

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.

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

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Annotations

Annotation	Meaning
	Benefit of doubt given
	Blank Page
	Contradiction
	Incorrect Response
	Error carried forward
	Follow through
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error
	Error in number of significant figures
	Correct Response
	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)	$u^2 = 2 \times 9.8(1) \times 1.7$ (= 33.32) $u = 5.8$ (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 $F \Delta t = 16 \times 75 \times 10^{-3}$ $16 \times 75 \times 10^{-3} = 0.13 \times [v - (-5.78)]$ $v = 3.5$ (ms ⁻¹) OR $a = F/m = 16/0.13$ ($a = 123$) (upwards positive) $v = -5.78 + 123 \times 75 \times 10^{-3}$ $= 3.5$ (m s ⁻¹)	C1 A1	Allow ECF from b(i) Allow $v = \frac{14}{23} \times 5.78$ (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 <u>opposite</u> directions Act on different bodies	B1 B1	Not act in different directions
	(c) (i)	$\frac{dm}{dt} = \rho Av$ $= 1 \times 10^3 \times 3.3 \times 10^{-4} \times 25$ (= 8.25 kg s ⁻¹)	B1	
	(ii)	Weight (of fireman) = 92g / 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 <u>and</u> F	B1	
		(ii)	G	B1	
		(iii)	$5\pi/4$ (= 1.25π) or 3.93 (rad)	B1	
	(b)	(i)	Correct shape graph (by eye) Through the points (-5,0) (0,50) <u>and</u> (5,0)	B1 B1	Note : Max KE = 80 – 30 = 50 (mJ)
		(ii)	$\frac{1}{2} (0.45)v_{max}^2 = 50 \times 10^{-3}$ $v_{max} = 0.47$ (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)	$v_{max} = \frac{2\pi A}{T}$ $T = \frac{2\pi(5.0 \times 10^{-2})}{0.47}$ $T = 0.67$ (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] $M = 6.4 \times 10^{23} \text{ (kg)}$	C1 A1	If square is omitted from 3.4×10^6 score is 0/2. Allow 1 mark for $M = 6.4 \times 10^{17}$ (Mars radius km not converted to m)
	(ii)	$g_h = \frac{g_s R^2}{(R+h)^2} = \frac{3.7 \times (3.4 \times 10^6)^2}{(6.8 \times 10^6)^2}$ $g_h = 0.93 \text{ (N kg}^{-1}\text{)}$	A1	Allow: $h = R$ so $g_h = \frac{1}{4} g_s$ 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)	$\left(\frac{R_D}{R_P}\right)^3 = \left(\frac{T_D}{T_P}\right)^2$ $R_D = 9.4 \times 10^3 \times \left(\frac{30}{7.7}\right)^{\frac{2}{3}}$ [any subject] $R_D = 2.3 \times 10^4 \text{ (km)}$	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 $M=6.4 \times 10^{17}$ leads to 2.3×10^2 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)	$F = \frac{GM_1M_2}{(R_1 + R_2)^2}$	B1	Ignore sign
		(ii)	$F_1 = \frac{4\pi^2 M_1 R_1}{T^2}$	B1	Allow $F_1 = \left(\frac{2\pi}{T}\right)^2 M_1 R_1$
	(b)		Centripetal forces on both star are same magnitude / $F_1 = F_2$ / answer to a(ii) equated to similar expression for S_2 Correct working starting from <u>correct</u> a(ii) forces $\frac{M_1}{M_2} = \frac{R_2}{R_1}$	M1 A1 A0	Eg $\frac{4\pi^2 M_1 R_1}{T^2} = \frac{4\pi^2 M_2 R_2}{T^2}$
	(c)		$\frac{R_2}{R_1} = 3 \quad \therefore R_2 = 3R_1 \quad \text{and} \quad R_1 + R_2 = 4.8 \times 10^{12}$ $R_1 = \frac{1}{4} \times 4.8 \times 10^{12} = 1.2 \times 10^{12} \quad (\text{m})$ $R_2 = \frac{3}{4} \times 4.8 \times 10^{12} = 3.6 \times 10^{12} \quad (\text{m})$	C1 A1 A1	Allow 2 marks if $R_1 = 3.6 \times 10^{12} \text{ (m)}$ And $R_2 = 1.2 \times 10^{12} \text{ (m)}$
	(d)		$v_1 = \frac{2\pi R_1}{T} = \frac{2\pi \times 1.2 \times 10^{12}}{4 \times 3.16 \times 10^7}$ $v_1 = 6.0 \times 10^4 \quad (\text{m s}^{-1})$	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)	$\frac{M_1 v_1^2}{R_1} = \left(\frac{4\pi^2 R_1 M_1}{T^2} \right) = \frac{GM_1 M_2}{(R_1 + R_2)^2}$ $M_2 = \frac{(6.0 \times 10^4)^2 \times (4.8 \times 10^{12})^2}{6.67 \times 10^{-11} \times 1.2 \times 10^{12}}$ $M_2 = 1.0 \times 10^{33} \text{ (kg)}$	<p>C1</p> <p>C1</p> <p>A1</p>	<p>Allow ECF from (c) and (d) only if method is correct</p> <p>Allow this C1 mark if M_1 has been cancelled</p> <p>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.</p>
	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 = $0.025 \times 9.8 \times 1.2$ (= 0.294) GPE converted in 50 inversions = 0.294×50 = 14.7 (J) (Use of $Q = mc\Delta\theta$ to give) $14.7 = 0.025 \times c \times 4.5$ $c = 130$ ($\text{J kg}^{-1} \text{K}^{-1}$)	C1 A1 C1 A1	Allow follow through from their total GPE converted Note answer to 3 sf = 131 ($\text{J kg}^{-1} \text{K}^{-1}$)
	(c)	<ul style="list-style-type: none"> 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 $mgh = mc\Delta\theta$ 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 = $80/0.004 (= 2 \times 10^4)$ $V = \frac{nRT}{p} = \frac{2 \times 10^4 \times 8.31 \times 294}{1.0 \times 10^5}$ $V = 490 \text{ (m}^3\text{)}$	C1 C1 A1	Allow use of $pV=NkT$ Use of T in $^{\circ}\text{C}$ is WP giving max 1 out of 3 Allow follow through (FT) from an error in n
		(ii) number of moles remaining = $\frac{pV}{RT} = \frac{1.2 \times 10^3 \times 1.4 \times 10^4}{8.31 \times 233}$ $= 8.68 \times 10^3$ Number of moles escaping = $2 \times 10^4 - 8.68 \times 10^3$ $= 1.1 \times 10^4$	C1 A1	Use of T in $^{\circ}\text{C}$ is WP 0/2
Total			7	

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