Edith Cowan University

2026 ATAR Revision Seminars

ATAR Physics

Curriculum Dot points

Examination and study tips

Revision notes Examination questions

Examination marker comments

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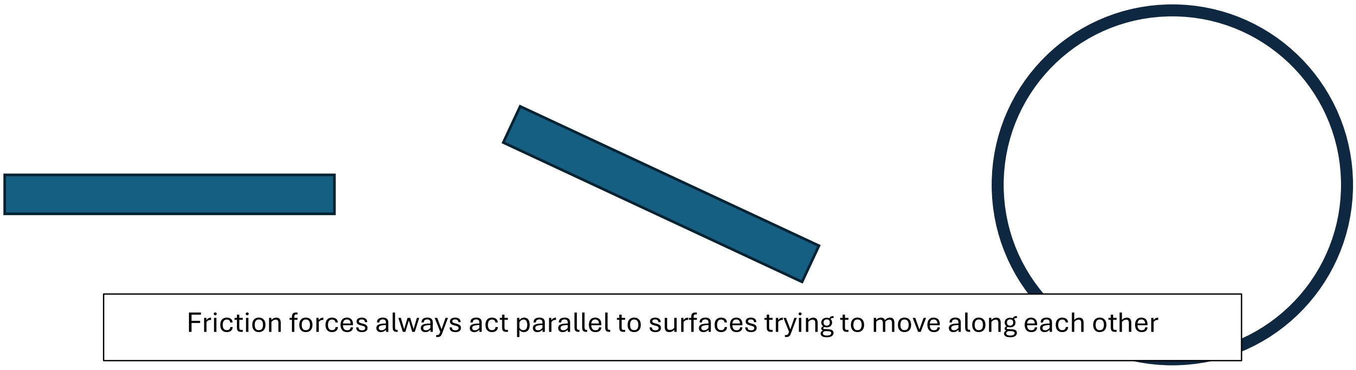
Vector Based Problems (ramps, circular motion, projectiles, etc)

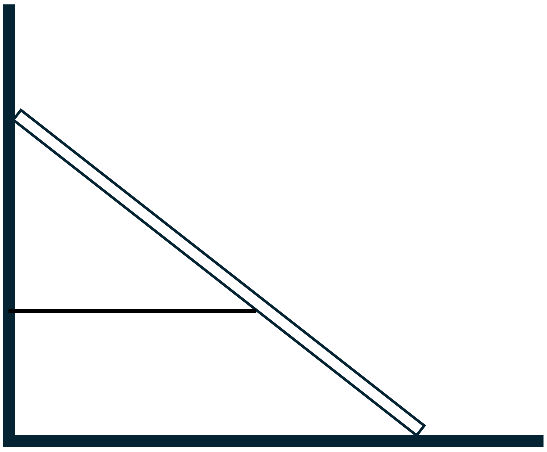
Most motion-based problems require knowing the forces, an understanding of the probable net force and initial conditions of the motion.

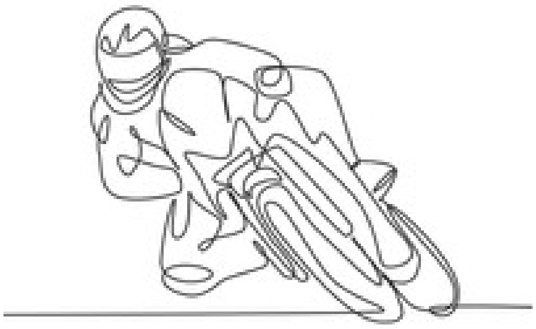
Normal forces always act perpendicular to surfaces trying to move through each other



Friction forces always act parallel to surfaces trying to move along each other

Tension forces always act along the source of the tension (cable, string, rod, etc.)





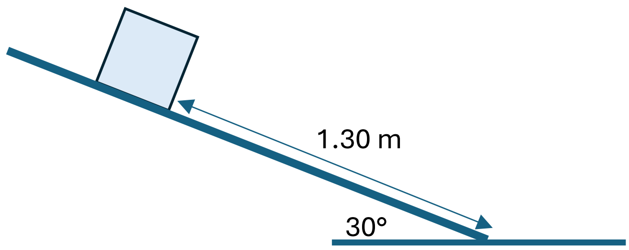
Reaction forces are the combination of the normal and friction forces of a surface – the resultant direction is based on the sizes of each.

Knowing the forces can lead to a calculation of the net force.

Net force allows for calculation of the acceleration.

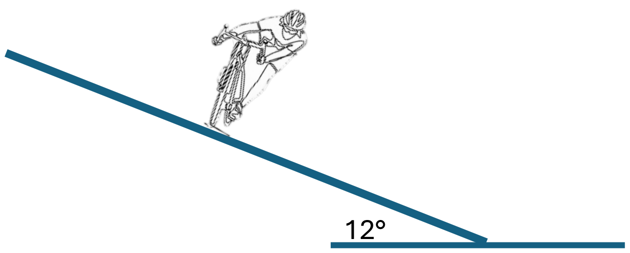
Acceleration can be used in equations of motion.

Example 1. A 12.0 kg moving box is placed on the moving truck's ramp seen below. The 45.0 N of friction is not sufficient to stop the box from accelerating down the ramp. Determine the time for the box to reach the base of the ramp.

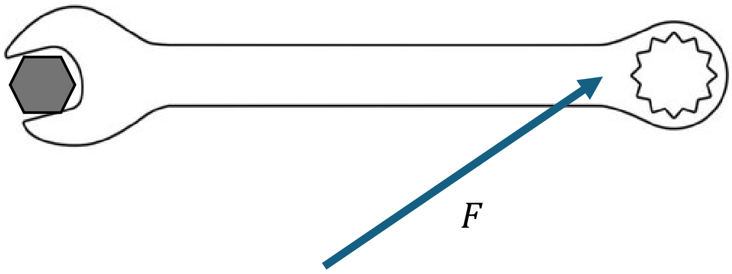


Example 2. A 67.0 kg cyclist in a velodrome is undergoing horizontal circular motion, leaning into the centre of the 18.0 m radius curve to produce frictional forces to assist with maintaining a 15.0 m s^{-1} speed. Determine the magnitude of the frictional force.

[Ans: 683 N]



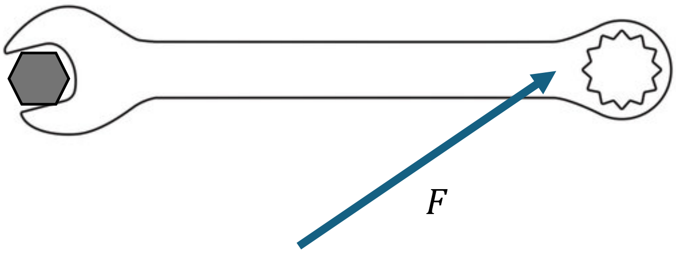
Torque and Equilibrium

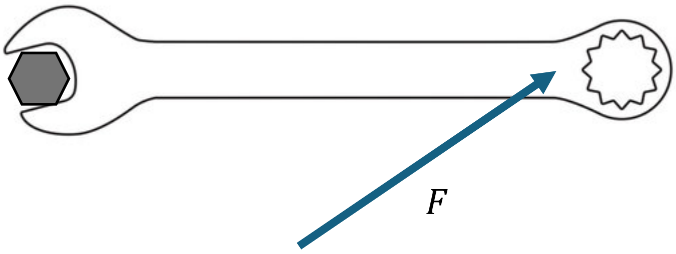


The $sin\theta$ in $\tau = Frsin\theta$ is to ensure the force is ***perpendicular*** to the lever arm.

It is just as valid to find the component of the distance from the pivot that is ***perpendicular*** to the force.

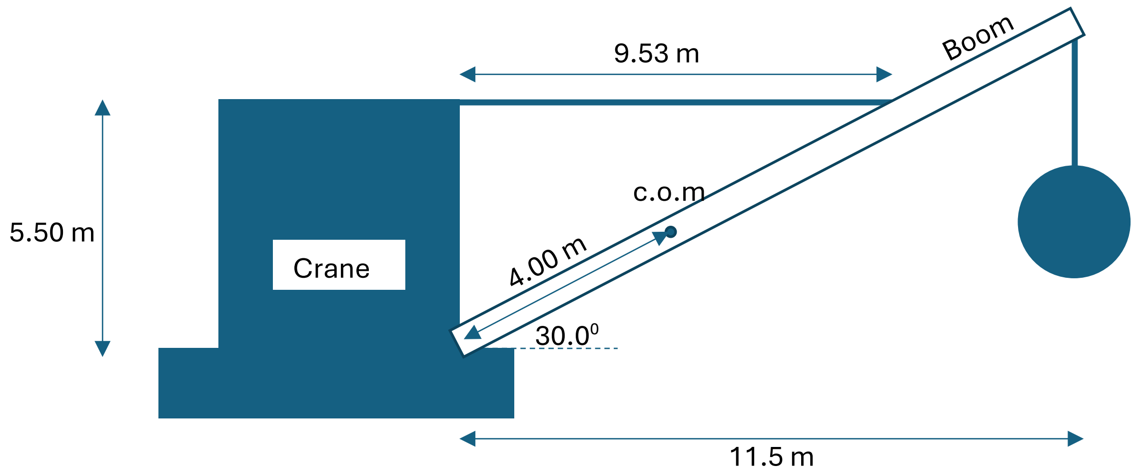
The perpendicular force	The perpendicular distance





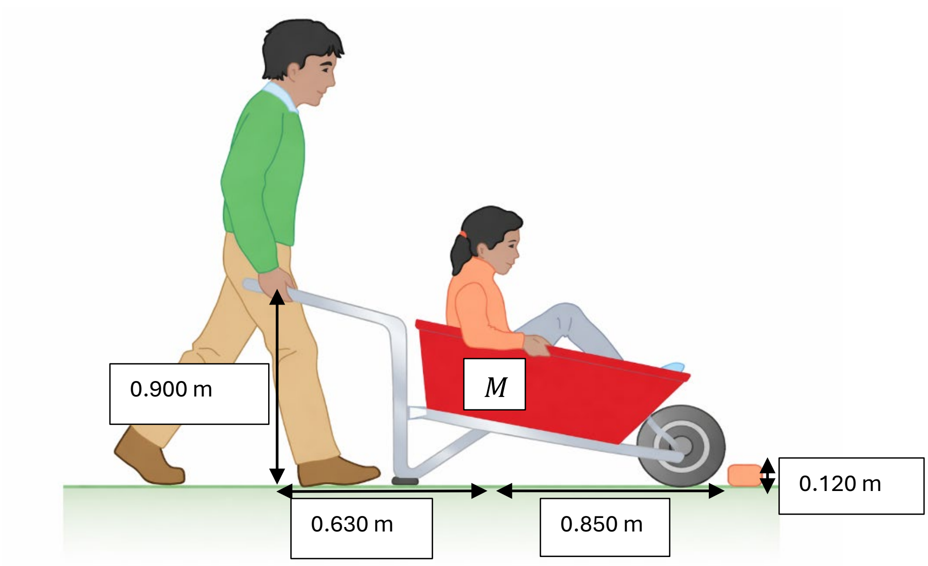
Being flexible in our thinking by considering both approaches can make problems easier to solve. In the problems below, some torques are easier to find by applying $Frsin\theta$ while others are easier if we use the perpendicular distance or the perpendicular force given within the question's information.

Example 3. The 265 kg boom attached to the crane below has a centre of mass located 4.00 m along the boom. The boom is holding a 6000 N load at its end. Find the tension in the horizontal cable that connects the boom to the crane's main body.



Example 4. A father pushes his daughter in a wheelbarrow. The combined mass of the wheelbarrow and daughter is 82.0 kg and the centre of mass is located at point M. The wheelbarrow is stopped by a brick of height 0.120 m. Determine the minimum horizontal force the father would have to apply to get the wheelbarrow wheel to rotate over the brick.

[Ans: 876 N]



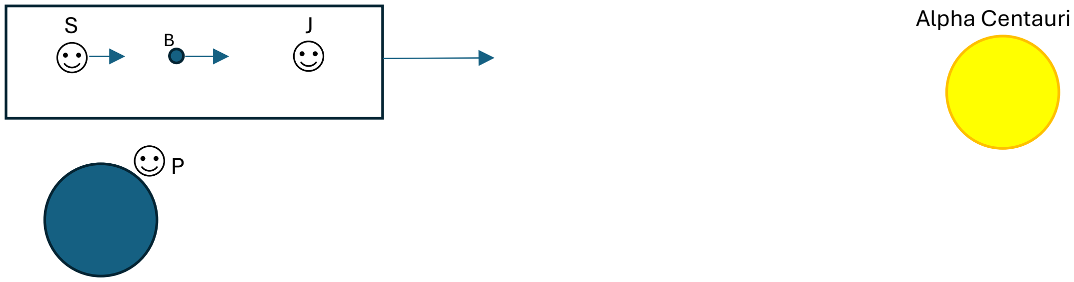
Relativistic Time and Length

A major challenge is selecting the correct reference frame. Quantities such as time, distance, velocity and momentum depend on the observer, so students must clearly distinguish measurements made from different frames of reference.

Time	Length
The proper time is measured when the **event** is observed to be occurring at rest. It is NOT when the observer and/or their clock is at rest. A dilated time is measured when the **event** is observed to be moving.	The proper length is measured between **two points** observed to be at rest. It is NOT when the observer and/or their ruler is at rest. A contracted length is measured between **two points** observed to be moving at the same velocity.

Example 5. For the scenario below, justify which reference frame has the proper time/proper length.

__J__ane is folding laundry in a rocket that is moving past Earth at high speed towards Alpha Centauri. __S__ue, also on the rocket, is running along the rocket's length and throws a __B__all towards the front of the rocket. __P__aul is on Earth.



- _______________'s frame has the proper time for the laundry folding, because

  ____.

- _______________'s frame has the proper length between Earth and Alpha Centauri,

  because____.

- _______________'s frame has the proper length from where the ball was thrown to the front

  of the rocket, because ____.

- _______________'s frame has the proper time for the ball reaching the front of the rocket,

  because ____.

Relativistic Addition of Velocities

$$u = \frac{v+u'}{1+\frac{vu'}{c^2}}$$

$$u' = \frac{u-v}{1-\frac{uv}{c^2}}$$

Where:

u is velocity of moving object in the stationary frame of reference

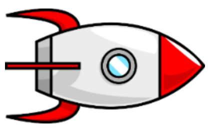
u' is velocity of moving object in the moving frame of reference

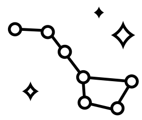
v is the velocity of the moving frame of reference

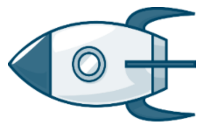
A method to assign u, u' and v

Three "observation" arrows where:

- u and u' are measurements **of** one frame
- u and v are measured **by** one frame

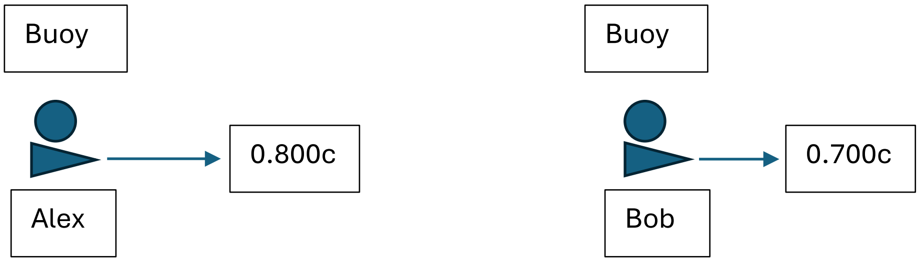






Example 6. Two spaceships approach an observer remaining at rest at the centre of the galaxy. Spaceship A approaches the observer at 0.800c. Spaceship A observes spaceship B on the far side of the galaxy approaching at 0.950c. Determine the speed and direction of spaceship B from the observer's frame.

Example 7. Two space buoys are used to mark the key locations in a race across the stars. All the buoys are at rest relative to each other. Alex is approaching the first of a pair of buoys at 0.800c, while Bob approaches the second buoy at 0.700c, as shown in the diagram below.



The diagram is showing a single instant in time when observers on the buoys see the spaceships line up with the respective buoys. Alex observes the distance between the buoys as 3000 km.

a. Determine the length between the buoys, as observed by Bob.

[Ans: 5000 km]

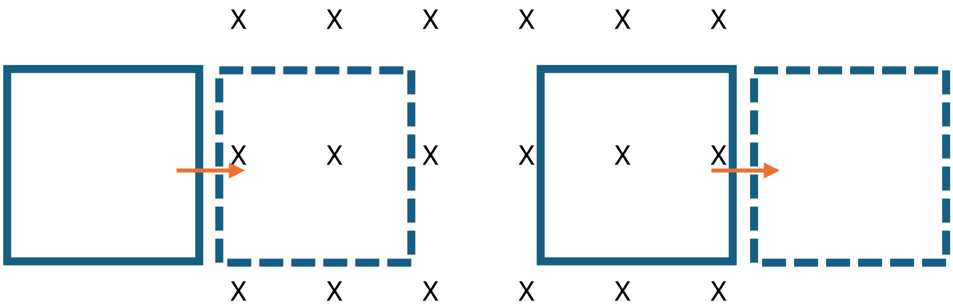
b. Determine the velocity of Bob, as observed by Alex.

[Ans 0.227c towards Alex]

c. When Alex passes the first Buoy, he looks ahead to observe the location of Bob. Justify whether Alex would observe Bob to be ahead of his position by 3000 km, 3570 km, 5000 km, or neither of these options.

Electromagnetic Induction

Coils



Strategy to determine current direction:

1. Describe the change in flux (magnitude and dir)
2. Describe the new flux (opposes change in flux)
3. Determine current that produces new flux (right hand curl rule)

Faraday

While a flux is changing within the area of a coil, there is an induced emf proportional to the rate of change in flux.

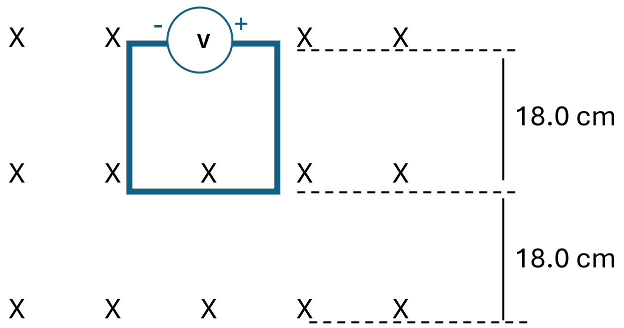
$$\varepsilon = -\frac{\Delta\Phi}{\Delta t}$$

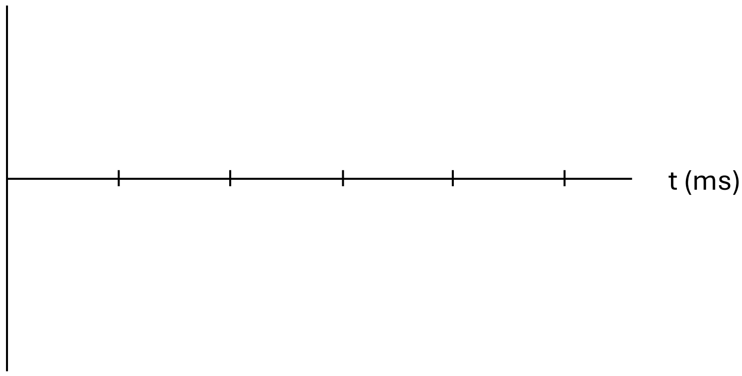
Lenz

A current driven by this emf produces a new field that opposes the **change** in flux within the coil.

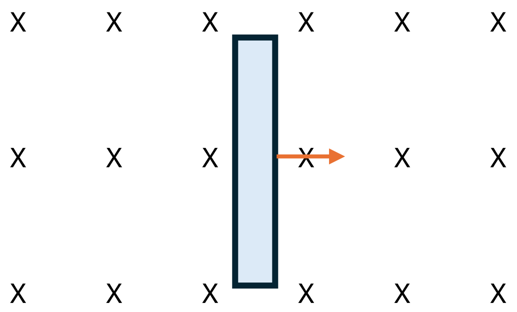
Two magnetic fields (original and new) interact to produce a force that opposes any relative motion.

Example 8. A square coil with 18.0 cm sides is moving at a steady 9.00 m s^{-1} down through a 2.00 T magnetic field and is approaching the bottom edge of the field. Assuming this velocity remains constant, sketch the emf measured within the coil over the next 50.0 ms.





Straight Conductors



Faraday

While a straight conductor cuts across field lines, an induced emf occurs across the conductor

$$\varepsilon = vBl \sin \theta$$

Lenz

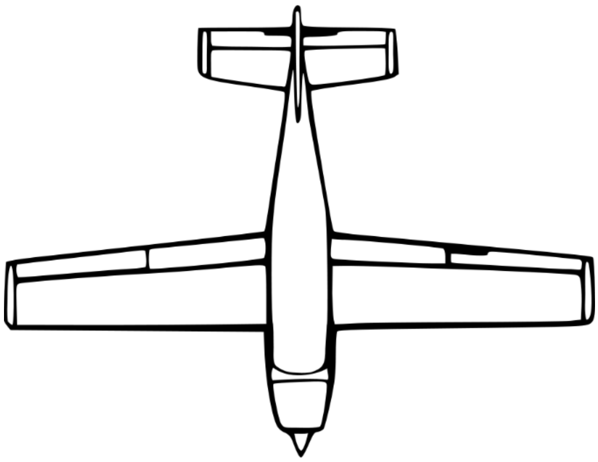
A current* driven by this emf produces a new field that opposes the relative motion of the conductor across the field.

*A conductor without an external circuit cannot sustain a current. A temporary current establishes the emf.

Strategy to determine current direction:

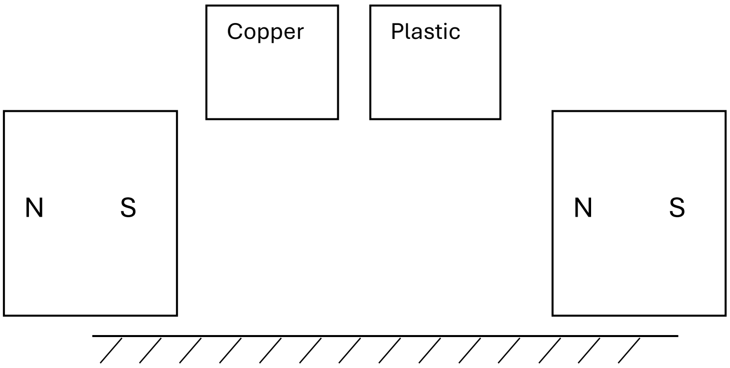
1. Describe the direction of the magnetic force on conductor (opposes motion of conductor)
2. Determine current that produces this magnetic force (right hand palm rule)

Example 9. A plane with a 3.80 m wingspan is flying south at 360 km h^{-1} in the northern hemisphere, where Earth's magnetic field is 55.8×10^{-6} T, angled at 28.0° to the horizon. Calculate the emf induced across the wings and label the polarity of the wings in the diagram.



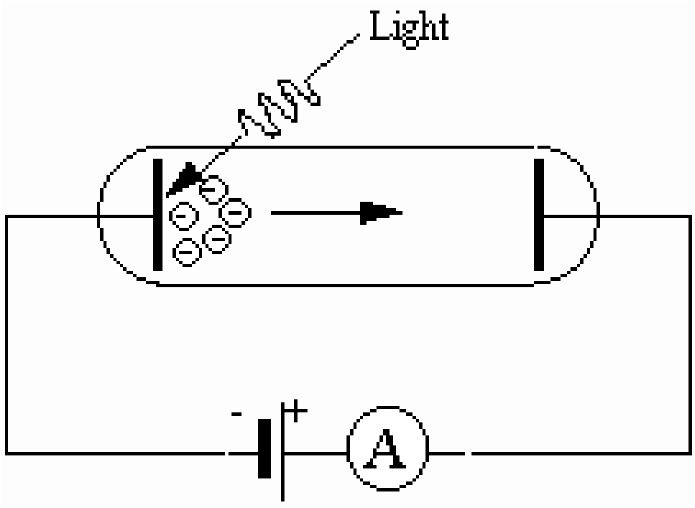
A systematic approach to theoretical answers

Example 10. A copper plate and plastic plate are dropped from rest simultaneously and fall through a region of space which contains a magnetic field acting horizontally. Explain which plate will reach the ground first.



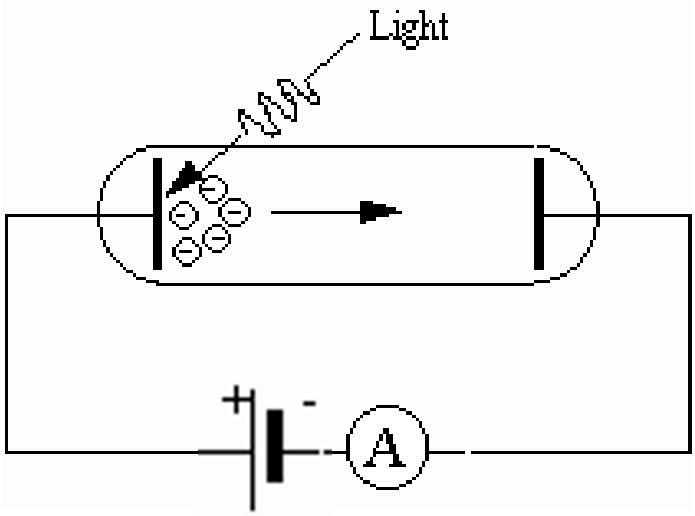
Photoelectric Effect

Comparing the set-up of the external voltage source



When the voltage source is in the **forward** direction:

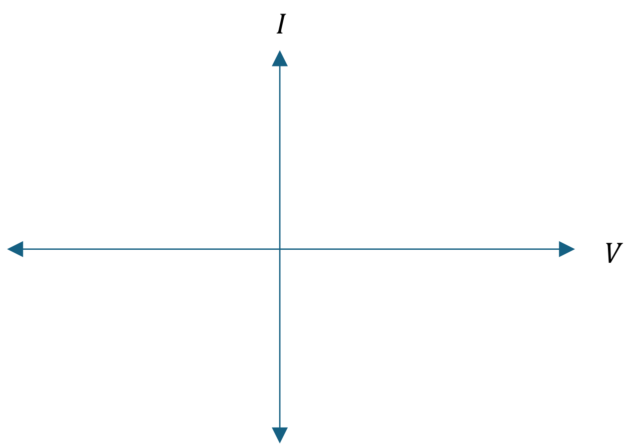
- Electric field will accelerate photoelectrons to collector plate
- Ammeter current indicates **rate** of photoelectrons **at collector plate**
- Increasing voltage has very little effect on current as current is limited to **rate** of photoelectrons ejected.



When the emf source is in the **reverse** direction:

- Electric force will oppose electron motion towards collector plate
- Adjusting voltage **will** change current as this changes the rate of electrons that are reaching the collector
- At the stopping voltage, all photoelectrons are repelled before reaching collector, thus current drops to zero.

Graphical Results

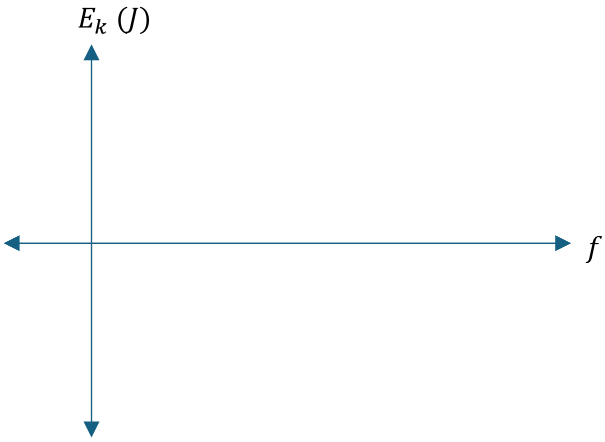


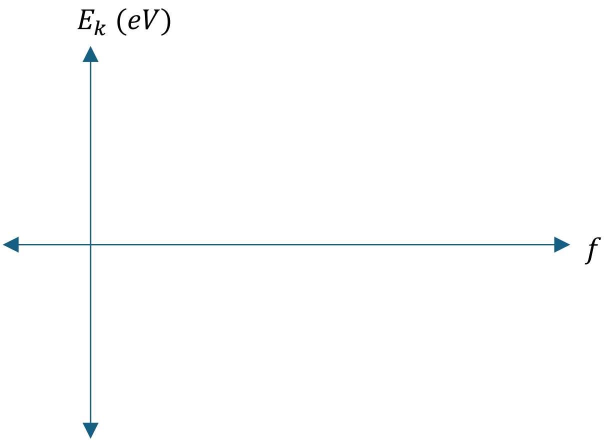
How current varies against external voltage.

Constant frequency and brightness of light.

How kinetic energy of **fastest** photoelectrons varies against light frequency.

Stopping voltage used to determine maximum kinetic energy.





Example 11. A metal has a 3.85 eV work function. Monochromatic light is used to release photoelectrons from this target metal with 1.36×10^{-19} J of kinetic energy.

a. Determine the frequency of the light.

b. Determine the stopping voltage for this frequency of incident light.

c. Determine the minimum frequency of light that could be used to release photoelectrons from this target metal.

X-rays

There are two mechanisms of X-ray production when high velocity electrons strike a target metal:

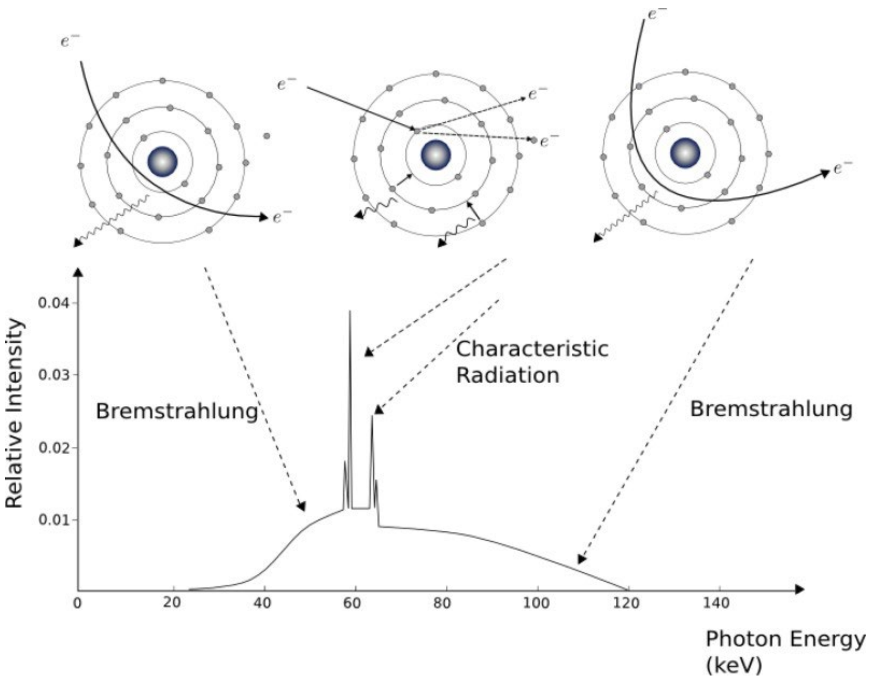
1) Bremsstrahlung (Braking Radiation)

Incident electrons scatter inelastically, converting kinetic energy into EM waves (x-ray).

The possible loss of kinetic energy is continuous, hence continuous spectrum of x-rays are formed.

2) Characteristic X-rays

Inner orbit (n=1 or 2) electrons are knocked out of the metal atoms. Outer orbit electrons fall to take their place, emitting high energy photons (x-rays).



Example 12. Electrons are accelerated from rest through a potential difference of 42.0 kV before striking a tungsten target. The resulting X-ray spectrum contains a continuous range of wavelengths together with two prominent characteristic peaks.

a. Calculate the maximum kinetic energy gained by each electron.

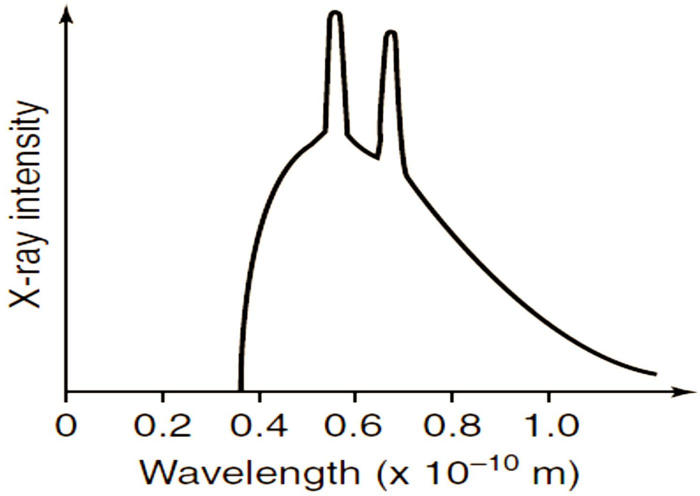
b. Hence calculate the minimum wavelength of the X-rays produced.

c. The accelerating potential difference is increased while the target material remains unchanged. State what happens to:

i. the minimum wavelength X-rays produced

ii. the wavelengths of the characteristic peaks

Example 13. Using the X-ray spectrum below,



a. Estimate the accelerating voltage required to produce these X-rays.

[Ans: ≈33 to 34 kV]

b. Estimate the difference in energy levels, in keV, between the n=1 and n=2 levels of the target metal atoms used to produce these X-rays.

[Ans: ≈4 keV]

Uncertainty

Representing Uncertainty

Absolute Uncertainty x = value ± uncertainty

$L = 1.25 \pm 0.01\, m$

Percentage Uncertainty = $\left(\frac{uncertainty}{value}\right) \times 100$

$\%unc(L) = \frac{0.01}{1.25} \times 100 = 0.80\ \%$

$L = 1.25\, m \pm 0.80\%$

Significant Figures

Uncertainty is given to a maximum of two significant figures (one also acceptable).

Value is given to the same precision as the place value of the uncertainty.

Propagation of Uncertainty

When calculations are performed using uncertain data, the answer is also uncertain. There are rules for propagating the uncertainty of data into the uncertainty of the calculated answer.

Addition and Subtraction

Absolute uncertainties add.
unc(A$\pm$B) = unc(A) + unc(B)

Multiplication and Division

Percentage uncertainties add. Conversion between absolute and percentage uncertainty is usually required.
%unc(AB or A/B) = %unc(A) + %unc(B)

Powers

Multiply percentage uncertainty by the power.
%unc(A^n)= n×%unc(A)

Example 14. The radius of a circle is measured as r = 4.20 ± 0.05 cm.
Determine the area A = πr^2 (in cm^2) and its uncertainty.

Example 15. The period of a pendulum is given by $T = 2\pi\sqrt{\frac{L}{g}}$, where:

- L = 1.20 ± 0.01 m
- g = 9.81 ± 0.05 m/s^2

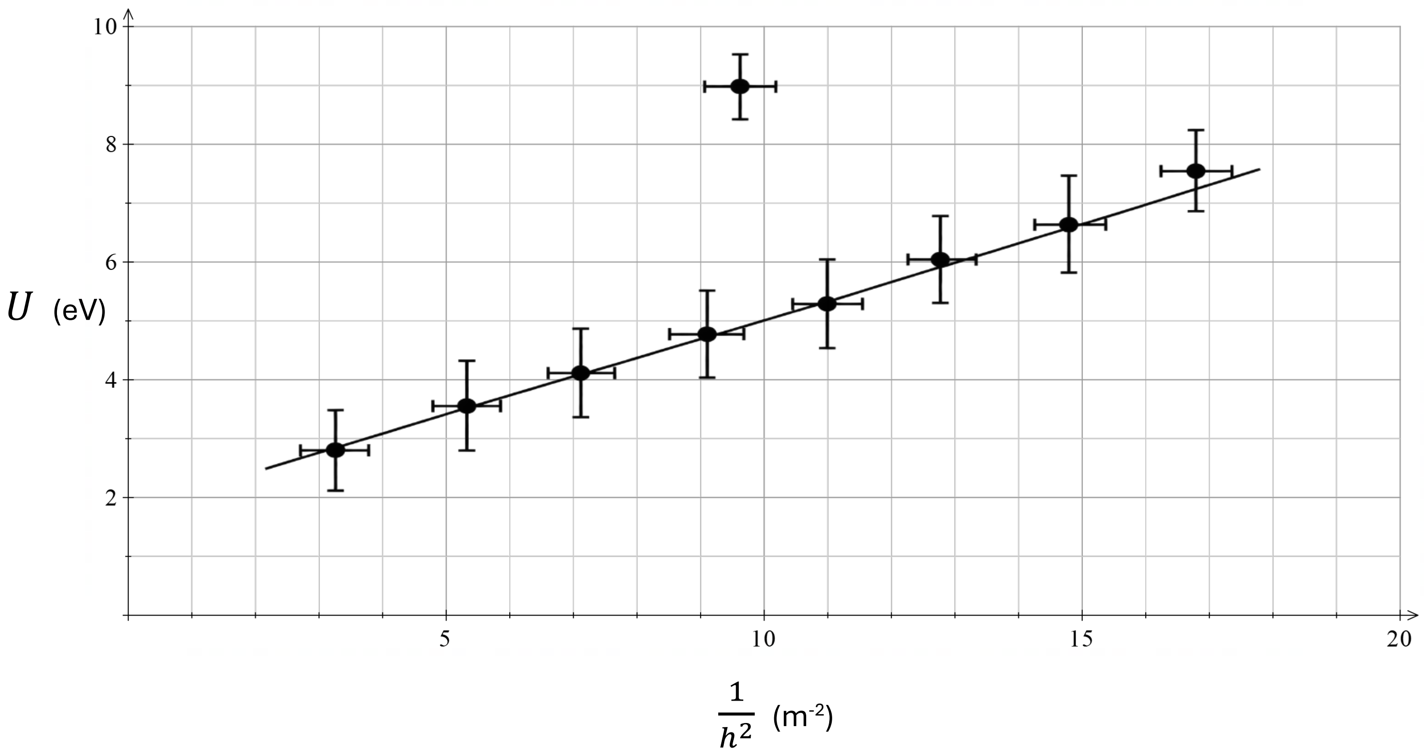
Determine the period and its uncertainty.

[Ans: 2.198 ± 0.015 s]

Graphing Skills

Marks for Graphs

- Even scale across each axis with labels and units
- Avoid scale breaks unless absolutely necessary
- Draw error/uncertainty bars before the line of best fit
- Line of best fit to pass through all error bars, and as close to points as possible
- If there is an error bar that the line of best fit cannot pass through, label as an outlier



Marks for Gradient Calculations

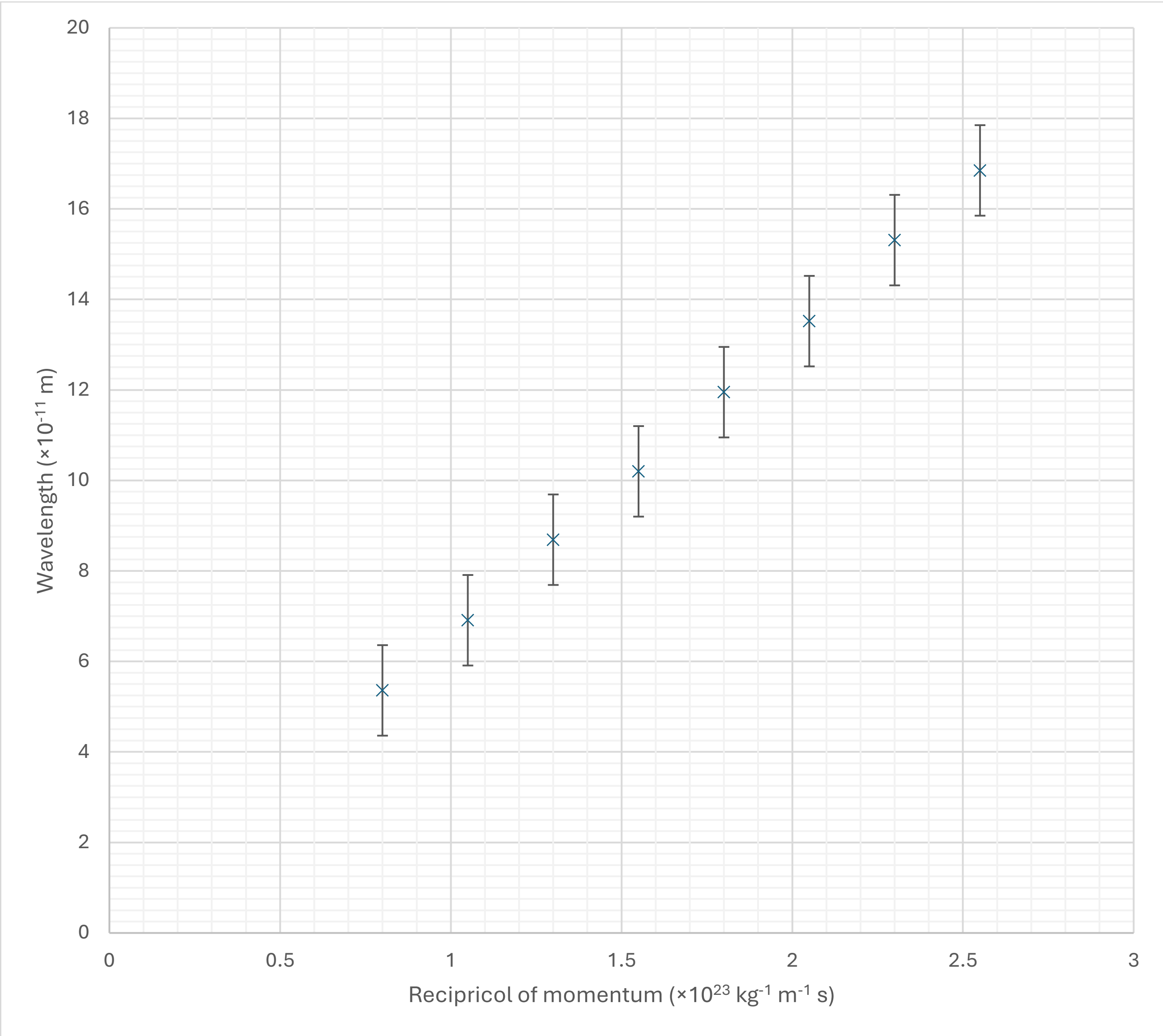
- Show construction lines
- Do NOT use data from the table
- Choose points separated by more than half the length of the line of best fit
- Determine the units from the axes

Marks for using the gradient to find a constant

Use a formula from the data booklet, or from the information in the question in a structure that mimics that of a linear equation. E.g. The graph above is for an experiment testing $h = \sqrt{\frac{j}{(U-f)}}$

$$y = m\,x \;+\; c$$

Example 16. In an electron-diffraction experiment, the momentum of each electron beam was determined and the corresponding de Broglie wavelength was measured. The measurements below are second-hand data supplied by an independent laboratory. The wavelength error bars are in the graph but there is negligible uncertainty in the $\frac{1}{p}$ data.



a. Estimate the percentage uncertainty of the lowest wavelength measurement.

b. Draw two lines representing the steepest and shallowest possible gradients within the uncertainty of the results in the experiment.

c. Use the maximum and minimum possible gradients of these lines to determine the average value for Planck's constant, h. Report your result with its absolute uncertainty and the appropriate SI unit.