

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Level

MARK SCHEME for the May/June 2015 series

9709 MATHEMATICS

9709/51

Paper 5, maximum raw mark 50

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1	$EE(B) = \frac{\lambda \times 0.5^2}{2 \times 0.7} \left[= \frac{5\lambda}{28} \right]$	B1		Correct EE when AP = 1.2 m Correct EE when AP = 0.9 m
	$OR \ EE = \frac{\lambda \times 0.2^2}{2 \times 0.7} \left[= \frac{\lambda}{35} \right]$			
	$\frac{\Lambda \times 0.5^2}{2 \times 0.7} - \frac{\lambda \times 0.2^2}{2 \times 0.7} = \frac{0.3 \times 4^2}{2}$	M1		Using EE loss = KE gain
	$\lambda = 16 \text{ N}$	A1	[3]	
2	(i) $\frac{dy}{dx} = 1.2 - 2(0.15x) = 0$	M1		Solving trajectory derivative = 0
	$y = 2.4$	A1	[2]	From $x = 4$
	OR			
	Greatest height at half range (ii)	M1		Uses $y = 1.2x - 0.15x^2$ with $x =$ distance in (ii) $\div 2$
	$y = 2.4$	A1		
	(ii) Twice 'x' for greatest height	M1		Using 'x' from (i)
	Distance = 8 m	A1	[2]	No ft
	OR			
	$1.2x - 0.15x^2 = 0$	M1		Solves quadratic with $y = 0$
	Distance = 8 m	A1		
3	(i) $T \sin \theta = m \omega^2 r$	M1		Newton's 2nd law, acceleration = $5^2 r$ and component of T
	$3\omega \sin \theta = \left(\frac{\omega}{g} \right) 5^2 (L \sin \theta)$	A1		$3mg \sin \theta = m 5^2 (L \sin \theta)$
	$L = 1.2 \text{ m}$	A1	[3]	
	AG			
	(ii) $3\omega \cos \theta = \omega$	M1		Resolves vertically for P
	$\theta = 70.53^\circ$	A1		OR $\theta = \cos^{-1} \left(\frac{1}{3} \right),$ $\theta = \sin^{-1} \sqrt{\frac{8}{9}}$ etc.
	$v = 5 \times 1.2 \sin \theta$	M1		$v = \omega r$
	$v = 5.66 \text{ ms}^{-1}$	A1	[4]	

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4	(i)	$x' = 15\cos 30 \quad (= 12.990..)$	B1		
		$y' = 15\sin 30 - 3g \quad (= -22.5)$	B1		Or with signs reversed
		$v^2 = (15\cos 30)^2 + (15\sin 30 - 3g)^2$ or $\tan \theta = \frac{3g - 15\sin 30}{15\cos 30}$	M1		
		$v = 26(.0) \text{ ms}^{-1}$	A1		
		$\theta = 60^\circ$ to the horizontal	A1	[5]	Or 30° to the vertical
	(ii)	$y = 3(15\sin 30) - \frac{3^2 g}{2}$	M1		Uses $s = ut + \frac{1}{2}at^2$
		Height = 22.5 m	A1	[2]	N.B. this is also y'
		OR			
		$(-22.5)^2 = (15\sin 30)^2 - 2 \times 10y$	M1		Uses $v^2 = u^2 + 2as$
		Height = 22.5 m	A1		
5	(i)	$0.3g = \frac{18e}{0.9}$	M1		Uses $T = \frac{\lambda x}{l}$
		$e = 0.15 \text{ m}$	A1	[2]	
	(ii) (a)	$12 = \frac{18\text{ext}}{0.9}$ and $ht = 3 - 0.9 - \text{ext}$	M1		Both ideas needed, ext = 0.6
		$ht = 1.5 \text{ m}$	A1	[2]	
	(ii) (b)	$\frac{0.3 \times 6^2}{2} - \frac{0.3u^2}{2} + 0.3g(0.6 - 0.15)$	M1		KE/PE/EE balance up to string breaking
		$= \frac{18 \times 0.6^2}{2 \times 0.9} - \frac{18 \times 0.15^2}{2 \times 0.9}$	A1		
		$\left(\frac{0.3u^2}{2} = 3.375 \right)$			$u^2 = 22.5$
		$0.3v^2 = 0.3u^2 + 0.3g(3 - 0.6 - 0.9)$ OR $v^2 = u^2 + 2g(3 - 0.6 - 0.9)$	M1		KE/PE balance after string breaks or $v^2 = u^2 + 2g(ht)$ using ht from (ii)(a)
		$v = 7.25 \text{ ms}^{-1}$	A1	4	7.2456
6	(i)	$0.1v \frac{dv}{dx} = -0.2 e^{-x}$	M1		Newton's 2nd law, 1 force Must have negative coefficient
		$v \frac{dv}{dx} = -2e^{-x}$			
		$k = -2$	A1*	[2]	

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7	(ii)	$\int v dv = \int -2e^{-x} dx$	M1		Integrates
		$\frac{v^2}{2} = 2e^{-x} (+ c)$	D*A1		Needs first A1 in (i)
		$c = \left(\frac{2.2^2}{2} - 2e^0 \right) = 0.42$	M1		Or uses limits of 2 and 2.2 for v and x and 0 for x
		$\frac{2^2}{2} = 2e^{-x} + 0.42$	A1	[4]	
		$x = 0.236$			
	(iii)	$\frac{v^2}{2} = 2e^{-\infty} + 0.42$	M1		OR finds x when $v = 0.9165$
		$v = 0.917 \text{ ms}^{-1}$ AG	A1	[2]	No solution when $v = 0.917$
	(i)	$d(0.6 \times 0.8 + 0.6^2) =$ $0.4(0.6 \times 0.8) - (0.6/3) \times 0.6^2$	M1 A1		Moments about BAD
		$d = 0.143 \text{ m}$	A1	[3]	Exact 1/7
	(ii) (a)	$21 \times 0.143 = 1.2P$	M1		Moments about B
		$P = 2.5(0)$	A1	[2]	
	(ii) (b)	$F_r = 21\sin 45 - 2.5\cos 45$ and $R = 21\cos 45 + 2.5\sin 45$	B1		
			M1		For using $F_r = \mu R$
		$\mu = 0.787$	A1	[3]	
(iii)		$P \times 0.6 = 21 \times (0.143 + 0.6)$	M1		Moments about C
		$P = 26(.0)$	A1		
		Required $F_r = 26\sin 45 - 21\sin 45$	M1		3.5355..
		Max $F_r = 26(.155)$	A1		$0.787 \times (26\cos 45 + 21\cos 45)$
		As actual $F_r < \max F_r$, no sliding	A1	[5]	

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1	$F = 0.6 \times 3^2 \times 0.4$ $F = 2.16 \text{ N}$ Radial, direction PO	M1 A1 B1	3	Uses $a = \omega^2 r$ Do not allow direction OP
2 (i)	$mg = 30(0.8 - 0.5)/0.5$ $m = 1.8 \text{ kg}$ AG	M1 A1	2	
(ii)	$EE = 30(1.2 - 0.5)^2 / (2 \times 0.5)$ $1.8v^2/2 = 30(1.2 - 0.5)^2 / (2 \times 0.5)$ $- 1.8 \times (1.2 - 0.5)g$ $v = 1.53 \text{ ms}^{-1}$	B1 M1 A1	3	KE/EE/PE equation, 3 terms RHS = 2.1
3 (i)	$d(3+3+4) = 3 \times 0.4\sin 30 \times 2$ $d = 0.12 \text{ m}$	M1 A1 A1	3	Taking moments about AC
(ii)	$(3+3+4) \times 0.12 = F \times 0.8\sin 30$ $F = 3$ At hinge, 7 N upwards	M1 A1 B1	3	Taking moments about A, allow candidate's d Ft 10 – candidate's value (F) (downwards if negative)
4 (i)	$r = 0.3 \text{ m}$ $0.4T/0.5 - 2(0.4/0.5) = 6$ $T = 9.5 \text{ N}$ $9.5(0.3/0.5) + 2(0.3/0.5) = 6v^2/(0.3g)$ $v = 1.86 \text{ ms}^{-1}$	B1 M1 A1 M1 A1	5	Can be implied Resolving vertically for the particle Newton's Second Law radially for P
(ii)	$[0.4T/0.5 = 6], T = 7.5$ $7.5(0.3/0.5) = (6/g) \omega^2 (0.3)$ $\omega = 5 \text{ rad s}^{-1}$ AG	B1 M1 A1	3	Uses tension in BP = 0 and resolves vertically Newton's Second Law radially for P
5 (i)	CP = 0.8 $T = 12 \times (0.8 - 0.4)/0.4$ $T = 12 \text{ N}$	B1 M1 A1	3	P is the point where the string is attached to the plane Uses $T = \lambda x/l$

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	(ii)	Moment of T at B = $0.4 \times 12\cos 30$ $0.4 \times 12\cos 30 =$ $0.2W\cos 30 - 0.2W\sin 30$ $W = 56.8 \text{ N}$	B1✓ M1 A1 A1	4	ft for their T in (i) Moments about B Or $\text{RHS} = 0.2\sqrt{2} \cos 75^\circ W$ or $W(0.2 - 0.2\tan 30)\cos 30$
6	(i)	$U\cos\theta = 18\cos 30$ ($=9\sqrt{3} = 15.588\dots$) $U\sin\theta - 2g = -18\sin 30$ $U^2 = 15.588^2 + 11^2$ $U = 19.1$ $\theta = 35.2$	B1 B1 M1 A1 A1	5	$U\sin\theta = 11$ Pythagoras or $\tan\theta = 11/15.588$
	(ii)	$X = 0.8V\cos 30$ $Y = -0.8V\sin 30 + g(0.8)^2/2$ $(3.2 - 0.4V)/(0.8V\cos 30) = \tan 60$ $V = 2$ OR working perpendicular to the wall $a = g\cos 60$ $0 = 0.8V - g\cos 60(0.8)^2/2$ $V = 2$	B1 B1 M1 A1 B1* DB1* M1 A1	4	Horizontal displacement Vertical displacement Or $0.8V\cos 30 / (3.2 - 0.4V) = \tan 30$ Uses $s = 0$
7	(i)	$R = 0.2g - 0.4 \times 2\sin 30$ $F_R = 0.4 \times 2\cos 30$ $\mu = 0.433$ $0.2g = 0.4 t\sin 30$ $t = 10$	M1 M1 A1 M1 A1	5	Resolving vertically, 3 terms Use $F = \mu R$ Solves for t when $R = 0$
	(ii)	$0.2\text{d}v/\text{d}t =$ $0.4t\cos 30 - 0.433(0.2g - 0.4 t\sin 30)$ $\text{d}v/\text{d}t = 2.165t - 4.33(0)$ AG	M1 A1 A1	3	Newton's Second Law with both forces $f(t)$

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(iii)	$\int dv = \int (2.165t - 4.33) dt$	M1		Attempts to integrate
	$v = 2.165t^2/2 - 4.33t (+ c)$	A1		
	$v = 0, t = 2 \quad [c = 4.33]$	M1		Must use $t = 2$
	$v = 2.165 \times 10^2/2 - 4.33 \times 10 + 4.33$ $v = 69.3$	A1	4	Puts t (i) in integrand

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	(ii)	$0.17mg = 0.8(6\cos 20)$ $m = 2.66 \text{ kg}$	M1 A1 ^{ft} A1	3	Moments about B ft candidate value (0.17) Accept 2.65
2	(i)	Vert comp vel = $V\sin 60 - 1.5g$ $V\cos 60 = V\sin 60 - 1.5g$ $V = 41(.0)$	B1 M1 A1	3	$(V\sin 60 - 1.5g)/(V\cos 60) = \tan 45$
	(ii)	$X [= (41\cos 60) \times 1.5] = 30.7 \text{ m}$ $Y [= (41\sin 60) \times 1.5 - g1.5^2/2] = 42(.0) \text{ m}$	B1 ^{ft} B1 ^{ft}	2	ft candidate value $(41.0) \times 0.75$ Allow 30.8 ft candidate value $(41.0) \times 1.3 - 11.25$
3	(i)	$20x/0.4 = 0.5g\sin 30$ $x = 0.05 \text{ m}$	M1 A1	2	$\lambda_{\text{ext/nat length}} = \text{comp weight}$
	(ii)	$20(0.05)^2/(2 \times 0.4) + 0.5 \times 5^2/2 =$ $20e^2/(2 \times 0.4) + 0.5 \times 2^2/2$ $-0.5(e-0.05)g\sin 30$ $2.5e^2 - 2.5e - 5.1875 = 0$ $e = 0.508$	M1 A1 M1 A1	4	KE/PE/EE balance with 2 KE and 2 EE terms All terms without e correct Creates /attempts to solve a 3 term quadratic equation
4	(i)	$-1.5 = 29\sin 30t - gt^2/2$ $t = 3$ AG	M1 A1	2	$5t^2 - 14.5t - 1.5 = 0$
	(ii)	$y' = 29\sin 30 - 3g$ $v^2 = (29\cos 30)^2 + 15.5^2$ or $v^2 = 29^2 + 2g \times 1.5$ or $\tan \theta = (3g - 29\sin 30)/(29\cos 30)$ $v = 29.5 \text{ ms}^{-1}$ $\theta = 31.7^\circ$ with the horizontal	B1 M1 A1 A1	4	15.5 ms^{-1} down, landing 58.3° to the vertical
5	(i)	C of M is 0.1 m from AB $0.05T = 20(0.25 - 0.1)$ $T = 60 \text{ N}$ AG	B1 M1 A1	3	Moments about D

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	(ii)	$60 = 48e/0.6$ $e = 0.75 \text{ m}$ $2.5v^2/2 + 48(0.75)^2/(2 \times 0.6) =$ $2.5g(0.75 + 0.6)$ $v = 3 \text{ ms}^{-1}$	M1 A1 M1 A1 A1	5	Toppling $T = \lambda_{\text{ext}}/\text{nat length}$ KE/EE/PE balance
6	(i)	$60dv/dt = 150 - 12v$ $5dv/dt = 12.5 - v$ AG	M1 A1	2	Newton's Second Law, 2 force terms
	(ii)	$\int 5dv/(12.5 - v) = \int dt$ $-5\ln(12.5 - v) = t (+ c)$ $t = 0, v = 11.5$ hence $c = 0$ $v = 12.5 - e^{-0.2t}$ AG	M1 A1 M1 A1	4	Separates variables and attempts to integrate Explicit after integration (or limits)
	(iii)	$x = \int (12.5 - e^{-0.2t}) dt$ $x = 12.5t - e^{-0.2t}/(-0.2) (+ c)$ $t = 0, x = 0$ so $c = -5$ $x = 12.5t + 5e^{-0.2t} - 5$	B1 M1 A1	3	Award if $+c$ omitted Or limits
7	(i)	$T\cos\theta = 0.7g$ $T = 25 \text{ N}$ $25 \times 0.48/0.5 \geq 0.7 \omega^2 \times 0.48$ $\omega \leq 8.45 \text{ rad s}^{-1}$	M1 A1 M1 A1	4	$\cos\theta = 0.14/0.5$ Uses accn. $= \omega^2 r$ Accept $<$
	(ii)	$T\cos\theta = 0.7g - 1.4$ $T\sin\theta = 0.7 \times 2.5^2/(0.5\sin\theta)$ $T\sin^2\theta = 8.75$ $T\sin^2\theta/T\cos\theta = 8.75/5.6$ $1 - \cos^2\theta = 1.5625\cos\theta$ $\cos\theta = 0.487(746..)$ $T = 11.5 \text{ N}$ $h = 0.244$	B1 M1 A1 M1 A1 A1 A1	7	$T\cos\theta = 5.6$ $T\sin^2\theta + T\cos^2\theta = 8.75 + 5.6^2/T$ $T^2 = 8.75T + 5.6^2$ $\theta = 60.8^\circ$ $T = 11.5 \text{ N}$