OCR
Oxford Cambridge and RSA

GCE

Physics A

Unit **G484**: The Newtonian World

Advanced GCE

Mark Scheme for June 2014

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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.

These are the annotations, (including abbreviations), including those used in scoris, which are used when marking

Annotation	Meaning
BP	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.
	correct response
	incorrect response
BOD	benefit of the doubt (where professional judgement has been used)
NBOD	benefit of the doubt **not** given
ECF	error carried forward
^	information omitted
CON	contradiction (in cases where candidates contradict themselves in the same response)
FT	follow through
SF	error in number of significant figures
POT	error in the power of 10 in calculation
AE	arithmetic or calculation error
NAQ	not answered question
?	wrong physics
RE	reading error or rounding error

Abbreviations, annotations and conventions used in the detailed Mark Scheme.

/	=	alternative and acceptable answers for the same marking point
(1)	=	separates marking points
allow	=	answers that can be accepted
not	=	answers which are not worthy of credit
reject	=	answers which are not worthy of credit
ignore	=	statements which are irrelevant
( )	=	words which are not essential to gain credit
__	=	underlined word (or the equivalent) must be present in answer to score a mark
ecf	=	error carried forward
AW	=	alternative wording
ora	=	or reverse argument

Subject-specific Marking Instructions

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 answers to 2 or more significant figures.
If an answer is given to fewer than 2 sf, then penalise once only in the entire paper
If an answer is incorrectly rounded to **2 sf**, then penalise once only in the entire paper.

Any exception to this rule will be mentioned in the Additional Guidance.

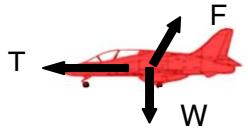
<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td></td><td>
<table>
<tr><th>Statement</th><th>Elastic collision</th><th>Inelastic collision</th></tr>
<tr><td>Total momentum for the objects is conserved.</td><td>✓</td><td>✓</td></tr>
<tr><td>Total kinetic energy of the objects is conserved.</td><td>✓</td><td></td></tr>
<tr><td>Total energy is conserved.</td><td>✓</td><td>✓</td></tr>
<tr><td>Magnitude of the impulse on each object is the same.</td><td>✓</td><td>✓</td></tr>
</table>
</td><td>B1

B1</td><td>Allow: Clear notation as alternative to tick.
Award mark only if all responses for elastic collisions are correct.
Award mark only if all responses for inelastic collisions are correct.</td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td>(Velocity) <u>increases</u> at a <u>constant</u> / <u>uniform</u> rate</td><td>B1</td><td>Allow: steady rate.
Allow: (velocity) increases with <u>constant</u> / <u>uniform</u> acceleration.
Do not allow reference to speed.</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Impulse = Area under curve
$\text{Area} = \left(\frac{1}{2}\times 0.6\times 10^{-3}\times 2.2\times 10^{3}\right)+\left(0.3\times 10^{-3}\times 2.2\times 10^{3}\right)$
$+\left(\frac{1}{2}\times 0.6\times 10^{-3}\times 2.2\times 10^{3}\right)$
$= 0.66+0.66+0.66$

$\text{Area} = 1.98$ (Ns)</td><td>C1

A1</td><td>Allow: use of trapezium formula.
Allow: counting squares.
If value is in range 780 – 800 small squares and one small square represents 2.5 x 10^{-3} (Ns) or equivalent then max of 2 marks.
If number of squares is outside this range allow max 1 mark

Allow:
Area = 2.0 (N s) but not 2 (sf error)
1 mark for Area = 2.0 x 10^{-3} omitting kN
1 mark for Area = 2000 omitting ms</td></tr>
<tr><td></td><td></td><td>(iii)</td><td>Impulse = $\Delta(mv)$
$v = \frac{1.98}{140\times 10^{-3}} = 14$ (m s^{-1})</td><td>B1</td><td>Possible ecf from b(ii)
Answer to 3 sf = 14.1 (m s^{-1}) [14.3 if using 2.0 N s]</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>6</td><td></td></tr>
</table>

Question			Answer	Mark	Guidance
2	(a)	(i) (ii)	 Correct direction and labelling for W and T	B1	**Both** forces must be correct to score this mark.
		(iii)	Straight line for F Correct direction **not** horizontal or vertical	B1	**Allow:** Freehand sketch of *F* must lie between 15º and 75º to the horizontal to score this mark.
	(b)	(i)	$a = T / m$ $a = 28 \times 10^3 / 6200$ (= 4.516) $v^2 = u^2 + 2as$ $56^2 = 0 + 2 \times 4.516s$ (any subject) $s = 350$ (m)	C1 C1 A1	Must substitute to score this mark. Answer to 3 sf = 347 (m). **Allow:** max 2 marks if v is not squared but correct formula was quoted. [Expect $s = 6.2$ (m)] **Allow:** $Fs = ½ mv^2$ [C1] $28 \times 10^3 \; s = ½ \times 6200 \times 56^2$ [C1] (any subject) $s = 350$ (m) [A1] **Allow:** $Ft = mv$ $t = 12.4$ (s) [C1] $s = ½ vt = ½ \times 56 \times 12.4$ [C1] $s = 350$ (m) [A1]
		(ii)	Air resistance/drag/friction acts on aircraft decreasing **either** the net forward force **or** the acceleration Fs = ΔKE so reduced force must act over a longer distance to produce enough kinetic energy for take-off OR $v^2 = (u^2) + 2as$ so reduced acceleration means longer distance to reach take-off speed.	M1 A1	**Not:** 'slowing the aircraft down'. **Allow** word equation. **Note:** This mark cannot be given if the previous (M1) mark has not been scored.
	(c)	(i)	$L \cos 35^\circ = 6200 \times 9.81$ $L = \frac{6200 \times 9.81}{\cos 35^\circ}$ OR $L = 7.42 \times 10^4$ $L = 7.4 \times 10^4$ (N)	M1 A0	**Allow:** Use of 9.8 **Note:** There is no mark for the answer as it is given in the question. Marks in 'Show' questions are for the working.

Question			Answer	Mark	Guidance
		(ii)	$L\sin 35^\circ = mv^2/r$ $r = \frac{6200 \times 86^2}{7.4 \times 10^4 \sin 35^\circ}$ r = 1100 (m)	C1 C1 A1	Possible ecf from (c)(i). Correct answer to 3 sf = 1.08 x 10^3 (m). **Allow:** 1 mark for using cos 35º instead of sin 35º. Expect gives an answer of 760 (m). **Allow:** 2 marks for correct working using v = 56 (m s^{-1}) Expect an answer of r = 460 (m). No marks for using tan 35º or for omitting a trig function.
	(d)	(i)1	Indication at 'top' of circle (by eye)	B1	
		(i)2	0 (N)	B1	
		(ii)	P is not the resultant force **OR** Resultant force must be towards centre of circle so *P* must have a component acting vertically upwards, equal in magnitude to *W* (AW)	B1	**Allow:** (Horizontal) component of *P* provides centripetal acceleration and vertical component of *P* is equal to weight. (AW)
			Total	14	

Question			Answer	Marks	Guidance
3	(a)	(i)	T = 2.4 (s) f = 1/T = 1/2.4 = 0.42 (Hz)	A1	No marks for T = 3 (s) leading to f = 0.33 (Hz).
		(ii)	$v_{max} = 2\pi fA$ $v_{max} = 2\pi \times \frac{1}{2.4} \times 50 \times 10^{-3}$ $v_{max} = 0.13 \quad (m\,s^{-1})$	C1 A1	**Allow:** Tangent drawn on graph at any x = 0 point (C1) calculation of gradient to give value in range 0.12 to 0.14 ($m\,s^{-1}$) (A1) Mark is for substitution. Possible ecf from a(i). Answer to 3 sf = 0.131 ($m\,s^{-1}$). Expect v_{max} = 0.10 ($m\,s^{-1}$) if answer in (i) f = 0.33 Hz (T=3).
	(b)	(i)	frequency is the same / not changed since (in SHM) it is independent of amplitude / (starting) displacement (AW)	B1	**Allow:** ...since length of pendulum is unchanged
		(ii)	(maximum velocity) is reduced because amplitude / (starting) displacement is reduced (AW) (Max) KE is reduced to one quarter / 4 times smaller	B1 B1	**Allow:** (Max) KE is smaller since amplitude/ (starting) displacement is smaller **Allow:** (Max) KE is smaller because GPE is smaller
	(c)	(i)	Straight line through origin means acceleration ∝ displacement Negative gradient means acceleration and displacement are in opposite directions / acceleration directed is towards the midpoint/equilibrium point (AW)	B1 B1	**Allow:** Straight line through origin means a ∝ x **Allow:** 1 mark for straight line through origin and negative gradient means $a \propto -x$ (hence SHM)
		(ii)	$(\text{Magnitude})\ \text{Gradient} = \quad \omega^2 = 5/0.004 \quad = (2\pi f)^2$ $f = 5.6 \quad (\text{Hz})$	C1 A1	C1 mark is for substitution of gradient for ω^2 or $(2\pi f)^2$ Answer to 3 sf = 5.63 (Hz) **Allow:** 1 mark for f = 0.178 (Hz) not converting mm to m
			Total	10	

Question			Answer	Marks	Guidance
4	(a)		Spaceship is (always vertically) above the same point on (the surface of the Earth/ planet) (AW)	B1	**Allow:** Spaceship must orbit the equator with a period of 24 h/ 1 day **and** must have the same direction of rotation as Earth / planet (AW) **Not :** same point in sky
	(b)	(i)	Centre of spaceship's orbit must coincide with the centre of mass of Benzar **OR** orbit must be equatorial (AW)	B1	S Pole is on axis of rotation (radius of orbit is zero)
			Velocity of spaceship must be parallel to the velocity of a point on the surface of Benzar. **OR** Spaceship must orbit in the same direction as Benzar rotates (AW)	B1	Spacecraft must be stationary /not orbiting planet / spinning on its axis OR Spacecraft will only pass over S Pole once in each orbit
		(ii)	$R^3 = \frac{GT^2M}{4\pi^2}$	C1	Must have R or R^3 as subject
			$R^3 = \frac{6.67\times10^{-11}\times(1.2\times10^5)^2\times8.9\times10^{25}}{4\pi^2}$	C1	Mark is for substitution
			$R = 1.3\times10^8$ (m)	A1	Answer to 3 sf is 1.29×10^8 (m)
			Total	6	

Question			Answer	Marks	Guidance
5			**Diagram showing** • Oil in (insulated) container • Electrical heater <u>fully immersed in oil</u> • <u>Thermometer / Temperature sensor</u> **Electrical circuit** • Ammeter in series , voltmeter in parallel with heater / joulemeter in parallel with heater • Power supply /+ & - signs marked on wires **Measurements** • Measure mass of oil /use known mass of oil, • Measure change in temperature / initial and final temperatures • Measure current, pd and (fixed) time / energy **Calculation** $\text{Input Energy} = E = Pt = VIt$ and $c = \frac{E}{m\Delta\vartheta}$ **Uncertainties** Any **two** together with minimising action. • Heat losses (make $\Delta\vartheta$ uncertain) - minimise by using initial ϑ below and final ϑ <u>same amount</u> above, room temperature • Temperature varies throughout oil - minimise by stirring before taking temperature readings • Some energy is required to raise temperature of the container / heater (etc) - allow by including in calculation. • Temperature will continue to rise after heater is turned off – find max temperature.	B1 B1 B1 B1 2 x B1	**Not:** oven or hotplate **Allow:** 'Fully immersed' seen in the body of text **Thermometer /Temperature sensor** must be spelled correctly on diagram All elements should be shown to score these diagram marks. Ignore appropriate additional items Connections to heater should be clear. Must have all elements. **Allow:** Use of symbols **Allow:** Take energy reading from joulemeter **Not:** use given power rating of heater Input energy must be consistent with equipment used. c must be the subject of the equation and temperature **rise** ($\Delta\vartheta$ or $\vartheta_2 - \vartheta_1$) must be clear. **Allow**: Draw graph of temperature against time $c = VI$ / [gradient x mass] These points may be scored in the description of method. No credit for other uncertainties including heat lost to surroundings
			Total	6	

Question			Answer	Marks	Guidance
6	(a)	(i)	Molecules (of the liquid) are in random / haphazard motion (AW)	B1	Not zig-zag
			Molecules (of liquid) are smaller than pollen grains	B1	must compare to pollen grains **Ignore** mass is smaller
		(ii)	Increase the temperature (of the liquid)	B1	**Allow:** Heating the liquid
	(b)	(i)	Any **three** from: • Collisions with the walls/container/sides are elastic • force between molecules is negligible / zero except during collisions • Volume of the molecules is negligible compared to the volume of the container (AW) • Time within a collision is negligible compared to time between collisions **Max 3**	(B1) (B1) (B1) (B1) B3	**Collision/collides** must be spelled correctly to score the mark Ignore collisions between gas molecules Must refer to comparison to score either of the last two points. Ignore references to incomplete assumptions and assumption not given in expected answer.
		(ii)	Momentum of the molecule changes when it collides with the wall (AW) Force on the molecule is rate of change of momentum (by N 2nd Law) (By N 3rd Law) Force on wall is equal to and opposite to the force on the molecule pressure = **sum** of forces (due to all molecules) / Area of wall	B1 B1 B1 B1	**Allow:** There is an impulse on molecule when it collides with wall.

Question			Answer	Marks	Guidance
	(c)		$\rho = \frac{m}{V}$ (any subject) $n = \frac{m}{M}$ (any subject) $pV = nRT$ $p\left(\frac{m}{\rho}\right) = \left(\frac{m}{M}\right)RT$ $p = \frac{\rho RT}{M}$	M1 M1 A1 A0	**Allow:** $\rho = \frac{m}{V}$ (M1) A clear statement of "n = 1 then m = M" (M1) **Note:** Both M marks must be scored and the method **must be clear** to score the A1 mark. $pV = nRT$ $p\left(\frac{M}{\rho}\right) = RT$ (A1) $p = \frac{\rho RT}{M}$ (A0)
	(d)	(i)	Use of $p \propto \rho T$ or $\frac{p_T}{p_B} = \frac{\rho_T T_T}{\rho_B T_B}$ $0.35 = \frac{\rho_T \times 240}{1.3 \times 293}$ $\rho_T = \frac{0.35 \times 1.3 \times 293}{240}$ $\rho_T = 0.56$ (kg m^{-3})	C1 C1 A1	**Allow:** any subject **Allow:** any subject **Allow:** Max 1 mark if temperatures are not converted to kelvin. Expect density to be – 0.276 kg m^{-3} Answer to 3 sf is 0.555 (kg m^{-3})
		(ii)	**Correct** use of $N \propto \frac{p}{T}$ or $\frac{N_T}{N_B} = \frac{p_T T_B}{p_B T_T}$ $\frac{N_T}{N_B} = \frac{0.35 \times 293}{240}$ $\frac{N_T}{N_B} = 0.43$	C1 A1	Do not penalise use of ºC if already penalised in (i) **Allow:** Alternative approach using $\frac{N_T}{N_B} = \frac{\rho_T}{\rho_B}$ with possible ecf from (i) Answer to 3 sf is 0.427
			Total	18	

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