# OCR
Oxford Cambridge and RSA

**GCE**

**Physics A**

Unit **H156/02:** Depth in physics

Advanced Subsidiary GCE

# Mark Scheme for June 2016

Oxford Cambridge and RSA Examinations

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Annotations

| Annotation | Meaning |
|---|---|
| BOD | Benefit of doubt given |
| CON | Contradiction |
| ✖ | Incorrect response |
| ECF | Error carried forward |
| L1 | Level 1 |
| L2 | Level 2 |
| L3 | Level 3 |
| TE | Transcription error |
| NBOD | Benefit of doubt not given |
| POT | Power of 10 error |
| ∧ | Omission mark |
| SF | Error in number of significant figures |
| ✔ | Correct response |
| ? | Wrong physics or equation |
| BP | Blank Page |

Abbreviations, annotations and conventions

| Annotation | Meaning |
|---|---|
| / | alternative and acceptable answers for the same marking point |
| **reject** | Answers which are not worthy of credit |
| **not** | Answers which are not worthy of credit |
| **Ignore** | Statements which are irrelevant |
| **Allow** | Answers that can be accepted |
| **( )** | Words which are not essential to gain credit |
| __ | Underlined words must be present in answer to score a mark |
| **ECF** | Error carried forward |
| **AW** | Alternative wording |
| **ORA** | Or reverse argument |

**CATEGORISATION OF MARKS**

The marking schemes categorise marks on the MACB scheme.

**B** marks:      These are awarded as <u>independent</u> marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

**M** marks:      These are <u>method</u> marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

**C** marks:      These are <u>compensatory</u> method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

**A** marks:      These are accuracy or <u>answer</u> marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

**Note about significant figures:**

If the data given in a question is to 2 sf, then allow to 2 or <u>more</u> significant figures.
If an answer is given to fewer than 2 sf, then penalise once only in the <u>entire</u> paper.
Any exception to this rule will be mentioned in the Guidance.
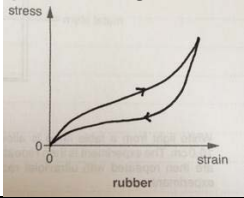
| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 1 | (a) | | Transverse: <u>vibrations /oscillations</u> are perpendicular / right angles to the direction of travel / energy transfer (AW)<br><br>Longitudinal: <u>vibrations /oscillations</u> are parallel to / in the same direction as the direction of travel / energy transfer (AW) | B1<br><br><br>B1 | **Allow** 1 mark for 'For one of the waves, the oscillations / vibrations are at right angles and for the other they are parallel to the direction of travel' (AW)<br>**Not** move for vibrations / oscillations<br>**Allow** 1 mark for transverse (waves) can be polarised ORA |
| | (b) | (i) | 40 (mV) | B1 | |
| | | (ii) | ($T =$) 3 x 0.5 = 1.5 (ms)<br><br>$f$ = 670 (Hz) | C1<br><br>A1 | **Note**: Answer to 3 SF is 667 (Hz)<br>**Note**: 0.67 or 0.667 scores 1 mark |
| | | (iii) | ($330 = 670 \times \lambda$)<br><br>$\lambda$ = 0.49 (m) | <br><br>B1 | **Possible** ECF from **(b)(ii)**<br>**Note**: $\lambda$ = 0.495 (m) if 667 Hz is used, therefore allow 0.50 or 0.5 (m) here |
| | (c) | | Amplitude / height (of trace / signal) is smaller<br><br>$I \propto A^2$ <u>and</u> amplitude (of sound or signal) is halved / amplitude is 2 div / amplitude is 20 (mV) | B1<br><br>B1 | <br><br>**Note** this will also score the first B1 mark |
| | | | **Total** | 8 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 2 | (a) | (i) | (When two or more waves meet at a point) the resultant <u>displacement</u> is equal to the sum of the <u>displacements</u> of the (individual) waves. | B1 | **Allow**: net / total for 'resultant' <br> **Not** amplitude |
| | | (ii) | There is a constant / fixed phase difference (between the waves) | B1 | **Allow** constant / fixed phase relationship <br> **Ignore** 'the frequency / wavelength is the same' <br> **Not** the same phase difference <br> **Not** zero phase difference |
| | (b) | | 1. $\lambda$ <br><br> 2. $\frac{3\lambda}{2}$ or $1.5\lambda$ | B1 <br><br> B1 | |
| | (c) | | $\lambda = \dfrac{ax}{D}$ stated <u>and</u> $D$ and $\lambda$ are constants. <br><br> Separation decreases (AW) | M1 <br><br><br> A1 | **Allow** $x \propto a^{-1}$ <br><br><br> **Allow** other correct answers, e.g. in terms of path difference and angles |
| | | | **Total** | 6 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 3 | (a) | (i) | $(t =) \dfrac{6.3}{9.8(1)}$<br><br>$(t =) 0.6(42….s)$ | M1<br><br><br>A0 | **Allow** other correct methods, e.g:<br><br>$(t) = \sqrt{\dfrac{2 \times 2.0}{9.8(1)}}$  or  $(t) = \dfrac{2 \times 2.0}{6.3}$<br><br>**Not** $a = 10$ m s$^{-2}$<br>**Note** $t$ must be the unknown |
| | | (ii) | $(v_H =) \dfrac{18}{0.64}$ or $\dfrac{18}{0.6}$<br><br>$(v_H =) 28$ (m s$^{-1}$) or 30 (m s$^{-1}$) | M1<br><br><br>A0 | **Note** $v$ must be the unknown |
| | | (iii) | $v = \sqrt{6.3^2 + 30^2}$<br><br><br>$v = 31$ (m s$^{-1}$) | C1<br><br><br>A1 | $v = \sqrt{6.3^2 + 28^2}$<br>**Allow** trigonometry methods<br><br>$v = 29$ (m s$^{-1}$)<br>**Note** 940 scores one mark |
| | (b) | (i) | $(E_k = \frac{1}{2}mv^2 = \frac{1}{2} \times 0.16 \times 30.7^2)$<br>$E_k = 75$ (J) | B1 | Possible ECF from **(a)(iii)** |
| | | (ii) | $(E_p = mgh = 0.16 \times 9.81 \times 2.0 =)$ 3.1 (J) | B1 | **Allow** $(E_k = \frac{1}{2}mv^2 = \frac{1}{2} \times 0.16 \times 6.3^2) = 3.2$(J) |
| | | (iii) | **(b)(i) − (b)(ii)** ; $(75 - 3.1)$  or  $(E_k = \frac{1}{2} \times 0.16 \times 30^2)$<br><br>kinetic energy =  72 (J) | <br><br>B1 | <br><br>Possible ECF from **(b)(i)** and **(b)(ii)**<br>**Note:** Answer is 63 (J) when 28 (m s$^{-1}$) is used from **(a)(ii)** |
| | (c) | | The path is always below the original path<br><br>The maximum height of path is reached before the front of the hockey goal | M1<br><br>A1 | |
| | | | **Total** | 9 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 4 | (a) | | (1 C =) (1) A s | C1 | **Allow** alternative methods |
| | | | (1 J = ) (1) $kg\,m\,s^{-2} \times m$    or    (1) N = (1) $kg\,m\,s^{-2}$ | C1 | |
| | | | $V = \dfrac{kg\,ms^{-2} \times m}{As} = \dfrac{kgm^2s^{-2}}{As}$ | M1 | **Note** this mark is for clear substitution and working |
| | | | $kg\,m^2A^{-1}s^{-3}$ | A0 | |
| | (b) | (i) | p.d. across 1.2 kΩ = 0.9 V | C1 | |
| | | | $\dfrac{R_{LDR}}{1200} = \dfrac{5.1}{0.9}$     or     determines current and $R = 5.1 / I$ | C1 | |
| | | | $R_{LDR}$ = 6800 (Ω) | A0 | **Allow**: 6.8 k(Ω) |
| | | | Or $5.1 = \dfrac{R}{R+1.2} \times 6.0$ | C1 | |
| | | | $0.9R = 6.12$     or     $0.15R = 1020$ | C1 | **Allow** $\dfrac{6.8}{6.8+1.2} \times 6.0 = 5.1$ for two marks |
| | | | $R_{LDR}$ = 6.8 (kΩ) | A0 | **Allow**: 6800(Ω) |
| | | (ii) | $(I = \dfrac{5.1}{6800} = \dfrac{6}{8000} = \dfrac{0.9}{1200})$ <br> current = $7.5 \times 10^{-4}$ (A) | B1 | |
| | (c) | | Resistance of LDR decreases / (total) resistance (of circuit) decreases (AW) | M1 | |
| | | | Current / ammeter reading increases (AW) | A1 | |
| | | | With increase in current the p.d. across (fixed) resistor / 1.2 kΩ resistor increases (AW) | B1 | **Allow** p.d. across resistor increases / p.d. across LDR decreases / resistor has greater share of p.d. / LDR has smaller share of p.d. |
| | | | (For fixed e.m.f.) <u>voltmeter</u> reading decreases (AW) | B1 | |
| | | | **Total** | 10 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| **5** | **(a)** | | $(V =) \dfrac{0.1}{5300}$ | **M1** | **Note** the mark is for substitution of values |
| | | | $1.89 \times 10^{-5}$ (m$^3$) | **A0** | |
| | **(b)** | **(i)** | To ensure whole cross-sectional area or end of the conducting putty is in contact with the metal plate (AW) | **B1** | **Not** good electrical contact / reduces contact resistance / surface area |
| | | **(ii)** | Use a (Vernier) caliper / micrometer (screw gauge) | **B1** | **Allow** ruler |
| | | | Repeat measurements <u>along</u> the conducting putty | **B1** | |
| | **(c)** | **(i)** | 6.6 | **B1** | **Allow** 6.56 <br> **Ignore** $10^{-3}$ factor |
| | | **(ii)** | $\left(\% \text{ uncertainty} = \dfrac{2 \times 0.001}{0.049} \times 100 =\right)$ 4.1 % | **B1** | **Ignore** significant figures <br> **Allow** 4 % |
| | **(d)** | **(i)** | Plots the missing point to less than a half small square | **B1** | **Allow** ECF from **(c)(i)** <br> Penalise blob of half a small square or larger |
| | | | Draws <u>straight</u> line of best fit | **B1** | **Allow** ECF <br> Expect to be balance of points about line of best-fit. Judge straightness by eye. <br> **Not** a top point to bottom point line / not a top point to (2.0, 10) line |
| | | **(ii)** | Gradient $= \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{\Delta y}{\Delta x}$ | **M1** | **Not** one R/L$^2$ value using the line or a data point <br> **Ignore** POT for M1 |
| | | | gradient = 5700 (5550 – 5850) | **A1** | **Allow** ± 150 for the value of gradient <br> **Ignore** units |
| | **(e)** | | $\rho = 5700 \times 1.9 \times 10^{-5}$ | **C1** | **Note**: ECF from **(d)(ii)** <br> **Allow** any subject for equation <br> **Not** use of data points from table |
| | | | $\rho = 0.108$ <u>given to 2 or 3 sf</u> | **A1** | |
| | | | $\Omega$ m | **B1** | |
| | | | **Total** | **13** | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 6 | (a) | | **Level 3 (5–6 marks)**<br>Clear procedure, measurements **and** analysis<br><br>*There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.*<br><br>**Level 2 (3–4 marks)**<br>Some procedure, some measurements and some analysis.<br><br>*There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.*<br><br>**Level 1 (1–2 marks)**<br>Limited procedure and limited measurements<br>**or** limited analysis<br><br>*The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.*<br><br>**0 marks**<br>No response or no response worthy of credit. | **B1**<br>**x6** | **Indicative scientific points may include:**<br><br>**Procedure**<br>• labelled diagram<br>• incremental increase in load / mass until wire breaks<br>• method of attaching wire at fixed end<br>• method of attaching load at other end<br>• use of safety screen / goggles to protect eyes<br>• method of securing retort stand<br><br>**Measurements**<br>• measurement of load / mass<br>• measurement of diameter<br>• use micrometer to measure diameter<br>• averages diameter<br>• repeats experiment<br><br>**Analysis**<br>• equation to determine force, e.g. $mg$<br>• equation to determine cross-sectional area or $A = \pi r^2$<br>• (breaking) stress = (max) force / cross-sectional area or $\sigma = \dfrac{F}{A}$ |
| | (b) | | Glass: A straight line from the origin.<br><br>Rubber: A correct sketch for loading and unloading sections, with the graph starting and finishing at the origin.<br><br> | **B1**<br><br>**B1** | **Ignore** arrows<br><br>**Allow** either arrows or labelled curves |
| | | | **Total** | **8** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 7 (a) | **Level 3 (5–6 marks)**<br>Clear explanation of observations **and** clear evidence of particulate nature of electromagnetic waves<br><br>*There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.*<br><br>**Level 2 (3–4 marks)**<br>Clear explanation of observations **or** clear evidence of particulate nature of electromagnetic waves **or** has limited explanation of observations and limited evidence of particulate nature of  EM radiation<br><br>*There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.*<br><br>**Level 1 (1–2 marks)**<br>Has limited explanation of observations **or** limited evidence of particulate nature of  EM radiation<br><br>*The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.*<br><br>**0 marks**<br>No response or no response worthy of credit. | B1 | **Indicative scientific points may include:**<br><br>**Explanation of Observations**<br>• Discharge due to the emission of electrons / negative charge<br>• Intensity depends on distance<br>• <u>Rate</u> of incident photons is more at smaller distances<br>• Greater intensity / rate of uv photons linked to quicker fall<br>• uv causes instantaneous discharge<br>• No effect with light<br>• Intensity of light has no effect on the discharge<br>• Natural discharge over a long period of time<br><br>**Evidence of particulate nature of em**<br>• Wave theory suggests leaf would fall with light<br>• Photon as packet of energy<br>• One to one interaction<br>• uv <u>photon</u> greater energy than work function/greater frequency than threshold frequency<br>• Light <u>photons</u> have less energy than the work function<br>• $E = hf$ / photon energy depends on frequency<br>• Energy of photon independent of intensity<br>• Energy conserved in interaction<br>• Einstein's equation (words or symbol) |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| **(b)** | | | $3.2 \times 1.6 \times 10^{-19}$    or    $6.63 \times 10^{-34} \times 960 \times 10^{12}$ | **C1** | |
| | | | $E_{k\ max} = 6.63 \times 10^{-34} \times 960 \times 10^{12} - 5.12 \times 10^{-19}$ | **C1** | |
| | | | $E_{k\ max} = 1.2 \times 10^{-19} (J)$ | **A1** | **Note** answer to 3 SF is $1.24 \times 10^{-19}$ (J) |
| | | | **Total** | **9** | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 8 | (a) | | (kinetic energy =) $1.6 \times 10^{-19} \times 300$ | C1 | |
| | | | $eV = \frac{1}{2}mv^2$ | C1 | |
| | | | $v = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 300}{9.11 \times 10^{-31}}}$ | C1 | **Note** $1.05 \times 10^{14}$ scores 2 marks; omitted square rooting |
| | | | speed = $1.03 \times 10^7$ (m s$^{-1}$) | A0 | |
| | (b) | | $\lambda = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 1.0 \times 10^7}$ | C1 | **Allow** ECF from **(a)** |
| | | | $\lambda = 7.3 \times 10^{-11}$ (m) | A1 | **Allow** 2 marks for $7.1 \times 10^{-11}$, $v = 1.03 \times 10^7$ used |
| | (c) | | Momentum / (kinetic) energy / speed (of electrons) increases / (de Broglie) wavelength decreases | B1 | |
| | | | Radius / diameter of rings decreases / pattern becomes 'smaller' (AW) or the rings are now brighter | B1 | |
| | | | **Total** | 7 | |

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