
MATHEMATICS

9709/51

Paper 5

October/November 2016

MARK SCHEME

Maximum Mark: 50

Published

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Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International A Level – October/November 2016	9709	51

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M Method mark, awarded for a valid method applied to the problem. Method marks are not 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. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.

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).

B Mark for a correct result or statement independent of method marks.

- When a part of a question has two or more “method” steps, the M marks are generally independent unless the scheme specifically says otherwise; and similarly when there are several B marks allocated. The notation DM or DB (or dep*) is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.
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1	$T = 12 \text{ N}$ $T = 0.3 \times 4^2/r$ $12 = 4.8/(2L)$ $L = 0.2$	B1 M1 A1 ✓ A1	4	$T = 12(2L-L)/L$ $\text{Accn} = v^2/r$ ft candidates expression for T
2 (i)	$\text{CoM}(\text{large}) = 0.6/(\pi/2)$ or $\text{CoM}(\text{small}) = 0.3/(\pi/2)$ $(\pi \times 0.6 + \pi \times 0.3)D =$ $\pi \times 0.6(1.2/\pi) - \pi \times 0.3(0.6/\pi)$ $D = 0.191 \text{ m}$	B1 M1 A1 AG	3	OR $(2+1)D = 2(1.2/\pi) - 1(0.6/\pi)$ Moments about ACB
(ii)	$(\pi \times 0.6 + \pi \times 0.3)H =$ $\pi \times 0.6 \times 0.6 + \pi \times 0.3 \times 0.9$ $H = 0.7$ $\tan\theta = 0.191/0.7$ $\theta = 15.3^\circ$	M1 A1 M1 A1	4	OR $3H = 2 \times 0.6 + 1 \times 0.9$ Moments about A
3 (i)	$0.25v dv/dx = 2 + 0.3x^2$ $v dv/dx = 1.2x^2 + 8$	M1 A1 AG	2	
(ii)	$\int v dv = \int (1.2x^2 + 8) dx$ $v^2/2 = 0.4x^3 + 8x (+c)$ $v = 5.17$	M1 A1 A1	3	Allow $c = 0$ without working
(iii)	$0.25v dv/dx = 0.3x^2 + 1.5 - 0.75x$ Force is $0.5 + 0.75x \text{ N}$ towards O	M1 A1	2	
4 (i)	$(0.9a + 0.9a/2)Y =$ $0.9a \times 0.45 + 0.45a \times 0.9 \times 2/3$ $Y = 0.5 \text{ m}$	M1 A1	2	$1.5Y = 1 \times 0.45 + 0.5 \times 0.6$ Moments about AD
(ii)	$(0.9a + 0.9a/2)X =$ $0.9a \times a/2 + 0.45a \times (a + a/3)$ $X = 7a/9$	M1 A1	2	$1.5X = 1 \times a/2 + 0.5 \times 4a/3$
(iii)	$0.5 \times 6 = (a - 7a/9) \times 18$ $a = 0.75$	M1 A1 ✓ A1	3	Ft [Yi and (a–Xii)]

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5	(i)	$\theta (= \tan^{-1} 0.45/0.6 = 36.87..) = 36.9^\circ$ $0.4v^2/0.6 = 5\cos\theta$ $v = 2.45 \text{ ms}^{-1}$	B1 M1 A1	3	Or $\tan\theta = 3/4$ Or $\sqrt{6}$
	(ii)	$T\sin\theta = 0.4g$ $T = 6.67 \text{ N}$ $0.4\omega^2 \times 0.6 = 6.67\cos\theta$ $\omega = 4.71 \text{ rad s}^{-1}$	M1 A1 M1 A1	4	Accept $0.66, 6\frac{2}{3}, 20/3$ Accept 4.72 rad s^{-1}
6	(i)	$EE = 8(0.9\pi - 1.2)^2/(2 \times 1.2)$ $8.83 = 0.2g \times 0.9 + 0.2v^2/2 + 8(0.9\pi/2 - 1.2)^2/(2 \times 1.2)$ $v = 8.29 \text{ ms}^{-1}$	B1 M1 A1 A1	4	Initial EE = 8.83 J
	(ii)	$\theta = 1.2/0.9 = 4/3 \text{ rad } (=76.4^\circ)$ $8.83 = 0.2g \times 0.9 + 0.2g \times 0.9\cos\theta + 0.2v^2/2$ $v = 8.13 \text{ ms}^{-1}$	B1 M1 A1	3	$0.2 \times 8.29^2/2 = 0.2g \times 0.9\cos\theta + 0.2v^2/2$
7	(i)	$a = 14k - 0.8(1 + k^2)$ and $2a = 42k - 7.2(1 + k^2)$ $42k - 7.2(1 + k^2) = 2[14k - 0.8(1 + k^2)]$ $k = 1/2$ and 2 $\theta = \tan^{-1}k$ $\theta = 63.435$ AG	M1 M1 B1 M1 A1	5	Creates 2 simultaneous equations Creates a single equation in k Both values With 1 of the candidates value of k
	(ii)	$t = 14/(35\cos 63.435)$ $t (= 0.89442..) = 0.894 \text{ s}$	M1 A1	2	

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(iii)	$V_v = 35 \sin 63.4 - g[42/(35 \cos 63.4)]$ $\tan \alpha = 4.495/(35 \cos 63.4)$	M1		$V_v = 4.495$
	$\alpha = 15.9^\circ$ above the horizontal	A1		Accept $16(.0)^\circ$
	$V^2 = 4.495^2 + (35 \cos 63.4)^2$	M1		
	$V = 16.3 \text{ m s}^{-1}$	A1	4	
	OR			
	$2a = 48$ $V^2 = 35^2 - 2g \times 48$	M1		$42 \times 2 - 7.2(1 + 2^2)$
	$V = 16.3 \text{ m s}^{-1}$	A1		
	$\cos \alpha = 35 \cos 63.435/16.3$ $\alpha = 15.9^\circ$	M1 A1	4	

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1	$Y = g1.6^2 / 2$ $12.8 / (1.6V) = \tan 30$ $V = 13.9 \text{ m s}^{-1}$	B1 M1 A1	[3]	12.8 m $1.6V = X = 22.17 \text{ m}$
2 (i)	$5 = 24e / 0.6$ $AP = 0.725 \text{ m}$	M1 A1	[2]	Hence $e = 0.125$
(ii)	$24 \times 0.125^2 / 2 \times 0.6$ $0.5g \times 0.725 =$ $24 \times 0.125^2 / 2 \times 0.6 + 0.5v^2 / 2$ $v = 3.64 \text{ m s}^{-1}$	B1 M1 A1	[3]	EE at eqm (= 0.3125) KE/EE/PE conservation
3 (i)	$F \cos 45 = 10 \cos 60$ $F = 7.07$ $F \sin 45 + 10 \sin 60 = W$ $W = 13.7$	M1 A1 M1 A1	[4]	Resolving horizontally $7.071 \dots = 5\sqrt{2}$ Resolving vertically $13.660 \dots = 5(\sqrt{2} + \sqrt{3})$
(ii)	$Wd \cos 30 = (F \sin 75) 0.5$ $d = 0.289 \text{ m}$	M1 A1 A1	[3]	Moments about A
4 (i)	$-20 \sin 30 = 20 \sin 30 - gT$ $T = 2 \text{ s}$ $OA = 34.6 \text{ m}$	M1 A1 B1	[3]	
(ii)	$V_v^2 = 18^2 - (20 \cos 30)^2$ $V_v = (\pm) 4.899$ $4.899 = 20 \sin 30 - gt$ $t = 0.51(0) \text{ s}$ $-4.899 = 8 - gt$ $t = 1.29$ $T = 3.29 \text{ s}$	M1 A1 M1 A1 A1	[5]	

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5	(i)	$0.4dv/dt = 3e^{-t} - 0.4g\sin 30$ $dv/dt = 7.5e^{-t} - 5$ AG	M1 A1	[2]	
	(ii)	$\int_0^v dv = \int_0^t (7.5e^{-t} - 5) dt$ $v = 7.5 - 7.5e^{-t} - 5t$	M1 M1 A1	[3]	Integrates accn Limits or finds integration constant
	(iii)	Solves $dv/dt = 0$ $\int_0^x dx = \int_0^{0.405} (7.5 - 7.5e^{-t} - 5t) dt$ $x = 0.13(0) \text{ m}$	M1 M1 A1	[3]	$t = 0.405(46\dots)$ Integrates expression for v and uses $t = 0.405$
6	(i)	CoM semi-circle from $DF = 4r/3\pi$ $(0.4 \times 1.8) \times 0.2 = (\pi r^2 / 2) \times (4r/3\pi)$ $r = 0.6$ AG	B1 M1 A1	[3]	Moments about A
	(ii)	$P\cos 60(0.4 + 0.6\cos 60)$ $P\cos 30(1.8 - 0.6 + 0.6\sin 60)$ $15 \times 0.4 =$ $P\cos 60(0.4 + 0.6\cos 60)$ $+ P\cos 30(1.8 - 0.6 + 0.6\sin 60)$ $P = 3.26 \text{ N}$ AG	B1 B1 M1 A1	[4]	Moment of vertical component Moment of horiz component 3.2622...
	(iii)	$\mu = 3.262\sin 60 / (15 - 3.262\cos 60)$ $\mu = 0.211$	M1 A1	[2]	
7	(i)	$R\cos 30 = 0.5g$ $R = 5.77(35\dots)$ $R\sin 30 = 0.5\omega^2 \times 0.4$ $\omega = 3.8(0) \text{ rad s}^{-1}$ AG	M1 A1 M1 A1	[4]	

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(ii)	$T = 36(0.5 - 0.45) / 0.45$	M1	[6]	4 N
	Vert cmpt = $4 \times 0.3 / 0.5 = 2.4$	A1		
	Horiz cmpt = $4 \times 0.4 / 0.5 = 3.2$	A1		
	$R \cos 30 + 2.4 = 0.5g$	M1		
	$R = 3(.00\dots) \text{ N}$	M1		
	$0.5v^2 / 0.4 = 3.2 + R \sin 30$	M1		
	$v = 1.94 \text{ m s}^{-1}$	A1		

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	OR			
	$2a = 48$ $V^2 = 35^2 - 2g \times 48$	M1		$42 \times 2 - 7.2(1 + 2^2)$
	$V = 16.3 \text{ m s}^{-1}$	A1		
	$\cos \alpha = 35 \cos 63.435/16.3$ $\alpha = 15.9^\circ$	M1 A1	4	