UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2011 question paper for the guidance of teachers

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.

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1 Planning (15 marks)

Defining the problem (3 marks)

P *r* is the independent variable, *B* is the dependent variable or vary *r* and measure *B*. [1]

P Keep the number of turns on the coil(s) constant. [1]
Do not accept same coil.

P Keep the current in the coil constant. [1]

Methods of data collection (5 marks)

M1 Diagram showing coil and labelled Hall probe positioned in the centre of a coil. Solenoids will not be credited. [1]

M2 Circuit diagram for coil connected to a (d.c.) power supply. [1]

M3 Connect Hall probe to voltmeter/c.r.o.
Allow galvanometer but do not allow ammeter. [1]

M4 Measure diameter or radius with a ruler/vernier callipers. [1]

M5 Method to locate centre of coil.
e.g. determine max V_H; cross rules; projection [1]

Method of analysis (2 marks)

A Plot a graph of *B* against 1/*r* [allow lg *B* against lg *r* or other valid graph] [1]

A Relationship is valid if the graph is a straight line passing through the origin
[if lg-lg then straight line with gradient = –1 (ignore reference to *y*-intercept)] [1]

Safety considerations (1 mark)

S Precaution linked to (large) heating of coil, e.g. switch off when not in use to avoid overheating coil; do not touch coil because it is hot. [1]

Additional detail (4 marks)

D Relevant points might include [4]

1 Use large current/large number of turns to create a large magnetic field.
2 Use of rheostat to keep current constant in coil.
3 Monitor constant current with ammeter to check current is constant.
4 Hall probe at right angles to direction of magnetic field/plane of coil.
5 Reasoned method to keep Hall probe in constant orientation (e.g. use of set square, fix to rule, optical bench or equivalent).
6 *B* is proportional to voltage across Hall probe/calibrate Hall probe in a known magnetic field.
7 Repeat experiment with Hall probe reversed and average.
8 Repeat measurement for *r* or *d* and average.

Do not allow vague computer methods.

[Total: 15]

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2 Analysis, conclusions and evaluation (15 marks)

<table>
<tr><th>Part</th><th>Mark</th><th>Expected Answer</th><th>Additional Guidance</th></tr>
<tr><td>(a)</td><td>A1</td><td>1.5 or 3/2</td><td>Ignore y-intercept (incorrect y-intercept will be penalised in (d)(i)).</td></tr>
<tr><td>(b)</td><td>T1
T2</td><td><table><tr><td>8.111 or 8.1106</td><td>4.38</td></tr><tr><td>8.258 or 8 2577</td><td>4.62</td></tr><tr><td>8.625 or 8.6253</td><td>5.188 (5.19)</td></tr><tr><td>8.827 or 8.8267</td><td>5.483 (5.48)</td></tr><tr><td>9.029 or 9.0294</td><td>5.771 (5.77)</td></tr><tr><td>9.274 or 9.2742</td><td>6.152 (6.15)</td></tr></table></td><td>Allow a mixture of decimal places.
T1 must be table values.
T2 must be a minimum of 2 d.p.
Ignore rounding errors.</td></tr>
<tr><td></td><td>U1</td><td>From $\pm$ 0.07 or $\pm$ 0.08, to $\pm$ 0.005</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.
Do not allow 'blobs' (more than half a small square).
Ecf allowed from table.</td></tr>
<tr><td></td><td>U2</td><td>Error bars in lg T plotted correctly</td><td>All error bars to be plotted. Must be accurate to less than half a small square.</td></tr>
<tr><td>(c) (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 (8.0, 4.20) and (8.0, 4.28) and upper end of line should pass between (9.4, 6.32) and (9.4, 6.38).
Allow ecf from points plotted incorrectly – examiner judgement.</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.
Examiner judgement on worst acceptable line. Lines must cross. Mark scored only if error bars are plotted.</td></tr>
<tr><td>(c) (iii)</td><td>C1</td><td>Gradient of best fit line</td><td>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.</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>
<tr><td>(c) (iv)</td><td>C2</td><td>Negative y-intercept</td><td>Must be negative. FOX does not score.
Check substitution into $y = mx + c$.
Allow ecf from (c)(iii).</td></tr>
<tr><td></td><td>U4</td><td>Uncertainty in y-intercept</td><td>Uses worst gradient and point on WAL.
Do not check calculation.
FOX does not score.</td></tr>
<tr><td>(d) (i)</td><td>C3</td><td>Method to determine k</td><td>$k = 10^{2 \times y\text{-intercept}}$ [k is about 10^{-16}, if FOX 10^{8}]</td></tr>
<tr><td></td><td>U5</td><td>Uncertainty in k</td><td>Best k – worst k using y-intercept.
Allow ecf for method from (c)(iv).</td></tr>
<tr><td>(d) (ii)</td><td>C4</td><td>M between 2.36×10^{26} and 2.36×10^{28} given to 2 or 3 s.f.</td><td>Must be in range. Allow between 2.4×10^{26} and 2.4×10^{28} for 2 s.f.</td></tr>
</table>

[Total: 15]

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Uncertainties in Question 2

(c) (iii) Gradient [E3]
Uncertainty = gradient of line of best fit – gradient of worst acceptable line
Uncertainty = ½ (steepest worst line gradient – shallowest worst line gradient)

(iv) [E4]
Uncertainty = *y*-intercept of line of best fit – *y*-intercept of worst acceptable line
Uncertainty = ½ (steepest worst line gradient – shallowest worst line gradient)

(d) (i) [E5]
Uncertainty = best k –worst k

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