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**PHYSICS**

**9702/31**

Paper 3 Advanced Practical Skills 1

**May/June 2017**

MARK SCHEME

Maximum Mark: 40

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**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.

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**PUBLISHED**

| Question  | Answer                                                                                                                                                                                                                                                                                                                                             | Mark |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 1(b)(iii) | Value(s) of $I_1$ with unit in the range 30–200 mA.                                                                                                                                                                                                                                                                                                | 1    |
| 1(c)(iii) | $I_2 > I_1$ (ECF unit from <b>1(b)(iii)</b> ).                                                                                                                                                                                                                                                                                                     | 1    |
| 1(d)      | Six sets of readings of $x$ (different values), $I_1$ , $I_2$ with correct trend and without help from Supervisor scores 5 marks, five sets scores 4 marks etc.                                                                                                                                                                                    | 5    |
|           | Range: $x_{\max} \geq 90$ cm.                                                                                                                                                                                                                                                                                                                      | 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. $x / \text{m}$ , $I_2 / \text{mA}$ , $I_2 / I_1$ no unit.                                                                                               | 1    |
|           | Consistency:<br>All values of $x$ must be given to the nearest mm.                                                                                                                                                                                                                                                                                 | 1    |
|           | Significant figures:<br>All values of $I_2 / I_1$ must be given to the same number of s.f. as (or one more than) the s.f. in raw $I_1$ and $I_2$ (using the s.f. of the $I$ value with the lowest number of s.f.).                                                                                                                                 | 1    |
|           | Calculation:<br>Values of $I_2 / I_1$ are correct.                                                                                                                                                                                                                                                                                                 | 1    |
| 1(e)(i)   | Axes:<br>Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions).<br>Scales must be chosen so that the plotted points occupy at least half the graph grid in both $x$ and $y$ directions.<br>Scales must be labelled with the quantity that is being plotted.<br>Scale markings should be no more than three large squares apart. | 1    |
|           | Plotting of points:<br>All observations must be plotted on the grid.<br>Diameter of plotted points must be $\leq$ half a small square (no “blobs”).<br>Points must be plotted to an accuracy of half a small square.                                                                                                                               | 1    |

**PUBLISHED**

| Question  | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Mark     |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
|           | <p>Quality:<br/>           All values of <math>I_2/I_1</math> must be greater than 1.<br/>           All points in the table must be plotted for this mark to be awarded.<br/>           It must be possible to draw a straight line that is within <math>\pm 0.05</math> on the <math>I_2/I_1</math> axis (normally y axis) of all plotted points.</p>                                                                                                                                                | <b>1</b> |
| 1(e)(ii)  | <p>Line of best fit:<br/>           Judge by balance of all points on the grid about the candidate's line (at least 5). There must be an even distribution of points either side of the line along the full length.<br/>           Allow one anomalous point only if clearly indicated (i.e. circled or labelled) by the candidate. There must be at least five points left after the anomalous point is disregarded.<br/>           Lines must not be kinked or thicker than half a small square.</p> | <b>1</b> |
| 1(e)(iii) | <p>Gradient:<br/>           Gradient sign on answer line matches graph drawn.<br/>           The hypotenuse of the triangle used must be greater than half the length of the drawn line.<br/>           Method of calculation must be correct. Do not allow <math>\Delta x / \Delta y</math>.<br/>           Both read-offs must be accurate to half a small square in both the x and y directions.</p>                                                                                                | <b>1</b> |
|           | <p>y-intercept:<br/>           Correct read-off from a point on the line substituted correctly into <math>y = mx + c</math> or an equivalent expression.<br/>           Read-off accurate to half a small square in both x and y directions.<br/> <b>or</b><br/>           Intercept read directly from the graph, with read-off at <math>x = 0</math>, accurate to half a small square in y direction.</p>                                                                                            | <b>1</b> |
| 1(f)      | <p>Value of <math>P</math> = candidate's gradient <b>and</b> value of <math>Q</math> = candidate's intercept.<br/>           The values must not be fractions.</p>                                                                                                                                                                                                                                                                                                                                     | <b>1</b> |
|           | <p>Unit for <math>P</math> is correct (e.g. <math>\text{m}^{-1}</math>) <b>and</b> <math>Q</math> stated without a unit.</p>                                                                                                                                                                                                                                                                                                                                                                           | <b>1</b> |

**PUBLISHED**

| Question  | Answer                                                                                                                                                                                                                                            | Mark |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 2(b)(ii)  | Values of time in the range 3–7 s and within 0.4 s of each other.<br>All raw readings stated to same precision <b>and</b> to at least 0.1 s.                                                                                                      | 1    |
| 2(c)(ii)  | x on the answer line in the range 35.0–40.0 cm <b>and</b> all value(s) of raw x to nearest mm with unit.                                                                                                                                          | 1    |
| 2(c)(iii) | Absolute uncertainty in x in range 2–5 mm.<br>If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown.<br>Correct method of calculation to obtain percentage uncertainty. | 1    |
| 2(e)(i)   | Value of $n$ on answer line in the range 10 to 20. No unit.                                                                                                                                                                                       | 1    |
|           | Evidence of repeat readings.                                                                                                                                                                                                                      | 1    |
| 2(e)(ii)  | Correct calculation of $(n + 1)^2/n^2$ .                                                                                                                                                                                                          | 1    |
| 2(f)      | Second value of $x$ .                                                                                                                                                                                                                             | 1    |
|           | Second value of $n$ .                                                                                                                                                                                                                             | 1    |
|           | Quality: second value of $n <$ first value of $n$ (if $x_2 < x_1$ allow $n_2 > n_1$ ).                                                                                                                                                            | 1    |
| 2(g)(i)   | Two values of $k$ calculated correctly.                                                                                                                                                                                                           | 1    |
| 2(g)(ii)  | Valid comment consistent with calculated values of $k$ , testing against a criterion specified by the candidate.                                                                                                                                  | 1    |
| 2(h)      | Correct calculation of $L$ written to 3 s.f. and correctly rounded to 3 s.f.                                                                                                                                                                      | 1    |

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| Question | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Mark     |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 2(i)(i)  | <p>A Two readings are not enough to draw a valid conclusion (<b>not</b> “not enough for accurate results”, “few readings”).</p> <p>B Difficult to judge when the balls are back in phase.</p> <p>C Balls hit each other/blown by moving air/balls move sideways/irregular movement.</p> <p>D Difficult to ensure both lengths 35 cm or difficult to measure <math>x</math> with a reason e.g. string kinked/parallax error.</p> <p>E Damping/oscillations die out quickly.</p> <p>F Difficulty linked to fixing <u>block/wood</u> with reason e.g. longer block requires more tape (therefore an unfair test)/block comes unstuck/blocks attached at an angle (<math>x</math> not constant).</p> <p>G For <u>two/both</u> balls the release point is different or release instant is different.</p> <p><i>1 mark for each point up to a maximum of 4.</i></p> | <b>4</b> |
| 2(i)(ii) | <p>A Take more readings <u>and</u> plot a graph/take more readings <u>and</u> compare <math>k</math> values (<b>not</b> “repeat readings” on its own).</p> <p>B Video/film/record <b>and</b> perpendicular to plane of oscillation/from the side.</p> <p>C Turn off air conditioning/close windows/use windshield/use a longer rod.</p> <p>D Improved method of measuring 35 cm or <math>x</math> e.g. use clamps to fix loop and ball.</p> <p>F Improved method of attachment e.g. Blu-Tack/glue/Velcro/stickier tape/stronger adhesive on the tape.</p> <p>G Improved method of release e.g. bar to hold both balls then drop away like a gate.</p> <p><i>1 mark for each point up to a maximum of 4.</i></p>                                                                                                                                               | <b>4</b> |

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**PHYSICS**

**9702/32**

Paper 3 Advanced Practical Skills 2

**May/June 2017**

MARK SCHEME

Maximum Mark: 40

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**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.

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**PUBLISHED**

| Question | Answer                                                                                                                                                                                                                                                                                                                                            | Marks |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 1(a)(v)  | Value of $p$ in the range 20.0–30.0 cm, with unit.                                                                                                                                                                                                                                                                                                | 1     |
|          | Value of $q$ less than $p$ .                                                                                                                                                                                                                                                                                                                      | 1     |
| 1(b)     | Six sets of readings of $p$ , $q$ and $V$ (with correct trend and without help from Supervisor) scores 5 marks, five sets scores 4 marks etc.                                                                                                                                                                                                     | 5     |
|          | Range:<br>$p_{\max} \geq 40.0$ cm and $p_{\min} \leq 10.0$ cm.                                                                                                                                                                                                                                                                                    | 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. $1/p/\text{cm}^{-1}$ .                                                                                                                                 | 1     |
|          | Consistency:<br>All values of $p$ and $q$ must be given to the nearest mm.                                                                                                                                                                                                                                                                        | 1     |
|          | Significant figures:<br>Significant figures for every value of $1/q$ must be same as, or one greater than, the s.f. of $q$ as recorded in table.                                                                                                                                                                                                  | 1     |
|          | Calculation:<br>Values of $1/q$ calculated correctly.                                                                                                                                                                                                                                                                                             | 1     |
| 1(c)(i)  | Axes:<br>Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions).<br>Scales must be chosen so that the plotted points occupy at least half the graph grid in both $x$ and $y$ directions<br>Scales must be labelled with the quantity that is being plotted.<br>Scale markings should be no more than three large squares apart. | 1     |
|          | Plotting of points:<br>All observations must be plotted on the grid.<br>Diameter of plotted points must be $\leq$ half a small square (no “blobs”).<br>Plots must be accurate to within half a small square in both $x$ and $y$ directions.                                                                                                       | 1     |

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| Question  | Answer                                                                                                                                                                                                                                                                                                                                                                                                                 | Marks    |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
|           | <p>Quality:<br/> All points in the table must be plotted (at least 5) for this mark to be awarded.<br/> It must be possible to draw a straight line that is within <math>\pm 1.0 \text{ m}^{-1}</math> (<math>\pm 0.01 \text{ cm}^{-1}</math>) of all the plotted points in the <math>1/q</math> direction.</p>                                                                                                        | <b>1</b> |
| 1(c)(ii)  | <p>Line of best fit:<br/> Judge by balance of all points on the grid (at least 5) about the candidate's line. There must be an even distribution of points either side of the line along the full length.<br/> Allow one anomalous point only if clearly indicated (i.e. circled or labelled) by the candidate.<br/> Lines must not be kinked or thicker than half a small square.</p>                                 | <b>1</b> |
| 1(c)(iii) | <p>Gradient:<br/> The hypotenuse of the triangle used must be greater than half the length of the drawn line.<br/> Method of calculation must be correct. Do not allow <math>\Delta x / \Delta y</math>.<br/> Both read-offs must be accurate to half a small square in both the <math>x</math> and <math>y</math> directions.</p>                                                                                     | <b>1</b> |
|           | <p><math>y</math>-intercept:<br/> Correct read-off from a point on the line substituted into <math>y = mx + c</math> or an equivalent expression.<br/> Read-off accurate to half a small square in both <math>x</math> and <math>y</math> directions.<br/> <b>or</b><br/> Intercept read directly from the graph, with read-off at <math>x = 0</math> accurate to half a small square in <math>y</math> direction.</p> | <b>1</b> |
| 1(d)      | <p>Value of <math>a</math> = candidate's gradient <b>and</b> value of <math>b</math> = candidate's intercept.<br/> Values must not be fractions.</p>                                                                                                                                                                                                                                                                   | <b>1</b> |
|           | <p>There must be no unit for <math>a</math>.<br/> Unit for <math>b</math> correct e.g. <math>\text{m}^{-1}</math> or <math>\text{cm}^{-1}</math>.</p>                                                                                                                                                                                                                                                                  | <b>1</b> |

**PUBLISHED**

| Question  | Answer                                                                                                                                                                                                                                                   | Marks |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 2(a)(ii)  | Value of $h_1$ to nearest 0.1 cm.                                                                                                                                                                                                                        | 1     |
|           | $h_2 < h_1$ .                                                                                                                                                                                                                                            | 1     |
| 2(a)(iv)  | Absolute uncertainty in $h_2$ of 2–5 mm and correct method of calculation to obtain percentage uncertainty.<br>If repeated readings have been taken, then the absolute uncertainty can be half the range (but not zero) if the working is clearly shown. | 1     |
| 2(b)(i)   | Correct calculation of $k$ .                                                                                                                                                                                                                             | 1     |
| 2(b)(ii)  | Justification for s.f. in $k$ linked to s.f. in $m$ , $g$ and $(h_1 - h_2)$ <b>or</b> $m$ , $g$ , $h_1$ and $h_2$ .                                                                                                                                      | 1     |
| 2(c)(iii) | Value of $T$ in range 1.00–3.00 s.                                                                                                                                                                                                                       | 1     |
|           | Evidence of repeat readings of $nT$ with $n \geq 5$ .                                                                                                                                                                                                    | 1     |
| 2(d)      | Second values of $h_1$ and $h_2$ .                                                                                                                                                                                                                       | 1     |
|           | Second value of $T$ .                                                                                                                                                                                                                                    | 1     |
|           | Quality: $T$ for three springs $>$ $T$ for two springs.                                                                                                                                                                                                  | 1     |
| 2(e)(i)   | Two values of $C$ calculated correctly.                                                                                                                                                                                                                  | 1     |
| 2(e)(ii)  | Valid comment consistent with the calculated values of $C$ , testing against a criterion specified by the candidate.                                                                                                                                     | 1     |

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| Question | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Marks    |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 2(f)(i)  | <p>A Two readings are not enough to draw a (valid) conclusion (<b>not</b> “not enough for accurate results”, “few readings”).</p> <p>B (Difficulty) measuring <math>h</math> because of parallax/metre rule not vertical.</p> <p>C Oscillation dies away quickly/oscillation damped.</p> <p>D Difficult to judge/tell end of oscillation/decide when to operate stopwatch.</p> <p>E Other modes of oscillation occur.</p> <p>F Some movement at joints still occurs.</p> <p><i>1 mark for each point up to a maximum of 4.</i></p>                                                                                                                                                                                           | <b>4</b> |
| 2(f)(ii) | <p>A Take more readings <u>and</u> plot a graph/take more readings <u>and</u> compare <math>C</math> values (<b>not</b> “repeat readings” on its own).</p> <p>B Use set square against rule (with detail)/use pointer attached to bottom of mass/use set square from rule to bottom of mass.</p> <p>C Twist through larger angle to get more rotations.</p> <p>D View (video) recording/film of motion with timer in view <b>or</b> put mark on mass to make it easier to see motion.</p> <p>E Workable method of restricting vertical/swinging movement (e.g. enclose in transparent tube).</p> <p>F Better method of fixing joints/use two complete springs.</p> <p><i>1 mark for each point up to a maximum of 4.</i></p> | <b>4</b> |

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**PHYSICS**

**9702/33**

Paper 3 Advanced Practical Skills 1

**May/June 2017**

MARK SCHEME

Maximum Mark: 40

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| Question | Answer                                                                                                                                                                                                                                                                                                                                             | Marks |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 1(a)     | Value of $L$ with unit to the nearest mm in the range 2.5–3.5 cm.                                                                                                                                                                                                                                                                                  | 1     |
| 1(c)     | Value of $T$ with unit in the range 0.7 s to 1.5 s.                                                                                                                                                                                                                                                                                                | 1     |
|          | Evidence of repeated timings. Must see $nT$ repeated where $n \geq 5$ .                                                                                                                                                                                                                                                                            | 1     |
| 1(d)     | Six sets of readings of $n$ (different values) and time with correct trend and without help from Supervisor scores 4 marks, five sets scores 3 marks etc.                                                                                                                                                                                          | 4     |
|          | Range of $n \geq 9$ .                                                                                                                                                                                                                                                                                                                              | 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. $T/s$ . No unit for $n$ or $\sqrt{n}$ .                                                                                                                 | 1     |
|          | Consistency:<br>All values of raw time must be given to either 0.1 s or 0.01 s.                                                                                                                                                                                                                                                                    | 1     |
|          | Significant figures:<br>All values of $\sqrt{n}$ must be given to 3 significant figures.                                                                                                                                                                                                                                                           | 1     |
| 1(e)(i)  | Axes:<br>Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions).<br>Scales must be chosen so that the plotted points occupy at least half the graph grid in both $x$ and $y$ directions.<br>Scales must be labelled with the quantity that is being plotted.<br>Scale markings should be no more than three large squares apart. | 1     |
|          | Plotting of points:<br>All observations must be plotted on the grid.<br>Diameter of plotted points must be $\leq$ half a small square (no “blobs”).<br>Points must be plotted to an accuracy of half a small square.                                                                                                                               | 1     |
|          | Quality:<br>All points in the table must be plotted for this mark to be awarded.<br>It must be possible to draw a straight line that is within $\pm 0.10$ on the $\sqrt{n}$ axis of all plotted points.                                                                                                                                            | 1     |

**PUBLISHED**

| Question  | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Marks |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 1(e)(ii)  | Line of best fit:<br>Judge by balance of all points on the grid about the candidate's line (at least 5). There must be an even distribution of points either side of the line along the full length.<br>Allow one anomalous point only if clearly indicated (i.e. circled or labelled) by the candidate. There must be at least five points left after the anomalous point is disregarded.<br>Lines must not be kinked or thicker than half a small square. | 1     |
| 1(e)(iii) | Gradient:<br>The hypotenuse of the triangle used must be greater than half the length of the drawn line.<br>Method of calculation must be correct. Do not allow $\Delta x / \Delta y$ .<br>Both read-offs must be accurate to half a small square in both x and y directions.                                                                                                                                                                               | 1     |
|           | y-intercept:<br>Correct read-off from a point on the line substituted correctly into $y = mx + c$ or an equivalent expression.<br>Read-off accurate to half a small square in both x and y directions.<br><b>or</b><br>Intercept read directly from the graph, with read-off at $x = 0$ , accurate to half a small square in y direction.                                                                                                                   | 1     |
| 1(f)      | Value of $P$ = candidate's gradient <b>and</b> value of $Q$ = candidate's intercept.<br>The values must not be fractions.                                                                                                                                                                                                                                                                                                                                   | 1     |
|           | Units for $P$ and $Q$ both s.                                                                                                                                                                                                                                                                                                                                                                                                                               | 1     |
| 1(g)      | Correct calculation of $g = L\pi^2 / P^2$ with consistent unit.                                                                                                                                                                                                                                                                                                                                                                                             | 1     |

**PUBLISHED**

| Question  | Answer                                                                                                                                                                                                                                                                              | Marks |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 2(a)      | Value(s) of $A$ with unit in the range 97.5–99.5 cm.                                                                                                                                                                                                                                | 1     |
| 2(b)(ii)  | Values of all raw $x$ to nearest mm.                                                                                                                                                                                                                                                | 1     |
| 2(c)(iii) | Value of $y > x$ .                                                                                                                                                                                                                                                                  | 1     |
| 2(c)(iv)  | Correct calculation of $(y - x)$ .                                                                                                                                                                                                                                                  | 1     |
| 2(c)(v)   | Percentage uncertainty in $(y - x)$ based on absolute uncertainty of 2–5 mm.<br>If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown.<br>Correct method of calculation to obtain percentage uncertainty. | 1     |
| 2(d)(i)   | Correct calculation of $m(A - 2y)$ .                                                                                                                                                                                                                                                | 1     |
| 2(d)(ii)  | Justification for s.f. in $m(A - 2y)$ linked to s.f. in $A$ , $y$ and $m$ <b>or</b> $(A - 2y)$ and $m$ .                                                                                                                                                                            | 1     |
| 2(e)(i)   | Second value of $y$ .                                                                                                                                                                                                                                                               | 1     |
|           | Quality: second value of $y >$ first value of $y$ .                                                                                                                                                                                                                                 | 1     |
| 2(f)(i)   | Two values of $k$ calculated correctly.                                                                                                                                                                                                                                             | 1     |
| 2(f)(ii)  | Valid comment consistent with calculated values of $k$ , testing against a criterion specified by the candidate.                                                                                                                                                                    | 1     |
| 2(g)      | Correct calculation of $M = 1/k - B$ .                                                                                                                                                                                                                                              | 1     |

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| Question | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Marks    |
|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 2(h)(i)  | <p>A Two readings are not enough to draw a (valid) conclusion (<b>not</b> “not enough for accurate results”, “few readings”).</p> <p>B Difficult to measure <math>x</math> or <math>y</math> <u>with reason</u> e.g. markings on rule obscured because of thickness of string/twist in string/ruler oscillating/ruler swinging/rule slides in loop/string not vertical.</p> <p>C Large (%) uncertainty in <math>(y - x)</math> <b>or</b> <math>(y - x)</math> is small.</p> <p>D Little difference in <math>y</math> values.</p> <p>E Difficult to balance rule.</p> <p><i>1 mark for each point up to a maximum of 4.</i></p> | <b>4</b> |
| 2(h)(ii) | <p>A Take more readings <u>and</u> plot a graph/take more readings <u>and</u> compare <math>k</math> values (<b>not</b> “repeat readings” on its own).</p> <p>B Use thinner string/tie a knot in loop/use two loops/use a hook/use longer loop/string.</p> <p>C Heavier (added/slotted) masses (<b>not</b> heavier hangers).</p> <p>D Use wider range of (added) masses.</p> <p>E Suspend rule from its top edge/balance on fulcrum/use thicker string with reason such as <u>to make easier to balance/prevent rule from slipping</u>.</p> <p><i>1 mark for each point up to a maximum of 4.</i></p>                          | <b>4</b> |

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**PHYSICS**

**9702/34**

Paper 3 Advanced Practical Skills 2

**May/June 2017**

MARK SCHEME

Maximum Mark: 40

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| Question | Answer                                                                                                                                                                                                                                                                                                                                             | Marks |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 1(a)(v)  | Value of $T$ in the range 0.10–0.90 s.                                                                                                                                                                                                                                                                                                             | 1     |
|          | Evidence of repeated readings. Must see $nT$ repeated where $n \geq 5$ .                                                                                                                                                                                                                                                                           | 1     |
| 1(b)     | Six sets of readings of $M$ , $h$ and $T$ showing the correct trend and without help from the Supervisor scores 5 marks, five sets scores 4 marks etc.                                                                                                                                                                                             | 5     |
|          | Range: $M_{\max} \geq 450 \text{ g}$ <b>and</b> $M_{\min} \leq 200 \text{ g}$ .                                                                                                                                                                                                                                                                    | 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. $T^3 / \text{s}^3$ .                                                                                                                                    | 1     |
|          | Consistency:<br>All values of $h$ must be given to the nearest mm.                                                                                                                                                                                                                                                                                 | 1     |
|          | Significant figures:<br>Significant figures for every value of $T^3$ must be the same as (or one greater than) the s.f. of raw times as recorded in table.                                                                                                                                                                                         | 1     |
|          | Calculation:<br>Values of $T^3$ calculated correctly.                                                                                                                                                                                                                                                                                              | 1     |
| 1(c)(i)  | Axes:<br>Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions).<br>Scales must be chosen so that the plotted points occupy at least half the graph grid in both $x$ and $y$ directions.<br>Scales must be labelled with the quantity that is being plotted.<br>Scale markings should be no more than three large squares apart. | 1     |
|          | Plotting of points:<br>All observations must be plotted on the grid.<br>Diameter of plotted points must be $\leq$ half a small square (no “blobs”).<br>Points must be plotted to an accuracy of half a small square.                                                                                                                               | 1     |
|          | Quality:<br>All points in the table must be plotted (at least 5) for this mark to be awarded.<br>It must be possible to draw a straight line that is within $\pm 1.0 \text{ cm}$ (to scale) of all the plotted points in the $h$ direction.                                                                                                        | 1     |

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| Question  | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Marks    |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 1(c)(ii)  | <p>Line of best fit:<br/>           Judge by balance of all points on the grid (at least 5) about the candidate's line. There must be an even distribution of points either side of the line along the full length.<br/>           Allow one anomalous point only if clearly indicated (i.e. circled or labelled) by the candidate. There must be at least five points left after the anomalous point is disregarded.<br/>           Lines must not be kinked or thicker than half a square.</p> | <b>1</b> |
| 1(c)(iii) | <p>Gradient:<br/>           The hypotenuse of the triangle used must be greater than half the length of the drawn line.<br/>           Method of calculation must be correct. Do not allow <math>\Delta x / \Delta y</math>.<br/>           Both read-offs must be accurate to half a small square in both the x and y directions.</p>                                                                                                                                                           | <b>1</b> |
|           | <p>y-intercept:<br/>           Correct read-off from a point on the line substituted into <math>y = mx + c</math> or an equivalent expression.<br/>           Read-off accurate to half a small square in both x and y directions.<br/> <b>or</b><br/>           Intercept read directly from the graph, with read-off at <math>h = 0</math>, accurate to half a small square in y direction.</p>                                                                                                | <b>1</b> |
| 1(d)      | <p>Value of <math>a</math> = candidate's gradient <b>and</b> value of <math>b</math> = candidate's intercept.<br/>           The values must not be fractions.</p>                                                                                                                                                                                                                                                                                                                               | <b>1</b> |
|           | <p>Unit for <math>a</math> correct (e.g. <math>\text{s}^3 \text{cm}^{-1}</math>).<br/>           Unit for <math>b</math> is <math>\text{s}^3</math>.</p>                                                                                                                                                                                                                                                                                                                                         | <b>1</b> |

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| Question  | Answer                                                                                                                                                                                                                                                                       | Marks |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 2(a)      | Value for $x_0$ to nearest 0.1 cm.                                                                                                                                                                                                                                           | 1     |
| 2(b)(ii)  | $x$ greater than $x_0$ .                                                                                                                                                                                                                                                     | 1     |
| 2(b)(iii) | Raw $\theta$ in range 91–110° and recorded to nearest degree.                                                                                                                                                                                                                | 1     |
| 2(b)(v)   | Absolute uncertainty in $(\phi - 90^\circ)$ of 2–5° and correct method of calculation to obtain percentage uncertainty.<br>If repeated readings of $\phi$ have been taken, then the absolute uncertainty can be half the range (but not zero) only if working shown clearly. | 1     |
| 2(c)(ii)  | Second value of $x$ .                                                                                                                                                                                                                                                        | 1     |
|           | Second value of $\phi$ .                                                                                                                                                                                                                                                     | 1     |
|           | Quality: second value of $\phi \geq$ first value of $\phi$ .                                                                                                                                                                                                                 | 1     |
| 2(d)(i)   | Two values of $k$ calculated correctly.                                                                                                                                                                                                                                      | 1     |
| 2(d)(ii)  | Justification for s.f. in $k$ linked to s.f. in $\theta$ , $x$ and $x_0$ .                                                                                                                                                                                                   | 1     |
| 2(d)(iii) | Valid comment consistent with calculated values of $k$ , testing against a criterion specified by the candidate.                                                                                                                                                             | 1     |
| 2(e)(ii)  | Raw value(s) of $D$ <b>and</b> $d$ recorded to the nearest 0.1 cm.                                                                                                                                                                                                           | 1     |
| 2(e)(iv)  | Value of $\rho$ calculated correctly.                                                                                                                                                                                                                                        | 1     |

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| Question | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Marks |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 2(f)(i)  | <p>A Two readings are not enough to draw a (valid) conclusion (<b>not</b> “not enough for accurate results”, “few readings”).</p> <p>B Difficult to get/adjust wooden strip so that it is horizontal/parallel to bench.</p> <p>C Difficulty when measuring <math>x</math> (or <math>x_0</math>), with reason e.g. parallax error/thickness of string/difficult to judge centre of nail.</p> <p>D Difficult to measure angle with reason, e.g. parallax error/hard to hold protractor steady/hard not to touch wooden strip/difficult to align protractor correctly.<br/>(Do not credit parallax error twice for both C and D.)</p> <p>E Large (percentage) uncertainty in <math>(\phi - 90^\circ)</math> <b>or</b> <math>(\phi - 90^\circ)</math> is small.</p> <p>F Difficult to measure <math>D</math> (or <math>d</math>) with reason linked to use of ruler.</p> <p>1 mark for each point up to a maximum of 4.</p> | 4     |
| 2(f)(ii) | <p>A Take more readings and plot a graph/take more readings and compare <math>k</math> values (<b>not</b> “repeat readings” on its own).</p> <p>B Use thinner nail/fulcrum/prism.</p> <p>C Mark a scale on the wooden strip/use a thinner string.</p> <p>D Hold protractor in a clamp/<br/>take photograph and measure angle on photo/<br/>trigonometric method with detail e.g. measure height(s) of end(s) of wooden strip</p> <p>E Method to increase <math>(\phi - 90^\circ)</math> e.g. more paper clips/larger values of <math>x</math>/move pipe and pivot closer.</p> <p>F Use vernier/digital calipers/travelling microscope.</p> <p>1 mark for each point up to a maximum of 4.</p>                                                                                                                                                                                                                           | 4     |

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**PHYSICS**

**9702/35**

Paper 3 Advanced Practical Skills 1

**May/June 2017**

MARK SCHEME

Maximum Mark: 40

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**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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**PUBLISHED**

| Question  | Answer                                                                                                                                                                                                                                                                                                                                             | Marks |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 1(a)(iii) | Value of $x$ with unit to the nearest mm in the range 10.0–15.0 cm.                                                                                                                                                                                                                                                                                | 1     |
| 1(b)(ii)  | Evidence of repeated timings. Must see $nT$ repeated where $n \geq 5$ .                                                                                                                                                                                                                                                                            | 1     |
| 1(c)      | Six sets of readings of $x$ (different values) and time with correct trend and without help from Supervisor scores 5 marks, five sets scores 4 marks etc.                                                                                                                                                                                          | 5     |
|           | Range: $x_{\min} \leq 5.0 \text{ cm}$ <b>and</b> $x_{\max} \geq 20.0 \text{ cm}$ .                                                                                                                                                                                                                                                                 | 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. $x^2 / \text{m}^2$ .                                                                                                                                    | 1     |
|           | Consistency:<br>All values of raw $x$ must be given to the nearest mm.                                                                                                                                                                                                                                                                             | 1     |
|           | Significant figures:<br>All values of $x^2$ must be given to the same number of s.f. as (or one more than) the s.f. in raw $x$ .                                                                                                                                                                                                                   | 1     |
| 1(d)(i)   | Axes:<br>Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions).<br>Scales must be chosen so that the plotted points occupy at least half the graph grid in both $x$ and $y$ directions.<br>Scales must be labelled with the quantity that is being plotted.<br>Scale markings should be no more than three large squares apart. | 1     |
|           | Plotting of points:<br>All observations must be plotted on the grid.<br>Diameter of plotted points must be $\leq$ half a small square (no “blobs”).<br>Points must be plotted to an accuracy of half a small square.                                                                                                                               | 1     |
|           | Quality:<br>All points in the table must be plotted for this mark to be awarded.<br>It must be possible to draw a straight line that is within $\pm 0.025 \text{ s}$ on the $T$ axis of all plotted points.                                                                                                                                        | 1     |

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| Question  | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Marks |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 1(d)(ii)  | Line of best fit:<br>Judge by balance of all points on the grid about the candidate's line (at least 5). There must be an even distribution of points either side of the line along the full length.<br>Allow one anomalous point only if clearly indicated (i.e. circled or labelled) by the candidate. There must be at least five points left after the anomalous point is disregarded.<br>Lines must not be kinked or thicker than half a small square. | 1     |
| 1(d)(iii) | Gradient:<br>The hypotenuse of the triangle used must be greater than half the length of the drawn line.<br>Gradient sign must match graph.<br>Method of calculation must be correct. Do not allow $\Delta x / \Delta y$ .<br>Both read-offs must be accurate to half a small square in both the x and y directions.                                                                                                                                        | 1     |
|           | y-intercept:<br>Correct read-off from a point on the line substituted correctly into $y = mx + c$ or an equivalent expression.<br>Read-off accurate to half a small square in both x and y directions.<br><b>or</b><br>Intercept read directly from the graph, with read-off at $x^2 = 0$ , accurate to half a small square in the y direction.                                                                                                             | 1     |
| 1(e)      | Value of $P$ = candidate's gradient <b>and</b> value of $Q$ = candidate's intercept.<br>The values must not be fractions.                                                                                                                                                                                                                                                                                                                                   | 1     |
|           | Unit for $P$ dimensionally correct (e.g. $\text{s m}^{-2}$ or $\text{s cm}^{-2}$ or $\text{s mm}^{-2}$ ).<br>Unit for $Q$ correct (s).                                                                                                                                                                                                                                                                                                                      | 1     |
| 1(f)(iii) | Correct calculation of x.                                                                                                                                                                                                                                                                                                                                                                                                                                   | 1     |

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| Question  | Answer                                                                                                                                                                                                                                                                            | Marks |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 2(a)      | Value of raw $L$ with unit in range 1.5–2.5 cm.                                                                                                                                                                                                                                   | 1     |
| 2(c)(ii)  | Value of $y \geq L$ and to the nearest mm.                                                                                                                                                                                                                                        | 1     |
| 2(c)(iii) | Value of raw $\theta$ to the nearest degree.                                                                                                                                                                                                                                      | 1     |
| 2(d)      | Percentage uncertainty in $\theta$ based on absolute uncertainty of 2–10°.<br>If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown.<br>Correct method of calculation to obtain percentage uncertainty. | 1     |
| 2(e)(i)   | Correct calculation of $(y - L)$ .                                                                                                                                                                                                                                                | 1     |
| 2(e)(ii)  | Correct calculation of $\cos(\theta/2)$ .                                                                                                                                                                                                                                         | 1     |
| 2(e)(iii) | Justification for s.f. in $\cos(\theta/2)$ linked to s.f. in $\theta$ .                                                                                                                                                                                                           | 1     |
| 2(f)      | Second value of $y$ .                                                                                                                                                                                                                                                             | 1     |
|           | Second value of $\theta$ .                                                                                                                                                                                                                                                        | 1     |
|           | Quality: second value of $\theta >$ first value of $\theta$ .                                                                                                                                                                                                                     | 1     |
| 2(g)(i)   | Two values of $k$ calculated correctly.                                                                                                                                                                                                                                           | 1     |
| 2(g)(ii)  | Valid comment consistent with calculated values of $k$ , testing against a criterion specified by the candidate.                                                                                                                                                                  | 1     |

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| Question | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Marks    |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 2(h)(i)  | <p>A Two readings are not enough to draw a (valid) conclusion (<b>not</b> “not enough for accurate results”, “few readings”).</p> <p>B Moving hands affecting keeping 15 cm the same or measuring <math>y</math> or <math>\theta</math>.</p> <p>C Parallax error affecting the measurement of <math>y</math> or <math>\theta</math>.</p> <p>D Reason for <math>d</math> not remaining constant e.g. loops slip on stand.</p> <p>E Difficult to know where to measure from for the angle or <math>y</math>.</p> <p><i>1 mark for each point up to a maximum of 4.</i></p>                                                                                             | <b>4</b> |
| 2(h)(ii) | <p>A Take more readings <u>and</u> plot a graph/take more readings <u>and</u> compare <math>k</math> values (<b>not</b> “repeat readings” on its own).</p> <p>B Use another stand for valid purpose (e.g. instead of hand to hold spring).</p> <p>C Photo or still from video to measure <math>\theta</math> <b>or</b> including scale in frame to measure <math>y</math>.</p> <p>D Improved method of fixing springs onto stand e.g. use Blu-Tack/tape/vertically clamped hacksaw blade/bulldog clips or use sandpaper to make stand rough.</p> <p>E Use a grid behind the springs/markers on spring.</p> <p><i>1 mark for each point up to a maximum of 4.</i></p> | <b>4</b> |