GCE

Physics B

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

Advanced Subsidiary GCE

Mark Scheme for June 2016

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

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
MP	Marking point
(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: 1(b)(i), 2(b), 3(b), 4(d).
Ticks must NOT be used in 5(c) or 6(e).

Question			Answer	Marks	Guidance
Section A					
1	(a)		$P = 1/f = 1/(4.0\times10^{-3}\text{ m}) = 250$ (D)	1	
	(b)	(i)	$u = -0.24$ m $\Rightarrow 1/v = P + 1/u$ $1/v = 250$ D – (1/0.24m) (1); $1/v = 250$D- 4.16D = 246 D $v = 1/246$ D = 0.00407 m /4.07 mm (1); This is 0.07 mm from 4.0 mm (which is less than 0.1 mm) (1)	3	Consistent use of 'real is positive' convention can get full credit. In either system, $1/v = -1/0.24$ m + 250 D $1/v = 250$ D **+** (1/0.24m) $\Rightarrow v = 1/254$ D =3.93 mm is a gross error of physics and loses the first two marks 4.06mm is a rounding error and loses MP2 only. Ecf from v = 3.93 mm (using positive u) or v = 4.06 mm gets this mark
	(b)	(ii)	magnification = v/u = 0.00407 m/0.24 m = 0.017 / 1/59 (1); size = 3mm/59 / 3 mm × 0.017 = 0.051 mm (≈ 0.05 mm) (1)	2	allow 1/60. ecf own value of v from (b)(i) ORA 0.05 mm/3 mm = 0.0167 ≈ 0.017
	(b)	(iii)	1 pixel on the CCD = 6.4 mm/2592 = 0.00247 mm (1); This is 0.017 ×/ 1/59 of size on object, size on object = 0.00247mm /0.017 = 0.15 (mm) (1)	2	2.47×10^{-6} m 0.15 (mm) gets both marks even without working
	(b)	(iv)	Smallest feature of the equation is about 1 mm, which is about 6 pixels (1); smallest feature (subscript 2) needs to have several pixels across to be distinguished from other digits, e.g. 3 or 5 (1)	2	ecf answer to (b)(iii) and allow smallest feature in range 1 – 3 mm .
			Total	**10**	
2	(a)		detector is receiving waves from the source and wave reflected off the plate (1); These are not in phase /out of phase/destructively interfere (1)	2	MP1 is for identifying two different wave paths Allow description in non-technical language e.g. cancel
	(b)		At y_1 / y_3 waves are in antiphase/have phase difference of 180° or π rad / have path difference of ½ λ (+ $n\lambda$) (1); At y_2 waves are in phase/have phase difference of 360° or 2π rad / have path difference of λ (+ $n\lambda$) (1); At y_3, path difference is λ different from that at y_1 (1)	3	Accept either phase difference or path difference argument Can compare y_3 with y_2, ignore whether path difference has increased or decreased $y_1 \rightarrow y_2 \rightarrow y_3$
	(c)		More maxima (for the same movement of the reflector) (1); the signal would go 'min..max..min' 2 × as frequently. (1)	2	MP1 is a qualitative mark for 'more maxima' MP2 is quantitative looking for the doubling factor in path difference or phase difference or movement between maxima or minima. Is implied by e.g. 'y_1 , y_2, y_3 will all be maxima' which would get 2 marks by itself.
			Total	**7**	

Question		Answer	Marks	Guidance
3	(a)	Advantage: allows greater range of values to be displayed / produces a straight line graph which is easier to read (1); Disadvantage: difficult to read/plot values not lying exactly on a graph grid marking (1)	2	MP2 requires recognition of the difficulty of interpolating values in reading from the graph
	(b)	intensity should go from (about) 100 lux to (about) 500 lux /≈ between home and office conditions (1); corresponds to R_X between 1 kΩ and 10 kΩ (1); *R* should be similar to/in the range of R_X (1)	3	MP1 is identifying the appropriate intensity which could be a single value in the range. There should be a range stated or implied by the chosen value(s) of R_X for this mark. MP1 is about processing the data in the table. MP2 is reading appropriate resistance(s) for the intensity/intensities of MP1. This marking point can be inferred from choice of *R*. MP2 is about estimating resistance value(s) of R_X from the log-log graph. If candidate finds a mean R_X over the range of intensities, then the chosen *R* should be that value. If there is only one value of R_X chosen, then the answer on the dotted line should be that one. MP3 is about recognising that the two resistors in the potential divider need to be similar in magnitude.
		Total	**5**	
		Section A total	**22**	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td colspan="3">Section B</td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>(a)</td><td></td><td>smaller λ light has photons of higher energy ORA (1);
phosphor cannot emit more energy than it receives/ energy received cannot be ‘stored’ up from several photons and released in more energetic ones (1)</td><td>2</td><td>For MP2 candidate needs to be clear about the implication of conservation of energy in this example.</td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td>$(1.0 \times 10^{-3}\text{ m})/1100 = 9.09 \times 10^{-7}$ m (which $\approx 9 \times 10^{-7}$ m)</td><td>1</td><td>must see evidence of evaluation, e.g. substituted equation or evaluation to at least 2 s.f.</td></tr>
<tr><td></td><td>(b)</td><td>(ii)</td><td>$\lambda = d \sin \theta = 9.09 \times 10^{-7}\text{ m} \times \sin(32°) = 4.8 \times 10^{-7}$ m (1);
= 480 nm (1)</td><td>2</td><td>9×10^{-7} m $\Rightarrow$ 477 nm; unrounded answer from (i) $\Rightarrow$ 482 nm
correct value 477/480/482 nm gets both marks without working</td></tr>
<tr><td></td><td>(b)</td><td>(iii)</td><td>Sharp peak at 480 nm (1);

broad, lower bump to the right of the peak (1)</td><td>2</td><td>e.c.f. own wavelength from (b)(ii) peak should be between 450 & 500 nm and width at half-height needs to be < 100 nm

allow broad bump to overlap 480 nm peak but not drop below it
Presence of sharp peak + more than one other peak loses MP2</td></tr>
<tr><td></td><td>(c)</td><td>(i)</td><td>$f = c/\lambda = (3.0\times10^{8}\text{ m s}^{-1})/ 4.8 \times 10^{-7}\text{ m} = 6.25 \times 10^{14}$ Hz (1);
$E = hf = 6.6\times10^{-34}\text{ J s} \times 6.25 \times 10^{14}\text{ Hz} = 4.1\times 10^{-19}$ J (1)</td><td>2</td><td>Can use $E = hc/\lambda$ when it’s (1) for quoting the formula (can be implied from the substitution) and (1)substitution & evaluation.
4.1×10^{-19} J with no working gets both marks</td></tr>
<tr><td></td><td>(c)</td><td>(ii)</td><td>many more levels (1); because lots of λs/fs emitted (1)
OR
levels closer together/with smaller energy differences (1);
because photons less energetic (1)</td><td>2</td><td></td></tr>
<tr><td></td><td>(d)</td><td></td><td>CFLs need recycling/damage the environment (1);

compares running costs – LED is cheaper (1)

compares output in lumens (guidance) – LED is better, or no significant difference (1);

compares capital cost – LED is cheaper (1);</td><td>4</td><td>Can use greater $P \Rightarrow$ more pollutants produced in power station

can compare powers providing link with energy & cost is clear

not just comparison of brightness or power. Allow comparison of ‘output per watt of power’ if developed, e.g. costs less for same light output

must factor in the 3 × greater life of LED lamps for this mark
some illustrative values – candidate
<table><tr><th>variable</th><th>CFL</th><th>LED</th></tr><tr><td>output/lumens</td><td>750</td><td>800</td></tr><tr><td>capital cost / 10 000 hours</td><td>£3.50</td><td>£2.17</td></tr></table></td></tr>
<tr><td colspan="3"></td><td>Total</td><td>15</td><td></td></tr>
</table>

Question			Answer	Marks	Guidance
5	(a)	(i)	$W = ½ F x$ = 0.5 × 84 N × 0.71 m (1); = 29.8 J = 30 J (1)	2	Using 84 N × 0.71 m is a gross error of physics and gets 0 or Mean force is 84 N/2 = 42 N (1); work done = 42 N × 0.71 m = 29.8 J = 30 J (1) or k = 84 N/0.71 m = 118 N m^{-1} (1); and then $W = ½ k x^2$ = 0.5 × 118 N m^{-1} × $(0.71 \text{ m})^2$ = 29.7 J = 30 J (1)
	(a)	(ii)	$E_k = ½ m v^2$ = 0.5 × 0.026 kg × $(45 \text{ m s}^{-1})^2$ = 26.3 J = 26 J (1); energy is dissipated in / raising the internal energy of the bow and string/kinetic energy of moving bow/string (1)	2	NOT air resistance/friction with air. Allow 'heat energy produced.' Ignore ref. to sound. If several mechanisms suggested, mark the first one only. 'Sound & heat' = 1 mark (ignoring sound) but 'air resistance and heat' = 0.
	(b)	(i)	vertical component of velocity = (45 m s^{-1}) sin (34°) (1); = 25.2 m s^{-1} Using $s = ut + ½at^2$, 0 = (1); (25.2 m s^{-1})t + ½(-9.8 m s^{-2})t^2 t = (25.2 m s^{-1})/{ ½(-9.8 m s^{-2})} = 5.14 s = 5.1 s (1)	3	MP2 for equation choice and setting s = 0; MP3 for evaluation with e.c.f own velocity component. Alternative two-step approaches are possible. Candidates may answer (b)(i) and (b)(ii) in reverse order, or both together 5.1(4) (s) with no working gets 3/3
	(b)	(ii)	horizontal component of velocity = (45 m s^{-1}) cos (34°) = 37.3 m s^{-1} (1); distance = 36.9 m s^{-1} × 5.1 s = 190 m (1)	2	using unrounded values of cos (34°) and sin (34°) ⇒ 192 m Using 5 s from stem ⇒ 187 m candidates may use the mechanics equation for range: distance = (u^2/g) sin (2θ) when quoting the equation gets MP1 and correct substitution and evaluation gets MP2. ecf own time, and ecf own velocity component in both this part and in 5(b)(i), correct answer (187/190/192 (m)) gets 2/2 even if working unclear

Question	Answer	Marks	Guidance
5(c)*	**(Level 3) (5 – 6 marks)** Shows clear understanding of the meaning of two of range, accuracy and consistency ***and*** compares structure and properties of yew bow/string and modern bow/string. *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)** Shows clear understanding of the meaning of two of range, accuracy and consistency ***or*** compares structure and properties of yew bow/string and modern bow/string. *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)** Shows limited understanding of the meaning of one of range, accuracy and consistency ***or*** makes a limited comparison between the structure and properties of yew bow/string and modern bow/string. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **(0 marks)** Insufficient or irrelevant science. Answer not worthy of credit.	[6]	**Indicative scientific points may include:** **Range** • range depends on (initial) velocity and angle of release • range depends on arrow design also • speed depends on mean force and length of draw • length of draw greater for composite bow • a bow/string which is pulled back more will store (and release) more elastic potential energy **Accuracy and consistency** • accuracy means arrow can be fired so that it strikes the centre of the target • so that it is possible for a skilled archer to hit exactly what is aimed at • consistency means that subsequent arrows may be loosed in exactly the same way • allowing an archer to improve performance with each shot **Structure & properties of bow types** • yew bow and linen string are natural materials and so vary within the sample, e.g. weak spots, knots in the wood, small cracks • yew bow may rotate and so draw/release differently each time while composite bow is designed/built to be stable • temperature and humidity changes will affect both yew bow and linen bowstring • making their performance change with time • while the composite bow and polymer fibre will be more consistent • yew bow has smaller draw than composite bow • polymer string can take greater tension than linen and is less likely to snap in use • shape change on drawing stores more energy in the composite bow **Use the L1, L2, L3 annotations in Assessor; do not use ticks.**
	Total	**15**	
	Section B total	**30**	

Question	Answer	Marks	Guidance
Section C			
6 (a)	u is mean of the values of u (1); Δu is the difference between u and largest/smallest value (1); u is rounded to the same number of s.f. as the original data(1); Δu is rounded to 1 s.f. (1);	**3**	Any three points or Δu = (largest value - smallest value)/2.
(b)	Quotes $v^2 - u^2 = 2as$ (1); Relates to a graph with gradient $2a$ where $a = g$ (1)	**2**	e.g. equating $v^2 - u^2 = 2as$ with $y = mx(+c)$ where m=2a & c= 0 MP2 is for deducing gradient $m = 2a = 2g$.
(c) (i)	max. $v^2 - u^2 = (2.61 + 0.03)^2 - (1.40 - 0.04)^2$ m^2 s^{-2} $= 5.12$ m^2 s^{-2} (1); min. $v^2 - u^2 = (2.61 - 0.03)^2 - (1.40 + 0.04)^2$ m^2 s^{-2} $= 4.58$ m^2 s^{-2} $\Delta(v^2 - u^2) = ½\,(5.12 - 4.58)$ m^2 s^{-2} =0.27 m^2 s^{-2} = 0.3 m^2 s^{-2} (1)	**2**	MP1 is calculating either max. $v^2 - u^2$ or min. $v^2 - u^2$ MP2 is for deducing $\Delta(v^2 - u^2)$ either by halving the difference between those two extrema or by taking the difference between either and the mean value 4.85 m^2 s^{-2} Allow approach based on percentage uncertainties: % uncertainty in u = 100×0.04/1.40 = 2.86% & %uncertainty in v = 100×0.03/2.61 = 1.15% for MP1 % uncertainty in $(v^2 - u^2)$ = 2 × 2.86% + 2 ×1.15% = 8% 8% of 4.9 m^2 s^{-2} (= 0.39 m^2 s^{-2}) ≈ 0.3/0.4 m^2 s^{-2} for MP2.
(c) (ii)	greater $s \Rightarrow$ greater value of v / smaller Δt (1); similar uncertainty in timing $\Rightarrow$ greater uncertainty in v^2 (1)	**2**	Ignore any suggested changes in u. Allow other reasonable suggestions (e.g. air resistance increases, weighted card may fall less straight over greater fall) with MP1 for possible mechanism and MP2 for effect on $\Delta(v^2 - u^2)$.
(d)	appropriate lines drawn (1); gradient found (needs 'triangle' of base > 0.1 m) and g = gradient/2 calculated (1); (Award this mark for any calculation of gradient to give g correctly done.) 'extreme' line drawn and its gradient found to give an extreme value of g and hence Δg (1)	**3**	Can award MP1 for a single line if only one is drawn. Or steepest possible line drawn and its gradient found (1); shallowest possible line drawn and its gradient found (1); mean gradient and its uncertainty calculated and processed to give $g \pm \Delta g$ (1) If candidate did not halve gradient for MP2, ignore same error in finding Δg No s.f. penalty here as 6(a) examines this issue

Question	Answer	Marks	Guidance
6(e)*	**(Level 3) (5 – 6 marks)** Describes a clear method of taking measurements and deducing *g* from Simon's image **and** makes a judgement on Simon's method compared with Anna's based on the physics of the system. *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)** Describes an essentially correct method of taking measurements and deducing *g* from Simon's image **or** makes a judgement on Simon's method based on the physics of the system, probably with no comparison with Anna's method. *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)** Describes a method of taking measurements from the image but unclear about how to process the data. No scientific comparison of the two methods. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **(0 marks)** Insufficient or irrelevant science. Answer not worthy of credit.	**[6]**	**Indicative scientific points may include:** **How to use Simon's results** • measure positions on image and scale to give displacements • use data to infer speeds (e.g. difference in adjacent distances / 0.033 s) or measure displacements from a start position • process data to get table of *v* against *t* or *s* against t^2 • straight line graph with gradient *g* or ½*g* • any or all of the above can be deduced from the candidate using measurements to obtain *g* (data give 10 m s^{-2}) **Advantages to Anna's method** • greater precision of measurements • can repeat for many different 'drops' • get results quicker **Advantages to Simon's method** • lots of data in the one photo • no external apparatus (light gate, card attached to falling mass) which could affect the fall **Use the L1, L2, L3 annotations in Assessor; do not use ticks.**
	Total	**18**	

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

Education and Learning
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

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Facsimile: 01223 552553