OCR
Oxford Cambridge and RSA

GCE

Physics A

Unit **G484**: The Newtonian World

Advanced 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.

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Annotations

Annotation	Meaning
BOD	Benefit of doubt given
BP	Blank Page
CON	Contradiction
	Incorrect Response
ECF	Error carried forward
FT	Follow through
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error
SF	Error in number of significant figures
	Correct Response
AE	Arithmetic error
	Wrong physics or equation

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

Subject-specific Marking Instructions

All questions should be annotated with ticks where marks are allocated; One tick per mark.

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 Guidance.
Penalise a rounding error in the second significant figure **once** only in the paper.

Question			Answer		Mark	Guidance
1	(a)	(i)	Gradient /It is the **acceleration** which is the same (for both) (AW)		B1	**Note:** **acceleration** must be spelled correctly for this mark **Allow**: Gradient /It is the **acceleration** and **acceleration** is free fall/*g/9.8 (1)*
		(ii)	Collision is inelastic / kinetic energy is lost (on impact with the ground) Idea that area is height (above ground) / Height (at E) is less (than height of A) (AW)		B1 B1	 **Not** heights are not the same **Allow:** displacement or distance travelled by ball for height
	(b)	(i)	$u^2 = 2\times 9.8(1)\times 1.7 \quad (=33.32)$ $u = 5.8 \ (\text{m s}^{-1})$		B1	**Not** g = 10 **Note** answer to 3 sf is 5.78 (m s^{-1})
		(ii)	**EITHER** $F\Delta t = m(v-u)$ **and** $F\Delta t = 16\times 75\times 10^{-3}$ $16\times 75\times 10^{-3} = 0.13\times[v-(-5.78)]$ $v = 3.5 \quad (\text{ms}^{-1})$	**OR** $a = F/m$ = 16/0.13 (a =123) (upwards positive) v = -5.78 +123 x 75 x 10^{-3} = 3.5 (m s^{-1})	C1 A1	**Allow** ECF from b(i) **Allow** v = $\frac{14}{23}$ x 5.78 (from graph for C1 mark) **Note:** answer to 3 sf is 3.46 (ms^{-1}) Using u = - 5.8 leads to v = 3.4 scores 2/2 Using u = +5.78 leads to v = 15 scores 1/2 Using equation of motion with a = 9.8(1) is WP scores 0/2
		(iii)	$h = \frac{v^2}{2g} = \frac{3.46^2}{2\times 9.8}$ $h = 0.61$ (m)		B1	**NO ECF** **Allow** graphical method using $h \propto v^2$ **Allow** answer in range 0.59 – 0.63 (m)
				Total	**7**	

Question			Answer	Mark	Guidance
2	(a)		A body will remain at rest or keep travelling at constant velocity unless acted upon by a resultant/net (external) force (AW)	B1	**Allow** 'speed in straight line' for velocity **Allow** 'uniform motion'
	(b)	(i)	They have equal magnitude/ same size They are the same type / nature	B1 B1	**Allow** act for the same time **Allow** have same line of action
		(ii)	Act in opposite directions Act on different bodies	B1 B1	**Not** act in different directions
	(c)	(i)	$\frac{dm}{dt} = \rho A v$ $= 1\times10^{3}\times3.3\times10^{-4}\times25$ $(=8.25\,\text{kg s}^{-1})$	B1	
		(ii)	Weight (of fireman) = 92*g* / *W* = 92 x 9.8(1) (= 903 N) Vertical component of water force = 8.25 x 25 sin 55 (= 169 N) Vertical component of contact force = 169 + 903 = 1100 N	C1 M1 A1	**Allow** use of 8.3 leading to 170 N **Note** answer to 3 sf is 1070 N **Note:** a **bald** $\frac{92g}{\sin 55} = 1100$ is WP scores 0/3
			Total	**9**	

Question			Answer	Marks	Guidance
3	(a)	(i)	C and F	B1	
		(ii)	G	B1	
		(iii)	$5\pi/4$ (= 1.25 π) or 3.93 (rad)	B1	
	(b)	(i)	Correct shape graph (by eye) Through the points (-5,0) (0,50) and (5,0)	B1 B1	**Note :** Max KE = 80 – 30 = 50 (mJ)
		(ii)	½ (0.45)v_{max}^2 = 50 x 10^{-3} v_{max} = 0.47 (m s^{-1})	A1	**Allow** ECF if max value on y axis from b(i) is used. If max KE = 80 mJ then v_{max} = 0.596 = 0.60 (m s^{-1})
		(iii)	$v_{max} = \frac{2\pi A}{T}$ $T = \frac{2\pi(5.0\times10^{-2})}{0.47}$ $T = 0.67\,(s)$	C1 A1	**Allow** C1 mark for correct frequency =1.5 (Hz) ECF from b(ii) Using v_{max} = 0.60 leads to T = 0.52 (s) and using v_{max} = 0.596 leads to T = 0.53 (s)
			Total	**8**	

Question			Answer	Marks	Guidance
4	(a)	(i)	$M = \frac{gR^2}{G}$ $M = \frac{3.7 \times (3.4 \times 10^6)^2}{6.67 \times 10^{-11}}$ [any subject] $M = 6.4 \times 10^{23}$ (kg)	C1 A1	If square is omitted from 3.4 x 10^6 score is 0/2. **Allow** 1 mark for M = 6.4 x 10^{17} (Mars radius km not converted to m)
		(ii)	$g_h = \frac{g_s R^2}{(R+h)^2} = \frac{3.7 \times (3.4 \times 10^6)^2}{(6.8 \times 10^6)^2}$ $g_h = 0.93$ (N kg^{-1})	A1	**Allow**: $h = R$ so $g_h = ¼\ g_s$ **Allow** use of $g_h = \frac{GM}{(R+h)^2}$ **Allow** ECF from a(i)
	b	(i)	$T^2 \propto R^3$ with T = period **and** R = orbital radius	B1	**Allow** separation / distance between bodies Do **not** allow bald radius for R
		(ii)	$\left(\frac{R_D}{R_P}\right)^3 = \left(\frac{T_D}{T_P}\right)^2$ $R_D = 9.4 \times 10^3 \times \left(\frac{30}{7.7}\right)^{2/3}$ [any subject] $R_D = 2.3 \times 10^4$ (km)	C1 A1	C1 mark is for correct substitution **Allow** use of $R^3 = \frac{GMT^2}{4\pi^2}$ with possible ECF from a(i) [Note M=6.4 x 10^{17} leads to 2.3 x 10^2 km]
	(c)		Speed will increase Because a decrease in orbital radius results in a decrease in period (by Kepler's law) / Correct reference to centripetal force = gravitational force or $v^2 = Gm/R$	M0 A1	**Allow** GPE decreases so KE increases
			Total	**7**	

Question			Answer	Marks	Guidance
5	(a)	(i)	$F = \dfrac{GM_1M_2}{(R_1 + R_2)^2}$	B1	Ignore sign
		(ii)	$F_1 = \dfrac{4\pi^2 M_1 R_1}{T^2}$	B1	Allow $F_1 = \left(\dfrac{2\pi}{T}\right)^2 M_1R_1$
	(b)		Centripetal forces on both star are same magnitude / $F_1 = F_2$ / answer to a(ii) equated to similar expression for $\mathbf{S}_2$ Correct working starting from <u>correct</u> a(ii) forces $\dfrac{M_1}{M_2} = \dfrac{R_2}{R_1}$	M1 A1 A0	Eg $\dfrac{4\pi^2 M_1R_1}{T^2} = \dfrac{4\pi^2 M_2R_2}{T^2}$
	(c)		$\dfrac{R_2}{R_1} = 3 \quad \therefore \quad R_2 = 3R_1$ *and* $R_1 + R_2 = 4.8\times10^{12}$ $R_1 = \dfrac{1}{4}\times 4.8\times10^{12} = 1.2\times10^{12}$ (m) $R_2 = \dfrac{3}{4}\times 4.8\times10^{12} = 3.6\times10^{12}$ (m)	C1 A1 A1	Allow 2 marks if $R_1 = 3.6 \times 10^{12}$ (m) And $R_2 = 1.2 \times 10^{12}$ (m)
	(d)		$v_1 = \dfrac{2\pi R_1}{T} = \dfrac{2\pi\times1.2\times10^{12}}{4\times3.16\times10^7}$ $v_1 = 6.0\times10^4 \quad (\text{m s}^{-1})$	C1 A1	Possible ECF Mark is for substitution Max 1 mark if T is not converted to seconds (leads to speed = 1.9×10^{12})

Question			Answer	Marks	Guidance
	(e)		$\frac{M_1 v_1^2}{R_1} = \left(\frac{4\pi^2 R_1 M_1}{T^2}\right) = \frac{GM_1M_2}{(R_1+R_2)^2}$	C1	**Allow ECF** from (c) and (d) **only** if method is correct **Allow** this C1 mark if M_1 has been cancelled
			$M_2 = \frac{(6.0\times10^4)^2 \times (4.8\times10^{12})^2}{6.67\times10^{-11}\times1.2\times10^{12}}$	C1	
			$M_2 = 1.0\times10^{33}$ (kg)	A1	**Special case** Use of $T^2 \propto R^3$ will lead to 1.73×10^{33} (kg) this scores 1 mark. Do not allow any ECF if this method is used.
			Total	**12**	

Question			Answer	Marks	Guidance
6	(a)		(Gravitational) potential energy is converted to kinetic energy which is then converted to thermal energy/heat Statement that KE to thermal takes place on impact	B1 B1	Not 'GPE to KE and thermal'
	(b)		GPE converted in one inversion = 0.025 x 9.8 x 1.2 (= 0.294) GPE converted in 50 inversions = 0.294 x 50 = 14.7 (J) (Use of Q =mcΔθ to give) 14.7 = 0.025 x c x 4.5 c = 130 (J kg^{-1} K^{-1})	C1 A1 C1 A1	**Allow** follow through from their total GPE converted **Note** answer to 3 sf = 131 (J kg^{-1} K^{-1})
	(c)		• No heat is absorbed by the tube/ lost (by conduction) through the tube/all heat goes to pellets • All the lead falls through the same height or length of tube/ Lead does not bounce on impact	B1 B1	**Ignore** 'heat lost to surroundings/air'
	(d)		Temperature change is the same (Since mass is doubled) (max) GPE/KE/total energy is doubled **AND** Q is doubled	M1 A1	**Allow** mgh = mcΔθ and m is same **or** m cancels **Alternative answer** **Allow** 2 marks for any sensible practical suggestions why T is **not** the same eg double mass means more lead which will **not** fall full length of tube.
			Total	**10**	

Question			Answer	Marks	Guidance
7	(a)		An ideal gas has zero/negligible (electrical) PE / All internal energy is (translational) KE (translational) KE $\propto$ absolute/ thermodynamic /kelvin temperature	B1 B1	 **Allow** internal energy $\propto$ absolute/ thermodynamic /kelvin temperature Note: absolute/thermodynamic/kelvin must be used and spelled correctly for second mark
	(b)	(i)	Number of moles of helium = 80/0.004 (= 2 x 10^4) $V = \frac{nRT}{p} = \frac{2\times10^4 \times 8.31 \times 294}{1.0\times10^5}$ $V = 490$ (m^3)	C1 C1 A1	**Allow** use of $pV=NkT$ Use of T in ºC is WP giving max 1 out of 3 **Allow** follow through(FT) from an error in n
		(ii)	number of moles remaining $= \frac{pV}{RT} = \frac{1.2\times10^3 \times 1.4\times10^4}{8.31\times233}$ = 8.68 x 10^3 Number of moles escaping = 2 x 10^4 - 8.68 x 10^3 = 1.1 x 10^4	C1 A1	Use of T in ºC is WP 0/2
			Total	**7**	

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