OCR
Oxford Cambridge and RSA

GCE

Physics B

Unit **H157/01:** Foundations of physics

Advanced Subsidiary GCE

Mark Scheme for June 2016

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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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Annotations available in RM Assessor

Annotation	Meaning
BOD	Benefit of doubt given
CON	Contradiction
	Incorrect response
ECF	Error carried forward
L1	Level 1
L2	Level 2
L3	Level 3
TE	Transcription error
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
SF	Error in number of significant figures
	Correct response
	Wrong physics or equation

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
(1)	Separates marking points
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

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.

Note about 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.

Section A: MCQs

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

Section B

Question			Answer	Marks	Guidance
21	(a)		apple in range 0.9 to 5 (N) ✓	1	**Accept** order of magnitude answers if clear and within the accepted range e.g. order of magnitude = 0 would gain the mark for this
21	(b)		current in range 3 to 13 (A) ✓	1	**Accept** order of magnitude answers if clear and within the accepted range
21	(c)		volume in range 0.1 to 1.0 (m^3) ✓	1	**Accept** order of magnitude answers if clear and within the accepted range
			Total	3	

Question			Answer	Marks	Guidance
22	(a)		(transverse) waves that have one direction / plane of oscillation / vibration ✓	1	**NOT** move in one plane
22	(b)		(starts at 0º max then) drops to zero / minimum at 90º, and then increases / back to max (at 180º) ✓	1	both points for 1 mark
			Total	2	

Question			Answer	Marks	Guidance
23	(a)		16 levels / $2^4 = 16$ / $\log_2 16$ ✓ (bits) = 4 ✓	1 1	**Accept** 16 anywhere for first mark **Accept** 15 levels (as zero may have been ignored) No marks awarded if method is clearly incorrect .e.g. using noise limitation formula or $\log_2$ (voltage range)
23	(b)		($f = 1/T = 1/2 \times 10^{-3}$) = 500 (Hz) ✓	1	**accept** in range 480 to 520 (Hz)
			Total	3	

Question			Answer	Marks	Guidance
24	(a)		(C^+) ions or electrons move / flow in the gap between plates / complete the circuit ✓ current is the flow of charged particles / ions / electrons / charge carriers ✓ (C^+) ions or electrons are charge carriers ✓ no ions in air before candle is introduced / high temperature of flame ionises the air between plates ✓	1 1	**accept** any two correct points **ignore** idea of attraction between charges and plates unless movement of charges indicated **penalise** charges moving to incorrect plate (e.g. electrons move to negative plate) **not** just formula e.g. $I = \Delta Q / \Delta t$
24	(b)		(number per s) = current /charge / = I / e ✓ (= $28 \times 10^{-6} / 1.6 \times 10^{-19}$) = 1.8×10^{14} (s^{-1}) ✓	1 1	method **accept** q = e evaluation **accept** 1.75×10^{14} (s^{-1})
			Total	4	

Question			Answer	Marks	Guidance
25	(a)		net / resultant force on ball is zero / forces are balanced / ball in equilibrium ✓	1	**not** just T_1 equal and opposite to weight **W** **accept** equal and opposite forces as only two forces are acting **accept** no acceleration / remains at rest **NOT** ball is at rest / stationary
25	(b)		vertical component of T_2 still balances weight / **W** / $T_2 \cos\theta$ = **W** ✓	1	method
			(T_2 = **W** / cos θ = 4600 / cos 35) = 5600 (N) ✓	1	**accept** 5620 / 5610 (N) penalise > 3 S.F.
25	(c)		(**H** = **W** tan θ = 4600 x tan 35) = 3200 (N) / (**H** = T_2 sin θ = 5600 x sin 35) = 3200 (N) / ($H^2 = T_2^2 - W^2 = 5600^2 - 4600^2$) = 3200 (N) ✓	1	**accept** 3220 / 3221 (N) answer in range 3210 to 3220 (N) ecf from 25(b) answer in range 3190 to 3230 (N) ecf from 25(b)
			Total	4	

Question			Answer	Marks	Guidance
26	(a)		(=(MV – mv) / (M +m)) = (8000 x 30 – 1500 x 4) / 9500 ✓ = 24.6 m s^{-1} ✓	1 1	Method **accept** 25 m s^{-1}
26	(b)		($F = \Delta(mv) / \Delta t$) = 8000 x (30 – 24.6) / 0.020 ✓	1	method **accept** 1500 (24.6 – (-4)) / 0.020 = 2.1 x 10^6 (N) **accept** calculates change in momentum (43200) or acceleration of either vehicle (lorry = 270, truck = 1430) for first mark
			= 2.16 x 10^6 (N) ✓	1	ecf on value of combined velocity from 26(a) evaluation **accept** 2.2 x 10^6 (N) / 2.0 x10^6 (N) using 2 SF velocity values / **accept** answers based on use of 24 m s^{-1} from 26(a)
			Total **Total section B**	4 20	

Section C

Question			Answer	Marks	Guidance
27	(a)		$D_{Fe} = \pi D_{ring} / 48$ / $= \pi \times 3.8 \times 10^{-9} / 48$ ✓ $= 2.5 \times 10^{-10}$ (m) ✓ **or** scale factor of 3.8nm/39mm **and** diameter of atom between 1 – 2 mm ✓ $= 9.7 \times 10^{-11}$ to 1.9×10^{-10} (m) ✓	**1** **1**	method algebra / numbers evaluation **accept** 2.49×10^{-10} (m) **not** for scale factor alone
27	(b)	(i)	ripples / waves are (concentric circles) which are equally spaced / distance between (consecutive) ripples is ½ x wavelength / electron probability/density has set up a standing wave pattern (shown by circles inside the ring of atoms) ✓	**1**	**accept** wavefronts are equally spaced **accept** distance is equal to the wavelength **accept** there are nodes and antinodes present
27	(b)	(ii)	distance between complete waves divided by correct number of waves ✓ then appropriately scaled ✓ **OR** distance between gaps divided by correct number of waves, then appropriately scaled ✓ then doubled ✓ **OR** multiplies single peak to peak distance by scale factor ✓ then doubled ✓	**1** **1**	e.g. 2.2cm / 3 waves x (3.8nm /3.9cm) = 7.1×10^{-10} (m) e.g. 2.2cm / 6 gaps x (3.8nm /3.9cm) / = 3.6×10^{-10} (m) x 2 = 7.1×10^{-10} (m) e.g. 0.36mm x (3.8nm /3.9cm) = 0.35nm x 2 = 7.0×10^{-10} (m) **accept** λ value in range 0.66 to 0.76 nm **with** correct working **accept** factor of 2 multiplication at any point in calculation
27	(b)	(iii)	($mv = h/\lambda = 6.63 \times 10^{-34} / 0.71 \times 10^{-9}$) = 9.3×10^{-25} kg m s^{-1} ✓	**1**	**expect** answers in range 8.7×10^{-25} to 10×10^{-25} from (b)(ii) ecf from 27(b)

Question			Answer	Marks	Guidance
27	(b)	(iv)	$E_K = (mv)^2 / 2m$ / $E_K = p^2 / 2m$ / $E_K = 1/2m \times (p/m)^2$ $v = p/m$ = (b)(iii)/9.11 x 10^{-31} = 1.0 x 10^6 (m s^{-1}) ✓	1	method **or** evaluation of velocity (ecf from (b)(iii))
			evaluation = 4.6 x 10^{-19} (J) ✓	1	expect answers between 4.2 x 10^{-19} and 5.5 x 10^{-19} (J) ecf from (b)(iii)
			Total	8	

Question			Answer	Marks	Guidance
28	(a)	(i)	**A** for diode because it is <u>not</u> linear / <u>not</u> proportional / <u>not</u> ohmic /does not conduct until threshold voltage / about 0.4V ✓	1	**accept B** is linear / proportional / ohmic / follows Ohm's law so **B** is resistor (and **A** is diode)
28	(a)	(ii)	$R = V / I$ = 1 / 0.080 = 12.5 (Ω)	1	**accept** bare answer / 13 (Ω)
28	(b)	(i)	current will become too large / overheat component ✓	1	**NOT** just current becomes large **accept** thermal runaway / heating decreases resistance of semiconductors
28	(b)	(ii)	In series, the components draw the same current and p.d.s add to 1.5 V ✓ = 65 (mA) ✓	1 1	method **accept** draw horizontal lines and find the one where sum of voltage intercepts is ≈ 1.5 V evaluation **accept** currents in range 62 to 68 (mA)
28	(c)		In normal operation / low voltages / small currents (through the ammeter): the diode is not turned on / conducts negligibly / has very high resistance ✓ (as) p.d. across μA at f.s.d. = 0.10 V ✓ in overload / with large currents: diode conducts / has low resistance ✓ current bypasses ammeter ✓ because p.d. rises above 0.3 V / 0.4 V / 0.6 V / threshold voltage ✓ two diodes protect from large currents in both senses ✓ R_{diode} at 0.6 V = 0.6 / 0.02 = 30 Ω / about 1/33 R_{meter} ✓ meter can dissipate up to 10 μW in normal operation f.s.d. diode can shunt e.g. about 12 mW at 0.6 V ✓	1 1 1 1	**accept** any 4 points for **max 4 marks**, but if only overload discussed max 3/4 **accept** no current through /shunted by diodes **accept** current is shunted by diodes needs to imply threshold voltage has been exceeded **accept** directions of applied voltage **accept** other sensible estimates for R_{diode} e.g. ≈ 200 Ω at 0.4 V / ≈ 70 Ω at 0.5 V if compared to R_{meter} **accept** other sensible estimates for power dissipated e.g. meter can dissipate 0.36 mW before damage occurs
			Total	9	

Question			Answer	Marks	Guidance
29	(a)	(i)	{(2 x 0.9)+(3 x1.0)+ (4 x 1.1)+(2 x 1.2)+(1 x 1.3)} / 12 = 1.1 (s) ✓	1	method **penalise** here if outlier is counted in – look for division by 13 **accept** 1.08 / 1.075
			Uncertainty = 0.2 (s) ✓	1	For second mark, decimal places in mean time and raw uncertainty must be max 2 and the same i.e. 1.1 ± 0.2 or 1.08 ± 0.20 **accept** 1.08 ± 0.22 **allow** percentage uncertainty of 18% or 20% (2sf max) **accept** (14.5 /13) = 1.1 ± 0.4 (s) / 1.12 ± 0.35 (s) if outlier used for second mark only
29	(a)	(ii)	(1.6 s is outlier) as further than 2 x spread from mean ✓	1	**NOT** outside of the range
29	(a)	(iii)	$v_{terminal}$ = 1.85 / 1.1 = 1.7 (m s^{-1}) ✓	1	evaluation for $v_{terminal}$ value **accept** 1.68 (or 1.71 from t_{drop} = 1.08 or 1.72 from t_{drop} = 1.075 (m s^{-1}) **ecf** from 29(a)
			% in t_{drop} is ± 18 % OR ± 20% and % in d ± 1% so use ± 18 % OR ± 20% ✓	1	calculations and justification **allow** ecf on their ± value from (i) **accept** percentage errors combined / added (eg 19% or 21%)
			± (1.7 x 0.18) = ± 0.3 (m s^{-1}) ✓	1	complete answer with uncertainty **accept** ± 0.34 / ± 0.4 (m s^{-1}) if correctly followed through from rounding no penalty here for difference in decimal places in terminal velocity and uncertainty
			alternative method for uncertainty: max $v_{terminal}$ = 1.87 / 0.9 = 2.08 (second marking point) (or min $v_{terminal}$ = 1.83 / 1.3 = 1.41) difference from mean = 2.08 - 1.7 = 0.38 (third marking point) (or difference from mean = 1.7 - 1.41 = 0.29)		**allow** ecf on their ± value from (i) accept ± 0.3 or ± 0.4 using this method **allow** using average of max and min differences values if both calculated

Question			Answer	Marks	Guidance
29	(a)	(iv)	method assumes at $v_{terminal}$ for whole drop / may not reach terminal velocity drop ✓	1	**accept** time includes the time of acceleration up to $v_{terminal}$ / not at $v_{terminal}$ for whole of time period measured / **accept** estimate made is too small / low in value
			method underestimates the $v_{terminal}$ systematically ✓ **or** reaction time (at start and/or end) links smaller time to larger $v_{terminal}$ or vice versa **or** incorrect height measurement due to plausible reason links smaller distance to smaller $v_{terminal}$ or vice versa	1	**NOT** human error in timing e.g. ruler at an angle, parallax, starting above ground answer must state clearly whether measured length is too short or too long for second mark
29	(b)	(i)	using $\Delta s / \Delta t$ from table or from graph ✓	1	method from gradient of linear section of graph (allow between 0.7 and 1.4) Δt at least 0.3s e.g. (2.08 – 0.72) / (1.3 – 0.7) = 1.36 / 0.6 = 2.3 (2.27) (m s^{-1}) **or** from table of results (averaging at least 3 intervals) for interval from 0.7 s to 1.3 s (allow between 0.7 and 1.4)
			evaluation **accept** in range 2.2 to 2.3 (m s^{-1}) ✓	1	e.g. 2.2, 2.3, 2.1, 2.3, 2.3, 2.4 average gives 2.3 (2.27)(m s^{-1}) **MAX 1** if Δt from graph < 0.3s or <3 intervals from table used bare answer in range max 1
29	(b)	(ii)	Ultrasonic sensor motion with data-logger / position sensor with data-logger / video with ruler or tape / strobe photography with ruler or tape ✓	1	apparatus and capture method **not** ticker-tape (inappropriate) **not** light gates (impractical)
			record data and review position every 0.1 s ✓	1	accept set pulse / frame rate to 0.1s
			shows where $v_{terminal}$ is constant / smaller ± % uncertainty in time measurement / reduced to about ± 5% / eliminates reaction time systematic error ✓	1	**accept** shows acceleration phase uncertainty of velocity calculations from table is reduced to ≈ 1 part in 20 **ignore** references to reducing human error
			Total **Total section C** **Total sections B & C**	**13** **30** **50**	

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