

AS Physics 9702

Practical and data skills

Worked answers

Try the separate worksheet first. These worked answers explain methods as well as results. Equivalent valid reasoning and sensible rounding may also be correct. Suggested marks are RevisionTown practice guidance, not Cambridge marking instructions.

Scope: Cambridge International AS Physics 9702, 2025–2027 learning outcomes. The published 2028–2030 AS scope has been checked separately and is substantively unchanged. Version: 11 October 2026.

P3-Q1 · 20 marks

(a) Length = $18.7 - 2.3 = 16.4$ cm. For the stated conservative bound, $\Delta L = 0.05 + 0.05 = 0.10$ cm. Report (16.4 ± 0.1) cm. View perpendicular to the rule with the scale close to the rod, so eye position does not shift the apparent alignment. [3]

(b) Observed diameter = $12 + 17 \times 0.02 = 12.34$ mm. A positive zero reading is subtracted: corrected diameter = $12.34 - 0.04 = 12.30$ mm. Retain two decimal places to match the instrument's resolution. [3]

(c) Observed thickness = $5.5 + 23 \times 0.01 = 5.73$ mm. Corrected thickness = $5.73 - (-0.02) = 5.75$ mm. Use the ratchet gently, keeping the measuring faces clean and square to the object. [3]

(d) Each division is $0.60/30 = 0.020$ A. The current is $22 \times 0.020 = 0.44$ A. Half a division is 0.01 A, giving (0.44 ± 0.01) A under the specified estimate. [2]

(e) 0.186 A = 186 mA. Display resolution is not the same as accuracy: the specified uncertainty is ± 2 mA, larger than the 1 mA display increment. Use the stated ± 0.002 A. [2]

(f) Volume = 43 cm^3 . Place the cylinder vertically on a level surface and view the bottom of the water meniscus at eye level. [2]

(g) Sample mass = $47.3 - 12.6 = 34.7$ g. [1]

(h) The acute angle is 39° . The temperature is 67°C . Choosing the opposite protractor scale would turn the acute angle into its supplement. [2]

(i) One division is $2.0/20 = 0.1$ N. Observed force = $16 \times 0.1 = 1.6$ N. Corrected force = $1.6 - 0.1 = 1.5$ N. A zero check in the working orientation is important because orientation can affect a spring meter. [2]

P3-Q2 · 12 marks

(a) X is the ammeter because it is in series in the main current path. Y is the voltmeter because its branch connects across the test resistor. Trace the loop from the supply through the switch, variable resistor, X and test resistor back to the supply; Y measures the potential difference specifically across the test resistor. Check d.c. mode, terminals and polarity with the switch open before energising the circuit. [3]

(b) Start on 0–2.00 A because it covers the permitted 0.30 A current. A 0–0.20 A range would overload above 0.20 A, so it cannot cover the entire authorised current interval. [2]

(c) Suitable target voltages are 0.50, 1.00, 1.50, 2.00, 2.50 and 3.00 V, provided the current limit is respected at each setting. They sample the widest permitted interval at regular steps, helping constrain the relationship. If a limit is reached earlier, stop increasing the setting and record the actual usable range. [2]

(d) Check the meter zero with no input and check for stable connections. Limit heating by switching off between readings and allowing cooling as needed. Use only the specified low-voltage supply, avoid short circuits and open the switch before reconnecting. Temperature matters because resistance can change as the resistor warms. [3]

(e) $R = V/I = 2.75/0.250 = 11.0 \, \Omega$. The variable resistor and other circuit elements can take some supply voltage, so the test resistor's potential difference must be measured across its own terminals. [2]

P3-Q3 · 14 marks

(a) Use a fixed marker near the centre of the swing. Start when the bob passes the marker in a chosen direction, count that passage as zero, and stop after twenty complete returns through the marker in the same direction. Start and finish at equivalent phases. [3]

(b) Mean time = $(28.2 + 28.4 + 28.3)/3 = 28.3 \, \text{s}$. $T = 28.3/20 = 1.415 \, \text{s}$. This calculated result uses one more significant figure than the three-figure time, consistent with the normal Paper 3 guidance. Retaining working digits avoids round-off in later calculations. [3]

(c) Half-range = $(28.4 - 28.2)/2 = 0.1 \, \text{s}$. This describes the observed repeat spread, but the separately assessed $\pm 0.2 \, \text{s}$ timing uncertainty is larger. A short set of repeats does not guarantee the smaller estimate captures all timing effects. [2]

(d) $\Delta T = 0.2/20 = 0.010 \, \text{s}$. Percentage uncertainty = $100 \times 0.010/1.415 = 0.707\%$, about 0.71%. Equivalently, calculate $100 \times 0.2/28.3$. [3]

(e) For one cycle, percentage uncertainty = $100 \times 0.2/1.4 = 14.3\%$. Twenty cycles make the timed interval much longer without multiplying the same start-stop uncertainty twentyfold. Timing too many cycles can cause amplitude drift, damping, miscounting or excessive time use; name any one relevant limitation. [3]

P3-Q4 · 14 marks

(a) Record $L_0 = 11.8 \, \text{cm}$ beside the table. A suitable completed table is:

m / g	L / cm	x / m	F / N
50.0	14.2	0.024	0.491
100.0	16.7	0.049	0.981
150.0	19.1	0.073	1.47
200.0	21.6	0.098	1.96
250.0	24.0	0.122	2.45

m / g	L / cm	x / m	F / N
300.0	26.5	0.147	2.94

Award credit for correct headings and units, all raw values, all six extensions and all six forces. [6]

(b) $x = (14.2 - 11.8)/100 = 0.024$ m. $F = (50.0/1000) \times 9.81 = 0.4905$ N, reported as 0.491 N. A rule with 1 mm divisions supports 0.1 cm raw increments, so 14.2 cm is sensible. The limiting mass and g each have three significant figures, making three or four figures acceptable for force; this table uses three. [4]

(c) Advance preparation lets readings go directly into the correct columns and exposes omissions. Keeping raw values allows calculations, conversions and anomalies to be checked; derived values alone cannot reconstruct every measurement reliably. [2]

(d) The data extend to the maximum authorised mass and include distributed intermediate settings. Add separate repeat-length columns or clearly labelled repeat rows, then a mean column if required. Preserve each actual measurement. [2]

P3-Q5 · 18 marks

(a) Label x / m and F / N. One suitable choice is 0.020 m per 2 cm horizontally, from 0 to 0.160 m, and 0.5 N per 2 cm vertically, from 0 to 3.0 N. Label every 2 cm. Horizontal point span = $16 \times (0.147 - 0.024)/0.160 = 12.3$ cm, exceeding half the 16 cm width. Vertical span = $12 \times (2.94 - 0.491)/3.0 = 9.80$ cm, exceeding half the 12 cm height. [4]

(b) Relative to the lower-left origin, the point positions in centimetres are approximately (2.40, 1.96), (4.90, 3.92), (7.30, 5.88), (9.80, 7.84), (12.20, 9.80) and (14.70, 11.76). Use visible fine crosses or encircled dots under 1 mm wide and locate them to better than 1 mm. Draw a continuous straight line under 1 mm thick with balanced scatter, rather than joining consecutive points. For the independent reading task, the two recorded coordinate pairs must lie on the learner's own line and be separated by more than half its drawn length. Check them against that graph, rather than requiring one fixed pair. The gradient calculated from those readings should be consistent with the marked triangle and close to 20 N m^{-1} . Award credit for plotting, fit quality, valid coordinate reading and a consistent gradient with its unit. Small differences between reasonable hand-drawn best fits are expected. [6]

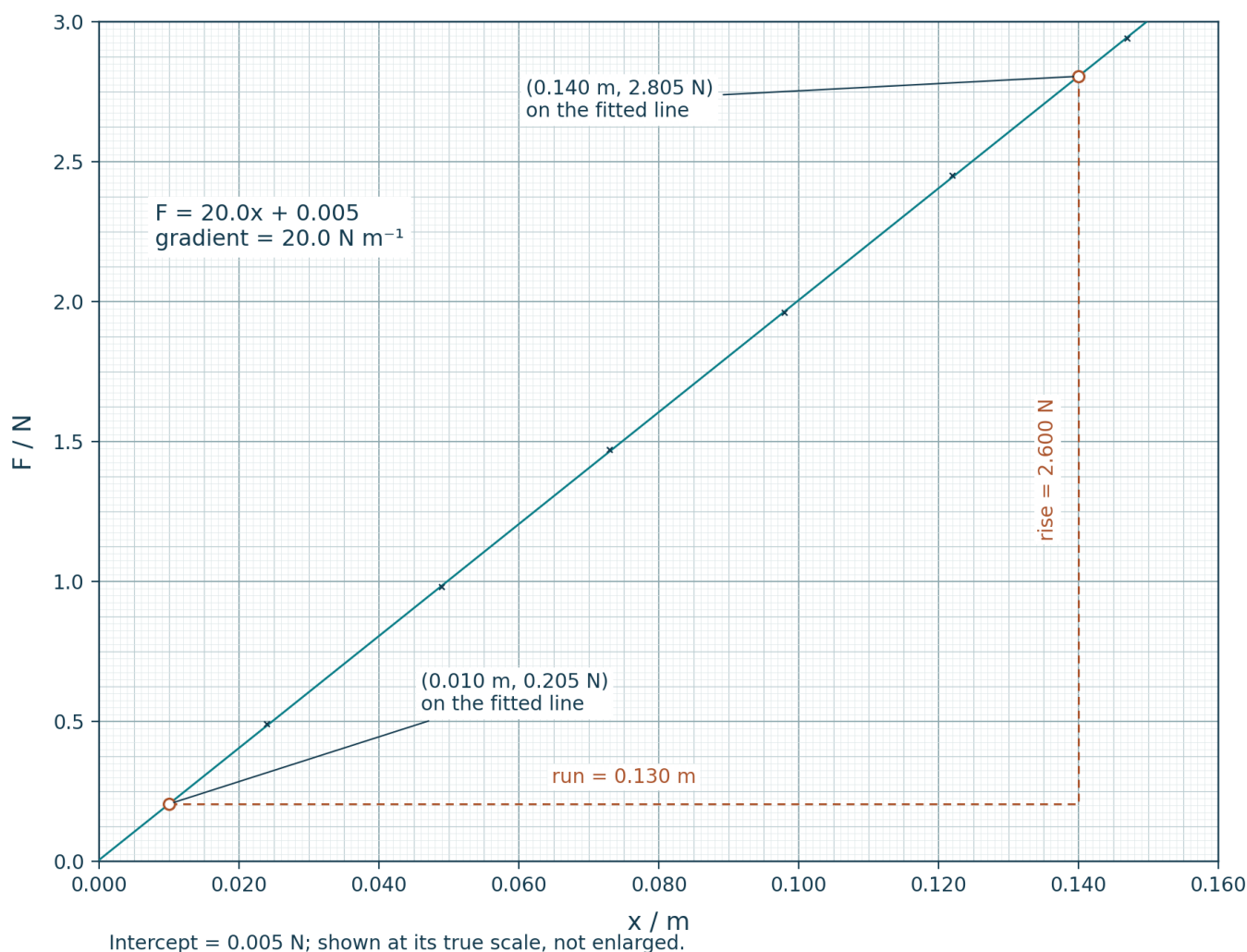
(c) Gradient = $(2.805 - 0.205)/(0.140 - 0.010) = 2.600/0.130 = 20.0 \text{ N m}^{-1}$. Intercept = $0.205 - 20.0 \times 0.010 = 0.005$ N. These points lie on the fitted trend; choosing them uses the whole dataset's trend rather than the random deviations of two observations. Their horizontal separation is 0.130 m, greater than half the plotted line length for this graph. [5]

(d) $k = 20.0 \text{ N m}^{-1}$. At $x = 0.100$ m, $F = 20.0 \times 0.100 + 0.005 = 2.005$ N, approximately 2.01 N. Do not force an origin crossing merely because an ideal model predicts one; inspect the measured trend and possible offset first. [3]

Figure for P3-Q5 — worked answer

Representative spring graph

× observations ○ chosen line coordinates — representative hand-fit



Print at 100% / Actual size. The inner grid should measure 16.0 cm by 12.0 cm.

P3-Q6 · 16 marks

(a) Expanding gives $T^2 = (4\pi^2/g)L + (4\pi^2/g)e$. Thus $y = T^2$, $x = L$, $m = 4\pi^2/g$, and $c = me$. [4]

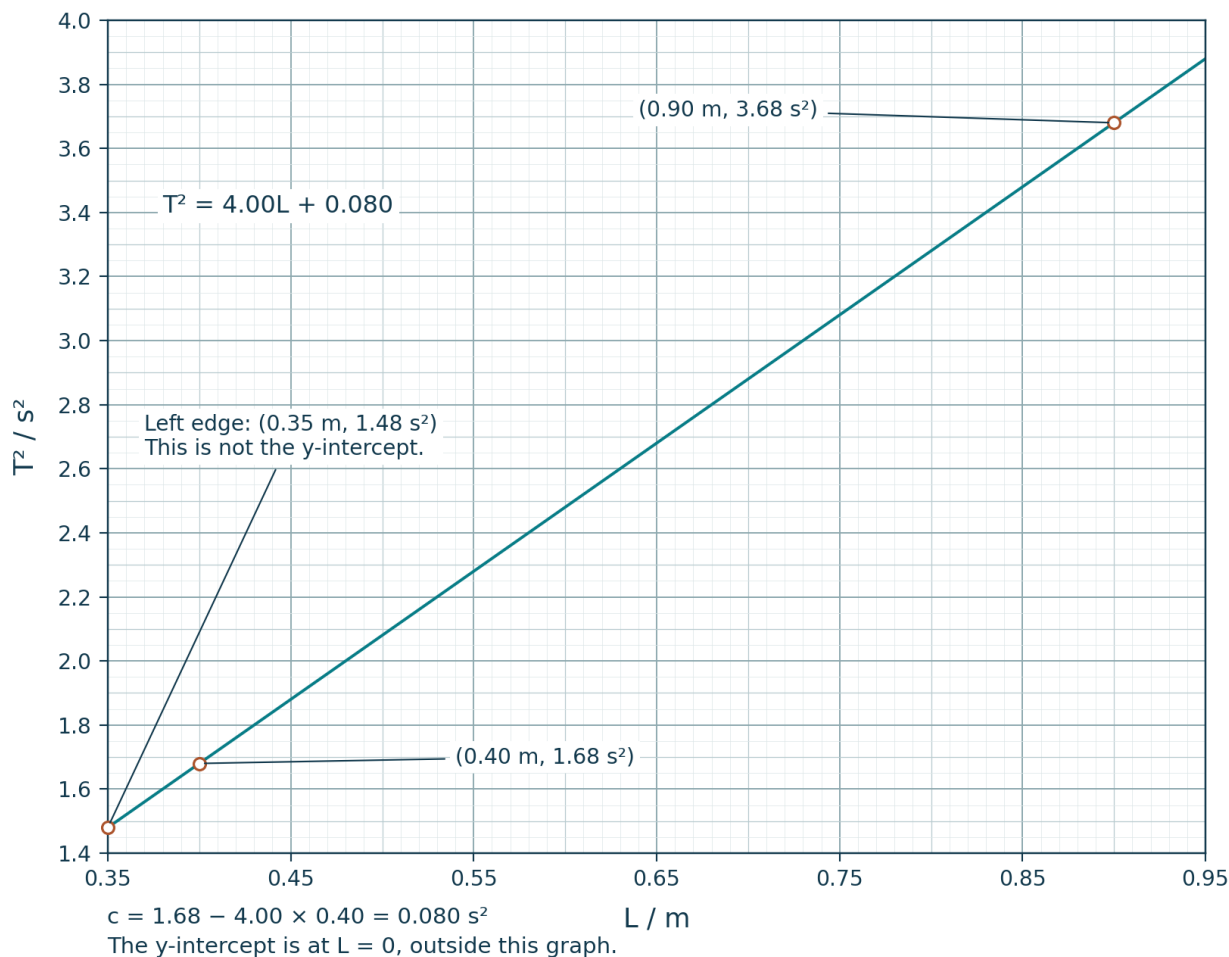
(b) $m = (3.68 - 1.68)/(0.90 - 0.40) = 2.00/0.50 = 4.00 \text{ s}^2 \text{ m}^{-1}$. $c = y - mx = 1.68 - 4.00 \times 0.40 = 0.080 \text{ s}^2$. [4]

(c) The left edge represents $L = 0.35 \text{ m}$, whereas the true y-intercept is the value at $L = 0$. The line's height there is $4.00 \times 0.35 + 0.080 = 1.48 \text{ s}^2$. The false origin therefore makes a direct intercept reading impossible. [3]

(d) $g = 4\pi^2/m = 39.4784/4.00 = 9.87 \text{ m s}^{-2}$. $e = c/m = 0.080/4.00 = 0.020 \text{ m}$. [3]

(e) $T^2 = 4.00 \times 0.65 + 0.080 = 2.68 \text{ s}^2$; $T = \sqrt{2.68} = 1.64 \text{ s}$. The length lies inside the investigated interval, so this is interpolation. [2]

Figure for P3-Q6 — worked answer

A false origin hides the true intercept**P3-Q7 · 14 marks**

(a) Plot all six pairs with t / s horizontally and $\theta / ^\circ\text{C}$ vertically, using convenient scales that spread the data over at least half the grid in each direction. Draw a continuous smooth cooling curve following the overall trend without corners or forced point-to-point segments. At 20 s, construct a straight tangent matching the curve's local direction and extend it; mark two well-separated points on this tangent. The reference answer has a slope near $-0.87 ^\circ\text{C s}^{-1}$, but judge a learner's construction against their own reasonable smooth curve. A chord joins two separate points and gives an average rate across an interval, which need not equal the instantaneous rate at 20 s. Award credit for plotted data/axes, smooth curve, correctly placed local tangent, well-separated marked tangent points and the chord distinction. [5]

(b) Gradient = $(44 - 70)/(35 - 5) = -26/30 = -0.867 ^\circ\text{C s}^{-1}$. Near 20 s the temperature is falling by about $0.87 ^\circ\text{C}$ each second. [3]

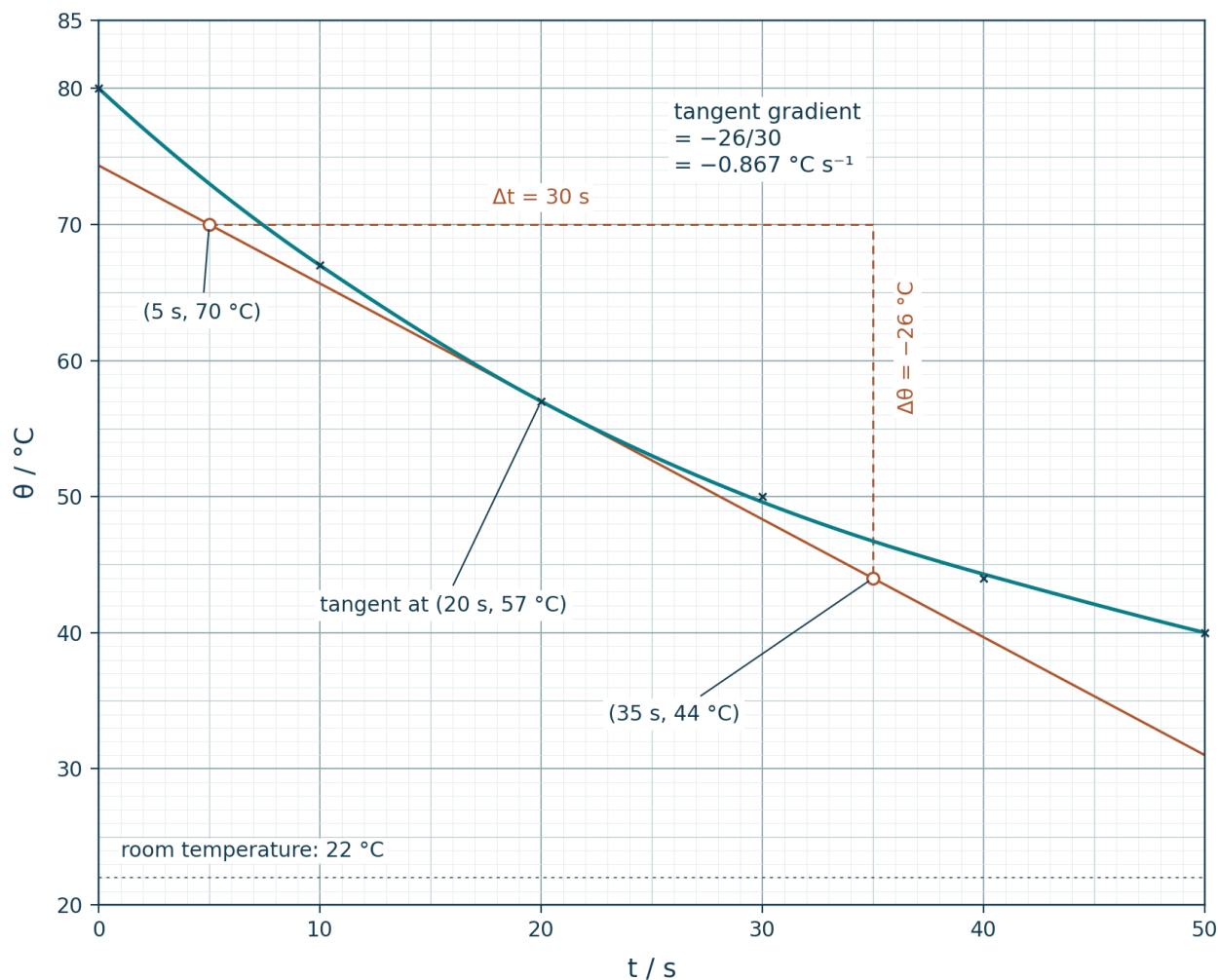
(c) $c = 70 - (-0.8667 \times 5) = 74.3 ^\circ\text{C}$. This is the intercept of the tangent, not of the cooling curve. The tangent approximates the curve only locally; the actual initial temperature is $80 ^\circ\text{C}$. [3]

(d) $\theta \approx 74.333 - 0.86667 \times 22 = 55.3 \text{ }^{\circ}\text{C}$. At 80 s the same line predicts about $5.0 \text{ }^{\circ}\text{C}$, but this is far from the point of tangency and below the stated room temperature. The changing slope means this extrapolation is not a valid cooling prediction. [3]

Figure for P3-Q7 — worked answer

A tangent gives the local cooling rate

x observations teal: smooth curve brown: tangent at 20 s



The tangent follows the curve locally; it is not a cooling model for all times.

P3-Q8 · 12 marks

(a) $R = V/I$. First result: $1.2/0.1032 = 11.627906... \Omega$, reported as 11.6Ω . Second: $1.8/0.1497 = 12.024048... \Omega$, reported as 12.0Ω . Third: $2.4/0.2010 = 11.940298... \Omega$, reported as 11.9Ω . [4]

(b) Each voltage has two significant figures while each current has four. For division, the syllabus guidance normally permits the limiting two figures or one extra, so three is justified. A long calculator display claims precision unsupported by the voltage measurements. [3]

(c) The final zero in 0.2010 records the 0.0001 A increment and is significant. Writing 1.20 V implies 0.01 V precision, which this stated voltmeter reading does not provide. [2]

(d) $P = VI = 1.2 \times 0.1032 = 0.12384 \text{ W} \approx 0.124 \text{ W}$. Using 103.2 as if it were amperes makes the numerical denominator 1000 times too large, so the calculated resistance is 1000 times too small. Convert 103.2 mA to 0.1032 A first. [3]

P3-Q9 · 14 marks

(a) $x = 262 - 250 = 12 \text{ mm}$. $\Delta x = 1 + 1 = 2 \text{ mm}$. Thus $x = (12 \pm 2) \text{ mm}$ and percentage uncertainty $= 100 \times 2/12 = 16.7\%$, about 17%. The small difference has a much larger fractional uncertainty than either total length. [4]

(b) Mean $= (43.2 + 43.5 + 43.3 + 43.4)/4 = 43.35 \text{ cm}$. Half-range $= (43.5 - 43.2)/2 = 0.15 \text{ cm}$. Percentage uncertainty $= 100 \times 0.15/43.35 = 0.346\%$, approximately 0.35%. Writing $(43.35 \pm 0.15) \text{ cm}$ describes the mean and the chosen uncertainty estimate; it does not alter the raw ruler readings. [4]

(c) Corrected mean $= 43.35 - 0.40 = 42.95 \text{ cm}$. Repeats alone do not remove a common systematic offset; the calibration correction must be applied. If the correction itself has uncertainty, that would also need consideration. [2]

(d) $\Delta t = (3.0/100) \times 0.80 = 0.024 \text{ s}$. [2]

(e) A display can round different underlying values to the same digit, and a calibration error can shift every result together. The observed repeat range can therefore be zero even when the measurement uncertainty is not. [2]

P3-Q10 · 14 marks

(a) $k_1 = 0.082/0.020^2 = 205 \text{ N m}^{-2}$. $k_2 = 0.177/0.030^2 = 196.6667 \text{ N m}^{-2}$. The unit follows from force divided by length squared. Values 205 and 197 N m^{-2} are suitable three-figure displayed results, but retain the unrounded second value for comparison. [4]

(b) Mean $k = (205 + 196.6667)/2 = 200.8333 \text{ N m}^{-2}$. Percentage difference $= 100 \times 8.3333/200.8333 = 4.149\%$, approximately 4.15%. Since 4.15% is smaller than the given 6% tolerance, the measurements support the hypothesis within that criterion. State support rather than proof. [4]

(c) $F = 200.8333 \times 0.025^2 = 0.1255208 \text{ N} \approx 0.126 \text{ N}$. Because 0.025 m lies between 0.020 and 0.030 m, this is interpolation. [3]

(d) Only two settings have been tested, and a systematic effect or another relationship might give similar constants over this narrow interval. Collect several further settings spanning the allowed range and repeat uncertain readings. More settings investigate the shape; repeats estimate variability. [3]

P3-Q11 · 14 marks

(a) Average vertical speed = $0.800/0.74 = 1.081... \text{ m s}^{-1}$, about 1.08 m s^{-1} . Distance percentage uncertainty = $100 \times 0.002/0.800 = 0.25\%$. Time percentage uncertainty = $100 \times 0.20/0.74 = 27.0\%$. Timing dominates by a very large margin. Because the cone may drift sideways, this is the magnitude of its mean vertical velocity; total path length divided by time could be larger. This calculation does not by itself establish terminal speed. [4]

(b) Manual start-stop response is large compared with the short fall time. A variable hand push changes the initial velocity. Draughts alter the cone's motion and can cause it to leave the intended vertical path. Each statement identifies a physical cause rather than an unspecified operator fault. [3]

(c) Record video with verified frame timing, a fixed side-on camera and visible height markers, then identify the frames when the same point on the cone crosses each marker; alternatively use appropriately aligned light gates if the cone reliably interrupts them. This reduces manual timing dependence. Use a gentle mechanical release that opens without pushing the cone, at a fixed location and orientation, to standardise initial conditions. Place a sufficiently wide transparent draught screen around the fall region, leaving adequate clearance so it neither constrains the cone nor significantly changes its local airflow. This reduces variable room draughts while preserving the investigation. Closing the window is a sensible immediate control, but alone may not earn an improvement mark if it was already possible while following the original instructions. Each improvement includes a mechanism. [6]

(d) The phrase names neither the uncertain measurement nor its cause and gives no reproducible modification. [1]

P3-Q12 · 12 marks

(a) Place the measuring cylinder upright and read the bottom of the meniscus at eye level. Immerse the thermometer's sensing region without touching the cup or base; gently mix with the separate stirrer where the method allows, and wait for the thermometer to respond. Any two relevant details earn the marks. [2]

(b) Use headings t / s and $\theta / ^\circ\text{C}$, with additional θ repeat / $^\circ\text{C}$ columns if repeat runs are made, and a mean $\theta / ^\circ\text{C}$ column when required. Prepare the table before collection. Entries at 0, 30, 60, ..., 300 s give 11 temperatures, not 10. [3]

(c) Hot water can scald: keep the supported cup on a stable surface, avoid overfilling and use appropriate handling protection under teacher supervision. A glass thermometer can break and cause cuts: support it securely, avoid striking the container and use the stirrer rather than the thermometer to mix. Other sensible hazard-precaution pairs can receive credit. [4]

(d) Change only lid presence for the comparison. Keep water volume and initial temperature fixed, and also use the same cup and similar room conditions. Compare the temperature fall over the same 300 s interval or compare cooling rates at the same temperature. Repeat runs to examine variability. This extends the original investigation with a clearly defined new question. [3]

P3-Q13 · 16 marks

Award two marks per valid paired diagnosis and correction, up to 16, while meeting the category requirements. A full set of possible responses is:

- Recording: lengths have inconsistent or unjustified raw precision. Use 12.0 cm, 14.2 cm and 16.4 cm if these are the actual millimetre-resolved readings; do not invent missing information if the original observation was not recorded accurately.
- Recording: 's' is only a unit. Use a quantity and unit such as t / s.
- Recording: erasing repeats removes evidence. Preserve raw repeat columns and add a separate mean column in a table prepared before measurement.
- Layout: axes lack quantities and units. Label both explicitly, including powers in transformed quantities.
- Layout: 30% width fails the half-grid condition. Choose a scale or appropriate false origin that spreads the data across at least half the width, and check the vertical span too.
- Layout: end-only labels obstruct reading. Place evenly spaced numerical labels along each axis at least every 2 cm.
- Layout: 0.3 units per large square makes interpolation awkward. Choose a convenient 1, 2 or 5 based scale, with a power of ten where needed.
- Plotting: thick dots hide exact coordinates. Use fine visible crosses or encircled dots less than 1 mm across and plot to better than 1 mm.
- Fitting: joining consecutive observations mistakes noise for the trend. Draw one appropriate straight best-fit line or smooth curve with balanced scatter.
- Fitting: silently omitting a point conceals evidence. Plot it, recheck if feasible, and identify it explicitly as anomalous if excluding it from the fit is justified.
- Analysis: neighbouring raw points give a noisy gradient. Use two points on the fitted line separated by more than half its drawn length.
- Analysis: $x = 0.40$ is not $x = 0$. Find the true intercept from $c = y - mx$ instead of reading the left-edge crossing.
- Evaluation: the advice does not name a limiting quantity or mechanism. Describe a concrete limitation, then a realistic apparatus or procedure change that addresses it and is not merely correct use already possible under the original instructions.

P3-Q14 · 20 marks

(a) The added column is:

L / m	V / V	R / Ω
0.200	0.281	1.405
0.300	0.359	1.795
0.400	0.441	2.205
0.500	0.519	2.595

L / m	V / V	R / Ω
0.600	0.602	3.010
0.700	0.679	3.395

For example, $R = 0.281/0.200 = 1.405 \Omega$. Both measured electrical quantities have three significant figures, so three or four are normally acceptable; four is the requested choice. [4]

(b) One possible 12 cm by 12 cm grid uses L from 0.15 to 0.75 m at 0.10 m per 2 cm, and R from 1.0 to 4.0 Ω at 0.5 Ω per 2 cm. The horizontal point span is 10.0 cm and vertical span is $(3.395 - 1.405) \times 4 = 7.96$ cm; both exceed 6 cm. Label axes L / m and R / Ω and number every 2 cm. Plot all six fine points, then draw a single thin straight line with balanced deviations. A line close to $R = 4.00L + 0.600$ represents the data well. [5]

(c) $r = (3.600 - 1.200)/(0.750 - 0.150) = 2.400/0.600 = 4.00 \Omega \text{ m}^{-1}$. $R_0 = 1.200 - 4.00 \times 0.150 = 0.600 \Omega$. These are the gradient and y-intercept by comparison with $y = mx + c$. The left edge is at $L = 0.15$ m, not zero; its line crossing is 1.200 Ω and is not R_0 . [5]

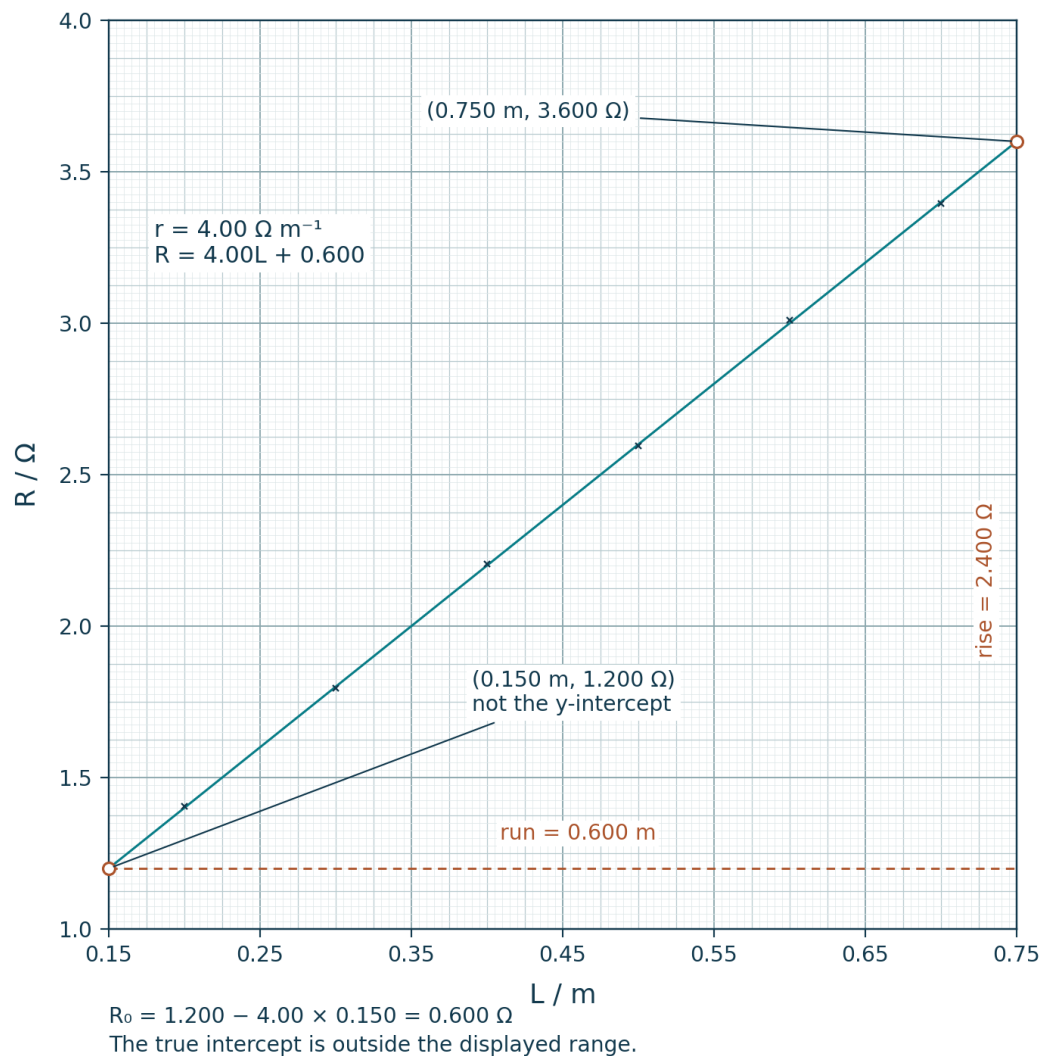
(d) $R = 4.00 \times 0.450 + 0.600 = 2.400 \Omega$. $V = IR = 0.200 \times 2.400 = 0.480$ V. This is interpolation. [2]

(e) A broad crocodile-clip contact makes the effective electrical endpoint uncertain: replace it with a narrow defined contact or knife-edge contact fixed beside the ruler, while keeping the same wire investigation. Wire heating can change resistance between settings: use brief current-on readings, switch off between them and allow the wire to return to a consistent temperature. Another valid pair is wire sag making ruler distance differ from actual wire length, addressed by supporting a straight, gently tensioned wire parallel and close to the ruler without stretching it. Credit two specific cause-improvement pairs. [4]

Figure for P3-Q14 — worked answer

Representative resistance graph

× observations ○ chosen line coordinates



Print at 100% / Actual size. The inner grid should measure 12.0 cm by 12.0 cm.

Use with the full notes

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