OCR
Oxford Cambridge and RSA

# GCE

# Physics A

Unit **H556/03:** Unified physics

Advanced GCE

# Mark Scheme for June 2018

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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.

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Annotations available in RM Assessor

| **Annotation** | | Meaning |
|---|---|---|
|  | Correct response | Used to indicate the point at which a mark has been awarded (one tick per mark awarded). |
|  | Incorrect response | Used to indicate an incorrect answer or a point where a mark is lost. |
| **AE** | Arithmetic error | Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors. |
| BOD | Benefit of doubt given | Used to indicate a mark awarded where the candidate provides an answer that is not totally satisfactory, but the examiner feels that sufficient work has been done. |
| **BP** | Blank page | Use BP on additional page(s) to show that there is no additional work provided by the candidates. |
| CON | Contradiction | No mark can be awarded if the candidate contradicts himself or herself in the same response. |
| ECF | Error carried forward | Used in numerical answers only, unless specified otherwise in the mark scheme. Answers to later sections of numerical questions may be awarded up to full credit provided they are consistent with earlier incorrect answers. Within a question, ECF can be given for AE, TE and POT errors but not for XP. |
| L1 | Level 1 | L1 is used to show 2 marks awarded and L1^ is used to show 1 mark awarded. |
| L2 | Level 2 | L2 is used to show 4 marks awarded and L2^ is used to show 3 marks awarded. |
| L3 | Level 3 | L3 is used to show 6 marks awarded and L3^ is used to show 5 marks awarded. |
| POT | Power of 10 error | This is usually linked to conversion of SI prefixes. Do not allow the mark where the error occurs. Then follow through the working/calculation giving ECF for subsequent marks if there are no further errors. |
| **SEEN** | Seen | To indicate working/text has been seen by the examiner. |
| SF | Error in number of significant figures | Where more SFs are given than is justified by the question, do not penalise. Fewer significant figures than necessary will be considered within the mark scheme. Penalised only once in the paper. |
| TE | Transcription error | This error is when there is incorrect transcription of the correct data from the question, graphical read-off, formulae booklet or a previous answer. Do not allow the relevant mark and then follow through the working giving ECF for subsequent marks. |
| XP | Wrong physics or equation | Used in numerical answers only, unless otherwise specified in the mark scheme. Use of an incorrect equation is wrong physics even if it happens to lead to the correct answer. |
| ^ | Omission | Used to indicate where more is needed for a mark to be awarded (what is written is not wrong but not enough). |

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific 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 |

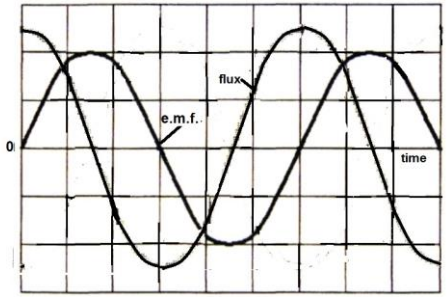
| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 1 | *(a) | | **Level 3 (5–6 marks)**<br>Clear description and analysis<br><br>*There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.*<br><br>**Level 2 (3–4 marks)**<br>Some description 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 description or analysis<br><br>*There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.*<br><br>**0 marks**<br>No response or no response worthy of credit. | B1 x 6 | **Indicative scientific points may include:**<br><br>**Description**<br>Determine $R_0$ using ice water mixture or*<br>Record $V$ and $I$ for various temperatures<br>If wire is not insulated some conduction through water/use insulated wire<br>Use small current to minimise heating effect or connect to supply for short time for readings<br>Stir the water<br>Wait for temperature to stabilise/bath to come to equilibrium<br>Avoid parallax errors when reading instruments<br>Comment about large scale increments on instruments/digital meters for precision of measurements/AW<br><br>**Analysis**<br>• Determine resistance from $R = V/I$<br>• Graph of $R$ against $\theta$ is a straight line / Graph of $R/R_0$ against $\theta$ is a straight line<br>• Correct interpretation of gradient $m$ to find $k$; i.e. $k = m/R_0$ or $k = m$<br>• $*R_0$ by extrapolation from linear graph<br><br>*descriptors D1 and A4 are alternatives |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| | (b) | (i) | $R = V^2/P$ or $P = V^2/R$<br><br>$R = 230^2/1000 = 52.9$ or 53(Ω) | C1<br><br>A1 | **or** $P = VI$ and $R = V/I$ with $I = 4.34$ (A)<br><br>This is a 'show that' question so the A1 mark is for giving both the full substitution of values and the final answer.<br>The final answer may be to 2 or more SF. |
| | | (ii) | number of turns, n = 180/1.5 (= 120)<br><br>length $(l = \pi dn)$ = 3.14 (or π) x 0.014 x120 = 5.28 (m) | C1<br><br>A1 | <br><br>This is a 'show that' question so the A1 mark is for giving both the full substitution of values and the final answer.<br>The final answer may be to 2 or more SF. |
| | | (iii) | $A = (\rho l/R) = 1.1 \times 10^{-6} \times 5.28/52.9$<br><br>$A = 0.11 \times 10^{-6}$ ($m^2$)<br><br>so swg = 28 | M1<br><br>A1<br><br>A1 | **allow** 53<br>**allow** solution which calculates diameter of wire using $\pi d^2/4$ rather than finding $A$<br>**give max** 1/3 for using data from the table, i.e. finding $R = 53$ Ω using correct value of $A$<br>**or** $d = 0.37$ (mm)<br><br>the A marks cannot be awarded unless the M mark is awarded. |
| | | | **Total** | **13** | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 2 | (a) | | $\omega = (2\pi f =) 2\pi \times 0.15$ or $0.3\pi$ (= 0.942 rad $s^{-1}$)<br>$a_{max} = (-\omega^2 A =) 4\pi^2 f^2 A = 0.050$<br>$A = 0.05/(2\pi \times 0.15)^2$<br>$A = 5.6 \times 10^{-2}$ (m) | **C1**<br><br>**C1**<br>**A1** | $\omega$ mark can be implicit in calculation<br><br>$\omega^2 = 0.88$ or 0.89 using 0.942 or 0.94<br>**allow** 0.057 (m); **N.B**. answer is 0.053 if use $\omega$ instead of $\omega^2$ mark as a TE **max** 2/3 |
| | (b) | | Maximum energy is transferred between tower (driver) and sphere<br><br>when sphere (driven) is at/close to the natural frequency of the tower<br>**or** in this forced oscillation/resonance situation | **B1**<br><br>**B1** | **allow** causes maximum damping of the tower **or** maximum amplitude of the sphere/AW<br><br>**allow** AW e.g. sphere must be driven close to/at the natural/resonance frequency of the tower |
| | (c) | (i) | $\omega^2 = k/m$ **or** $(2\pi f)^2 = k/m$ **or** $kA = ma_{max}$<br>$k = (m4\pi^2 f^2) = 6.6 \times 10^5 \times (2\pi \times 0.15)^2$<br><br>**or** $(k = ma_{max}/A) = 6.6 \times 10^5 \times 0.05/0.056$<br><br>$k = 5.9 \times 10^5$ (N $m^{-1}$) | **C1**<br>**M1**<br><br><br><br>**A1** | **allow** $\omega$ or $\omega^2 = 0.88$ or 0.89 quoted from **(a)**<br>**ecf** value of A from **(a)**<br>as this is a 'show that' question some definite evidence of working must be shown.<br><br>**not** $k = 6 \times 10^5$ **allow** answer to 2 or more SF. |
| | (c) | (ii) | $E = \frac{1}{2}kA^2 = = 0.5 \times 5.9 \times 10^5 \times 0.71^2$<br><br>$E = 1.5 \times 10^5$ (J) | **C1**<br><br>**A1** | **allow** value from (c)**(i)** or 6;<br>**or** $a = (k/m)A$ , $F = ma$, $E = \frac{1}{2}FA$<br>**accept** 1.48 to 1.51 or value from **ecf**<br>**special case:** give 1/2 for $E = 3(.0) \times 10^5$ (J) where **it is clear that** 2k has been used as the spring constant |
| | | | **Total** | **10** | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 3 | (a) | (i) | (For circular orbit) <u>centripetal</u> force provided by <u>gravitational</u> force (of attraction)<br><br>(Gravitational / centripetal) force is along line joining stars which must therefore be diameter of circle (AW) | M1<br><br>A1 | |
| | (a) | (ii) | $T = 20.5 \times 86400$ (= $1.77 \times 10^6$ s) **and** $R = 1.8 \times 10^{10}$ (m)<br><br>$m = 16 \times \pi^2 \times (1.8 \times 10^{10})^3 / G \times (20.5 \times 86400)^2$<br><br>giving $m = 4.4 \times 10^{30}$ so $m = 2.2\ M_\odot$ | C1<br><br>C1<br><br>A1 | values of T **and** R scores first mark; **both** incorrect 0/3<br><br>correct substitution allowing $\pi^2$ and G<br>$m = 16 \times 9.87 \times 1.8^3 \times 10^{30} / 6.67 \times 10^{-11} \times 1.8^2 \times 10^{12}$<br><br>using 2R gives $35.2 \times 10^{30} = 17.6\ M_\odot$ or using T = 1 day gives $1850 \times 10^{30} = 930\ M_\odot$ **award** 2/3 |
| | (a) | (iii) | $v = 2\pi R/T = 2 \times 3.14 \times 1.8 \times 10^{10} / 1.8 \times 10^6$ (giving $v = 6.3$ or $6.4 \times 10^4$ )<br><br>$\Delta\lambda = (v/c)\lambda = (6.3/3) \times 10^{-4} \times 656 = 0.14$ (nm) | C1<br><br>A1 | **do not** penalise repeated error for R or T<br><br>**ecf** for incorrect v, gives $\Delta\lambda = v \times 2.2 \times 10^{-6}$<br>$\Delta\lambda = 0.28$ for 2R; $\Delta\lambda = 2.9$ for 1 day and $\Delta\lambda = 5.7$ for both incorrect |
| | (b) | (i) | Two circles with centres at CoM with radii in ratio 4 :1<br>CoM at surface of larger star on line joining stars | B1 | **allow** diameter of m orbit through CoM as 44 ± 10 % for example; full reasonable circles required; ignore arrows; |
| | (b) | (ii) | Same period/(angular) frequency of stars<br><br>but longer path for smaller star/AW<br>**or** $v = 2\pi R/T$ **or** $v \propto R$ **or** stars stay at opposite ends of line through CoM | B1<br><br>B1 | any arguments using $F = mv^2/r$ score zero |
| | | | **Total** | 10 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 4 | (a) | | (change in) KE = (change in) GPE /AW | M1 | **allow** mgh = ½Mv$^2$ as long as it is clear that m and M are different, i.e. NOT mgh = ½mv$^2$<br>**allow** linear motion equation $v^2 = u^2 + 2as$ and $F = Ma$ |
| | | | ½($m$ + 0.8)$v^2$ = 0.6 $mg$ (and hence equation as shown on QP) | A1 | $(W =)\ mg = (m + 0.8)a$; $u = 0$ and $s = 0.6$ |
| | (b) | (i) | (v$^2$ =) 4.93 | B1 | **allow** 4.9 |
| | | | (±) 0.22 | B1 | (±) 0.2 (same number of decimal places) |
| | | (ii) | Point (and error bar) plotted correctly | B1 | tolerance ±½ small square; possible **ecf** from (b)**(i)** |
| | | | Line of best-fit drawn through all points shown (use protractor tool at 49$^o$) | B1 | **allow ecf** from point plotted incorrectly or point omitted |
| | (c) | (i) | $v^2 = \frac{1.20mg}{(m + 0.800)}$ compared with $y = mx + c$ | B1 | **allow minimum of** gradient = v$^2$/[m/(m +0.8)] = 1.2 g<br>**or expect** $y = v^2$ and $x = m/(m + 0.800)$ so gradient = 1.20$g$ |
| | | (ii) | one acceptable worst-fit line drawn | B1 | roughly between extremes of top and bottom error bars or by eye; consequential **ecfs** for rest of **(ii)** |
| | | | large triangle used to determine gradient | B1 | Δx > 0.13; |
| | | | Gradient (used to determine 'worst' $g$) | B1 | **expect** steepest 12.5 ± 0.2 or shallowest 10.3 ± 0.2<br>if point from **bii** not plotted steepest line is 12.9 |
| | | | absolute uncertainty given to **one decimal place** | B1 | answer from ± 0.8 to 1.1(m s$^{-2}$); **allow ecf** from gradient value |
| | (d) | | card appears shorter or time measured shorter<br>calculated speed of trolley larger<br>gradient of graph steeper **or** v$^2$ α g /AW<br>**so** calculated $g$ is greater | B1<br>B1<br>B1<br>B1 | **N.B.** each B mark is consequential on the previous statement; e.g. **ecf max** of 3 marks for correct consequences of stating card appears longer **or** time longer |
| | | | **Total** | 15 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 5 | (a) | (i) | the flux in the coil changes/ increases/ decreases/ varies (caused by the spinning/rotating magnet)<br><br>causing a sinusoidal/alternating e.m.f./AW | B1<br><br>B1 | **or** e.m.f. is proportional to /equals rate of change of flux linkage/linking the coil<br><br>**or qualification, e.g.** magnet vertical gives minimum flux through core or maximum rate of change of flux or vice versa with magnet horizontal<br><br>**or** maximum flux is when emf is zero **or** minimum flux is when emf is maximum **or** vice versa |
| | | (ii) |  | B1 | **allow** ± cos wave of correct period, constant amplitude at least one cycle<br>**N.B.** quality: curve must look like a reasonable sine wave as one is present on the page to copy |
| | | (iii) | $\varphi = BA = V/2\pi fN = 1.2/(2 \times \pi \times 24 \times 150)$<br><br>$\varphi = 5.3 \times 10^{-5}$<br><br>Wb / T $m^2$ | <br><br>B1<br><br>B1 | <br><br><br><br>**allow no other** unit combinations; NOT T $m^{-2}$ |
| | (b) | | **see page 9** | B1 x 6 | |
| | | | **Total** | 11 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 5 | | | **Level 3 (5–6 marks)**<br>Clear description, some measurements and full 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 description, 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 description and/or limited measurements and/or limited analysis<br><br>*There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.*<br><br>**0 marks**<br>No response or no response worthy of credit. | B1 x 6 | **Indicative scientific points may include:**<br><br>**Description**<br>**a.** Signal generator/a.c. supply connected to coil X<br>**b.** Coil Y connected to voltmeter / oscilloscope (can be on diagram)<br>**c.** Use oscilloscope to determine period / frequency or read off signal generator<br>**d.** Adjust signal generator / use of rheostat to keep current constant in coil X<br><br>**Measurements**<br>**1.** Vary *f* and measure *V*<br>**2.** Keep current in coil X constant<br>**3.** Detail on how to measure e.m.f. e.g. 'height x *y*-gain'<br>**4.** Detail on how to measure period on oscilloscope screen using time base and hence *f*<br><br>**Analysis**<br>**1.** Determine f from period measurement, f = 1/T<br>**2.** Plot a graph of *V* against *f*<br>**3.** Relationship valid if straight line through the origin |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 6 | (a) | (i) | sin $C$ = 1/$n$ = 1/1.69 (= 0.592)<br><br>$C$ = 36$^{o}$ | C1<br><br>A1 | |
| | | (ii) | Total internal reflection occurs<br><br>because the angle of incidence (at the surface) is greater than the critical angle/ 36$^{o}$ | B1<br><br>B1 | <br><br>**allow** because $i > C$ |
| | (b) | | $E$ = ($hc/\lambda$ =) 6.63 $\times$ 10$^{-34}$ $\times$ 3.0 x 10$^{8}$/450 $\times$ 10$^{-9}$<br><br>$E$ = 4.42 $\times$ 10$^{-19}$ (J)<br><br>energy = 2.76 (eV) | C1<br><br>C1<br><br>A1 | <br><br><br>**N.B.** the answer here must be 2 SF or more |
| | (c) | (i) | 2.76 – 2.3 = 0.46 eV (so only 0.5% of energy/AW) | B1 | **allow** 2.8 – 2.3 = 0.5 eV and 3.0 – 2.3 = 0.7 eV<br>possible **ecf** from **(b)** |
| | | (ii) | $n$ = 2000 $\times$ 4$^{9}$ (= 5.24 $\times$ 10$^{8}$)<br><br>$Q$ = $ne$ = 8.4 $\times$ 10$^{-11}$ (C)<br><br>$I$ = 8.4 $\times$ 10$^{-11}$ / 2.5 $\times$ 10$^{-9}$<br><br>average current = 0.034 (A) | C1<br><br>C1<br><br><br>A1 | **allow ecf** for wrong n<br><br><br><br>**allow** 34 m(A); answer is 1.7 x 10$^{-5}$ A if 2000 omitted (2/3) |
| | | | **Total** | 11 | |

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