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**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

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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)$\phi$ is the dependent variable, or measure (tan) $\phi$. [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 $\phi$ for tilted cylinder.
Allow distances marked to determine $\phi$ 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 $\phi$. [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 $\phi$
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.

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## 2 Analysis, conclusions and evaluation (15 marks)

| | Mark | Expected Answer | Additional Guidance |
|---|---|---|---|
| **(a)** | A1 | gradient = $\frac{4\rho}{\pi E d^2}$<br>$y$-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<br>5.0 or 5.00<br>5.9 or 5.88<br>6.7 or 6.67<br>7.7 or 7.69<br>8.3 or 8.33 | Allow a mixture of significant figures.<br>Must be table values. |
| | U1 | ± 0.2 to ± 0.6 or ± 0.7 or ± 0.8 | Allow more than one significant figure. |
| **(c) (i)** | G1 | Six points plotted correctly | Must be within half a small square.<br>Do not allow "blobs".<br>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).<br>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.<br>Examiner judgement on worst acceptable line.<br>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 $y = mx + c$.<br>Allow ECF from **(c)(iii)**.<br>(Should be about 0.7–1.5.) |

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

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

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

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

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

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