OCR
Oxford Cambridge and RSA

GCE

Physics A

H156/02: Depth in physics

Advanced Subsidiary GCE

Mark Scheme for November 2020

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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.

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 answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

A marks These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to 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.

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 answers.

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

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, formulæ 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

Question			Answer	Marks	Guidance
1	(a)	(i)	Vibrations or oscillations parallel to direction of travel of the wave / direction of energy transfer	B1	
		(ii)	Amplitude of 2 cm (in each direction)	B1	
			Sinusoidal shape (by eye) with period of 4 cm – at least two waves	B1	Check peak, equilibrium and trough positions
	(b)	(i)	Microwave: 2 cm	B1	
			X-ray 200 pm	B1	
		(ii)	Any two from: May be reflected / refracted / diffracted / interference May be polarised Travel in a vacuum (at a constant speed / 3 x 10^8 m s^{-1}) Oscillation of electric and magnetic fields.	B1 x 2	**Allow** speed of light
			Total	7	

Question			Answer	Marks	Guidance
2	(a)	(i)	$(f = v/\lambda) = 3.00 \times 10^{8} \div 4.69 \times 10^{-7}$ (= 6.40 x 10^{14} Hz)	B1	6.397 x 10^{14} Hz
		(ii)	1.96×10^{8} (ms^{-1})	B1	
			3.07×10^{-7} (m)	B1	**Allow** 3.06×10^{-7} (m) (uses **(i)**) **Not** ECF for incorrect speed
	(b)	(i) 1.	$p = 30°$	B1	
		2.	sin $q = 0.5 \times 1.53$ or 0.765	C1	
			$q = 50°$	A1	**Allow** 49.9° **Note** 19 ° does not score
		(ii)	p always equals i or p increases with i / when $i = 60°$, $p = 60°$	B1	
			Any three from:	B1 x3	
			as i increases, q increases (until i equals the critical angle)		
			when i = critical angle, $q = 90°$		
			critical angle = 41°		
			when i is greater than critical angle, <u>total internal reflection</u> occurs		
			when $i = 60°$, there is no angle q or no refracted ray		**Not** $q = 0$
	(c)		Straight line to centre of block and reflects along original ray P	B1	
			Straight line to centre of block and refracts with angle q less than 49.9° but greater than 30°	B1	
			Total	12	

Question			Answer	Marks	Guidance
3	(a)	(i)	points <u>on the line</u> read to the nearest half square size of triangle is greater than half the length of the drawn line <u>and</u> Δy / Δx	B1 B1	**Allow** Δy for $y_2 - y_1$ and Δx for $x_2 - x_1$ $\Delta x \geq 0.1625$
		(ii)	$\left(\frac{9.81}{0.12}\right) = 81.75$ 82 N m^{-1} given to 2 or 3 significant figures	C1 A1	**Allow** ECF from (a)(i) **Allow** 81.8 N m^{-1} **Note** POT must be correct for given unit **Allow** kg s^{-2}
	(b)	(i)	steepest or shallowest line <u>that passes through all the error bars</u>	B1	
		(ii)	gradient determined: 0.10 m kg^{-1} or 0.13 m kg^{-1}	B1	**Allow ECF** from (b)(i)
		(iii)	Δgradient (0.13 - 0.12 or 0.12 - 0.10) $\frac{\Delta\text{gradient}}{\text{gradient}} \times 100 = 8.3\%$ or 17% OR Δk (82 – 75 or 98-82) $\frac{\Delta k}{k} \times 100 = 8.5\%$ or 20%	C1 A1 C1 A1	**Allow ECF** from (b)(i) and (ii) **Not** 10% without justification
			Total	8	

Question			Answer	Marks	Guidance
4			**Level 3 (5–6 marks)** Detailed procedure including labelled diagram and measurements to be taken **and** detailed analysis *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)** A diagram, some procedure, some measurements and some analysis **or** detailed analysis and limited procedure with limited diagram **or** detailed procedure including diagram and measurements to be taken and limited analysis *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)** Limited procedure and limited measurements **or** limited analysis *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.	**B1 x 6**	**Indicative scientific points may include:** **Diagram and procedure** • labelled diagram • horizontal surface supported • description of procedure • method to release ball • method to identify position ball hits the ground • repeats experiment for each *v* • method to prevent ball rolling on floor in laboratory **Measurements** • measuring instruments to determine *v* • measurements to determine *v* e.g. *mgh* conversion or one light gate with diameter of ball measured or two light gates with distance between light gates measured • use of ruler to measure *R*. **Analysis** • equation to determine *v* • appropriate graph, e.g. plot *R* against *v* or plot R^2 against v^2 • Expect straight line passing through origin • $Q = g$ x gradient^2 or $Q = g$ x gradient
			Total	**6**	

Question			Answer	Marks	Guidance
5	(a)		20 (m s^{-1})	B1	
	(b)		(After 0.75 s) gradient <u>decreases</u> with time Indicating velocity is decreasing/ deceleration	M1 A1	
	(c)		Tangent drawn at t = 1.75 s (judge by eye) Gradient in the range 11.0 (m s^{-1}) to 13.0 (m s^{-1})	B1 B1	
	(d)		∆time = 1.75 – 0.75 OR 3.25 - 0.75 Using **(c):** $F = 950 \times \frac{20-12}{1.75-0.75}$ or using graph: $F = 950 \times \frac{20-0}{3.25-0.75}$ or $F = \frac{950 \times 20}{3.25-0.75}$ 7600 (N)	C1 C1 A1	**Allow** use of **(c)** and **(a)** **Allow** a= 8.0 m s^{-2} for $v^2=u^2+2as$ or $s=ut+\frac{1}{2}at^2$ methods **Not** ECF for incorrect time **Ignore** sign
	(e)		Maximum of two from: (thinking) time is the same (braking) time is halved / 1.25 s total time is 2 s **AND** maximum of two from: (thinking) distance / displacement travelled (before braking) halved / 7.5 m (braking) distance / displacement quarters / 6.25 m total distance / displacement = 13.75 m	B1 x 3	
			Total	11	

Question			Answer	Marks	Guidance
6	(a)		$\pi \times \frac{(32\times10^{-3})^2}{4} \times 100 \times 10^{-3}$ or 8.04×10^{-5}	C1	**Ignore** POT
			$\frac{7.0}{9.81}$ or 0.714	C1	
			8900 (kg m^{-3})	A1	8881 2200 scores two marks
	(b)	(i)	4.4 – 4.6 (N)	B1	
		(ii)	Weight of cylinder 3.5 cm vertically (judge by eye)	M1	
			Correct closed triangle drawn including T_A	M1	
			Correct directions indicated for weight and T_A and T_A = 6.4 ± 0.2 (N)	A1	
		(iii)	39 ± 1°	A1	**Allow ECF** from **(b)(ii)** for trigonometry methods
	(c)		F x 100 or 7.0 x 16	C1	**Ignore** POT
			$F = \frac{7.0\ x\ 16}{100} = 1.1$ (N)	A1	1.12 **Not** 1.067
			Total	10	

Question			Answer	Marks	Guidance
7	(a)	(i)	$R = \frac{150}{1.5^2}$ 67 Ω	C1 A1	**Allow** $V = \frac{150}{1.5} = 100$ V and $R = \frac{100}{1.5}$
		(ii)	Q = 1.5 x 5.0 x 60 x 60 or 27000 $N = \frac{1.5 \times 5.0 \times 60 \times 60}{1.6 \times 10^{-19}}$ = 1.7 x 10^{23}	C1 A1	**Note** use of 150 (W) does not score 1.7 x 10^{25} 1.68 x 10^{23} 4.7 x 10^{19} scores one mark **Not** 1.7 x 10^{25} (uses 150 W)
		(iii)	$v = \frac{1.5}{7.9 \times 10^{28} \times 4.1 \times 10^{-9} \times 1.6 \times 10^{-19}}$ 0.029 (m s^{-1})	C1 A1	
	(b)		150 (x 10^{-3}) x 5 x 16 12 (p)	C1 A1	**Not** time in minutes or seconds **Allow** ECF for POT on power
	(c)		Silicon will have a smaller number density, ORA Silicon will have a larger resistivity, ORA	B1 B1	**Allow** semiconductor for silicon; metal for nichrome
			Total	10	

Question			Answer	Marks	Guidance
8			**Level 3 (5–6 marks)** Description and explanation of pattern changes **and** quantitatively explains link between de Broglie wavelength and potential difference. *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)** Clear description of how pattern changes and explanation of pattern changes and qualitatively explains link between de Broglie wavelength and potential difference **or** limited description of how pattern changes and quantitatively explains link between de Broglie wavelength and potential difference. *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)** Limited description of how pattern changes and limited attempts to explain qualitatively the link between de Broglie wavelength and potential difference **or** qualitatively explains link between de Broglie wavelength and potential difference. *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** No response or no response worthy of credit.	**B1 x 6**	***Indicative scientific points may include:*** ***Description of pattern changes*** • Rings become closer (not just smaller) • Rings become brighter ***Qualititative explanation of pattern changes in terms of de Broglie wavelength and potential difference*** • Electrons gain greater energy • Electrons have a greater speed • Electrons have a greater momentum • Implies smaller wavelength • Smaller wavelength means less diffraction • Shorter wavelength gives shorter path differences between areas of constructive and destructive interference ***Quantitative explanation of pattern changes in terms of de Broglie wavelength and potential difference*** • $eV = \frac{1}{2}mv^2$ • $p = mv$ • $v^2 \propto V$ or $p^2 \propto V$ • $\lambda = \frac{h}{p}$ or $\lambda \propto \frac{1}{v}$ • $\lambda = \frac{h}{\sqrt{2meV}}$ or $\lambda \propto \frac{1}{\sqrt{V}}$

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