

Physics A

Advanced GCE

Unit **G484**: The Newtonian World

Mark Scheme for January 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.

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
	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

The abbreviations, annotations and conventions used in the detailed Mark Scheme are:

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**Note about significant figures:**

If the data given in a question is to 2 sf, then allow answers to 2 or more sf.


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 Column.

CATEGORISATION OF MARKS

The mark scheme 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.

Question		Answer	Marks	Guidance
1	(a)	Rate of change of momentum (of a body) is proportional / equal to the (net) force (acting on it) and takes place in the direction of that force.	M1 A1	Allow: Force = change in momentum / time (taken)  Note: momentum must be spelled correctly to score the mark. Allow this mark if the M1 mark is lost for spelling error
	(b) (i)	$(3 \times 5) - (7 \times 2) = 10v$ $v = (15 - 14)/10$ $= 0.10 \text{ (m s}^{-1}\text{)}$ to the right (AW)	C1 M1 A1	Signs must be correct for the mark to be scored Allow 1 sf answer Not forwards/towards B but allow correct arrow \rightarrow or east
	(ii)	Impulse = $3(0.1 - 5)$ $(= -14.7) = (-)15 \text{ (Ns)}$ to the left (AW)	M1 A1	Allow: ecf from (b)(i) Ignore sign Not backwards/towards A but allow correct arrow \leftarrow or west
	(iii)	(Newton's 3 rd law says) Force on B (due to A) is equal and opposite to force on A (due to B) time (of contact) / t is same for both AND Impulse = Ft impulse on A is equal and opposite to impulse on B	M1 A1 A0	Allow: use of minus sign to indicate 'opposite' Not: Action and reaction are equal and opposite.
		Total	9	

Question		Answer	Marks	Guidance
2	(a)	(i)		
		(ii)		
	(b)	(i)		
		(ii)		

Question		Answer	Marks	Guidance
	(c)	suitable example: eg weather / spy / surveying / mapping / GPS	B1	Ignore TV / radio / communications
		Total	10	

Question		Answer	Marks	Guidance
3	(a)	Force is proportional to the product of the masses and inversely proportional to the square of their separation (AW)	B1	Allow: $F = \frac{GmM}{r^2}$ with all symbols defined.
	(b) (i)	$mg = \frac{GmM_J}{r^2}$ $M_J \left(= \frac{g r^2}{G} \right) = \frac{7.5 \times (1.3 \times 10^8)^2}{6.67 \times 10^{-11}}$ $M_J = 1.9 \times 10^{27} \text{ (kg)}$	C1 C1 A1	Allow: formula with m cancelled Allow: use of $T^2 = \frac{4\pi^2 r^3}{GM_J} \Rightarrow M_J = \frac{4\pi^2 (1.3 \times 10^8)^3}{6.67 \times 10^{-11} \times (7.2 \times 60^2)^2}$ Note: mark is for substitution with any subject
	(ii)	$\frac{g_M}{g_A} = \frac{r_A^2}{r_M^2}$ $\frac{g_M}{7.5} = \frac{(1.3 \times 10^8)^2}{(2.4 \times 10^{10})^2}$ $g_M = 2.2 \times 10^{-4} \text{ (N kg}^{-1}\text{)}$	C1 A1	Allow: use of $g = \frac{GM_J}{r^2}$ with possible ecf for M_J from (b)(i) $g_M = \frac{(6.67 \times 10^{-11}) \times (1.9 \times 10^{27})}{(2.4 \times 10^{10})^2}$ Note: mark is for substitution $g_M = 2.2 \times 10^{-4} \text{ (N kg}^{-1}\text{)}$
	(iii)	$T^2 \propto r^3 \text{ OR } T^2/r^3 = \text{constant (} = 4\pi^2/GM_J \text{)}$ $\frac{T_M^2}{7.2^2} = \frac{(2.4 \times 10^{10})^3}{(1.3 \times 10^8)^3}$ $T_M = 1.8 \times 10^4 \text{ (hours)}$	C1 C1 A1	Allow: possible ecf for M_J from b(i) Allow: use of other correct formulae Note: mark is for substitution Note using times in seconds gives $T_M = 6.49 \times 10^7 \text{ (s)}$ scores 2 marks
Total			9	

Question	Answer	Marks	Guidance
4 (a)	<p>Obtain a set of readings for: mass m, time period AND calculate frequency using $f = \frac{1}{T}$.</p> <p>Plot graphs of f against $1/m$ AND f against $1/\sqrt{m}$</p> <p>The graph which is a straight line through the origin provides the correct relationship</p> <p>Reference to one method of improving reliability eg counting more than 5 oscillations to find T or f taking repeat measurements of T or f (and average values) time oscillations from equilibrium position</p>	<p>B1</p> <p>B1</p> <p>B1</p> <p>B1</p>	<p>Not number of oscillations in a set time</p> <p>Allow: product method using two or more points (B1) Select the relation which gives a constant product (B1)</p> <p>Allow: plot $\ln f$ against $\ln m$ (B1) gradient = -1 then $f \propto 1/m$ or gradient = -0.5 then $f \propto 1/\sqrt{m}$ (B1)</p>
(b) (i)	$v_{\max} = 2\pi f A = 2\pi \left(\frac{1}{1.2}\right) \times 36 \times 10^{-3}$ $v_{\max} = \frac{3\pi}{50} \quad (= 0.188)$ $KE_{\max} = \frac{1}{2} \times 0.4 \times \left(\frac{3\pi}{50}\right)^2$ $KE_{\max} = 7.1 \times 10^{-3} \quad (\text{J})$	<p>C1</p> <p>C1</p> <p>A1</p>	<p>Note: mark is for substitution</p>
(ii)	$a_{\max} = (2\pi f)^2 A = \left[2\pi \left(\frac{1}{1.2}\right)\right]^2 \times 36 \times 10^{-3}$ $a_{\max} = 0.99 \quad (\text{ms}^{-2})$	<p>C1</p> <p>A1</p>	<p>Note: mark is for correct substitution</p>

Question	Answer	Marks	Guidance
(c)	<p>Reference to : kinetic energy (of masses and spring), gravitational potential energy (of mass and spring), elastic (potential) energy / strain energy of spring</p> <p>KE: <u>zero</u> (at lowest point), increasing to max at equilibrium point, decreasing to <u>zero</u> (at highest point)</p> <p>GPE: increases (as masses rise from lowest to highest point) (clearly worded ora)(AW)</p> <p>strain / elastic energy: decreases (as masses rise from lowest to highest point) (clearly worded ora) (AW)</p>	<p>B1</p> <p>B1</p> <p>B1</p> <p>B1</p>	<p>Note: mark to be awarded only if all 3 forms are quoted ✍ Note: potential must be spelled correctly throughout to score this mark</p>
	Total	13	

Question			Answer	Marks	Guidance
5	(a)	(i)	n = number of moles (in sample) AND N = number of atoms / molecules (in sample)	B1	Note: both definitions are required Not: particles / Avogadro's constant
		(ii)	n or N AND T is constant (and R and k are constants) for a fixed mass (of gas), $pV = \text{constant} / p \propto 1/V$	M1 A1	nRT or NkT is constant is not sufficient
		(iii)	Shows that $Nm^{-2} \times m^3 = Nm$	B1	Allow: Use of base units for both pV and work done
	(b)	(i)	Calculates $p \times (1/V)^{-1}$ at two points on the graph values are the same $pV = \text{constant} / p \propto 1/V / nRT = \text{constant}$	M1 A1	Expected values for pV are 7500 (Nm) or $0.075 (x 10^{-5})$ for most points Allow: Correct calculation of gradient (M1) Calculates intercept = 0 hence graph is through the origin and $pV = \text{constant} / p \propto 1/V$ (A1)
		(ii)	Number of moles in 0.050 kg = $0.05/0.016$ (= 3.125) $T = \frac{pV}{nR} = \frac{7500}{3.125 \times 8.31}$ = 289 (K) $T = 16$ (°C)	C1 C1 A1	Allow: possible ecf from (b)(i) or error in n but apply POT error for use of $pV = 0.075$ leading to $T = 2.9 \times 10^{-3}$ K Note: Mark is for correct conversion of their T (K) value Note: Allow full range of marks for other sensible alternative approaches e.g. use of a molecular mass of 0.032 kg/mol giving a temperature of 305°C
			Total	9	

Question			Answer	Marks	Guidance
6	(a)	(i)	vibrate (about their 'fixed' positions)	B1	Allow: molecules vibrate
		(ii)	greater amplitude / greater frequency (of vibration)	B1	Not: faster / more / bigger /more vigorous (vibrations)
		(iii)	Either internal energy increases Or potential energy (of molecules) increases and the kinetic energy remains constant temperature remains constant	B1 B1	
	(b)	(i)	$P t = m c \Delta\theta$ $48 \times 720 = 0.98 \times c \times (54 - 18)$ + $0.027 \times 850 \times (38-18)$ $c = 970 \text{ (J kg}^{-1} \text{ K}^{-1}\text{)}$	C1 C1 C1 A1	Note: mark is for correct substitution for total energy input and heat gained by metal Note: mark is for adding a correct substitution for heat gained by insulation into this equation Note: answer to 3 sf = 967 Calculation of $c = 980$ ignoring energy used to heat insulation scores 2 marks
		(ii)	Without the insulation there will be more heat lost to the surroundings / air (AW) final temperature will be lower OR a lower temperature rise OR more energy will be required to give the same temperature rise / final temperature AND hence c is higher than that calculated in (i)	M1 A1	Not: lost to wires / data logger
			Total	10	

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