OCR
RECOGNISING ACHIEVEMENT

GCE

Mathematics (MEI)

Advanced Subsidiary GCE

Unit **4761:** Mechanics 1

Mark Scheme for January 2012

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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 and abbreviations

Annotation in scoris	Meaning
✓and ✗	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
Highlighting	

Other abbreviations in mark scheme	Meaning
E1	Mark for explaining
U1	Mark for correct units
G1	Mark for a correct feature on a graph
M1 dep*	Method mark dependent on a previous mark, indicated by *
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working

Subject-specific Marking Instructions for GCE Mathematics (MEI) Mechanics strand

a Annotations should be used whenever appropriate during your marking.

The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks. It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

For subsequent marking you must make it clear how you have arrived at the mark you have awarded.

b An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct *solutions* leading to correct answers are awarded full marks but work must not be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly.

Correct but unfamiliar or unexpected methods are often signalled by a correct result following an *apparently* incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, award marks according to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) you should contact your Team Leader.

c The following types of marks are available.

M
A suitable method has been selected and *applied* in a manner which shows that the method is essentially understood. Method marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, eg by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.

A
Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated Method mark is earned (or implied). Therefore M0 A1 cannot ever be awarded.

B
Mark for a correct result or statement independent of Method marks.

E

A given result is to be established or a result has to be explained. This usually requires more working or explanation than the establishment of an unknown result.

Unless otherwise indicated, marks once gained cannot subsequently be lost, eg wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

d When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation 'dep *' is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

e The abbreviation ft implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only — differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, exactly what is acceptable will be detailed in the mark scheme rationale. If this is not the case please consult your Team Leader.

Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be 'follow through'. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

f Unless units are specifically requested, there is no penalty for wrong or missing units as long as the answer is numerically correct and expressed either in SI or in the units of the question. (e.g. lengths will be assumed to be in metres unless in a particular question all the lengths are in km, when this would be assumed to be the unspecified unit.)

We are usually quite flexible about the accuracy to which the final answer is expressed and we do not penalise over-specification.

When a value is given in the paper

Only accept an answer correct to at least as many significant figures as the given value. This rule should be applied to each case.

When a value is not given in the paper

Accept any answer that agrees with the correct value to 2 s.f.

ft should be used so that only one mark is lost for each distinct error made in the accuracy to which working is done or an answer given.

Refer cases to your Team Leader where the same type of error (e.g. errors due to premature approximation leading to error) has been made in different questions or parts of questions.

There are some mistakes that might be repeated throughout a paper. If a candidate makes such a mistake, (eg uses a calculator in wrong angle mode) then you will need to check the candidate's script for repetitions of the mistake and consult your Team Leader about what penalty should be given.

There is no penalty for using a wrong value for *g*. E marks will be lost except when results agree to the accuracy required in the question.

g Rules for replaced work

If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

If there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others.

NB Follow these maths-specific instructions rather than those in the assessor handbook.

h For a *genuine* misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A mark in the question.

Marks designated as cao may be awarded as long as there are no other errors. E marks are lost unless, by chance, the given results are established by equivalent working.

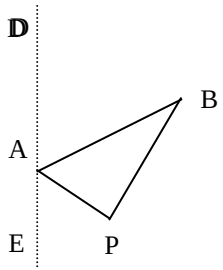
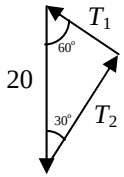
'Fresh starts' will not affect an earlier decision about a misread.

Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

i If a graphical calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers (provided, of course, that there is nothing in the wording of the question specifying that analytical methods are required). Where an answer is wrong but there is some evidence of method, allow appropriate method marks. Wrong answers with no supporting method score zero. If in doubt, consult your Team Leader.

j If in any case the scheme operates with considerable unfairness consult your Team Leader.

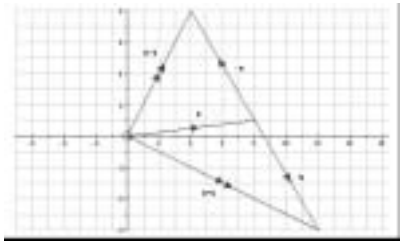
Question			Answer	Marks	Guidance	
1			Let the tension in the string be T N and the acceleration be a m s^{-2}	M1	One correct equation which must involving a and a weight	
			3 kg block: $T - 3g = 3a$ 5kg block: $5g - T = 5a$	M1	A second correct equation; this one must involve a, T and a weight	
			$2g = 8a$	M1	Elimination of both T and a from their equations or substitution of their a in their 3-term equation	
			$a = g/4 = 2.45$ (m s^{-2})	A1	Cao dependent on at least one of the first two M marks	
			$T = 36.75$ (N)	A1	Cao dependent on at least one of the first two M marks	
				[5]		

2	(i)		 $\angle BAD = 60°$ and $\angle PAE = 60° \Rightarrow \angle PAB = 60°$ (Angles on straight line) $\angle PAB = 60°$ and $\angle ABP = 30° \Rightarrow \angle APB = 90°$ (Angles in triangle)	B1 **[1]**	Any valid argument Allow an "argument" containing only numbers and no words	
2	(ii)			B1 B1 B1	**Diagram** A triangle with angles of approximately 90^o, 60^o and 30^o. No mark for an isosceles or equilateral triangle. No extra forces. Do not award this mark to candidates who draw a force diagram, ie showing 3 concurrent forces. **Arrows** Triangle: the sides are marked with arrows following a cycle round the triangle Force diagram: the directions of the three forces are indicated by arrows. No extra forces. **Labels** Triangle: all sides are labelled consistently and unambiguously with the angles, ie 20 opposite 90^o, T_{AP} opposite 30^o and T_{BP} opposite 60^o. Force diagram: all forces labelled Condone $20g$ or W	

			T_1 = Tension in AP. T_2 = Tension in BP	**[3]**		
	(iii)		$T_2 = 20\cos 30°$ Tension in string BP is 17.3 N Tension in string AP is 10 N	M1 A1 A1 **[3]**	An attempt to apply trigonometry to a triangle of forces to find the tension in either string No mark if derived from "weight = 20*g*" (giving 169.7) FT for "weight = 20*g*" (giving 98)	
2.	(iii)		**Alternative** Horizontal equilibrium: $T_2\cos 60° = T_1\cos 30°$ Vertical equilibrium: $T_2\sin 60° + T_1\sin 30° = 20$ Tension in BP is 17.3 N Tension in AP is 10 N	 (M1) (A1) (A1) **([3])**	Award up to all 3 marks for using horizontal and vertical equilibrium An attempt at both horizontal and vertical equilibrium equations No mark if derived from "weight = 20*g*" (giving 169.7) FT from "weight = 20*g*" (giving 98)	
2.	(iii)		**Alternative** $T_1 = 20\cos 60°,\ \ T_2 = 20\cos 30°$ Tension in BP is 17.3 N Tension in AP is 10 N	 (M1) (A1) (A1) **([3])**	Award up to all 3 marks for using equilibrium in directions PA and PB An attempt to resolve the weight in the directions PA and PB. This method may be implied by subsequent work No mark if derived from "weight = 20*g*" (giving 169.7) FT from "weight = 20*g*" (giving 98)	

3	(i)		$v = \int (4 - t)\mathrm{d}t$ $v = 4t - \frac{1}{2}t^2 + c \quad (t = 0, v = 0 \Rightarrow c = 0)$ $v = 4t - \frac{1}{2}t^2$ for $0 \le t \le 4$ When $t = 4$, $v = 8$ and for $t > 4$, $a = 0$ so $v = 8$ for $t > 4$	M1 A1 B1 **[3]**	Attempt to integrate Condone no mention of arbitrary constant $a = 0$ must be seen or implied	
	(ii)		$s = \int (4t - \frac{1}{2}t^2)\mathrm{d}t$ $s = 2t^2 - \frac{1}{6}t^3$ When $t = 4$, Nina has travelled $2 \times 4^2 - \frac{1}{6} \times 4^3 = 21\frac{1}{3}$ m When $t = 5\frac{1}{3}$, Nina has travelled $21\frac{1}{3} + 8 \times 1\frac{1}{3} = 32$ m	M1 A1 A1 F1 **[4]**	Again condone no mention of arbitrary constant Allow follow through from their $21\frac{1}{3}$ Exact answer required; if rounded to 32, award 0	
	(iii)		When $t = 5\frac{1}{3}$, Marie has run $6 \times 5\frac{1}{3} = 32$ m. Nina has also run 32 m so caught up Marie	B1 **[1]**	Allow an equivalent argument that when Marie has run 32 m, $t = 5\frac{1}{3}$, as for Nina This mark is dependent on an answer 32 in part (ii) but allow this where it is a rounded answer and in this particular case the rounding can be in part (iii)	

4	(i)	(*A*) (*B*)	Height 5 m g has been taken to be 10 m s^{-2}	B1 B1 **[2]**	No units required; apply ISW if incorrect units given Allow +10 or –10. No units required; apply ISW if incorrect units given	
4	(ii)		Displacement is $\begin{pmatrix}150\\80\end{pmatrix}-\begin{pmatrix}90\\80\end{pmatrix}$ $=\begin{pmatrix}60\\0\end{pmatrix}$	M1 A1 **[2]**	Displacement must be given as a vector. Allow a description of a vector in words. Attempts at substitution for t and subtraction of vectors must be seen Cao If the candidate then goes on to give a non-vector answer of "60 m", apply ISW.	
4	(iii)		$x=30t$ $y=5+40t-5t^2$ $y=5+40\times\left(\frac{x}{30}\right)-5\times\left(\frac{x}{30}\right)^2$ $y=5+\frac{4}{3}x-\frac{x^2}{180}$	B1 B1 M1 A1 **[4]**	 Attempt to eliminate t No errors	

5	(i)		$\lvert\mathbf{p}\rvert = \sqrt{8^2 + 1^2}$ $\lvert\mathbf{p}\rvert = \sqrt{65}$ $\lvert\mathbf{q}\rvert = \sqrt{4^2 + (-7)^2} = \sqrt{65}$ They are equal	M1 A1 A1 **[3]**	For applying Pythagoras theorem Condone no explicit statement that they are equal	
5	(ii)		$\mathbf{p} + \mathbf{q} = 12\mathbf{i} - 6\mathbf{j}$ $\mathbf{p} + \mathbf{q} = 6(2\mathbf{i} - \mathbf{j})$ so $\mathbf{p} + \mathbf{q}$ is parallel to $2\mathbf{i} - \mathbf{j}$	M1 E1 **[2]**	 Accept argument based on gradients being equal. "Parallel" may be implied	
5	(iii)		 The angle is 90^o	B1 B1 B1 **[3]**	One mark for each of $\mathbf{p} + \mathbf{q}$ and $\mathbf{p} - \mathbf{q}$ drawn correctly SC1 if arrows missing or incorrect from otherwise correct vectors Cao	

6	(i)		$v^2 - u^2 = 2as$ $0^2 - 40^2 = 2 \times a \times 125$ $\Rightarrow a = -6.4$ $F = ma$ $F = 800 \times (-)6.4 = (-)5120$	 M1 A1 M1 E1 **[4]**	 Substitution required. For *u v* interchange award up to M1 A0 Condone no – sign Allow +5120 or –5120	
6	(ii)		$v = u + at$ $0 = 40 - 6.4 \times t$ $t = 6.25$ It takes 6.25 seconds to stop	 M1 A1 **[2]**	 FT for *a*	
			Alternative $s = \frac{1}{2}(u+v)t$ $125 = \frac{1}{2}(40+0) \times t$ $t = 6.25$ it takes 6.25 seconds to stop	 (M1) (A1) **[2]**		
			Alternative $s = ut + \frac{1}{2}at^2$ $125 = 40t + \frac{1}{2} \times (-6.4)t^2$ $3.2t^2 - 40t + 125 = 0$ $t = 6.25$	 (M1) (A1) **([2])**		

6	(iii)		Reaction distance $< 155 - 125 =$ 30 m Time taken to travel 30 m at 40 m s^{-1} is 0.75 s	M1 E1 **[2]**	30 must be seen and used	
6	(iv)		Distance travelled before braking $= 20 \times 0.675 = 13.5\,\text{m}$ Distance travelled while braking $= \frac{20^2}{2 \times 6.4} = 31.25$ Stopping distance $= 13.5 + 31.25 = 44.75\,\text{m}$	B1 B1 B1 **[3]**	Cao	

6	(v)		The distance travelled during the reaction time is not affected by the slope. It is $20 \times 0.675 = 13.5\,\text{m}$		13.5 is rewarded later	
			Component of the car's weight down the slope	M1	Allow cos for sin for M1 Allow omission of g for this mark only	
			$= mg\sin\alpha = 800 \times 9.8 \times \sin 5^\circ\ (= 683.3\text{ N})$	A1	Cao	
			Force opposing motion when the brakes are applied $= 5120 - 683.3 = 4436.9$	M1	The resistance (5120) and their weight component (683.3) must have opposite signs.	
			Acceleration $= (-)\dfrac{4436.7}{800} = (-)5.546\ \text{ms}^{-2}$	A1		
			Distance travelled while braking $= -\dfrac{u^2}{2a} = -\dfrac{400}{2 \times (-)5.546} = 36.06\,\text{m}$	A1		
			Stopping distance $= 13.5 + 36.06 = 49.56\,\text{m}$	F1	Allow FT for 36.06 from previous answer. Allow FT of 13.5 from part (iv)	
				[6]		
6	(vi)		Increase in stopping distance on account of slope $= 49.56 - 44.75 = 4.81\,\text{m}$			
			Percentage increase $= \dfrac{4.81}{44.75} \times 100 = 11\%$	B1	Cao This mark is dependent on a correct final answer to part (v)	
				[1]		

7	(i)		Vertical motion: initial speed $40\sin\alpha$ $h = (40\sin\alpha)t - \frac{1}{2}gt^2$	B1		
			$h = 0 \Rightarrow t = 0$ or $\dfrac{2\times 40\times\sin\alpha}{g}$	M1	Correct expression for h must be seen. Condone omission of the case $t = 0$	
			$\Rightarrow T = \dfrac{80\sin\alpha}{g}$	E1	Perfect argument (but still condone omission of $t = 0$)	
			Alternative Vertical motion: initial speed $40\sin\alpha$ $v = 40\sin\alpha - gt$	(B1)		
			When $v = 0$, $t = \dfrac{T}{2}$	(M1)	Correct expression for v must be seen	
			$\Rightarrow T = \dfrac{80\sin\alpha}{g}$	(E1)	Perfect argument	
			Horizontal motion: initial speed $40\cos\alpha$	B1		
			$R = 40\cos\alpha \times T$	M1	There must be evidence of intention to use T	
			$\Rightarrow R = \dfrac{3200\sin\alpha\cos\alpha}{g}$	E1	Perfect argument	
				[6]		
7	(ii)		$\alpha = 30°$: $T = \dfrac{80\sin 30°}{9.8} \simeq 4.08$ $\Rightarrow R = \dfrac{3200\times\sin 30°\times\cos 30°}{9.8} = 141.4$	B1	Both answers required for the mark. Evidence of substitution required	
			$\alpha = 45°$: $T = 5.77$	B1		

			$\alpha = 45°$: $R = 163.3$	B1 **[3]**	Accept 3 significant figures	
7	(iii)		The standard model is not accurate; 125 is much less than 141.4	B1 **[1]**	The comment must be based on the figures given in the question	
7	(iv)		Horizontal motion: $s = ut + \frac{1}{2}at^2$ $x = 40\cos 30° \times t - \frac{1}{2} \times 2 \times t^2$ $x = 40t\cos 30° - t^2$ Flight time = 4.08 s $R = 40 \times \cos 30° \times 4.08 - \frac{1}{2} \times 2 \times 4.08^2$ $R = 124.7$ This is close to the experimental result of 125 m	M1 A1 M1 E1 **[4]**	Use of correct formula A comparison with 125 m is required	

7	(v)		When $\alpha = 45°$, $T = 5.77$ $R = 40 \times \cos 45° \times 5.77 - \frac{1}{2} \times 2 \times 5.77^2$ $R = 129.9$ 129.9 m is not very close to 135 m so the model is not very accurate for this angle.	M1 A1 B1 **[3]**	Use of correct formula, with substitution for α and T. FT their T from (ii) but not 4.08. SC1 for substituting for T but using 30^o for α Comparison of their 129.9 with 135 If 4.08 used for T and answer 98.8 obtained for R allow FT for this mark Allow argument that to get to 135m takes 6.07 s which is greater than 5.77 s	
7	(vi)		Allow for resistance in the vertical direction as well	B1 **[1]**	Any sensible comment, but do not award a mark for "Allow for air resistance" without mention of the vertical direction.	

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