OCR
Oxford Cambridge and RSA

GCE

Mathematics (MEI)

Unit **4762**: Mechanics 2

Advanced GCE

Mark Scheme for June 2014

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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.

These are the annotations, (including abbreviations), including those used in scoris, which are used when marking

Annotation in scoris	Meaning
BP	Blank Page – this annotation **must** be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
✓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.

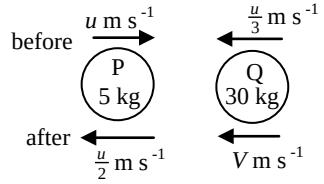
Marks designated as cao may be awarded as long as there are no other errors. E marks are lost unless, by chance, the given results are established by equivalent working.

'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.

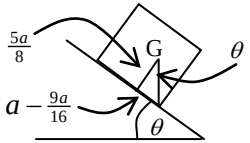
i If a graphical calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers (provided, of course, that there is nothing in the wording of the question specifying that analytical methods are required). Where an answer is wrong but there is 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	(a)	(i)		B1	Accept V in either direction. Given velocities and masses must be correct.
			PCLM $\rightarrow$ +ve		
			$5u - 30\frac{u}{3} = -5\frac{u}{2} - 30V$	M1	PCLM. Allow sign errors only
			so $V = \frac{u}{12}$	A1	Award even if direction of V used in PCLM does not match their diagram, so $\frac{u}{12}$ or $-\frac{u}{12}$ will get this A1
				A1	WWW. Direction of V correct (may be implied from diagram).
			$e = \frac{\frac{u}{2} - \frac{u}{12}}{u + \frac{u}{3}}$	M1	FT **their** V : allow sign errors, but must be right way up
			$= \frac{\frac{5}{12}}{\frac{4}{3}} = \frac{5}{16}$ (= 0.3125)	A1	cao
				[6]	
1	(a)	(ii)	$\rightarrow$ +ve		
			$30\left(-\frac{u}{12} - \left(-\frac{u}{3}\right)\right)$	M1	Allow sign errors.
			$7.5u$	A1	
			Or: find impulse on P **and** reverse the sign	M1 A1	$5\left(-\frac{u}{2} - u\right) = -\frac{15}{2}u$ **and** $7.5u$ cao M0A0 unless sign is reversed

Question			Answer	Marks	Guidance	
				[2]	Direction must be given (may be implicit from diagram).	
1	(b)	(i)	**Either**			
			As the parts move at 90°, PCLM in final directions	M1		
			For 2kg: $5\times 6\sin\alpha = 2u$	M1	PCLM	
			so $5\times 6\times \frac{3}{5} = 2u$	A1	Any form	
			and $u = 9$	A1		
			For 3kg: $5\times 6\sin\beta = 3v$	M1	PCLM	
			so $5\times 6\times \frac{4}{5} = 3v$	A1	Any form	
			and $v = 8$	A1		
			Or PCLM $\rightarrow 5\times 6 = 2u\sin\alpha + 3v\sin\beta$	M1	PCLM Allow cos instead of sin if error in both terms; allow sign errors; masses need to be there. Award if embedded in vector method	
			so $30 = 2u\times\frac{3}{5} + 3v\times\frac{4}{5}$	A1	Any form	
			PCLM $\uparrow$			
			$2u\cos\alpha - 3v\cos\beta = 0$	M1	PCLM Allow sin instead of cos if error in both terms and cos used in previous PCLM eqn; allow sign errors; masses need to be there. Award if embedded in vector method	
			so $2u\times\frac{4}{5} = 3v\times\frac{3}{5}$	A1	Any form	
			Solving	M1	A complete method involving 2 equations each in u and v	
			$u = 9$	A1	cao for one of u or v	
			$v = 8$	F1	for the other: FT substitution into their eqn	
				[7]	Note: Award SC5 for v = 6, u = 12 (from cos/sin reversal) Uses velocity instead of mmtum: M0M0M1A0F1 max 2/7 Uses mass in one eqn only: M1A1M0M1A0F1 max 4/7	

Question			Answer	Marks	Guidance	
1	(b)	(ii)	Δ KE is $\frac{1}{2}\times 2\times 9^2+\frac{1}{2}\times 3\times 8^2-\frac{1}{2}\times 5\times 6^2$ = 87 J	 M1 A1 **[2]**	 M1 for attempt at difference of KE (3 terms of correct form) cao	
2	(i)		Let the mass of each face be *m* $5m\bar{z}=4m\times\frac{a}{2}+0\times m$ so $\bar{z}=\frac{2a}{5}$	 M1 A1 A1 **[3]**	 Any complete method. Accept no mention of *m* oe. CLOSED/bottomless box is NOT a MR. Mark as per scheme giving method mark if appropriate: max 1/3	
2	(ii)		By symmetry , $\bar{x}=0$ or by calculation $8m\bar{y}=5m\frac{a}{2}+2m\frac{a}{2}+ma$ $=\frac{9a}{2}$ so $\bar{y}=\frac{9a}{16}$ $8m\bar{z}=5m\frac{2a}{5}+3ma$ = 5*a* so $\bar{z}=\frac{5a}{8}$	M1 A1 M1 E1 M1 A1 **[6]**	 Can be awarded if closed/bottomless box used Any complete method. Accept no mention of *m* oe. Shown (answer given) Any complete method. Accept no mention of *m* oe. cao CLOSED/bottomless box: max M1A1M1A0M1A0	
			Alternative form of solution: $8m\begin{pmatrix}\bar{x}\\ \bar{y}\\ \bar{z}\end{pmatrix}=m\begin{pmatrix}0\\ 0\\ a/2\end{pmatrix}+m\begin{pmatrix}0\\ a/2\\ 0\end{pmatrix}+m\begin{pmatrix}a/2\\ a/2\\ a/2\end{pmatrix}+m\begin{pmatrix}0\\ a\\ a/2\end{pmatrix}$ $+m\begin{pmatrix}-a/2\\ a/2\\ a/2\end{pmatrix}+m\begin{pmatrix}-a/2\\ a/2\\ a\end{pmatrix}+m\begin{pmatrix}0\\ a\\ a\end{pmatrix}+m\begin{pmatrix}a/2\\ a/2\\ a\end{pmatrix}$	M1 A1	Each coordinate cao	

Question			Answer	Marks	Guidance	
			$= m\begin{pmatrix}0\\9a/2\\5a\end{pmatrix}$ so $\bar{x}=0,\ \bar{y}=9a/16,\ \bar{z}=5a/8$			
2	**(iii)**			B1	G vertically above bottom edge	
				B1	Use of their $\bar{z}$ and $a-\bar{y}$ oe.	
				M1	Use of tan (or equivalent) with either $\bar{z}$ or $a-\bar{z}$ and $\bar{y}$ or $a-\bar{y}$	
			$\tan\theta=\frac{\frac{7a}{16}}{\frac{5a}{8}}=0.7$	M1	(or equivalent)	
			so $\theta=34.992...$ so 35° (3 s. f.)	A1 **[5]**	cao. 55 as answer can get B1B1M1M0A0: 3/5	
2	**(iv)**		Friction F N, normal reaction R N		Allow $8a^2$ as M throughout	
			$R=Mg\cos 30$	B1		
			N2L down plane			
			$Mg\sin 30-F=2M$	M1	Attempt to use N2L with all terms (allow a missing g). Allow sign errors	
				A1		
			$F=\mu R$	M1	Used correctly	
			so $\mu=\frac{g\sin 30-2}{g\cos 30}=0.34169\ldots$			
			so 0.342 (3 s. f.)	A1 **[5]**		

Question			Answer	Marks	Guidance	
3	(a)	(i)	Vertical through C intersects AB at X			
			BX = 1 and XA = 3	B1	May be implied	
			$\uparrow\ R - Y - 60 = 0$	B1	Must have an correct equation involving Y .	
			ac moments about A			
			$60 \times 4 - R \times 3 = 0$ so $R = 80$	B1	AG	
			$Y = R - 60 = 20$ and $X = 0$	B1	Both. Can be awarded independent of previous B1	
				[4]	MR-1 for AB = 2	
3	(a)	(ii)	In the solutions below all internal forces are set as tensions	B1	All (8 forces, with labelled pairs of arrows for internal forces) present and consistent . R and Y can be used	
				[1]		
3	(a)	(iii)	For example: B $\downarrow\ 60 + T_{BC}\cos 30 = 0$	M1	Attempt an equation for the equilibrium in any direction at any pin-joint (all correct (resolved) terms present, allow sign errors, $s \leftrightarrow c$	
			so $T_{BC} = -40\sqrt{3}$ (Force of $40\sqrt{3}$ N (C))	A1	Ignore T/C ; sign of force must be consistent with their T/C convention	
			A $\downarrow\ 20 + T_{AC}\sin 30 = 0$	M1	2nd equilibrium equation attempted	
			so $T_{AC} = -40$ Force of 40 N (C)	A1	Ignore T/C ; sign of force must be consistent with their T/C convention	
			A $\leftarrow\ T_{AB} + T_{AC}\cos 30 = 0$	M1	3rd equilibrium equation attempted	
			so $T_{AB} = 20\sqrt{3}$ Force of $20\sqrt{3}$ N (T)		Ignore T/C	
			All three internal forces correct, including T/C	A1	NOTE: Award first A1 for ANY force correct (need not be first one calculated) Award second A1 for a second force correct, FT if dependent on first one. Award third A1 as cao for everything correct, including T/C.	
				[6]		

Question			Answer	Marks	Guidance	
3	(b)	(i)	Take force as P to give + ac moment about B ac moments about B			
			$\cos\theta = \frac{8}{17}$	B1	Seen or implied, e.g. in $\cos 61.9^\circ$	
			$2P + 68\times 2\times\cos\theta - 102\times 4\times\sin\theta = 0$	M1	Moments equation with all terms attempted and no extras. Allow $s \leftrightarrow c$ and sign errors Moments about other points must include all relevant forces	
				A1	Substitution of sin/cos not required	
			P = 148	A1	cao	
				[4]		
3	(b)	(ii)	Take Q $\rightarrow$ ac moments about B			
			$2Q\sin\theta + 68\times 2\times\cos\theta - 102\times 4\times\sin\theta = 0$	M1	Moments equation with all terms attempted and no extras. Allow $s \leftrightarrow c$ and sign errors Moments about other points must include all relevant forces	
			so Q = 167.7333… so 168 (3 s. f.)	F1	FT errors in 2,4,cos,sin, sign from part(i) in 2nd and 3rd terms	
			Horiz force at B is 102 + 167.733..	B1	Adding. FT their Q	
			Magnitude is $\sqrt{269.7333..^2 + 68^2}$	M1	FT their horizontal force at B; Must use 68	
			= 278.172… so 278 N (3 s. f.)	A1	cao	
			Alternative for the B1M1A1: finding compts of force at B along and perpendicular to the rod: $Y = 102\sin\theta - 68\cos\theta + Q\sin\theta$ $X = 102\cos\theta - 68\sin\theta + Q\cos\theta$			
			$X = 187.06;\quad Y = 206.34$	B1	FT their Q	
			Magnitude is $\sqrt{\left(187.06^2 + 206.34^2\right)}$	M1	FT their X and Y	
			= 278.172… so 278 N (3 s. f.)	A1	cao	
				[5]		

Question			Answer	Marks	Guidance	
4	(a)	(i)	KE at A is ½ × 10 × 16.6 ^{2} = 1377.8 J GPE at B is 10 × 9.8 × 14 = 1372 J KE at A > GPE at B so gets beyond B	 M1 E1 **[2]**	 Calculate relevant quantities (KE at A and PE at B or v = 1.08 at B or h = 14.1) Clear argued comparison (e.g. 1377.8 > 1372)	
4	(a)	(ii)	Let speed at D be v m s $^{-1}$ A to D: $\frac{1}{2}\times 10\times v^2-\frac{1}{2}\times 10\times 16.6^2$ $=-10\times 9.8\times 7-25\times 14$ $(v^2=68.36)$ so v = 8.2680… so 8.27 (3 s. f.) OR: B to D: $\frac{1}{2}\times 10\times v^2-(1377.8-1372)$ $=10\times 9.8\times 7-25\times 14$ $(v^2=68.36)$ so v = 8.2680… so 8.27 (3 s. f.)	 M1 B1 M1 A1 A1 M1 M1 B1 A1 A1 **[5]**	Note: No use of friction can get B1 max Use of WD = 14x x = 25 WE equation with at least one KE, ΔGPE and WD by friction terms, all of correct form Allow only sign errors cao WE equation with at least one KE, ΔGPE and WD by friction terms, all of correct form Use of WD = 14x x = 25 Allow only sign errors cao	
4	(a)	(iii)	Consider only the vertical motion. Suppose the object hits the ground at V m s $^{-1}$ and rises h m $V=\sqrt{2\times 9.8\times 7}$ (11.7) AND $\frac{1}{2}V=\sqrt{2\times 9.8\times h}$ (5.86)	 M1	 Use of $v^2=2gs$ oe Must be 7 in V. Using '8.27' as u gives M0	

Question			Answer	Marks	Guidance	
				M1	*e* used appropriately: must use their attempt at a vertical velocity	
			so $h = ¼ \times 7 = 1.75$	A1	cao [Award SC 2 if 1.75 seen WWW]	
				[3]		
4	**(b)**		Driving force (D) = $\frac{P}{50}$	B1	Use of P = force x velocity. May be implied e.g. by sight of $0.8P/50$ or $0.2P/50$ in N2L	
			$P = 50F$ ($D = F$)	B1	Accept any form	
			N2L along the road			
			$\frac{0.8P}{50} - F = 1500 \times -0.08$	M1	Use of N2L with all terms attempted and consistent with power reduction. Allow sign errors.	
			so $0.8P - 50F = -6000$	A1	Accept any form	
			Solving gives			
				M1	Attempt to solve 2 equations each involving P and F. Dependent on N2L equation attempted with 3 terms.	
			$F = 600$ $P = 30\,000$	A1	cao both	
					[Taking 80% reduction in P gives $P = 7500$ and $F = 150$ for 5/6]	
				[6]		

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