OCR
Oxford Cambridge and RSA

GCE

Physics B

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

Advanced Subsidiary 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.

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

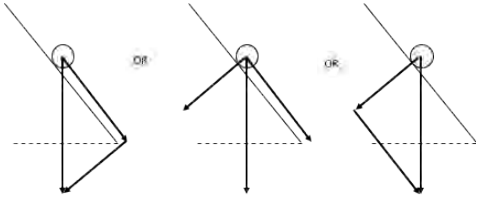
Section A: MCQs

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

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

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

Question			Answer		Marks	Guidance
24	(a)		(11 500 x 2) = 23 000 (Hz)	✓	1	Evaluation. Allow 23 **k**Hz if unit altered. **Do not** allow 23 000 calculated from (2 x (11500 – 200))
24	(b)		n = log 3000 / log 2 / = 11.6 bits = 12 (bits)	✓ ✓	1 1	or $\log_2(3000)$. Allow 11.5 bits 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.
			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)		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. ✓ (*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. ✓ OR (*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.	**1** **1**	General statement of how/where Newton's Third Law applies. Explanation of why Newton's Third Law does not apply in this case using a pair of forces. Also acceptable to identify the correct N3 reaction force to each force in one of the pairs (*T*,*D*), (*W*,*L*), 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 Alternative solution: !st 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.
26	(b)		The aircraft slows / decelerates / *v* reduces ✓ as there is an unbalanced / resultant force acting in the direction against the motion. ✓ OR The vertical height decreases / aircraft falls (✓) as (reduced *v* will cause a reduced *L* and so) a resultant downwards force (✓)	**1** **1**	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. Bald statement of Newton's second law (resultant force cause acceleration) can score 1/2. No credit for simple F=ma.

Question			Answer	Marks	Guidance
26	(c)		a (= F / m = 1.2 x 10^6 / 4 x 10^5) = (-) 3.0 (m s^{-2}) ✓	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 = info / rate = $5.8 \times 10^6 / 110 \times 10^3$) = 53 (s) ✓	1	Allow 52.7 (s). Allow $(5.8 \times 1024^2)/110 \times 1024 = 54$ (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 x 1024 = 731 pixel using height 711 pix = 4.8cm, R = 5/4.8 x 711 = 740 pixel
			Determination of R in length units (approx. 243 km) ✓	1	e.g. 735 x 330 = 243000 (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 (2nd and 3rd mark). Methods leading to 100km < D < 500km using incorrect scaling, max 2/3. (2nd and 3rd mark). Methods leading to > 500km using incorrect scaling, max 1/3. (3rd 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 1st mark: width of photograph = 1024 x 300 = 337920m 2nd mark: radius = $337920/2^{1/2}$ = 238946m 3rd mark: diameter = 2 x R = 478 km

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

Question			Answer		Marks	Guidance
28	(a)	(i)	(3.0 / 12) = 0.25 (MN m^{-1})	✓	1	Any pair of values from the graph leading to correct answer.
28	(a)	(ii)	$E = F L / A$ $x = (F / x) L / A = k L / A$ 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 $k = E A / L$ Allow routes from stress and strain formula that give the correct equation. Allow reverse argument
28	(a)	(iii)	$L = E A / k$ / $2.1 \times 10^{11} \times 1.0 \times 10^{-3} / 0.25 \times 10^{6}$	✓	1	method: rearrangement in algebra / numbers
			= 840 (m)	✓	1	evaluation ecf on k from (a)(i). POT error loses one.
28	(b)	(i)	½ x 3 x 10^6 x 12 = 18 x 10^6 (J) or ½ x 3 x 12 = 18 (MJ)	✓	1	Evaluation Allow use of ½ $k x^2$. (½ x 0.25 x 12^2) leading to 18 (MJ) Ecf on (a)(i). Condone missing unit, but penalise incorrect unit.
28	(b)	(ii)	½ $m v^2$ = (½ (ρ A L) v^2) = 18 MJ	✓	1	reasoning of energy conservation **allow** $E_{kinetic}$ = $E_{elastic\ (potential)}$ ecf elastic potential in (b)(i)
			v^2 = 2 x 18 x 10^6 / (7900 x 1 x 10^{-3} x 840) or v = [36 x 10^6 / (7900 x 1 x 10^{-3} x 840)]$^{1/2}$	✓	1	rearrangement and substitution ecf on L in (a)(iii)
			= 74 (m s^{-1})	✓	1	evaluation. POT error loses one mark per error.
			Total		8	

Question			Answer	Marks	Guidance
29	(a)		1st 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).
			2nd marking point: *T* at either fixed point explained ✓	1	e.g. immerse thermistor in (melting/crushed) ice in water for lower fixed 0 ºC, **OR** boiling water at 100 ºC for upper fixed point. **allow** heat to 100 ºC IF heat source mentioned (e.g. with heater).
			3rd marking point: indication of measurements of *V* (or output) at **regular** *T* intervals ✓	1	**allow** named ΔT intervals e.g. 5 or 10 ºC **allow** heat (and record *V*) at ΔT =10 ºC
			4th 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 3rd and 4th marking points if clear. **allow** start with boiling/hot water and add cool/cold water/ice to cool
29	(b)		(At 46 ºC 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 ºC and then) decreases (a little per degree Celsius above about 30 ºC) ✓	1	**allow** up to between 20 ºC and 40 ºC **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)	**Tangent** at 50 ºC ✓	1	Allow any reasonable attempt at a tangent at 50 ºC
			Transcription of correctly read values into $(V_2 - V_1) / (T_2 - T_1)$ with ΔT >=40 ºC e.g. (4.8 – 1.6) / (100 – 0) ✓	1	Allow one half square misread. Allow pairs of readings **from line** at this point if ΔT <=20 ºC and centred around 50 ºC (e.g. 3.4 – 2.8) / 60 – 40
			= 0.032 (V ºC^{-1})) ✓	1	evaluation **allow** in range 0.028 to 0.036 V ºC^{-1} If ΔT <=20 ºC **from tangent**, or pairs of readings not centred around 50 ºC, or pairs of readings ΔT >=20 ºC allow for values slightly outside of this range from correct readings. No credit for single point from line.
29	(d)		Smallest uncertainties (±3 mV) at highest and lowest temperatures / largest uncertainties at intermediate temperatures / (✓)	Max 4	**Max 3** for **analysis and comment** **1** for simple **comment** accept valid alternatives
			Uncertainties fall between 20 to 60 ºC / uncertainties occur as repeated values different / uncertainty will be calculated by half of range of values (✓)		**1** for more detailed **comment** accept valid alternatives
			Calculation of a percentage error OR observation (✓)		**1** for simple percentage uncertainty **analysis** **allow** one percentage calculation e.g. 1.2% at 20 ºC **allow** percentage errors are smallest at extremities / largest at intermediate values / fall between 20 to 60 ºC
			Calculation of (at least) two percentage error calculations with comment (✓)		**1** for more detailed **percentage** uncertainty **analysis** e.g. calculation of percentage errors at 0 ºC and 100 ºC and relevant/appropriate comment
			in fixed point temperatures / in ice and steam points because temperatures are stable		**Max 2** for **causes** of data limitations. Accept valid alternatives.

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

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