OCR
RECOGNISING ACHIEVEMENT

GCE

Mathematics

Advanced GCE

Unit **4730:** Mechanics 3

Mark Scheme for January 2013

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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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 (OCR) 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 awa 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 schem assist in marking incorrect solutions. Correct *solutions* leading to correct answers are awarded full marks but work mu the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the wo 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 must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, awa the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involv 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 not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candida intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an specified.

A
Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be give 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 e. n th
of an unknown result.

Unless otherwise indicated, marks once gained cannot subsequently be lost, eg wrong working following a correc
ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to
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 schem
otherwise; and similarly where there are several B marks allocated. (The notation 'dep *' is used to indicate that a par
dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate
wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On th
two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be

e. The abbreviation ft implies that the A or B mark indicated is allowed for work correctly following on from previously inc
Otherwise, A and B marks are given for correct work only — differences in notation are of course permitted. A (accura
given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage
may be various alternatives that are equally acceptable. In such cases, exactly what is acceptable will be detailed in t
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 wil
through'. In such cases you must ensure that you refer back to the answer of the previous part question even if this is
image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-

f. Unless units are specifically requested, there is no penalty for wrong or missing units as long as the answer is numeric
expressed either in SI or in the units of the question. (e.g. lengths will be assumed to be in metres unless in a particula
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-s

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 t

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 p e app
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 accu

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 exa
the candidate requests.

If there are two or more attempts at a question which have not been crossed out, examiners should mark what appear
(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 rema
according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally
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, t
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 co
(provided, of course, that there is nothing in the wording of the question specifying that analytical methods are require
is wrong but there is some evidence of method, allow appropriate method marks. Wrong answers with no supporting r
in doubt, consult your Team Leader.

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

Answer			Marks	Guidance	
1			M1		Use of ... on missing 2/ for M1
		$I^2 = 2.04^2 + 0.9^2 - 2\text{x}2.04\text{x}0.9\text{x}\frac{15}{17}$	A1	And attempt to square root	Condone + for −
		1.32 (N)	A1	CAO	(1.3159)
			M1	Correct use of sin rule from their diagram oe	Can be in terms of I
		46.8(°) with initial direction of ball	A1	CAO	(46.8476) (0.8176 r Accept 46.7 from us
				OR $0.9 + I\cos\theta = 0.6\text{x}3.4\text{x}15/17$ M1 $I\sin\theta = 0.6\text{x}3.4\text{x}8/17$ M1 square and add to find I^2; or divide to find θ M1	Allow missing 0.6 a error for these 2 ma
			[5]	I, θ A1 A1 CAO	
2	(i)	Vel unchanged perp to L o C $0.6\sin30° = v\cos30°$ $0.2\sqrt{3}$ (ms^{-1})	M1 M1 A1 [3]		Stated or used Allow 1 sign or trig (0.34641)
2	(ii)	Use momentum equation	M1		Allow their v; allow omission of m
		$0.3m - 0.6m\cos 30° = am + 0.2\sqrt{3}m\cos 60°$ (a =) 0.393 to left	A1ft A1 [3]	Follow through on v Direction must be clearly stated or implied from working. WWW	m's not necessary; (0.39282) Away from B/opp d
2	(iii)	Use of NLR $(0.2\sqrt{3})\cos 60° - (-0.393) = e(0.6\cos 30° + 0.3)$ 0.691	M1 A1ft A1 [3]	Ft on a and v CAO	Allow sign error and (0.69082 or 0.69056

Answer			Marks	Guidance	
3	(i)	Use of $F = ma$, using $v\frac{dv}{dx}$	M1*		Allow sign
		$0.3v\frac{dv}{dx} = 1.5x$	A1		
		Attempt to rearrange and integrate	*M1	$0.3v^2 = 1.5x^2 (+c)$	No need for c. At le integrated correctly
		$v = \sqrt{5}x$ **AG**	A1 **[4]**	correct derivation WWW	
3	(ii)	Integrate to find x in terms of t	M1	$dx/x = \sqrt{5}dt$ and int 1 side correctly	Need to separate var
		$\ln x = \sqrt{5}t + c$	A1		No need for c for fin
		$x = e^{\sqrt{5}t}$	A1		Must include showi
		$v = \sqrt{5}\, e^{\sqrt{5}t}$	A1 **[4]**	CAO	
		OR Integrate to find v in terms of t	M1	Use jn $0.3\frac{dv}{dt} = 1.5x$ and int 1 side correctly	No need for c for fin
		$\frac{dv}{v} = \sqrt{5}dt$			
		$\ln v = \sqrt{5}t + c$	A1		
		$\ln v = \sqrt{5}t + \ln(\sqrt{5})$	A1		Must include showi
		$v = \sqrt{5}\, e^{\sqrt{5}t}$	A1	CAO	

		Answer	Marks	Guidance	
4	(i)	Conservation of energy	M1 M1		Need 4 ter Both KE or b
		$\frac{1}{2}0.4v^2 + \frac{1}{2}0.6v^2 + 0.4ga\sin\theta - 0.6g\theta = 0$	A1		completely correc
		$v^2 = 3.92a(3\theta - 2\sin\theta)$	M1 A1	Attempt to find v^2 dep both earlier M1s **AG**	Allow with sign and No errors
		F = ma radially for P	M1*		Allow sign and trig
		$0.4g\sin\theta - R = \frac{0.4v^2}{a}$	A1		
		$R = -4.704\theta + 7.056\sin\theta$	*M1 A1 **[9]**	Manipulation attempted, leading to $a\theta+b\sin\theta$	Allow sign and trig $2.352(-2\theta + 3\sin\theta)$
4	(ii)	Using $R = 0$ (k =) $\frac{2}{3}$	M1 A1 **[2]**	$0 = -4.704\theta + 7.056\sin\theta$	Must be from corre
5	(i)	$2.5g = 36.75\ e/3$ $e = 2$ $v^2 = 0^2 + 2g(3 + e)$ $v = 7\sqrt{2}$ $1 \times v = 3.5\ V$ Combined speed = $2\sqrt{2}$ (ms-1)	M1 A1 M1 A1 M1 A1 **[6]**	P in equilibrium **AG**	Allow missing g May be implied by Convincing derivati

		Answer	Marks	Guidance	
5	(ii)	change in PE is $3.5gX$ change in KE is $0.5\text{x}3.5\ (2\sqrt{2})^2$ change in EE is $36.75(X+2)^2/(2\times3)-36.75\times2^2/(2\times3)$ Use conservation of energy $35X^2 - 56X - 80 = 0$	B1 B1 M1 A1 M1 A1 **[6]**	$34.3X$ 14 $\frac{36.75(X+2)^2}{2\times3} = \frac{36.75\times2^2}{2\times3} + 3.5gX - \frac{3.5}{2}V^2$ **AG**	Allow sign error Allow 'x' or '$x + 5$ terms or difference Allow sign errors; a term Convincing derivati may see $36.75X^2 - 5$
6	(i)	Moments about C for CD $Wl\sqrt{3}/2(\cos30°) = Ql\sqrt{3}(\cos30°)$ $(Q =)\ W/2$ Resolve vert $(R =)\ \frac{3}{2}W$	M1 A1 A1 M1 A1 **[5]**	 **AG** CAO	allow M if sin/cos w
6	(ii)	$X = 0$ Resolve vert for CD or AB $Y = W/2$ Vertically downwards	B1 B1* *B1 **[3]**	 $Y + Q = W$ or $Y + W = R$	

Answer			Marks	Guidance	
6	(iii)	Moments about C for AB	M1		Allow M1 errors; need a
		$Pl\cos30° + Fl\cos30° = Rl\sin30°$	A1	Correct	
		Use P in terms of F	M1	$F = P$ or other correct 2nd step	Allow if missing te
		Find F in terms of W, or in terms of R	M1	$F = \frac{\sqrt{3}}{4}W$	Or getting 'their' F μR in moment equat
		$\mu = (F/R) = \sqrt{3}/6$	A1	Accept decimal answers from 0.288675	
			[5]		
		OR Moments about A for AB	M1		Allow M if sin/cos v errors; need all term
		$Wl\sin30° + (Y)l\sin30° + F2l\cos30° = R2l\sin30°$	A1		May have X term if
		Write Y (and X) in terms of W	M1		
		Find F in terms of W, or in terms of R, oe	M1	$F = \frac{\sqrt{3}}{4}W$	
		$\mu = (F/R) = \sqrt{3}/6$	A1	Accept decimal answers from 0.288675	
7	(i)	Use of energy equation	M1		Allow M1 if sign er missing and/or mis
		$0.5\text{ m }(0.3)^2 = m\text{x}9.8\text{x}0.8\text{x}(1 - \cos\theta)$	A1		
		$\theta = 0.107$	A1	No errors **AG**	0.107194171
			[3]		
7	(ii)	Use $F = ma$	M1	$m \text{ x } 9.8 \sin\theta = -m \text{ x } 0.8\ \ddot{\theta}$	allow M1 if sign err
		$\ddot{\theta} = -12.25\,\theta$	A1		Allow fraction
		small θ	B1	Dep on having seen acc = $k\sin\theta$	Rigorous
		Use of $T = \frac{2\pi}{\omega}$	M1	or sight of $\omega = 3.5$	
		$T = 1.80$	A1		accept $\frac{4\pi}{7}$ (1.795
			[5]		

Answer			Marks	Guidance	
7	(iii)	identifying amplitude as 0.107	B1		ft from (i)
		Use of ($\dot{\theta}$) = 0.107x3.5xcos(3.5t)	M1	or sin(3.5t+ε), ε not 0	ft for a and ω
		Use of $\dot{\theta} = -0.25$	A1	Consistent angle or length	
		$t = 0.658$	A1		(0.6576339)
		Use of $\theta = 0.107 \sin(3.5t)$	M1	ft from velocity equation (matches, ignore sign)	
		(θ =) 0.0797rads	A1	accept 5.20°	(0.0796678 or 0.07
			[6]		

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