GCE

Further Mathematics B (MEI)

Y411/01: Mechanics A

Advanced Subsidiary GCE

Mark Scheme for June 2019

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.

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 a result or establishing a given result
dep*	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
AG	Answer given
awrt	Anything which rounds to
BC	By Calculator
DR	This indicates that the instruction **In this question you must show detailed reasoning** appears in the question.

Subject-specific Marking Instructions for A Level Mathematics B (MEI)

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, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.
If you are in any doubt whatsoever 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, e.g. 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, e.g. 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, what is acceptable will be detailed in the mark scheme. If this is not the case please, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.
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; over-specification is usually only penalised where the scheme explicitly says so. 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. Follow through should be used so that only one mark is lost for each distinct accuracy error, except for errors due to premature approximation which 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 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	AOs	Guidance	
1			$d = 2(10)$	B1	1.1		
			$350 = 20d\cos\theta$	M1	1.1	Correct use of WD = $Fd\cos\theta$ with their d	
			$\theta = 29(.0)$	A1	1.1	cao	28.955024…
				[3]			
2	(a)		$[g] = \mathrm{LT}^{-2}$	B1	1.2	Correct dimensions of g soi	
			$[S] = \left[\frac{mg}{2l}\right] = \frac{\mathrm{M}(\mathrm{LT}^{-2})}{\mathrm{L}}$	M1	3.4	Correctly substitution for m and l. Allow g or 'their' g.	Accept $\mathrm{M} = \frac{(2)[\mathrm{S}]\mathrm{L}}{\mathrm{LT}^{-2}}$
			$[S] = \mathrm{MT}^{-2}$	A1	2.2a	www	Sc B1 if done using units
				[3]			
	(b)		$[\rho] = \mathrm{ML}^{-3}$	B1	1.2	Dimensions of density soi	
			$\mathrm{RHS} = \frac{\mathrm{MT}^{-2}}{(\mathrm{ML}^{-3})(\mathrm{LT}^{-2})(\mathrm{L})} = \mathrm{L}$	B1	1.1	RHS correctly shown Sc Allow if consistent errors in g and S which cancel out	Ft from (a)
			State same as LHS = L	B1	1.1	www Sc allow full marks for proof that units are consistent	Dependent on first two marks
				[3]			

Question			Answer	Marks	AOs	Guidance	
	(c)		$r = \frac{2S}{\rho g h}$ $= \frac{2 \times 0.475}{13\,500 \times 9.8 \times 0.1}$ $= 7.18 \times 10^{-5}$	**M1**	**3.4**	Correct substitution into correct equation for r	
			Depth = $1.4(4) \times 10^{-4}$ (m) Or $\frac{19}{132300}$ m	**A1**	**1.1**	cao (oe e.g. 0.0143613…(cm)) SC If 0, allow B1 for figs (72) or figs (14(4)) as final answer.	Accept cm or m answer without units; accept mm if specified
				[2]			
	(d)		$L = \left(MT^{-2}\right)^{\alpha}\left(ML^{-3}\right)^{\beta}\left(LT^{-2}\right)^{\gamma}$	**M1**	**3.3**	Set up with correct substitutions	Allow M marks with their S and g
			$\alpha + \beta = 0,\ -3\beta + \gamma = 1,\ -2\alpha - 2\gamma = 0$	**M1** **A1**	**1.1** **1.1**	Compare coeffs of M, L and T All 3 equations correct	All three needed
			$\alpha = \frac{1}{2},\ \beta = -\frac{1}{2},\ \gamma = -\frac{1}{2}$	**A1**	**2.2a**	All correct www	
				[4]			

3	(a)		$W\sin\alpha + F = 70$	M1*	3.3	Resolving forces parallel to the plane; 3 terms and resolving essential	Condone sign errors, wrong use of g and cos/sin confusion
			$F = 70 - 130\times\sin(12)$	A1	1.1		42.97148019…
			$R = 130\cos(12)$ or $R = 130\sqrt{1-(\sin(12))^2}$	B1	1.1	soi	127.1591881…
			$\mu = \frac{42.971...}{127.159...}$	*M1	3.4	Using $\mu = \frac{F}{R}$	
			$\mu = 0.34$	A1	1.1		0.3379345…
				[5]			
	(b)		The weight component (27.0285…N) is less than the maximum possible frictional force (42.97…N).	M1	3.1b	Attempt to compare the weight component parallel to the plane and the max frictional force. At least one correct value seen.	$130\sin 12°$ May see 15.9(4) > 0
			Box does remain in equilibrium	A1	3.2a	www	
				[2]			

4	**(a)**	**(i)**		**M1**	**3.1b**	Table of values idea soi – both blade and handle used	
			$(1.25+0.5)\bar{y}$	**B1**	**2.1**	Correct LHS	
			$=0.125(1.25)$	**A1**	**1.1**	Correct first term on RHS	0.15625
			$+0.5(0.25+0.6\cos\alpha)$	**A1**	**1.1**	Correct second terms on RHS	0.25 + 0.576 = 0.826
			$\bar{y}=0.325$	**A1**	**2.2a**	2 s.f. or better	0.3252857143… or $\frac{2277}{7000}$
				[5]			
	(a)	**(ii)**	$(1.25+0.5)\bar{z}=0.5(0.6\sin\alpha)$	**M1**	**1.1**	Table of values idea soi	Allow sin/cos confusion; wrong mass / length on right 0.084
			$\bar{z}=0.048$	**A1**	**1.1**	cao	
				[2]			
	(b)		$\tan\theta=\frac{0.048}{0.325...}$	**M1**	**3.4**	Use of tan with their answers to (a) and (b) – allow reciprocal	
			8.4°	**A1**	**1.1**	Cao; www	8.4014… − 8.394136…
				[2]			

5	**(a)**			**M1**	**3.3**	Attempt at N2L parallel to the slope with all terms and weight component resolved	Allow with sign errors, sin/cos confusion and errors with g
			$D-850-4000g\sin\theta=4000(0.75)$	**A1**	**1.1**	Correct eqn – allow $\sin\theta$ or 0.1	
			$D=7770$	**A1**	**1.1**	Could be implied by later working	
			$P=7770(18)$	**M1**	**3.4**	Use of P = (tractive force) × (velocity)	Used at some point
			139860 (W)	**A1**	**2.2a**	Cao (2 s.f. or better)	$=140\,\text{kW}$
				[5]			
	(b)		KE change $=\frac{1}{2}\times4000\left(25^2-18^2\right)$	**B1**	**1.1**		1250000 – 648000 = 602000 (J)
			PE gained = $4000g(\text{AB}\sin\theta)$	**B1**	**1.1**	In terms of AB	
			WD by car's engine $=139860\times17.8$	**B1ft**	**1.1**	2489508 J − follow through their power from (a)	
			$1250000+3920(\text{AB})-648000=$ $139860(17.8)-850(\text{AB})$	**M1**	**3.3**	Work-energy principle – all terms present	
			Distance AB = 400 m	**A1**	**1.1**	Cao 2 s.f. or better	395.70398
				[5]			

6	**(a)**		Let the speeds of A and B after the collision be u_A and u_B				Allow sign errors for all M marks
			$5u = 5u_A + 3u_B$	**M1**	**3.3**	Conservation of linear momentum – correct number of terms	Allow wrong mass for linear momentum marks
			$u_A - u_B = -\frac{1}{3}u$	**M1**	**3.3**	Use of NEL, correct number of terms and consistent with CLM	No masses for NEL marks
			$u_A = \frac{1}{2}u,\ \ u_B = \frac{5}{6}u$	**A1**	**1.1**	Solve simultaneous equation correctly	Note: can be done in terms of, for example, u_B
			w_B & w_C – speeds of B & C after				
			$3\left(\frac{5}{6}u\right) = 3w_B + w_C$	**M1**	**1.1**	Conservation of linear momentum - correct number of terms	Can use u_B or their u_B
			$w_B - w_C = -\frac{1}{3}\left(\frac{5}{6}u\right)$	**M1**	**1.1**	Use of NEL, correct number of terms and consistent with CLM	Can use u_B or their u_B
			$w_B = \frac{5}{9}u, \qquad w_C = \frac{5}{6}u$	**A1**	**1.1**		
			No further collisions as $w_B > u_A$ an $w_C > w_B$	**A1**	**2.4**	Consider all 3 particles – values + justification	All vels must be correct to gain this mark
			Alternative Method: First A1 may be gained later by proving that $w_B > u_A$ Second A1 may be gained by proving that $w_C > w_B$ Third A1 is then gained for complete correct solution				
				[7]			
	(b)		Initial KE = $\frac{5}{2}u^2$	**B1**	**1.1**		
			Change = $\frac{5}{2}u^2 - (\frac{1}{2}(5){u_A}^2 + \frac{1}{2}(3){u_B}^2)$	**B1ft**	**1.1**		
			$\frac{1}{2}.5u^2 - \left(\frac{1}{2}.5\left(\frac{1}{2}u\right)^2 + \frac{1}{2}.3\left(\frac{5}{6}u\right)^2\right) = 4.8$	**M1**	**1.1**	Setting up an equation in u with correct number of terms	Might be in terms of u_B Allow sign errors
			$u = 2.4$	**A1**	**1.1**		
				[4]			

7			Taking moments about C; correct number of terms	**M1**	**3.1b**	M0 throughout if no use of trig for components	Allow sign errors, missing g and sin / cos confusion for M marks
			$R \times 4a = mg \times 2a\cos 30°$	**A1**	**1.1**		
			$mg \times 2a\cos 30° = R \times 4a\sin 30° + F \times 4a\cos 30°$	**M1** **A1**	**3.3** **1.1**	Taking moments about B for the rod; correct no of terms	F could be in opposite sense
			$F = \frac{1}{4}mg$ and $R = \frac{\sqrt{3}}{4}mg$	**A1** **A1**	**1.1**	May be implied by later working	F could be negative
			$\mu = \frac{F}{R}$	**M1**	**3.4**	Their expressions must be subst'd - dep on all previous M marks	
			$\frac{\sqrt{3}}{3}$ oe	**A1**	**2.2a**	Accept $1/\sqrt{3}$	0.5773502692…
			OR				
			Taking moments about A – correct number of terms	**M1**	**3.1b**	M0 throughout if no use of trig for components	Allow sign errors, missing g and sin/cos confusion for M marks
			$mg(2a\sin 60) = T(4a\sin 30)$	**A1**	**1.1**		
			$R = T\sin 30$	**B1**	**3.3**	Resolving horizontally	
			$T = \frac{1}{2}mg\sqrt{3}$ and $R = \frac{1}{4}mg\sqrt{3}$	**A1**	**1.1**	May be implied by later working	
				M1	**3.3**	Resolving vertically – correct no of terms; tensions resolved	
			$F + T\cos 30 = mg$	**A1**	**1.1**	Correct eqn in terms of F and T	
			$\mu = \frac{mg - T\cos 30}{T\sin 30}$	**M1**	**3.4**	Use of $F = \mu R$ - dependent on all previous M marks	
			$= \frac{1}{\sqrt{3}}$	**A1**	**2.2a**	oe	0.5773502692… NB Other methods possible
				[8]			

OCR (Oxford Cambridge and RSA Examinations)
The Triangle Building
Shaftesbury Road
Cambridge
CB2 8EA

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