OCR
Oxford Cambridge and RSA

GCE

Physics B

Unit **H157/02:** Physics in depth

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 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

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
(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
(1)m	a method mark, awarded if a correct method is used
(1)e	an evaluation mark, awarded for correct substitution and evaluation

The following questions should be annotated with ticks to show where marks have been awarded in the body of the text: any question where the mark total is 3 or 4 marks, and any two-marker where the MS reads 'any 2 points.'
Ticks must NOT be used in 6(a) or 8(b); 6 marks will be indicated by L3, 5 marks by L3^, 4 marks by L2, 3 marks by L2^, 2 marks by L1, 1 mark by L1^ and 0 marks by 0.

Question	Answer	Marks	Guidance
Section A			
1 (a)	$1/v = 1/u + P \Rightarrow P = 1/v - 1/u$ $= 1/[2.1 \times 10^{-2}] - \{-1/[25 \times 10^{-2}]\}$ (1) ; $= 1/[2.1 \times 10^{-2}] + 1/[25 \times 10^{-2}]$ (= 51.6 D) = 52 D(1)	**2**	Allow use of 'real is positive' convention. Correct final answer with no working ⇒(2); ignore s.f.e. Wrong sign for u gives 43.6 D = 44 D which gains 1 mark ecf 1 mark for correct calc of f = 1.9 cm
(b)	$M = d/2.5\ \mu m = v/\|u\| = 2.1$ cm/ 25 cm = 0.084 $d = 2.5\ \mu m/0.084$ (1) ; $= 29.8\ \mu m = 30\ \mu m = 3.0 \times 10^{-5}$ m (1)	**2**	Mp1 is a method mark mp2 is evaluation. Correct final answer with no working ⇒(2); ignore s.f.e. or rounding error Allow 30 μm on answer line only if μ clearly included
(c)	books held much closer to the eye than 1.5 m / ~30 cm away (1) ; $v/\|u\|$ will be 1.5 m/25 cm = 6 × smaller, so resolution will be 6 × poorer/ identical image on the retina needs object 6× larger (1) ;	**2**	Give one mark maximum for descriptive answer e.g. lens focusses behind retina, lens not powerful enough even if mp1 is gained Calc of her resolution as 1.79×10^{-4} m gets both marks
	Total	**6**	
2 (a)	$1280 \times 720 \times 3 = 2.76 \times 10^6$ B per screen (1) ; No. of screens = 30×60×60 = 108000 total = $108000 \times 2.76 \times 10^6$ B = 2.99×10^{11} B = 299/300 GB (1)	**2**	Correct final answer with no working ⇒(2); ignore s.f.e. If only one error, gets 1 mark e.c.f. Accept 1GB = 2^{30} B = 1.074×10^9 B which is strictly a gibibyte [GiB]; answer would then be 278 (GiB ≈ GB)
(b)	signal compressed (1) ; not every pixel needs encoding each time/restricted to changes from last screen/similar adjacent pixels do not need encoding (1)	**2**	or other reasonable suggestion about technique of compression
	Total	**4**	
3 (a)	cable mass = 420 m × 2.8×10^{-3} m^2 × 7800 kg m^{-3} = 9170 kg (1) ; total mass = 9170 kg + 1200 kg = 10 400 kg total weight = 10 400 kg × 9.8 N kg^{-1} = 1.02×10^5 N (1) ; so stress = 1.02×10^5 N / 2.8×10^{-3} m^2 = 3.6(4) ×10^7 Pa(1)	**3**	Correct final answer with no working ⇒(3); ignore s.f.e. Allow intermediate rounding to 2 or 3 s.f. throughout Using mass is a gross error of physics Ecf own weight iff plausibly calculated (ignoring weight of the cage + passengers gives 9170 kg, 8.99×10^4 N & 3.2 ×10^7 Pa, ignoring the cable 1200 kg, 1.176×10^4 N & 4.2 ×10^6 Pa)
(b)	Maximum stress is at top of the cable as also includes all weight of cable/ bottom of cable holds only the cage/passengers (1) ; mean stress is less owtte, so strain and extension will be less than predicted (wrongly) from E, L and stress from (a) (1)	**2**	Must explain in terms of reduced mean stress

	Total	**5**	
Question	**Answer**	**Marks**	**Guidance**
4 (a)	momentum gained per second = [47/1000] kg × 110 m s^{-1} = 5.17 kg m s^{-1} (1) ; This is $\Delta p/\Delta t$ which is $F \approx 5$ N (1)	**2**	Using $F = \Delta p/\Delta t$ or $F = \Delta(mc)/\Delta t$ is getting m.p.2 more explicitly
(b)	Upward force = thrust from (a) – weight of rocket = 5.17 N – [0.27 kg × 9.81 N kg^{-1}] = 2.5(2) N (1) ; $a = F/m$ = 2.52 N / 0.27 kg = 9.34 / 9.3 m s^{-2} (1) **or** actual acc. = (5.15 N or 5 N) ÷ 0.27 kg – g (1) ; = (18.5 or 19.1 m s^{-2}) – 9.8 m s^{-2} = (8.7 or 9.3 m s^{-2}) (1)	**2**	Correct final answer with no working ⇒(2); ignore s.f.e. one mark for method, one for evaluation. allow e.c.f for incorrect force providing attempt to allow for rocket weight has been made Using F= 5 N [from (a)] – 0.27 kg × 9.81 N kg^{-1} = 2.4 / 2.35 N gives 8.7(1) m s^{-2}
(c)	**Any two points** As rocket climbs, fuel is being burnt/ejected (1); rocket mass is dropping, so the same force will produce a different /larger acceleration (1); rate of burning & ejection of gas changes (as fuel runs out) (1)	**2**	**ALLOW** Air resistance has increased (1) ; as it is moving fast(er) (1)
	Total	**6**	
5 (a)	There are 3 transitions between energy levels: between **C** & **B**, between **C** and **A**, and between **B** and **A** (1) ; each transition corresponds to a single energy and therefore a single frequency. (1)	**2**	may be shown on the diagram (**ALLOW** either absorption or emission in this part) mp2 depends on idea of transition between levels
(b)	$f = c/\lambda$ = 3.0 × 10^{8} m s^{-1}/650 ×10^{-9} m = 4.6(2)×10^{14} Hz (1); $E = hf$ = 6.6 × 10^{-34} J s ×4.62×10^{14} Hz = 3.05 ×10^{-19} J = 3.0 ×10^{-19} J (1); (this is the smallest fall) from **C** → **B** (1)	**3**	Ignore s.f.e. or rounding error Quoting or using $E = hc/\lambda$ is enough for mp1 Correct E gets mp1 & mp2 even if no f calculated
	Total	**5**	
	Section A total	**26**	

Question	Answer	Marks	Guidance
Section B			
6 (a)*	**(Level 3) (5 – 6 marks)** Circuit diagram completely correct. Procedure details how to obtain a good ranges of value of *V* and *I*. Graphical process explained with correct references to intercept and gradient. Uncertainties related to extreme possible placement of straight-line. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **(Level 2) (3 – 4 marks)** Circuit diagram completely correct. Procedure details how to obtain a good range of values of *V* and *I*. Graphical process explained with mostly correct references to intercept and gradient. May not discuss uncertainties or do so in a confused manner. *There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.* **(Level 1) (1 – 2 marks)** Circuit diagram mostly or completely correct. May just calculate values from single value of *R*, possibly repeated. May just repeat the information given. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **(0 marks)** Insufficient or irrelevant science. Answer not worthy of credit.	**[6]**	**Indicative scientific points may include:** **Circuit diagram:** • Correct symbols for variable resistor and meters • Meters correctly placed • Method may use only one meter **Description of procedure** • External resistance varied • May use calibrated variable *R* and one meter, e.g. ammeter and then $IR = \mathcal{E} - Ir$ • Appropriate meter readings taken • Equation $V = \mathcal{E} - Ir$ used • data plotted on *V* – *I* axes • best-fit straight line drawn • $\mathcal{E}$ = *V*-axis intercept • *r* = gradient • *r* may change (due to current drawn) • Uncertainties deduced from comparison of above with values from steepest/least steep possible lines • If only one meter used, need to deduce emf or recast equation in terms of measured variable and known values of variable resistance **Use the L1, L2, L3 annotations in Scoris; do not use ticks.**

Question	Answer	Marks	Guidance
6 (b) (i)	$Q = It$ = 1200 × 10^{-3} A × 60^2 = 4320 C ≈ 4000 C (1)	1	Calculation of 4320 C/4300 C is enough for the mark
(b) (ii)	Total resistance = $R + r$ = 2 × 0.32 Ω + 5.2 Ω = 5.84 Ω (1) ; $I = \varepsilon/[R + r]$ = [2 × 3.6 V]/ 5.84 Ω = 1.233 A (1) ; $t = Q/I$ = 4320 C/1.233 A = 3504 s (/58.4 min / 58 min 24 s) (1)	3	e.c.f. own charge from (a) or use of 'show that' value of 4 kC. May use potential divider idea to find V = 6.41 V (1); and hence $I = V/R$ or $I = [\varepsilon - V]/r$ = 1.233 A (1); must see calc of I: if candidate uses 1200 mAh to get 1.2 A, max mark here = 1 for m.p.1 (if resistance correct) ecf own current if not 1.2 A as above. 4 kC gives 3244 s. Allow intermediate rounding of I.
(b) (iii)	External energy dissipated in resistance $R = I^2Rt$ (1) ; total energy dissipated = $I^2[R+2r]t$ (1) ; efficiency = energy dissipated in R/total energy= $R/[R+2r]$ (so percentage efficiency = $100R/[R+2r]$) (1)	3	Can do via ratio of powers Or via energy supplied = EIt. Energy dissipated = VIt. Ratio = V/E plus use of potential divider equation.
(c)	Identifies trend of decrease in energy storage with repeated charging & discharging (1) ; Identifies correlation of decrease in relative capacity with increased current drain (1) ; Identifies mobile phone as drawing low current <u>and</u> electric car as drawing high current (1)	3	Smaller current drain means it lasts longer
	Total	**16**	

Question	Answer	Marks	Guidance
7 (a) (i)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 80.752/80.75/80.8/81 (m s^{-1}) award 2 marks ✓✓** λ = 2 × 0.980 m = 1.96 m (1) ; $v = f\lambda$ = 41.2 Hz × 1.96 m = 80.752 m s^{-1} = 80.8 m s^{-1} (1)	**2**	λ = 0.980 m ⇒ v = 40.4 m s^{-1} gets 1 mark total ignore s.f.e.
(a) (ii)	Standing/stationary wave is set up (1) ; with a node where the string is touched (1) ; $f = 5f_0$ = 5 × 41.2 Hz = 206 Hz (1) ; x = 0.980 m/5 = 0.196 m = 19.6 cm or 78.4 cm(1)	**4**	May be in labelled diagram Allow factor of 4 instead of 5, i.e. 24.5 or 73.5 cm and 165 Hz If f and x not expressed to 3 s.f., award only 1 mark of the last two m.ps.
(a) (iii)	$f_0 = \frac{1}{2L}\sqrt{\frac{T}{\rho A}} \Rightarrow A = \frac{T}{\rho(2Lf_0)^2}$ (1) ; A = 290 N/(8100 kg m^{-3}×(2×0.98 m×41.2 Hz)^2 (1) ; = 5.49×10^{-6} m^2 d ={(√[A/π]}×2 = 2.644×10^{-3} m = 2.6(4)×10^{-3} m (1)	**3**	m.p.1 (rearrangement) and m.p.2 (substitution and evaluation) can be done in reverse order to m.p.2 (substitution) and m.p.1 (rearrangement and evaluation to include value of area) m.p.3 is for correct evaluation from calculated area
(b) (i)	rearranges to get $\rho A = T/[2L\ f_0]^2$ (1) ; states/implies (2 &) f_0 are constant ⇒ $\rho A \propto T/L^2$ (1)	**2**	m.p.2 needs to be clear; may be expressed differently
(b) (ii)	calculates T/L^2 for each & finds T/L^2 is greater for d. bass (1) ; A, and therefore d, will be smaller for bass guitar (1) ; d.b. string is thicker / tauter than that of the b. guitar and so harder to pluck ORA (1)	**3**	d.bass gives 302 N m^{-2}, b. guitar has 257 N m^{-2} Either point. For m.p.3, ALLOW any clearly reasoned alternative based on dimensions, tension or posture of player.
	Total	**14**	
	Section B total	**30**	

Section C			
8 (a) (i)	**FIRST CHECK THE ANSWERS ON THE ANSWER LINES** **If answer = 6.1 ± 0.2 (cm) award 3 marks ✓✓✓** Mean = [5.9 + 6.2 + 6.1 + 6.1 + 5.9 + 6.3] cm/6 = 6.08 cm (1) ; uncertainty= spread= ½ range = ½ [6.3 – 5.9] cm = 0.2 cm (1) ; answers rounded to 6.1 ± 0.2 cm (1)	**3**	or uncertainty = max – mean (0.22 cm) or mean – min (0.28 cm) or their average (0.25) for m.p.2 allow 6.08 ± 0.25 cm if that uncertainty chosen
(a) (ii)	**Any two points** more readings will allow errors/outliers/anomalies to be seen (and investigated/repeated) (1) ; if only 2 readings taken, cannot tell which is an outlier (1) ; more data checks on repeatability / gives a more accurate mean value (1) ;	**2**	e.g. by smoothing out random uncertainties. Not just 'allows you to calculate a mean'
(a) (iii)	**Any three points** y is the mean of y_1 and y_2 (1) ; Use y/x = tan θ to give θ (1) ; Use the grating equation / $\lambda = d \sin \theta$ (to give λ) (1) ; Use $c = f\lambda$ to give f (1)	**3**	Or use small angle approximation $y/x = \theta$ in radians **ALLOW** use of Young's slits equation for mp2 & mp3

Question	Answer	Marks	Guidance
8 (b) *	**(Level 3) (5 – 6 marks)** Recognises that the gradient is correct, but poor use has been made of the best-fit line. Comments on the inadequate allocation of uncertainty bars in terms of spread of data/best-fit line. May criticise ignoring uncertainties in *E*. Suggests way to get uncertainty in *h* and makes recommendations for improving the data, e.g. checking points which are well off the line, adding extra measurements for different LEDs. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **(Level 2) (3 – 4 marks)** Recognises that the value is correct and that there is considerable spread in the data. May comment on the inadequate gradient triangle. May state that line does not pass through all uncertainty bars but does not follow that through to action needed to correct it. *There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.* **(Level 1) (1 – 2 marks)** Recognises that the value is correct, but does not comment on shortcomings of graphical analysis or use of uncertainties. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **(0 marks)** Insufficient or irrelevant science. Answer not worthy of credit.	**[6]**	**Indicative scientific points may include:** **Calculation of *h*** • Final value is close to expected value • Best-fit straight line is reasonable • Triangle used to calculate gradient is too small • No attempt to calculate uncertainty in *h* • Suggested method for finding Δh, e.g. drawing maximum or minimum possible gradient to get extreme value, or use of percentage uncertainty in data • Candidate may check actual gradient 6.7×10^{-34} J s (Check the graph on the QP) **Spread of data and uncertainty bars** • uncertainty bars belie the spread observed in the data • could be errors in data • or uncertainties could have been underestimated • no attempt to include uncertainties in *E* • these could have been significant • should have checked data, e.g. 4.5×10^{-19} J • could have taken extra readings for different LEDs • Candidate may attempt to check Δh value (Check the graph added to the response) **Use the L1, L2, L3 annotations in Scoris; do not use ticks.**
	Section C Total	**14**	

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