# GCE

## Physics B (Advancing Physics)

Advanced Subsidiary GCE

Unit **G491:** Physics in Action

# Mark Scheme for January 2012

Any enquiries about publications should be addressed to:
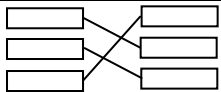
**Annotations available in SCORIS**

| Annotation | Meaning |
|---|---|
| BOD | Benefit of doubt given |
| CON | Contradiction |
| ✖ | Incorrect response |
| ECF | Error carried forward |
| FT | Follow through |
| NAQ | Not answered question |
| NBOD | Benefit of doubt not given |
| POT | Power of 10 error |
| ^ | Omission mark |
| RE | Rounding error |
| SF | Error in number of significant figures |
| ✔ | Correct response |
| AE | Arithmetic error |
| ？ | Wrong physics or equation |

**Subject-specific Marking Instructions**

**Annotations on the detailed mark scheme**

| Annotation | Meaning |
|---|---|
| / | alternative and acceptable answers for the same marking point |
| (1) | Separates marking points |
| 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) | | Pa   ;   S | 2 | do **not accept** any ≡ units not listed e.g.  N m$^{-2}$   ;   A V$^{-1}$ <br>**accept** PA |
| | (b) | | W   ;   V | 2 | do **not accept** any ≡ units not listed e.g.  J s$^{-1}$   ;   J C$^{-1}$ |
| **2** | (a) | | 3800 (Hz) | 1 | |
| | (b) | | 8000 (Hz) | 1 | **not** 7600 (Hz) |
| | (c) | | $2^7$  =  128  ( ≈ $V_{total}$ / $V_{noise}$ ) | 1 | **accept** log $_2$ (128) = 7 |
| | (d) | | 8000 x 7  =  56 x 10$^3$ (bit s$^{-1}$) | 1 | **allow** ecf on (b) x 7    e.g. 7600 x 7  =  53.2 x 10$^3$ (bit s$^{-1}$) |
| **3** | (a) | | less noise(s)  /  sharper  /  contrast  changed  / brightness changed  /  edges clearer | 1 | **ignore** smoother <br>**accept** more details are visible / darker  AW <br>**not** less pixelated |
| | (b) | | | 2 | **3** links correct scores  2/2 <br>**1 or 2** link(s) correct scores  1/2 <br>**CON** multiple connections from any box |
| **4** | (a) | | B  and E  ringed (or any clear consistent indication) | 2 | **one** mark for each correct  but each extra ring above 2 removes 1 mark |
| | (b) | (i) | $V = \varepsilon - I r$  /  = 3.0 – 0.45 x 0.38   ;   = 2.83 (V) | 2 | method ; evaluation **requires** 3$^{rd}$ S.F. because show that |
| | | (ii) | ( $R = V / I$  =  2.83 / 0.45 )  = 6.3 (Ω) | 1 | evaluation  ecf on voltage from (bi) if less than 3 V <br>**accept**  6.2(2) (Ω) on show that p.d. value of 2.8 V <br>**accept** potential divider calculation |
| **5** | (a) | | centre of **X** placed at lens focus or <u>vertically</u> aligned within marking tool | 1 | **accept** labelled point / line / arrow ending at focus ± 1 mm align marking tool to edge of last incoming wavefront |
| | (b) | | adds curvature (to the wavefronts arriving at lens) | 1 | **accept** zero curvature entering lens and positive curvature leaving lens <br>**accept** curves waves (if correct sense of curve is explicit) e.g. curves waves converging  /  curves to a focus <br>**not** adds negative curvature  /  just lens focuses / curves waves <br>**not** bends waves  /  any credit for refraction explained |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| **6** | | | $v = c / n$ / $\quad = 3 \times 10^8 / 2.4$ | 1 | method **accept** algebraic / numerical |
| | | | $= 1.25 \times 10^8$ (m s$^{-1}$) | 1 | evaluation **accept** $1.3 \times 10^8$ (m s$^{-1}$) **not** $1.2 \times 10^8$ (m s$^{-1}$) |
| **7** | (a) | | diameter | 1 | **accept** 0.25 ( ± 0.01) mm / $D$ |
| | (b) | | has largest % / largest relative uncertainty / has largest % of measurement standalone mark even if error in (a) | 1 | **not** has largest uncertainty / because diameter squared **accept** ± 4% estimate in diameter if calculated or ± 8% estimate in area if calculated or ± % uncertainty is doubled because D squared |
| | | | **Total** | 22 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 8 | (a) | | stiff / high YM ; so does not stretch (too far under stress) / tough / not brittle ; so does not break easily / cracks don't propagate / so does not snap easily | 2 | **only allow** stiff<u>ness</u> / YM / tough<u>ness</u> if qualified by explanation that needs large value<br>**explanation** must be linked to the property<br>**accept** compliant ; so flexible to bend around pulley<br>**accept** elastic ; returns to its original length when unstressed<br>**not** strong / hard / ductile / malleable / durable |
| | (b) | | method x-area = $F / \sigma$ / = $5.4 \times 10^4 / 1.1 \times 10^8$<br>evaluation = $4.9 \times 10^{-4}$ (m$^2$) | 1<br>1 | method **accept** algebra / numbers **not** just $\sigma = F / A$<br>evaluation **accept** $5 \times 10^{-4}$ m$^2$ / 4.9 cm$^2$ / 5 cm$^2$ |
| | (c) | (i) | method $\varepsilon = \sigma / E$ / = $1.1 \times 10^8 / 2.1 \times 10^{11}$<br>evaluation = 0.000<u>52</u>(4) ( ≈ 0.05 % ) | 1<br>1 | method **accept** algebra / numbers<br>evaluation needs 2 or more S.F. for show that<br>**ignore** attempts to convert to % |
| | | (ii) | method $x = \varepsilon \times L$ / = 0.00052 x 650<br>evaluation = 0.34 m | 1<br>1 | method **accept** algebra / numbers **not** just $\varepsilon = x / L$<br>If working from YM then must have $x = FL / AE$ for first mark<br>**accept** 0.32(5) m using show that strain 0.05%<br>**accept** ecf on strain from (ci) x 650<br>**max 1** for calculating with $\varepsilon$ % (POT) |
| | (d) | | for safety (margin) /<br>awareness of engineering safety limits /<br>avoid getting near to permanently changing length of the cable | 1 | **accept** to avoid getting near to plastic / permanent deformation in cable<br>**accept** to stay well below elastic limit<br>**accept** to allow for material / manufacturing defects<br>**accept** to allow for cyclic loading / fatigue / corrosion<br>**not** just elastic limit is yield point<br>**not** just so cable does not break / snap / crack / fail |
| | | | **Total** | 9 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 9 | (a) | (i) | Idea of (two) resistors in series / sharing the (total) p.d. (in proportion to their resistances) | 1 | AW **accept** algebraic versions e.g. $V_1 / V_2 = R_1 / R_2$ |
| | | (ii) | resistance ratio $R_{fixed} / R_{thermistor}$ changes | 1 | penalise any error of physics **max 1/3** e.g. p.d. through / current across / current remains constant when $R_{thermistor}$ changes |
| | | | (correct sense) ratio rises (so p.d. across $R_{fixed}$ rises) ORA | 1 | |
| | | | **OR** | | $V_{thermistor}$ falls so $V_{fixed}$ rises scores 1 for physics |
| | | | total $R$ less ; | | **not** any credit for repeating root of question |
| | | | so current increases through fixed resistor (and p.d. across it rises) | 1 | part explanation without physics errors and no more than 1 error in SPG for 3rd QoWC mark |
| | (b) | (i) | (sensitivity) decreases (as temperature rises) | 1 | |
| | | (ii) | gradient / $\Delta V / \Delta T$ / $\Delta y / \Delta x$ / $\Delta$output / $\Delta$input / change dependent / change independent variables | 1 | method **look at graph below answers** **accept** e.g. (3.7 -1.1) / 70 = (0.037) (V °C$^{-1}$) for **max 1** |
| | | | values e.g. 0.5 / 20 | 1 | **accept** values from graph / linear extrapolation of tangent at 70 °C / sensible small triangles drawn on graph around 70 °C **not** any further credit for $V / T$ calculations 0.053 (V °C$^{-1}$) |
| | | | evaluation = 0.025 (V °C$^{-1}$) | 1 | evaluation **accept** within range 0.021 to 0.029 (V °C$^{-1}$) |
| | | (iii) | from graph $V_{(\text{fixed at } 70°C)}$ = 3.7 V | 1 | standalone mark reading from graph **not** any tolerance but credit even if associated with thermistor |
| | | | method mark: any correctly substituted divider equation e.g. $R / 800 = 3.7 / 2.3$ OR $I = 2.3 / 800 = 2.9$ mA | 1 | method **allow** ecf on 3.6 to 3.8 V **accept** $3.7 / 6.0 = R / (R + 800)$ |
| | | | $R$ = 1300 / 1290 / 1287 (Ω) | 1 | evaluation **accept** other values in range 1275 to 1300 Ω for full credit (due to intermediate rounding); **accept** other values in outer range 1200 to 1400 Ω for **max 2** **not** any further credit for $R$ = 500 ± 10 (Ω) |
| | | | **Total** | 11 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 10 | (a) | (i) | ( $M = v / u$ = 0.055 / 10 ) = 0.0055 | 1 | evaluation **accept** 5.5 x 10$^{-3}$ **ignore** - ve signs |
| | | (ii) | $P$ OR 1/ $f$ = 1 / $v$ - 1 / $u$ / = 1 / 0.055 - 1 / (-10) | 1 | method **accept** clear statement of **approximation** $P \approx \frac{1}{v}$ / $f \approx v$ / $P \approx 1/ 0.055$ <br> **accept** calculation of $f$ = 0.0547 m for 1$^{st}$ mark |
| | | | = 18.3 (D) | 1 | evaluation accept 18.2 (D) **must** have 3 S.F. for show that **not** 18.1 (D) (from sign error) |
| | | (iii) | magnification x $D$ / using similar triangles<br>67 mm x 0.0055 | 1 | method **allow** ecf mag (ai) x D correctly evaluated for 2 marks<br>**accept** 67 mm / 182 (NB 1 / $M$ = 182 ) |
| | | | = 0.00037 m ( $\approx$ 0.4 mm ) | 1 | evaluation 0.37 / 0.3685 mm must have at least 2 S.F. for show that |
| | (b) | (i) | = 70 x 0.37 $\approx$ 26 / 25.9 (integer not necessary)<br>( = 70 x 0.4 = 28 ) using show that value | 1 | **accept** 70 x 0.3685 = 25.8<br>**accept** ecf for image size from (aiii) in mm x 70<br>**not** 4690 |
| | | (ii) | = 67 mm / 25.8 = 2.6 x 10$^{-3}$ (m)<br>( = 67 / 28 = 2.39 mm ) using show that value | 1 | **accept** 2.6 mm / 1 S.F. answers so 3 mm OR 2 mm<br>**accept** other methods 1/70 mm / 0.0055 OR 1/70 mm x 182 / similar triangles methods |
| | (c) | | = 0.085(2) m (based on $\pm$ 1 pixel on each image)<br>must have unit | 1 | **accept** 0.0826 m OR 0.083 m ( based on $\pm$ 1 pixel)<br>**accept** any answers in range 0.082 m to 0.086 m<br>**allow** ecf on (0.08 + bii ) OR (0.08 + 2 x bii) up to max value of 0.090 m |
| | | | bii is the resolution of ball's position (at 10 m from camera) / recognition that on CCD resolution is to nearest integer of pixels **standalone explanation** | 1 | **accept** AW and other sensible comments:<br>**accept** reasoning about whole numbers of pixels / about use of 1 or 2 pixels uncertainty in 2 images<br>**not** any credit for answers that imply a "perfect" measurement |
| | | | **Total** | 9 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| **11** | (a) | (i) | ( 25 / 12 ) = 2.08 (A) | 1 | 2.1 (A) to 2 S.F. **not** 2 (A) to 1 S.F. |
| | | (ii) | ( 2.08 / 12 ) = 0.17(3) (S) | 1 | 0.17 (S) to 2 S.F. **not** 0.2 (S)<br>**accept** 0.174 **/** 0.175 / 0.18 (S) from rounding<br>**accept** ecf on ai / 12 correctly evaluated |
| | (b) | | many / high density of ;<br>free / delocalised / unbound / gas / sea of / soup ;<br>electrons which act as ;<br><br>movement of <u>charge</u> carriers / transfer (negative) <u>charge</u> / carry charge | 1<br>1<br>1 | any 3 / 4 marking points in a well organised sentence for 3rd QWC mark<br>**ignore** lattice of positive ions<br><br>**accept** idea of flow of <u>charge</u> / idea of drift velocity of charge **must** mention charge in motion **not** just are charged |
| | (c) | (i) | there are no free charge carriers / electrons | 1 | **accept** electrons are localised in ionic/covalent bonds<br>**accept** not many / few / low density free electrons |
| | | (ii) | lamp runs hot / heating identified as a problem<br>ceramics don't melt in the lamp ORA for plastics<br>ceramics have a high(er) melting point (scores 2 heating implicit) | 1<br>1 | **accept** plausible thermal properties explained e.g. ceramics have a small(er) thermal expansion so pins do not loosen / ceramics better / good thermal conductors so do not overheat for **2 marks** (running hot is implicit)<br>**not** heat resistance / temperature resistance for 2nd mark |
| | | (iii) | plastics are tough(er) / not brittle / less brittle (than ceramics) | 1 | **accept** AW less likely to break under impacts<br>**ignore** safer because plastic is electrical insulator / cheaper / easier to manufacture / easy to mould / durable |
| | | | **Total** | 9 | |

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