Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2016**

MARK SCHEME

Maximum Mark: 30

Published

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Question 1 Planning (15 marks)

Defining the problem (2 marks)

P θ is the independent variable and a is the dependent variable, or vary θ and measure a. [1]

P Keep F constant. [1]

Methods of data collection (4 marks)

M Diagram showing inclined plane with labelled support
(not if a ruler used as the inclined plane or as vertical support). [1]

M Method to measure angle e.g. use a protractor to measure θ or use a ruler to measure marked distances from which $\sin\theta$ or θ may be determined.
(Allow a labelled protractor in the correct position.) [1]

M Method to measure a time or velocity to determine a, e.g. measure the time using a stopwatch, light gate(s) connected to a timer, motion sensor connected to a time display. [1]

M Use a balance to measure the mass of the trolley. [1]

Method of analysis (3 marks)

A	Plot a graph of a against $\sin\theta$.	or	Plot a graph of ma against $\sin\theta$.	or	Plot a graph of ma against $mg\sin\theta$.	[1]

A Relationship is valid if the graph is a straight line and does **not** pass through the origin [1]

A	$k = F - m \times$ (y-intercept)	or	$k = F -$ (y-intercept)	or	$k = F -$ (y-intercept)	[1]

Do not allow lg-lg graphs.

Additional detail (6 marks)

Relevant points might include: [6]

1 Keep mass of trolley constant/use same trolley.

2 Correct trigonometry relationship to determine $\sin\theta$ or θ using marked lengths.

3 Use ruler to measure appropriate distance to determine a, e.g. length of slope, length of card for light gate method, position of motion sensor.

4 Equation to determine a from measurements taken appropriately with a as the subject.

5 Measurement of F for a valid method e.g. take reading from newton-meter or from stretched elastic/spring from extension (allow falling weight e.g. $F = mg$).

6 Use a constant extension to produce a constant force when using stretched spring/elastic.

7 Method to ensure the inclined plane is the same height each side of the plane or spirit level across plane or ensure force F (or string) is parallel to the plane.

8 Safety precaution linked to falling mass/trolley or spring/elastic breaking (not string).

9 Rearrangement of relationship into $y = mx + c$ e.g. $ma = -mg \sin \theta + (F - k)$ or $a = -g \sin\theta + \frac{F-k}{m}$ or correct y-intercept (subject must be y-axis).

10 Repeat experiment for each angle θ to find average for a.

Do not allow vague computer methods.

Question 2 Analysis, conclusions and evaluation (15 marks)

	Mark	Expected Answer	Additional Guidance
(a)	A1	$\frac{4\rho L}{\pi}$	
(b)	T1	$\frac{1}{d^2}$ / $10^6\,\text{m}^{-2}$	
	T2	1.2 or 1.21 3.2 or 3.19 4.7 or 4.73 6.9 or 6.93 9.8 or 9.77 14 or 13.7	All values to 2 s.f. or 3 s.f. Allow a mixture of significant figures. Must be values in table.
	U1	From ± 0.03 to ± 1	Allow more than one significant figure. Allow zero for first uncertainty and up to 1.2 for largest uncertainty.
(c) (i)	G1	Six points plotted correctly	Must be within half a small square. Do not allow "blobs". ECF allowed from table.
	U2	Error bars in $\frac{1}{d^2}$ plotted correctly	All error bars to be plotted. Length of bar must be accurate to less than half a small square and symmetrical.
(ii)	G2	Line of best fit	Lower end of line must pass between (2.6, 4.0) and (3.0, 4.0) **and** upper end of line must pass between (12.4, 18.0) and (13.0, 18.0).
	G3	Worst acceptable straight line. Steepest or shallowest possible line that passes through all the error bars.	Line should be clearly labelled or dashed. Examiner judgement on worst acceptable line. Must be steepest/shallowest line. Mark scored only if error bars are plotted.
(iii)	C1	Gradient of line of best fit	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 1.4 –1.5 × 10^{-6}.)
	U3	Absolute uncertainty in gradient	Method of determining absolute uncertainty: difference in worst gradient and gradient.

	Mark	Expected Answer	Additional Guidance
(d) (i)	C2	$\frac{\pi \times \text{gradient}}{4L} = 0.7854 \times \text{gradient}$	Must use gradient value. Do not penalise POT (Should be about 1×10^{-6}.)
	C3	Ω m	Correct unit and correct power of ten.
(ii)	U4	Percentage uncertainty in ρ	Percentage uncertainty in gradient + 1%.
(e)	C4	*R* in the range 25.5 to 28.4 and given to 2 or 3 s.f.	Allow 26 or 27 or 28. Allow ECF for POT error in **(d)(i)** e.g. 2.7×10^7.
	U5	Absolute uncertainty in *R*	Percentage uncertainty must be greater than 8.6%.

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]

$$\text{percentage uncertainty} = \left(\frac{\Delta\text{gradient}}{\text{gradient}} + \frac{0.01}{1.00}\right)\times 100 = \left(\frac{\Delta\text{gradient}}{\text{gradient}}\right)\times 100 + 1\%$$

$$\max \rho = \frac{\pi \times \text{max gradient}}{4 \times \min L} = \frac{\pi \times \text{max gradient}}{4 \times 0.99}$$

$$\min \rho = \frac{\pi \times \text{min gradient}}{4 \times \max L} = \frac{\pi \times \text{min gradient}}{4 \times 1.01}$$

(e) [U5]

$$\text{percentage uncertainty} = \left(\frac{\Delta\text{gradient}}{\text{gradient}} + 2\times\left(\frac{0.01}{0.23}\right)\right)\times 100 = \left(\frac{\Delta\text{gradient}}{\text{gradient}} + 0.086\right)\times 100$$

$$\text{percentage uncertainty} = \left(\frac{\Delta\rho}{\rho} + \frac{0.01}{1.00} + 2\times\left(\frac{0.01}{0.23}\right)\right)\times 100 = \left(\frac{\Delta\rho}{\rho} + 0.096\right)\times 100$$

$$\max R = \frac{\text{max gradient}}{d_{\min}^2}$$

$$\max R = \frac{4\times L_{\max} \times \rho_{\max}}{\pi\times d_{\min}^2}$$

$$\min R = \frac{\text{min gradient}}{d_{\max}^2}$$

$$\min R = \frac{4\times L_{\min} \times \rho_{\min}}{\pi\times d_{\max}^2}$$