

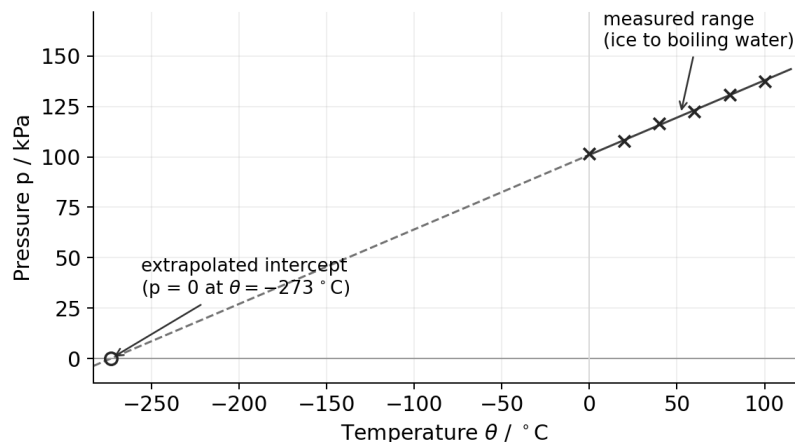
Exercise walk-through

6.4

Log graphs and linearisation

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

Safety and data loggers name their mechanism

Situation	Named mechanism	Action
hot water, heater	burns on contact	tongs; clamp the heater
electrolytic capacitor	polarity, rating, stored charge	connect correctly; discharge first
data logger probes	simultaneous pairs, no parallax	better resolution than a thermometer

Time many oscillations, mark the centre

Displace the mass a small distance and release.



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



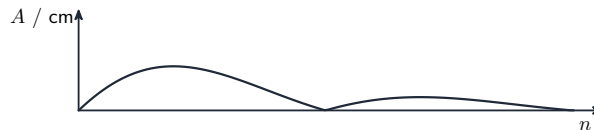
Time ten oscillations; repeat and record the totals.



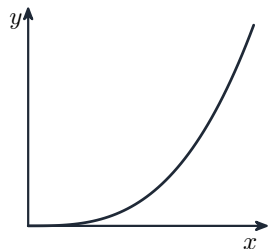
Divide the mean total by ten for the period.

Exercises 2.1·2.2

2.1 The amplitudes of a damped oscillator are recorded as 9.5, 7.8, 6.3, 5.1, 4.2, 3.4 cm. Calculate $\ln(A/\text{cm})$ for each value, giving your answers to three decimal places. [2]

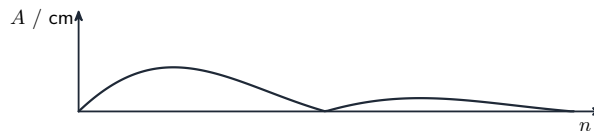


2.2 A quantity follows $y = kx^3$. State the graph you would plot to test this, and what its gradient and intercept would represent. [2]



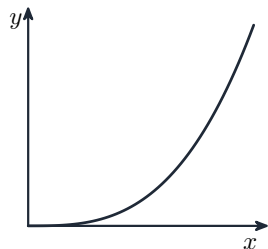
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2.1 Each value passed through the natural log: 2.251, 2.054, 1.841, 1.629, 1.435, 1.224, all to three decimal places and consistent.

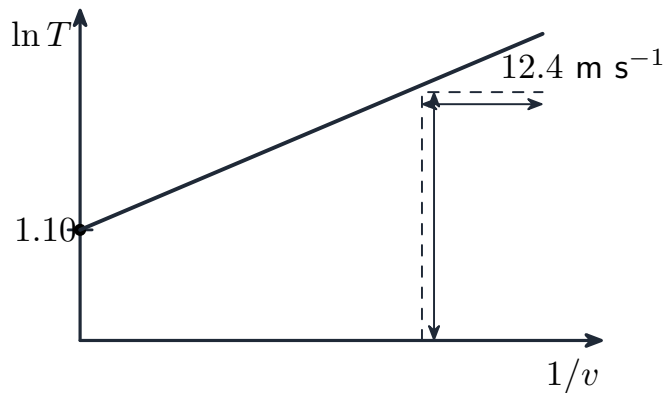
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2.2 Plot $\lg y$ against $\lg x$; gradient = 3 and intercept = $\lg k$. (Plotting y against x^3 with

Exercise 2.3

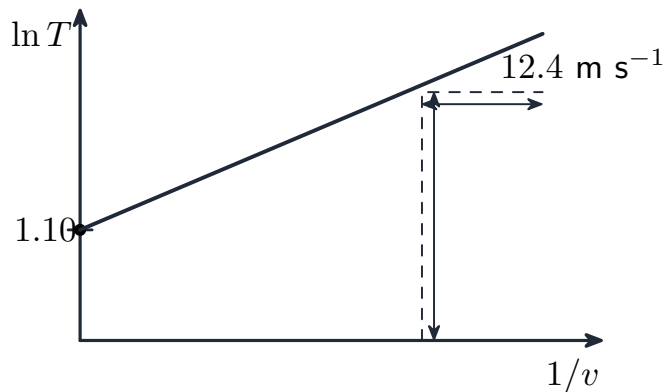
2.3 A line of $\ln T$ against $1/v$ has intercept 1.10 and gradient 12.4 m s^{-1} . The model is $T = Ae^{B/v}$. Determine A and B . [2]



3 Exam-style questions

Exercise 2.3

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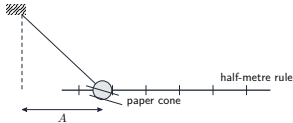
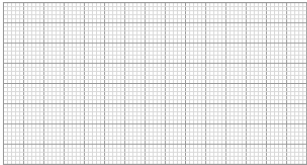
2.3 $A = e^{1.10} = 3.0$; matching $\ln T = \ln A + B/v$ to $y = c + mx$ gives $B = +12.4 \text{ m s}^{-1}$ – the sign is positive because the exponent is $+B/v$ here.

Exercise 3.1

3.1 A paper cone is attached to a pendulum bob as a damper. The amplitude A follows $A = A_0 e^{-\lambda n}$, where n counts oscillations.

n	A / cm
5	9.5
10	7.8
15	6.3
20	5.1
25	4.2
30	3.4

- (a) Copy and complete the additional column with $\ln(A/\text{cm})$ to three decimal places. [1]
- (b) Plot $\ln(A/\text{cm})$ against n on the grid and draw a best-fit line. [3]
- (c) Use a large triangle to determine λ . [2]
- (d) Determine A_0 from your graph. [2]
- (e) Explain why the value of A_0 from the graph may not be the true initial amplitude. [2]

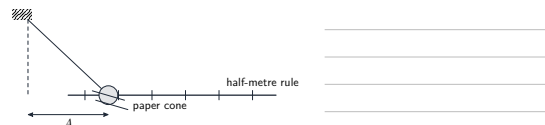
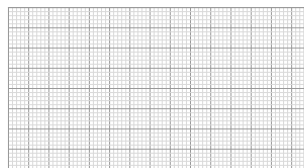


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3.1 (a) $\ln(A/\text{cm})$: 2.251, 2.054, 1.841, 1.629, 1.435, 1.224. (b) Axes labelled $\ln(A/\text{cm})$ and n , sensible scales, points plotted to half a small square, thin best-fit line. (c) Large triangle on the line, e.g. from (5, 2.25) to (30, 1.22): $\lambda = -\text{gradient} = (2.25 - 1.22)/(30 - 5) = 0.041$, accept 0.040–0.043, no unit. (d) Intercepts: extend the line to $n = 0$ and read $\ln A_0 \approx 2.46$, then $A_0 = e^{2.46} = 11.7 \text{ cm}$ (accept 11–12 cm, unit matching the logged quantity). (e) Any paired reasoning: there is no data below $n = 5$, so the line's position at $n = 0$ is an extrapolation that scatter makes uncertain; or a systematic error in judging

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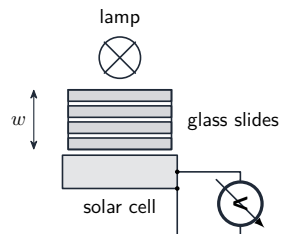
Exercise 3.2

3.2 Light passes through stacks of glass slides of total thickness w . The voltmeter reading across a solar cell follows $V = Ae^{-Bw}$, where A and B are constants.

w / mm	V / mV
2	413
4	406
6	399
8	392
10	385

(a) Explain how a graph of $\ln(V/\text{mV})$ against w determines B . [2]

(b) The graph gives a gradient of -0.0088 mm^{-1} . Determine the minimum number of 2.0 mm slides needed to reduce V to at most 60% of its value with no glass. [4]



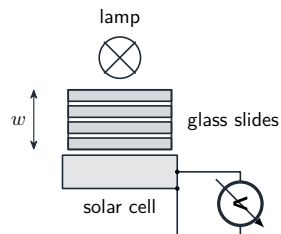
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3.2 (a) Taking logs: $\ln V = \ln A - Bw$, so the plot is straight with gradient $-B$. (b) With no glass $V = A$, so the target is $V/A = 0.60$:

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$$\ln 0.60 = -Bw \quad \Rightarrow \quad w = \frac{\ln 0.60}{-0.0088 \text{ mm}^{-1}} = 58 \text{ mm}$$

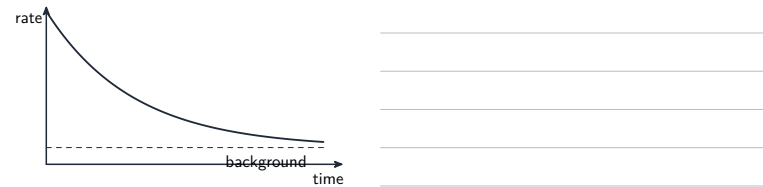
Dividing by the 2.0 mm thickness gives $58/2.0 = 29$, so at least 30 slides: 29 leave the reading marginally above 60%.

Exercise 3.3

3.3 A source decays with activity $R = R_0e^{-\lambda t}$. The background rate is a constant 20 min^{-1} . The gross monitor rate is recorded every ten minutes:

t / min	Gross rate / min^{-1}
0	470
10	367
20	288
30	227
40	179
50	143

- (a) Explain why the graph must use $\ln(R_{\text{corr}}/\text{min}^{-1})$ rather than the gross rate. [2]
- (b) Process the data and describe how the plotted graph determines λ . [3]
- (c) The line gives $\lambda = 0.026 \text{ min}^{-1}$. Determine the half-life. [2]
- (d) The source's data sheet states a half-life of 25 minutes. The percentage uncertainty in the half-life is estimated at 5%. Deduce whether the measurement agrees with the data sheet. [2]



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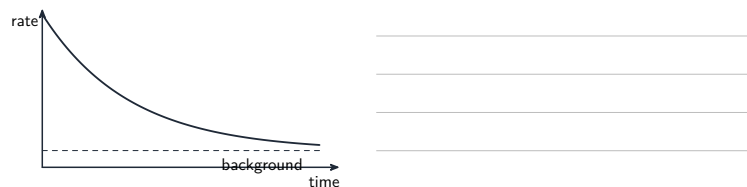
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3.3 (a) The gross rate is the source's activity plus a constant background; $\ln$ of a sum is not linear in t . Subtracting the background first leaves $R_{\text{corr}} = R_0 e^{-\lambda t}$, whose log is linear. (b) Corrected rates: 450, 347, 268, 207, 159, 123 min^{-1} ; logs to three decimal places: 6.109, 5.849, 5.591, 5.333, 5.069, 4.812; plot $\ln(R_{\text{corr}}/\text{min}^{-1})$ against t , best-fit

Full solution 3.3

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$$t_{1/2} = \frac{\ln 2}{\lambda} = \frac{0.693}{0.026 \text{ min}^{-1}} = 26.7 \text{ min}$$

so the half-life is 26.7 minutes. (d) Interval: $26.7 \times (1 \pm 0.05) = 25.4$ to 28.0 min. The data-sheet 25 minutes lies just below the lower limit, so strictly the measurement does not agree at that uncertainty; alternatively a percentage difference of $\frac{26.7-25}{25} \times 100\% = 6.8\%$ exceeds 5%, again not in agreement. A conclusion that follows the chosen comparison earns the mark.