

**GCE**

**Physics A**

**H156/01: Breadth in physics**

Advanced Subsidiary GCE

**Mark Scheme for June 2019**

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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.

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Here are the subject specific instructions for this question paper.

### CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

- B** marks    These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answer.
- M** marks    These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answer. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.
- C** marks    These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.
- A** marks    These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.



### SIGNIFICANT FIGURES

If the data given in a question is to 2 sf, then allow an answer to 2 or more significant figures.

If an answer is given to fewer than 2 sf, then penalise once only in the entire paper.

Any exception to this rule will be mentioned in the Guidance.

Annotations available in RM Assessor

Annotation		Meaning
	Correct response	Used to indicate the point at which a mark has been awarded ( <b>one tick per mark awarded</b> ).
	Incorrect response	Used to indicate an incorrect answer or a point where a mark is lost.
<b>AE</b>	Arithmetic error	Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors.
<b>BOD</b>	Benefit of doubt given	Used to indicate a mark awarded where the candidate provides an answer that is not totally satisfactory, but the examiner feels that sufficient work has been done.
<b>BP</b>	Blank page	Use BP on additional page(s) to show that there is no additional work provided by the candidates.
<b>CON</b>	Contradiction	No mark can be awarded if the candidate contradicts himself or herself in the same response.
<b>ECF</b>	Error carried forward	Used in <u>numerical answers only</u> , unless specified otherwise in the mark scheme. Answers to later sections of numerical questions may be awarded up to full credit provided they are consistent with earlier incorrect answers. Within a question, ECF can be given for AE, TE and POT errors but not for XP.
<b>L1</b>	Level 1	L1 is used to show 2 marks awarded and L1^ is used to show 1 mark awarded.
<b>L2</b>	Level 2	L2 is used to show 4 marks awarded and L2^ is used to show 3 marks awarded.
<b>L3</b>	Level 3	L3 is used to show 6 marks awarded and L3^ is used to show 5 marks awarded.
<b>POT</b>	Power of 10 error	This is usually linked to conversion of SI prefixes. Do not allow the mark where the error occurs. Then follow through the working/calculation giving ECF for subsequent marks if there are no further errors.
<b>SEEN</b>	Seen	To indicate working/text has been seen by the examiner.
<b>SF</b>	Error in number of significant figures	Where more SFs are given than is justified by the question, do not penalise. Fewer significant figures than necessary will be considered within the mark scheme. <b>Penalised only once in the paper.</b>
<b>TE</b>	Transcription error	This error is when there is incorrect transcription of the correct data from the question, graphical read-off, formulae booklet or a previous answer. Do not allow the relevant mark and then follow through the working giving ECF for subsequent marks.
<b>XP</b>	Wrong physics or equation	Used in <u>numerical answers only</u> , unless otherwise specified in the mark scheme. Use of an incorrect equation is wrong physics even if it happens to lead to the correct answer.
<b>^</b>	Omission	Used to indicate where more is needed for a mark to be awarded (what is written is not wrong but not enough).

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

<b>Annotation</b>	<b>Meaning</b>
/	alternative and acceptable answers for the same marking point
<b>Reject</b>	Answers which are not worthy of credit
<b>Not</b>	Answers which are not worthy of credit
<b>Ignore</b>	Statements which are irrelevant
<b>Allow</b>	Answers that can be accepted
( )	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
<b>ECF</b>	Error carried forward
<b>AW</b>	Alternative wording
<b>ORA</b>	Or reverse argument

### SECTION A

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

## SECTION B

**General rule:** For substitution into an equation, allow any subject - unless stated otherwise in the guidance

Question		Answer	Marks	Guidance
21	(a)	Resultant / net / total moment = 0	<b>B1</b>	<b>Allow</b> sum of / $\Sigma$ moments = 0 <b>Allow</b> 'total torque = 0' <b>Allow</b> clockwise moment = anticlockwise moment
	(b)	(i) Earth	<b>B1</b>	<b>Allow</b> planet / ground
		(ii) The forces are not of the same type / The forces act on the same object	<b>B1</b>	<b>Allow</b> The forces do not act on different objects
	(c)	(i) $87.4\cos 50^\circ$ <b>or</b> $68.0\sin 10^\circ$  $F = 68.0$ (N)	<b>C1</b>  <b>A1</b>	<b>Allow</b> $87.4\sin 40^\circ$ <b>or</b> $68.0\cos 80^\circ$ <b>Allow</b> cosine and sine rules being used, e.g. $F^2 = 68.0^2 + 87.4^2 - 2 \times 68.0 \times 87.4 \times \cos 50^\circ$ <b>or</b> $F = 87.4 \times \sin 50^\circ / \sin 80^\circ$ <b>or</b> $F = 68.0 \times \sin 50^\circ / \sin 50^\circ$  <b>Allow</b> 2 SF answer here
		(ii) $68 = m \times 9.81$  $m = 6.9$ (kg)	<b>C1</b>  <b>A1</b>	Possible ECF from (c)(i) <b>Allow</b> $68 = mg$  <b>Note</b> answer to 3 SF is 6.93 (kg) <b>Allow</b> $g = 9.8$ ; this gives 6.94 (kg) <b>Not</b> $g = 10$ ; this gives 6.8 (kg). Only the first C1 mark can be scored
		(iii) $E = \frac{\text{stress}}{\text{strain}}$ (Any subject)  (Tension and $E$ increase by the same factor of 1.29)  ratio = 1.0	<b>C1</b>  <b>A1</b>	<b>Allow</b> $E = \frac{\sigma}{\epsilon}$ <b>or</b> $E = \frac{FL}{Ax}$ (Any subject)  <b>Allow</b> 1 SF answer <b>Allow</b> 1:1
<b>Total</b>			<b>9</b>	

Question		Answer	Marks	Guidance
22	(a)	<p>velocity = <u>gradient</u> or velocity = rate of change of displacement</p> <p>Any <u>three</u> from:</p> <ul style="list-style-type: none"> <li>• speed / (magnitude of) velocity increases (until 0.50 s / hits grounds)</li> <li>• speed / (magnitude of) velocity decreases after 0.50 (s) / hitting ground</li> <li>• direction (of velocity / motion) changes at / after 0.50 (s) / hitting ground</li> <li>• speed / (magnitude of) velocity after impact is smaller than the speed / (magnitude of) velocity before the impact</li> </ul>	<p><b>B1</b></p> <p><b>B1×3</b></p>	<p><b>Ignore</b> any statements about the motion before 0.2 s</p> <p><b>Note</b> this must be <b>clear</b> statement - not implied</p> <p><b>Allow</b> accelerates</p> <p><b>Allow</b> decelerates</p> <p><b>Allow</b> after hitting ground / 0.50 (s) the ball travels up / bounces (back / up) or change in direction (of velocity / motion) indicated by <u>change</u> in sign</p>
	(b)	<p>(s =) 1.23 (m) or (t =) 0.50 (s)</p> <p><math>v^2 = 2 \times 9.81 \times 1.23</math>  <b>or</b> <math>1.23 = 0.50 \times \frac{v}{2}</math>  <b>or</b> <math>1.23 = v \times 0.50 - \frac{1}{2} \times 9.81 \times 0.50^2</math>  <b>or</b> <math>v = 9.81 \times 0.50</math>  <b>or</b> <math>1.23 = \frac{1}{2} \times 9.81 \times t^2</math>; <math>t = 0.50</math> (s) <b>and</b> <math>v = 9.81 \times 0.50</math></p> <p><math>v = 4.9</math> (m s<sup>-1</sup>)</p>	<p><b>C1</b></p> <p><b>C1</b></p> <p><b>A0</b></p>	<p><b>Note</b> there are no marks for gradient calculations here</p> <p><b>Allow</b> s between 1.22 (m) and 1.26 (m)  <b>Allow</b> t between 0.495 (s) and 0.505 (s)</p> <p>Substitution into <math>v^2 = u^2 + 2as</math> with <math>u = 0</math>  Substitution into <math>s = \frac{(v+u)}{2} \times t</math> with <math>u = 0</math>  Substitution into <math>s = vt - \frac{1}{2} at^2</math>  Substitution into <math>v = u + at</math> with <math>u = 0</math>  Substitution into <math>s = ut + \frac{1}{2} at^2</math> and <math>v = u + at</math> with <math>u = 0</math>  <b>Allow</b> <math>g = 9.8</math>  <b>Not</b> <math>g = 10</math>, unless already penalised in <b>21(c)(ii)</b></p>



	(c)	<p>Correct tangent at <math>t = 0.50</math> s with positive gradient</p> <p>Attempt at calculating the gradient of a tangent</p> <p>Gradient calculated in the range 3.20 to 3.80 (<math>\text{m s}^{-1}</math>)</p>	<p><b>B1</b></p> <p><b>M1</b></p> <p><b>A1</b></p>	<p><b>Note</b> must evidence for <math>\Delta s</math> and <math>\Delta t</math> values either here or on Fig. 22</p> <p><b>Allow</b> this M1 mark for tangent not drawn at <math>t = 0.50</math> s</p> <p><b>Note</b> this mark can only be scored if the tangent is drawn at <math>t = 0.50</math> s and the calculated value falls in this range</p>
	(d)	<p><math>(\Delta v =) 4.9 + 3.5</math> or <math>(\Delta v =) 8.4</math> (<math>\text{m s}^{-1}</math>)</p> <p>force = <math>\frac{8.4 \times 0.056}{1.8 \times 10^{-3}}</math></p> <p>force = 260 (N)</p>	<p><b>C1</b></p> <p><b>A1</b></p>	<p>Possible ECF from (c)</p> <p><b>Allow</b> <math>(\Delta p =) (4.9 + 3.5) \times 0.056</math> or <math>(\Delta p =) 0.47</math> (<math>\text{kg m s}^{-1}</math>)</p> <p><b>Allow</b> 1 mark for 44 (N); <math>\Delta v = 4.9 - 3.5</math> used</p> <p><b>Ignore</b> sign</p>
		<b>Total</b>	<b>11</b>	

Question			Answer	Marks	Guidance
23	(a)	(i)	$(R_B =) 9.5 \times 0.40$ or $3.8 (\Omega)$ (parallel resistance =) $[3.8^{-1} + 1.8^{-1}]^{-1}$ or $1.22\dots (\Omega)$ (total resistance =) $1.22\dots + 0.62$ or $1.84 (\Omega)$ $I = \frac{1.4}{1.22\dots + 0.62}$ $I = 0.76 (A)$	<b>C1</b>  <b>C1</b>  <b>C1</b>  <b>A1</b>	Possible ECF from $R_B$  Possible ECF from parallel resistance  Possible ECF from total resistance <b>Allow</b> 3 marks for 0.66 A; $R_B = 9.5 \Omega$ used
		(ii)	$P = IV$ or $P = I^2R$ or $P = \frac{V^2}{R}$  $(P_{\text{int}} =) 0.76^2 \times 0.62$ ; $(P_{\text{total}} =) 1.4 \times 0.76$ ; ratio = $\frac{0.76^2 \times 0.62}{1.4 \times 0.76}$  ratio = 0.34	<b>C1</b>        <b>A1</b>	Possible ECF from (a)(i) <b>Note</b> there are many other correct methods  <b>Allow</b> 0.34:1 <b>Not</b> an answer expressed as a fraction, e.g 31/92
	(b)		Any <u>three</u> from: <ul style="list-style-type: none"> <li>Fig. 23.3 - p.d. split equally / (p.d. across each =) <b>3.0 (V)</b></li> <li>Fig. 23.3 - current = <b>0.36 (A)</b> (from the graph)</li> <li>Fig. 23.4 - p.d. = <b>6.0 (V)</b> (across each or combination)</li> <li>Fig. 23.4 - current (= <math>2 \times 0.50</math>) = <b>1.0(0) (A)</b></li> </ul> $0.36 \times 3 (= 1.08)$ is about 1.0 (A)	<b>M1</b> ×3       <b>A1</b>	<b>Note</b> that each of the M1 mark can be implied in a calculation  <b>Note</b> 8.3.. ( $\Omega$ ) will score the <b>3.0 V</b> and the <b>0.36 A</b> marks <b>Note</b> 12 ( $\Omega$ ) will score the <b>6.0 V</b> mark  <b>Note</b> this mark is for showing that $I_P$ is about 3 times $I_S$
<b>Total</b>				<b>10</b>	

Question		Answer	Marks	Guidance
24	(a)	<p>Clear indication that angles of incidence and refraction are being measured relative to the normals</p> <p>refractive index = <math>\sin i / \sin r</math></p> <p>Any <u>one</u> from:</p> <ul style="list-style-type: none"> <li>• Measure angle(s) using a protractor</li> <li>• Plot <math>\sin i</math> against <math>\sin r</math> graph <b>or</b> average <math>\sin i / \sin r</math> values</li> <li>• Use narrow beam of light (for ray box) / draw thin pencil lines</li> <li>• Conduct experiment in a dark room</li> </ul>	<p><b>B1</b></p> <p><b>B1</b></p> <p><b>B1</b></p>	<p><b>Note</b> this can be scored from a clear diagram. The angles must have sensible labels, e.g. <math>i</math>, <math>r</math>, <math>\theta_1</math>, <math>\theta_2</math>, etc</p> <p><b>Ignore</b> angle of refraction &gt; angle of incidence</p> <p><b>Allow</b> <math>n</math> for refractive index</p> <p><b>Allow</b> <math>n_1 \sin \theta_1 = n_2 \sin \theta_2</math>, as long as all labels have been correctly identified <u>and</u> the refractive index for air/vacuum is taken as 1</p> <p><b>Not</b> <math>n = c/v</math></p>
	(b)	(i)	<p>Straight-line of best fit drawn</p> <p>gradient = 170 (Hz m)</p>	<p><b>B1</b></p> <p><b>B1</b></p> <p><b>Allow</b> value in range 160.0 to 180.0</p>
		(ii)	<p><math>v = f\lambda</math> <b>or</b> <math>\lambda = 2L</math> <b>or</b> <math>v = 2fL</math> (Any subject)</p> <p>Clear steps leading to gradient = <math>\frac{v}{2}</math> using <math>y = mx</math></p>	<p><b>C1</b></p> <p><b>Allow</b> separation between adjacent nodes = <math>\frac{\lambda}{2}</math></p> <p><b>A1</b></p> <p><b>Allow</b> gradient = <math>f \div (\lambda/2)^{-1} = f\lambda/2 = v/2</math></p>
		(iii)	<p><math>v = 2 \times 170</math></p> <p><math>v = 340 \text{ (m s}^{-1}\text{)}</math></p>	<p>Possible ECF from (b)(i)</p> <p><b>B1</b></p>

		(iv)	<p>Decrease frequency / <math>f</math> (ORA)  <math>L / \lambda</math> increases (so, smaller % uncertainty) (ORA)</p> <p><b>or</b></p> <p>Measure distance between several nodes / antinodes  Distance measured is larger (so, smaller % uncertainty)</p> <p><b>or</b></p> <p>Use a small(er) microphone  Easier to locate position of node / antinode (so, smaller % uncertainty)</p>	<p><b>M1</b> <b>A1</b></p> <p><b>M1</b> <b>A1</b></p> <p><b>M1</b> <b>A1</b></p>	<p><b>Allow</b> other sensible suggestions</p> <p><b>Allow</b> increase wavelength / <math>\lambda</math> (ORA)  <b>Allow</b> <math>L</math> increases (so, smaller % uncertainty) (ORA)</p> <p><b>Allow</b> reduce reflection of sound (other than from the wall)</p>
			<b>Total</b>	<b>10</b>	

Question		Answer	Marks	Guidance
25	(a)	Diffraction (of electrons by matter)	B1	
	(b)	(i) $(KE =) 210 \times 1.60 \times 10^{-19} \text{ (J)}$ or $3.36 \times 10^{-17} \text{ (J)}$  $\frac{1}{2} \times 9.11 \times 10^{-31} \times v^2 = 3.36 \times 10^{-17}$  $v = 8.6 \times 10^6 \text{ (m s}^{-1}\text{)}$	C1  C1  A1	Note using $KE = 210 \text{ (J)}$ is wrong physics XP  Note the answer must be to more than 1 SF
		(ii) $\lambda = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 8.6 \times 10^6}$  $\lambda = 8.5 \times 10^{-11} \text{ (m)}$	C1  A1	Possible ECF from (i)  Allow 2 marks for $8.1 \times 10^{-11} \text{ (m)}$ ; $v = 9 \times 10^6 \text{ m s}^{-1}$ used
	(c)	One photon interacts with one electron  energy of photon = (maximum) $KE$ (of electron) + work function (of the metal)  Work function is the <u>minimum energy</u> (required) to remove <u>electron</u> (from the surface of a metal)  Electron removed / photoelectric effect when energy of photon is greater than / equal to work function (of the metal)	B1  B1  B1  B1	Ignore references to frequencies and threshold frequency Allow photoelectron instead of electron throughout  Note an equation is required Allow $hf = KE_{(max)} + \phi$ , with $*hf$ = energy of photon, $KE_{(max)}$ = (maximum) $KE$ (of electron) and $\phi$ = work function *Not $hf$ = Planck constant $\times$ frequency (since there is no reference to 'energy of photon') Allow energy of photons = ..... as BOD  Allow $\phi$ instead of work function for this mark Allow 'work done' instead of 'energy' Allow ... electrons ... as BOD  Allow electron removed / photoelectric effect when $hf > \phi$ or electron removed / photoelectric effect when $hf = \phi$ or electron not removed / no photoelectric effect when $hf < \phi$ Allow electrons and photons as BOD
<b>Total</b>			<b>10</b>	

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