mats, helmets and cushioned surfaces deform or stretch, increasing the time taken to stop.

Link the feature to time and then force:
longer stopping time → smaller rate of momentum change → smaller average force.

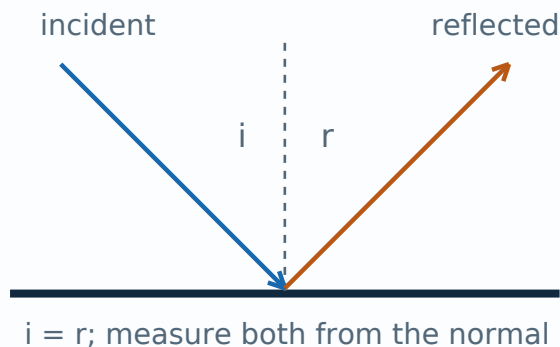
The sketch compares impacts with the same momentum change; it does not imply their peak forces are equal.

P6 Wave boundaries and practical rays

Separate Physics extras | AQA 8463 | CORE

Use alongside the shared topic notes. Foundation + Higher content.

Reflection at a boundary

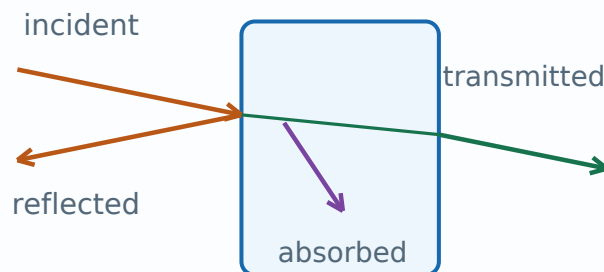


The angle of incidence equals the angle of reflection. Measure both angles from the **normal**, drawn at 90° to the surface.

Use a ruler for rays and a protractor for angles. Add arrowheads to show light's direction.

Different surfaces give different patterns: a smooth surface gives specular reflection; a rough surface scatters light in many directions.

Reflection, absorption, passage

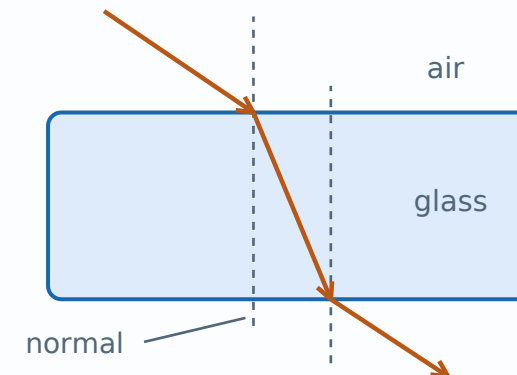


At a boundary, waves can be reflected, absorbed or transmitted. More than one process may happen.

Absorbed wave energy transfers to the material. Transmitted waves continue into or through the material.

A material can transmit some wavelengths and absorb others. The proportions depend on the material and the wave.

Required practical 9



Trace a block's outline. Shine a narrow ray into it, mark ray positions, remove the block and join the marks. Draw a normal at each boundary.

Measure angles from the normal. Repeat for different incidence angles or substances. Compare smooth and rough reflecting surfaces.

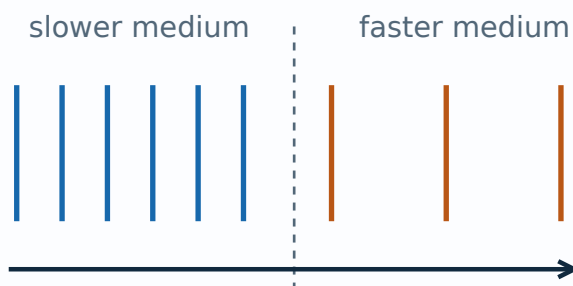
Use several well-spaced marks, fine pencil lines and a narrow ray. Avoid shining the ray box into eyes. The glass path shown bends towards the normal on entry.

P6 Sound speed, frequency and wavelength

Separate Physics extras | AQA 8463 | CORE

Use alongside the shared topic notes. Foundation + Higher content.

A boundary changes wave speed



Same frequency; wavelength is larger at right

The speed of sound depends on the medium. Sound can travel through solids, liquids and gases, but not a vacuum.

When a sound wave passes into a different medium, its frequency stays the same because it is set by the vibrating source.

If the speed changes while frequency stays fixed, the wavelength must change. The lines represent compressions, not paths followed by particles.

Use the shared wave equation

$$v = f \lambda$$

Wave speed v is in m/s, frequency f in Hz and wavelength λ in m.

Example: a 1000 Hz sound travels at 340 m/s in air. Its wavelength is $340 \div 1000 = \mathbf{0.340 \text{ m}}$.

In water at 1500 m/s, the same frequency gives a wavelength of $1500 \div 1000 = \mathbf{1.50 \text{ m}}$.

$$\lambda = \frac{v}{f}$$

Higher speed gives a longer wavelength for the same frequency. Use the wave speed for the medium named in the question.

Reason from observations

If a source produces 500 vibrations each second, every medium receives a 500 Hz disturbance. The boundary does not create extra oscillations.

A wavelength is the distance between neighbouring compressions, or between other corresponding points on successive waves.

Check: if speed doubles at unchanged frequency, wavelength doubles. If speed stays fixed and frequency doubles, wavelength halves.

Convert before calculating: 2 kHz = 2000 Hz; 40 cm = 0.40 m.

Do not use loudness as a measure of speed. Amplitude relates to the size of a disturbance, whereas speed, frequency and wavelength are linked by $v = f\lambda$.

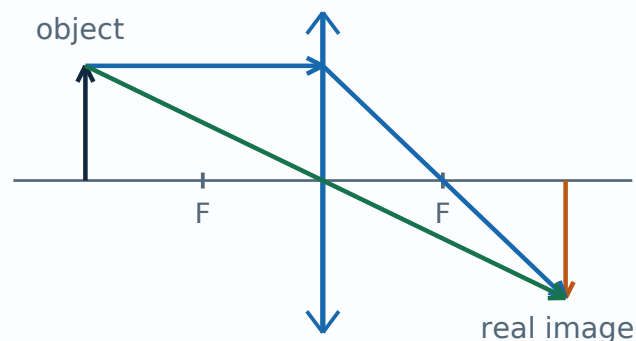
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P6 Lenses and image formation

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Use alongside the shared topic notes. Foundation + Higher content.

Convex: a real image

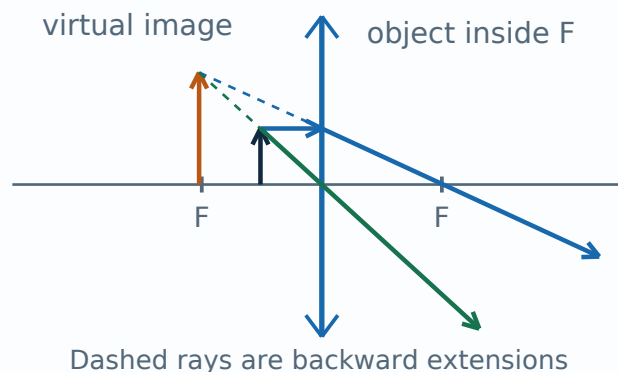


A convex lens converges parallel rays at its principal focus F. Focal length is the distance from lens to F.

For an object beyond F, a real image forms where the rays meet. It is inverted and can be projected onto a screen.

Draw a ray parallel to the axis, refracted through the far F, and a ray through the lens centre, continuing straight.

Convex: a virtual image

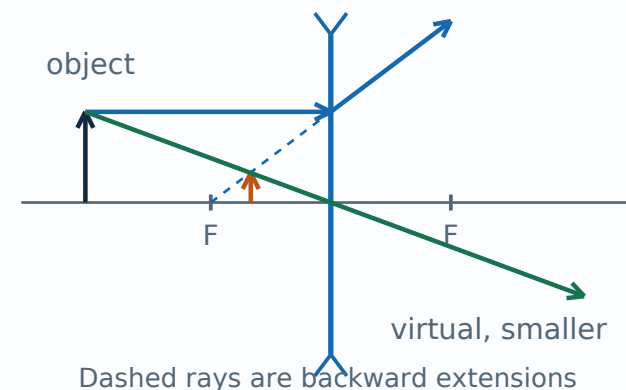


With the object between F and the convex lens, outgoing rays diverge. Their backward extensions meet on the object's side.

The image is **virtual, upright and magnified**. It cannot be projected onto a screen: actual rays do not meet at the image.

Draw backward extensions as dashed lines. A magnifying glass uses this arrangement.

Concave + magnification



A concave lens diverges rays and forms a virtual, upright, diminished image. A parallel ray emerges as if it came from the near F.

$$\text{magnification} = \frac{\text{image height}}{\text{object height}}$$

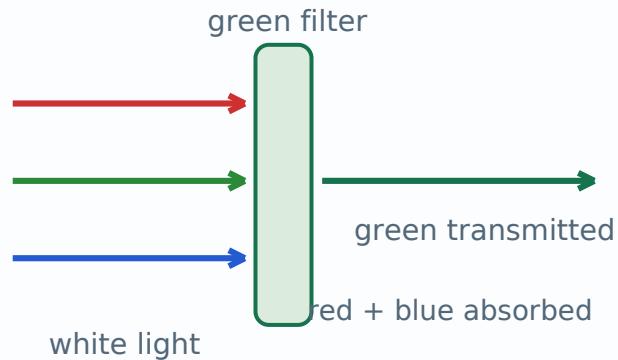
Use the same units for both heights. Magnification has no unit. A 30 mm image of a 10 mm object has magnification 3.

P6 Colour and thermal radiation

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Use alongside the shared topic notes. Foundation + Higher content.

Explain colour and filters



A filter transmits selected wavelengths and absorbs others. White light includes the full visible spectrum.

An opaque object's colour depends on the wavelengths it reflects. Under white light a red object reflects red more strongly and absorbs most other colours.

A red object illuminated only with green light looks dark if it absorbs that green light.

Surfaces and visible light

Each visible colour occupies a narrow band of wavelengths and frequencies. Red has a longer wavelength than violet.

White opaque surface: reflects visible wavelengths roughly equally. **Black opaque surface:** absorbs them strongly.

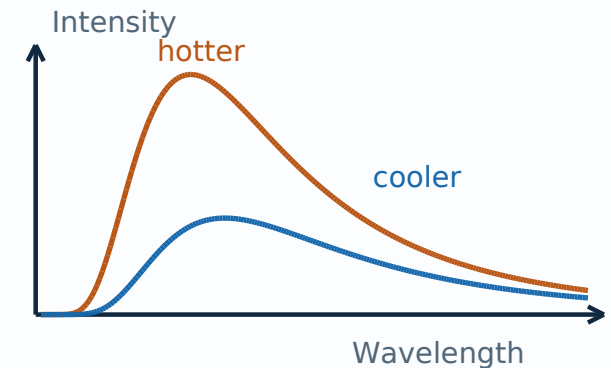
Transparent: transmits light with little scattering, so a clear image can be seen.

Translucent: transmits but scatters light.

Specular reflection sends parallel rays in one direction from a smooth surface. Diffuse reflection scatters them from a rough surface.

The law of reflection still applies at each point on a rough surface; the local normals differ.

Black bodies and temperature



All bodies emit and absorb infrared radiation. A hotter body emits more radiation per second.

A perfect black body absorbs all incident radiation: none is reflected or transmitted. It is also the best possible emitter.

Temperature changes both intensity and wavelength distribution. A hotter black body has a higher peak at a shorter wavelength. The curves are schematic.

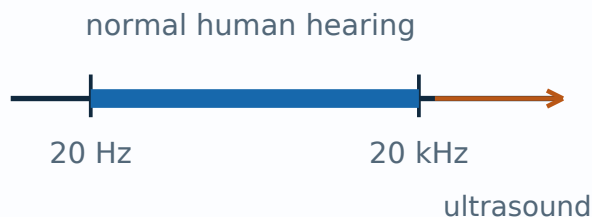
P6 Sound, echoes and hidden structures

Separate Physics extras | AQA 8463 | HIGHER ONLY

Use alongside the shared topic notes. Higher-tier material is kept on this separate page.

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Hearing and ultrasound



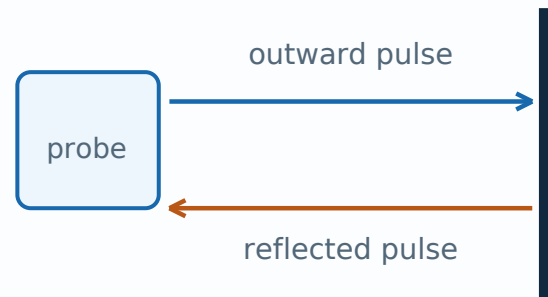
Vibrations are detected over a limited range

Sound causes solids to vibrate, including the eardrum and other parts of the ear. This produces the sensation of hearing.

Conversion between sound waves and solid vibrations works over a limited frequency range. Normal human hearing is about 20 Hz to 20 kHz.

Ultrasound has frequency above 20 kHz. Some animals can hear higher frequencies than humans.

Use echo times



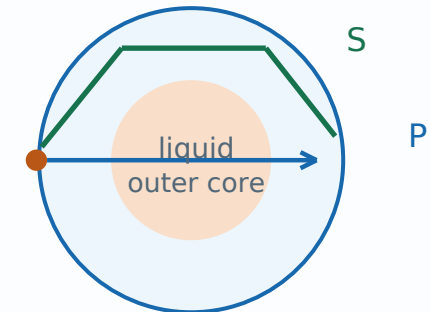
Measured time includes out + back

$$\text{distance} = \frac{\text{wave speed} \times \text{time}}{2}$$

A pulse partly reflects at a boundary between media. The echo time is for the outward and return journeys.

At 1500 m/s, an echo after 0.080 s locates a boundary 60 m away. Ultrasound images internal organs and detects flaws; echo sounding measures water depth.

Seismic evidence



S-waves cannot pass through liquid

Earthquakes produce seismic waves. **P-waves** are longitudinal and travel through solids and liquids at different speeds.

S-waves are transverse and do not travel through liquids. Their paths and missing arrival regions help reveal Earth's liquid outer core.

Differences in speed, absorption and reflection allow hidden structures to be inferred. New observations can change scientific models.

P6 Radiation balance and Earth

Separate Physics extras | AQA 8463 | HIGHER ONLY

Use alongside the shared topic notes. Higher-tier material is kept on this separate page.

Compare rates, not totals

Earth's energy balance

Interpret a change

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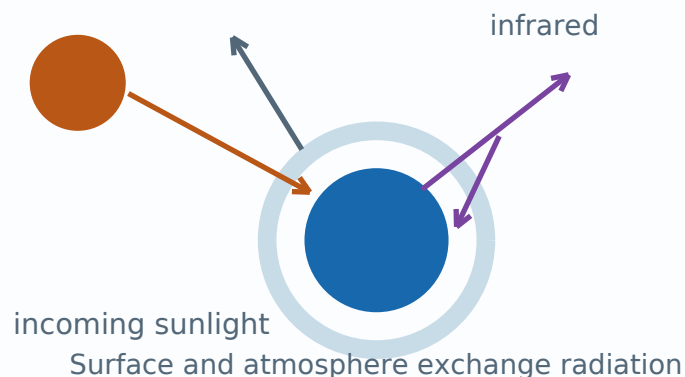
Equal rates $\rightarrow$ constant temperature

Rate means energy transferred per second

When radiation is the only energy-transfer mechanism, an object at constant temperature absorbs radiation at the same rate as it emits it.

In this model, if absorption is faster than emission, temperature rises. If emission is faster, temperature falls.

As temperature rises, emission increases. A new steady temperature can be reached when the rates balance again.



Earth's temperature depends on incoming radiation, the fraction reflected into space, and radiation emitted by the surface and atmosphere.

Some incoming solar radiation is reflected; some is absorbed. Earth emits infrared radiation.

The atmosphere absorbs and emits infrared. Changes in absorption, emission or reflection can alter the surface's equilibrium temperature.

Example: a surface absorbs 240 W/m^2 and emits 220 W/m^2 . With radiation as the only energy transfer, it gains energy at 20 W/m^2 and its temperature tends to rise.

$$\text{net rate} = \text{absorbed} - \text{emitted}$$

If reflective cloud cover or ice changes, the fraction of sunlight absorbed can change. Use the information supplied to predict the direction of the effect.

At the eventual steady temperature, the overall rates balance. This does not mean radiation stops passing between the surface, atmosphere and space.

Always define the system in a diagram: a surface, the atmosphere, or Earth as a whole.

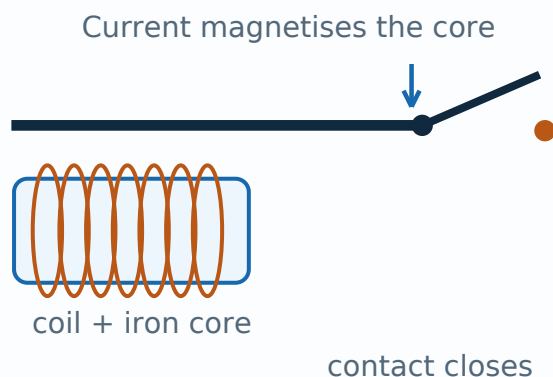
P7 Interpreting electromagnetic devices

Separate Physics extras | AQA 8463 | CORE

Use alongside the shared topic notes. Foundation + Higher content.

From current to motion

An electromagnet is a coil with an iron core. Current produces a magnetic field; the core becomes magnetised and strengthens the field.



In this simplified relay, the magnetised core attracts an iron armature. Its movement closes contacts in a separate circuit.

When the coil current stops, the core loses most of its magnetism and a spring can reopen the contacts.

Read an unfamiliar diagram

1. Trace the circuit containing the coil. Decide when current flows.
2. Identify the iron core and the part it can attract. Follow the mechanical movement.
3. Decide whether that movement opens or closes another circuit, strikes a bell, or lifts a magnetic load.
4. Explain what happens when the current stops. A spring or gravity often returns the moving part.

Label each link in the chain: current → magnetic field → attraction → movement → device output.

A coil does not attract every material. Iron is magnetic; many plastics and metals such as aluminium are not attracted in this simple model.

Apply the shared ideas

More current or an iron core can make the electromagnet stronger. More turns per unit length also strengthen the field of a solenoid.

A lifting magnet can pick up iron or steel when switched on and release it when switched off.

A relay allows one circuit to operate a switch in another. Use the supplied diagram to identify which contacts change.

For a self-interrupting bell, attraction opens the coil circuit; the magnet weakens; the spring restores the contact; the cycle repeats.

Tier boundary: this diagram interpretation is core Physics. Loudspeakers, induction, microphones and transformer calculations are Higher only.

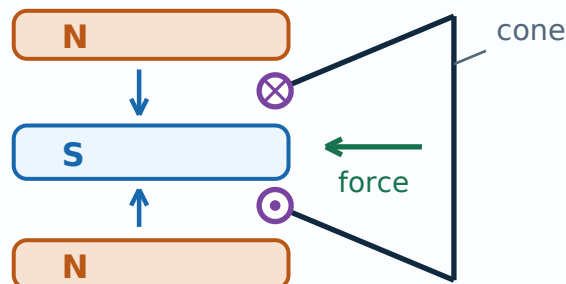
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P7 Loudspeakers and microphones

Separate Physics extras | AQA 8463 | HIGHER ONLY

Use alongside the shared topic notes. Higher-tier material is kept on this separate page.

Loudspeaker: electrical to sound



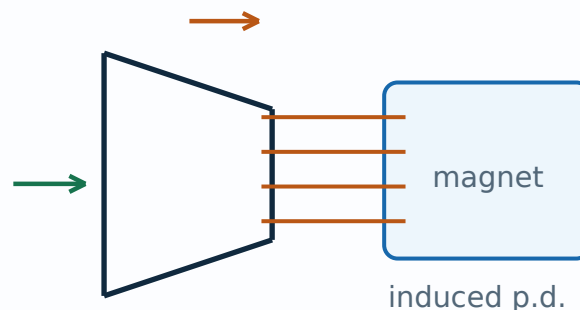
Coil current: ⊗ into page; ⊙ out of page

An alternating current in a coil produces a changing force in a permanent magnetic field: the motor effect.

The coil is attached to a cone. As current reverses, force reverses, so the cone vibrates and creates pressure variations in air.

The sound frequency matches the alternating current frequency. Headphones use the same principle.

Microphone: sound to electrical



sound moves diaphragm + coil

Sound pressure variations make a diaphragm and attached coil vibrate in a magnetic field.

Movement changes the magnetic field linked with the coil, inducing a potential difference. In a complete circuit an induced current flows.

The electrical signal follows the sound vibration. This is the generator effect, with energy transferred from sound to the electrical circuit.

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Keep the two effects distinct

Motor effect: current in a magnetic field produces a force. A loudspeaker turns a varying electrical signal into motion and sound.

Generator effect: movement relative to a field, or a changing field, induces p.d. A microphone turns motion into a varying electrical signal.

A stationary coil in an unchanging field does not produce a continuous induced p.d.

In both devices, the magnet provides the field and the coil is connected to the moving diaphragm or cone.

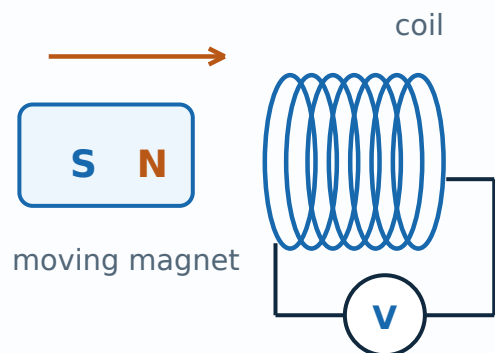
Explain in order: name the input → explain the coil's role → identify the physical effect → describe the output.

P7 Induction, alternators and dynamos

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Use alongside the shared topic notes. Higher-tier material is kept on this separate page.

Induce a potential difference

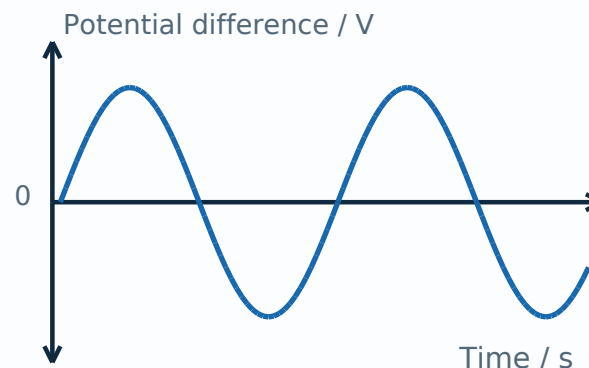


Relative movement between a conductor and magnetic field, or a changing field around it, induces p.d. A complete circuit allows induced current.

Faster change, a stronger field or more turns of wire can increase the induced p.d. Reversing motion or the field reverses its direction.

An induced current produces a magnetic field that opposes the original change. Work must be done to keep a generator moving.

Alternator: alternating output



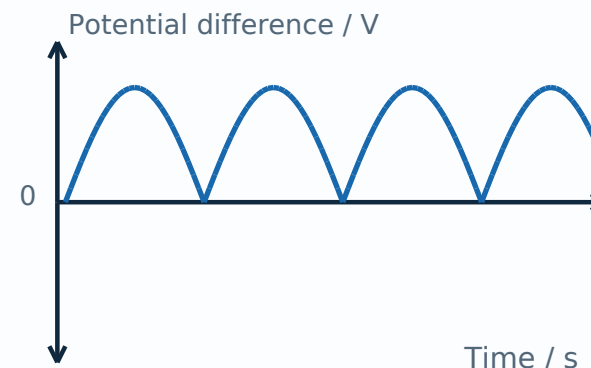
A coil rotates in a magnetic field. The induced p.d. reverses each half-turn, producing ac.

Slip rings and brushes maintain the electrical connection while allowing the coil to rotate.

Read the graph: positive and negative values show opposite directions of p.d. The time for one complete repeat is the period.

Faster rotation gives a higher frequency and can increase the peak p.d., if other factors stay constant.

Dynamo: one-direction output



A dynamo uses a split-ring commutator. It reverses the coil's connection to the external circuit every half-turn.

The external current stays in one direction: dc. Its size can still vary, giving the pulsing output shown.

Distinguish the coil's induced p.d. from the output after the commutator. The commutator changes the connections; it does not remove induction.

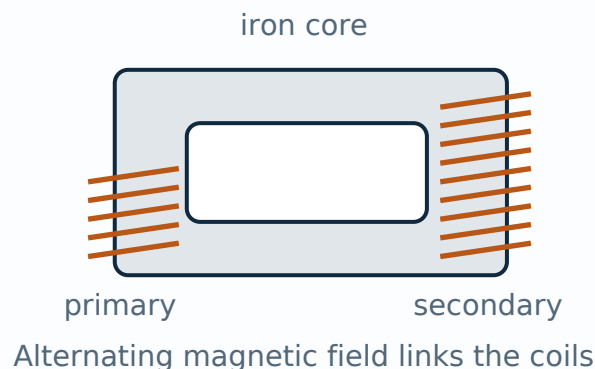
The output graphs are idealised teaching sketches.

P7 Transformers and power transmission

Separate Physics extras | AQA 8463 | HIGHER ONLY

Use alongside the shared topic notes. Higher-tier material is kept on this separate page.

A changing field links coils



Alternating current in the primary coil creates an alternating magnetic field in the iron core. This changing field induces p.d. in the secondary.

Iron is used because it is easily magnetised. A steady dc input does not give a continuous changing field, so it cannot produce a continuous transformer output.

More secondary turns gives a step-up transformer; fewer gives step-down.

Use turns and power ratios

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

V_p and V_s are primary and secondary potential differences. n_p and n_s are the numbers of turns on the coils.

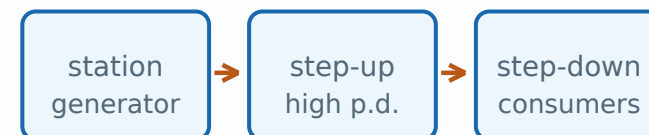
For an ideal (100% efficient) transformer, input power equals output power:

$$V_p I_p = V_s I_s$$

Example: 230 V primary, 460 turns; 24 turns secondary. $V_s = 230 \times 24 \div 460 = \mathbf{12 \text{ V}}$. At 2.0 A output, power = 24 W, so $I_p = 24 \div 230 \approx \mathbf{0.104 \text{ A}}$.

Why the Grid uses high p.d.

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Same power: higher p.d. → lower current

Lower current → less heating of cables

For a given power, a higher transmission p.d. means a smaller current because $P = VI$.

$$\text{Pheating} = I^2 R$$

A lower current means less energy dissipated by heating the cables. Step-up transformers raise p.d. for transmission; step-down transformers reduce it near users.

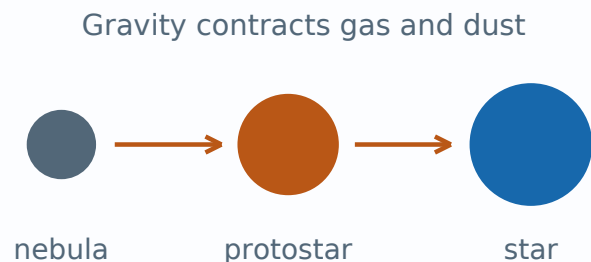
Do not assume current stays the same when p.d. is changed while power is held constant.

P8 Stars, fusion and elements

Separate Physics extras | AQA 8463 | CORE

Complete Physics-only topic. Foundation + Higher content.

A star is born



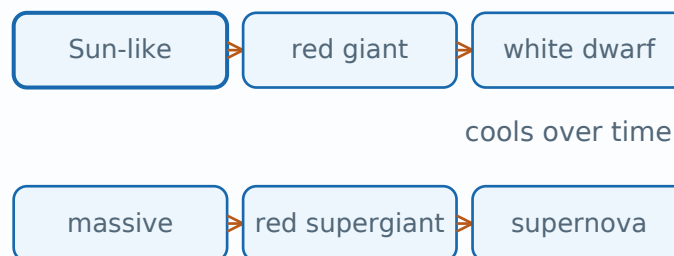
Core heats until fusion starts

Gravity pulls gas and dust in a nebula together. As the protostar contracts, its core temperature rises until fusion starts.

Fusion releases energy. A stable main-sequence star has a balance between inward gravitational collapse and the outward effect of energy released by fusion.

The Sun is one star in the Milky Way galaxy. Our solar system contains eight planets, dwarf planets and natural satellites.

Mass determines the life cycle



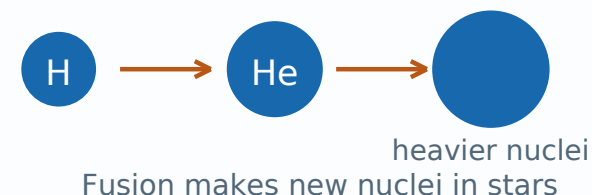
Supernova remnant: neutron star or black hole

A Sun-like star becomes a red giant, then leaves a white dwarf after losing its outer layers. The white dwarf gradually cools.

A much more massive star becomes a red supergiant and explodes as a supernova. The remnant is a neutron star or, if sufficiently massive, a black hole.

A black hole is not the final stage of every star.

Where elements come from



AQA model: beyond iron in supernovae

Fusion joins light nuclei into heavier nuclei, forming new elements. Stars build up heavier nuclei through fusion.

In the AQA model, elements heavier than iron are formed in a supernova. The explosion spreads elements through space.

This material can later become part of new stars, planets and living organisms. The Sun did not create all the elements in Earth by itself.

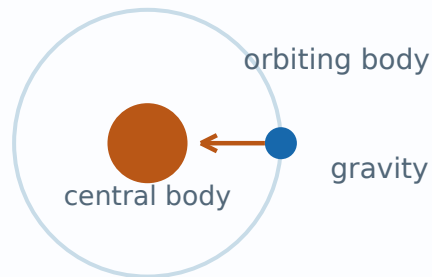
The diagrams simplify stages and are not to scale.

P8 Orbits, red-shift and the universe

Separate Physics extras | AQA 8463 | CORE

Complete Physics-only topic. Foundation + Higher content.

Planets and satellites



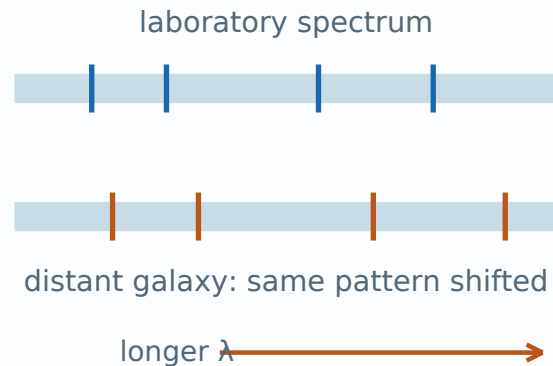
Gravity acts towards the centre

Planets orbit stars. Moons are natural satellites orbiting planets. Artificial satellites are human-made objects placed in orbit.

Gravity provides the force that maintains the circular orbits used in this model. It acts towards the central body.

Objects in orbit still experience gravity. Being in orbit does not mean that the gravitational force has disappeared.

Read the red-shift evidence

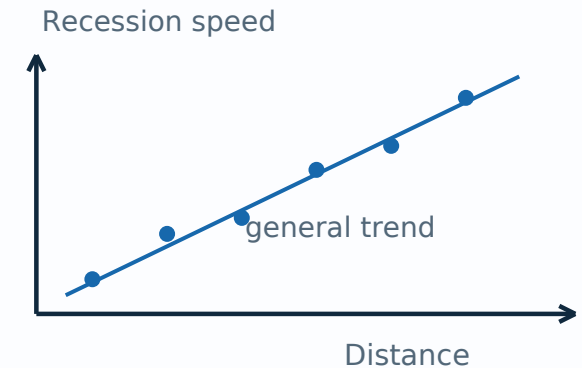


Light from most distant galaxies has a longer observed wavelength than the corresponding laboratory spectrum: it is red-shifted.

The farther away a galaxy is, the greater its red-shift and, in the observed trend, the faster it is receding.

Identify a shifted pattern of spectral lines, not just a galaxy that looks red. Some nearby galaxies do not follow the general recession pattern.

An evolving scientific model



Red-shift evidence supports an expanding universe and the Big Bang model: the universe began in a very small, extremely hot, dense region.

Supernova observations since 1998 suggest the expansion is accelerating. Scientists test models against observations and revise explanations.

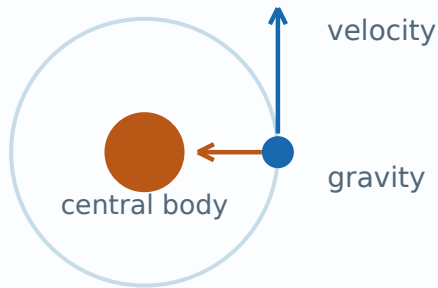
Much remains unexplained, including dark matter and dark energy. These names describe gaps in our understanding, not a complete account of their nature.

P8 Speed, velocity and stable orbits

Separate Physics extras | AQA 8463 | HIGHER ONLY

Complete Physics-only topic. Higher-tier material is kept on this separate page.

Velocity changes in a circle



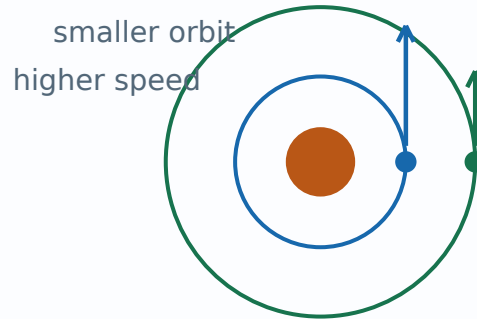
Gravity acts towards the centre

Velocity includes direction. In uniform circular motion the speed stays constant, but the direction of motion changes continuously.

Gravity acts towards the centre and continually changes the velocity. The object accelerates even though its speed stays constant.

The velocity arrow is tangential to the orbit. The force arrow points inward; these arrows show different physical quantities.

A stable orbit has a condition



Comparing stable circular orbits of one body

For stable circular orbits around the same central body, orbital speed and radius are linked. A smaller radius corresponds to a higher orbital speed.

If the speed changes, the radius must change for another stable circular orbit. The original stable circular orbit cannot simply persist at the new speed.

Do not assume a sudden speed change instantly produces a new circular orbit; the path may become non-circular.

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Build a complete explanation

Prompt: a satellite moves at constant speed around a planet. Explain why it is accelerating.

Answer chain: gravity produces a resultant inward force → its direction of motion changes → its velocity changes → it accelerates.

Prompt: compare two stable circular orbits around the same planet.

Answer chain: a smaller orbital radius needs a greater stable orbital speed; a larger radius has a lower stable orbital speed.

The required treatment is qualitative. These sheets do not introduce a circular-orbit equation beyond the GCSE specification.

Core orbital descriptions and red-shift are on the preceding core page; only these specified orbital explanations are Higher only.