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 will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the October/November 2015 series for most Cambridge IGCSE®, Cambridge International A and AS Level components and some Cambridge O Level components.
1 Planning (15 marks)

Defining the problem (3 marks)

P \( m \) is the independent variable and \( E \) is the dependent variable or vary \( m \) and measure \( E \). Do not allow time. \( [1] \)

P Keep the temperature change of water constant. Allow two specified temperatures. Do not allow "keep temperature constant". \( [1] \)

P Keep the mass or volume of water constant. \( [1] \)

Methods of data collection (5 marks)

M Labelled diagram including labelled thermometer with bulb in water and at least one other label. \( [1] \)

M Workable circuit diagram to determine \( E \): power supply, heater and ammeter and voltmeter, or joulemeter or wattmeter. \( [1] \)

M Method to determine change in temperature: measure initial temperature, measure final temperature and subtract, or measure initial temperature and specific temperature change. \( [1] \)

M Use balance/scales to measure mass of blocks. \( [1] \)

M Stir water (so that metal is in thermal equilibrium). \( [1] \)

Method of analysis (2 marks)

A Plot a graph of \( E \) against \( m \). Do not allow log–log graphs. \( [1] \)

A \( a = \) gradient and \( b = y \)-intercept; must be consistent with suggested graph. \( [1] \)

Safety considerations (1 mark)

S Precaution linked to hot heater/water, e.g. use gloves or use tongs for hot blocks. Do not allow goggles. \( [1] \)

Additional detail (4 marks)

D Relevant points might include

1 Method to ensure that e.m.f. of the power supply is constant/current in heater is constant, e.g. adjust variable power supply/variable resistor to ensure p.d./current is constant

2 Keep the starting temperature of water/metal constant

3 Wait for water and metal temperatures to equalise

4 Add insulation to sides of beaker/lid (to prevent energy losses)

5 Use of timer and equation, e.g. \( E = Pt = ItV \) for candidate’s method

6 Use large temperature change to reduce percentage uncertainty

7 Relationship is valid if the graph is a straight line that does not pass through the origin

Do not allow vague computer methods.
## Analysis, conclusions and evaluation (15 marks)

<table>
<thead>
<tr>
<th>Mark</th>
<th>Expected Answer</th>
<th>Additional Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) A1</td>
<td>gradient = ( \frac{P_g}{m} )</td>
<td></td>
</tr>
<tr>
<td>(b)</td>
<td></td>
<td>Allow ( T(s) ), ( v(\text{ms}^{-1}) ) and ( v^2(\text{m}^2\text{s}^{-2}) ).</td>
</tr>
<tr>
<td>T2</td>
<td></td>
<td>Must be values of ( v^2 ) in table (if ( v ) not rounded). All values of ( v^2 ) must be 2 s.f. or 3 s.f. Allow a mixture of significant figures.</td>
</tr>
<tr>
<td>U1</td>
<td>From ± 0.9 or 1 to ± 3</td>
<td>Allow more than one significant figure.</td>
</tr>
<tr>
<td>(c) (i) G1</td>
<td>Six points plotted correctly</td>
<td>Must be within half a small square. Do not allow “blobs”. ECF allowed from table.</td>
</tr>
<tr>
<td>U2</td>
<td>Error bars in ( v^2 ) plotted correctly</td>
<td>All error bars to be plotted. Must be accurate to less than half a small square. Length of bar must be accurate to less than half a small square.</td>
</tr>
<tr>
<td>(ii) G2</td>
<td>Line of best fit</td>
<td>If points are plotted correctly then lower end of line should pass between (0.16, 10) and (0.18, 10) and upper end of line should pass between (0.70, 50) and (0.72, 50). Line should not go from top to bottom points.</td>
</tr>
<tr>
<td>G3</td>
<td>Worst acceptable straight line. Steepest or shallowest possible line that passes through all the error bars.</td>
<td>Line should be clearly labelled or dashed. Examiner judgement on worst acceptable line. Lines must cross. Mark scored only if error bars are plotted.</td>
</tr>
<tr>
<td>(iii) C1</td>
<td>Gradient of line of best fit</td>
<td>The triangle used should be at least half the length of the drawn line. Check the read-offs. Work to half a small square. Do not penalise POT. (Should be about 72.)</td>
</tr>
<tr>
<td>U3</td>
<td>Absolute uncertainty in gradient</td>
<td>Method of determining absolute uncertainty: difference in worst gradient and gradient.</td>
</tr>
<tr>
<td>(d) (i) C2</td>
<td>( P = \frac{m}{g} \times \text{gradient} ) [ \text{or} \quad 2.55 \times 10^{-3} \times \text{gradient} ]</td>
<td>Must use gradient. Should be about 0.19.</td>
</tr>
<tr>
<td>C3</td>
<td>kg</td>
<td></td>
</tr>
<tr>
<td>(ii) U4</td>
<td>Percentage uncertainty in ( P )</td>
<td>Must be greater than 4%.</td>
</tr>
</tbody>
</table>
Uncertainties in Question 2

(c) (iii) Gradient [U3]

uncertainty = gradient of line of best fit – gradient of worst acceptable line

uncertainty = ½ (steepest worst line gradient – shallowest worst line gradient)

(d) (ii) [U4]

\[
\text{percentage uncertainty} = \left( \frac{\Delta \text{gradient}}{\text{gradient}} + \frac{0.001}{0.025} \right) \times 100 = \left( \frac{\Delta \text{gradient}}{\text{gradient}} + 0.04 \right) \times 100
\]

\[
\text{max. } P = \frac{0.026}{9.81} \times \text{max. gradient}
\]

\[
\text{max. } P = \frac{0.024}{9.81} \times \text{min. gradient}
\]

(e) (ii) [U5]

\[
\text{percentage uncertainty} = \frac{1}{2} \left( \frac{\Delta P}{P} + \frac{0.005}{0.5} \right) \times 100
\]

\[
\text{max. } v = \sqrt{\frac{\text{max. } P \times 9.81 \times 0.505}{0.040}}
\]

\[
\text{min. } v = \sqrt{\frac{\text{min. } P \times 9.81 \times 0.495}{0.040}}
\]