OCR
RECOGNISING ACHIEVEMENT

GCE

Mathematics (MEI)

Advanced GCE

Unit **4762:** Mechanics 2

Mark Scheme for June 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 (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)	$3 \times 4 + 21 \times 2 = 4U$ $4U = 54$ so $U = 13.5$ and speed is 13.5 m s^{-1}	M1 A1 **[2]**	Use of PCLM and $I = Ft$
			OR $21 = 4a : a = 5.25$ and $v = 3 + 2 \times 5.25$ speed is 13.5 m s^{-1}	M1 A1 **[2]**	Use of $F = ma$ and *suvat*
1	(a)	(ii)	Let V be the speed of S in direction PQ $54 - 2 \times 3 = (4 + 2)V$ $6V = 48$ so $V = 8$ and velocity is 8 m s^{-1} in direction PQ	 M1 E1 **[2]**	 PCLM for coalescence Answer given. Accept no reference to direction.
1	(a)	(iii)	Let velocities of R be u before and v after, both in the direction SR		
			$6 \times 8 + 4u = 6 \times 5 + 4v$	M1	Use of PCLM. Allow any sign convention. All masses and speeds must be correct.
			$v - u = 4.5$	A1	Any form.
			$\frac{v-5}{u-8} = -\frac{1}{4}$	M1	Use of NEL correct way up; allow sign errors
			$4v + u = 28$	A1	Any form signs consistent with PCLM eqn
			Solving $u = 2$ so 2 m s^{-1} in the direction SR	 A1	 cao **NOTE that a sign error in NEL leads to u =-2; this gets A0**
			$v = 6.5$ so 6.5 m s^{-1} in the direction SR	A1 **[6]**	cao. Withhold only 1 of the final A marks if the directions not clear. Directions can be inferred from a CLEAR diagram

Question			Answer	Marks	Guidance
1	(b)	(i)	Find v, the speed at which particle hits the plane		
			$\frac{1}{2} \times 0.2 \times v^2 - \frac{1}{2} \times 0.2 \times 5^2 = 0.2 \times 10 \times 10$	M1	Use of WE or *suvat* must use distance of 10 allow $g = 9.8$
			so $v^2 = 225$ and $v = 15$	A1	Answer not required ($v = 14.9$ if $g = 9.8$)
			$\cos\alpha = \frac{4}{5}$, $\sin\alpha = \frac{3}{5}$	B1	Use of either expression or use of 36.9°
			Let velocity after be at β to the plane		
			Parallel to the plane		
			$15\cos\alpha = 13\cos\beta$	M1	Attempt to conserve velocity component parallel to plane. Allow use of 5 instead of 15
			So $\cos\beta = \frac{12}{13}$ and $\beta = 22.61..$ so $22.6°$ (3 s. f.)	A1	($\beta = 23.8^\circ$ if $g = 9.8$)
			Perpendicular to the plane: $13\sin\beta = e \times 15\sin\alpha$	M1	Attempt to use NEL perpendicular to plane: Allow use of 5 instead of 15 or use $\tan\beta = e\tan\alpha$
			$\sin\beta = \frac{5}{13}$	A1	o.e. find $\tan\beta = \frac{5}{12}$
			so $13 \times \frac{5}{13} = 15 \times \frac{3}{5} \times e$ and $e = \frac{5}{9}$	A1	cao Accept 0.56 ($e = 0.589$ if $g = 9.8$)
				[8]	
			OR: First three marks as above	M1A1B1	
			Parallel to plane, $u_x = 15\cos\alpha (= 12)$ and $v_x = u_x (= 12)$	M1	Attempt to conserve velocity component parallel to plane. Allow use of 5 instead of 15
			$\cos\beta = \frac{v_x}{v} = \frac{12}{13}$ $\beta = 22.6^\circ$	A1	
			Perpendicular to plane, $u_y = 15\sin\alpha (= 9)$ and $v_y = eu_y (= 9e)$	M1	Attempt to use NEL perpendicular to plane. Allow use of 5 instead of 15
			$v_x^2 + v_y^2 = 13^2$	A1	Use Pythagoras' theorem for velocities after collision in attempt to find e
			$12^2 + (9e)^2 = 13^2$ so $e^2 = \frac{25}{81}$ $e = \frac{5}{9}$	A1	
				[8]	

Question			Answer	Marks	Guidance
1	(b)	(ii)	Impulse is perp to plane with mod $0.2(13\sin\beta-(-15\sin\alpha))$ = 0.2(5 – (– 9)) = 2.8 N s	M1 A1 **[2]**	For use of $I = m(v-u)$ perp to the plane 0.2(5-9) gets M1A0 cao
2	(i)		WD is 800 × 9.8 × 6 + 400 × 6 J = 49 440 Power is 49440 ÷ 12 = 4120 W	M1 E1 M1 A1 **[4]**	WD as *Fd* Used in TWO terms Power is WD / Δt cao
2	(ii)		Power is (800 × 9.8 + 400) × 0.55 = 4532 W	M1 A1 A1 **[3]**	Power as *Fv* in one term All correct cao
2	(iii)		Let speed be *v* $\frac{1}{2}\times800v^2=800\times9.8\times3-400\times3$ $v^2=55.8$ so v = 7.4699… and speed is 7.47 m s^{-1} (3 s.f.)	M1 A1 A1 A1 **[4]**	Use of W-E equation Must include KE and at least one WD term Allow only sign errors All correct SC: Use of N2L and *suvat* : M1 Complete method A1 7.47 cao
2	(iv)		$\frac{1}{2}\times800\times\frac{v^2}{4}-\frac{1}{2}\times800\times v^2$ = (800 × 9.8 – 400) × 0.8 – WD WD is 22 692 so 22 700 J (3 s. f.)	M1 B1 B1 A1 A1 **[5]**	Use of W-E equation Must include 2 KE terms and a WD term Final KE term correct. FT their *v*. One correct WD term All terms present. Allow sign errors and FT their *v*. cao SC Use of N2L and *suvat*: Award maximum of B1 for 'Average force (28365) x 0.8'

Question			Answer	Marks	Guidance
3	(i)		c.w. moments about A		Condone using cm not m in moments in any part if consistent
			$60\cos 40\times 0.3 - 60\sin 40\times 0.1$	M1	oe e.g. $60(0.3-0.1\tan 40)\sin 50$ or $60\times\frac{1}{\sqrt{10}}\cos\left(90^\circ-\arctan 3+40^\circ\right)$ Method of dealing with moment of weight. Allow $\cos \leftrightarrow \sin$
				A1	Both weight terms correct. Allow wrong overall sign but not both terms with the same sign
			= 9.93207… so 9.93 N m (3 s. f.)	E1 **[3]**	
3	(ii)		$P\cos 40\times 0.2 - 9.93207... = 0$	M1	Moments of all relevant forces attempted. No extra terms. Allow $\cos \leftrightarrow \sin$
			P = 64.827… so 64.8 (3 s. f.)	A1 **[2]**	cao (64.813… if 9.93 used)
3	(iii)		a.c. moments about A to find NR, R, at B		
			$R\times 0.8 = 9.93$ or $R\times 0.8 + 60\sin 40\times 0.1 - 60\cos 40\times 0.3 = 0$	M1	Attempt to use moments to find R. Moments of all relevant forces attempted. No extra terms. Allow $\cos \leftrightarrow \sin$ Note that mmts about B can score M1 only if mmt of horiz compt of force at A is included. If R is taken as vertical, M0
			R = 12.4150…	A1	FT their moment of weight from (i) Not a required answer
			Resolve vertically		
			$Y - 60 + R\cos 40 = 0$	depM1	Note that the second M mark awarded in this part must be for a complete method to find Y:
			so Y = 50.489… so 50.5 N (3 s. f.)	A1 **[4]**	FT their calculated R

Question			Answer	Marks	Guidance
3	(iv)		resolve perp to plane		
			$R - 60\cos 40 - 200\sin 40 = 0$	M1	All terms present and no extra terms. Components of 60 and 200; allow cos ↔ sin
				A1	
			R = 174.52…		Not a required answer
			N2L up the plane		
			$200\cos 40 - F - 60\sin 40 = \frac{60}{9.8} \times 1.75$	M1	Use of N2L with all terms present and no extras. Components of 60 and 200; allow cos ↔ sin Allow use of 60 for mass
				B1	Use of mass not weight
				A1	FT use of weight and/or sign errors
			F = 103.927…	A1	All correct. Not a required answer
			As friction limiting $F = \mu R$ so		
			$\mu = \frac{103.927...}{174.520...}$	M1	FT their F and their R
			= 0.59550.. so 0.596 (3 s. f.)	A1	cao
				[8]	

Question			Answer	Marks	Guidance
4	(a)	(i)	Write $d = 0.8$		
			$(2.5+1.2+1.3+2.4)\times d\times\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix}$	M1	Method for c.m (length is 7.4 m, mass is 5.92 kg)
			$=2.5d\begin{pmatrix}1.2\\ -0.35\end{pmatrix}+1.2d\begin{pmatrix}2.4\\ -0.1\end{pmatrix}+1.3d\begin{pmatrix}1.8\\ 0.25\end{pmatrix}+2.4d\begin{pmatrix}1.2\\ 0\end{pmatrix}$	B1	One rod mass and cpts correct or if done by separate x and y equations 2 rod components and masses correct. (Allow length used instead of mass)
			OR: $(2+0.96+1.04+1.92)\times\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix}$		
			$=2\begin{pmatrix}1.2\\ -0.35\end{pmatrix}+0.96\begin{pmatrix}2.4\\ -0.1\end{pmatrix}+1.04\begin{pmatrix}1.8\\ 0.25\end{pmatrix}+1.92\begin{pmatrix}1.2\\ 0\end{pmatrix}$	B1	Another rod dealt with correctly or if done by separate x and y equations, the other equation attempted with 2 rod components and masses correct. (Allow length used instead of mass)
			$7.4\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix}=\begin{pmatrix}3+2.88+2.34+2.88\\ -0.875-0.12+0.325+0\end{pmatrix}=\begin{pmatrix}11.1\\ -0.67\end{pmatrix}$		
			OR:		
			$5.92\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix}=\begin{pmatrix}2.4+2.304+2.304+1.872\\ -0.7-0.096+0.26+0\end{pmatrix}=\begin{pmatrix}8.88\\ -0.536\end{pmatrix}$		
			$\bar{x}=1.5$	E1	Clearly shown, with at least one intermediate step
			$\bar{y}=-0.090540...=-0.0905$ (3 s. f.)	A1	Condone - 0.09
				[5]	

Question			Answer	Marks	Guidance
4	(a)	(ii)	EITHER: New c.m. has $\bar{x} = 1.2$ $(5.92 + m) \times 1.2 = 5.92 \times 1.5 + m \times 0$ $m = 1.48$	M1 M1 A1 **[3]**	Identifying and using a suitable condition. Complete method cao
			OR: Moment about any point is zero e.g. about S: $1.2mg = 0.3 \times 5.92g$ $m = 1.48$	M1 M1 A1 **[3]**	Identifying a suitable condition. Allow g omitted. Correct number of terms must be included cao
4	(b)	(i)	Consider the equilibrium at R Resolving horizontally gives $T_{QR} = 0$ Then resolving vertically gives $T_{OR} = 0$	 E1 E1 **[2]**	
4	(b)	(ii)	c.w. moments about O $120 \times 1 + 60 \times 2 = 3T$ so $T = 80$ Resolve to give $X = 80$ and $Y = 180$	 M1 A1 A1 **[3]**	May also be argued by first considering internal forces FT $X = T$. Only Y =180 scores 0
4	(b)	(iii)		B1 **[1]**	All correct. Accept T, X and Y labelled but not substituted. Accept mixes of T and C. Require pairs of arrows with label on OQ, OP and PQ.
4	(b)	(iv)	Take angle OPQ as α At P $\downarrow$ $60 + T_{OP} \sin\alpha = 0$ $\sin\alpha = \frac{3}{\sqrt{13}}$: $\alpha = 56.3^\circ$ $T_{OP} = -\frac{60}{\sin\alpha} = -20\sqrt{13}$ so $20\sqrt{13}$ N (C) At P $\leftarrow$ $T_{QP} + T_{OP} \cos\alpha = 0$ so $T_{QP} = 40$ so 40 N (T)	 M1 A1 A1 M1 A1 **[5]**	Forces internal to the rods have been taken to be tensions. Equilibrium at ANY pin-joint (not R) Correct equation(s) that leads directly to finding T_{OP} or T_{QP} o.e. Accept 72.1 N A second equilibrium equation leading to a second internal force cao T/C correct for both rods

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