

GCE

Physics B

Unit **H157/01**: Foundations of physics

Advanced Subsidiary GCE

Mark Scheme for June 2018

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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

Annotation	Meaning
DO NOT ALLOW	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

Section A: MCQs

Question			Answer	Marks	Guidance
1			C	1	
2			A	1	
3			B	1	
4			C	1	
5			A	1	
6			B	1	
7			A	1	
8			B	1	
9			D	1	
10			D	1	
11			B	1	
12			D	1	
13			A	1	
14			D	1	
15			C	1	
16			A	1	
17			C	1	
18			B	1	
19			C	1	
20			A	1	
			Total	20	

Section B

Question		Answer	Marks	Guidance
21	(a)	$n = (\sin i / \sin r) / \sin 60^\circ / \sin 41^\circ$ ✓	1	Method.
		= 1.32 ✓	1	Evaluation. Expect 3sf. Allow 1.3 ONLY if $\sin 60^\circ / \sin 41^\circ$ is seen. Bare answer only scores 1/2. Condone transfer error leading to correct conclusion e.g. $\sin 60^\circ / \sin 40^\circ = 1.35$ for 1/2.
21	(b)	is refracted more / bent a little further / moves more towards the normal / angle r (slightly) $< 41^\circ$ ✓	1	Allow calculation giving new angle $r = 40.(3)^\circ$. Allow ecf with statement on correctly calculated angle from (a) for both marks.
		(violet light) slows down on entering water (more than orange light) ✓	1	
Total			4	

Question		Answer	Marks	Guidance
22		magnitude = $(24^2 + 24^2)^{1/2} / 1152^{1/2}$ ✓	1	Method
		= 34 (m) ✓	1	Evaluation. Allow 33.9 (m)
		direction = N 45° E / bearing $45^\circ / 045^\circ / 45^\circ$ ✓	1	Allow NE / North East.
Total			3	

Question		Answer	Marks	Guidance
23	(a)		✓ 1	<p>Δ diagram must be carefully completed to scale with directions of components clear and that they sum to W</p> <p>If Δ is drawn off W vector it must match to scale and alignment to score</p> <p>allow labelled right angles that are slightly out by eye</p>
23	(b)	$= 600 \sin 50^\circ$ $= 460 \text{ (N)}$	✓ 1 ✓ 1	<p>allow $600 \cos 40^\circ$</p> <p>allow $= -460 \text{ (N)}$. Allow 1/2 for incorrect component, leading to 386(N) i.e. $600 \sin 40^\circ$ or $600 \cos 50^\circ$</p>
		Total	3	

Question		Answer	Marks	Guidance
24	(a)	$(11\,500 \times 2) = 23\,000 \text{ (Hz)}$	✓ 1	<p>Evaluation. Allow 23 kHz if unit altered. Do not allow 23 000 calculated from $(2 \times (11500 - 200))$</p>
24	(b)	$n = \log 3000 / \log 2 \quad / \quad = 11.6 \text{ bits}$ $= 12 \text{ (bits)}$	✓ 1 ✓ 1	<p>or $\log_2(3000)$. Allow 11.5 bits</p> <p>allow $2^{11} = 2048$ and $2^{12} = 4096$ leading to 12 for 2/2 Bald correct answer (12) gains both marks. Note: It could be argued that 11 is the correct answer as it avoids redundancy. Do not allow 11 unless this is made clear by the candidate.</p>
		Total	3	

Question		Answer	Marks	Guidance
25	(a)	dislocation ✓	1	allow edge dislocation / extra half plane/extra line of atoms
25	(b)	$(10/0.06) = 167$ / $(10/0.07) = 143$ ✓	1	Correct responses in range 140 to 170 allow inverse response ($0.06/10 = 0.006$ or $0.07/10 = 0.007$)
		Total	2	

Question		Answer	Marks	Guidance
26	(a)	<p>Idea that Newton's Third Law applies to pairs of forces acting on different bodies / that the pairs of forces are of the same type. ✓</p> <p>(W,L) – although these forces are equal and opposite, they both act on the aircraft / one is a gravitational force, the other is a force due to the effect of airflow over the wings. ✓</p> <p>OR</p> <p>(T,D) - although these forces are equal and opposite, they both act on the aircraft / one is a force due to the effect of airflow over the aircraft body, the other is due to the push of the exhaust gases.</p>	<p>1</p> <p>1</p>	<p>General statement of how/where Newton's Third Law applies.</p> <p>Explanation of why Newton's Third Law does not apply in this case using a pair of forces.</p> <p>Also acceptable to identify the correct N3 reaction force to each force in one of the pairs (T,D), (W,L),</p> <p>e.g. reaction to T is backwards force on the jet exhaust gases / reaction to D is forwards force on the air from the plane / reaction to W is upwards force on the Earth / reaction to L is downwards force on the air from the plane</p> <p>Alternative solution: 1st mark: Appreciation that a stated pair are not always equal: e.g. L and W / T and D are not always equal 2nd mark: Consequence or explanation of them being different: e.g. L could be bigger than W or the aircraft would not rise / T could be bigger than D or the aircraft could not accelerate / D could be larger than T or the aircraft would not slow.</p>
26	(b)	<p>The aircraft slows / decelerates / v reduces ✓</p> <p>as there is an unbalanced / resultant force acting in the direction against the motion. ✓</p> <p>OR</p> <p>The vertical height decreases / aircraft falls (✓)</p> <p>as (reduced v will cause a reduced L and so) a resultant downwards force (✓)</p>	<p>1</p> <p>1</p>	<p>No need to specifically refer to Newton's Second Law, but either response must have the idea of an unbalanced or resultant force and its direction. Allow ideas such as forwards force is zero and backwards force is still the same so it decelerates, or upward force falls and downward force remains the same so it falls.</p> <p>Bald statement of Newton's second law (resultant force cause acceleration) can score 1/2.</p> <p>No credit for simple $F=ma$.</p>

Question		Answer	Marks	Guidance
26	(c)	$a (= F/m = 1.2 \times 10^6 / 4 \times 10^5) = (-) 3.0 \text{ (m s}^{-2}\text{)}$ ✓	1	evaluation ignore - sign
		Total Total section B	5 20	

Section C

Question			Answer	Marks	Guidance
27	(a)	(i)	$(5.8 \times 10^6 / (1024 \times 711)) = 8$ ✓	1	Evaluation. Must be integer (i.e. not 7.9(7)) but condone 8.0. If candidate has used (5.8×1024^2) for bits, allow 8 or 9.
27	(a)	(ii)	$(t = \text{info} / \text{rate} = 5.8 \times 10^6 / 110 \times 10^3) = 53 \text{ (s)}$ ✓	1	Allow 52.7 (s). Allow $(5.8 \times 1024^2) / 110 \times 1024 = 54 \text{ (s)}$. But MUST use 1024 in both info and rate.
27	(b)	(i)	Determination of R in pixels by ratio (approx. 735 pixel) ✓	1	e.g. radius = 5.0 cm, using width 1024 pix = 7.0cm, $R = 5/7 \times 1024 = 731$ pixel using height 711 pix = 4.8cm, $R = 5/4.8 \times 711 = 740$ pixel
			Determination of R in length units (approx. 243 km) ✓	1	e.g. $735 \times 330 = 243000 \text{ (m)}$. Ignore units at this stage.
			$D = 2 R$ evaluated (approx. 485 km) ✓	1	Unit must be present in final answer, unless clear comparison made. i.e. $485 < 500$. Expect answers in range 482 to 488 km but allow answers slightly outside of this range by rounding. Alternative responses: if 711 is used for the pixel length of the radius, leading to 469 km, max 2/3 (2 nd and 3 rd mark). Methods leading to $100\text{km} < D < 500\text{km}$ using incorrect scaling, max 2/3. (2 nd and 3 rd mark). Methods leading to $> 500\text{km}$ using incorrect scaling, max 1/3. (3 rd mark) Methods using small differences in measurements (e.g. radius = 4.9 or 5.1cm radius, width = 6.9 or 7.1cm, height = 4.7 or 4.9cm) leading to correct answers can gain full credit. Alternative method: Using Pythagoras 1 st mark: width of photograph = $1024 \times 300 = 337920\text{m}$ 2 nd mark: radius = $337920/2^{1/2} = 238946\text{m}$ 3 rd mark: diameter = $2 \times R = 478 \text{ km}$

Question			Answer	Marks	Guidance
27	(b)	(ii)	<p>use of similar Δ's leading to Δ at moon is similar to Δ on camera ✓</p> <p>distance to moon / width of moon similar to focal length of camera / width of camera</p> <p>OR $f = W_{\text{CCD}} \times D / (\text{no. of pixels} \times \text{res.})$</p> <p>OR $f = (1024 \times 5 \times 10^{-6} \text{ m}) \times (6 \times 10^6 \text{ m}) / (1024 \times 330 \text{ m})$</p> <p>= 0.091 (m) ✓</p>	<p>1</p> <p>1</p>	<p>Method allow equal angles argument $\text{arc} = R \theta$</p> <p>evaluation allow 0.0909 m</p>
			Total	7	

Question			Answer	Marks	Guidance
28	(a)	(i)	$(3.0 / 12) = 0.25 \text{ (MN m}^{-1}\text{)}$ ✓	1	Any pair of values from the graph leading to correct answer.
28	(a)	(ii)	$E = FL / Ax = (F/x) L / A = kL / A$ ✓ leading to $k = EA/L$	1	expect to see: $E = FL/Ax$ in any arrangement (except for F/x as subject) and substitution and/or cancellation leading to correct equation. But not simply $F/x = EA/L$ so $k = EA/L$ Allow routes from stress and strain formula that give the correct equation. Allow reverse argument
28	(a)	(iii)	$L = EA / k$ / $2.1 \times 10^{11} \times 1.0 \times 10^{-3} / 0.25 \times 10^6$ ✓ $= 840 \text{ (m)}$ ✓	1 1	method: rearrangement in algebra / numbers evaluation ecf on k from (a)(i). POT error loses one.
28	(b)	(i)	$\frac{1}{2} \times 3 \times 10^6 \times 12 = 18 \times 10^6 \text{ (J)}$ ✓ or $\frac{1}{2} \times 3 \times 12 = 18 \text{ (MJ)}$	1	Evaluation Allow use of $\frac{1}{2} k x^2$. ($\frac{1}{2} \times 0.25 \times 12^2$) leading to 18 (MJ) Ecf on (a)(i). Condone missing unit, but penalise incorrect unit.
28	(b)	(ii)	$\frac{1}{2} m v^2 = (\frac{1}{2} (\rho A L) v^2) = 18 \text{ MJ}$ ✓ $v^2 = 2 \times 18 \times 10^6 / (7900 \times 1 \times 10^{-3} \times 840)$ ✓ or $v = [36 \times 10^6 / (7900 \times 1 \times 10^{-3} \times 840)]^{1/2}$ $= 74 \text{ (m s}^{-1}\text{)}$ ✓	1 1 1	reasoning of energy conservation allow $E_{\text{kinetic}} = E_{\text{elastic (potential)}}$ ecf elastic potential in (b)(i) rearrangement and substitution ecf on L in (a)(iii) evaluation. POT error loses one mark per error.
			Total	8	

Question		Answer	Marks	Guidance	
29	(a)	1 st marking point: apparatus. Voltmeter / DVM (across output) and thermometer, with one other of beaker of water (and stirrer), heater. ✓	1	allow suitable alternatives. Can be shown on labelled diagram. allow datalogger, temperature sensor and voltage sensor for voltmeter and thermometer).	
		2 nd marking point: T at either fixed point explained ✓	1	e.g. immerse thermistor in (melting/crushed) ice in water for lower fixed 0 °C, OR boiling water at 100 °C for upper fixed point. allow heat to 100 °C IF heat source mentioned (e.g. with heater).	
		3 rd marking point: indication of measurements of V (or output) at regular T intervals ✓	1	allow named ΔT intervals e.g. 5 or 10 °C allow heat (and record V) at $\Delta T = 10$ °C	
		4 th marking point: relevant experimental detail ✓	1	e.g. heat slowly so temperature measurement is accurate / stop heating and stir before taking temperature measurement / take temperature and p.d. readings of $V(T)$ at same time / place thermistor and thermometer close together / repeat and average results. Use of datalogger, temperature sensor and voltage sensor can score 3 rd and 4 th marking points if clear. allow start with boiling/hot water and add cool/cold water/ice to cool	
29	(b)	(At 46 °C graph reading is) 3 (V) ✓	1	Mark for correct reading from graph. allow any use of 3 in a ratio type calculation (unless the value of 3 is clearly not a voltage).	
		(As this is half of input pd, the resistances are equal in the divider so) 470 Ω ✓	1	Bare answer with no reasoning scores 0/1. Allow use of full potential divider equation for both marks.	
29	(c)	(i)	Sensitivity is the gradient of the line ✓	1	Any implication of link.
			(is nearly constant up to about 30 °C and then) decreases (a little per degree Celsius above about 30 °C) ✓	1	allow up to between 20 °C and 40 °C allow decreasing 'slowly' but fairly steadily and at an almost constant rate.

Question			Answer	Marks	Guidance
					as gradient decreases, sensitivity decreases will be 2/2.
29	(c)	(ii)	<p>Tangent at 50 °C ✓</p> <p>Transcription of correctly read values into $(V_2 - V_1) / (T_2 - T_1)$ with $\Delta T \geq 40$ °C e.g. $(4.8 - 1.6) / (100 - 0)$ ✓</p> <p>= 0.032 (V °C⁻¹) ✓</p>	<p>1</p> <p>1</p> <p>1</p>	<p>Allow any reasonable attempt at a tangent at 50 °C</p> <p>Allow one half square misread. Allow pairs of readings from line at this point if $\Delta T \leq 20$ °C and centred around 50 °C (e.g. $3.4 - 2.8$) / $60 - 40$</p> <p>evaluation allow in range 0.028 to 0.036 V °C⁻¹ If $\Delta T \leq 20$ °C from tangent, or pairs of readings not centred around 50 °C, or pairs of readings $\Delta T \geq 20$ °C allow for values slightly outside of this range from correct readings. No credit for single point from line.</p>
29	(d)		<p>Smallest uncertainties (± 3 mV) at highest and lowest temperatures / largest uncertainties at intermediate temperatures / (✓)</p> <p>Uncertainties fall between 20 to 60 °C / uncertainties occur as repeated values different / uncertainty will be calculated by half of range of values (✓)</p> <p>Calculation of a percentage error OR observation (✓)</p> <p>Calculation of (at least) two percentage error calculations with comment (✓)</p> <p>in fixed point temperatures / in ice and steam points because temperatures are stable</p>	<p>Max 4</p>	<p>Max 3 for analysis and comment 1 for simple comment accept valid alternatives</p> <p>1 for more detailed comment accept valid alternatives</p> <p>1 for simple percentage uncertainty analysis allow one percentage calculation e.g. 1.2% at 20 °C allow percentage errors are smallest at extremities / largest at intermediate values / fall between 20 to 60 °C</p> <p>1 for more detailed percentage uncertainty analysis e.g. calculation of percentage errors at 0 °C and 100 °C and relevant/appropriate comment</p> <p>Max 2 for causes of data limitations. Accept valid alternatives.</p>

Question	Answer	Marks	Guidance
	<p>larger systematic errors in the other readings because of temperature drift / thermistor still warming during measurement interval</p> <p>uncertainty decreases (from ± 24 mV to ± 12 mV) with rising T because sensitivity also decreases with T</p> <p>noise signal persists into drift readings because they are not linearly increasing in small time interval (✓✓)</p> <p>improve systematic / drift errors by stopping heating / stirring water / giving time for thermistor to equilibrate to water temperature / use water bath with thermostat</p> <p>start with hot water and cool slowly to reduce temperature fluctuations</p> <p>improve small random errors using a less noisy DVM(✓✓)</p>		<p>Max 2 for improvements. Accept valid alternatives.</p> <p>expect good level of response not just use better DVM</p>
	<p>Total</p> <p>Total section C</p> <p>Total sections B & C</p>	<p>15</p> <p>30</p> <p>50</p>	

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