OCR
Oxford Cambridge and RSA

GCE

Mathematics (MEI)

Unit **4762**: Mechanics 2

Advanced GCE

Mark Scheme for June 2015

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.
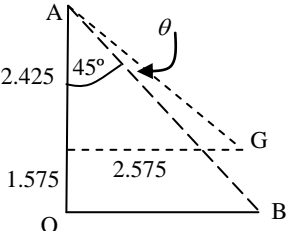
Question			Answer	Marks	Guidance	
1	**(i)**		Suppose $\uparrow$ U N at J and V N at point of contact with cylinder Taking moments about point of contact with the cylinder or J $0.8U - 0.2 \times 30 = 0$ or $0.8V - 0.6 \times 30 = 0$ so $U = 7.5$ or $V = 22.5$ Resolve $\uparrow$ $U + V - 30 = 0$ so $V = 22.5$ or $U = 7.5$	M1 A1 B1	A correct moments equation FT use of 1st answer. (Or use moments again)	3
	(ii)		Taking moments about point of contact with the cylinder $0.4W - 0.2 \times 30 = 0$ so $W = 15$	M1 A1	A correct moments equation and reaction at J = 0 Award SC2 for 15 seen WWW	2
	(iii)		Taking moments about point of contact $S \times 0.9\cos\theta - 30 \times 0.3\cos\theta = 0$ so $S = 10$ cw moments about J $30 \times 0.6\cos\theta - R \times 0.9 = 0$ so $R = 20\cos\theta$ resolve up the rod $S\sin\theta + F - 30\sin\theta = 0$ so $F = 20\sin\theta$ **SC** Resolving vert and horiz leads to simultaneous eqns. $R = 20\cos\theta$ $F = 20\sin\theta$	M1 A1 M1 A1 A1 M1 A1 A1 M1 A1 M1 A1 A1 A1	A moments equation about point of contact: allow sin instead of cos: Must be trig fn in both terms. Allow slip in distances if clearly taking moments about point of contact Award SC2 for 10 seen WWW Attempt at moments or resolution, involving F or R but not both, with all appropriate terms present and no extras. No need to substitute for S, if it is present. Or $R = (30 - S)\cos\theta$ o.e. FT their S Attempt at another moments or resolution, that will enable F or R to be found, with all appropriate terms present and no extras No need to substitute for S, if it is present. Or $F = (30 - S)\sin\theta$ o.e. FT their S One eqn in F and R Second eqn in F and R AND attempt to solve simult eqns for F or R Or $R = (30 - S)\cos\theta$ o.e. FT their S Or $F = (30 - S)\sin\theta$ o.e.FT their S	8

Question			Answer	Marks	Guidance	
	(iv)		Need $F \le \mu R$	B1	Use of $F \le \mu R$ or $F = \mu R$ or $F < \mu R$	
			$20\sin\theta \le \mu \times 20\cos\theta$	M1	Needs an inequality, using their F and R from **(iii)**	
			so $\mu \ge \tan\theta$	A1	FT incorrect S (Strict inequality gets 2/3)	
						3
				16		
2	**(i)**		The system *loses* $10gh - 8g\frac{h}{2} = 6gh$ or $58.8h\ J$	M1	Difference of GPEs	
				B1	Use of $\frac{h}{2}$ or $h\sin 30°$ (sight of $39.2h$)	
				A1	Clearly shown: *Loss* must be stated	
						3
	(ii)	**(A)**	$\frac{1}{2} \times 18 \times v^2 = 6g \times 1.2$ (= 70.56)	M1	Use of WE equation (a KE = a GPE)	
				B1	Use of '18'.	
			$v = 2.8$ so 2.8 m s^{-1}	A1	cao	3
			OR			
			$10g - 8g\sin 30° = 18a$	M1	Use N2L AND use *suvat*	
				B1	Use of '18'.	
			$a = g/3$ or 3.26: $v^2 = 0.8g = 7.84$: $v = 2.8$	A1	cao	3
	(ii)	**(B)**	Q passes through point 0.3 m above floor going down at 1.05 m s^{-1}			
			$\frac{1}{2} \times 18 \times V^2 - \frac{1}{2} \times 18 \times 1.05^2 = 6g \times 0.3$	M1	WE with 2 KE terms and a difference in GPE terms: must be using 18; may consider motion of P and motion of Q separately	
				A1	Allow FT on their 6g	
			$(V^2 = 3.0625)$ and $V = 1.75$ so 1.75 m s^{-1}	A1	cao	
			OR			
			$10g - 8g\sin 30° = 18a$ and *suvat* eqn	M1	Use N2L (both particles considered) AND use *suvat:* must be using 18	
			$a = g/3 \,(= 3.26)$	A1	cao	
			$(V^2 = 3.0625)$ and $V = 1.75$ so 1.75 m s^{-1}	A1	cao	3

Question		Answer	Marks	Guidance	
(iii)		$F_{max} = 0.9 \times 8g \cos 30$	M1	Attempt to use $F = \mu R$ with weight of $8g$	
			A1	May not be evaluated ($61.10675\ldots$ or $35.28\sqrt{3}$)	
		$\frac{1}{2} \times 18 \times 2^2 = 6gh + F_{max}h$	M1	WE. Correct KE term (with 18), a GPE term and Fh. Allow sign errors	
			A1	All correct	
		$h = 0.30023\ldots$ so 0.300 m (3 s. f.)	A1	cao	5
		OR			
		$F_{max} = 0.9 \times 8g \cos 30$	M1	Attempt to use $F = \mu R$ with mass of 8	
			A1	May not be evaluated ($61.10675\ldots$)	
		$F + 10g - 8g\sin 30° = 18a$	M1	Use N2L for both particles, or combined system, must be $18a$; all terms present and use *suvat*	
		$a = -6.66$	A1	cao	
		$h = 0.30023\ldots$ so 0.300 m (3 s. f.)	A1	cao	
					5
(iv)		Could P stay at rest in equilibrium? Force up the plane on P is $10g = 98$ N. Force down plane on P due to its weight is $8g\sin30 = 39.2$ N	M1	Attempt to compare forces up and down the plane including friction OR: Force needed for equilibrium $= 10g - 8g\sin 30° = 58.8$ and compare with max frictional force 61.1	
		$39.2 + F_{max} \approx 100.3 > 98$ so yes, stays at rest	E1	A clear argument 58.8 is less than 61.1 so equilibrium possible	2
(v)		$2 \times 61.10675\ldots$	M1	Attempt to use $P = Fv$ with v = 2 and their frictional force	
		$= 122.21\ldots$ so 122 W (3 s. f.)	F1		2
			18		

Question			Answer	Marks	Guidance	
3		(i)	either $\bar{x}=\bar{y}$ by symmetry	B1	Consider a square side 1 removed from a square side a Or by calculation	
			For $\bar{x}$ $$a^2\sigma\frac{a}{2}=\left(a^2-1\right)\sigma\bar{x}+1\sigma\frac{1}{2}$$	M1	Allow σ omitted	
				A1	Any one term correct	
				A1	All correct	
			Hence $\dfrac{a^3}{2}-\dfrac{1}{2}=\left(a^2-1\right)\bar{x}$		At least one intermediate step shown	
			and $\bar{x}=\dfrac{\left(a^3-1\right)}{2\left(a^2-1\right)}:\bar{x}=\dfrac{a^2+a+1}{2\left(a+1\right)}$	E1		5
			or $\bar{x}=\bar{y}$ by symmetry	B1	Splitting horizontally into 2 rectangles Or by calculation	
			$\left(\left(a-1\right)a+1\left(a-1\right)\right)\sigma\bar{x}=\left(a-1\right)a\times\dfrac{a}{2}\sigma+\left(a-1\right)\dfrac{\left(a+1\right)}{2}\sigma$	M1	Allow σ omitted. o.e.	
				A1	Any one term correct	
				A1	All correct	
			…. hence $\left(a+1\right)\bar{x}=\dfrac{a^2}{2}+\dfrac{\left(a+1\right)}{2}$		Dividing by $(a-1)$ o.e.	
			and $\bar{x}=\dfrac{a^2+a+1}{2\left(a+1\right)}$	E1	Some simplification shown [*Or splitting vertically into 2 rectangles or…*]	
		(ii)	Need $\bar{x}=\dfrac{a^2+a+1}{2\left(a+1\right)}=1$	B1		
			so $a^2+a+1=2a+2$ and $a^2-a-1=0$ Solving for the +ve root gives	M1	oe	
			$a=\dfrac{1+\sqrt{1+4}}{2}=\dfrac{1+\sqrt{5}}{2}$	A1		3

Question	Answer	Marks	Guidance	
	OR Substitute expression for a into expression for $\bar{x}$ and attempt to simplify Obtain $\bar{x} = 1$ This is on perimeter of shape	M1 A1 B1	Includes an attempt at squaring out.. Decimals used M0	3
(iii)	$a = 4$ gives $\bar{x} = \bar{y} = 2.1$ Take the mass of the particle to be m $4m\begin{pmatrix}\bar{x}\\\bar{y}\end{pmatrix} = m\begin{pmatrix}4\\0\end{pmatrix} + 3m\begin{pmatrix}2.1\\2.1\end{pmatrix}$ $\bar{x} = 2.575$ $\bar{y} = 1.575$ G is vertically below A $\theta = \arctan\frac{2.575}{2.425} - 45$ $\theta = 45 - \arctan\frac{2.425}{2.575}$ $= 1.71835\ldots$ so $1.72°$ (3 s. f.)	B1 M1 A1 A1 A1 B1 M1 M1 A1 A1	 Allow if a not substituted as 4 At least 1 correct term Allow if a not substituted as 4 FT for 1 of the final answer marks if there is a single error May be implied Note: Can use cosine rule in triangle AGB: AG = 3.537, AB = 5.657, GB = 2.124: M1 for attempt to find all three lengths A1 all correct M1 use cosine rule A1 1.72 cao Correct angle attempted (may be scored below) Use of arctan oe to find angle OAG must be using their 2.575 and 4 - their 1.575 Use of appropriate lengths. FT their values. cao	10
		18		

Question			Answer	Marks	Guidance	
4	(a)	(i)	Let speed of P after collision be u m s^{-1} $\frac{1}{2} \times 4 \times u^2 = \frac{1}{2} \times 4 \times 36 \times \frac{4}{9}$	M1	Use of KE; allow use of $\frac{5}{9}$ in an equation involving only u	
				B1	Correct use of $\frac{4}{9}$ of a KE term	
			$u = 4$	E1	Condone ± 4	
			Cannot be in the direction of Q as $4 > 3$	E1	Can use PCLM and NEL to show 'in direction of Q' gives negative e	
						4
		(ii)	Taking $\leftarrow$ +ve			
			Impulse is $4(4 - (-6))$	M1	Allow sign error. Must be 4(final vel - initial vel); condone 4(6 +4)	
			$= 40$ N s	A1	Note: impulse on Q = 5(3 - - 5) = 40 needs to be related to impulse on P to score any marks	
			Let force be F N $40 = F \times \frac{1}{5}$	M1	Use of Impulse $= Ft$	
			so $F = 200$	A1	Sign consistent with sign of impulse	
						4
		(iii)	Taking $\rightarrow$ +ve and vel of Q as U m s^{-1} PCLM $24 + 5U = -4 \times 4 + 5 \times 3$	M1	o.e. e.g. using impulse	
			so $U = -5$ i.e. to the left	A1	Must state direction but could be implied by diagram or equivalent	
			$e = \frac{4+3}{6+5} = \frac{7}{11}$ (0.636 to 3 sig figs)	M1		
				F1	FT their U	
						4

Question			Answer	Marks	Guidance	
(b)	**(i)**		Vert cpt of vel in m s^{-1} is $5.95 \times \frac{15}{17} = 5.25$	B1	May be implied	
			Particle hits the plane with vert speed			
			$\sqrt{5.25^2 + 2 \times 9.8 \times 2.5}$	M1	Must be vertical component	
			$= 8.75$	A1	May be implied	
			Particle leaves plane with vert speed			
			$8.75 \times 0.8 = 7$	B1	Award for the $\times 0.8$ on vert cpt (dependent on M1)	
			Height reached is given by			
			$0 = 7^2 - 2 \times 9.8 \times h$ so $h = 2.5$	E1	Clearly shown cwo	
						5
	(ii)		Time taken in seconds is			
			down $\dfrac{8.75 - 5.25}{9.8} = \dfrac{5}{14} = 0.357$:up $\dfrac{7}{9.8} = \dfrac{5}{7} = 0.714$:	M1	Finding both times and adding	
			so $\dfrac{15}{14}$ s	F1	FT only their 8.75 from (i)	
			Horiz distance is $\dfrac{15}{14} \times 5.95 \times \dfrac{8}{17} = 3$ m	A1	cao	
						3
				20		

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