

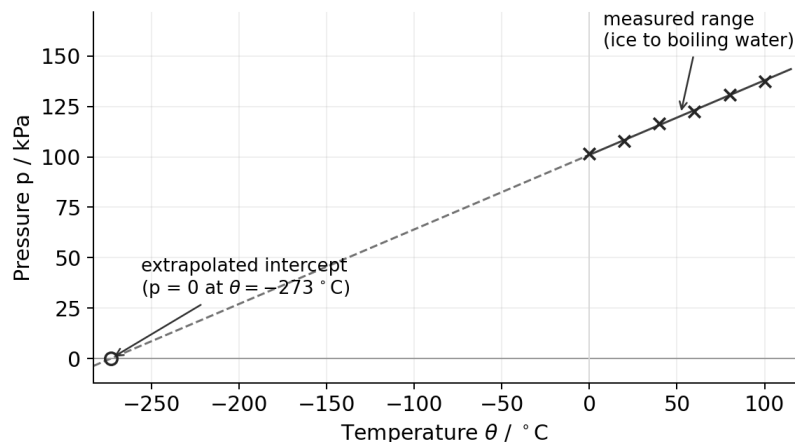
Exercise walk-through

6.3

Compounded uncertainties and justified conclusions

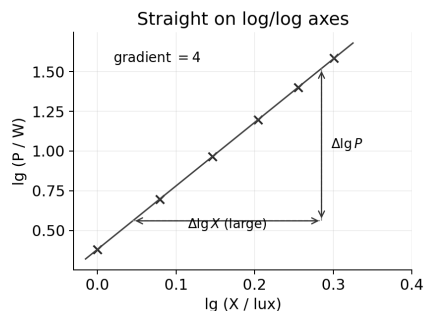
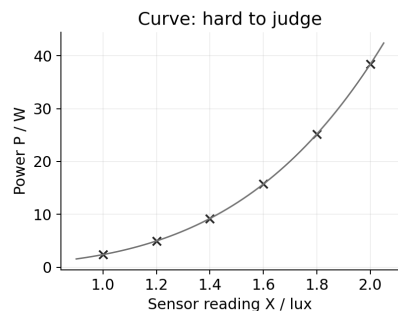
Pearson Edexcel · International A-Level · Physics

Plan an extrapolation to absolute zero



- 1 **Range** ice to boiling water bounds the measured temperatures
- 2 **Readings** at least five paired pressure and temperature values, stirred and perpendicular
- 3 **Graph** best-fit line extended to zero pressure; the intercept estimates -273 °C

The power-law graph and its controls



- 1 **Controls** distance and alignment fixed; background light removed
- 2 **Data** $P = IV$ at five or more current settings
- 3 **Graph** lg P against lg X ; gradient 4 confirms $P = kX^4$

Time many oscillations, mark the centre

Displace the mass a small distance and release.



Start timing only after several oscillations, at the centre marker.



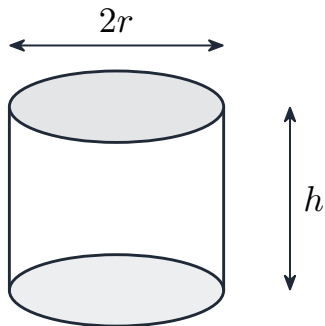
Time ten oscillations; repeat and record the totals.



Divide the mean total by ten for the period.

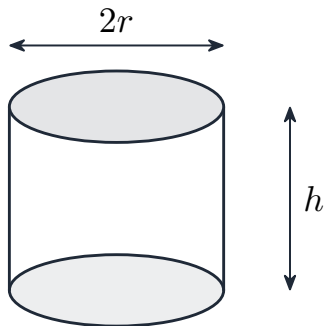
Exercise 2.1

2.1 A cylindrical can has radius $r = 33 \text{ mm} \pm 1\%$ and height $h = 115 \text{ mm} \pm 2 \text{ mm}$. Show that the percentage uncertainty in its volume $V = \pi r^2 h$ is about 4%. [3]



Exercise 2.1

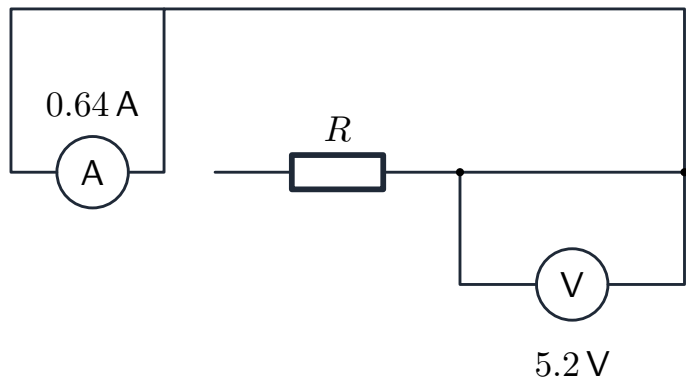
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2.1 Height percentage: $\%U(h) = \frac{2}{115} \times 100\% = 1.7\%$. Volume rule: $\%U(V) = 2 \times \%U(r) + \%U(h)$. $\%U(V) = 2 \times 1\% + 1.7\% = 3.7\% \approx 4\%$.

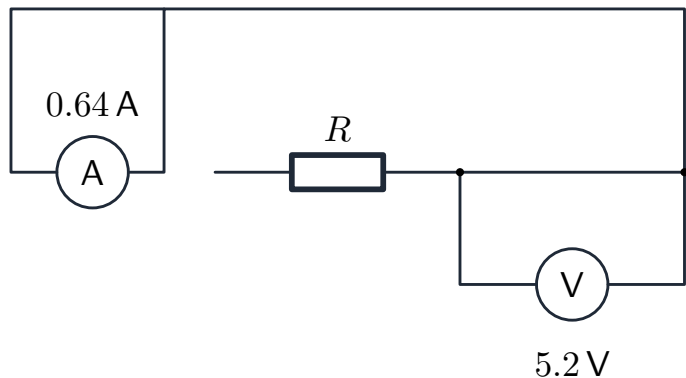
Exercise 2.2

2.2 A resistor's value is found from $R = V/I$, with $V = 5.2 \text{ V} \pm 0.1 \text{ V}$ and $I = 0.64 \text{ A} \pm 0.02 \text{ A}$. Calculate R and its percentage uncertainty. [3]



Exercise 2.2

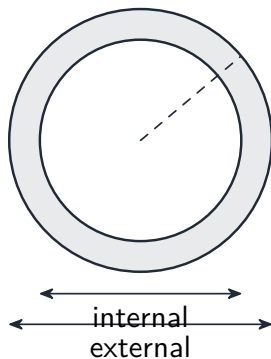
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2.2 $R = V/I = 5.2/0.64 = 8.125 \approx 8.1 \text{ } \Omega$. $\%U(R) = \frac{0.1}{5.2} \times 100\% + \frac{0.02}{0.64} \times 100\% = 1.9\% + 3.1\% = 5.0\%$.

Exercise 2.3

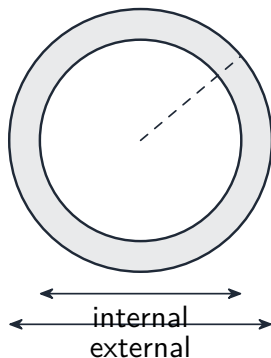
2.3 The external and internal diameters of a pipe are $26.2 \text{ mm} \pm 0.1 \text{ mm}$ and $24.8 \text{ mm} \pm 0.1 \text{ mm}$. Determine the wall thickness and its absolute uncertainty. [2]



3 Exam-style questions

Exercise 2.3

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3 Exam-style questions

2.3 Thickness = $(26.2 - 24.8)/2 = 0.7 \text{ mm}$. Diameters are subtracted then halved: absolute uncertainties add, $\pm(0.1 + 0.1) = \pm 0.2 \text{ mm}$ on the diameter difference, so the thickness is $0.7 \text{ mm} \pm 0.1 \text{ mm}$. (Halving halves the absolute uncertainty; the percentage is unchanged.)

Exercise 3.1

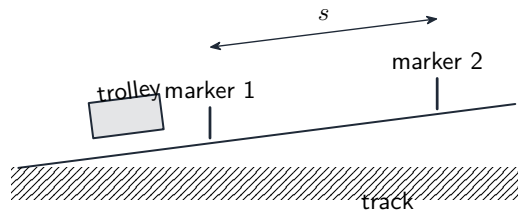
3.1 A trolley accelerates uniformly from rest through a distance s in a time t , with $s = \frac{1}{2}at^2$.

The student records $s = 0.900 \text{ m} \pm 0.002 \text{ m}$ and $t = 1.40 \text{ s} \pm 0.05 \text{ s}$.

(a) Determine the acceleration a . [2]

(b) Show that the percentage uncertainty in a is about 8%. [3]

(c) The track is inclined at 5.5° to the horizontal, so the predicted acceleration is $g \sin 5.5^\circ = 0.94 \text{ m s}^{-2}$. Deduce whether the student's value is accurate. [2]



Exercise 3.1

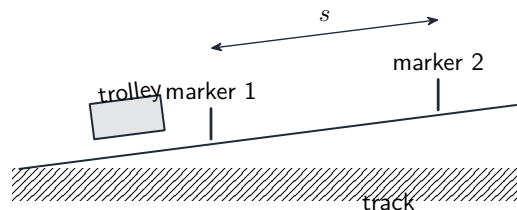
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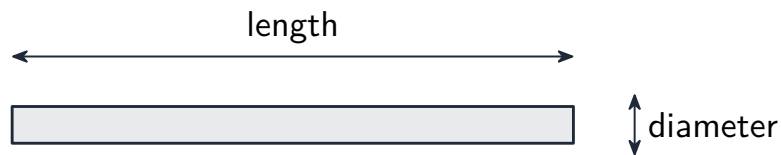


3.1 (a) Rearranged: $a = 2s/t^2$. $a = 2 \times 0.900/1.40^2 = 1.80/1.96 = 0.918 \text{ m s}^{-2}$. (b) $\%U(s) = \frac{0.002}{0.900} \times 100\% = 0.22\%$ and $\%U(t) = \frac{0.05}{1.40} \times 100\% = 3.6\%$. a divides by t^2 , so $\%U(a) = 0.22\% + 2 \times 3.6\% = 7.4\%$, about 8%. (c) Interval: $0.918 \times (1 \pm 0.074) = 0.85$ to 0.99 m s^{-2} . The predicted 0.94 m s^{-2} lies inside the interval, so the measurement is accurate to the precision claimed.

Exercise 3.2

3.2 A student measures the resistivity of a wire as $\rho = 1.75 \times 10^{-8} \Omega \text{ m}$ with a percentage uncertainty of 3%. The data-book value for copper is $1.72 \times 10^{-8} \Omega \text{ m}$.

Determine the interval for the student's value and deduce whether the wire could be copper. [3]



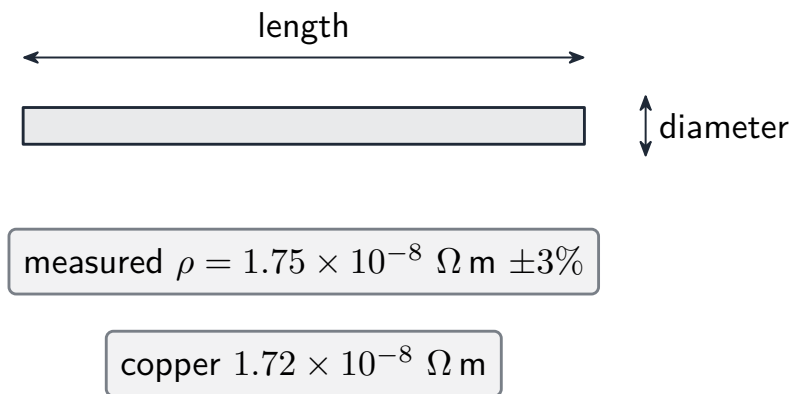
measured $\rho = 1.75 \times 10^{-8} \Omega \text{ m} \pm 3\%$

copper $1.72 \times 10^{-8} \Omega \text{ m}$

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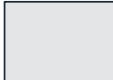
3.2 Absolute uncertainty: $0.03 \times 1.75 \times 10^{-8} = 0.0525 \times 10^{-8} \Omega \text{ m}$. Interval: 1.70 to

Exercise 3.3

3.3 A radiation monitor reads a gross rate of 480 min^{-1} with the source in place and a background of 45 min^{-1} with the source removed. Each rate is counted for the same time, giving each reading an absolute uncertainty of 10 min^{-1} .

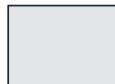
- Calculate the corrected count rate and its absolute uncertainty. [3]
- Determine the percentage uncertainty in the corrected rate. [2]
- The half-life of the source is later determined with a percentage uncertainty of 5%, dominated by the count rates. Explain which measurement most limits this result and one change that would improve it. [3]

source


monitor


480 min^{-1}

monitor, source removed



45 min^{-1}

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(a) Calculate the corrected count rate and its absolute uncertainty. [3]

(b) Determine the percentage uncertainty in the corrected rate. [2]

(c) The half-life of the source is later determined with a percentage uncertainty of 5%, dominated by the count rates. Explain which measurement most limits this result and one change that would improve it. [3]



3.3 (a) Corrected rate $R = 480 - 45 = 435 \text{ min}^{-1}$. Subtracted readings add absolute uncertainties: $\Delta R = 10 + 10 = 20 \text{ min}^{-1}$, so $R = 435 \pm 20 \text{ min}^{-1}$. (b) $\%U(R) = \frac{20}{435} \times 100\% = 4.6\%$. (c) The corrected rate's 4.6% is the dominant contribution to the stated 5%. Count for a longer time at each distance: more counts means a smaller

Full solution 3.3

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