As part of CIE’s continual commitment to maintaining best practice in assessment, CIE has begun to use different variants of some question papers for our most popular assessments with extremely large and widespread candidature. The question papers are closely related and the relationships between them have been thoroughly established using our assessment expertise. All versions of the paper give assessment of equal standard.

The content assessed by the examination papers and the type of questions are unchanged.

This change means that for this component there are now two variant Question Papers, Mark Schemes and Principal Examiner’s Reports where previously there was only one. For any individual country, it is intended that only one variant is used. This document contains both variants which will give all Centres access to even more past examination material than is usually the case.

The diagram shows the relationship between the Question Papers, Mark Schemes and Principal Examiner’s Reports.

<table>
<thead>
<tr>
<th>Question Paper</th>
<th>Mark Scheme</th>
<th>Principal Examiner’s Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>Introduction</td>
<td>Introduction</td>
</tr>
<tr>
<td>First variant Paper</td>
<td>First variant</td>
<td>First variant</td>
</tr>
<tr>
<td>Second variant Paper</td>
<td>Second variant</td>
<td>Second variant</td>
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</tbody>
</table>

Who can I contact for further information on these changes?
Please direct any questions about this to CIE’s Customer Services team at: international@cie.org.uk
UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2009 question paper
for the guidance of teachers

9702 PHYSICS
9702/21 Paper 2 (AS Structured Questions), maximum raw mark 60

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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- CIE will not enter into discussions or correspondence in connection with these mark schemes.

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<table>
<thead>
<tr>
<th>Question</th>
<th>Mark Scheme: Teachers’ version</th>
<th>Syllabus</th>
<th>Paper</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 (a)</strong></td>
<td></td>
<td>9702</td>
<td>21</td>
</tr>
<tr>
<td>(i)</td>
<td>micrometer (screw gauge) / travelling microscope</td>
<td>B1</td>
<td>[1]</td>
</tr>
</tbody>
</table>
| (ii) | *either* ohm-meter *or* voltmeter and ammeter  
*or* multimeter/avo on ohm setting | B1 | [1] |
| (iii) | *either* (calibrated) c.r.o. *or* a.c. voltmeter and $\times \sqrt{2}$ | B1 | [1] |
| (b) | density $= \frac{\text{mass}}{\text{volume}}$ | C1 | |
| | $= \frac{580}{6^3} = 2.685 \text{ g cm}^{-3}$  
*(allow 2.68, 2.69, 2.7)* | A1 | [5] |
| | % uncertainty in mass $= \frac{10}{580} \times 100 = 1.7\%$ | C1 | |
| | % uncertainty in volume $= 3 \times \left(\frac{0.1}{6}\right) \times 100 = 5.0\%$ | C1 | |
| | uncertainty in density $= 0.18 \text{ g cm}^{-3}$  
density $= 2.7 \pm 0.2 \text{ g cm}^{-3}$ | A1 | [5] |
| 2 (a) | ball moving in *opposite* direction (after collision) | B1 | [1] |
| (b) (i) | change in momentum $= 1.2 \left(4.0 + 0.8\right)$  
*(correct values, 1 mark; correct sign \{values added\}, 1 mark)*  
$= 5.76 \text{ N s}$  
*(allow 5.8)* | C2 | |
| | force $= \frac{\Delta p}{\Delta t}$ *or* $\frac{m\Delta v}{\Delta t}$ | C1 | [3] |
| | $= 5.76 / 0.08$ *or* $1.2 \times 4.8 / 0.08$ | C1 | |
| | $= 72 \text{ N}$ | A1 | [3] |
| (c) | $5.76 = 3.6 \times V$ | C1 | |
| | $V = 1.6 \text{ m s}^{-1}$ | A1 | [2] |
| (d) | *either* speed of approach $= 4.0 \text{ m s}^{-1}$ *and*  
speed of separation $= 2.4 \text{ m s}^{-1}$ | M1 | |
| | not equal and so inelastic | A1 | |
| or | kinetic energy before $= 9.6 \text{ J}$ *and*  
kinetic energy after collision $= 4.99 \text{ J}$ | M1 | |
| | kinetic energy after is less / not conserved so inelastic | A1 | [2] |
| 3 (a) | product of (magnitude of one) force and distance between forces | M1 | |
| | reference to *either* perpendicular distance between forces  
*or* line of action of forces and perpendicular distance | A1 | [2] |
| (b) (i) | $90^\circ$ | B1 | [1] |
| (ii) | $130 = F \times 0.45$ *(allow e.c.f. for angle in (i))* | C1 | |
| | $F = 290 \text{ N}$ | A1 | [2] |

*(allow 1 mark only if angle stated in (i) is not used in (ii))
<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>4 (a) (i)</td>
<td>change of shape / size / length / dimension</td>
<td>C1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>when (deforming) force is removed, returns to original shape / size</td>
<td>A1</td>
<td>[2]</td>
</tr>
<tr>
<td>(ii)</td>
<td>$L = ke$</td>
<td>B1</td>
<td>[1]</td>
</tr>
<tr>
<td>(b)</td>
<td>$2e$</td>
<td>B1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\frac{\lambda}{2k}$ (allow e.c.f. from extension)</td>
<td>B1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\frac{1}{2}e$ and $2k$</td>
<td>B1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\frac{3}{2}e$ (allow e.c.f. from extension in part 2)</td>
<td>B1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\frac{2}{3}k$ (allow e.c.f. from extension)</td>
<td>B1</td>
<td>[5]</td>
</tr>
<tr>
<td>5 (a)</td>
<td>either phase difference is $\pi$ rad / 180° or path difference (between waves from $S_1$ and $S_2$) is $\frac{\lambda}{2} / (n + \frac{1}{2})\lambda$</td>
<td>B1</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>either</em> same amplitude / intensity at M or <em>or</em> ratio of amplitudes is 1.28 / ratio of intensities is $1.28^2$</td>
<td>B1</td>
<td>[2]</td>
</tr>
<tr>
<td>(b)</td>
<td>path difference between waves from $S_1$ and $S_2 = 28$ cm</td>
<td>B1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>wavelength changes from 33 cm to 8.25 cm</td>
<td>B1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>minimum when $\lambda = (56$ cm,) $18.7$ cm, $11.2$ cm, $(8.0$ cm)</td>
<td>B1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>so two minima</td>
<td>B1</td>
<td>[4]</td>
</tr>
<tr>
<td>6 (a) (i)</td>
<td>$E = \frac{V}{d}$</td>
<td>C1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$= 350 / (2.5 \times 10^{-2})$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$= 1.4 \times 10^4$ N C$^{-1}$</td>
<td>A1</td>
<td>[2]</td>
</tr>
<tr>
<td>(ii)</td>
<td>force = $Eq$</td>
<td>C1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$= 1.4 \times 10^4 \times 1.6 \times 10^{-15}$</td>
<td>M1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$= 2.24 \times 10^{-15}$</td>
<td>A0</td>
<td>[2]</td>
</tr>
<tr>
<td>(b) (i)</td>
<td>$F = ma$</td>
<td>C1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$a = (2.24 \times 10^{-15}) / (9.1 \times 10^{-31})$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$= 2.46 \times 10^{15}$ m s$^{-2}$ (allow $2.5 \times 10^5$)</td>
<td>A1</td>
<td>[2]</td>
</tr>
<tr>
<td>(ii)</td>
<td>$s = \frac{1}{2}at^2$</td>
<td>C1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$2.5 \times 10^{-2} = \frac{1}{2} \times 2.46 \times 10^{15} \times t^2$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$t = 4.5 \times 10^9$ s</td>
<td>A1</td>
<td>[2]</td>
</tr>
<tr>
<td>(c)</td>
<td><em>either</em> gravitational force is normal to electric force or electric force horizontal, gravitational force vertical</td>
<td>B2</td>
<td>[2]</td>
</tr>
<tr>
<td></td>
<td><em>special case</em>: force/acceleration due to electric field &gt;&gt; force/acceleration due to gravitational field, allow 1 mark</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7 (a) (i) $R$ ........................................................................................................ B1 [1]
(ii) $0.5R$ ........................................................................................................ B1 [1]
(iii) $2.5R$ ...(allow e.c.f. from (ii)) .................................................................. B1 [1]

(b) (i) $I_1 + I_2 = I_3$ .................................................................................... B1 [1]
(ii) $E_2 = I_3R + I_2R$ .............................................................................. B1 [1]
(iii) $E_1 - E_2 = 2I_1R - I_2R$ ................................................................. B1 [1]

8 (a) rate of decay / activity / decay (of nucleus) is not affected by external factors / environment / surroundings ........................................................................................................ B2 [2]
(If states specific factor(s), rather than giving general statement above, then give 2 marks for two stated factors, but 1 mark only if one factor stated)

(b) (i) gamma / $\gamma$ .................................................................................... B1 [1]
(ii) alpha / $\alpha$ .......................................................................................... B1 [1]
(iii) gamma / $\gamma$ .................................................................................... B1 [1]
(iv) beta / $\beta$ .......................................................................................... B1 [1]
UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2009 question paper
for the guidance of teachers

9702 PHYSICS
9702/22 Paper 2 (AS Structured Questions), maximum raw mark 60

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Advanced Level and Advanced Subsidiary Level syllabuses and some Ordinary Level syllabuses.
1 (a) e.g. time (s), current (A), temperature (K), amount of substance (mol), luminous intensity (cdl)
   1 each, max 3 ................................................................. B3 [3]

(b) density = mass / volume ...................................................... C1

   unit of density: \( \text{kg m}^{-3} \) .............................................. C1

   unit of acceleration: \( \text{m s}^{-2} \) ......................................... C1

   unit of pressure: \( \text{kg m}^{-1} \text{s}^{-2} \) .................................. B1

   \( \text{kg m}^{-1} \text{s}^{-2} \) ....................................................... B1 [5]

\( (\text{allow 4/5 for solution in terms of only dimensions}) \)

2 (a) 2.4 s ............................................................................... A1 [1]

(b) in (b) and (c), allow answers as (+) or (–)

recogises distance travelled as area under graph line ................. C1

   height = \( \left( \frac{1}{2} \times 2.4 \times 9.0 \right) - \left( \frac{1}{2} \times 1.6 \times 6.0 \right) \) ............. C1

   = 6.0 m \( (\text{allow 6m}) \) .................................................. A1 [3]

\( (\text{answer 15.6 scores 2 marks}) \)

\( (\text{answer 10.8 or 4.8 scores 1 mark}) \)

\( (\text{alternative solution: } s = ut - \frac{1}{2} at^2) \)

\( = (9 \times 4) - \frac{1}{2} \times \left( \frac{9}{2.4} \right) \times 4^2 \)

\( = 6.0 \text{ m} \)

\( (\text{answer 66 scores 2 marks}) \)

\( (\text{answer 36 or 30 scores 1 mark}) \)

(c) (i) change in momentum = \( 0.78 (9.0 + 4.2) \) \( (\text{allow 4.2} \pm 0.2) \) .................. C1

   = 10.3 N s \( (\text{allow 10 N s}) \) ............................................. A1 [2]

(ii) force = \( \frac{\Delta p}{\Delta t} \) or \( \frac{m\Delta v}{\Delta t} \) ................................. C1

   = 10.3 / 3.5 / 0.08

   = 2.9 N .............................................................. A1 [2]

(d) (i) 2.9 N .............................................................................. A1 [1]

(ii) \( g = \frac{\text{weight}}{\text{mass}} \) ......................................................... C1

   = 2.9 / 0.78

   = 3.7 m s\(^{-2}\) ............................................................ A1 [2]

3 (a) product of \((\text{magnitude of one})\) force and distance between forces .............. M1

   reference to \textit{either} perpendicular distance between forces

   or line of action of forces \& perpendicular distance  .................. A1 [2]

(b) (i) 90° .............................................................................. B1 [1]

(ii) \( 130 = F \times 0.45 \) \( (\text{allow e.c.f. for angle in (i)}) \) ....................... C1

   \( F = 290 \text{N} \) .......................................................... A1 [2]

\( (\text{allow 1 mark only if angle stated in (i) is not used in (ii)}) \)
4 (a) (i) change of shape / size / length / dimension ................................. C1
when (deforming) force is removed, returns to original shape / size .......... A1 [2]

(ii) \( L = ke \) .......................................................... B1 [1]

(b) \( 2e \) .......................................................... B1
\( \frac{1}{2}k \) (allow e.c.f. from extension) ............................................. B1
\( \frac{1}{2}e \) and \( 2k \) .......................................................... B1
\( \frac{3}{2}e \) (allow e.c.f. from extension in part 2) .................................. B1
\( \frac{2}{3}k \) (allow e.c.f. from extension) ............................................. B1 [5]

5 (a) constant phase difference ......................................................... B1 [1]

(b) allow wavelength estimate 750 nm \( \rightarrow \) 550 nm .......................................................... C1
separation = \( \frac{\lambda D}{x} \) ...................................................... C1
\( = \frac{(650 \times 10^{-9} \times 2.4)}{(0.86 \times 10^{-3})} \)
\( = 1.8 \text{ mm} \) .................................................. A1 [3]
(allow 2 marks from inappropriate estimate if answer is in range 10 cm \( \rightarrow \) 0.1 mm)

(c) no longer complete destructive interference /
amplitudes no longer completely cancel ........................................ M1
so dark fringes are lighter ......................................................... A1 [2]

6 (a) (i) \( E = \frac{V}{d} \) .......................................................... C1
\( = 350 / (2.5 \times 10^{-2}) \)
\( = 1.4 \times 10^{4} \text{ N C}^{-1} \) .................................................. A1 [2]

(ii) force = \( Eq \) .......................................................... C1
\( = 1.4 \times 10^{4} \times 1.6 \times 10^{-19} \) ......................................... M1
\( = 2.24 \times 10^{-15} \) .................................................. A0 [2]

(b) (i) \( F = ma \) .......................................................... C1
\( a = \frac{(2.24 \times 10^{-15})}{(9.1 \times 10^{-31})} \)
\( = 2.46 \times 10^{15} \text{ m s}^{-2} \) (allow 2.5 \( \times \) 10\(^6\)) .................................. A1 [2]

(ii) \( s = \frac{1}{2}at^2 \) .......................................................... C1
\( 2.5 \times 10^{-2} = \frac{1}{2} \times 2.46 \times 10^{15} \times t^2 \)
\( t = 4.5 \times 10^{-9} \text{ s} \) .................................................. A1 [2]

(c) either gravitational force is normal to electric force
or electric force horizontal, gravitational force vertical ......................... B2 [2]
special case: force/acceleration due to electric field \( \gg \) force/acceleration
due to gravitational field, allow 1 mark
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<td>22</td>
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(a) \(\infty\)……………………………………………………………………………………………... A1
\(2R\) …………………………………………………………………………………………………. A1
\(R\) ………………………………………………………………………………………………… A1 [3]

(b) (i) \(I_1 + I_3 = I_2 + I_4\) …………………………………………………………………… A1 [1]
(ii) \(E_2 - E_1 = I_3R\) ……………………………………………………………………………. A1 [1]
(iii) \(E_2 = I_3R + 2I_4R\) ……………………………………………………………………….. A1 [1]

8 (a) rate of decay / activity / decay (of nucleus) is not affected by external factors / environment / surroundings B2 [2]
(If states specific factor(s), rather than giving general statement above, then give 2 marks for two stated factors, but 1 mark only if one factor stated)

(b) (i) gamma / \(\gamma\) ……………………………………………………………………………... B1 [1]
(ii) alpha / \(\alpha\) ………………………………………………………………………………… B1 [1]
(iii) gamma / \(\gamma\) ………………………………………………………………………………… B1 [1]
(iv) beta / \(\beta\) …………………………………………………………………………………... B1 [1]