

Physics A

Advanced GCE

Unit **G484**: The Newtonian World

Mark Scheme for June 2013

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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
	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	Marks	Guidance
1	(a)	(i)	(Resultant) force (acting on an object) is (directly) proportional to the <u>rate of change of momentum</u> (and occurs in the same direction)(AW)	B1	Allow: 'equal' instead of proportional, Allow: 'change in momentum <u>divided</u> by time taken' Not: a definition involving acceleration Not: 'change in momentum over time taken' Not: an equation unless all terms are defined
		(ii)	$F = \frac{\Delta(mv)}{\Delta t}$ $F = m \frac{\Delta(v)}{\Delta t} \text{ (if m is constant)}$ $F = ma$	M1 A1 A0	Allow: Any subject. Not: $\Delta p / \Delta t$ for M mark Allow: $F \propto \frac{(mv - mu)}{\Delta t}$ Allow: Use of t for Δt
	(b)	(i)	(Impulse) $F\Delta t$ = area (under graph) OR Clear use of $\frac{1}{2} \times 4 \times 20$ in $F\Delta t = m\Delta v$ $\Delta v = \frac{40}{2.5}$ $\Delta v = 16 \text{ (ms}^{-1}\text{)}$	C1 C1 A1	Note: Area = 40 (N s) Allow: any subject
		(ii)	$a = \frac{(v - u)}{t}$ $a = \frac{16}{4}$ $a = 4.0 \text{ (ms}^{-2}\text{)}$	B1	Possible ecf from (b)(i) Allow: mean force $\langle F \rangle = 10 \text{ N}$ mean acceleration ($= \langle F \rangle / m$) = $10 / 2.5$ = $4.0 \text{ (ms}^{-2}\text{)}$
		(iii)	'acceleration increases to 2s and then decreases ' Reference to the rate of change of acceleration being constant / linear change in acceleration / acceleration changes at uniform rate in either section.	M1 A1	No credit for any reference to deceleration . Not: accelerating constantly / uniform acceleration / constant acceleration / increasing rate of change of acceleration
			Total	9	

Question			Answer	Marks	Guidance
2	(a)	(i)	Diagram showing at least 4 radial lines outside Earth, appearing to meet at centre of Earth (as judged by eye – in a square containing letters a and r of label) AND at least 4 arrows directed towards the Earth	B1	Do not award this mark if any arrow is in wrong direction. Allow: line(s) to continue inside the Earth
		(ii)	Any two from the following: - Field lines are parallel to each other - Field lines are equally/evenly/uniformly/constantly spaced (AW) - Field lines are perpendicular / vertical / right angles (to surface of the Earth)	B1 B1	Note: vertical, parallel, perpendicular /right angles wherever used to be spelled correctly
	(b)	(i)	$g = \frac{GM}{R^2}$ $g = \frac{6.67 \times 10^{-11} \times 5.7 \times 10^{26}}{(6 \times 10^7)^2}$ $g = 11 \text{ (Nkg}^{-1}\text{)}$	C1 A1	Note: Mark is for substitution Answer is 10.6 (N kg ⁻¹) to 3 sf Ignore sign
		(ii)1	$\frac{mv^2}{r} = \frac{GMm}{r^2} \text{ or } v^2 = \frac{GM}{r}$ $v^2 = \frac{6.67 \times 10^{-11} \times 5.7 \times 10^{26}}{5.3 \times 10^8} \text{ (= } 7.17 \times 10^7 \text{)}$ $v = 8.5 \times 10^3 \text{ (ms}^{-1}\text{)}$	C1 C1 A1	Allow $T^2 = \left(\frac{4\pi^2}{GM}\right)r^3$ and $v = \frac{2\pi r}{T}$ Expected value for $T = 3.93 \times 10^5$ s Note: Mark is for substitution Answer is 8470 (m s ⁻¹) to 3 sf Note: Using - mass of Rhea (2.3×10^{21}) gives $v = 17$ (m s⁻¹) g from b(i) in $v = \sqrt{gr}$ gives $v = 7.5 \times 10^4$ [correct value of g at Rhea's orbit is 0.135 N kg^{-1}] Both score max 1 mark for use of correct formula
		(ii)2	$E_k = \frac{1}{2} \times 2.3 \times 10^{21} \times 7.17 \times 10^7$ $E_k = 8.2 \times 10^{28} \text{ (J)}$	B1	Possible ecf for v from (ii)1 Note: Using $v = 17$ gives $E_k = 3.3 \times 10^{23}$ (J) Using $v = 7.5 \times 10^4$ gives $E_k = 6.5 \times 10^{30}$ (J) Using b(ii)1 to 2sf gives $E_k = 8.3 \times 10^{28}$ (J)
Total				9	

Question			Answer	Marks	Guidance
3	(a)		Is in the opposite direction to the displacement Increases as the speed of the object decreases	B1 B1	If more than 2 ticks are given mark all and deduct 1 mark for each error
	(b)	(i)	$f = \frac{1}{T} = \frac{1}{1.2}$ $f = 0.83 \text{ (Hz)}$	B1	Allow: the fraction 5/6 only
		(ii)	$v_{\max} = (2\pi f) A$ $0.08 = (2\pi \times 0.83)A$ $A = \frac{0.08}{(2\pi \times 0.83)} = 0.015 \text{ (m)}$	C1 A1	Possible ecf from (b)(i) Note: Mark is for substitution; any subject Answer is 0.0153 (m) to 3 sf
		(iii)	$a_{\max} = (2\pi f)^2 A$ $a_{\max} = (2\pi \times 0.83)^2 \times 0.015$ $a_{\max} = 0.42 \text{ (ms}^{-2}\text{)}$	C1 A1	Possible ecf from (b)(i) and (ii) Note: Mark is for substitution Ignore sign Expect to see 0.41 if 2 sf values are used Allow: tangent used at $v = 0$ (M1) gradient of tangent calculated in range 0.37 to 0.44 (m s^{-2}) to 2sf (A1). Accept gradient of tangent = 0.4 (m s^{-2})
	(c)	(i)	Graph(s) tending to single peak with axes labelled in words or appropriate symbols Peak labelled as <u>natural / resonant</u> frequency (of system) or f_0 • Resonance occurs when the <u>driving frequency</u> matches <u>natural / resonant</u> frequency (of system) • the <u>amplitude</u> of vibrations / energy (transferred) is then a <u>maximum</u> (AW)	B1 B1 B1 B1	Can be scored even if horizontal axis is not correctly labelled
		(ii)	A valid example of resonance Explanation to include • what does the driving and what is being driven • that this occurs at specific (driver) frequency	B1 B1	Allow: Mirror in car, Washing machine, Child on swing, microwave (oven), radio (tuning), Structures (in wind etc) MRI Not musical instruments
			Total	13	

Question			Answer	Marks	Guidance
4	(a)		Mass of air = $4.5 \times 4 \times 2.4 \times 1.3$ (= 56.2)	B1	Allow: follow through (FT) for mass of air Note: Max 1 mark out of 3 if temperature rise is given as 282 K.
			$Q = mc\Delta\theta = 56.2 \times 990 \times (21 - 12)$ $Q = 5.0 \times 10^5$ (J)	C1 A1	
	(b)	(i)	$t = \frac{Q}{P} = \frac{5.0 \times 10^5}{2300}$ $t = 220$ (s)	C1 A1	Possible ecf from (a) Answer is 217 (s) or 218 (s) to 3 sf depending on accuracy of Q used from (a)
		(ii)	Volume of gas, $V = \frac{5.0 \times 10^5}{39 \times 10^6}$ (= 0.0128 (m ³)) Mass of gas = $V\rho = 0.0128 \times 0.72$ Mass = 9.2×10^{-3} (kg)	C1 A1	Possible ecf from (a)
	(c)		Any two from the following : - thermal energy/heat is lost through or to walls / ceiling / floor/windows /door of room (AW) - other objects within the room (AW) - warm <u>air</u> may escape from room / cold <u>air</u> or draughts may enter the room	B1 B1	Not: Bald 'Heat lost to surrounding' Ignore any references to heater
			Total	9	

Question			Answer	Marks	Guidance
5	(a)		Kinetic energy is conserved (when molecule collides) / collision is elastic (so velocity after collision is $-v$) Momentum change = $mv - [-mv]$ $= 2mv$	M1 A1 A0	Note: Kinetic and elastic , wherever used, to be spelled correctly Allow: $m[v-(-v)]$ or $-mv - mv$ Allow: A1 mark if M1 mark has been lost for incorrect spelling
	(b)		Increase in temperature causes an increase in velocity / speed (of molecules) Collisions are more frequent (AW) Greater (rate of) change in momentum (in each collision with the surface) Hence force increases	B1 B1 B1 A0	Note: No credit for references to pressure [NAQ]
	(c)	(i)	$\frac{p_2}{T_2} = \frac{p_1}{T_1}$ $p_2 = \frac{2.2 \times 10^5}{(273 + 18)} \times (273 + 54)$ $p_2 = 2.5 \times 10^5 \text{ (Pa)}$	C1 A1	Note: Mark is for substitution; any subject No marks if temperatures are not converted to kelvin Answer to 3 sf is $2.47 \times 10^5 \text{ (Pa)}$
		(ii)	Original area = $\frac{W}{p_1} = \frac{1200 \times 9.8}{2.2 \times 10^5} (= 5.35 \times 10^{-2}) \text{ (m}^2\text{)}$ Final area = $\frac{W}{p_2} = \frac{1200 \times 9.8}{2.47 \times 10^5} (= 4.77 \times 10^{-2}) \text{ (m}^2\text{)}$ Change in area = $(5.35 - 4.77) \times 10^{-2} = 5.8 \times 10^{-3} \text{ (m}^2\text{)}$	C1 C1 A1	Possible ecf from (c)(i) Allow: Full credit if 2 sf values are used eg $6.4 \times 10^{-3} \text{ (m}^2\text{)}$ using $p_2 = 2.5 \times 10^5$
			Total	10	

Question			Answer	Marks	Guidance
6	(a)	(i)	For a <u>fixed / constant mass</u> of gas at constant temperature Pressure is inversely proportional to volume / pressure x volume = constant	B1 B1	
		(ii)	Axes labelled p and $1/V$ OR V and $1/p$	B1	No ecf from a(i) Note: Only one tick
	(b)	(i)1	$pV = nRT$ $n = \frac{pV}{RT} = \frac{1.2 \times 10^7 \times 0.05}{8.31 \times (273 + 21)}$ $n = 250$	C1 A1	Allow: use of $pV = NkT$ leading to $N = 1.48 \times 10^{26}$ (C1) and $n = N/N_A$ giving $n = 250$ (A1) Mark is for substitution; any subject. No credit if 21°C is used giving $n = 3438$
		(i)2	mass = $n \times 0.029 = 246 \times 0.029$ = 7.1 kg	mass = $n \times 0.029 = 250 \times 0.029$ = 7.3 kg A1	Possible ecf from (b)(i)1 Allow ecf if $n = 3438$ leads to mass = 99.7 kg

Question			Answer	Marks	Guidance
6	(b)	(ii)	$n_{\text{air added}} = \frac{pV}{RT} = \frac{1.0 \times 10^5 \times 1.5}{8.31 \times (273 + 21)}$ $n_{\text{air added}} = 61.4$ $n_{\text{total}} = n_{\text{initial}} + n_{\text{air added}} = 246 + 61.4 \quad (= 307)$ $p_{\text{final}} = n_{\text{total}} \left(\frac{RT}{V} \right) = 307 \times \left(\frac{8.31 \times (273 + 21)}{0.050} \right)$ $p_{\text{final}} = 1.5 \times 10^7 \quad (\text{Pa})$	C1 C1 C1 A1	Possible ecf from (b)(i)1 or 2 Allow follow through for incorrect $n_{\text{air added}}$ value Using $n = 250$ from b(i)1 leads to $n_{\text{total}} = 250 + 61.4 \quad (= 311)$ Use of $T = 21^\circ\text{C}$ or $V = 1.55$ is wrong physics so can not score last two marks ALTERNATIVE METHOD Calculates pressure of air pumped in if it were to occupy a volume equal to cylinder $p_2 = \frac{1 \times 10^5 \times 1.5}{0.05} \quad (\text{C1})$ $p_2 = 3.0 \times 10^6 \quad (\text{C1})$ When added to air already in cylinder $p_{\text{final}} = p_{\text{original}} + p_2$ $p_{\text{final}} = 1.2 \times 10^7 + 3.0 \times 10^6 \quad (\text{C1})$ $p_{\text{final}} = 1.5 \times 10^7 \quad (\text{Pa}) \quad (\text{A1})$ SPECIAL CASES Using alternative method but with final volume taken as 1.5 m^3 $p_2 = 4.0 \times 10^5 \text{ (Pa)}$ and final pressure is $5.0 \times 10^5 \text{ (Pa)}$ Scores 2 marks . No credit if final volume taken as 1.55 m^3
			Total	10	

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