OCR
Oxford Cambridge and RSA

GCE

Physics B

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

Advanced Subsidiary GCE

Mark Scheme for June 2017

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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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

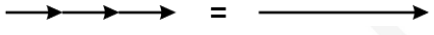
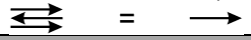
Annotations available in RM Assessor

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: 4(a)(ii) & 6(b) Ticks must NOT be used in 6(c) or 8(c).

Question	Answer	Marks	Guidance
Section A			
1 (a)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 667 (lines mm^{-1}) award 2 marks** no. = 1.00 × 10^{-3} m/1.50 × 10^{-6} m = 666.6… ✓ = 667 (lines mm^{-1}) ✓	**2**	must be 3 s.f. for the second mark If number per metre calculated and then correctly rounded to 6.67×10^{5}, give 1 mark
(b)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 51.0 / 51 / 51.02 (°) award 2 marks** $2\lambda = d \sin\theta_2 \Rightarrow$ 2×583×10^{-9} m = [1.50 × 10^{-6} m] sin θ_2 ✓m θ_2 = arcsin{[2×583×10^{-9} m]/[1.50 × 10^{-6} m]} = 51° ✓e	**2**	
(c)	$3\lambda/d$ = [3×583×10^{-9} m]/[1.50 × 10^{-6} m] ✓= 1.166 and so θ_3 is impossible/there's no value of sine > 1 ✓	**2**	or n_{max} for θ_n = 90 ° → 2.6 ✓and 2.6 < 3 ✓ or maximum possible path difference = 1.50 × 10^{-6} m ✓ and 3λ = 3×583×10^{-9} m = 1.75 × 10^{-6} m which is greater ✓
	Total	**6**	
2 (a)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 1.05×10^{-5} / 1.1×10^{-5} (V) award 3 marks** $R = \rho L/A$ = [2.3 × 10^{-8} Ω m] × [3.2 ×10^{-3} m]/{π×[10 ×10^{-6} m]^2} = [7.36 ×10^{-11} Ω m^2]/[3.14 × 10^{-10} m^2] ✓s = 0.234 Ω ✓ e $V_1 = IR$ = 4.5×10^{-5} A × 0.234 Ω = 1.05×10^{-5}/1.1×10^{-5} V ✓	**3**	m.ps. 1 & 2 are ✓m method of finding R and ✓e its evaluation. Allow intermediate rounding e.g. 0.23 Ω gives 1.0(35) ×10^{-5} Ecf own R / rounding error
(b)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 0.026 / 0.0265 (V) award 2 marks** $V_2 = I/G$ = 4.5×10^{-5} A /1.7 × 10^{-3} S ✓ = 0.026(5) V/ 26(.5) mV ✓	**2**	or R = 1/G = 588/590 Ω ✓ followed by $V_2 = IR$ ✓ Needs at least 2 sig figs. **NOT** 0.027. If G = 1.7 S, do not give mp1 allow e.c.f. for incorrect G/R ***or*** I, but not if ***both*** incorrect
	Total	**5**	
3 (a)		**2**	Same length and direction ✓ Resultant = sum of lengths, horizontal ✓ No ecf
(b)	 (= 0)	**1**	Same length, head-to-tail closed loop
(c)	equal angles between the phasor components ✓ correct answer (up down up, maybe rotated) ✓ 	**2**	
	Total	**5**	

Question	Answer	Marks	Guidance
4 (a) (i)	(**X** is a) dislocation ✓	1	
(a) (ii)	Any two points from: Shearing stress/stress applied perpendicular to dislocation ✓ individual atoms slip **OR** atoms move one at a time ✓ smaller force/less energy needed to deform metal ✓ dislocation moves ✓ whole layer of atoms moves ✓	2	Any of these may be obtained from clear additions to the figure.
(b)	Any two points from: Foreign atom different in size from the native atoms ✓ may occupy the gap in the dislocation ✓ 'pins' dislocation by preventing slip/ preventing movement /sliding of layers ✓	2	
	Total	5	
5 (a)	**FIRST CHECK THE CANDIDATE'S CALCULATED ANSWER** **If answer = 3.9×10^{17} / 3.94×10^{17} (s^{-1}) award 3 marks** $f = c/\lambda = [3.0\times 10^{8}\ m\ s^{-1}]/[520\times 10^{-9}\ m] = 5.77 \times 10^{14}$ Hz ✓ $E = hf = 6.6 \times 10^{-34}$ J s $\times$ 5.77×10^{14} Hz $= 3.81\times10^{-19}$ J ✓ no. of photons/s= $[150\times10^{-3}$ W$]/[3.81\times10^{-19}$ J$]$ $= 3.94\times10^{17}\ s^{-1}$ ✓	3	Allow intermediate rounding to 2 s.f. so if answer is close but not as shown left, check the candidate's calculation (E=3.8×10^{-19} J gives $3.95\times10^{17}\ s^{-1}$, f = 5.8×10^{14} Hz gives E=$3.83.\times10^{-19}$ J gives $3.92\times10^{17}\ s^{-1}$) Or $E = hc/\lambda$ ✓ Evaluation of E ✓
(b)	**FIRST CHECK THE CANDIDATE'S CALCULATED ANSWER** **If answer = 1.27 / 1.3 × 10^{-27} (km m s^{-1}) award 1 mark** $p = h/\lambda = [6.6 \times 10^{-34}$ J s$]/[520\times 10^{-9}$ m$] = 1.27/1.3\times 10^{-27}$ N s ✓	1	
(c)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 4.95 / 5.0 × 10^{-10} N award 1 mark** F = no. of photons/s × momentum of 1 photon $= 3.94 \times10^{17}\ s^{-1} \times 1.27 \times 10^{-27}$ N s $= 5.0 \times 10^{-10}$ N ✓	1	e.c.f. own answer to (b) and allow use of 'show that' value(s) from (a) $4 \times 10^{17}\ s^{-1} \times 1.3 \times 10^{-27}$ N s $= 5.2 \times 10^{-10}$ N or $4 \times 10^{17}\ s^{-1} \times 1 \times 10^{-27}$ N s $= 4 \times 10^{-10}$ N
	Total	5	
	Section A total	26	

Question	Answer	Marks	Guidance
Section B			
6 (a) (i)	choice of equation: $s = ut + ½ a t^2$ & $u = v \sin\theta$ and substitution for $s = 0$ ✓ rearrangement to $t = \frac{2v \sin\theta}{g}$ ✓	**2**	mp1 is for equation choice and setting boundary condition e.g. s = 0, v = - u, g and u have opposite signs alternative approaches possible, e.g. finding max height from $v^2 = u^2 + 2as$ where $u = v \sin\theta$ (1) ; then $v=u+at \Rightarrow 0 = v \sin\theta - gt$ (1) ; and doubling to get total time (1)
(a) (ii)	$t = \frac{2v \sin\theta}{g} = 2 \times 24 \text{ m s}^{-1} \sin(76°)/(9.8 \text{ m s}^{-2}) = 4.75 \text{ s}$ ✓ $R = v \cos\theta\, t = 24 \text{ m s}^{-1} \cos(76°) \times 4.75 \text{ s} = 27.6 \text{ m}$ ✓ plotted correctly from own tabulated value and maximum > 58 m & < 62 m read ✓	**3**	If there's no working but 27.6 is entered the in table, award both mp1 & mp2 mp3 needs the line to have been drawn: no line = no mark
(b)	Choose from the suggested differences and explanations in the guidance. Allow other reasonable responses. 'Difference' may be illustrated by sketch on the graph. For 3 marks, at least one must be an explanation of the difference stated. Annotate this question with ticks and crosses, so there will be three annotations in the question.	**3**	NB shape of curve is not the projectile trajectory Pairs of difference & explanation: all values of R less for any given values of θ ✓ because air resistance opposes horizontal motion ✓ $R - \theta$ will become asymmetrical ✓ because air resistance changes with time as the projectile moves ✓ reduction in R greater for larger θ ✓ because projectile in the air for longer ✓ Mean horizontal velocity will be less ✓ Because air resistance acts on the horizontal component of velocity, ✓

Question	Answer	Marks	Guidance
6 (c)*	**(Level 3) (5 – 6 marks)** Discussion reveals understanding of the physics of at least two events. Relates initial velocity of projectile to impulse delivered / power developed during throw/ work done in throw/force applied and projectile mass. May relate range to factors such as impulse, angle of throw and projectile mass. Discusses differences in technique between different throwing methods (even if incorrect: candidate may have no experience of these sports) *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)** Discussion reveals some understanding of the physics of at least one event, possibly with errors. Equates greater range to higher velocity. Relates initial velocity of projectile to force applied and projectile mass. Discusses differences in technique between two different throwing methods. *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)** No discussion of relevant physics – may use technical vocabulary in an everyday fashion. Makes simple comparison between masses of objects and ranges, relating these to force and acceleration, possibly loosely. Comments on differences between events in differences of throwing technique in a purely descriptive way. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **(0 marks)** No response or no response worthy of credit.	**[6]**	**Indicative scientific points may include:** **Difference between events:** • masses not all the same • shot and hammer involve very different bodily movements • javelin allows a run-up to give the javelin greater initial momentum • javelin and discus streamlined to air progress through air • angle tilt of discus generates lift • angle of throw may be constrained by the particular projectile in the event **Discussion of power and impulse** • large range needs high velocity (in optimal direction) • great impulse means more momentum transferred to projectile • same momentum change/force will accelerate lighter projectile more • time of transfer depends on (relative) velocity of projectile during throw • greater power means more kinetic energy transferred to projectile during time of throw **Discussion of range and angle** • optimal angle is about 45° • but will be affected by interaction with the air • and object is not thrown from ground level • throwing action may not allow projectile to be thrown at optimal angle **Use the L1, L2, L3 annotations in RM Assessor; do not use ticks.**
	Total	**14**	

Question	Answer	Marks	Guidance
7 (a) (i)	(2^8 levels/shades of grey and) $2^8 = 256$ ✓ 0 to 255 is 256 (different values) ✓	2	or $\log_2 256 = 2$ NOT $\log_2 255$ as need to demonstrate knowledge that there are 256 levels mp2 needs to be explicit; mention of '256' by itself is not enough (8 bits is in question).
(a) (ii)	White/random/dark specks due to noise ✓ Some/many 'dots'/pixels are **very** different from surrounding ones (and unlikely to be realistic representations of surface) ✓	2	Mp1 = identify tiny dots as pixels (possibly implied) Mp2 = imply they are well off any reasonable value.
(b)	25 km ≈ 20 pixels ✓ so resolution = 25 km/20 = 1250 / 1300 m ✓	2	Allow range 15 – 25 pixels. accept answer in range 1000 – 1700 km from above No ecf from mp1
(c)	Advantage: suggestion ✓ explanation ✓ Disadvantage: suggestion ✓ explanation ✓	4	e.g. clearer/better quality/easy to interpret ✓ no distracting speckles/more like the actual surface of Mercury ✓ e.g. loss of detail/contrast ✓ genuine bright/dim areas smoothed out (at edges) ✓ need to process data ✓ need more computer time/power ✓
(d)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 48 (s), award 3 marks** **If answer = 47.8 (s), award 2 marks** quantity of data = 22 × 31944 × 8 = 5622144 bits ✓ time = no. of bits/bit rate = 5622144/[117.6×10^3 s^{-1}]✓m&s = 47.8 s = 48 s ✓e	3	e.c.f mp1 , e.g. 22 × 31944 gives 6 s would give mp2 & mp3 = 2 marks while 5.98 s would not get mp3 = 1 mark.
	Total	**13**	
	Section B total	**27**	

Question	Answer	Marks	Guidance
Section C			
8 (a) (i)	percentage uncertainty in width = [0.1/10]×100% = 1% ✓ and percentage uncertainty in t < [4 μs/0.1 s] ×100% (= 0.004 %) which is (very, very) much smaller ✓	**2**	Calculation of one percentage uncertainty = mp1; calculation of the other and comparison = mp2. Calculation can be implied by correct values 1% &/or 0.004%
(a) (ii)	mean = [0.10 m]/[0.1453 s] = 0.6882 m s^{-1} ✓ uncertainty Δv = 1% of own value of mean = 0.006882 / 6.882×10^{-3} m s^{-1} ✓ rounded Δv to 1 s.f. and rounded v to same no of d.p., = [0.688 ± 0.007] m s^{-1} ✓	**3**	or e.g. 688.2 **mm s^{-1}** or 68.8 **cm s^{-1}** or: $\Delta v = v_{max}$ – 0.6882 × 10^{-3} m s^{-1} = [0.101 m]/[0.1453 s] - 0.6882 × 10^{-3} m s^{-1} = 0. 6951 m s^{-1} - 0.6882 × 10^{-3} m s^{-1} = 0.0069 m s^{-1} Allow [0.69 ± 0.01] m s^{-1}
(b) (i)	(t is a scalar but) ***v* and *p*** are **vectors** and so can go in + or – direction.	**1**	not just 'are vectors' without linking to the movement in Fig. 8.1 e.g. '(Time is scalar but) velocity and momentum are vectors so can go in a negative direction' is a minimum for the mark
(b) (ii)	Δp_1 = 0.649 N s + [-0.761 N s] = - 0.112 N s Δp_2 = [-0.486] N s + 0.377 N s = -0.109 N s ✓ The difference (= 0.003 N s) is negligible (about 3% of either value) ✓ because percentage uncertainty of 1% for each of 4 readings (⇒4%) is more than this ✓	**3**	e.c.f own momenta providing values are not very different from each other
(b) (iii)	E_k before: ½ × 0.800 kg × [0.811 m s^{-1}]^2 + ½ × 0.800 kg × [-0.951 m s^{-1}]^2 = 0.6249 J = 0.625 J ✓ E_k after: ½ × 0.800 kg × [-0.608 m s^{-1}]^2 + ½ × 0.800 kg × 0.471 m s^{-1}]^2 = 0.2366 J = 0.237 J which (significantly) less than the initial kinetic energy so energy has been transferred to e.g. increased internal energy of trolleys ✓	**2**	Allow intermediate rounding to 2 s.f. in (b)(iii) m.p.2 needs a repeat calculation and a reasoned comment that this is significantly less than the original kinetic energy.

Question	Answer	Marks	Guidance
8 (c)*	**(Level 3) (5 – 6 marks)** Comments on improvement obtained by more results in terms of better means and quantified uncertainty with consequences for analysis of momenta and energies. Suggests a reasonable and detailed method of producing similar initial velocity and suggests a plausible way to measure *v* with greater precision. *There is a line of reasoning presented with some structure. 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)** Comments on improvement obtained by more results in terms of better means and quantified uncertainty. Suggests a reasonable method, possibly incomplete, of producing similar initial velocity. Comments on accuracy of velocity measurements. *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)** Suggests simple method of producing similar velocities without any physical justification. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **(0 marks)** No response or no response worthy of credit.	**[6]**	**Indicative scientific points may include:** **Repeatable set-up** • catapult • weight/pulley with release • ramp • pull over marked distance with newton-meter at fixed setting **Advantages of repeated similar velocities** • allows calculation of mean and uncertainty in *v* • can calculate uncertainty in *p*, E_k • can quantify energy losses in the impact • can check on 'lost' *p* i.e. other unallowed-for forces **Improving timing method** • not a priority as current method is not the weakest link • cut card with greater precision • measure length with better resolution (e.g. travelling microscope) • longer card to reduce percentage error • ensure card cuts light-gate beam at right angles (e.g. by observing and discarding results where it doesn't) **Other suggestions** • use of linear air track • use of motion sensors (NOT tickertape) • can investigate *p*, E_k losses in trolley running along surface without collision to allow for these **Use the L1, L2, L3 annotations in RM Assessor ; do not use ticks.**
	Section C Total	**17**	

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