# Cambridge International AS & A Level

**PHYSICS** **9702/32**

Paper 3 Advanced Practical Skills 2 **May/June 2024**

MARK SCHEME

Maximum Mark: 40

**Published**

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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This document consists of **8** printed pages.

| Question | Answer | Marks |
|---|---|---|
| 1(a) | Value of $T$ in range 5.00–8.00 s with unit. | **1** |
| | Evidence of repeat measurements of $T$. | **1** |
| 1(b) | Six sets of readings of $V_S$ (different values) and $T$ with correct trend (average $T$ increases as $V_S$ decreases) and without help from the Supervisor scores 5 marks, five sets scores 4 marks etc. | **5** |
| | Range: $V_S$ (min) $\leqslant$ 4.00 V **and** $V_S$ (max) $\geqslant$ 10.00 V. | **1** |
| | Column headings:<br>Each column heading must contain a quantity and a unit where appropriate.<br>The presentation of quantity and unit must conform to accepted scientific convention e.g. $1 / T / s^{-1}$. | **1** |
| | Consistency: <u>All</u> values of $T$ must be given to the nearest 0.01 s (or <u>all</u> to the nearest 0.1 s). | **1** |
| | Significant figures:<br>Values of $1 / T$ given to same number of s.f. as (or one more than) the number of s.f. in $T$. | **1** |
| | Calculation: Values of $1 / T$ calculated correctly | **1** |
| 1(c)(i) | Axes:<br>Axes must be labelled with the required quantities.<br>Scales must be chosen so that the plotted points occupy at least half the graph grid in both the $x$ and $y$ directions.<br>Scale markings are no more than 2 cm (one large square) apart.<br>Sensible scales must be used. Scales must not be awkward (e.g. 3:10 or fractions). | **1** |
| | Plotting of points:<br>All observations in the table must be plotted on the grid.<br>Diameter of plotted points must be $\leqslant$ half a small square.<br>Points must be plotted to an accuracy of half a small square in both the $x$ and $y$ directions. | **1** |
| | Quality:<br>All points in the table (at least 5) must be plotted on the grid.<br>Trend must be correct.<br>It must be possible to draw a straight line that is within $\pm$ 0.40 V on the $V_s$ axis of all plotted points. | **1** |

| Question | Answer | Marks |
|---|---|---|
| 1(c)(ii) | Line of best fit:<br>'Best fit' is judged by balance of all points on the grid (at least 5 points) about the candidate's line.<br>There must be an even distribution of points either side of the line along the full length.<br>Lines must not be kinked or thicker than half a small square.<br><br>Some candidates may choose to identify an anomalous point. If they identify **one** point as anomalous (e.g. by circling or labelling) then this point is to be disregarded when judging the line of best fit. There must be at least 5 points left after the anomalous point is disregarded. | **1** |
| 1(c)(iii) | Gradient:<br>The hypotenuse of the triangle used should be greater than half the length of the drawn line.<br>Both read-offs must be accurate to half a small square in both the *x* and *y* directions.<br>The method of calculation must be correct, not $\Delta x / \Delta y$.<br>The gradient sign on the answer line must be consistent with the graph drawn. | **1** |
| | *y*-intercept:<br>Correct read-off from a point on the line and substituted correctly into $y = mx + c$ or an equivalent expression.<br>Read-off accurate to half a small square in both the *x* and *y* directions.<br>**or**<br>Intercept read directly from the graph, with read-off at $V_s = 0$, accurate to half a small square in *y* direction. | **1** |
| 1(d) | Value *a* = candidate's gradient **and** value of *b* = candidate's intercept.<br>Values must not be written as fractions or given to only one significant figure. | **1** |
| | Units for *a* and *b* correct and consistent with the readings taken (e.g. $V^{-1}\,s^{-1}$ for *a* and $s^{-1}$ for *b*). | **1** |

| Question | Answer | Marks |
|---|---|---|
| 2(a)(i) | Value for $L_0$ to nearest mm and in range 0.050–0.200 m. | **1** |
| 2(a)(ii) | Value for $T$ with unit. | **1** |
| | Evidence of repeat readings: at least two measurements each of at least $5T$. | **1** |
| 2(a)(iii) | Justification linked to significant figures in time / $T$ (and $\alpha$). | **1** |
| 2(b)(i) | Value for $L$ greater than $L_0$. | **1** |
| | Value for $\theta$ to nearest degree and in range 15°–25°. | **1** |
| 2(b)(ii) | Absolute uncertainty in $\theta$ in range 2°–5°.<br>Correct method of calculation to obtain percentage uncertainty e.g. (absolute uncertainty / value from **(b)(i)**) × 100.<br>If several readings have been taken, then the absolute uncertainty can be half the range (but not zero) provided the working is shown clearly. | **1** |
| 2(b)(iii) | Second value of $L$. | **1** |
| | Second value of $\theta$. | **1** |
| | Second value of $L$ > first value of $L$. | **1** |
| 2(c) | Two values of $D$ calculated correctly.<br>The final $D$ values must not be written as fractions or given to only one significant figure. | **1** |
| 2(d) | Calculation of percentage difference between candidate's two $D$ values.<br>Comparison of percentage difference with 10% leading to a consistent conclusion. | **1** |

| Question | Answer | Marks |
|---|---|---|
| 2(e)(i) | A Two readings are not enough to draw a (valid) conclusion (**not** “not enough for accurate results”, “few readings”).<br><br>B Difficult to measure $T$ with reason, e.g. difficult to judge/determine/decide end or start of a complete oscillation.<br><br>C Difficult to measure $L$ or $L_0$ with reason, e.g. parallax error / difficult to hold ruler steady next to spring / spring moves when touched by ruler / ruler not parallel to spring.<br><br>D Difficulty with setting up apparatus e.g. difficult to ensure wooden rod is parallel to bench / difficult to ensure that spring is vertical / stands slide on bench or fall over when setting larger angle.<br><br>E Difficult to measure $\theta$ with reason e.g. parallax / difficult to hold protractor steady / strings (or plumb line) move when touched by protractor / thick strings.<br><br>*1 mark for each point up to a maximum of 4.* | **4** |
| 2(e)(ii) | A Take more readings and plot a graph **or** take more readings and compare $D$ values (**not** “repeat readings” on its own).<br><br>B Method to improve measurement of $T$ with detail<br>e.g. use marker placed at midpoint/equilibrium point of oscillation<br>**or**<br>record/film/video with timer **or** record/film/video and view frame by frame<br>**or**<br>use a position/distance sensor placed below mass with data logger.<br><br>C Improved method of measuring $L$ or $L_0$ e.g. calipers/clamp ruler (next to spring).<br><br>D Measure from rod to bench at both ends / use spirit level beside wooden rod / spirit level beside spring (for $L_0$) / plumb line beside spring (for $L_0$)<br>**or**<br>method to stop stand sliding e.g. G-clamp (to bench) **or** add mass to base **or** use heavier stand(s).<br><br>E Method to improve measurement of $\theta$ e.g. hold protractor in clamp / measure using photograph / use thinner string / use of trigonometry with length measurements described.<br><br>*1 mark for each point up to a maximum of 4.* | **4** |