CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2014 series

9702 PHYSICS

9702/51 Paper 5 (Planning, Analysis and Evaluation), maximum raw mark 30

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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1 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 10 s 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 $C = y\text{-intercept} \times \frac{5g}{28\pi^2} = \frac{\text{y} - \text{intercept}}{\text{gradient}}$ (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]

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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-intercept = $\frac{28\pi^2 C}{5g}$)

Do not allow vague computer methods.

[Total: 15]

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2 Analysis, conclusions and evaluation (15 marks)

<table>
<tr><th></th><th>Mark</th><th>Expected Answer</th><th>Additional Guidance</th></tr>
<tr><td>(a)</td><td>A1</td><td>gradient = –R
y-intercept = –R/P</td><td>Must be negative.</td></tr>
<tr><td>(b)</td><td>T1
T2</td><td><table><tr><td>6.7 or 6.67</td><td>–5.1 or –5.13</td></tr><tr><td>4.5 or 4.55</td><td>–3.8 or –3.75</td></tr><tr><td>3.0 or 3.03</td><td>–2.8 or –2.75</td></tr><tr><td>2.0 or 2.00</td><td>–2.1 or –2.06</td></tr><tr><td>1.5 or 1.52</td><td>–1.8 or –1.75</td></tr><tr><td>1.1 or 1.11</td><td>–1.5 or –1.50</td></tr></table></td><td>Allow a mixture of significant figures.
T1 and T2 must be table values.
Ignore “–” omissions.</td></tr>
<tr><td></td><td>U1</td><td>From ± 0.3 or ± 0.4 to ± 0.1 or ± 0.2</td><td>Allow more than one significant figure.</td></tr>
<tr><td>(c) (i)</td><td>G1</td><td>Six points plotted correctly</td><td>Must be within half a small square.
Penalise “blobs”.
Ecf allowed from table.</td></tr>
<tr><td></td><td>U2</td><td>Error bars in V / E plotted correctly</td><td>All error bars to be plotted. Must be accurate to less than half a small square.</td></tr>
<tr><td>(ii)</td><td>G2</td><td>Line of best fit</td><td>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).</td></tr>
<tr><td></td><td>G3</td><td>Worst acceptable straight line.
Steepest or shallowest possible line that passes through <u>all</u> the error bars.</td><td>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.</td></tr>
<tr><td>(iii)</td><td>C1</td><td>Gradient of best fit line</td><td>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.)</td></tr>
<tr><td></td><td>U3</td><td>Uncertainty in gradient</td><td>Method of determining absolute uncertainty.
Difference in worst gradient and gradient.</td></tr>
</table>

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(iv)	C2	Negative *y*-intercept	Must be negative. Check substitution into $y = mx + c$ Allow ecf from **(c)(iii)**. (Should be about –0.8.) FOX does not score.
	U4	Uncertainty in *y*-intercept	Uses worst gradient and point on WAL. Check method. FOX does not score.
(d) (i)	C3	$P = R$ / *y*-intercept = –gradient / *y*-intercept	Include unit [Ω] for *P* and *R*. Do not penalise POT.
	C4	*R* = gradient in the range 620 to 680 and given to 2 or 3 s.f.	
(ii)	U5	Percentage uncertainty in *P*	Percentage uncertainty in gradient + percentage uncertainty in *y*-intercept

[Total: 15]

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)

(c) (iv) [U4]

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

Uncertainty = ½ (steepest worst line *y*-intercept – shallowest worst line *y*-intercept)

(d) (i) [U5]

Percentage uncertainty in gradient + percentage uncertainty in *y*-intercept

$$\max P = \frac{\max R}{\min \text{ y} - \text{intercept}} = \frac{\max \text{ gradient}}{\min \text{ y} - \text{intercept}}$$

$$\min f = \frac{\min R}{\max \text{ y} - \text{intercept}} = \frac{\min \text{ gradient}}{\max \text{ y} - \text{intercept}}$$

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