GCE 2004

June Series

Mark Scheme

Mathematics A

Unit MAM3

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

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Key to Mark Scheme

M	mark is for	method
m	mark is dependent on one or more M marks and is for	method
A	mark is dependent on M or m marks and is for	accuracy
B	mark is independent of M or m marks and is for	method and accuracy
E	mark is for	explanation
√ or ft or F		follow through from previous incorrect result
CAO		correct answer only
AWFW		anything which falls within
AWRT		anything which rounds to
AG		answer given
SC		special case
OE		or equivalent
A2,1		2 or 1 (or 0) accuracy marks
-*x* EE		deduct *x* marks for each error
NMS		no method shown
PI		possibly implied
SCA		substantially correct approach
c		candidate
SF		significant figure(s)
DP		decimal place(s)

Abbreviations used in Marking

MC – *x*	deducted *x* marks for mis-copy
MR – *x*	deducted *x* marks for mis-read
ISW	ignored subsequent working
BOD	given benefit of doubt
WR	work replaced by candidate
FB	formulae booklet

Application of Mark Scheme

No method shown:

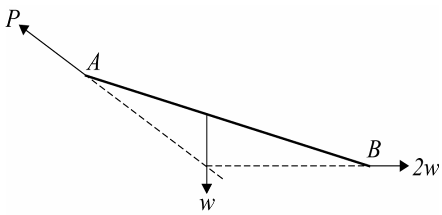
Correct answer without working	mark as in scheme
Incorrect answer without working	zero marks unless specified otherwise

More than one method/choice of solution:

2 or more complete attempts, neither/none crossed out	mark both/all fully and award the mean mark rounded down
1 complete and 1 partial attempt, neither crossed out	award credit for the complete solution only

Crossed out work	do not mark unless it has not been replaced
Alternative solution using a correct or partially correct method	award method and accuracy marks as appropriate

MAM3

Q	Solution	Marks	Total	Comments
1(a)	$X = 2W$	B1		
	$Y = W$	B1	2	
(b)	Moments about A:			
	$Wa\sin\theta = 2W\ 2a\cos\theta$	M1A1		
	$\theta = \tan^{-1}4$ ($\approx 76.0°$)	A1	3	
(c)	P must pass through the point of intersection of the lines of action of W and $2W$ 	B1		Lines of action of W, $2W$ clearly indicated.
		B1	2	Line of action of P clearly passing through the intersection of lines of action of W, $2W$.
	Total		**7**	
2(a)	2 revs per second $= 4\pi$ rad s^{-1}	A1		
	angular momentum $= 1.5 \times 4\pi$	M1		
	$= 6\pi$ (≈ 18.8 kg m^2s^{-1})	A1	3	Units not required
(b)	Angular momentum conserved:	M1		
	$6\pi = 8\omega$			
	$\omega = \frac{3\pi}{4}$ (≈ 2.36 rad s^{-1})	A1	2	
	Total		**5**	

MAM3 (Cont)

Q	Solution	Marks	Total	Comments
3(a)	$X = 4 + 3 + 3 + 2 = 12$			
	$Y = 3 + 4 + (-3) + 1 = 5$	B1		
		B1		
	$F = \sqrt{(12^2 + 5^2)}$	M1		Full credit if 5,12,13 seen
	$= 13$	A1	4	
(b)	Moments clockwise about O:			Or anticlockwise – must be consistent throughout
	$3 \times 2 + 3 \times 3 + 3 \times 4 - 1 \times 3 = 24$	M1A1		
	$-5d = 24$	M1		
	$d = -4.8$	A1	4	
(c)	L = 24 clockwise	A1FA1	2	ft on magnitude
	Total		**10**	
4(a)	$I = \frac{1}{2} \times 10m \times a^2$			
	$= 5ma^2$	A1	1	
(b)	(Taking tension in AB as T_1, in BC as T_2)			
	accelerations of A and C are equal:			May be implied by later working for full credit
	$f_A = f_C = a\dot{\omega}$	B1		
	for B: $a(T_2 - T_1) = 5ma^2\dot{\omega}$	M1A1		
	for A: $T_1 = ma\dot{\omega}$	M1A1		M1 if <u>both</u> particles attempted
	for C: $2mg - T_2 = 2ma\dot{\omega}$	A1		
	$\therefore\ 2mg - 2ma\dot{\omega} - ma\dot{\omega} = 5ma\dot{\omega}$	M1		Clear attempt to eliminate T_1, T_2
	$2mg = 8ma\dot{\omega}$			
	$\dot{\omega} = \frac{g}{4a}$	A1	8	AG
	(Alternative solution considering energy changes) $2mgh = \frac{1}{2}mv^2 + \frac{1}{2}2mv^2 + \frac{1}{2}I\dot{\theta}^2$	*(M1A2)*		– A1 each error
	but $v = a\dot{\theta}$, $h = a\theta$	*(B1)*		May be implied
	$\therefore\ 2mga\theta = \frac{3}{2}a^2\dot{\theta}^2 + \frac{5}{2}a^2\dot{\theta}^2$	*(M1)*		
	$g\theta = 2a\dot{\theta}^2$	*(A1)*		
	$\dot{\theta}^2 = \frac{g}{2a}\theta$	*(M1)*		May assume constant acceleration for full credit using:
	$2\dot{\theta}\ddot{\theta} = \frac{g}{2a}\dot{\theta}$			$\dot{\theta}^2 = \dot{\theta}_0^2 + 2\ddot{\theta}\theta$ $\dot{\theta}^2 = 2\ddot{\theta}\theta$
	$\ddot{\theta} = \frac{g}{4a}$	*(A1)*	*(8)*	$g\theta = 2a.2\ddot{\theta}\theta$ $\ddot{\theta} = \frac{g}{4a}$
	Total		**9**	

MAM3 (Cont)

Q	Solution	Marks	Total	Comments
5(a)	(Using tension in $AB = T_{AB}$, in $BC = T_{BC}$ and in $AC = T_{AC}$) Moments about A: $12 \times 2a\cos 60° = Q \times \sqrt{3}\,a\cos 60°$ $Q = 8\sqrt{3}$	M1A1 A1	3	
(b)(i)	Resolving along BA at B: $T_{AB} = Q\cos 30°$ $= 8\sqrt{3} \times \frac{\sqrt{3}}{2}$ $= 12$ Resolving along BC at B $T_{BC} = Q\sin 30°$ $= 8\sqrt{3} \times \frac{1}{2}$ $= 4\sqrt{3}$	M1 A1 A1 A1 A1 A1	6	Resolving in either direction Alternative solution by resolving horizontally and vertically at B, then solving for T_{AB} T_{BC} full credit.
(ii)	T_{AB} is a tension	A1	1	Marks in b(ii), b(iii) only awarded if M1 awarded in b(i)
(iii)	T_{BC} is a tension	A1	1	
(c)	Resolving vertically at C: $12 = 4\sqrt{3} + T_{AC} \times \frac{\sqrt{3}}{2}$ $T_{AC} = 4\sqrt{3}$	M1 A1	2	Candidates may solve forces in a different order (e.g. T_{BC}, T_{AC}, T_{AB}, Q) and gain full credit.
	Total		**13**	

MAM3 (Cont)

Q	Solution	Marks	Total	Comments
6(a)	$I_G = \frac{1}{3}m(3a)^2 = 3ma^2$	M1		Parallel axes
	$I_B = 3ma^2 + ma^2$ $= 4ma^2$	A1	2	
(b)(i)	Rod turned through angle θ : P.E. lost = $mga\sin\theta$			
	K.E. gained = $\frac{1}{2}I\dot{\theta}^2$ $= 2ma^2\dot{\theta}^2$			
	hence, $2ma^2\dot{\theta}^2 = mga\sin\theta$	M1A1		
	$\dot{\theta}^2 = \frac{g\sin\theta}{2a}$			
	$\dot{\theta} = \sqrt{\frac{g\sin\theta}{2a}}$	A1	3	AG
(ii)	For the rod in motion:			
	$I\ddot{\theta} = mga\cos\theta$ $4ma^2\ddot{\theta} = mga\cos\theta$	M1A1		Or by differentation of $\dot{\theta}^2$
	$\ddot{\theta} = \frac{g\cos\theta}{4a}$	A1	3	
(iii)	$mg\cos\theta - X = ma\ddot{\theta}$	M1A1		
	$X = mg\cos\theta - \frac{mag\cos\theta}{4a}$			
	$= \frac{3mg\cos\theta}{4}$	A1	3	
(c)	$Y - mg\sin\theta = ma\dot{\theta}^2$	M1		
	$Y = mg\sin\theta + \frac{mag\sin\theta}{2a}$			For M1 must be in context with attempted substitution
	$= \frac{3mg\sin\theta}{2}$	A1		
	At point of slipping $Y = \mu X$			
	$\frac{3mg\sin\theta}{2} = \mu\frac{3mg\cos\theta}{4}$	M1 A1		AG
	$\Rightarrow \tan\theta = \frac{\mu}{2}$	A1	5	
	Total		**16**	
	Total		**60**	