OCR
RECOGNISING ACHIEVEMENT

GCE

Mathematics (MEI)

Advanced GCE

Unit **4762:** Mechanics 2

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 accuracy error, except for errors due to premature approximation which should be penalised only once in the examination.

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.

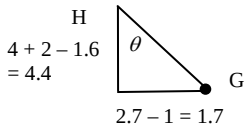
'Fresh starts' will not affect an earlier decision about a misread.

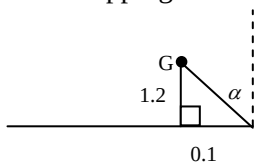
Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

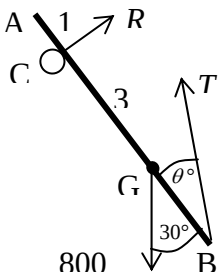
i If a graphical calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers (provided, of course, that there is nothing in the wording of the question specifying that analytical methods are required). Where an answer is wrong but there is 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.

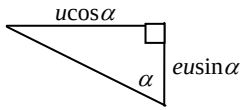
Question			Answer	Marks	Guidance
1					In this question, penalise use of 8 instead of 8000 only in (ii) and final mark in each of (iv) and (v)
1	(i)		20 000 × 60 = 1 200 000 J (1.2 MJ)	M1 A1 [2]	Use of $WD = Pt$. Allow use of 1 for 60 and 20 for 20 000 isw
1	(ii)		½ × 8000 × (12^2 - 8^2) = 4000 × 80 = 320 000 J (increase)	M1 B1 A1 [3]	Use of difference of non-zero KE terms ONLY Use of 8000 cao Neglect reference to increase.
1	(iii)		1 200 000 = 320 000 + 125 000 + 8000 × 9.8× h h = 9.63010… so 9.63 m (3 s.f.)	M1 B1 A1 A1 [4]	Use of W - E. Must include their (i), PE and at least one other term (KE terms count as one) Use of mgh Award for g written instead of 9.8 All terms present and correct. Accept sign errors cao
1	(iv)		$P = Fv$ so 26 000 = 6.5F and F = 4000 Using N2L 4000 – 8000 × 9.8 × sin θ – 225 = 0 θ = 2.759888… so 2.76° with the horizontal	M1 A1 M1 A1 B1 A1 [6]	Use of $P = Fv$ All terms present. No extras. Allow sign errors; allow sin ↔ cos All correct; allow missing g in weight term weight term correct cao
1	(v)		EITHER 26 000 + (155 – 225) × 6.5 = 25 545 W	M1 A1 [2]	
			OR $(8000g\sin\theta + 155) \times 6.5$ =25 545 W	M1 A1 [2]	Allow only sign errors

Question			Answer	Marks	Guidance
2	(i)		$20\begin{pmatrix}\bar{y}\\ \bar{z}\end{pmatrix}=16\begin{pmatrix}3\\1\end{pmatrix}+4\begin{pmatrix}1.5\\4\end{pmatrix}$	M1	A systematic method for at least 1 cpt
				A1	*Either* all *y* or all *z* values correct *or* 1 vector term correct
			so $20\begin{pmatrix}\bar{y}\\ \bar{z}\end{pmatrix}=\begin{pmatrix}54\\32\end{pmatrix}$		Need not be explicit
			Hence $\bar{y}=2.7$	A1	
			and $\bar{z}=1.6$	A1 [4]	Allow FT for either if only error is common
2	(ii)				
				M1	Identifying correct angle. May be implied
				B1	At least 1 relevant distance found. FT (i)
			tan θ = $\frac{1.7}{4.4}$	M1	Use of arctan **their** $\frac{1.7}{4.4}$ or $\frac{4.4}{1.7}$ o.e.
			so θ = 21.1247… so 21.1° (3 s.f.)	A1 [4]	cao
2	(iii)		$20\begin{pmatrix}\bar{x}\\ \bar{y}\\ \bar{z}\end{pmatrix}=4\begin{pmatrix}2\\1.5\\2\end{pmatrix}+2\begin{pmatrix}-0.5\\0\\1\end{pmatrix}+6\begin{pmatrix}-1.5\\4\\1\end{pmatrix}+8\begin{pmatrix}0\\2\\1\end{pmatrix}$	M1	A systematic method for at least 1 cpt
				A1	*Either* all *x* or all *y* or all *z* values correct *or* 2 vector terms correct on RHS
				A1	Completely correct expressions seen for all components
			$20\begin{pmatrix}\bar{x}\\ \bar{y}\\ \bar{z}\end{pmatrix}=\begin{pmatrix}-2\\46\\24\end{pmatrix}$		Need not be explicit
			Hence $\bar{x}=-0.1$	E1	
			$\bar{y}=2.3$	A1	
			and $\bar{z}$ = 1.2	A1 [6]	

Question			Answer	Marks	Guidance
2	(iv)		Let c.m. be at G To be on point of tipping G is vert above OA	B1	May be implied
			 	B1	Appropriate lengths found. FT (iii).
			For G to reach the vertical the bracket must rotate through α where α= arctan $\frac{0.1}{1.2}$	M1	Use of arctan **their** $\frac{0.1}{1.2}$ or $\frac{1.2}{0.1}$ o.e. or take moments for component parts
			so angle is 4.76324… so 4.76° (3 s.f.)	A1 [4]	cao Note that 85.24 will get 3/4
3	(i)		In these solutions R N is reaction at peg and T N the tension in the string a.c. moments about C		
			$5T - 3\times 800 = 0$	M1	Moments with all forces present
			so T = 480. Tension is 480 N	A1	
			↑ $T + R - 800 = 0$	M1	May take moments again
			so R = 320. Normal reaction is 320 N	F1 [4]	
3	(ii)		a.c. moments about C		
			$5T\sin 70 - 3 \times 800 = 0$	M1	Attempt at moments with resolution. All forces present. Could use (i)
			so T = 510.80533… so 511 N (3 s.f.)	A1	
			R = 320	B1	Accept WW. May derive again.
			Friction is F ←		
			← $F - T\cos 70 = 0$	M1	Resolve horizontally; allow $\sin \leftrightarrow \cos$
			(so F = 174.7057…)	A1	Correct expression seen
			$\mu = \frac{F_{\max}}{R}$	M1	
			= $\frac{174.7057...}{320}$ = 0.54595… so 0.546 (3 s.f.)	A1 [7]	cao

Question			Answer	Marks	Guidance
3	(iii)				
			a.c. moments about C		
			$5 \times T\sin\theta - 3 \times 800\sin 30 = 0$	M1	Attempt at moments: requires at least T or 800 resolved
			so $T\sin\theta = 240$	A1	Any form
			up the beam		
			$T\cos\theta - 800\cos 30 = 0$	M1	Attempt at resolution or moments to establish a second equation in T and θ
			so $T\cos\theta = 400\sqrt{3}$	A1	Any form
			Dividing		
			$\tan\theta = 0.3464101\ldots$	M1	Dependent on at least one of previous M1's being earned
			so $T = 733.212111$ so 733 (3 s. f.)	A1	cao
			so $\theta = 19.1066\ldots$ so 19.1 (3 s.f.)	A1	FT
					[Award 1st of θ and T found cao and 2nd FT]
			alternative method		
			Use of concurrence to find θ	M1	A clear attempt
				A1	A clear diagram showing *R,T and W*
				M1	Indicating all the required values and the correct angle
			$\theta = 19.1066\ldots$so 19.1 (3 s.f.)	A1	
			Finding an equation connecting T and θ	M1	Attempt at moments or resolution
			$T = 733.212111$ so 733 (3 s.f.)	A1	Any form
				F1	
				[7]	
4	(a)	(i)	$(0.02 + 0.1)V = 0.108$	M1	PCLM: must be sum of masses on lhs
			so $V = 0.9$ and speed is 0.9 m s^{-1}	A1	Accept no direction given
				[2]	

Question			Answer	Marks	Guidance
4	(a)	(ii)	**method 1**		
			$2.43t = 0.108$	M1	Equate given LM to impulse of the resistance
			$t = \frac{2}{45}$ so $\frac{2}{45}$ s [0.0444 (3 s.f.)]	A1	0.04 gets A0
			Acceleration constant so	M1	Using $s = 0.5(u+v)t$ or use W-E
			$s = \frac{1}{2} \times (0.9+0) \times \frac{2}{45} = 0.02$ so 0.02 m	A1	
					[Could use both W-E and I-M in either order or either with *suvat* for M1A1]
			method 2		
			N2L $\leftarrow$: $-2.43 = 0.12a$		Use N2L to find acceleration
			$a = -20.25$		
					Whichever of t and s found first, FT to second calculation; also FT a
			$0.9 = 20.25t$	M1	Using (N2L and) *suvat*
			time is $\frac{2}{45}$ s [0.0444 (3 s.f.)]	A1	Accept sign errors
			$s = \frac{1}{2} \times (0.9+0) \times \frac{2}{45}$	M1	Using (N2L and) *suvat*
			distance is 0.02 m	A1	Accept sign errors
				[4]	
4	(a)	(iii)	Speed of object is 0.108/0.1 so 1.08 m s^{-1}	B1	
			take +ve $\leftarrow$		
			PCLM		
			$0.108 = 0.02v_N + 0.1\,v_O$	M1	PCLM
				A1	Any form
			NEL		
			$\frac{v_N - v_O}{0 - 1.08} = -\frac{1}{3}$	M1	Fraction must be correct way up
				F1	Any form. FT their 1.08
			Solving for v_N: $v_N = 1.2$ so 1.2 m s^{-1}	A1	cao. Accept no direction
				[6]	

Question			Answer	Marks	Guidance
4	(b)	(i)	Up and towards plane +ve Before parallel: $u\cos\alpha$; perp: $u\sin\alpha$ After parallel: $u\cos\alpha$ perp: $-eu\sin\alpha$	 B1 B1 B1 [3]	 Both FT FT (direction must be clearly indicated: a diagram with correct arrows is sufficient)
4	(b)	(ii)	vel cpts after impact  $\tan\alpha = \dfrac{u\cos\alpha}{eu\sin\alpha}$ $\tan\alpha = \dfrac{1}{e\tan\alpha} \Rightarrow \tan^2\alpha = \dfrac{1}{e} \Rightarrow \tan\alpha = \dfrac{1}{\sqrt{e}}$	M1 A1 E1 [3]	Any relevant argument: position of α o.e. must be explicit o.e.
4	(b)	(iii)	$e \le 1 \Rightarrow \tan\alpha \ge 1 \Rightarrow \alpha \ge 45°$	E1 [1]	Convincing argument with no errors seen