OCR
Oxford Cambridge and RSA

GCE

Physics A

Unit **H156/02:** Depth in physics

Advanced Subsidiary GCE

Mark Scheme for June 2018

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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 answers.

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.

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 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 Additional 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

Question			Answer	Marks	Guidance
1	(a)		Deceleration is indicated by the negative gradient/slope (between t =1.5 to t =4.5)	B1	
			A straight line/constant (negative) gradient (between t =1.5 to t =4.5) (indicates constant deceleration)	B1	Constant negative gradient scores two marks
	(b)		area under graph = displacement or distance	C1	**ALLOW** $s = \frac{(u+v)}{2}t$ or $s = ut + \frac{1}{2}at^2$ and a=14/3
			$\frac{1}{2} \times 3 \times 14 = 21$ (m)	M1	$\frac{(14+0)}{2} \times 3$ OR 7×3 **Allow** ECF for mis read of t or v
			1 (m)	A1	**Do not accept** t = 4.5 **Ignore** "-" sign
			Total	**5**	

Question			Answer	Marks	Guidance
2			**Level 3 (5–6 marks)** Clear diagrams and procedure and measurements **and** 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. *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** **x6**	**Indicative scientific points may include:** **Diagram and procedure** • labelled diagram • correct circuit diagram • description of procedure • use of cushion in case load falls • repeats experiment. **Measurements** • use of balance to measure load • use of ruler to measure height • use stopwatch to measure time • use of ammeter to measure current • use of voltmeter to measure p.d. **Analysis** • equation to determine input power/energy (IV/IVt) • equation to determine output power/energy (*mgh*/*t* or *mgh*) • equation to determine efficiency • use of gradient of appropriate graph
			Total	**6**	

Question			Answer	Marks	Guidance
3	(a)		*h* measured with a metre rule/ruler (electronic) timer/data logger (started and stopped electronically) Method to start timer (and release ball), e.g. electromagnet or light gate to start timer Method to stop timer, e.g. trap door, second light gate	B1 B1 B1 B1	**Allow** metre stick, tape measure **Not** stopwatch **Allow** one mark for use light gates without reference to timer/starting/stopping
	(b)		0.185 (s^2)	B1	
	(c)	(i)	Plots one missing plot to less than a half small square Draws straight line of best fit	B1 B1	**Allow** ECF from **(b)** **Allow** ECF Expect to be balance of points about line of best-fit. Judge straightness by eye. **Not** thick lines, multiple lines
		(ii)	Determines gradient correctly and gradient in the range 0.210 to 0.225	B1	Ignore significant figures.
	(d)	(i)	Evidence of use of $s = ut + \frac{1}{2}at^2$ (and $u = 0$) Manipulation leading to $t^2 = \left(\frac{2}{g}\right)h$	B1	
		(ii)	$g = \frac{2}{\text{(c)ii}}$ and given to 2 or 3 s.f.	B1	**Note**: Possible ecf from (c)(ii) **Ignore** rounding
			Total	10	

Question			Answer	Marks	Guidance
4	(a)		(weight of plank =) 50 x 9.81 or 490.5 OR uses a distance of 0.7m to calculate clockwise moment	C1	
			(anticlockwise moment =) $T\sin30° \times 1.5$ OR $0.75T$	C1	**Allow** $T\cos60° \times 1.5$
			(clockwise moment =) $490.5 \times 0.7 = 343$ (N m)	C1	**Allow** 344,
			$T\sin30° \times 1.5 = 343$ OR $T\sin30° = 229$	C1	
			$T = 457.8$ (N)	A0	**Allow 458.6**,
	(b)		$x = \frac{TL}{EA}$	C1	**Note** x must be the subject **Allow** alternative methods e.g. determines stress (4.18×10^7 Pa) C1 determines strain (1.99×10^{-4}) C1 determines x
			$x = \frac{460 \times 1.73}{210 \times 10^9 \times 11 \times 10^{-6}}$	C1	
			$x = 3.45 \times 10^{-4}$ (m)	A1	**Allow** 3.4, 3.5, 3.43, 3.44 **Allow** 2 marks for 3.45×10^n
			Total	7	

Question			Answer	Marks	Guidance
5	(a)		(Resultant) force is (directly) proportional to the rate of change of momentum.	B1	**Allow** equation with symbols defined. **Allow** equal for proportional **Ignore** reference to direction **Ignore** F=ma
	(b)	(i)	0.868 or 0.87	B1	**Allow** – 0.868 or – 0.87
		(ii)	change in momentum = $0.5 \times 17 \times 0.18$ or 1.53 (N s)	C1	**ECF** from (b)(i)
			Momentum of tennis ball = 1.53 – 0.868 = 0.662	C1	Or $0.062(v - -14) = 1.53$
			v = 0.662/0.062 = 10.6 or 10.7 (m s^{-1}) = 11 (m s^{-1})	A1	Or v = 24.7 -14 = 10.7 **Allow** 1 mark for 24.7 (m s^{-1}) or 38.7 (m s^{-1})
		(iii)	For an elastic collision, kinetic energy/KE is conserved	B1	**Allow** speed of approach = speed of separation
			speeds are different (so for the same mass KE is different)	B1	**Allow** correct calculations of KE for both speeds **Ignore** reference to the ball heating up
			Total	7	

Question			Answer	Marks	Guidance
6	(a)		**X** (filament) lamp **Y** (fixed)(ohmic) resistor	 **B1**	**Allow** ptc thermistor / heater element **Not** metallic conductor
	(b)		I_x = 0.5 A and I_Y = 0.36 A OR I= 0.86 A 9.6V – 7.2V or 2.4 V $r = \frac{9.6-7.2}{0.86} = 2.8\ \Omega$	**C1** **C1** **A1**	**Allow** Alternative correct methods 2.79 Ω
	(c)	(i)	Micrometer Repeat readings in different directions/along wire/different wires and average	**B1** **B1**	**Allow** calliper **Not** vernier scale
		(ii)	$A = \frac{\pi \times (0.12\times10^{-3})^2}{4} = 1.13 \times 10^{-8}$ OR $\rho = \frac{1.86\times A}{21}$ $\rho = \frac{17 \times 1.86 \times 1.1 \times 10^{-8}}{21}$ $\rho = 1.7 \times 10^{-8}$ (Ω m)	**C1** **C1** **A1**	**Note** ρ must be the subject **Allow** 2 marks for 1.0×10^{-9} (factor of 17 omitted) **Allow** 2 marks for 6.8×10^{-8} (diameter used instead of radius) **Allow** 2 marks for 0.017 (POT omitted)
		(iii)	$\frac{0.1}{21}$ or $\frac{0.02}{1.86}$ or $\frac{0.01}{0.12}$ $\left(\frac{0.1}{21} + \frac{0.02}{1.86} + 2 \times \frac{0.01}{0.12}\right) \times 100 = 18\ (.2)\%$	**C1** **A1**	**Allow** max/min methods $\rho_{max} = 2.03 \times 10^{-8}$ and $\rho_{min} = 1.41 \times 10^{-8}$ (B1) $\frac{\Delta\rho}{\rho} x100$ (B1) **Allow** 17.8% Do not penalise significant figures **Allow** 1 mark for 9.88% **Allow** 20% with evidence of working
			Total	**11**	

Question			Answer	Marks	Guidance
7	(a)		**Level 3 (5–6 marks)** Clear explanation of observations **and** correct determination of frequency. *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 observations **or** correct method to determine the frequency **or** some explanation of observations and some method for the determination of the frequency *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 observations **or** limited evidence of method to determine the frequency *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 x6**	**Indicative scientific points may include:** Explanation of observations • Metal sheet reflects microwaves • Idea/description of superposition • Constructive/destructive interference • Standing wave pattern between T and plate • Maxima are antinodes and and minima are nodes. • Phase difference at nodes and antinodes • Distance between successive maxima/minima is *λ/2* • Distance between adjacent regions of maximum and minimum intensities is *λ/*4 Determination of frequency • $f = \frac{v}{\lambda}$ • λ = 4 x 72 mm = 288 mm • $f = \frac{3\times10^8}{288\times10^{-3}} = 1.04 \times 10^9 \text{Hz}$
	(b)		Microwaves from **T** are transverse/polarised wtte At 0° or 180° the grille blocks (all) the (polarised) waves and at 90°the grille allows all the microwaves to pass.	**B1** **B1**	**Allow** E field perpendicular to direction of motion **Allow** explanation in terms of $I = I_0\cos^2\theta$
			Total	**8**	

Question			Answer	Marks	Guidance
8	(a)	(i)	1.36 1.97×10^{8}	B1 B1	**Not** 1.3 or 1.4 **Not** 1.9 or 2.0
		(ii)	$\left(\frac{5.2\times10^{-7}}{1.52}=\right)$ $3.4(2) \times 10^{-7}$ (m)	B1	**Allow** 3.41×10^{-7} (m) **Not** ECF from (a)(i)
	(b)	(i)	$\sin\theta = \frac{\sin 37}{1.52} (= 0.39593)$ $\theta = 23(.3)°$	C1 A1	
		(ii)	Ray in glass bends towards normal and ray in ethanol bends away from normal but at a smaller angle than 37° Rays are straight by eye	B1	**Note** Ray should not be parallel to incoming ray. **Not** angle of refraction is zero in glass
			Total	6	

Question			Answer	Marks	Guidance
9	(a)	(i)	Energy of a photon	B1	**Ignore** *h* is Planck constant and *f* is frequency
		(ii)	Minimum energy required to remove/emit (a single) electron from the metal surface	B1	**Ignore** 'it is work function' **Ignore** photoelectric effect
	(b)	(i)	4.1 eV = = $4.1 \times 1.6 \times 10^{-19}$ or 6.56×10^{-19} J OR $E_k = 6.63 \times 10^{-34} \times 1.2 \times 10^{15} - \phi$ $E_k = 6.63 \times 10^{-34} \times 1.2 \times 10^{15} - 6.56 \times 10^{-19}$ $E_k = 1.39 \times 10^{-19}$J $v = \sqrt{\frac{2 \times 1.39 \times 10^{-19}}{9.11 \times 10^{-31}}} = \sqrt{3.06 \times 10^{11}}$ 5.536×10^5 m s^{-1}	C1 C1 C1 C1 A0	**Allow** $f_0 = 9.9 \times 10^{14}$ Hz **Allow** $E_k = 6.63 \times 10^{-34} \times (1.2 \times 10^{15} - 9.9 \times 10^{14})$ **Allow** 1.4×10^{-19} J 3.06×10^{11} scores three marks
		(ii)	Maximum energy is independent of intensity/(number of photons has increased but) energy of photon is the same/energy of a photon is only dependent on frequency/intensity affects the number of photons/electrons released only/frequency of photon has not changed No change in maximum speed	M1 A1	 **Not "**Does not increase"
	(c)		$\lambda\left(=\frac{h}{mv}\right) = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 5.5 \times 10^5}$ $= 1.3(2) \times 10^{-9}$ (m)	C1 A1	
			Total	10	

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