Cambridge International AS & A Level

**Cambridge Assessment International Education**
Cambridge International Advanced Subsidiary and Advanced Level

**PHYSICS** **9702/51**

Paper 5 Planning, Analysis and Evaluation **October/November 2019**

MARK SCHEME

Maximum Mark: 30

**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.

Cambridge International will not enter into discussions about these mark schemes.

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**Generic Marking Principles**

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

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| GENERIC MARKING PRINCIPLE 5:<br><br>Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen). |
| GENERIC MARKING PRINCIPLE 6:<br><br>Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind. |

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| Question | Answer | Marks |
|---|---|---|
| 1 | **Defining the problem** | |
| | $r$ is the independent variable and $h$ is the dependent variable **or** vary $r$ and measure/determine $h$ | **1** |
| | keep $P$ constant | **1** |
| | **Methods of data collection** | |
| | labelled diagram of workable experiment including:<br>• labelled air blower<br>• labelled ball vertically (by eye) above the blower<br>• vertical (by eye) rule at least from top of blower to ball | **1** |
| | circuit diagram to determine $P$, e.g. voltmeter and ammeter connected to motor and power supply or wattmeter connected to motor and power supply | **1** |
| | use of micrometer/calipers/rule to measure diameter of ball | **1** |
| | measure the distance between the top/middle/bottom of the ball and the top of the blower | **1** |
| | **Method of Analysis** | |
| | plot a graph of $h$ against $1 / r^3$<br>(or lg $h$ against lg $r$) | **1** |
| | relationship valid if a straight line through (0,0)<br>(for lg $h$ against lg $r$ straight line with gradient = –3) | **1** |
| | $K = \frac{4\pi g \times \text{gradient}}{3P}$<br>(for lg $h$ against lg $r$, $K = \frac{4\pi g \times 10^{y\text{–intercept}}}{3P}$) | **1** |

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| Question | Answer | | Marks |
|---|---|---|---|
| 1 | **Additional detail including safety considerations** | | |
| | D1 | use large box/tray to collect ball (to prevent ball rolling on floor/bouncing)<br>**or**<br>reasoned method to avoid draughts, e.g. switch off fans, close windows, use a screen | **6** |
| | D2 | method to determine $P$ from correct circuit, e.g. $P = I \times V$ or use wattmeter to measure $P$ | |
| | D3 | stand on bench with clamped rule vertically to measure vertical distance | |
| | D4 | method to ensure clamped rule to measure $h$ is vertical, e.g.<br>correctly positioned set square indicated at right angles between the rule and the horizontal surface<br>**or**<br>plumb line shown in appropriate position | |
| | D5 | $r = d / 2$ when diameter measured | |
| | D6 | repeat diameter measurement in different directions and find average | |
| | D7 | repeat experiment for each value of $r$ and determine average $h$ | |
| | D8 | method to determine $h$, e.g.<br>$h$ = reading top of ball – $r$ – top of blower<br>**or**<br>$h$ = reading bottom of ball + $r$ – top of blower<br>**or**<br>$h$ = (distance from top of ball to top of blower + distance from bottom of ball to top of blower) / 2 | |
| | D9 | wait for the ball to become stationary (vertically) | |
| | D10 | video (camera) shown level with elevated ball and description of playback frame-by-frame or slow motion | |

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(a)</td><td>gradient = $q$<br>and<br>$y$-intercept = $\lg\left(\frac{2\pi}{\sqrt{k}}\right) = \lg 2\pi - \frac{1}{2}\lg k$</td><td>1</td></tr>
<tr><td>2(b)</td><td><table><tr><th>$T$ / s</th><th>lg ($T$ / s)</th></tr><tr><td>1.56</td><td>0.193 or 0.1931</td></tr><tr><td>1.79</td><td>0.253 or 0.2529</td></tr><tr><td>1.97</td><td>0.294 or 0.2945</td></tr><tr><td>2.14</td><td>0.330 or 0.3304</td></tr><tr><td>2.31</td><td>0.364 or 0.3636</td></tr><tr><td>2.45</td><td>0.389 or 0.3892</td></tr></table></td><td></td></tr>
<tr><td></td><td>Values of $T$ as above.</td><td>1</td></tr>
<tr><td></td><td>Values of lg $T$ as above.</td><td>1</td></tr>
<tr><td></td><td>Uncertainties in $T$ all ±0.04.</td><td>1</td></tr>
<tr><td></td><td>Uncertainties in lg ($T$/s) consistent with uncertainties in $T$ e.g. from ±0.011 to ±0.007.</td><td>1</td></tr>
</table>

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| Question | Answer | Marks |
|---|---|---|
| 2(c)(i) | Six points plotted correctly.<br>Must be accurate to the nearest half a small square. Diameter of points must be less than half a small square. | **1** |
| | Error bars in lg *T* plotted correctly.<br>All error bars must be plotted. Length of bar must be accurate to less than half a small square and symmetrical. | **1** |
| 2(c)(ii) | Line of best fit drawn.<br>Lower end of line should pass between (2.22, 0.22) and (2.25, 0.22) **and** upper end of line should pass between (2.49, 0.34) and (2.51, 0.34).<br>Do not accept line from first to last plot. | **1** |
| | Worst acceptable line drawn (steepest or shallowest possible line that passes through all the error bars).<br>All error bars must be plotted. | **1** |
| 2(c)(iii) | Gradient determined with clear substitution of data points from the line of best fit into $\Delta y / \Delta x$.<br>Distance between data points must be greater than half the length of the drawn line. | **1** |
| | uncertainty = gradient of line of best fit – gradient of worst acceptable line<br>**or**<br>uncertainty = ½ (steepest worst line gradient – shallowest worst line gradient) | **1** |
| 2(c)(iv) | *y*-intercept determined by substitution of correct point from the line of best fit into $y = mx + c$. | **1** |
| 2(d) | *k* determined from *y*-intercept.<br>$k\left(=\left(\frac{2\pi}{10^{y\text{-intercept}}}\right)^2\right)=\left(\frac{2\pi}{10^{\text{(c)(iv)}}}\right)^2$ | **1** |
| | *q* = answer to **(c)(iii) and** given to 2 or 3 significant figures. | **1** |

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| Question | Answer | Marks |
|---|---|---|
| 2(e) | *M* determined from **(d) or (c)(iii) and (c)(iv)** with correct substitution shown.<br>$M = \sqrt[q]{\frac{T\sqrt{k}}{2\pi}} = \sqrt[q]{\frac{\sqrt{k}}{2\pi}} = \sqrt[2q]{\frac{k}{4\pi^2}}$<br>**or**<br>$\lg M = \frac{(\lg 1) - \lg\left(\frac{2\pi}{\sqrt{k}}\right)}{q}$<br>$\lg M = -\frac{y\text{-intercept}}{\text{gradient}} = -\frac{\textbf{(c)(iv)}}{\textbf{(c)(iii)}}$<br>$M = 10^{\left(-\frac{\textbf{(c)(iv)}}{\textbf{(c)(iii)}}\right)}$ | **1** |

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