OCR
RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced GCE **G481**

Mechanics

Mark Scheme for June 2010

Oxford Cambridge and RSA Examinations

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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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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.

Convention used when marking scripts

WRONG PHYSICS OR EQUATION – indicate by **?** on scoris
No credit is given for correct substitution, or subsequent arithmetic, in a physically incorrect equation.

ERROR CARRIED FORWARD – indicate by **ECF** on scoris
Answers to later sections of numerical questions may be awarded up to full credit provided they are consistent with earlier incorrect answers.

ARITHMETIC ERROR – indicate by **AE** on scoris
Deduct 1 mark for the error and then follow through the working/calculation giving full credit for subsequent marks if there are no further errors. The ruling also includes power of ten (POT).

TRANSCRIPTION ERROR – indicate by ^ on scoris
This error is when there is incorrect transcription of data from the question, formulae booklet or previous answer. For example 1.6×10^{-19} has been written down as 6.1×10^{-19} or 1.6×10^{19}. Deduct the relevant mark and then follow through the working giving full credit for subsequent marks.

SIGNIFICANT FIGURES – indicate by **SF** on scoris
Where more SFs are given than is justified by the question, do not penalise. Fewer significant figures than necessary will be considered within the mark scheme. An error in significant figures is penalised only once per paper.

BENEFIT OF DOUBT – indicate by **BOD** on scoris
This mark is awarded where the candidate provides an answer that is not totally satisfactory, but the examiner feels that sufficient work has been done.

RUBRIC INFRINGEMENT
If the candidate crosses out an answer but does not make any other attempt, then the work that is crossed out should be marked and the marks awarded without penalty.

CONTRADICTION – indicate by **CON** on scoris
No mark can be awarded if the candidate contradicts himself or herself in the same response. For example, '… t*he mass of the particle increases and decreases*.'

Q 1	Expected Answers	Marks	Additional Guidance
a	10^6 nano (n) 10^{12}	B1 B1 B1	**Allow**: 1000 000 **Allow**: nano / n / nano (N) as BOD **Allow**: 1000 000 000 000
b	Circled quantities: density and volume	B1	
c	$1.5\times10^{11} = 3.0\times10^{8}\times t$ time = $\frac{1.5\times10^{11}}{3.0\times10^{8}}$ / 500 (s) time = 8.33 (min) ≈ 8.3 (min)	C1 A1	**Allow**: Any subject **Note**: Bald 500 (s) scores 1 mark **Allow**: 2 marks for a bald answer of 8.3 **Allow**: Answer as a fraction – 25/3 (min) / 8 min 20 s **Allow**: 1 mark for '(500/3600 =) 0.139'
d(i)	Mention of weight or drag Net / total / resultant force (on drop) is zero 'upward force = downward force' / 'weight = drag' / 'weight balances drag'	B1 B1	**Allow:** (air) resistance / (air) friction for 'drag' **Not:** 'gravity' for 'weight' **but** 'force of gravity' is fine **Not**: 'acceleration = 0' since question requires answer in terms of forces **Not**: 'All forces are equal' **Note**: 'weight = drag' / 'weight balances drag' scores 2 marks
d(ii)1	A downward line / arrow (from the raindrop) leaning to the right	B1	**Note**: Answer **must** be on Fig. 1.2 Judge by eye – the angle is not important
d(ii)2	$v^2 = 1.5^2 + 4.0^2$ velocity = 4.27 (m s^{-1}) ≈ 4.3 (m s^{-1})	C1 A1	 **Allow**: 2 marks for a scale drawing with value in the range 4.1 to 4.5. If value in the range 4.0 to 4.1 or 4.5 to 4.6 then give 1 mark **Allow**: 2 marks for a bald answer of 4.3 (m s^{-1})
	Total	**11**	

Q 2	Expected Answers	Marks	Additional Guidance
a	‘heavy’ and ‘light’ objects / different weights / different masses dropped (from leaning tower of Pisa) / rolled down incline plane Objects have the same <u>acceleration</u> (of free fall) Objects hit ground at same time	B1 B1 B1	**Must use ticks on Scoris to show where the marks are awarded** **Not**: ‘dropping feather’ / ‘vacuum’ / ‘experiment on the Moon’ for this first B1 mark but can score subsequent B1 marks **Not**: ‘fall at the same rate / accelerates at the same rate / same speed’
b(i)	$s = ut + \frac{1}{2}at^2$ <u>and</u> $u = 0$ / $0.600 = \frac{1}{2} \times a \times (0.356)^2$ $a = \frac{2 \times 0.600}{0.356^2}$ $a = 9.47$ (m s^{-2})	C1 C1 A0	**Note**: There are no marks for just an answer, since this is a **‘show’** question **Allow**: 2 marks for correct substitution with ‘a’ the subject or $0.600 = \frac{1}{2} \times a \times (0.356)^2$ followed by $a = 9.469$ (more than 3 sf) **Note:** Using ‘v =.600/0.356’ followed by $a = \Delta v / \Delta t = 4.73$ scores zero. (Watch out for $4.734 \times 2 = 9.47$)
b(ii)	Air resistance or drag / residual magnetism or ‘sticky’ electromagnet / trapdoor takes time to open	B1	**Not**: ‘Experiment is not done in a vacuum’ / ‘friction/resistance’
b(iii)	A ‘parabola shape’ / graph of increasing positive gradient starting from <u>origin</u> and going through 0.356,0.6	B1	Judge the shape of the graph by eye. A horizontal line from 0.6 must cut the graph within the ‘vertical zone provided by 0.356 s ’ on the time axis
	Total	**7**	

Q 3	Expected Answers	Marks	Additional Guidance
a	The (net) force (is a newton) when a 1 kg mass has acceleration of 1 m s^{-2}	B1	**Not**: 1 N = 1 kg m s^{-2} because this is too brief for a definition
b(i)	weight = $1.9 \times 10^6 \times 9.81$ weight = 1.86×10^7 (N)	 B1	**Allow**: 9.8 (m s^{-2}) for *g* but not 10 (m s^{-2}) **Allow**: A bald answer of 1.9×10^7 N, but **not** if 10 (m s^{-2}) is seen
b(ii)	net force = 1.24×10^7 (N) or 1.2×10^7 (N) $a = \frac{F}{m} = \frac{1.24 \times 10^7}{1.9 \times 10^6}$ acceleration = 6.53 (m s^{-2}) or 6.5 (m s^{-2})	C1 A1	**Allow**: The C1 mark for "(net force) = $(3.1 - 1.86) \times 10^7$ (N)" **Allow**: 2 marks for a bald answer **Allow**: Answer of 6.3 (m s^{-2}) if 1.9×10^7 (N) is used for weight or net force of 1.2×10^7 (N) is used **Allow**: 1 mark for '$3.1 \times 10^7 / 1.9 \times 10^6 = 16.3$' **Not:** '$1.86 \times 10^7 / 1.9 \times 10^6 = 9.8$'
b(iii)	The mass / weight (of spaceship) decreases (as it loses fuel)	B1	**Allow**: 'g' / acceleration of free fall / gravitational field strength decreases (but **not** gravity decreases) **Not**: 'less drag / air resistance'
	Total	**5**	

Q 4	Expected Answers	Marks	Additional Guidance
a	✍work done = force × distance <u>moved</u> / <u>travelled</u> (in direction of force) **The term *distance* / *displacement* to be included and spelled correctly to gain mark**	B1	**Note**: Must have reference to 'distance moved / travelled' **Allow**: 'work done = force × displacement' **Must use tick or cross on Scoris to show if the mark is awarded**
b(i)	<u>gravitational</u> potential ✍ kinetic **The term *kinetic* to be included and spelled correctly to gain the second B1 mark**	B1 B1	**Not**: 'potential' on its own **Note**: Ignore any reference to sound **Must use ticks on Scoris to show where the marks are awarded**
b(ii)	(GPE =) $4000 \times 9.81 \times 110$ / (GPE =) 4.32×10^6 **or** (KE =) $\frac{1}{2} \times 4000 \times 20^2$ / (KE =) 8.0×10^5 Work done = $(4000 \times 9.81 \times 110) - (\frac{1}{2} \times 4000 \times 20^2)$ force = $\frac{3.516 \times 10^6}{510}$ force = 6.9×10^3 (N)	C1 C1 A1	 **Allow**: 2 marks if second line is written or $3.5(16) \times 10^6$ (J) is quoted **Allow**: 3 marks for a bald answer of 6.9×10^3 (N)
	Total	**6**	

Q 5	Expected Answers	Marks	Additional Guidance
a	The distance travelled (by the car) whilst the brakes are applied and the car stops (wtte)	B1	**Note**: The answer must have reference to car stopping
b	Any <u>two</u> factors from: mass, brakes, tyres / tread, road (surface) and 'slope' of road Correct description for each factor; see below: 1. Greater mass increases distance / distance ∝ mass 2. Worn brakes increases distance 3. Bald tyres increases distance (when wet) 4. Wet / icy /gravel road increases distance 5. An uphill road will decrease the distance (ora)	B1×2 B1×2	**Must use ticks on Scoris to show where the marks are awarded** **Allow:** Reference to just 'distance' since '<u>braking</u> distance' is in the question **Note**: For point 3, allow 'less tread increases (braking) distance (when wet)'.
c	Any <u>three</u> from: 1. Prevent collision with steering wheel / windscreen /dashboard 2. Time for stopping is more / distance for stopping is more / seat belt 'stretches' 3. Smaller deceleration / acceleration (of person) 4. Reference to '$KE = Fs$' or '$\frac{1}{2}mv^2 = Fs$'	B1×3	**Must use ticks on Scoris to show where the marks are awarded** **Allow**: Smaller 'rate of change of momentum' for the third B1 point **Not**: Less pressure (on driver because of larger area of belt)

Q 5	Expected Answers	Marks	Additional Guidance
d(i)1	thinking distance = 0.50×20 thinking distance = 10 (m)	B1	
d(i)2	braking distance = 30 (m) stopping distance = (30 + 10 =) 40 (m)	C1 A1	 **Allow**: 2 marks for a bald answer of 40 (m) **Allow**: 1 mark for 'answer to **(d)(i)1** + candidate's braking distance' if braking distance ≠ 30 (m) Possible ecf from **(d)(i)1**
d(ii)	$\frac{s}{32^2} = \frac{30}{20^2}$ / '$k = 0.075$' / '$k = 13.3$' (distance =) 77 (m) ---------- Or ---------- At speed of 16 (m s^{-1}), distance = 19 (m) (distance = $2^2 \times 19$ =) 76 (m)	C1 A1 ------- C1 A1	**Allow**: For the C1 any other equivalent and correct substitution into similar equation **Allow**: An answer in the range 76 - 78. Note bald answer in this range can score 2 marks **Allow**: distance in the range 19 to 19.5 (m) Possible ecf
	Total	**13**	

Q 6	Expected Answers	Marks	Additional Guidance
a(i)	torque = 4.0×0.03 torque = 0.12 (N m)	C1 A1	 **Note**: An answer of 12 scores 1 mark (because cm not converted into m) **Allow**: Full marks for if the centi prefix added; that is 12 N cm **Allow**: 2 marks for a bald 0.12 (N m)
a(ii)	 (total moment =) $(x + 0.03) \times 4.0 - 4.0x$ (total) moment = 0.12 (N m) It is the same as the torque (of the couple) / same as **(a)(i)**	 M1 A1 B1	**Condone** the use of 'N cm' in **a(ii)** **Allow**: Equation with x value of 0.06 (m) or 6 cm **Special case**: 1 mark for (anticlockwise moment =) $4.0x$ or (clockwise moment =) $[x + 0.03] \times 4.0$ seen anywhere on the script **Not**: '0.12 (N m)'
b	Net / total / resultant force = 0 Net / total torque / moment = 0	B1 B1	**Not**: 'forces are balanced' or 'force up = force down' **Allow**: clockwise moment(s) = anticlockwise moment(s)
c(i)	$\rho = \frac{M}{V}$ / density = $\frac{45}{0.600 \times 0.600 \times 0.050}$ density = 2.5×10^3 (kg m^{-3})	C1 A1	 **Allow**: 2 marks for a bald answer of 2.5×10^3 (kg m^{-3})
c(ii)	clockwise moment = anticlockwise moment **or** (weight =) 45×9.81 / (weight =) 441.45 $(45 \times 9.81) \times 0.150 = F \times 0.600$ F = 110 (N)	C1 C1 A1	 **Allow**: 3 marks for a bald 110 (N) **Allow**: 2 marks for 11.25 – mass of 45 kg not changed to N
	Total	**12**	

Q 7	Expected Answers	Marks	Additional Guidance
a	<table><tr><th>X</th><th>Y</th></tr><tr><td>✓</td><td></td></tr><tr><td></td><td>✓</td></tr><tr><td>✓</td><td></td></tr></table>	B1	All 3 ticks correctly placed for 1 mark
b(i)	Material is permanently deformed / longer when stress / force is removed (wtte)	B1	**Note**: The answer must make reference to stress or forces removed
b(ii)1	(stress = force/area) force = $3.00 \times 10^{9} \times 1.02 \times 10^{-7}$ force = 306 (N) or 310 (N)	C1 A1	**Allow**: Any subject **Allow**: 2 marks for a bald 306 (N) or 310 (N)
b(ii)2	(E = stress/strain) strain = $\frac{1.20\times10^{9}}{1.30\times10^{11}}$ / strain = 9.23×10^{-3} extension = $9.23 \times 10^{-3} \times 0.500$ extension = $4.6(15) \times 10^{-3}$ (m)	C1 A1	**Allow**: 4.6×10^{-3}, 4.61×10^{-3}, 4.62×10^{-3} **Allow**: 2 marks for a bald $4.6(15) \times 10^{-3}$ (m) **Allow**: 1 mark for using breaking stress of 3.0×10^{9} Pa; this gives an extension of 0.0115 (m) **Alternative answer:** $x = (1.20 \times 10^{9} \times 0.500)/1.30 \times 10^{11}$ C1 (Any subject) extension = $4.6(15) \times 10^{-3}$ (m) A1
	Total	**6**	

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