Oxford Cambridge and RSA

GCE

Physics A

H156/02: Depth in physics

Advanced Subsidiary GCE

Mark Scheme for Autumn 2021

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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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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, 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)		Constant phase difference (between two or more waves)	B1	**Ignore** in phase
	(b)	(i)	0.08 (m)	A1	
		(ii)	π (rad)	A1	
		(iii)	path difference = $\lambda / 2$ or 2×0.08 0.16 (m)	M1 A0	**Allow** ECF from **(b)(i)** **Allow** path difference shown at K
	(c)	(i)	period determined <u>using timebase</u> frequency = 1 / period	B1 B1	 **Allow** one mark for $f = 1 / T$ without T being defined
		(ii)	$v = 2.1 \times 10^3 \times 0.16$ 340 (m s^{-1})	C1 A1	**Allow ECF** from **(b)(iii)** 336 (3sf) **Allow** one mark for 0.336 or 0.34
			Total	8	

Question			Answer	Marks	Guidance
2	(a)	(i)	(Area under graph =) energy / elastic potential energy	B1	**Allow** work done on the elastic band
		(ii)	(Area of) 1cm^2 is 0.025 × 2.5 J or 0.0625 J (31 × 0.0625 =) 1.9 (J)	C1 A1	**Allow** other alternatives. **Do not accept** 0.5*Fx*
		(iii)	Energy transferred to the surroundings/ heating the rubber	B1	
	(b)	(i)	$\frac{49}{1.4 \times 10^{-7}}$ 3.5 × 10^8 Pa	C1 A1	
		(ii)	$\frac{3.5 \times 10^8}{180 \times 10^9}$ 0.0019	C1 A1	**Allow ECF** from **(b)(i)** **Ignore** units
		(iii)	0.0019 ×2.2 0.0042 (m)	C1 A1	**Allow ECF** from **(b)(i)** and **(ii)** **Allow** 0.0043 (m)
		(iv)	$\frac{1}{2} \times 49 \times 0.0043$ 0.10 (J)	C1 A1	**Allow ECF** from (**b)(i)**, **(ii)** and **(iii)** **Do not accept** 1sf
	(c)		Area increases by a factor of four / extension decrease by factor of four Elastic strain energy decreases by a factor of four	M1 A1	
			Total	**14**	

Question			Answer	Marks	Guidance
3	(a)		**Level 3 (5–6 marks)** Clear explanation of terms **and** explanation of results correctly comparing momentum and kinetic energy. *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 explanation of terms **and** limited explanation of results comparing momentum **or** limited explanation of terms **and** some explanation of results **or** correct comparison of momentum and kinetic energy. *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)** Has limited explanation of terms **or** limited comparison of momentum / kinetic energy. *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:*** ***Explanation of terms*** • $p = mv$ • $E_k = \frac{1}{2}mv^2$ • Total momentum conserved in all collisions • Total energy conserved in all collisions • E_k conserved in elastic collision • E_k NOT conserved in inelastic collision • Speed of approach = speed of separation in elastic collision ***Explanation of results*** • Initial p_A = 15 kg cm s^{-1} or 0.15 kg m s^{-1} • Initial E_{kA} = 0.015 J • Expt 1: ○ Speed of separation = 0.150 + 0.050 = 0.200 m s^{-1} ○ p_A after collision = (-) 0.375 kg m s^{-1} ○ p_B after collision = 0.1875 kg m s^{-1} ○ Total p after collision = 0.15 kg m s^{-1} ○ E_{kA} after collision = 0.0009375 J ○ E_{kB} after collision = 0.0140625 J ○ Total E_k after collision = 0.015 J ○ Collision is elastic since E_k conserved • Expt 2: ○ p after collision = 0.15 kg m s^{-1} ○ E_k after collision = 0.005625 J ○ Collison is inelastic since E_k not conserved • Momentum conserved in both collisions
	(b)		Area under graph = 0.5 × 0.4 × 18 or 3.6 $\frac{3.6}{0.045}$ 80 (m s^{-1})	**C1** **C1** **A1**	**Allow** alternative methods
			Total	**9**	

Question			Answer	Marks	Guidance
4	(a)	(i)	$\pi \times \frac{(2.9\times10^{-2})^2}{4}$ or $\pi \times (1.45\times10^{-2})^2$ 6.605×10^{-4} m^2 $\approx 6.6 \times 10^{-4}$	M1 A0	
		(ii)	$V = 6.6\times10^{-4} \times 12.0$ or 7.92×10^{-5} (m^3) $m = 400 \times 7.92 \times 10^{-5}$ or 0.03168 kg W = 0.31 (N)	C1 C1 A1	**Ignore** POT
	(b)		$V = \frac{0.31}{1000\times 9.81}$ or 3.16×10^{-5} $y = \frac{3.16\times10^{-5}}{6.6\times10^{-4}}$ y = 0.048 (m)	C1 C1 A1	Mass of water displaced = $\frac{0.31}{9.81} = 0.316$ $y = \frac{0.316}{1000\times6.6\times10^{-4}}$
	(c)		y = 0.053 m Same weight/mass displaced of oil Smaller density implies larger volume of oil displaced y is larger OR y α $1/\rho$	B1 B1 B1 B1	
			Total	**11**	

Question			Answer	Marks	Guidance
5	(a)		$\Sigma E = \Sigma V$ *or* $\Sigma E = \Sigma Ir$ $E = V + Ir \Rightarrow V = E - Ir$	C1 A1	
	(b)		E = y–intercept r = – gradient	B1 B1	E must be the subject R must be the subject **Do not accept** gradient = $-r$
	(c)	(i)	$\left(R = \frac{5.68}{0.025} =\right) 230\ \Omega$	A1	**Allow** 227
		(ii)	$\left(\frac{5.68^2}{\textbf{(c)(i)}} \text{ or } 0.025^2 \times \textbf{(c)(i)} \text{ or } 0.025 \times 5.68 =\right) 0.14$ 0.14 x 300 = 42 (J)	C1 A1	**Allow ECF** from **(c) (i)** 0.140 or 0.142 or 0.144 **Allow** 43 (J) (for 0.142 or 0.144)
		(iii)	$\left(Q = \frac{\text{(c)(ii)}}{5.68} \text{ or } 0.025 \times 300 =\right) 7.4 \text{ or } 7.5$ C	B1 B1	**Allow ECF** from **(c) (ii)**
			Total	9	

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Question			Answer	Marks	Guidance
6			**Level 3 (5–6 marks)** Correct circuit diagram **and** explanation including detailed calculations **and** explanation of circuit for different light intensities. *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 calculations / explanation. *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 diagram with incorrect position of voltmeter and limited calculations / explanation OR correct diagram with correct symbols. *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:** **Circuit Diagram** • Potential divider circuit • Correct symbols • Battery/power supply of at least 6.0 V • Voltmeter • Voltmeter correctly positioned across fixed resistor. **Explanation and calculations** • Potential divider equation • Appropriate value of fixed/variable resistor • V_{out} calculated when LDR is in very bright light / resistance value calculated • V_{out} calculated when LDR does not receive light / or resistance value calculated. **Explanation for different light intensities** • Use of variable resistor • Effect of increasing/decreasing the resistance of the fixed resistor.
			Total	**6**	

Question			Answer	Marks	Guidance
7	(a)	(i)	points from the graph read to the nearest half square	B1	**Allow** Δy and Δx to less than half a small square **Ignore** POT
			size of triangle is greater than half the length of the drawn line and Δy / Δx with correct power of ten shown	B1	**Note** triangle may be determined from read-offs Δx must be greater than 0.3×10^6
		(ii)	$h = \frac{1.2 \times 10^{-6} \times 1.60 \times 10^{-19}}{3.00 \times 10^{8}}$ or (a)(i) $\times 5.333 \times 10^{-28}$	C1	
			6.4×10^{-34} (J s) given to 2 significant figures	A1	
		(iii)	steepest or shallowest line that passes through all the error bars	B1	**Note** steepest line passes inside the lowest error bar (1.76) since it just cuts the bottom of second error bar.
		(iv)	gradient determined: 1.0×10^{-6} V m or 1.4×10^{-6} V m	M1	**Allow** ecf from **(iii)**
			$\Delta\text{gradient} = 0.2 \times 10^{-6}$ V m	C1	**Allow** Δh = 1.06 or 1.067
			$\frac{\Delta\text{gradient}}{\text{gradient}} \times 100$ = 15%	A1	**Allow** 16.7%
	(b)	(i)	4.1 eV = 6.56×10^{-19} (J)	C1	
			$\frac{6.63 \times 10^{-34} \times 3.00 \times 10^{8}}{98 \times 10^{-9}}$ *or* 2.03×10^{-18}	C1	**Allow** 1.96×10^{-18} for use of 6.4×10^{-34} (J s)
			1.4×10^{-18} (J)	A1	**Allow** 1.3×10^{-18} (J) for use of 6.4×10^{-34} (J s)
		(ii)	KE is independent of intensity (for constant wavelength) / intensity only affects the number of photons	M1	**Allow** decreasing intensity, decreases the number of photons / energy of a photon only depends on frequency or wavelength
			No change in KE_{max}	A1	
			Total	13	

OCR (Oxford Cambridge and RSA Examinations)
The Triangle Building
Shaftesbury Road
Cambridge
CB2 8EA

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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