

AS Physics 9702

Practical and data skills

Original worksheet

Name: _____ Date: _____

Suggested marks: 210. Work through the questions over more than one study session if needed. Use additional paper for extended working and graph paper where requested.

Show equations, substitutions, units and reasoning. Use the constants specified in each question. The questions are original practice, not an official Cambridge examination or mark scheme.

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

Instrument-reading station

All scale descriptions are invented for this exercise. Show units and corrections.

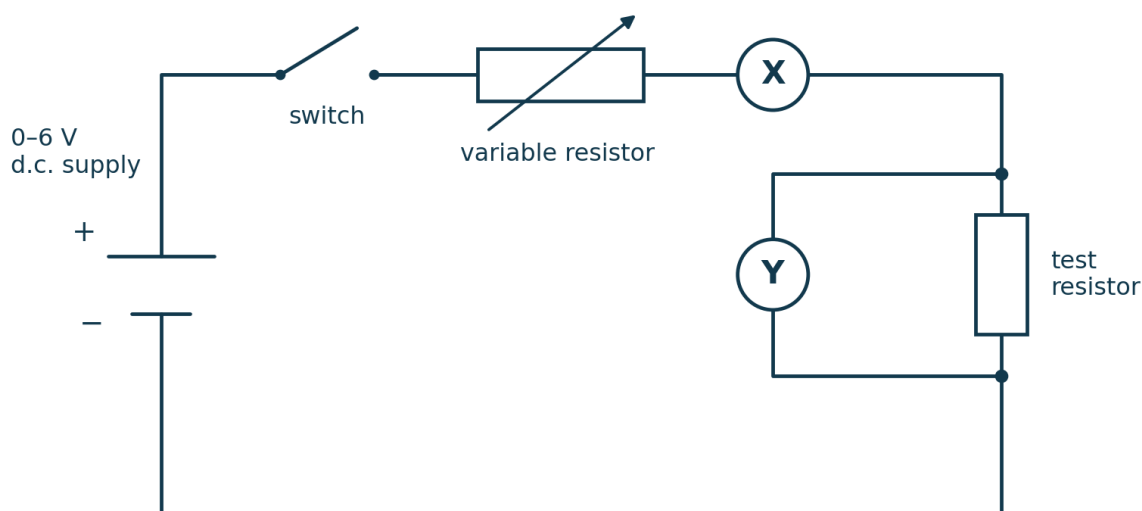
- (a) A rod's ends align with 2.3 cm and 18.7 cm on a millimetre rule. Find its length and the absolute uncertainty if each end reading is uncertain by ± 0.05 cm. Explain one way to reduce parallax. [3]
- (b) A vernier caliper has least count 0.02 mm. The main-scale reading is 12 mm and vernier division 17 aligns. The closed instrument reads +0.04 mm. Find the observed and corrected diameters. [3]
- (c) A micrometer sleeve shows 5.5 mm and thimble division 23 aligns; each thimble division is 0.01 mm. Its zero reading is -0.02 mm. Find the corrected thickness and state how to make consistent contact. [3]
- (d) An analogue ammeter has 30 equal divisions from 0 to 0.60 A. The pointer is on division 22. State the current and a half-division reading uncertainty. [2]
- (e) A digital ammeter displays 0.186 A. Express this in mA. The manufacturer specifies ± 0.002 A for this reading. Explain why quoting ± 0.001 A merely because of the display would be unjustified. [2]
- (f) Water's meniscus is halfway between 42 and 44 cm³ on a cylinder with 2 cm³ divisions. Record the volume and describe the viewing position. [2]
- (g) A container alone has mass 12.6 g and container plus sample 47.3 g. Find the sample mass. [1]
- (h) A protractor shows the acute angle as 39° on one scale and 141° on the other. A thermometer's liquid tip aligns with 67 °C. State the correct two readings. [2]
- (i) A newton meter has 20 equal divisions from 0 to 2.0 N. Its loaded pointer is at division 16 and its unloaded reading in the working orientation is +0.1 N. Find the observed and zero-corrected forces. [2]

P3-Q2 · 12 marks**Build and check a resistance experiment**

A method specifies a 0-6 V d.c. supply, a switch, a variable resistor and a test resistor in series. Measure current through the test resistor and potential difference across it. Keep current at or below 0.30 A. Available ammeter ranges are 0-0.20 A and 0-2.00 A. The voltage range permitted by the method is 0.50-3.00 V.

- (a) Use the accompanying circuit diagram. Identify which of meters X and Y is the ammeter and which is the voltmeter. Trace the main current path, and state which component has its potential difference measured. [3]
- (b) Select a safe initial ammeter range and explain why the more sensitive range is not suitable throughout this experiment. [2]
- (c) Choose six target voltages spanning the allowed interval and explain the benefit of this choice. [2]
- (d) State a zero or preliminary check, a control needed for valid resistance readings, and a concrete electrical safety precaution. [3]
- (e) At 2.75 V the current is 0.250 A. Calculate resistance and state one reason not to infer the component's voltage from the supply setting alone. [2]

Figure for P3-Q2



Circuit schematic. Identify meters X and Y from their connections.

P3-Q3 · 14 marks

Timing twenty oscillations

Three readings for twenty complete pendulum oscillations are 28.2 s, 28.4 s and 28.3 s. The watch displays 0.1 s increments. An independent assessment estimates ± 0.2 s uncertainty for a manually timed interval.

- (a) Describe a repeatable reference and counting procedure. [3]
- (b) Calculate mean time and period. State why intermediate digits should not be discarded too soon. [3]
- (c) Find half-range for the repeated total times. Explain why this is not automatically the complete uncertainty here. [2]
- (d) Using ± 0.2 s as the total-time uncertainty, calculate the absolute and percentage uncertainty of the period. [3]
- (e) Compare with timing a single 1.4 s period with ± 0.2 s uncertainty. State one practical reason not to time indefinitely many cycles. [3]

P3-Q4 · 14 marks

Create a usable spring table

A balance displays 0.1 g increments and a rule has millimetre divisions. The spring's unloaded length is 11.8 cm. Readings are:

Mass m / g	Loaded length L / cm
50.0	14.2
100.0	16.7
150.0	19.1
200.0	21.6
250.0	24.0
300.0	26.5

- (a) Prepare one complete table with raw mass and length, extension x in metres, and force F in newtons. Use $g = 9.81 \text{ m s}^{-2}$. [6]
- (b) Show the extension and force calculation for the 50.0 g row. Justify the displayed precision of the raw length and calculated force. [4]
- (c) Explain why the table should be prepared before measurements and why raw readings must be retained after calculations. [2]
- (d) The maximum permitted mass is 300.0 g. Explain one strength of the chosen range and how to record repeats without hiding the original readings. [2]

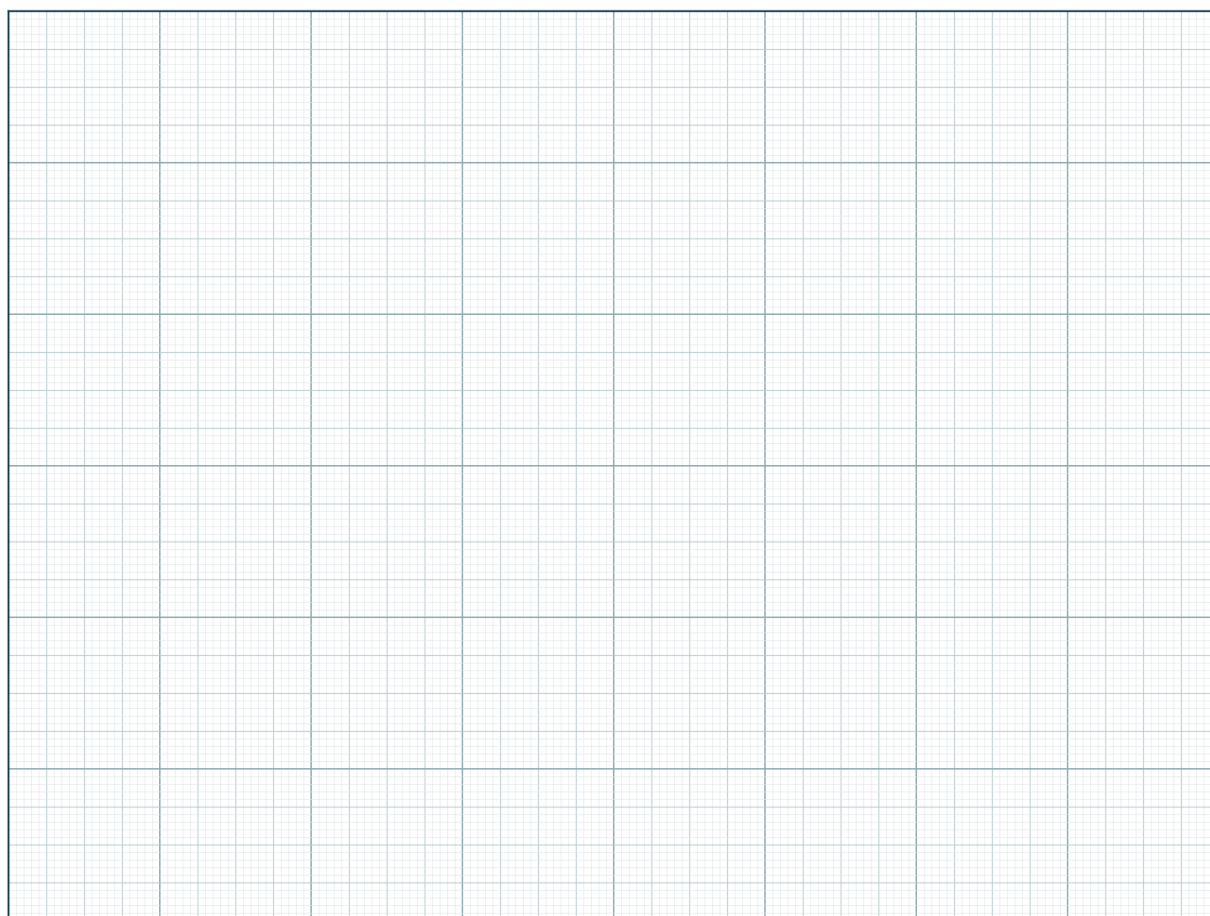
P3-Q5 · 18 marks**Plot and analyse a spring graph**

x / m	F / N
0.024	0.491
0.049	0.981
0.073	1.47
0.098	1.96
0.122	2.45
0.147	2.94

Draw F vertically against x horizontally on a grid 16 cm wide and 12 cm high. For the common numerical check in (c), a representative acceptable trend line passes through (0.010 m, 0.205 N) and (0.140 m, 2.805 N). Complete the independent coordinate-reading task in (b) before using that supplied pair.

- (a) Choose labelled scales and show that the points span at least half the grid in both directions. [4]
- (b) Plot all six points and draw a suitable best-fit straight line. Describe the required point and line quality. Choose two convenient points on your own fitted line, separated by more than half its drawn length, mark a gradient triangle, read and record both coordinate pairs from your graph, then calculate the gradient with its unit. Do not copy the supplied pair for this task. [6]
- (c) Using the supplied trend-line coordinates, calculate the gradient and intercept with units. Explain why these coordinates can be used even though they are not raw readings. [5]
- (d) Identify the spring constant for $F = kx + F_0$, and predict F when $x = 0.100$ m. Comment on forcing the line through the origin. [3]

Figure for P3-Q5



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

Use the grid above for your graph and additional paper for written working.

P3-Q6 · 16 marks

A hidden intercept

A pendulum investigation uses the supplied model $T^2 = (4\pi^2/g)(L + e)$. A graph of T^2 against L uses a horizontal scale from 0.35 to 0.95 m and a vertical scale from 1.40 to 4.00 s^2 . Two well-separated points on the fitted straight line are (0.40 m, 1.68 s^2) and (0.90 m, 3.68 s^2).

- (a) Identify y , x , gradient and intercept by comparison with $y = mx + c$. [4]
- (b) Calculate gradient and true y -intercept. [4]
- (c) Explain why the line's height at the left edge of this grid is not the y -intercept. Calculate that height. [3]
- (d) Determine g and e . [3]
- (e) Predict T at $L = 0.65$ m, stating whether this is interpolation. [2]

P3-Q7 · 14 marks**Cooling curve and tangent**

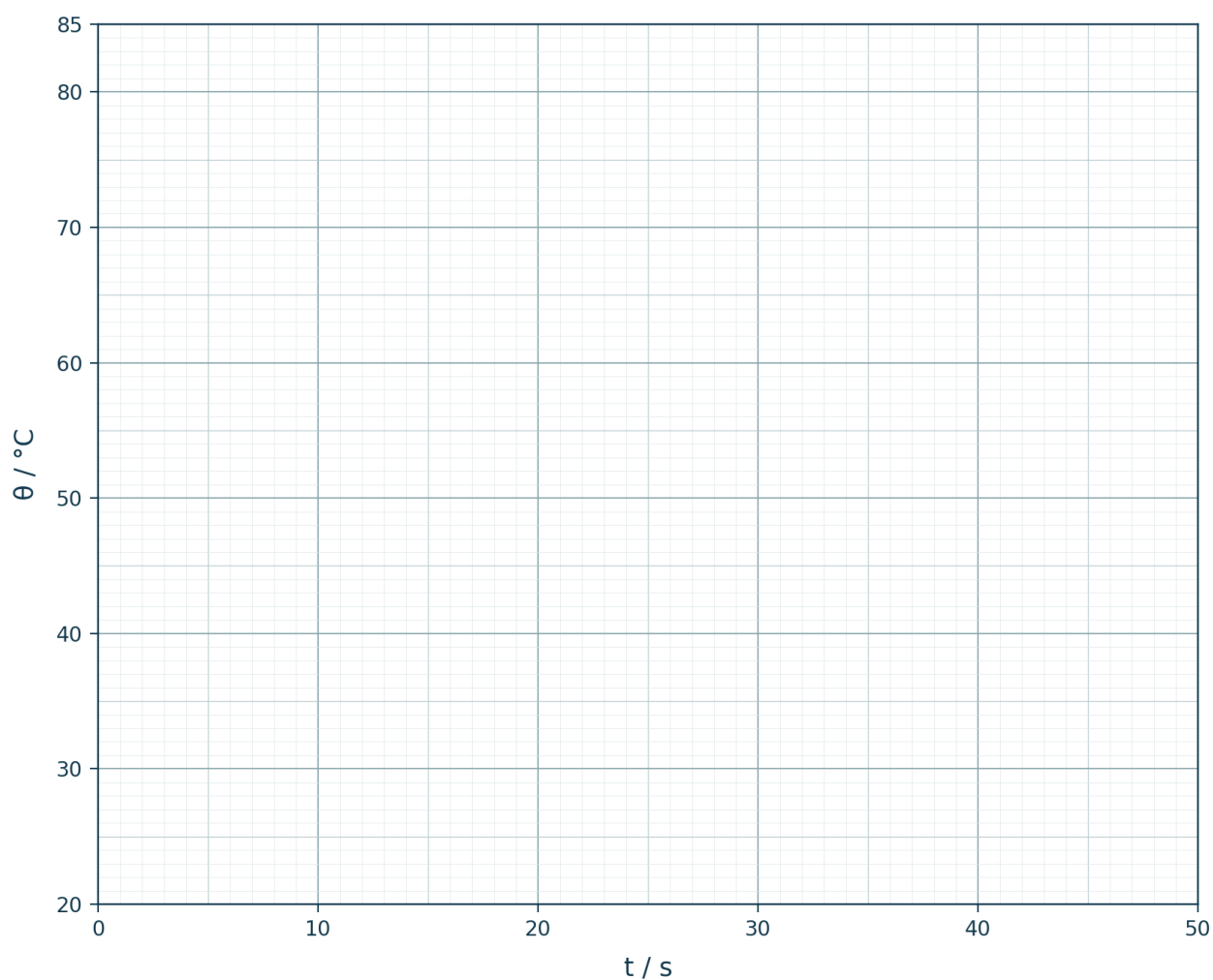
t / s	$\theta / ^\circ\text{C}$
0	80
10	67
20	57
30	50
40	44
50	40

For the common numerical checks in (b)-(d), a representative tangent to a smooth trend at $t = 20 \text{ s}$ passes through (5 s, 70 °C) and (35 s, 44 °C). Room temperature is 22 °C. Complete your own construction in (a) before using the supplied tangent coordinates.

- (a) Plot the six observations on labelled axes, draw a smooth cooling trend, and construct a tangent at $t = 20 \text{ s}$ by matching the curve's local direction. Extend the tangent and mark two well-separated points on it. Explain how it differs from a chord joining two observations. [5]
- (b) Calculate the tangent's gradient and interpret its sign and units. [3]
- (c) Find the tangent's y-intercept and explain why it differs from the measured initial temperature. [3]
- (d) Use the tangent to estimate the temperature at 22 s. Explain why its prediction at 80 s would be unreliable. [3]

Figure for P3-Q7

Cooling graph: construct your own curve and tangent



P3-Q8 · 12 marks

Precision audit of resistance calculations

A voltmeter is read to 0.1 V and an ammeter displays 0.0001 A increments.

V / V	I / A
1.2	0.1032
1.8	0.1497
2.4	0.2010

- (a) Calculate all three resistances, showing full working for the first and reporting each to three significant figures. [4]
- (b) Justify three significant figures using the measured inputs. Explain why 11.627907 Ω is unsuitable for the first result. [3]
- (c) Explain why 0.2010 A should not be rewritten as 0.201 A in the raw table and why 1.20 V would not represent the stated voltmeter precision. [2]
- (d) Calculate the electrical power at the first setting to three significant figures. A student instead divides 1.2 V by 103.2 without converting mA. Explain the factor-of-1000 error. [3]

P3-Q9 · 14 marks

Uncertainty from differences and repeats

- (a) An extension is found from $L = (262 \pm 1)$ mm and $L_0 = (250 \pm 1)$ mm. Using addition of absolute uncertainty bounds, calculate the extension, its absolute uncertainty and percentage uncertainty. [4]
- (b) Four repeated lengths are 43.2, 43.5, 43.3 and 43.4 cm. Find their mean, half-range and percentage uncertainty estimated from that half-range. [4]
- (c) A separate calibration reveals that every length in (b) was 0.40 cm too large. Calculate the corrected mean and explain whether taking more repeats alone would remove that offset. [2]
- (d) A time of 0.80 s has 3.0% uncertainty. Find its absolute uncertainty. [2]
- (e) Explain why identical repeat readings from a digital display do not prove zero uncertainty. [2]

P3-Q10 · 14 marks

Does a square relationship fit?

The hypothesis is $F = kx^2$. Two measurements give $x_1 = 0.020$ m, $F_1 = 0.082$ N and $x_2 = 0.030$ m, $F_2 = 0.177$ N. For this exercise, compare the constants using percentage difference relative to their mean. The supplied acceptance tolerance for that comparison is 6%.

- (a) Determine both constants, retaining working digits, and their units. [4]
- (b) Calculate percentage difference and reach a justified conclusion using the specified tolerance. [4]
- (c) Use the mean constant to predict the force at $x = 0.025$ m. Identify the type of prediction. [3]
- (d) Explain two reasons why agreement between two constants is not proof of the hypothesis and suggest a better data-collection strategy. [3]

P3-Q11 · 14 marks

Evaluate a falling-cone method

A paper cone falls through a marked vertical distance of (0.800 ± 0.002) m. A person times the motion with a stopwatch and obtains (0.74 ± 0.20) s. The cone is released by hand, sometimes with a slight push, and drifts sideways in a room with an open window. The task asks for improvements to this same falling-cone investigation.

- (a) Calculate average vertical speed (vertical distance divided by elapsed time) and the percentage uncertainties of distance and time separately. Identify the dominant contribution. [4]
- (b) Describe three distinct limitations, each identifying the affected quantity or condition and its cause. [3]
- (c) Give a specific feasible improvement for each limitation, explaining how it helps. [6]
- (d) Explain why 'human error: be more careful' is not an adequate evaluation. [1]

P3-Q12 · 12 marks

Safe cooling investigation and extension

A supervised school method uses 150 cm^3 of water initially near 80°C in an insulating cup supported inside a beaker. A thermometer is read every 30 s for 5 min. A measuring cylinder, thermometer, stopwatch and stirrer are provided.

- (a) Describe how to obtain meaningful volume and temperature readings, naming two positioning or reading details. [2]
- (b) Write appropriate table headings and state how many temperature entries include both $t = 0$ and $t = 300 \text{ s}$. [3]
- (c) Identify two specific hazards and pair each with a practical precaution. [4]
- (d) Extend the investigation to compare cooling with and without a lid. State the variable changed, two controls and a meaningful comparison. [3]

P3-Q13 · 16 marks

Audit an unreliable practical report

A report records millimetre-rule lengths as 12 cm, 14.20 cm and 16.4 cm. Its table has a column headed only 's'. Raw repeat times were erased after a mean was calculated. The graph has unlabelled axes, with points occupying only 30% of the width. Numerical axis labels appear only at the two ends. It uses a scale of 0.3 units per 2 cm. Thick dots hide nearby grid lines. A ruler joins every pair of consecutive observations, and a distant point has been silently omitted. The gradient uses two neighbouring raw readings. A grid starting at $x = 0.40$ is treated as though its left edge were $x = 0$. The evaluation says 'repeat and be careful'.

Select eight distinct problems. For each, state both what is wrong and a precise correction. Your eight must include at least two recording problems, two graph-layout or plotting problems, two fitting or analysis problems, and one evaluation problem. [16]

P3-Q14 · 20 marks

Integrated worksheet: resistance against wire length

This invented dataset rehearses written analysis; it is not a substitute for conducting the experiment. A low-voltage setup measures the potential difference V across different lengths L of the same wire while maintaining current $I = 0.200$ A. A proposed model is $R = rL + R_0$, where $R = V/I$.

L / m	V / V
0.200	0.281
0.300	0.359
0.400	0.441
0.500	0.519
0.600	0.602
0.700	0.679

- (a) Add a resistance column, calculating values to four significant figures. Explain why four is a suitable choice here. [4]
- (b) Draw a labelled R -against- L graph using sensible scales that fill at least half the grid in both directions. Plot all points and draw a suitable straight trend. [5]
- (c) A representative trend line passes through $(0.150 \text{ m}, 1.200 \Omega)$ and $(0.750 \text{ m}, 3.600 \Omega)$. Calculate r and R_0 and explain why a false-origin graph cannot give R_0 by merely reading its left edge. [5]
- (d) Predict the potential difference at $L = 0.450$ m when current remains 0.200 A. [2]
- (e) Give two distinct limitations affecting this experiment and a specific workable improvement for each. At least one should concern the length measurement. [4]

Use with the full notes

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