OCR
Oxford Cambridge and RSA

GCE

Further Mathematics B (MEI)

Unit **Y411**: Mechanics a

Advanced Subsidiary GCE

Mark Scheme for June 2018

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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.

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			$3 + 4\cos 60° + 5\cos 150° + R\cos\theta (= 0)$	M1	2.5	Oe; resolve horizontally; allow sign errors and sin / cos confusion for both M marks	X or $R\cos(180° - \theta)$ for $R\cos\theta$ oe
			$R\cos\theta = 2.5\sqrt{3} - 5\ (= -0.670)$	A1	1.1	− 0.66987	
			$4\sin 60° + 5\sin 150° - R\sin\theta\ (= 0)$	M1	1.1	Oe; resolve vertically	Accept Y for $R\sin\theta$ oe
			$R\sin\theta = 2.5 + 2\sqrt{3}\ (= 5.964)$	A1	1.1		
			R = 6.0(0)	A1	1.1	6.00160…Dep M2A2	Possibly **BC**
			θ = 96.4°	A1	1.1	96.40846…Dep M2A2	Possibly **BC**
				[6]			
2	(i)		$\frac{P}{25} - 920 = 0$	M1	1.1	Soi (by 23 000)	P is power of car
			$P = 23$ kW	A1	1.1		
				[2]			
	(ii)		$\frac{45000}{20} - 920 - R = 0$	M1	3.3	Must be 3 terms; allow sign errors	R is resistance due to 'van
			R = 1330 (N)	A1	1.1	If 0 scored, sc B1 for sight of 2250	
				[2]			
	(iii)		$\frac{68\,000}{20} - 920 - 1330 = 2400a$	M1	3.3	Allow M1 if mass or sign wrong or one resistance wrong or omitted	Resistances can be combined for M1A1
				A1	1.1		
			a = 0.479 (m s^{-2}) or $\frac{23}{48}$ (m s^{-2})	A1	1.1	0.47916666	
				[3]			
	(iv)		$\frac{1}{2} \times 2400 \times 20^2 + 68\,000T - 2250 \times 1024 = \frac{1}{2} \times 2400 \times 28^2$	B1	3.4	B1 for 68 000T or 2250×1024	
				M1	1.1	M1 for use of KE (at least once), work done & work against resistance	Allow sign errors; equation not needed for M1
				A1	1.1		
			T = 40.7 (seconds)	A1	1.1	40.658	Use of const accel: (B1)M0
				[4]			
	(v)		Eg: Resistance could have been modelled as a variable force (since it is more realistic to assume resistance is greater at a geater speed).	B1	3.5c	Or other correct reason	Ignore irrelevant reasons
				[1]			

Question			Answer	Marks	AOs		Guidance
3	(i)		(k is a dimensionless) constant	B1 [1]	1.2	Ignore extra comments	
	(ii)		M: $0 = \alpha$ L: $0 = \beta + \gamma$ T: $1 = -2\gamma$ $\alpha = 0 \quad \beta = \frac{1}{2} \quad \gamma = -\frac{1}{2}$	M1 A1 A1 [3]	1.1 1.1 1.1	Correct method; can be implied by $T = M^{\alpha}L^{\beta}(LT^{-2})^{\gamma}$ 3 correct equations soi	
	(iii) (*A*)		$1.8 = k\sqrt{\frac{0.8}{g}}$ $k = 6.3$	M1 A1 [2]	3.4 1.1	Ft attempt to use their values (but not all 0) www	
	(iii) (*B*)		$t = 6.3 \times \sqrt{\frac{1.4}{g}}$ Time = 2.38 (seconds) or $\frac{9\sqrt{7}}{10}$	M1 A1 [2]	3.4 1.1	Ft attempt to use their values (not all 0) and their k www 2.381176	SC: Use of 80 cm in (i) and 140 cm in (ii) leads to k = 0.63 (M1A0) and time = 2.38 (M1A1)
	(iv)		(a) It turns out that the formula is in fact independent of the mass OR (b) it is quite possible that it could have been dependent on another unknown quantity.	B1 [1]	2.2b	Or any valid equivalent statement (a) depends on $\alpha = 0$ in (ii)	

Question			Answer	Marks	AOs		Guidance
4	(i)		Equilateral triangle, plus symmetry or D is midpoint of BC	B1 [1]	2.4	Oe, eg reference to median	
	(ii)		Masses in right ratio; 4 : 1 : 3	B1	3.1a	May see $36\sqrt{3}\rho$, $9\sqrt{3}\rho$ and $27\sqrt{3}\rho$ oe	
			$4 \times 6 - 1 \times 9 = 3 \times \bar{x}$	M1	3.4	Allow sign error; one mass and one distance right, at least	
			Distance AD is $\sqrt{12^2 - 6^2}$	B1	1.1	AD = $6\sqrt{3}$	Implied by COM $2\sqrt{3}$ from D or $4\sqrt{3}$ from A
			$4 \times 2\sqrt{3} - 1 \times \sqrt{3} = 3 \times \bar{y}$	M1	1.1	Allow sign error; one mass and one distance (ft AD) right, at least	OR $m\begin{pmatrix}3\\\sqrt{3}\end{pmatrix} + m\begin{pmatrix}6\\4\sqrt{3}\end{pmatrix} + m\begin{pmatrix}6\\2\sqrt{3}\end{pmatrix} = 3m\begin{pmatrix}\bar{x}\\\bar{y}\end{pmatrix}$
			$\left(5, \frac{7}{3}\sqrt{3}\right)$	A1 [5]	3.2a	Or $(5, 4.04(145))$	Note: other methods may be seen
	(iii)		Use Centre of Mass vertically below D	M1*ft	3.1b	Must see 1 (or 6 – 5) and $\frac{7}{3}\sqrt{3}$	Ft from (ii)
			angle EDG $= \tan^{-1}\frac{3}{7\sqrt{3}}$ [+30]	*M1	1.1	Accept reciprocal; can be implied by angle 13.9° or 76.1°	Or find angle BDG (= 76.1°) 180 – 76.1 – 60 = 43.9° Note: Can find DG and use sin or cos
			Angle is 43.9°	A1 [3]	2.2a	43.897… or 0.76616… rads	

Question			Answer	Marks	AOs		Guidance
5	(i)		Use of $v^2 = u^2 + 2gs$ to find v or w	M1	3.1b	Or $\frac{1}{2}mv^2 = mg \times 1.6$	v is arrival speed
			$v = 5.6$ (m s^{-1})	A1	1.1	$v^2 = 0^2 + 2g \times 1.225$	w is leaving speed
			$w = 4.9$ (m s^{-1})	A1	1.1	$0^2 = w^2 - 2g \times 1.225$	
			Coefficient of restitution is $\frac{w}{v}$ $\left(= \frac{4.9}{5.6}\right)$	M1	1.2	Soi	$122.5 = 160 \times e^2$ M1A1A1
			$= \frac{7}{8}$ or 0.875	A1	1.1		$e = \frac{7}{8}$ M1A1
			Speed before 2nd bounce is also w	B1	3.3		$h = 122.5 \times \left(\frac{7}{8}\right)^2$ M1A1A1
			Speed after 2nd bounce is $e \times w$ $(= 0.875 \times 4.9)$	M1	1.1	4.2875 or $\frac{343}{80}$	
			Height = 93.8 (cm) or 0.938 m	A1 [8]	1.1	0.93789	May see 0.765625 (e^2)
	(ii)		To get height < 0.1m speed must be < 1.4 m s^{-1}	M1	3.4	$v^2 = 2g \times 0.1$	Allow = or any inequality; do not allow use of 0.099 oe. Allow for step-by step approach
			Solve $1.4 = \left(\frac{7}{8}\right)^n \times 5.6$ (or 4.9)	M1	1.1	OR $0.1 = \left(\frac{7}{8}\right)^{2n} \times 1.6$ (or 1.225)	
			$n = 11$	A1 [3]	2.2a		
	(iii)	(*A*)	The ball will stay on the horizontal surface after reaching it	B1 [1]	2.2a		
		(*B*)	The ball will return to a height of 160 cm (repeatedly)	B1 [1]	2.2a	OR bounce off floor at same speed as it hit the floor	

Question			Answer	Marks	AOs		Guidance
6	(i)		R at A perp'r to plane; T along string from B	B1 [1]	1.2	By eye; arrows needed	
	(ii)		$W \times a = R \times 2a \sin 60°$ $R = \frac{W}{3}\sqrt{3}$	M1 A1 [2]	3.3 1.1	Allow sin / cos confusion, sign error	a can be cancelled; ft R from (i) if R through A (not horiz) Accept $\frac{W}{\sqrt{3}}$
	(iii)		$T\cos\theta = R\cos 60°$ $T\cos\theta = \frac{W}{3}\sqrt{3}\cos 60°$ $6T\cos\theta = W\sqrt{3}$	M1 M1ft A1 [3]	3.4 1.1 2.1	Must have sin/cos in each term; allow sin / cos confusion Using their R from part (ii); allow sin / cos confusion **AG**	
	(iv)		$T\sin\theta + R\sin 60° = W$ $\frac{W\sqrt{3}}{6\cos\theta}\sin\theta + \frac{W}{3}\sqrt{3} \times \frac{\sqrt{3}}{2} = W$ $\tan\theta = \frac{6}{\sqrt{3}} \times \left(1 - \frac{\sqrt{3}\times\sqrt{3}}{3\times 2}\right)$ OR $T\sin\theta + \frac{W}{3}\sqrt{3}\sin 60° = W$ $T\sin\theta = \frac{W}{2}$; Solve with $T\cos\theta = W\frac{\sqrt{3}}{6}$ from (iii) $\theta = 60°$ $T = \frac{W}{3}\sqrt{3}$	M1* A1 *M1 (A1) (M1) A1 A1 [5]	3.1b 3.4 1.1 1.1 1.1	Resolve vertically for AB; must have T, R and W terms, comps of T and R; allow sign error Elim T and subst for R Attempt to re-arrange to find tan θ Subst for R Must be correct	OR Moments about A $Wa = T \times 2a\sin\theta$ M1 $\frac{T\times 2a\sin\theta}{6T\cos\theta} = \frac{Wa}{W\sqrt{3}}$ A1 $\tan\theta = \sqrt{3}$ M1

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