

GCE

Physics A

Unit **G484**: The Newtonian World

Advanced GCE

Mark Scheme for June 2015

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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
	Blank Page – this annotation must be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
	Benefit of doubt given
	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)	N & W act on the same body / Newton's 3 rd Law forces should act on different bodies N & W are different types (of force) / are not same type	B1 B1	Allow: 3 rd law pair to W acts on (centre of)Moon 3 rd law pair to N acts on <u>surface</u> of Moon Allow: N is electromagnetic/electrostatic/electrical/contact W is gravitational. Allow: Paired forces should be of the same type Ignore a general statement of Newton's 2 nd or 3 rd law
		(ii)	Equal to / same as W acting on (the centre of) the Moon	B1	Do not allow 'acts on surface of Moon Diagram is not sufficient for this mark
	(b)		Clear use of vertical motion with downward acceleration and horizontal motion at constant velocity vertically $0 = (u \sin \theta)t - \frac{1}{2} g_M t^2$ $t = \frac{2u \sin \theta}{g_M}$ horizontally $x = u \cos \theta \times \frac{(2u \sin \theta)}{g_M}$ $x \propto \frac{u^2}{g_M}$	B1 M1 A1 A0	If $\sin \theta$ and $\cos \theta$ are confused allow max 1/3. Allow: use of a for g_m Allow: determination of time to max height using $v=u + at$ Then total time = 2 x time to max height (M1) Allow use of 9.81 instead of g_m
Total				6	

Question			Answer	Mark	Guidance
2	(a)	(i)	$m = \frac{0.131}{6.02 \times 10^{23}}$ $m = 2.18 \times 10^{-25} \text{ (kg)}$	A1	
		(ii)	mass of xenonejected/ s = $m_{Xe} = 2.2 \times 10^{-25} \times 9.5 \times 10^{18} (= 2.07 \times 10^{-6})$ $F_{Xe} = \left(m_{Xe} \frac{\Delta v}{\Delta t} \right) = 2.2 \times 10^{-25} \times 9.5 \times 10^{18} \times 3.2 \times 10^4 (= 0.06627)$ $a_S = \left(\frac{F_{Xe}}{m_S} \right) = \frac{2.2 \times 10^{-25} \times 9.5 \times 10^{18} \times 3.2 \times 10^4}{5.2 \times 10^3}$ $a_S = 1.3 \times 10^{-5} \text{ (m s}^{-2}\text{)}$	C1 C1 A1	Possible ECF Allow: $5.2 \times 10^3 \times \Delta v = 2.07 \times 10^{-6} \times 3.2 \times 10^4$ $\Delta v = 1.3 \times 10^{-5}$ $a_S = 1.3 \times 10^{-5} \text{ (m s}^{-2}\text{)}$
		(iii)	Rate of change of momentum (of an object) is proportional to the <u>resultant / net</u> (external) force acting upon it. (AW) OR statement of law of Conservation of momentum in a closed system/no external forces	B1	 Momentum must be spelled correctly Allow: 'equal to' instead of 'proportional to' Allow: statement of Newton's 3 rd Law provided it is clear the forces act on different bodies and opposite is spelled correctly
		(iv)	Force (on spacecraft) is constant Mass (of spacecraft) decreases (as xenon is ejected) Acceleration <u>increases</u>	B1 M1 A1	Not: Weight (of spacecraft) or 'it is lighter'
	(b)	(i)	Area under graph in range 10.5 to 11.5 (Ns) Area under graph in range 10.8 to 11.2 (Ns) $\Delta v = \frac{\text{impulse}}{m} = \frac{\text{area}}{m}$ $= \frac{11.0}{180}$ $= 6.1 \times 10^{-2} \text{ (ms}^{-1}\text{)}$	C1 C1 C1 A1	Possible FT for using their area / 180 Use of mass of spacecraft rather than satellite scores 1 out of last 2 marks.
		(ii)	From 0 to 3 (ms) acceleration <u>increases</u> linearly/uniformly/ at constant rate/ at a steady rate. (From 6.5 ms) onwards/later/at end the acceleration <u>decreases</u>	B1 B1	Allow: upper limit on time in range 3.0 to 3.5 ms Do not credit use of ' constantly ' for this mark Not 'decelerates'
			Total	14	

Question			Answer	Marks	Guidance
3	(a)	(i)	Straight line <u>through</u> the origin Negative gradient and symmetrical about (0,0) by eye.	M1 A1	
		(ii)	Linking gradient to $[2\pi f]^2$. Frequency = $\frac{\sqrt{\text{gradient}}}{2\pi}$	C1 A1	Allow: use of a single data point used in $a = (-)[2\pi f]^2 x$ Note frequency must be the subject of this equation
	(b)	(i)	$A = \frac{v_{\max}}{2\pi f} = \frac{0.09}{2\pi \times 8.0}$ $A = 1.8 \times 10^{-3} \text{ (m)}$	C1 A1	Allow: values for T in range 0.125 to 0.13 s
		(ii)	$a_{\max} = (2\pi f)^2 A$ $a_{\max} = (2\pi \times 8.0)^2 \times 1.8 \times 10^{-3}$ $a_{\max} = 4.5 \text{ (ms}^{-2}\text{)}$	C1 A1	Possible ecf from b(i) Allow: Tangent drawn on graph at any $v = 0$ point (C1) calculation of gradient (A1)
	(c)		Curve with same frequency /period max velocities decreasing at three successive positive peaks	B1 B1	Allow: $\frac{1}{2}$ small square error on $v = 0$ points
	(d)		Axes labelled and graph showing correct bell shaped curve (amplitude increases then decreases) <u>Maximum/largest</u> amplitude or energy at $f=8 \text{ Hz}$ / natural frequency When <u>driving/oscillator's</u> frequency is equal to natural frequency / 8 Hz resonance occurs (AW).	B1 B1 B1	Allow this mark if curves are drawn asymptotically (to 8 Hz) May be scored on diagram or in text  'resonance' / 'resonant' to be spelled correctly for this mark to be scored.
Total				13	

Question		Answer	Marks	Guidance
4	(a)	(gravitational) force $\propto \frac{[\text{mass 1}] [\text{mass 2}]}{[\text{separation (of masses)}]^2}$	B1	Allow: equation in symbols if symbols are defined Allow: equality Not radius
	(b)	Use of $F = \frac{GMm}{R^2}$ AND $F = \frac{mv^2}{R}$ $v = \frac{2\pi R}{T}$ $\frac{GM}{R^2} = \frac{1}{R} \left(\frac{2\pi R}{T} \right)^2$ $R^3 = \frac{GM}{4\pi^2} T^2$ OR $R^3 \propto T^2$	B1 B1 B1 A1	Ignore signs Allow: equation with cancelling shown This mark is for some evidence of substitution and manipulation Allow: subject must be either R^3 or T^2 Allow: Max 1 mark for bald statement of $R^3 = \frac{GM}{4\pi^2} T^2$ without proof
	(c) (i)	Graph is a straight line / has constant gradient and passes <u>through the origin</u>	B1	
	(ii)	gradient of graph = $\frac{GM}{4\pi^2} = \frac{15 \times 10^{34}}{4.5 \times 10^{16}} = (3.3 \times 10^{18})$ $M = \frac{4\pi^2 \times 3.3 \times 10^{18}}{6.67 \times 10^{-11}}$ $M = 1.97 \times 10^{30}$ (kg)	C1 C1 A1	Allow: \pm half small square on reading off points on line Note 2 possible POT error in this equation would give max 1 out of 3 with FT. Allow: use of a point read from straight line substituted into Kepler's equation Allow: FT from their gradient value. 2.0×10^n where $n \neq 30$ scores max 2 out of 3 marks
		Total	9	

Question		Answer	Marks	Guidance
5	(a)	$E = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^8}{1.1 \times 10^{-6}}$ $E = 1.8 \times 10^{-19} \text{ (J)}$	M1 A0	Values must be substituted Answer to 3sf is 1.81×10^{-19} (J)
	(b)	$m = \rho V = 8.1 \times 10^{-12} \times 4.5 \times 10^3 = (3.645 \times 10^{-8})$ $\text{Thermal energy gained} = (mc \Delta\theta) = 3.645 \times 10^{-8} \times 520 \times [1700 - 20] \quad (= 0.0318)$ $1.81 \times 10^{-19} \times 6.3 \times 10^{19} \times t = 0.0318$ $t = 2.8 \times 10^{-3} \text{ (s)}$	C1 C1 A1	Allow: ecf from (a) and mass of titanium
	(c)	<p>Thermal energy is conducted / transferred to the rest of <u>titanium/metal</u></p> <p>Photons are reflected / scattered from / not absorbed the titanium surface</p>	B1 B1	Not: heat lost to surroundings
	(d)	<p>(Photon) energy is converted into potential energy (rather than kinetic energy) OR Energy is used to change solid to liquid / phase (rather than increase kinetic energy) OR Energy provides (specific) latent heat of fusion (rather than increase kinetic energy)</p>	B1	Allow: energy is used to overcome the forces between atoms / breakdown the crystal structure of titanium (rather than increase kinetic energy)
Total			7	

Question		Answer	Marks	Guidance
6	(a)	Idea of extrapolating graph back (to negative temperatures) <u>Volume is zero</u> at absolute zero / <u>negative volumes</u> are impossible	B1 B1	Can be shown on diagram Allow 'negligible <u>volume</u> ' rather than zero and use of -273 °C / 0 K
	(b)	(i)		
		(i)	B1	Allow :particles
		(ii)	B1 B1	Allow : potential energy of gas phase is ('close' to) zero
	(c)	(i)	C1 A1	No credit If temperature is not converted to kelvin
		(ii)	C1 C1 A1	Allow : ECF if temperature is used in °C only if penalised in (i) Otherwise max mark allowed is 1 out of 3 for $n = 602$ mol Allow : use of partial pressures
		(iii)	M1 A0	Allow : $p \propto T$ if (n and) <u>V constant</u>
Total			11	

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