Oxford Cambridge and RSA

# GCE

# Physics B

## H157/02: Physics in depth

Advanced Subsidiary GCE

# 2021 Mark Scheme (DRAFT)

This is a DRAFT mark scheme. It has not been used for marking as this paper did not receive any entries in the series it was scheduled for. It is therefore possible that not all valid approaches to a question may be captured in this version. You should give credit to such responses when marking learner's work.

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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.

1. 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 |

2. 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 |
|---|---|---|---|
| **Section A** | | | |
| **1 (a)** | Mean of remaining data = 0.278 mm ✓<br>Range of remaining data = 0.29 – 0.26 mm = 0.03 mm<br>Uncertainty (Spread) = ½ range = 0.015 mm ✓<br>Sig figs: Round uncertainty to 1 s.f., i.e. 0.01 or 0.02 mm ✓<br>Express mean to same number of d.p. as uncertainty ✓ | **4** | ECF own uncertainty |
| **(b)** | 0.34 mm is > 2× uncertainty from mean of remaining data ✓<br>Any reasonable suggestion for anomaly ✓ | **2** | Allow 'well away from all remaining readings' OWTTE<br>e.g. micrometer not perpendicular to wire |
| | **Total** | **6** | |
| **2 (a)** | Same current enters the electrolytic cell as leaves it ✓<br>Which requires each electrode to receive the same charge in the same time ✓ | **2** | |
| **(b)** | Arrow on 2+ to right and arrow on 1- to left AND Opposite charges attract ✓<br>Arrow on 2+ half the size of arrow on 1- ✓<br>Because same charge received per second requires twice as many 1- as 2+, so they move faster/twice as fast✓ | **3** | Can explain directions in terms of current produced by battery |
| | **Total** | **5** | |
| **3 (a)** | (Starts stiff and) gets easier to pull going O to A ✓<br>Gets harder to pull as you approach B ✓ | **2** | |
| **(b)** | Less work done by band (on the stretching agent) in the BCO ✓<br>Internal energy of band has increased/band is hotter ✓ | **2** | Credit A-level treatment but not expected here |
| | **Total** | **4** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 4 | Converts $\sigma$ to $\rho$ or $R$ to $G$ ✓<br>Correct values substituted into the relevant equation ✓<br>$A = 1.9(3) \times 10^{-7}$ ($m^2$) ✓ | 3 | $\rho = 1.06 \times 10^{-6}$ m, $G = 0.0378$ S<br>m.p.2 may subsume m.p.1 |
| | **Total** | **3** | |
| 5 (a) | $E = 3.31 \times 10^{-18}$ J - $2.99 \times 10^{-18}$ J = $3.2 \times 10^{-19}$ J<br>$P = 3.4 \times 10^{17}$ $s^{-1}$ × $3.2 \times 10^{-19}$ J = 0.109 W ✓ | 1 | |
| (b) | $f = E/h$ = 3.2×10 $^{-19}$ J/ 6.63×10 $^{-34}$ J $s^{-1}$ = 4.83×10 $^{14}$ Hz✓<br>$\lambda = c/f$ = 3.00×10 $^{8}$ m $s^{-1}$/4.83×10 $^{14}$ Hz = 6.22×10 $^{-7}$ m✓ | 2 | e.c.f own E value from (a)<br>Or: recall $E = hc/\lambda$ ✓ and evaluation ✓<br>Allow 2 or 3 s.f. |
| (c) | for each photon, $\Delta mv = h/\lambda$ = 6.63×10 $^{-34}$ J $s^{-1}$/6.22×10 $^{-7}$ m<br>= 1.06(7)×10 $^{-27}$ N s ✓<br>$F$ = 3.4 × 10 $^{17}$ $s^{-1}$ ×1.06(7)×10 $^{-27}$ N s = 3.62(7) ×10 $^{-10}$ N ✓ | 2 | |
| | **Total** | **5** | |
| | **Section A total** | **23** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| **Section B** | | | |
| **6 (a) (i)** | Resultant force $F = ma$ = 14 700 kg × 2.1 m s$^{-2}$ = 30870 N✓<br>Weight $W$ of lem = $mg$ = 14 700 kg × 1.62 N kg$^{-1}$ = 23814 N ✓<br>$F$ = thrust – $W$ so thrust = 30870 N + 23814 N = 54685 N ✓ | **3** | Comparison with 55 kN can be assumed |
| **(a) (ii)** | $s = ½ a t^2$ so 10 m = ½ × 2.1 m s$^{-2}$ × $t^2$ ✓<br>$t = \sqrt{(2s/a)} = \sqrt{(2\times10\text{ m}/2.1\text{ m s}^{-2})}$ = 3.086 s = 3.1 s ✓ | **2** | Choice of equation and substitution of values<br>Rearrangement and evaluation |
| **(a) (iii)** | $a$ = force per kg/1 kg = 54685 m s$^{-2}$ ✓<br>$\Delta t$ for 1 kg to leave rocket = 1/15 s<br>$v = a\Delta t$ = 54685 m s$^{-2}$ × 1/15 s = 3645.7 m s$^{-1}$ = 3650 m s$^{-1}$ ✓ | **2** | Use of $F=\Delta p/\Delta t$ is OK, but not AS |
| **(b)** | magnitude of displacement = $\sqrt{\{(300)^2 + (18)^2\}}$ km = 301 km ✓<br>mean speed = 301 000 m/440 s = 684 m s$^{-1}$ ✓ | **2** | Or vertical displacement is negligible, so displacement= 300 km<br>300 km gives 682 m s$^{-1}$ |
| **(c) (i)** | 8.0<br>12.0 ✓ | **1** | Both needed for the mark |
| **(c) (ii)** | 2.2(2)<br>2.5(0)<br>2.8(6)/2.9 ✓ | **1** | All three needed for the mark<br><Ignore sig figs for the third one?> |
| **(c) (iii)** | 8.4 ✓<br>13.4 ✓ | **2** | Ecf from (ii) |
| **(c) (iv)** | $m\downarrow \Rightarrow a\uparrow$✓<br>$v$ increases more rapidly/ $\Delta v$ will get increasingly larger ✓ | **2** | |
| | **Total** | **15** | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 7 | (a) | | One point from each category and any one other<br>*General*:<br>Lead-acid batteries much heavier than Li-ion for same energy/ Li-ion has much more energy per kg than lead-acid ✓<br>By a factor of 260/37 = 7 ✓<br>Total energy stored in Li-ion example is roughly double that in the lead-acid ✓<br>*Li-ion for car*:<br>Less massive car has greater acceleration (for same force) ✓<br>Requires less energy to go uphill ✓<br>Is more manoeuvrable ✓<br>*Lead-acid for fork-lift*:<br>Heavy, low battery makes the truck less likely to tip ✓<br>Truck needs to move slowly, so acceleration not an issue ✓<br>Doesn't need to go uphill ✓ | 4 | |
| | (b) | (i) | Energy stored = 275 kg × 940kJ $kg^{-1}$ = 2.585 × $10^8$ J ✓ | 1 | |
| | | (ii) | p.d. across motor = 350 V – (230 A x 0.030 Ω) = 343.1 V ✓<br>resistance of motor = 343.1V/ 230 A = 1.49 Ω✓ | 2 | NB if internal resistance ignored, V/I = 1.52Ω<br>$P/I^2$ = 1.51Ω |
| | | (iii) | $t$ = 200 km/80 km $h^{-1}$ = 2.5 h = 9000 s✓<br>$P = E/t$ = 2.574 × $10^8$ J/9000 s = 28600 W (which is about ⅓ of 80 kW) ✓ | 2 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 7 | (c)* | | **(Level 3) (5 – 6 marks)**<br>Compares performance of the two cars, both in terms of direct quotation of the data and in calculations of acceleration/force/energy. Uses the comparisons to produce a reasoned choice of the better family car.<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>Compares performance of the two cars in terms of direct quotation of the data and makes attempts, possibly unsuccessful, to calculate at least one of acceleration, force andenergy. Uses the comparisons to produce a reasoned choice of the better family car.<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>Compares the two cars in terms of direct quotation of the data and in calculations of acceleration/force/energy. Makes limited or no reference to desirable features of a family car.<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. | **[6]** | **Indicative scientific points may include:**<br><br>**Simple comparison of the data**<br>• Range for A is double that for B<br><br>**Calculations for the two cars**<br>• Acceleration of A = 2.44 m $s^{-2}$<br>• Due to resultant force 3.6 kN<br>• Acceleration of B = 1.75 m $s^{-2}$<br>• Due to resultant force 3.6 kN<br>• A runs at full power for 0.625 h = 38 minutes<br>• B runs at full power for 0.340 h = 20 minutes<br><br>**Desirable features for a family car**<br>• Needs to go a reasonable distance and back without charging<br>• Need to hold a typical family<br>• Should have good acceleration (to avoid accidents)<br><br>**Use the L1, L2, L3 annotations in Scoris; do not use ticks.** |
| | | | **Total** | **15** | |
| | | | **Section B total** | **30** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| **Section C** | | | |
| **8 (a)*** | **(Level 3) (5 – 6 marks)**<br>A detailed procedure described in such a way that an experimenter could use it to perform the experiment. Range of frequencies to be used is well reasoned. General procedural details related to reproducibility and accuracy are well described.<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>Main points of the procedure, how to vary and measure *L*, are covered but may lack detail. Range of frequencies to be used may be missing or not clear.<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>Incomplete or superficial description of the procedure which could probably not be done adequately by someone with no prior experience of the experiment. Suitable frequency range to use may be absent.<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. | **[6]** | **Indicative scientific points may include:**<br><br>**Preparatory calculations/estimates**<br>• Wavelengths produced by sig. gen. are in the range 1.7 mm to 34 m<br>• Max wavelength used = 4 × 35 cm = 1.4 m<br>• Corresponding to minimum frequency = 242 Hz<br>• Smallest reasonably measurable *L* is about 1 cm<br>• Corresponding to $f$ = 340 m s$^{-1}$/0.04 m ≈ 8.5 kHz<br><br>**General procedural details**<br>• Make repeated readings to get at least 3 readings for each *f*<br>• e.g. by going up and then down in regular intervals of *f*<br>• Check data for outliers and repeat as necessary<br>• Find mean *L* and $\Delta L$ for each set at a particular *f*<br>• Pay attention to safety<br>• e.g. avoid tipping hazard of trailing cables<br>• Have preliminary run to confirm feasibility<br><br>**Details related to the resonance experiment**<br>• Ruler clamped/ fastened next to the clamped tube<br>• Specified method of supporting outer cylinder securely or getting an second observer to read resonance position<br><br>**Use the L1, L2, L3 annotations in Scoris; do not use ticks.** |

| | | | | |
|---|---|---|---|---|
| **8** | **(b)** | $\lambda = 4L_1 + 4C$ ✓<br><br>$v = f\lambda \Rightarrow 1/f = \lambda/v$ ✓<br><br>$1/f = 4L_1/v + 4C/v$ + relating to $y=mx+c$ ✓ | **3** | |
| | **(c) (i)** | Higher f resonances less easy to determine ✓<br>Due to less variation in sound intensity ✓ | **2** | Allow any reasonable suggestion |
| | **(c) (ii)** | Variation in *f* small compared with variation in *L*/ signal generator sets f reliably precisely ✓ | **1** | |
| | **(c) (iii)** | *800* \| *0.0012 5*<br>*900* \| *0.0011 1*<br>**AND**<br>both points correctly plotted ✓ | **1** | Sig figs must be same as other 1/*f* data |
| | **(c) (iv)** | Reasonable best-fit line and one extreme passible line ✓<br><br>At least one correct gradient calculation with triangle base at least 0.1 m ✓<br><br>$v$ = 350 m s$^{-1}$ ✓<br>$\Delta v$ = 40 m s$^{-1}$ ✓ | **4** | e.c.f. own lines |
| | | **Section C Total** | **17** | |

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