OCR
Oxford Cambridge and RSA

GCE

Mathematics (MEI)

Unit **4762**: Mechanics 2

Advanced GCE

Mark Scheme for June 2016

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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 (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)	Take + ve → PCLM			
			$0.5\times4+0.75\times1=0.5\times2+0.75\times v_Q$	M1	Application of PCLM. Allow sign errors	
				A1	Correct. Any form	
			so $v_Q=\frac{7}{3}$	A1	Exact or anything that rounds to 2.33 or better	
			NEL			
			$\frac{\frac{7}{3}-2}{1-4}=-e$	M1	NEL. Accept sign errors but not approach/separation	
			so $e=\frac{1}{9}$ (or 0.11)	A1ft **[5]**	ft their v_Q	
		(ii)	Suppose direction reversed. Given LM conserved $0.5\times4+0.75\times1=-0.5\times2+0.75\times v_Q$	B1	Award for the correct LM equation	
			so $v_Q=5$			
			NEL gives $\frac{5+2}{1-4}=-e$ so $e=\frac{7}{3}$	M1	Using their re-calculated v_Q (not equal to 7/3 from (i))	
			e > 1 so not an elastic collision	E1 **[3]**	www	
			OR for last two marks: KE after collision = 10.375, before collision = 4.375:	M1		
			Increase in energy not possible, because no work put into system	E1		

Question			Answer	Marks	Guidance	
		(iii)	No (external horizontal) force acts on the truck so no change in momentum of truck (less object) (So no change in velocity. Still) $\frac{7}{3}$ m s^{-1}.	B1 B1 **[2]**	Force or momentum considered or correct momentum equation FT their value from (i): seen	
		(iv)	Before 0.5 kg at 2 m s^{-1} $\rightarrow$ After 0.05 kg at U m s^{-1} $\leftarrow$ and 0.45 kg at V m s^{-1} $\rightarrow$ PCLM $0.5\times 2 = -0.05\times U + 0.45\times V$ $U + V = 10$ Solving, $V = 3$ so 3 m s^{-1}	 M1 M1 B1 A1 **[4]**	 Allow if $(10 - 2) = 8$ used instead of U Allow only sign errors oe: relative velocity used correctly cao SC1 Using $U = 10$, giving $V = 10/3$	
	(b)		Consider the LM parallel to the plane Before: $m\times 10\cos 60 = 5m$ After: $m\times 6\cos 40 \approx 4.6$m Not the same. (LM not conserved.) Plane cannot be smooth.	M1 A1 E1 **[3]**	Accept considering the horizontal components of velocity before and after o.e. and arguing/stating they should be the same Need not include m. Using sine gets 0/3 Accept arguments from velocity	

Question			Answer	Marks	Guidance	
2	(a)	(i)	WD against resistance = KE lost	M1		
			$\frac{1}{2}\times 0.04\times 50^2 = 0.2F$	A1		
			so F = 250 and resistive force is 250 N	A1	Accept -250	
			OR:			
			Use *suvat*: $v^2 = u^2 + 2as$: $a = -\frac{2500}{0.4}$ $a = -\frac{2500}{0.4}$	M1	Complete method: *suvat* and N2L	
			Use N2L: F = 0.04 $\times a$ = - 250 $F = 0.04 \times a = -250$	A1	Correct a	
			Resistive force = 250 N	A1	Correct F	
				[3]		
		(ii)	PCLM			
			$0.04\times 50 = (3.96+0.04)V$	M1		
			so V = 0.5 so 0.5 m s^{-1}	A1	cao	
				[2]		
		(iii)	Energy lost is			
			$\frac{1}{2}\times 0.04\times 50^2 - \frac{1}{2}\times 4\times 0.5^2$	M1	Correct masses	
			= 49.5 J	A1ft	ft their 0.5 from (ii). May be implied	
			equating WD against resistance to energy lost			
			$250x = 49.5$	M1	ft their 250 x = a difference in non-zero KEs	
			so x = 0.198 and distance is 0.198 m	A1	cao	
				[4]		

Question			Answer	Marks	Guidance	
	(b)	**(i)**	Using W-E equation. Friction is F N			
			$\frac{1}{2}\times 6\times\left(7^2-1^2\right)=\left(91.5-F-6g\sin 30\right)\times 8$	M1	o.e. All 5 terms present, no extras. Allow sign errors	
				B1	KE terms (both)	
				B1	Resolved weight or GPE term	
				M1	WD is Force × distance	
			so $F = 44.1$	A1	cao	
			(As slipping) $F=\mu R$	M1	Used	
			$R=6g\cos 30^\circ=6g\times\frac{\sqrt{3}}{2}$	B1	Does not need to be evaluated	
			so $\mu=\frac{44.1}{3g\times\sqrt{3}}=\frac{1.5}{\sqrt{3}}=\frac{\sqrt{3}}{2}$ (0.8660…)	A1	cao Any form. 0.87 or better	
				[8]	Using suvat and N2L: Max possible is B1 for resolved weight, then last 3 marks. Award SC(4) if N2L and suvat used, and μ correct, www	
		(ii)	Power is $T \times v$	M1		
			so $91.5 \times 7 = 640.5$ W	A1	cao accept 640 or 641. Must be their final answer	
				[2]		

Question			Answer	Marks	Guidance	
3		(i)	$2M\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix} = M\begin{pmatrix}0.825\\ 0.6\end{pmatrix} + 0.6M\begin{pmatrix}0.825\\ 0\end{pmatrix} + 0.4M\begin{pmatrix}1.65\\ 0.6\end{pmatrix}$	M1 A1	Complete method At least 2 RHS vector terms or 3 component terms correct	
			$\bar{x} = 0.99$ $\bar{y} = 0.42$	A1 A1 **[4]**		
		(ii)	c.w moments about R $300 \times 0.99 - 1.65 \times Y_Q = 0$ so $Y_Q = 180$ $Y_Q + Y_R = 300$ so $Y_R = 120$	M1 A1 E1 **[3]**	Or moments about Q to find Y_R Must be established not using given Y_R AG	
		(iii)	Mark in 120 N and 180 N and all internal forces	B1 **[1]**	Accept labelled internal forces marked as T or C	
		(iv)	c.w moments about A $120 \times 0.75 + 180 \times 2.4 - 2 \times X_D = 0$ Or $300 \times (0.99 + 0.75) - 2 \times X_D = 0$ so $X_D = 261$	M1 E1 **[2]**	Appropriate moments considered Convincingly shown	

Question			Answer	Marks	Guidance	
		(v)	At B		This solution takes all internal forces +ve when T(ensions)	
			$\uparrow \ T_{AB}\sin\alpha - 180 = 0$	M1	Equilibrium at a pin-joint to find one of required forces (all relevant forces)	
			so $T_{AB} = 180 \times \frac{13}{5} = 468$ so force in AB is 468 N (T)	A1	Do not need T/C here	
			$\leftarrow \ T_{BC} + T_{AB}\cos\alpha = 0$	M1	2nd equilibrium at the same or another pin-joint to find another required force (all relevant forces)	
			so $T_{BC} = -468 \times \frac{12}{13} = -432$ so force in BC is 432 N (C)	F1	FT their values. Do not need T/C here	
			At D			
			$\rightarrow \ T_{DC}\cos\beta + X_D = 0$	M1	3rd equilibrium at a pin-joint (complete method to find third required force)	
			so $T_{DC} = -261 \times \frac{5}{3} = -435$ so force in DC is 435 N (C)	F1	FT their values and all T/C correct	
			$\uparrow \ Y_D + T_{DC}\sin\beta = 0$			
			so $Y_D = 435 \times \frac{4}{5} = 348$ so 348 N	B1	cao for the first of Y_D or Y_A found	
			$Y_D - Y_A = 300$ so $Y_A = 48$ so 48 N	B1	ft for the second of Y_D or Y_A: difference = 300	
				[8]		

Question			Answer	Marks	Guidance	
4		(i)	Let centre of mass be at G			
			G is on CO by symmetry	B1		
			Let CG = Y and curved surface density be σ		Accept σ taken to be 1 without comment. o. e.	
			$\left(\pi(0.1)^2\times 4\sigma + 2\pi\times 0.1\times h\times\sigma\right)Y = \pi(0.1)^2\times 4\sigma\times h + 2\pi\times 0.1\times h\times\sigma\times\frac{h}{2}$	M1	Complete method	
				B1	'masses' in correct ratios: 0.04: 0.2h	
				B1	Correct use of 'h' and 'h/2'	
				A1	All correct	
			so $Y = \frac{\left(5h^2+2h\right)}{2+10h}$	E1	Convincingly shown	
				[6]		
		(ii)	Let the lowest point of contact of the cylinder with the plane be A			
			On point of tipping G is vertically above A	B1	May be shown on a diagram	
			Angle AGO is α	B1	May be shown on a diagram can be implied by subsequent work	
			$\tan\alpha = \frac{0.1}{Y} = \frac{2}{3}$	M1	Allow reciprocal of RHS	
			so $0.3 = 2\times\frac{\left(2h+5h^2\right)}{2+10h}$	A1		
			so $50h^2+5h-3=0$ **AG**	A1	cwo and convincingly shown	
			Either			
			$(5h-1)(10h+3)=0$	M1	Clear evidence of 2 roots	
			(only positive root is) h = 0.2.	E1	No need to comment on the negative root	
			or			
			$50\times(0.2)^2+5\times 0.2-3=2+1-3=0$	B1		
			And this is the only positive root	E1	Need statement but no need to show this.	
				[7]		

Question			Answer	Marks	Guidance	
		(iii)	(sin β =0.6; cos β =0.8) c.w. moments about 'furthest' point of the base (through which acts the NR)	M1	Both forces present in a moments equation	
			$T\cos\beta\times0.5-T\sin\beta\times0.2-42\times0.1=0$	M1 A1 A1	Attempt to find moment of force of magnitude T in horizontal and vertical components oe Correct distances oe Correct equation, numerical values of cos/sin do not need to be substituted	
			(so $T(0.4-0.12)=4.2$)			
			so T = 15	A1 **[5]**	cao	

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

Education and Learning
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

For staff training purposes and as part of our quality assurance programme your call may be recorded or monitored

Oxford Cambridge and RSA Examinations
is a Company Limited by Guarantee
Registered in England
Registered Office; 1 Hills Road, Cambridge, CB1 2EU
Registered Company Number: 3484466
OCR is an exempt Charity

OCR (Oxford Cambridge and RSA Examinations)
Head office
Telephone: 01223 552552
Facsimile: 01223 552553

PART OF THE CAMBRIDGE ASSESSMENT GROUP

UKAS MANAGEMENT SYSTEMS 001