Cambridge Assessment International Education

# Cambridge International AS & A Level

**PHYSICS** **9702/52**

Paper 5 Planning, Analysis and Evaluation **October/November 2020**

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.

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This document consists of **10** printed pages.

**Annotations**

| | |
|---|---|
| ✓ | Correct point<br>Method of analysis marks in **Question 1** |
| ✓$_{1–10}$ | Additional detail marks in **Question 1** |
| **X** | Incorrect point |
| **^** | Omission |
| **BOD** | Benefit of the doubt |
| **NBOD** | No benefit of the doubt given |
| **ECF** | Error carried forward |
| **P** | Defining the problem marks in **Question 1**<br>Power of ten error in **Question 2** |
| **M0** | Methods of data collection marks in **Question 1** |

| Question | Answer | Marks |
|---|---|---|
| 1 | **Defining the problem** | |
| | *m* is the independent variable and *v* is the dependent variable **or** vary *m* and measure *v* | **1** |
| | keep *P* constant | **1** |
| | **Methods of data collection** | |
| | labelled diagram of workable experiment including:<br>• *P* attached to string<br>• string passing over a supported pulley<br>• string horizontally attached to trolley<br>• labels for pulley and *P* | **1** |
| | method to <u>determine *v*</u> e.g.<br>• light gate attached to a timer to <u>measure *v*</u><br>• motion sensor connected to data logger<br>• ticker tape timer<br>• measure *d*, and *t* with timer/stopwatch/light gate and timer (to calculate *v*) | **1** |
| | use a (top pan) balance to measure *m* | **1** |
| | measure *d* with a ruler | **1** |
| | **Method of Analysis** | |
| | plot a graph of $1 / v^2$ against *m* **or** *m* against $1 / v^2$ | **1** |
| | $Q = Pg - \frac{1}{2d \times \text{gradient}}$ **or** $Q = Pg - \frac{\text{gradient}}{2d}$ (consistent with graph) | **1** |
| | $R = 2d \times (Pg - Q) \times y\text{-intercept}$ $(= \frac{y\text{-intercept}}{\text{gradient}})$ **or** $R = -y\text{-intercept}$ (consistent with graph) | **1** |

| Question | Answer | | Marks |
|---|---|---|---|
| 1 | **Additional detail including safety considerations** | | **6** |
| | D1 | safety precaution related to falling mass *P* or preventing trolley falling e.g. cushion/sandbox for *P*, barrier for trolley | |
| | D2 | keep *d* constant | |
| | D3 | use a large distance for *d* | |
| | D4 | method to keep *d* constant, e.g. mark starting and end positions | |
| | D5 | *v* = distance / time for appropriate small distance on ticker tape/card/distance between light gates (**not** *d*)<br>**or**<br>use of $v = 2d / t$ if *d* and total time measured | |
| | D6 | method to ensure wooden surface is horizontal, e.g. spirit level | |
| | D7 | for same *m* repeat experiment to find average *v* or *t* | |
| | D8 | $\frac{1}{v^2} = \frac{m}{2d \times (Pg - Q)} + \frac{R}{2d \times (Pg - Q)}$ **or** $m = \frac{2d(Pg - Q)}{v^2} - R$ (consistent with graph) | |
| | D9 | relationship valid if a straight line (not passing through the origin) | |
| | D10 | method of attaching mass *m* to trolley e.g. tape, adhesive putty | |

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(a)</td><td>gradient = $\frac{4\sigma}{\rho g}$</td><td>1</td></tr>
<tr><td rowspan="2">2(b)</td><td><table><tr><td>$(1/d)/\text{mm}^{-1}$</td></tr><tr><td>0.91 or 0.909</td></tr><tr><td>0.77 or 0.769</td></tr><tr><td>0.67 or 0.667</td></tr><tr><td>0.59 or 0.588</td></tr><tr><td>0.50 or 0.500</td></tr><tr><td>0.43 or 0.435</td></tr></table></td><td>1</td></tr>
<tr><td>Absolute uncertainties in $\frac{1}{d}$ from ± (0.08 or 0.09) to ± (0.01 or 0.02).</td><td>1</td></tr>
<tr><td rowspan="2">2(c)(i)</td><td>Six points plotted correctly.<br>Must be accurate to nearest half a small square. Diameter of points must be less than half a small square.</td><td>1</td></tr>
<tr><td>Error bars in $\frac{1}{d}$ plotted correctly.<br>All error bars must be plotted. Total length of bar must be accurate to less than half a small square and symmetrical.</td><td>1</td></tr>
<tr><td rowspan="2">2(c)(ii)</td><td>Line of best fit drawn.<br>Points must be balanced. Do not accept line from top to bottom point.<br>Line must pass between (0.52, 10.5) and (0.55, 10.5) and between (0.84, 17.0) and (0.87, 17.0).</td><td>1</td></tr>
<tr><td>Worst acceptable line drawn (steepest or shallowest possible line that passes through all the error bars).<br>All error bars must be plotted.</td><td>1</td></tr>
</table>

| Question | Answer | Marks |
|---|---|---|
| 2(c)(iii) | Gradient determined with clear substitution of data points into $\Delta y / \Delta x$.<br>Distance between data points must be at least half the length of the drawn line. | **1** |
| | Gradient of worst acceptable line determined.<br><br>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(d)(i) | $\rho \left( = \frac{0.606 - 0.422}{146 \times 10^{-6}} = \frac{0.184}{146 \times 10^{-6}} \right) = 1260\,\text{kg m}^{-3}$<br><br>**and** given to three or four significant figures. | **1** |
| 2(d)(ii) | % uncertainty in $\rho$ = % uncertainty in $m$ + % uncertainty in $V$<br>$\left( = \left( \frac{2}{184} + \frac{2}{146} \right) \times 100 = 1.087 + 1.37 \right) = 2.5\%$<br><br>**or**<br><br>using max $\rho$ = 186 / 144 = 1292 and/or min $\rho$ = 182 / 146 = 1230 | **1** |

| Question | Answer | Marks |
|---|---|---|
| 2(e) | $\sigma$ determined using gradient with correct substitution shown.<br>$\sigma = \frac{\rho g \times \text{gradient}}{4} = \frac{\textbf{(d)(i)} \times 9.81 \times \textbf{(c)(iii)}}{4}$ | **1** |
| | $\sigma$ determined using gradient **and** correct SI unit given (N m$^{-1}$ or kg s$^{-2}$). | **1** |
| | Absolute uncertainty in $\sigma$ determined with correct substitution shown.<br>$\text{uncertainty} = \left(\frac{\textbf{(d)(ii)}}{100} + \frac{\Delta\text{gradient}}{\text{gradient}}\right) \times \sigma$<br>**or**<br>$\text{uncertainty} = \left(\frac{2}{184} + \frac{2}{146} + \frac{\Delta\text{gradient}}{\text{gradient}}\right) \times \sigma$<br>**or**<br>using $\max \sigma = \frac{\max\textbf{(d)(i)} \times 9.81 \times \max\textbf{(c)(iii)}}{4}$<br>**or**<br>using $\min \sigma = \frac{\min\ \textbf{(d)(i)} \times 9.81 \times \min\ \textbf{(c)(iii)}}{4}$ | **1** |
| 2(f) | $d$ determined to a minimum of two significant figures.<br>$d = \frac{\text{gradient}}{h}$<br>**or**<br>$d = \frac{4 \times \textbf{(e)(i)}}{h \times \textbf{(d)(i)} \times 9.81}$ | **1** |