

MARK SCHEME for the May/June 2013 series

9709 MATHEMATICS

9709/51

Paper 5, maximum raw mark 50

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	GCE AS/A LEVEL – May/June 2013	9709	51

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1	(i)	$x = (20\cos 45)t$	B1		Or $\sin 45$, $1/\sqrt{2}$, 0.707	
		$y = (20\sin 45)t - gt^2/2$	B1	[2]	Or $\cos 45$, $1/\sqrt{2}$, 0.707.	
	(ii)	$y = (20\sin 45)(x/(20\cos 45)) - g[x/(20\cos 45)]^2/2$	M1		Substitutes $t = x/(20\cos 45)$ at least once	
		$y = x - x^2/40$ AG	A1	[2]	Only from $g = 10$	
	(iii)	$x = 40 \text{ m}$	B1	[1]		[5]
2	(i)	$T = 19.2 \times (2.7 - 1.2)/1.2$	B1		$T = 24 \text{ N}$	
		$0.4a = 0.4g + T$	M1		Newton's Second Law with 3 terms	
		$a = 70 \text{ ms}^{-2}$	A1	[3]		
	(ii)	$19.2(2.7 - 1.2)^2/(2 \times 1.2)$	B1		Initial EE = 18	
		$0.4v^2/2 = 0.4g \times 2.7 + 19.2 \times (2.7 - 1.2)^2/(2 \times 1.2)$	M1		For a 3 term energy equation	
		$v = 12 \text{ ms}^{-1}$	A1	[4]		[7]
3	(i)		M1		Table of values or a moment equation	
		$0.2 \times 0.1 + 0.3 \times 0 = d(0.2 + 0.3)$	A1		Accept no mention of 0.3×0	
		$d = 0.04 \text{ m}$	A1	[3]		
	(ii)	$4 \times 0.3 = 0.04W$	M1		Moments about A	
		$W = 30 \text{ N}$	A1ft	[2]	ft $1.2/cv(d(i))$	
	(iii)	$\mu = 4/30$	M1		$4/cv(W(ii))$	
		$\mu = 0.133$	A1	[2]	Accept 2/15	[7]
4	(i)	$a = 10 - 0.45v$ AG	B1	[1]	$0.2a = 0.2g - 0.09v$ or similar should be seen	
	(ii)	$\int 1/(10 - 0.45v)dv = \int dt$	M1		An attempt at integration needed	
		$-\ln(10 - 0.45v)/0.45 = t (+c)$	A1			
		$t = 0, v = 4, c = -4.67(58..)$	DM1		Attempts to find c or uses correct limits	
		$-\ln(10 - 0.45v)/0.45 = 1.5 - 4.676$	M1		Uses $t = 1.5$ and evaluated c	

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	$v = 12.9$ or 13.0	A1	[5]		[6]
5	(i) $v_y = 50\sin 40 - 2.5g$	B1		Vertical component speed (=7.139...)	
	$v^2 = (50\sin 40 - 2.5g)^2 + (50\cos 40)^2$	M1		Uses Pythagoras with correct horizontal component	
	$v = 39(.0) \text{ ms}^{-1}$	A1	[3]		
	(ii) $x = 50\cos 40 \times 2.5$	B1		Horizontal displacement at 2.5s (=95.75..)	
	$y = 50\sin 40 \times 2.5 - 2.5^2 g/2$	B1		(=49.09..)	
	$\tan \theta = 49.09/95.75$	M1		Appropriate ratio to find angle	
	$\theta = 27.1^\circ$	A1	[4]		[7]
6	(i) Radial acc ⁿ = $1.2^2 / (0.2\cos 30)$	B1		Radial acc ⁿ = 8.31 ms^{-2}	
	$T\cos 30 = 0.3 \times 1.2^2 / (0.2\cos 30)$	M1		Component of tension = $m \times \text{radial acc}^n$	
	$T = 2.88 \text{ N}$	A1	[3]		
	(ii) (a) $T\cos 60 = 0.3g$	M1		Uses T max in limiting case when $R = 0$	
	$T = 6$	A1		May be implied	
	$6\cos 30 = 0.3 \omega^2 (0.2\cos 30)$	M1		Component of max T = $m \times \text{maximum radial acc}^n$	
	$\omega = 10$ AG	A1	[4]	From $g = 10$ only	
	OR $T\cos 30 = 0.3 \times 10^2 (0.2\cos 30)$	M1		Finds T max from $m \times \text{max(RA)}$	
	$T = 6$	A1			
	$R + 6\cos 60 = 0.3g$	M1		Resolves vertically with T max	
	$R = 0$ and a higher value of ω makes R negative which is impossible	A1		Additional justification needed of inequality	
	(ii) (b) $\text{KE} = 0.3(10 \times 0.2\cos 30)^2 / 2$	M1		Attempt at KE with $v = 10 \times \text{radius}$	
	$\text{KE} = 0.45 \text{ J}$	A1	[2]		[7]
7	$\text{OG} = 2r\sin(\pi/3)/(3\pi/3)$	B1		Centre of mass from O	
	$15r\cos(\pi - 2\pi/3)$	B1		Moment of 15 N about O	
	$20 \times \text{OG}\cos(\pi/3 - \theta)$	B1ft		Moment of weight about O, ft cv(OG) if used	

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	$15r\cos(\pi/3) \leq$ $20 \times 2r\sin(\pi/3)/\pi \times \cos(\pi/3 - \theta)$ $\cos(\pi/3 - \theta) \geq 0.68(017..)$ $\pi/3 - \theta \leq 0.82(279..)$ $\theta = 0.224$ $\theta \geq 0.224$	M1 A1ft A1 M1 A1 A1	[9] 	Uses moments, including 15 N and 20 N Accept $\prec$, $=$, $\succ$ as alternative to $\leq$ Accept $\succ$, $=$, $\prec$ as an alternative to $\geq$ Solves for θ , equation or inequality Correct value Correct sign, accept $\succ$ SR deduct 1 mark for assuming $r = 1$	[9]
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		$F = 3 \text{ N}$	A1	[2]		
	(ii)	$R^2 = 3^2 + (0.4g)^2$	M1		Uses Pythagoras with normal force from base and answer (i)	
		$R = 5$ AG	A1		From $g = 10$ only	[4]
2	(i)	$OG = (0.1061) = 0.106 \text{ m}$	B1	[1]	$OG = (2 \times 0.25 \sin \pi/2) / (3 \pi/2)$	
	(ii)	$\tan \theta = 0.1061/0.25$	M1		Candidate's OG	
		$\theta = 23(.0)^\circ$	A1	[2]		
	(iii)		M1		Takes moments about A	
		$0.1061W = (6 \cos 45) \times (2 \times 0.25)$	A1ft		ft cv(OG(i))	
		$W = 20(.0) \text{ N}$	A1	[3]		[6]
3	(i)	$EE = 18 \times (1.8 - 1.6)^2 / (2 \times 1.6)$	B1			
		$0.2 \times 1.5^2 / 2 =$	M1		Energy equation, 3 terms	
		$18(1.8 - 1.6)^2 / (2 \times 1.6) + KE_B$				
		$KE_B = 0$ leads to $v_B = 0$	A1	[3]		
	(ii)	$T = 18 \times (1.8 - 1.6) / 1.6$	B1		$T = 2.25$	
		$T \cos \theta + R = 0.2g$	M1			
		$2.25 \times 1.6 / 1.8 + R = 0.2g$	A1			
		$R = 0$	A1	[4]	Needs $g = 10$	[7]
4	(i)	$V \sin 40 - (1.8/2)g = 0$	M1		Or $0 = (V \sin 40) \times 1.8 - g \times 1.8^2 / 2$	
		$V = 14(.0) \text{ ms}^{-1}$	A1	[2]		
	(ii)	$(14 \sin 40)^2 = 2gh$	M1		Or $h = (V \sin 40) \times 0.9 - g \times 0.9^2 / 2$	
		$h = 4.05 \text{ m}$	A1	[2]		
	(iii)	$d = (14 \cos 40) \times 1.8$	M1		Or $d = V^2 \sin 80 / g$	
		$d = 19.3 \text{ m}$	A1	[2]		[6]
5	(i)	$Ext = 0.8 + 0.9 - 1.4 (= 0.3 \text{ m})$	B1		Ext when in limiting equilibrium	
		$EE = 70 \times 0.30^2 / (2 \times 1.4) (= 2.25 \text{ J})$	B1		EE in limiting equilibrium	
			M1		EE/PE/KE balance	

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	$0.3v^2/2 = 0.3gx0.8 - 2.25$ $v = 1 \text{ ms}^{-1}$ (ii) $T = 70 \times 0.3/1.4 (= 15\text{N})$ $15 = \mu (3g)$ $\mu = 0.5$	A1 A1 B1 M1 A1	[5] [3]	 Uses ext from part (i) $F = \mu R$, using mass of B	 [8]
6 (i)	 OG(0.5 + 0.2) = $0.5 \times 0.6/4 + 0.2 \times (0.6 - 0.4\cos60)$	M1 A1	 	Taking moments with 3 terms Correct equation	
OR	 (ii) OG = 0.221 m $T\cos60 + R\sin60 = 0.2 g$ $T\sin60 - R\cos60 = 0.2 \times 4^2 \times (0.4\sin60)$ Solves 2 simultaneous equations $T = 1.96 \text{ N}$ AG $R = 1.18 \text{ N}$ $0.2 \times 4^2 \times 0.4\sin60\cos30 = T - 0.2g\cos60$ $T = 1.96 \text{ N}$ AG $0.2 \times 4^2 \times 0.4\sin60\cos60 = 0.2g\sin60 - R$ $R = 1.18 \text{ N}$ (iii) $v = 1.39 \text{ ms}^{-1}$	A1 M1 A1 M1 A1 A1 M1 A1 A1 A1 B1	[3] [5] [1]	 Either for resolving horizontally or vertically Both equations correct 2 equations, 2 unknowns $g = 10$ only Allow values from g not 10 Resolves acc ⁿ and weight parallel to the slope From $g = 10$ only Resolves acc ⁿ and weight perpendicular to the slope Both equations correct Allow values from g not 10 $r\omega = 1.3856..$	 [9]
7 (i)	$0.5a = 0.16e^x$ $a = 0.32e^x$ $\int v dv = \int 0.32e^x dx$ $v^2/2 = 0.32e^x (+c)$ $x = 0, v = 0.8$ hence $c = 0$, so $v^2 = 0.64e^x$	M1 A1 M1 A1 M1	 	N2L, single force Forms integral from $vdv/dx = a$ Award if c omitted Trying to find the value of c	

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OR	$v = 0.8e^{x/2}$	AG	A1	[6]		
	$dv/dt = 0.8e^{x/2} x dx/dt$		M1		Uses chain rule on given answer	
	$dv/dt = 0.4e^{x/2} .v$		A1		Maybe implied by later work	
	$x = 0, v = 0.8e^0$		M1		Finding speed where $x = 0$	
	$x = 0, v = 0.8$		A1			
	$0.5dv/dt = (0.2e^{x/2})(0.8e^{x/2})$		M1		Expresses “ma” in terms of x	
	$0.5acc^n = 0.16e^x$		A1			
	(ii) $\int e^{-x/2} dx = \int 0.8dt$		M1		Forms integral from $dx/dt = 0.8e^{x/2}$	
	$e^{-x/2}/(-1/2) = 0.8t (+c)$		A1		Award if c omitted	
	$x = 0, t = 0$, hence $c = -2$ and $-2e^{-1.4/2} = 0.8t - 2$		M1		Finding c and using $x = 1.4$ or $[e^{-x/2}/(-1/2)]_0^{1.4} = 0.8t$	
	$t = 1.26 \text{ s}$		A1	[4]	1.2585..	[10]

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2	$0.3g \times (0.6 + e) = 45e^2/(2 \times 0.6)$ $37.5e^2 - 3e - 1.8 = 0$ $e = 0.263 \text{ m}$	M1 A1 M1 A1	[4]	PE/EE equated Solves 3 term quadratic equation	4
3 (i)	$v = 25 \text{ ms}^{-1}$ $\cos \theta = 5/25$ $\theta = 78.5^\circ$ (with horizontal)	B1 M1 A1	[3]	$\sqrt{5^2 + 2g \times 30}$ Forms a relevant trig ratio Ignore above/below	6
(ii)	$30 = gt^2/2$ $s = 5 \times 2.45$ $s = 12.2 \text{ m}$	M1 M1 A1	[3]	$t = 2.45$, award if found in (i) $5 \times \text{time of flight}$	
4 (i)	$\cos \theta = 0.8, \sin \theta = 0.6$ or $\cos \phi = 0.6, \sin \phi = 0.8$ $T \cos \theta = 0.2g$ or $T \sin \phi = 0.2g$ $T = 2.5 \text{ N}$	B1 M1 A1	[3]	Either θ = string angle with vert or ϕ = string angle with horiz Resolves T vertically	8
(ii)	$2.5\sin \theta$ or $2.5\cos \phi = 0.2\omega^2 \times 0.3$ $\omega = 5 \text{ rads}^{-1}$	M1 A1	[2]	N2L with $\text{acc}^n = 2\omega^2 \times 0.3$	
(iii)	$R + 2.5\sin \theta = 0.2 \times 1.8^2/0.3$ or $R + 2.5\cos \phi = 0.2 \times 1.8^2/0.3$ $R = 0.66 \text{ N}$	M1 A1 A1	[3]	N2L with 2 +ve radial forces	
5 (i)	$0.4g = 20e/0.5$ $OP = 0.6 \text{ m}$	M1 A1ft	[2]	Weight = $\lambda \text{ ext}/L$ ($e = 0.1$) $0.5 + cv(e)$	9
(iia)	4 N	B1			
(iib)	0 N	B1			
(iic)	$T = 0.4g - 20 \times 0.04/0.5$ $T = 2.4 \text{ N}$	M1 A1	[4]	Weight(P) – $\lambda \text{ ext}/L$	
(iii)	$0.4v^2/2 = 0.4g(0.6 - 0.54)$ $-[20(0.1)^2/(2 \times 0.5) - 20(0.04)^2/(2 \times 0.5)]$ $v = 0.6 \text{ ms}^{-1}$	M1 A1 A1	[3]	PE/KE/EE energy conservation EE change (0.168 J)	

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6 (i)	$38OG + 16 \times [0.4 + (0.8 - 3 \times 0.8/4)]$	M1		Table of moments idea	
	$= 54 \times (1.2 - 3 \times 1.2/4)$	A1			
	OG = 0.174	A1	[3]	0.17368..	
	(iia) $\mu (= 4/16) = 0.25, \frac{1}{4}$	B1	[1]		
	(iib) $4(1.2 - 0.4) < 16(1.2 - 0.4)\tan\theta$	M1		Moment equation involving toppling	
	$\theta > 14.0$ AG	A1	[2]		
	(iii) $\cos\theta = (0.8/\cos\theta)/(1.2 - 0.17368..)$	M1		Uses a ratio of relevant distances	
	$\cos^2\theta = 0.8/1.02631..$	A1		Accept unsimplified version with single trig ratio	
	$\theta = 28(.0)^\circ$	A1	[3]		9
	OR $\tan\theta = (0.4 - 0.17368..)/(0.8\tan\theta)$	A1		Uses a ratio of relevant distances	
7 (i)	$\tan^2\theta = 0.22631../0.8$	A1		Accept unsimplified version with trig ratio	
	$\theta = 28(.0)^\circ$	A1			
	OR $\sin\theta$	M1		Uses a ratio of relevant distances	
	$= [(0.4 - 0.17368.)/\sin\theta]/(1.2 - 0.17368.)$				
	$\sin^2\theta = 0.2631../1.02631..$	A1		Accept unsimplified version with single trig ratio	
	$\theta = 28(.0)^\circ$	A1			
	(ii) $0.2a = -k/(1-x)$	M1		N2L, single force	
	$a = -5k/(1-x)$	M1		Attempts $\int$, accept use of dv/dt	
	$\int v dv = -5k \int 1/(1-x) dx$				
	$v^2/2 = 5k \ln(1-x) (+c)$	A1			
7 (ii)	$x = 0, v = 1.2$, hence $c = 0.72$	M1		$[v^2/2]_{1.2}^0 = [5k \ln(1-x)]_0^{0.55}$	
	$5k \ln(1 - 0.55) + 0.72 = 0$	DM1			
	$k = 0.1803$ AG	A1	6		
	$0.2v dv/dx = 0.2g - 0.1803/(1-x)$	M1		N2L, difference of 2 forces	
	$0.2v^2/2 = 0.2gx + 0. (1-x) (+c)$	A1		Accept omission of c	
	$0.2v^2/2 = 0.2gx \cdot 0.1 + 0.1803 \ln(1 - 0.1)$	M1		nb $c = 0$, so can be omitted/lost	
	$v = 1.35 \text{ ms}^{-1}$	A1	4	1.345	10