CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the October/November 2015 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 m is the independent variable, or vary m. [1]

P (tan)ϕ is the dependent variable, or measure (tan) ϕ. [1]

P Keep the temperature of the oil constant. [1]

Methods of data collection (5 marks)

M Labelled diagram showing labelled protractor positioned to determine ϕ for tilted cylinder.
Allow distances marked to determine ϕ and use of a rule. [1]

M Use of balance/scales to measure the mass of the oil/cylinder. [1]

M Mass of oil = mass of (oil + cylinder) – mass of cylinder. [1]

M Use of vernier calipers/micrometer/rule to measure d. [1]

M Repeat each experiment for the same value of m and average ϕ. [1]

Method of analysis (2 marks)

A Plot a graph of $\frac{1}{\tan\phi}$ against m.
(Allow $\frac{m}{d^3}$ or $\frac{m}{\rho d^3}$ or $\frac{m}{\rho}$. Do not allow log-log graphs.) [1]

A a = gradient $\times \rho d^3$ and b = y-intercept; must be consistent with suggested graph. [1]

Safety considerations (1 mark)

S Precaution linked to preventing spilling oil, e.g. use a tray/lid/cloth to absorb oil (do not allow just wiping or mopping)
or precaution linked to preventing glass cylinder breaking, e.g. padding/cushion
or use of gloves to prevent skin irritation (do not allow "because oil is slippery"). [1]

Additional detail (4 marks)

D Relevant points might include [4]
1 Repeat measurements of d in different directions and average
2 Use of video with slow motion/frame by frame playback to determine ϕ
3 Use large protractor to reduce percentage uncertainty **or** trigonometry relationship related to measurements to be taken
4 Use the same (diameter) cylinder (not "same size" but allow "same size and shape")
5 Slowly/gently/gradually tilt cylinder of oil/use of rough surface (to prevent sliding)
6 Experimental method to determine density of oil and $\rho = m / V$
7 Relationship is valid if the graph is a straight line that does NOT pass through the origin / has an intercept; must be consistent with suggested graph

Do not allow vague computer methods.

2 Analysis, conclusions and evaluation (15 marks)

	Mark	Expected Answer	Additional Guidance
(a)	A1	gradient = $\frac{4\rho}{\pi E d^2}$ y-intercept = $\frac{r}{E}$	
(b)	T1	$\frac{1}{I}$ / A^{-1}	Allow $\frac{1}{I}$ (A^{-1}) or $\frac{1}{I}\left(\frac{1}{A}\right)$.
	T2	4.2 or 4.17 5.0 or 5.00 5.9 or 5.88 6.7 or 6.67 7.7 or 7.69 8.3 or 8.33	Allow a mixture of significant figures. Must be table values.
	U1	$\pm$ 0.2 to $\pm$ 0.6 or $\pm$ 0.7 or $\pm$ 0.8	Allow more than one significant figure.
(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 $1/I$ plotted correctly	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. Do not allow less than 0.05.
(ii)	G2	Line of best fit	If points are plotted correctly then lower end of line should pass between (41, 4.5) and (44, 4.5) **and** upper end of line should pass between (83, 8.0) and (88, 8.0). Line should not go from bottom to top points.
	G3	Worst acceptable straight line. Steepest or shallowest possible line that passes through <u>all</u> the error bars.	Line should be clearly labelled or dashed. Examiner judgement on worst acceptable line. Lines must cross. 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 8.)
	U3	Absolute uncertainty in gradient	Method of determining absolute uncertainty: difference in worst gradient and gradient.
(iv)	C2	y-intercept	Check substitution into $y = mx + c$. Allow ECF from **(c)(iii)**. (Should be about 0.7–1.5.)

	U4	Absolute uncertainty in y-intercept	Uses worst gradient and point on WAL. Do not check calculation.
(d) (i)	C3	$\rho = 2.415 \times 10^{-7} \times$ gradient Must be in the range 1.80×10^{-6} to 2.10×10^{-6} <u>and</u> given to 2 or 3 s.f.	Must use gradient. $\rho = \frac{\pi E d^2}{4} \times$ gradient [$2 \times 10^{-6}\ \Omega\,m = 2 \times 10^{-4}\ \Omega\,cm = 2 \times 10^{-3}\ \Omega\,mm$]
	C4	$r = E \times y$-intercept $= 3.2 \times y$-intercept <u>and</u> Ω m <u>and</u> Ω given	Must include units for ρ and r. Allow $V\,A^{-1}$ or $kg\,m^2\,A^{-2}\,s^{-3}$ for Ω.
(ii)	U5	Percentage uncertainty in ρ	Must be greater than 9.6%.

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)

(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) (ii) [U5]

$$\text{percentage uncertainty} = \left(\frac{\Delta m}{m} + \frac{0.1}{3.2} + 2 \times \frac{0.01}{0.31}\right) \times 100$$

$$= \left(\frac{\Delta m}{m} \times 100\right) + 3.125 + 2 \times 3.226$$

$$\text{max. } p = \frac{\pi \times 3.3 \times (0.32 \times 10^{-3})^2}{4} \times \text{max. gradient}$$

$$\text{min. } p = \frac{\pi \times 3.1 \times (0.30 \times 10^{-3})^2}{4} \times \text{min. gradient}$$