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 May/June 2014 series for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level components and some Ordinary Level components.
Planning (15 marks)

Defining the problem (3 marks)
- P \( r \) is the independent variable or vary \( r \). \[1\]
- P \( T \) (or \( t \)) is the dependent variable or measure \( T \) (or \( t \)). \[1\]
- P Keep the radius of curvature (of the track) or \( C \) constant (or radius of track constant). Do not allow “use same track”. \[1\]

Methods of data collection (5 marks)
- M Diagram showing ball in a (curved) track with supports for track, e.g. retort stands. Minimum of two labels (from ball, track, supports; not stopwatch, bench, micrometer).
  Supports making contact with track higher than ball/at least half way up. \[1\]
- M Measure time using stopwatch or light gates and timer or datalogger with motion sensor.
  Detail needed for video camera. \[1\]
- M Use many oscillations (at least 10 or at least 10s of timing) and determine \( T = t/n \). \[1\]
- M Measure diameter (radius) of ball with a micrometer/vernier calipers.
  Do not allow travelling microscope. \[1\]
- M radius = diameter/2. \[1\]

Method of analysis (2 marks)
- A Plot a graph of \( T^2 \) against \( r \) (or \( r \) against \( T^2 \))
  Do not allow log graphs. \[1\]
- A \( C = \frac{5g}{28\pi^2} = \frac{y-intercept}{\text{gradient}} \) (or for \( r \) against \( T^2 \), \( C = y\)-intercept) \[1\]

Safety considerations (1 mark)
- S Precaution linked to ball escaping on to floor, e.g. use barrier/safety screen/sand tray to prevent balls rolling on to floor. \[1\]
Additional detail (4 marks)

D Relevant points might include [4]
1 Add weights to/G-clamp retort stands
2 Keep the material/density of the ball constant
3 Use of fiducial marker near centre of track/mark on the track
4 Clean track/balls. Do not allow oil the track.
5 Repeat measurements of $t$ (for each ball) and average
6 Repeat measurement for $d$ (or $r$) and average
7 Relationship is valid if straight line, provided plotted graph is correct
8 Relationship is valid if straight line not passing through origin or has an intercept,
   provided plotted graph is correct (any quoted expression must be correct, e.g.
   \[ y\text{-intercept} = \frac{28\pi^2C}{5g} \])

Do not allow vague computer methods. [Total: 15]
## 2 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><strong>(a)</strong></td>
<td></td>
<td></td>
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</tbody>
</table>
| A1 | gradient $= -R$  
y-intercept $= -\frac{R}{P}$ | Must be negative. |
| **(b)** | \(T1\)  
\(T2\) | Allow a mixture of significant figures.  
\(T1\) and \(T2\) must be table values.  
Ignore “–” omissions. |
| T1  
T2 | 6.7 or 6.67  
4.5 or 4.55  
3.0 or 3.03  
2.0 or 2.00  
1.5 or 1.52  
1.1 or 1.11 | –5.1 or –5.13  
–3.8 or –3.75  
–2.8 or –2.75  
–2.1 or –2.06  
–1.8 or –1.75  
–1.5 or –1.50 |
| **(c) (i)** | | |
| G1 | Six points plotted correctly | Must be within half a small square.  
Penalise “blobs”.  
Ecf allowed from table. |
| U1 | From ±0.3 or ±0.4 to ±0.1 or ±0.2 | Allow more than one significant figure. |
| **(ii)** | | |
| G2 | Line of best fit | If points are plotted correctly then  
lower end of line should pass between  
(6.4,–5.0) and (6.6,–5.0) and upper  
end of line should pass between  
(1.0,–1.5) and (1.2,–1.5). |
| G3 | Worst acceptable straight line.  
Steepest or shallowest possible line  
that passes through all the error bars. | Line should be clearly labelled or  
dashed. Should pass from top of top  
error bar to bottom of bottom error bar  
or bottom of top error bar to top of  
bottom error bar. Mark scored only if all  
error bars are plotted. |
| **(iii)** | | |
| C1 | Gradient of best fit line | Must be negative. 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 –650.) |
| U3 | Uncertainty in gradient | Method of determining absolute  
uncertainty.  
Difference in worst gradient and  
gradiod.
Uncertainties in Question 2

(c) (iii) **Gradient [U3]**

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

Uncertainty = \( \frac{1}{2} \) (steepest worst line gradient – shallowest worst line gradient)

(c) (iv) **[U4]**

Uncertainty = y-intercept of line of best fit – y-intercept of worst acceptable line

Uncertainty = \( \frac{1}{2} \) (steepest worst line y-intercept – shallowest worst line y-intercept)

(d) (i) **[U5]**

Percentage uncertainty in gradient + percentage uncertainty in y-intercept

\[
\begin{align*}
\text{max } P &= \frac{\text{max } R}{\text{min } y - \text{intercept}} = \frac{\text{max gradient}}{\text{min } y - \text{intercept}} \\
\text{min } f &= \frac{\text{min } R}{\text{max } y - \text{intercept}} = \frac{\text{min gradient}}{\text{max } y - \text{intercept}}
\end{align*}
\]