Course notes

Pearson Edexcel · International A-Level · Physics

Pearson Edexcel International A-Level · Physics: teaching notes

Version: YPH11; Issue 3 (2021); first teaching 2018

These notes cover selected topics of the course; they are not the whole specification.

Assessment and course boundaries

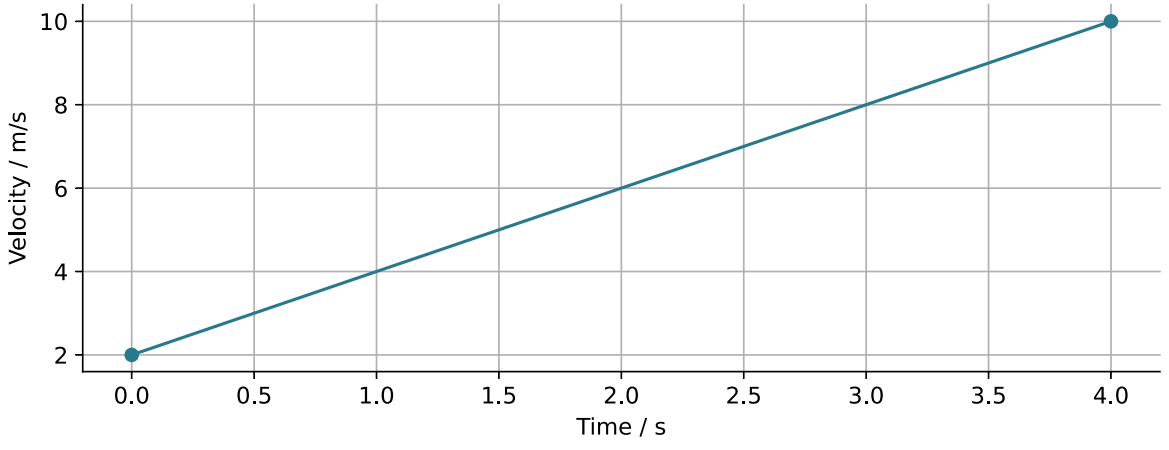
- Six separately assessed units; IAS uses Units 1–3, IAL uses Units 1–6.
- Units 3 and 6 are written practical-skills examinations based on experimental experience; they are not a Cambridge hands-on practical paper.
- Retain core-practical numbering from the specification.
- This package uses the 2018 specification, current for these assessments. Pearson announces first teaching of a redeveloped course from September 2027; do not mix its future content into the current Unit 1–6 route.

Motion graphs and acceleration

Official-unit focus: 1 Mechanics and Materials

A speedometer gives a reading at one moment. A journey average can hide stops and rapid changes in speed.

Displacement includes direction; distance counts total path length. Velocity is change in displacement per time. Acceleration is change in velocity per time.



The gradient of a displacement-time graph is velocity. The area under a velocity-time graph gives displacement. A constant-acceleration formula is valid only when its assumption is justified.

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Choose a positive direction and state it. Use a light gate or video with a known scale and frame interval for repeatable motion measurements. Avoid assuming hand timing is exact over very short intervals.

■ Checked worked case

Known: velocity rises uniformly from 2 to 10 metres per second in 4 s. a = (v-u)/t. a = (10-2)/4 = 2 metres per second squared. Displacement is trapezium area: s = (u+v)t/2 = (2+10)×4/2 = 24 m.

■ Common error

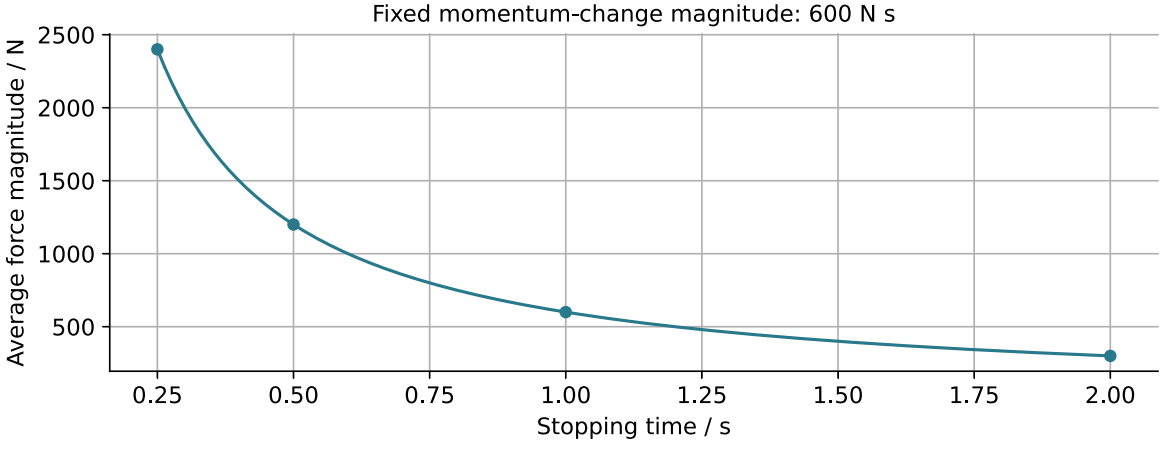
Negative velocity indicates direction under the chosen sign convention; it does not necessarily mean slowing down.

Forces, momentum and safe stopping

Official-unit focus: 1 Mechanics and Materials; 4 Further Mechanics, Fields and Particles

A passenger continues moving when a vehicle brakes. The seat belt provides the force needed to change the passenger momentum.

Resultant force causes acceleration, not motion itself. Momentum is mass multiplied by velocity. For an isolated system, total momentum is conserved even when kinetic energy is not.



Impulse equals momentum change. Increasing stopping time for the same momentum change reduces average force. Identify external forces before applying momentum conservation.

Draw a free-body diagram containing only forces on the selected object. For spring measurements, add loads in steps within the elastic range and measure extension from the unloaded position.

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■ Checked worked case

Known: a 60 kg passenger slows from 10 to 0 metres per second in 0.50 s. $\Delta p = m(v-u) = 60(0-10) = -600$ kg metres per second. Average $F = \Delta p/\Delta t = -600/0.50 = -1{,}200$ N. The sign shows the force opposes the initial motion.

■ Common error

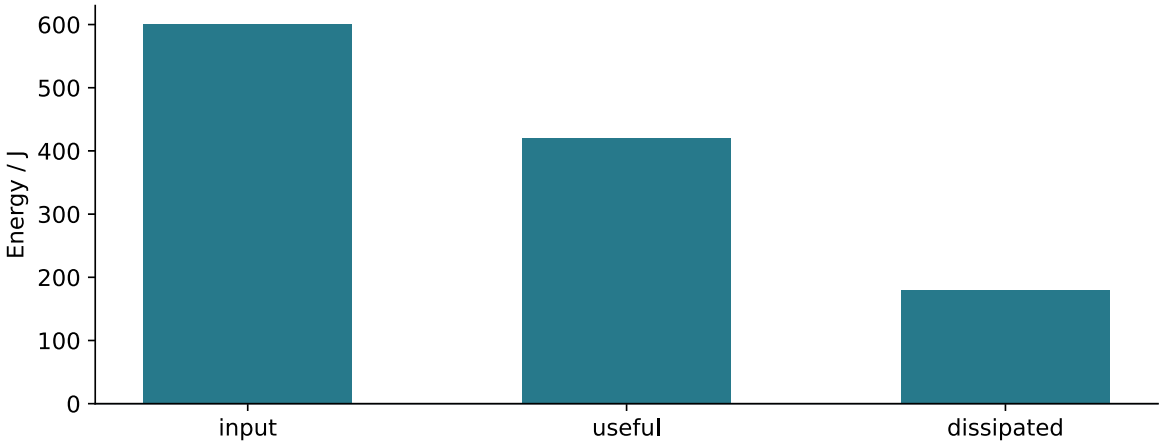
Balanced forces do not require the object to be at rest. Mass and weight have different units and meanings.

Energy stores, work and efficiency

Official-unit focus: 1 Mechanics and Materials

A motor can transfer some input energy to lifting and the rest to heating. Useful output is part of the total energy transfer.

Work done by a constant force parallel to displacement is force multiplied by distance. Kinetic energy depends on speed squared. Energy is conserved when all transfers and stores are included.



Define the system and useful output before calculating efficiency. Doubling speed quadruples kinetic energy at constant mass. Power describes transfer per time, not total energy.

Measure a lifting height and load, time the lift, and record electrical input with suitable instruments. Repeat trials and account for heating or friction as transfers, not missing energy.

■ Checked worked case

Known: a device receives 600 J and transfers 420 J usefully. Efficiency = useful output / total input. Efficiency = 420/600 = 0.70 = 70%. Over 3 s, useful power = useful energy/time = 420/3 = 140 W.

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■ Common error

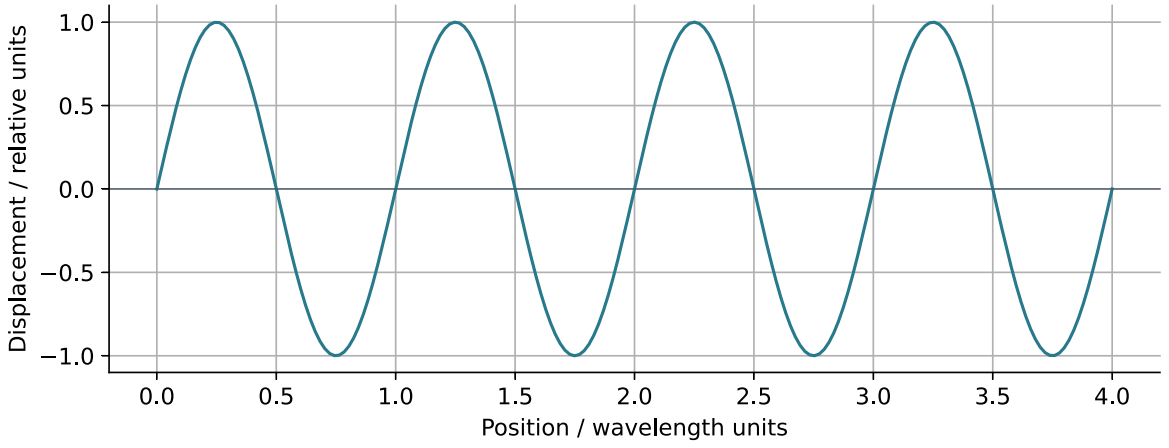
Efficiency cannot exceed 100% for a properly defined energy balance. Energy dissipated by heating is still conserved.

Waves, measurement and refraction

Official-unit focus: 2 Waves and Electricity

A wave can carry energy across water while a floating marker mainly oscillates. Energy transfer and bulk transfer of matter are different.

Frequency is oscillations per time; wavelength is distance between successive points in phase. Wave speed equals frequency multiplied by wavelength. Transverse oscillations are perpendicular to propagation.



At a boundary, frequency stays fixed by the source. A change of speed changes wavelength. Refraction follows from speed differences; angles are measured from the normal.

Measure several wavelengths and divide to reduce fractional reading uncertainty. Use a ray box with a normal drawn at the boundary. Keep the beam away from eyes and record incident and refracted angles clearly.

■ Checked worked case

Known: frequency 5 Hz and wavelength 0.40 m. Use $v = f\lambda$. $v = 5 \times 0.40 = 2.0$ metres per second. If speed falls to 1.5 metres per second at the same frequency, wavelength $= v/f = 1.5/5 = 0.30$ m.

■ Common error

The wave frequency does not change simply because the medium changes. A longitudinal wave has oscillations parallel to propagation.

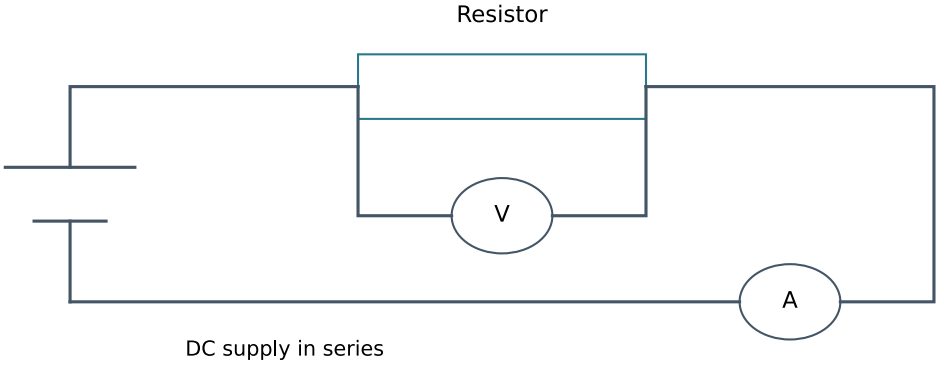
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Current, potential difference and resistance

Official-unit focus: 2 Waves and Electricity

A lamp becomes dimmer when another is added in series. Current and energy transfer depend on the whole circuit, not only one lamp.

Current is charge passing per time. Potential difference is energy transferred per charge. Resistance is potential difference divided by current for a stated operating point.



Ammeter in series; voltmeter across resistor

Current is the same through components in series. Potential differences add around the series path. In parallel, branches share the same potential difference, while branch currents sum at a junction.

Place an ammeter in series and a voltmeter in parallel. For an I-V investigation, change voltage in steps, reverse polarity when appropriate and limit current to reduce heating.

■ Checked worked case

Known: a resistor has 6.0 V across it and carries 0.30 A. Use R = V/I. R = 6.0/0.30 = 20 ohms. Power = VI. Power = 6.0×0.30 = 1.8 W. These quantities describe the same operating point.

■ Common error

Current is not used up by a lamp. A filament heats up, so its resistance need not remain constant as voltage changes.

Photons and the photoelectric effect

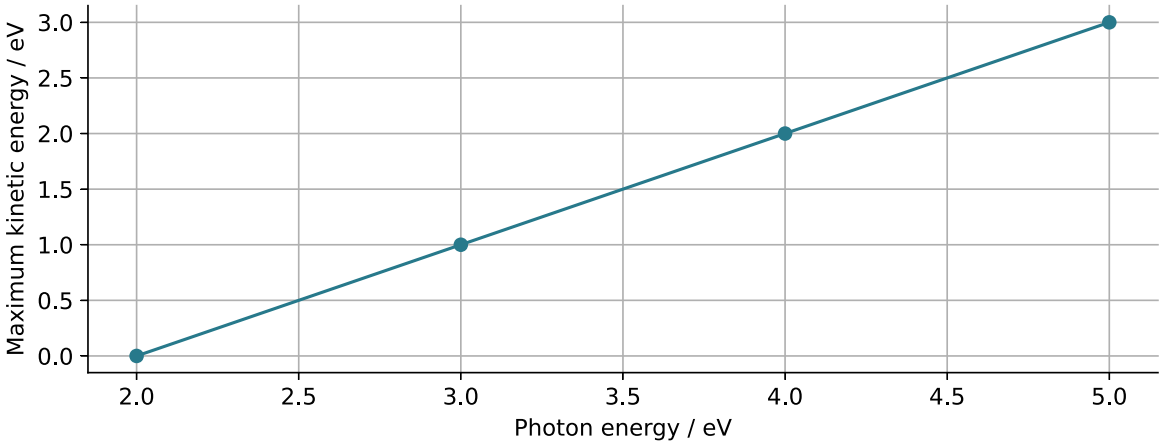
Official-unit focus: 2 Waves and Electricity

Bright low-frequency light can fail to eject electrons while dim higher-frequency light succeeds. Photon energy depends on frequency, not intensity alone.

A photon has energy proportional to frequency. The work function is the minimum

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energy needed to release an electron from a surface. Above threshold, excess photon energy can become electron kinetic energy.



Use photon energy = Planck constant × frequency. Maximum kinetic energy = photon energy - work function. Increasing intensity at fixed frequency increases photon arrival rate, not individual photon energy.

Read axes carefully on a stopping-potential or kinetic-energy graph. Identify threshold frequency from the zero-energy intercept. State the metal and experimental conditions because work function is material-specific.

■ Checked worked case

Known: photon energy is 5.0 electronvolts and work function is 2.0 electronvolts. Maximum kinetic energy = photon energy - work function = 5.0 - 2.0 = 3.0 electronvolts. A 1.5 electronvolt photon cannot cause emission from that surface in this model.

■ Common error

Electrons do not accumulate many sub-threshold photons in the elementary single-photon model. Do not confuse photon number with photon energy.

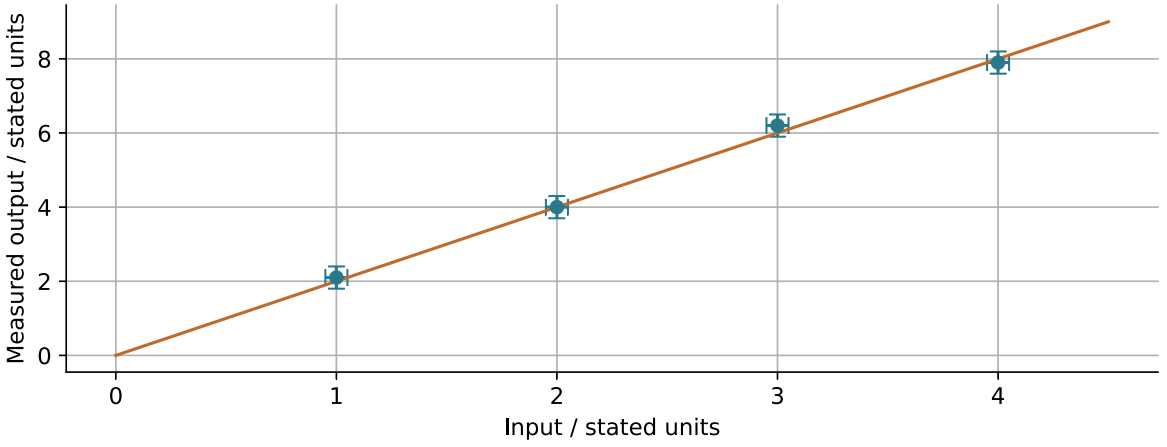
Uncertainty, gradients and model testing

Official-unit focus: 3 Practical Skills in Physics I; 6 Practical Skills in Physics II

A line passing near every data point is useful, but its gradient can still be uncertain. A graph is evidence for a model within the measurement range.

Random variation makes repeated readings differ. Systematic error shifts results consistently. Absolute uncertainty has the measured unit; relative or percentage uncertainty compares uncertainty with the measured value.

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For a product or quotient, adding fractional uncertainties is a common maximum-uncertainty approximation. For a difference, add absolute uncertainties. A nonzero intercept can reveal an offset or an incomplete model.

Show units on axes and choose a sensible scale. Plot uncertainty bars where justified, draw a best-fit line rather than joining every point, and estimate steepest and shallowest plausible gradients when the course method calls for them.

■ Checked worked case

Known: length = 50.0 mm with uncertainty 1.0 mm. Percentage uncertainty = absolute uncertainty/value $\times 100 = 1.0/50.0 \times 100 = 2.0\%$. For a quotient of two independently measured quantities with maximum percentage uncertainties 2% and 3%, the summed maximum estimate is 5%.

■ Common error

Repeating readings reduces random uncertainty in a mean but does not automatically remove a zero error. Do not quote more decimal places than your measurement can support.

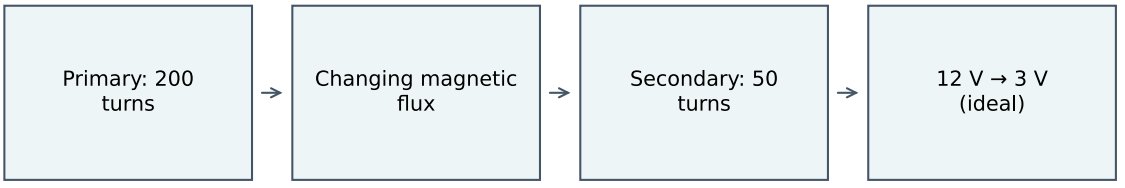
Fields, motors and induction

Official-unit focus: 4 Further Mechanics, Fields and Particles

A magnet beside a wire does not always produce a current. An induced electromotive force depends on changing magnetic flux linkage.

A field describes a force effect at positions in space. A current-carrying conductor in a magnetic field can experience a force. Electromagnetic induction occurs when magnetic flux linkage changes.

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Changing field strength, coil area, orientation or relative motion can change flux linkage. Lenz law describes an induced effect opposing the change producing it, consistent with energy conservation.

Use a coil and sensitive meter to compare magnet motion in each direction. Record that a stationary arrangement gives no induced signal. Use approved low-voltage supplies for motor demonstrations.

■ Checked worked case

Known: a transformer has 200 primary turns, 50 secondary turns and 12 V primary voltage. For an ideal transformer, Vs/Vp = Ns/Np. Vs = Vp Ns/Np = 12×50/200 = 3.0 V. Real transformers also dissipate energy.

■ Common error

A transformer needs changing magnetic flux; a steady DC input does not provide continuous transformer action. Magnetic field direction is not automatically the direction of force.

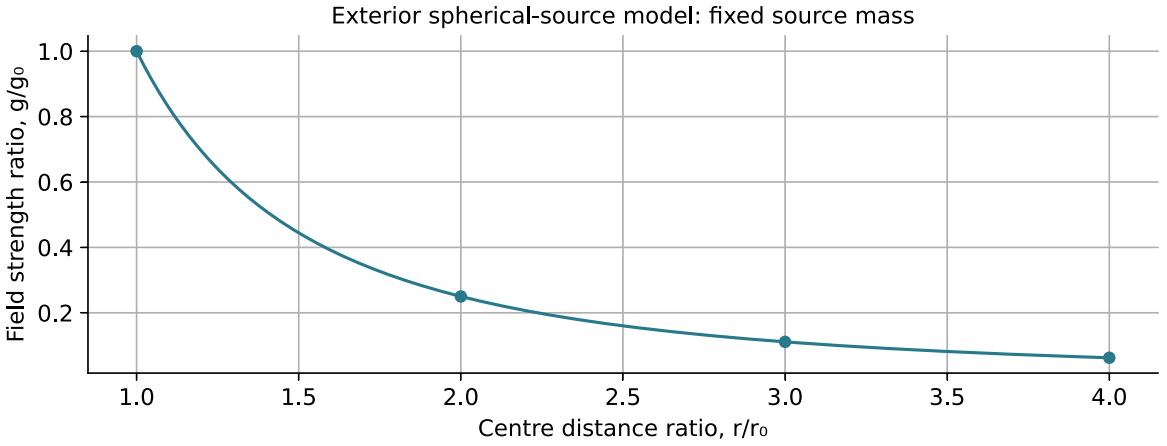
Gravitational fields and orbital motion

Official-unit focus: 4 Further Mechanics, Fields and Particles

An orbiting satellite is continuously falling while moving sideways. Being in orbit does not require gravity to vanish.

Gravitational field strength is force per unit mass. A gravitational force can provide the centripetal force for a circular orbit. Field and potential describe different quantities.

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For a point mass or outside a spherical mass, field strength follows an inverse-square distance dependence. Use distance from the centre, not height above the surface alone.

State the circular-orbit approximation and ignore atmospheric drag only when justified. Draw the force toward the central body and velocity tangential to the orbit. Do not add an outward force merely because the path is circular.

■ Checked worked case

Known: field strength is 8 units at distance r from a spherical source. At 2r, g2/g1=(r/2r)^2=1/4. g2=8/4=2 units. The gravitational force on a fixed test mass decreases in the same ratio.

■ Common error

Weightlessness in an orbiting spacecraft means apparent weight is small in free fall, not that there is no gravitational field.

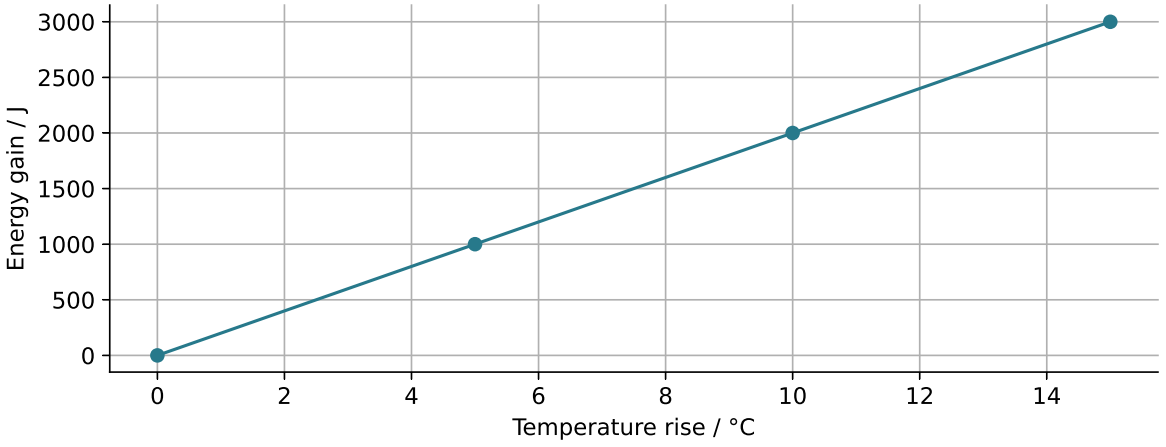
Thermal measurements and particle models

Official-unit focus: 5 Thermodynamics, Radiation, Oscillations and Cosmology

Two equal masses receive the same energy but show different temperature rises. Material properties determine how energy transfer changes temperature.

Specific heat capacity is energy needed to raise the temperature of unit mass by one degree. Specific latent heat relates energy to change of state without temperature change for the idealized process.

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Temperature relates to particle motion in a model; internal energy includes kinetic and potential contributions. During a change of state, energy can change particle arrangements rather than temperature.

Measure mass, electrical input and temperature change for an insulated block. Ensure the temperature sensor has good contact, allow time for equilibration, and consider energy transferred to the surroundings.

■ Checked worked case

Known: a 0.50 kg block gains 2,000 J and rises 10 °C. Use $E = mc\Delta T$. Rearranging gives $c = E/(m\Delta T)$. $c = 2{,}000/(0.50\times10) = 400$ J per kilogram per degree. Heat loss would make the value inferred from electrical input too large.

■ Common error

A flat section of a heating curve can show a phase change, not absence of energy transfer. Do not substitute temperature for a temperature difference in $E = mc\Delta T$.

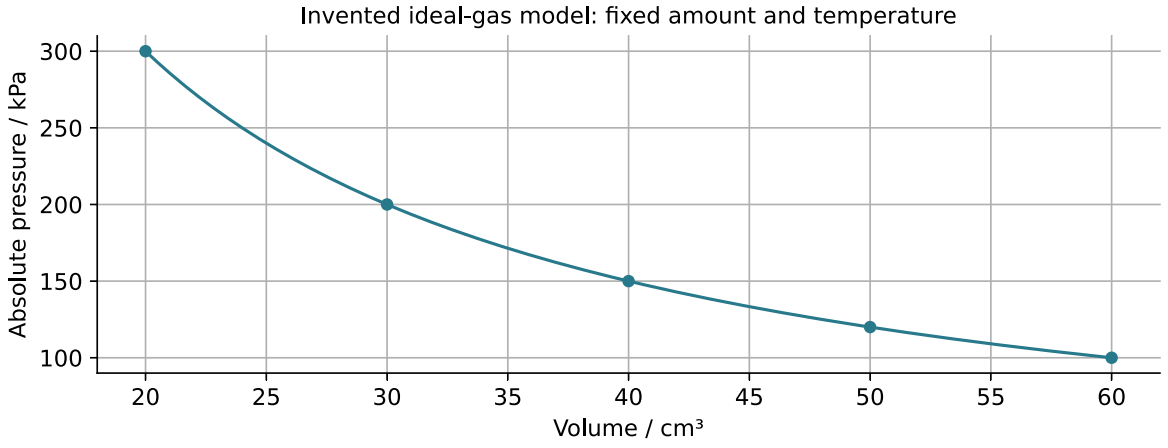
Gas models and absolute temperature

Official-unit focus: 5 Thermodynamics, Radiation, Oscillations and Cosmology

A sealed gas container changes pressure when heated. Celsius ratios cannot predict the pressure change because the gas model uses absolute temperature.

In a gas model, particles move randomly and pressure results from momentum transfer at walls. The ideal gas equation connects pressure, volume, amount and absolute temperature.

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At fixed amount and volume, pressure is proportional to kelvin temperature. At fixed temperature and amount, pressure is inversely proportional to volume. State which quantities are fixed before choosing a relationship.

Use approved apparatus with a temperature range and pressure limit set by the teacher. Allow thermal equilibrium and record pressure against kelvin temperature. Never heat an improvised sealed vessel.

■ Checked worked case

Known: pressure is 100 kPa at 300 K, with fixed volume and amount. At 330 K, p2/p1=T2/T1. p2=p1 T2/T1=100×330/300=110 kPa. A 30 °C rise is a 30 K change, but the temperature ratio must use kelvin.

■ Common error

An ideal gas is a model with conditions of validity. Celsius zero is not zero molecular motion, and internal energy is not determined by pressure alone.

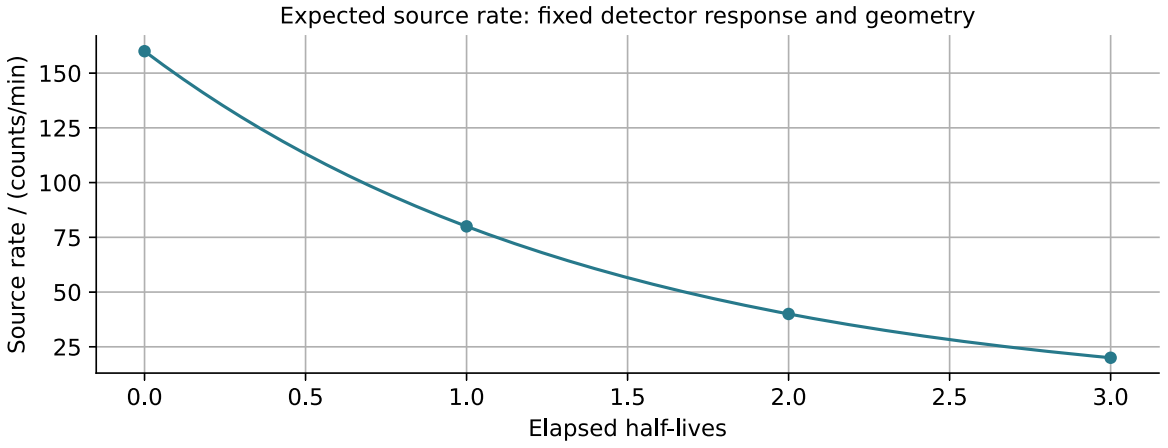
Nuclear changes and radiation evidence

Official-unit focus: 5 Thermodynamics, Radiation, Oscillations and Cosmology

A detector records counts even when the classroom source is removed. Background must be considered before attributing every count to the source.

Radioactive decay is spontaneous and random for an individual nucleus. Half-life describes the time for half the undecayed nuclei in a large population to decay, or for background-corrected activity to halve.

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Subtract background counts measured over the same time interval. Distinguish irradiation from contamination. Shielding, distance and reduced exposure time can reduce risk under a school-controlled procedure.

Use teacher-managed sources and the school radiation rules. Record count duration and repeat background measurements. Do not extrapolate a half-life from one nucleus or from uncorrected readings.

■ Checked worked case

Known: measured count rate falls from 100 to 55 counts per minute; background is 10. Source rates are 90 and 45, so one half-life has elapsed. Without subtraction, 55/100 would obscure the exact half in this example.

■ Common error

An irradiated object is not automatically radioactive. A half-life does not predict the exact decay time of one nucleus.

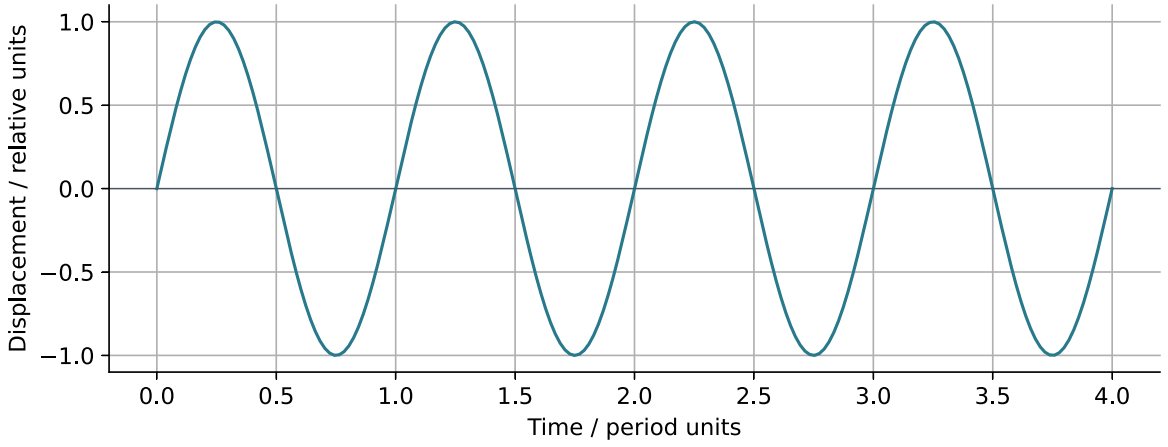
Oscillation, resonance and phase

Official-unit focus: 5 Thermodynamics, Radiation, Oscillations and Cosmology

A swing gains a large amplitude when pushes arrive with the right timing. The forcing frequency and damping help determine the response.

Simple harmonic motion has acceleration proportional to displacement and directed toward equilibrium. Period is time per cycle; frequency is its reciprocal. Damping transfers energy away from the oscillating system.

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Velocity is greatest near equilibrium for ideal SHM, while acceleration magnitude is greatest at extreme displacement. Resonance can occur near the natural frequency under periodic driving, with amplitude limited by damping.

Measure time for several complete oscillations and divide. Define a cycle consistently and use a small displacement when the model requires it. Keep pendulum paths clear and record damping effects rather than assuming perfect motion.

■ Checked worked case

Known: 20 cycles take 32 s. T=total time/cycles=32/20=1.6 s. Frequency=1/T=1/1.6=0.625 Hz. A shorter total timing interval would make reaction-time error a larger fraction of the measurement.

■ Common error

Not every repeated motion is SHM. A force proportional to displacement but directed away from equilibrium does not produce SHM.

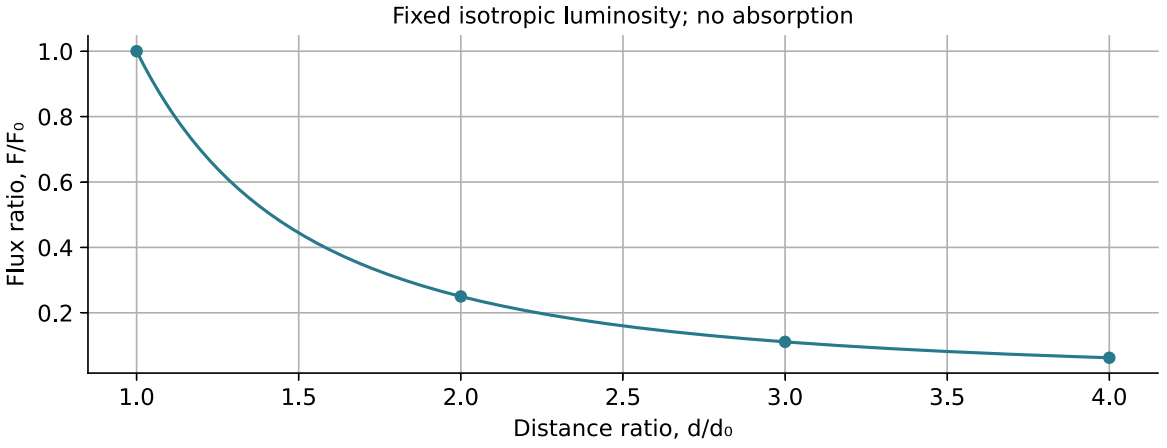
Stars, radiation and scale

Official-unit focus: 5 Thermodynamics, Radiation, Oscillations and Cosmology

Two stars can have the same apparent brightness while having different luminosities. Distance changes the flux reaching an observer.

Luminosity is total power emitted; flux is power received per area. A stellar spectrum carries information about surface temperature and composition. Fusion transfers energy as light nuclei combine.

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For isotropic emission without absorption, flux follows an inverse-square relationship with distance. Observed brightness alone therefore cannot establish luminosity.

Keep distance units consistent, identify which quantities are intrinsic to the star, and distinguish observational evidence from a model of stellar evolution. Do not confuse a red giant stage with every possible final remnant.

■ Checked worked case

Known: distance doubles while luminosity remains fixed. Use F proportional to $1/d^2$. Flux ratio $= 1/2^2 = 1/4$. A flux of 12 units becomes 3 units. This assumes no change in absorption or source output.

■ Common error

The Sun is not expected to become a supernova. Redshift can support cosmological expansion; it does not mean every nearby object must move away from every observer.

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