

**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

<b>Annotation</b>	<b>Meaning</b>
/	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
<b>IGNORE</b>	Statements which are irrelevant
<b>ALLOW</b>	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
<b>AW</b>	Alternative wording
<b>ORA</b>	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 <b>acceleration</b> which is the same (for both) (AW)	B1	<b>Note:</b>  <b>acceleration</b> must be spelled correctly for this mark <b>Allow:</b> Gradient /It is the <b>acceleration</b> and <b>acceleration</b> is free fall/g/9.8 (1)
		(ii)	Collision is inelastic / <b>kinetic</b> 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	<b>Not</b> heights are not the same <b>Allow:</b> 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 <sup>-1</sup> )	B1	<b>Not</b> $g = 10$ <b>Note</b> answer to 3 sf is 5.78 (m s <sup>-1</sup> )
		(ii)	<b>EITHER</b> $F \Delta t = m(v-u)$ <b>and</b> $F \Delta t = 16 \times 75 \times 10^{-3}$ $16 \times 75 \times 10^{-3} = 0.13 \times [v - (-5.78)]$ $v = 3.5$ (ms <sup>-1</sup> )  <b>OR</b> $a = F/m = 16/0.13$ ( $a = 123$ ) (upwards positive) $v = -5.78 + 123 \times 75 \times 10^{-3}$ $= 3.5$ (m s <sup>-1</sup> )	C1  A1	<b>Allow</b> ECF from b(i) <b>Allow</b> $v = \frac{14}{23} \times 5.78$ (from graph for C1 mark)  <b>Note:</b> answer to 3 sf is 3.46 (ms <sup>-1</sup> ) 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	<b>NO ECF</b> <b>Allow</b> graphical method using $h \propto v^2$ <b>Allow</b> answer in range 0.59 – 0.63 (m)
<b>Total</b>				<b>7</b>	

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	<b>Allow</b> 'speed in straight line' for velocity <b>Allow</b> 'uniform motion'
	(b) (i)	They have equal magnitude/ same size They are the same type / nature	B1 B1	<b>Allow</b> act for the same time <b>Allow</b> have same line of action
	(ii)	Act in <u>opposite</u> directions Act on different bodies	B1 B1	<b>Not</b> 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 <sup>-1</sup> )	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	<b>Allow</b> use of 8.3 leading to 170 N  <b>Note</b> answer to 3 sf is 1070 N <b>Note:</b> a bald $\frac{92g}{\sin 55} = 1100$ is WP scores 0/3
		<b>Total</b>	<b>9</b>	

Question			Answer	Marks	Guidance
3	(a)	(i)	C <u>and</u> F	B1	
		(ii)	G	B1	
		(iii)	$5\pi/4$ (= $1.25\pi$ ) 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	<b>Note</b> : Max KE = 80 – 30 = 50 (mJ)
		(ii)	$\frac{1}{2} (0.45)v_{max}^2 = 50 \times 10^{-3}$ $v_{max} = 0.47 \text{ (m s}^{-1}\text{)}$	A1	<b>Allow</b> ECF if max value on y axis from b(i) is used. If max KE = 80 mJ then $v_{max} = 0.596 = 0.60 \text{ (m s}^{-1}\text{)}$
		(iii)	$v_{max} = \frac{2\pi A}{T}$ $T = \frac{2\pi(5.0 \times 10^{-2})}{0.47}$ $T = 0.67 \text{ (s)}$	C1 A1	<b>Allow</b> C1 mark for correct frequency = 1.5 (Hz) ECF from b(ii) Using $v_{max} = 0.60$ leads to $T = 0.52 \text{ (s)}$ and using $v_{max} = 0.596$ leads to $T = 0.53 \text{ (s)}$
<b>Total</b>				<b>8</b>	




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 $3.4 \times 10^6$ score is 0/2. <b>Allow</b> 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	<b>Allow:</b> $h = R$ so $g_h = \frac{1}{4} g_s$ <b>Allow</b> use of $g_h = \frac{GM}{(R+h)^2}$ <b>Allow</b> ECF from a(i)
	b (i)	$T^2 \propto R^3$ with $T =$ period <b>and</b> $R =$ orbital radius	B1	<b>Allow</b> separation / distance between bodies Do <b>not</b> 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 <b>Allow</b> 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 $2.3 \times 10^2$ 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	<b>Allow</b> GPE decreases so KE increases
<b>Total</b>			<b>7</b>	

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 = $1.9 \times 10^{12}$ )

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><b>Allow ECF</b> from (c) and (d) <b>only</b> if method is correct</p> <p><b>Allow</b> this C1 mark if <math>M_1</math> has been cancelled</p> <p><b>Special case</b> Use of <math>T^2 \propto R^3</math> will lead to <math>1.73 \times 10^{33}</math> (kg) this scores 1 mark. Do not allow any ECF if this method is used.</p>
	<b>Total</b>	<b>12</b>	

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 = $0.294 \times 50$ = 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	<b>Allow</b> follow through from their total GPE converted  <b>Note</b> answer to 3 sf = 131 ( $\text{J kg}^{-1} \text{K}^{-1}$ )
	(c)	<ul style="list-style-type: none"> <li>No heat is absorbed by the tube/ lost (by conduction) through the tube/all heat goes to pellets</li> <li>All the lead falls through the same height or length of tube/ Lead does not bounce on impact</li> </ul>	B1  B1	<b>Ignore</b> 'heat lost to surroundings/air'
	(d)	Temperature change is the same  (Since mass is doubled) (max) GPE/KE/total energy is doubled <b>AND</b> Q is doubled	M1  A1	<b>Allow</b> $mgh = mc\Delta\theta$ and m is same <b>or</b> m cancels  <b>Alternative answer</b> <b>Allow</b> 2 marks for any sensible practical suggestions why T is <b>not</b> the same eg double mass means more lead which will <b>not</b> fall full length of tube.
<b>Total</b>			<b>10</b>	

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	<b>Allow</b> 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	<b>Allow</b> use of $pV=NkT$ Use of $T$ in $^{\circ}\text{C}$ is WP giving max 1 out of 3  <b>Allow</b> 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
<b>Total</b>			<b>7</b>	

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