OCR
Oxford Cambridge and RSA

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.

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 (**one tick per mark awarded**).
	Incorrect response	Used to indicate an incorrect answer or a point where a mark is lost.
AE	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.
BOD	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.
BP	Blank page	Use BP on additional page(s) to show that there is no additional work provided by the candidates.
CON	Contradiction	No mark can be awarded if the candidate contradicts himself or herself in the same response.
ECF	Error carried forward	Used in numerical answers only, 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.
L1	Level 1	L1 is used to show 2 marks awarded and L1^ is used to show 1 mark awarded.
L2	Level 2	L2 is used to show 4 marks awarded and L2^ is used to show 3 marks awarded.
L3	Level 3	L3 is used to show 6 marks awarded and L3^ is used to show 5 marks awarded.
POT	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.
SEEN	Seen	To indicate working/text has been seen by the examiner.
SF	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. **Penalised only once in the paper.**
TE	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.
XP	Wrong physics or equation	Used in numerical answers only, 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.
^	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).

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
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

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	
	Total	20	

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	B1	**Allow** sum of / Σ moments = 0 **Allow** 'total torque = 0' **Allow** clockwise moment = anticlockwise moment
	(b)	(i)	Earth	B1	**Allow** planet / ground
		(ii)	The forces are not of the same type / The forces act on the same object	B1	**Allow** The forces do not act on different objects
	(c)	(i)	87.4cos50° **or** 68.0sin10°	C1	**Allow** 87.4sin40° **or** 68.0cos80° **Allow** cosine and sine rules being used, e.g. $F^2 = 68.0^2 + 87.4^2 - 2 \times 68.0 \times 87.4 \times \cos 50°$ **or** $F = 87.4 \times \sin 50°/\sin 80°$ **or** $F = 68.0 \times \sin 50°/\sin 50°$
			F = 68.0 (N)	A1	**Allow** 2 SF answer here
		(ii)	$68 = m \times 9.81$	C1	Possible ECF from **(c)(i)** **Allow** $68 = mg$
			m = 6.9 (kg)	A1	**Note** answer to 3 SF is 6.93 (kg) **Allow** g = 9.8; this gives 6.94 (kg) **Not** 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)	C1	**Allow** $E = \frac{\sigma}{\varepsilon}$ **or** $E = \frac{FL}{Ax}$ (Any subject)
			ratio = 1.0	A1	**Allow** 1 SF answer **Allow** 1:1
			Total	**9**	

Question			Answer	Marks	Guidance
22	(a)				**Ignore** any statements about the motion before 0.2 s
			velocity = <u>gradient</u> **or** velocity = rate of change of displacement	**B1**	**Note** this must be **clear** statement - not implied
			Any <u>three</u> from: • speed / (magnitude of) velocity increases (until 0.50 s / hits grounds)	**B1×3**	**Allow** accelerates
			• speed / (magnitude of) velocity decreases after 0.50 (s) / hitting ground		**Allow** decelerates
			• direction (of velocity / motion) changes at / after 0.50 (s) / hitting ground		**Allow** 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
			• speed / (magnitude of) velocity after impact is smaller than the speed / (magnitude of) velocity before the impact		
	(b)				**Note** there are no marks for gradient calculations here
			(s =) 1.23 (m) **or** (t =) 0.50 (s)	**C1**	**Allow** s between 1.22 (m) and 1.26 (m) **Allow** t between 0.495 (s) and 0.505 (s)
			$v^2 = 2 \times 9.81 \times 1.23$ **or** $1.23 = 0.50 \times \frac{v}{2}$ **or** $1.23 = v \times 0.50 - ½ \times 9.81 \times 0.50^2$ **or** $v = 9.81 \times 0.50$ **or** $1.23 = ½ \times 9.81 \times t^2$; t = 0.50 (s) **and** $v = 9.81 \times 0.50$	**C1**	Substitution into $v^2 = u^2 + 2as$ with $u = 0$ Substitution into $s = \frac{(v+u)}{2} \times t$ with $u = 0$ Substitution into $s = vt - ½ at^2$ Substitution into $v = u + at$ with $u = 0$ Substitution into $s = ut + ½ at^2$ and $v = u + at$ with $u = 0$ **Allow** $g = 9.8$ **Not** $g = 10$, unless already penalised in **21(c)(ii)**
			v = 4.9 (m s^{-1})	**A0**	

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

Question			Answer	Marks	Guidance
23	(a)	(i)	(R_B =) 9.5 × 0.40 **or** 3.8 (Ω)	C1	
			(parallel resistance =) $[3.8^{-1} + 1.8^{-1}]^{-1}$ **or** 1.22… (Ω)	C1	Possible ECF from R_B
			(total resistance =) 1.22.. + 0.62 **or** 1.84 (Ω)	C1	Possible ECF from parallel resistance
			$I = \frac{1.4}{1.22...+0.62}$		
			I = 0.76 (A)	A1	Possible ECF from total resistance **Allow** 3 marks for 0.66 A; R_B = 9.5 Ω used
		(ii)	$P = IV$ **or** $P = I^2R$ **or** $P = \frac{V^2}{R}$	C1	
			(P_{int} =) $0.76^2 \times 0.62$; (P_{total} =) 1.4 × 0.76; ratio = $\frac{0.76^2 \times 0.62}{1.4 \times 0.76}$		Possible ECF from **(a)(i)** **Note** there are many other correct methods
			ratio = 0.34	A1	**Allow** 0.34:1 **Not** an answer expressed as a fraction, e.g 31/92
	(b)		Any <u>three</u> from: • Fig. 23.3 - p.d. split equally / (p.d. across each =) **3.0** (V) • Fig. 23.3 - current = **0.36** (A) (from the graph) • Fig. 23.4 - p.d. = **6.0** (V) (across each or combination) • Fig. 23.4 - current (= 2 × 0.50) = **1.0**(0) (A)	M1×3	**Note** that each of the M1 mark can be implied in a calculation **Note** 8.3.. (Ω) will score the **3.0** V and the **0.36** A marks **Note** 12 (Ω) will score the **6.0** V mark
			0.36 × 3 (= 1.08) is about 1.0 (A)	A1	**Note** this mark is for showing that I_P is about 3 times I_S
			Total	**10**	

Question			Answer	Marks	Guidance
24	(a)		Clear indication that angles of incidence and refraction are being measured relative to the normals	B1	**Note** this can be scored from a clear diagram. The angles must have sensible labels, e.g. i, r, θ_1, θ_2, etc **Ignore** angle of refraction > angle of incidence
			refractive index = sin$i$/sin$r$	B1	**Allow** n for refractive index **Allow** $n_1\sin\theta_1 = n_2\sin\theta_2$, as long as all labels have been correctly identified and the refractive index for air/vacuum is taken as 1 **Not** $n = c/v$
			Any one from: • Measure angle(s) using a protractor • Plot sin$i$ against sin$r$ graph **or** average sin$i$ /sin$r$ value**s** • Use narrow beam of light (for ray box) / draw thin pencil lines • Conduct experiment in a dark room	B1	
	(b)	(i)	Straight-line of best fit drawn	B1	
			gradient = 170 (Hz m)	B1	**Allow** value in range 160.0 to 180.0
		(ii)	$v = f\lambda$ **or** $\lambda = 2L$ **or** $v = 2fL$ (Any subject)	C1	**Allow** separation between adjacent nodes = $\frac{\lambda}{2}$
			Clear steps leading to gradient = $\frac{v}{2}$ using $y = mx$	A1	**Allow** gradient = $f \div (\lambda/2)^{-1} = f\lambda/2 = v/2$
		(iii)	$v = 2 \times 170$		Possible ECF from **(b)(i)**
			$v = 340$ (m s^{-1})	B1	

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

Question			Answer	Marks	Guidance
25	(a)		Diffraction (of electrons by matter)	B1	
	(b)	(i)	(KE =) 210 × 1.60 × 10^{-19} (J) **or** 3.36 × 10^{-17} (J)	C1	**Note** using KE = 210 (J) is wrong physics XP
			½ × 9.11 × 10^{-31} × v^2 = 3.36 × 10^{-17}	C1	
			v = 8.6 × 10^6 (m s^{-1})	A1	**Note** the answer must be to more than 1 SF
		(ii)	$\lambda = \frac{6.63\times10^{-34}}{9.11\times10^{-31}\times 8.6\times10^{6}}$	C1	Possible ECF from **(i)**
			λ = 8.5 × 10^{-11} (m)	A1	**Allow** 2 marks for 8.1 × 10^{-11} (m); v = 9 × 10^6 m s^{-1} used
	(c)		One photon interacts with one electron	B1	**Ignore** references to frequencies and threshold frequency **Allow photo**electron instead of electron throughout
			energy of photon = (maximum) KE (of electron) + work function (of the metal)	B1	**Note** an equation is required **Allow** $hf = KE_{(max)} + \phi$, with *hf = energy of photon, $KE_{(max)}$ = (maximum) KE (of electron) and ϕ = work function ***Not** hf = Planck constant × frequency (since there is no reference to 'energy of photon') **Allow** energy of photon**s** = ……. as BOD
			Work function is the **minimum energy** (required) to remove **electron** (from the surface of a metal)	B1	**Allow** ϕ instead of work function for this mark **Allow** 'work done' instead of 'energy' **Allow** … electron**s** …. as BOD
			Electron removed / photoelectric effect when energy of photon is greater than / equal to work function (of the metal)	B1	**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** electron**s** and photon**s** as BOD
			Total	10	

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