

MARK SCHEME for the May/June 2012 question paper
for the guidance of teachers

9709 MATHEMATICS

9709/51

Paper 5, maximum raw mark 50

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- Note: B2 or A2 means that the candidate can earn 2 or 0.
B2/1/0 means that the candidate can earn anything from 0 to 2.

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CAO	Correct Answer Only (emphasising that no “follow through” from a previous error is allowed)
CWO	Correct Working Only – often written by a ‘fortuitous’ answer
ISW	Ignore Subsequent Working
MR	Misread
PA	Premature Approximation (resulting in basically correct work that is insufficiently accurate)
SOS	See Other Solution (the candidate makes a better attempt at the same question)
SR	Special Ruling (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular circumstance)

Penalties

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1	$0.6 = 1.2 \omega$	M1	Uses $v = r \omega$
	$\omega = 0.5 \text{ rads}^{-1}$	A1 [2]	[2]
2 (i)	$(9 + 11)OG =$ $+/-[9 \times 0.7/(\pi/2) - 11 \times (2 \times 0.7)/3 \pi/2]$	M1 A1	Table of value idea with signs either way round.
	$OG = 0.0371 \text{ m}$ AG	A1 [3]	Accept –ve answer
(ii)	$\tan \theta = 0.0371(36..)/0.7$	M1	
	$\theta = 3.0^\circ$	A1	
	Lamina	B1 [3]	[6]
3 (i)	$F + F \cos 60 = mg$	M1	Resolves vertically for S
	$F = 10m/1.5$	A1	May be implied by later work
	$F \sin 60 = mv^2/0.6$	M1	$10m/1.5 = mv^2/0.6$
	$v = 1.86 \text{ ms}^{-1}$	A1 [4]	
(ii)	$F \cos 60 = 10m$	B1	May be implied by later work
	$F \sin 60 = m \omega^2/0.6$	M1	
	$\omega = 5.37 \text{ rads}^{-1}$	A1 [3]	[7]
4 (i)	$EE = 21(\sqrt{1.2^2 + 1.6^2} - 1.2)^2/(2 \times 1.2)$	B1	Use of EE formula (= 5.6 J)
	$m12^2/2 = mg \times 1.6 +$ $2 \times 21(\sqrt{1.2^2 + 1.6^2} - 1.2)^2/(2 \times 1.2)$	M1 A1	KE/EE/PE conservation
	$m = 0.2$	A1 [4]	
(ii)	$T = 21(\sqrt{1.2^2 + 0.5^2} - 1.2)/1.2$	B1	
	$ma = 2 \times 21(\sqrt{1.2^2 + 0.5^2} - 1.2)/1.2 \times \frac{0.5}{1.3}$ $- mg$	M1 A1	Newton's Second Law with component of T or reversed signs
	$a = (-)3.27 \text{ ms}^{-2}$	A1 [4]	[8]

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7 (i)	$x = (15\cos 41)t$	B1	
	$y = (15\sin 41)t - gt^2/2$	B1	
	$y = (15\sin 41)x/(15\cos 41) - 5 [x/(15\cos 41)]^2$	M1	
	$y = 0.869x - 0.0390x^2$	A1 [4]	$y = 0.86928..x - 0.03901..x^2$
(ii)	$H = 0.869 \times 1.5 - 0.039 \times 1.5^2 + 1.6$	M1	Must add height of O
	$H = 2.82 \text{ m}$	A1	
	$0.039x^2 - 0.869x - 1.6 = 0$	M1	Uses $y = -1.6$ and tries to solve
	$D = 23.99 - 1.5$	DM1	Solve a 3 term quadratic equation and minus 1.5
	$D = 22.5 \text{ m}$	A1 [5]	Accept 22.4 [9]

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1	$0.6v dv/dx = 0.3x$	M1	Newton's Second Law with $a = v dv/dx$
	$0.6v^2/2 = 0.3x^2/2 (+ c)$	A1	From $\int 0.6v dv = \int 0.3x dx$
	$[x^2/2]_0^8 = [v^2]_2^v$	M1	Uses limits of finds constant
	$v = 6 \text{ ms}^{-1}$	A1 [4]	[4]
2 (i)	$12 \times 3 \times 0.2/8 - 8 \times 0.2/2 = (8 + 12)d$	M1	Table of values or moment equation
	$d (= 0.1/20) = 0.005 \text{ m}$ AG	A1	$0.9 - 0.8 = 20d$
		A1 [3]	Accept $d = -0.005$
(ii)		M1	Moments about point of contact
	$F \times (2 \times 0.2) = (12 + 8) \times 0.005$	A1	
	$F = 0.25$	A1	
	OR		
	$F \times (2 \times 0.2) + 8 \times 0.1 = 12 \times 0.075$	M1	Moments about point of contact
	$F = 0.25$	A1 [3]	[6]
3 (i)	Length = $\sqrt{1.2^2 + 0.5^2} = 1.3$	B1	Pythagoras on $\frac{1}{2}$ string
	$2 \times [14.3 \times (1.3 - 1.1)/1.1] \times [0.5/1.3]$ $= mg$	M1* D* M1	Uses $T = \lambda x/L$ Component(s) T equated to weight
	$m = 0.2$	A1 [4]	
(ii)		M1	KE/EE/PE balance (4 terms)
	$0.2v^2/2 = 0.2g \times 0.5 -$ $[14.3 \times 0.2^2/(2 \times 1.1) -$ $14.3 \times 0.1^2/(2 \times 1.1)] \times 2$	A1 ✓	✓ candidate's value of m from (i)
	$v = 2.47 \text{ ms}^{-1}$	A1 [3]	[7]

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4 (i) $0.25dv/dt = -3t$ $v = -12t^2/2 (+ c)$ $0 = 12 \times 3^2/2 + c$ Initial speed = 54 ms^{-1}	M1	Newton's Second Law, – sign essential
	A1	Accept uncanceled form
	M1	Appropriate use of $v = 0, t = 3$
	A1 [4]	Goes beyond $c = 54$
(ii) $\int dx = \int (54 - 6t^2) dt$ $x = [54t - 6t^3/3]_0^3$ $x = 108 \text{ m}$	M1	Separates variables, integrates v
	A1✓	✓ candidates value [v in (i)]
	A1 [3]	[7]
5 (i) $0 = (25\sin 70)t - gt^2/2$ $t = 4.7(0) \text{ s}$ $OP = (25\cos 70 \times 4.7) = 40.2 \text{ m}$ OR $OP = 25^2 \sin(2 \times 70)/g$ $OP = 40.2 \text{ m}$ $t[= 40.2/(25\cos 70)] = 4.7 \text{ s}$ OR $0 = 25\sin 70 - 10t$ $t = 2.349, 2t = 4.70$ $OP = (25\cos 70 \times 4.7) = 40.2 \text{ m}$ OR $0 = x \tan 70 - gx^2/(2 \times 25^2 \cos^2 70)$ $x = 40.2 \text{ m}$ $t = 4.70$	M1	Uses $0 = ut - gt^2/2$
	A1	
	A1	
	M1	Uses $R = v^2 \sin 2\alpha / g$
	A1	
	A1	
	M1	Find time to greatest height and double it
	A1	
	A1	
	M1	Use trajectory equation
	A1	
	A1 [3]	
(ii) $t[= 17.1/(25\cos 70)] = 2 \text{ s}$ $-v = v - g \times 2$ $V^2 = 10^2 + (25\cos 70)^2$ $V = 13.2 \text{ ms}^{-1}$	B1	Finds time of flight
	B1ft	Finds vertical component of speed
	M1	For squaring components
	A1 [4]	[7]

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6 (i) $\frac{2(1)\sin(\pi/2)}{3\pi/2} \times \pi(1^2)/2 = \frac{2r\sin(\pi/2)}{3\pi/2} \times \pi(r^2)/2 + OG(\pi/2 - \pi r^2/2)$ $OG = 4\pi(1 - r^3)/3(1 - r^2)$ $OG = 4(1 + r + r^2)/3\pi(1 + r)$ AG	M1	Uses table of values or moment equation
	A1	Correct moment equation
	A1	
(ii) $r = 4(1 + r + r^2)/3\pi(1 + r)$ $(3\pi - 4)r^2 + (3\pi - 4)r - 4 = 0$ $r = 0.494$ AG OR $OG = 0.494$ if G on arc $OG = 4(1 + 0.494 + 0.494^2)/3\pi(1 + 0.494)$ $= 0.4937$ AG	A1 [4]	Must use $1 - r$ as a factor of $1 - r^3$ and $1 - r^2$
	M1*	Sets $r = \text{answer(i)}$
	D* M1	Sets up and starts solving quadratic equation
	A1 [3]	
	M1*	
(iii) $\tan \theta = 0.494/1$ $\theta = 26.3^\circ$	D* M1	Substitutes AG in OG expression
	A1	Shows value rounding to 0.494
7 (i) $T = 0.5 \text{ g}$ $T = 0.8 \times 6.25^2 \times r$ $r = 0.16 \text{ m}$ $v = 1 \text{ ms}^{-1}$	M1	
	A1	
	B1	$T = 5$
	[4]	
(ii) $T \cos 60 = 0.5 \text{ g}$ $r = 0.32 \text{ m}$ $T \sin 60 = 0.5 \times 6.25^2 \times R$ $R = 0.443(40) \text{ m}$ $L = 0.32 + 0.443(4)/\sin 60$ $L = 0.832 \text{ m}$	B1	$T = 10$
	B1	$\frac{1}{2} (2 \times \text{candidate's value of } r)$
	M1	Newton's Second Law with component of T
	A1	
	M1	
	A1 [6]	
		[9]
		[10]

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	$OY = (25\sin 30) \times 2 - g \times 2^2/2$	B1	5
	$OP^2 = 43.3^2 + 5^2$	M1	
	$OP = 43.6 \text{ m}$	A1 [4]	[4]
2	$OG = (0.7\sin 1)/1$	B1	0.589
		M1	Moments about <i>A</i> . Accept uncanceled form
	$+/-3 \times (0.589 - 0.7\cos 1) = F \times (0.7\sin 1) \times 2$	A1 ∇	∇ candidate's value of 0.589
	$F = 0.537 \text{ N}$	A1 [4]	[4]
3 (i)	$0.2v dv/dx = -0.4x$	M1	Newton's Second Law, – sign essential
	$v^2/2 = -2x^2/2 (+c)$	A1	Accept uncanceled form
	$0 = -2 \times 2.5^2/2 + c \rightarrow c = 6.25$	M1	
	$KE = 0.2 \times 6.25 = 1.25 \text{ J}$	A1 [4]	$v = 3.54 \text{ ms}^{-1}$
(ii)	$2^2/2 = -2x^2/2 + 6.25$	M1	$v = 2$ in accurate integral attempt at limits or finding arbitrary constant e.g. in (i)
	$x = 2.06$	A1 [2]	[6]
4 (i)	Vertical force = $10m$	B1	May be implied
	$10m = mv^2/0.4$	M1	Newton's Second Law radially
	$v = 2 \text{ ms}^{-1}$	A1 [3]	
(ii)	$T = 13 \times (0.4 - 0.25)/0.25$	B1	$T = 7.8 \text{ N}$
	$m \times 8^2 \times 0.4 = 7.8 + 10m$	M1	Newton's Second Law radially, 2 horizontal forces
	$m = 0.5$	A1 [3]	$m(25.6 - 10) = 7.8$
(iii)	$7.8 = m \times \omega^2 \times 0.4$	M1	Newton's Second Law radially, no horizontal reaction
	$\omega = 6.24$	A1 [2]	$(\sqrt{39})$ [8]

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5 (i) $45e/1.5 = 45(1 - e)/1.5 \pm 0.6g\sin 30$ $AP (= 0.55 + 1.5) = 2.05 \text{ m}$	M1	Uses $T = 45e/1.5$
	A1	Note either portion may be e
	A1 [3]	
(ii) $45 \times 1^2/(2 \times 1.5) =$ $45 \times 0.55^2/(2 \times 1.5)$ $+ 45 \times 0.45^2/(2 \times 1.5)$ $+ 0.6g \times 0.45\sin 30 + 0.6v^2/2$ $v = 4.5 \text{ ms}^{-1}$	M1	KE/EE/PE energy conservation
	A1	3 correct EE terms
	A1	Correct equation
	A1 [4]	
(iii) $45 \times 1^2/(2 \times 1.5)$ $= 45(1.6 - 1.5)^2/(2 \times 1.5)$ $+ 45(4 - 1.6 - 1.5)^2/(2 \times 1.5)$ $+ 0.6 \times 10(2.5 - 1.6)\sin 30$	M1	EE/PE conservation
	A1 [2]	Total energy = 15 [9]
6 (i) $(ah/2 + 0.5a)x$ $= (ah/2)(-h/3) + (0.5a)(0.5/2)$ $0.5a(1 + h)x = 0.5a(0.25 - h^2/3)$ $x = (3 - 4h^2)/(12 + 12h)$ AG	M1	Table of moments idea
	A1	Correct sum of parts
	M1	Must include cancelling of a
	A1 [4]	
(ii) $3 - 4h^2 = 0$ $h = 0.866$	M1	Uses $x = 0$
	A1 [2]	
(iii) $\tan \theta = x/(a/2) = (a/2)/h$ $(2/18)/(a/2) = (a/2)/0.5$ $a = 0.471$	M1	Correct trigonometry
	DM1	Ratios accurately substituted
	A1 [3]	[9]

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7 (i) $\theta = 31(.0)^\circ$ $0.017 = 10/[2(v\cos 31)]^2$ $v = 20$	AG	B1	M1	A1	[3]	$\theta = \tan^{-1}0.6$
(ii) $v^2 = (20\cos 31)^2 + [(20\sin 31)^2 - 2g \times 5.2]$ $v = 17.2 \text{ ms}^{-1}$ $0.017x^2 - 0.6x + 5.2 = 0$ $x = 20$ $dy/dx = 0.6 - 0.017(2x)$ $\tan \alpha = 0.6 - 0.017(2 \times 20)$ $\alpha = 4.6^\circ$ below the horizontal		M1	A1	M1		Accept $v^2 = 20^2 - 2g \times 5.2$
				A1		
			M1			Solves 3 term quadratic equation
			A1			Ignore smaller root if shown
		M1				
		A1				
		A1	[7]			4.57°
OR						
7 (i) $\theta = 31(.0)^\circ$ $0.017 = 10/[2(v\cos 31)]^2$ $v = 20$	AG	B1	M1	A1	[3]	$\theta = \tan^{-1}0.6$
(ii) $5.2 = 20\sin 31 - 10t^2/2$ $t = 1.17$ ($t = 1.166..$) $v_{\text{vert}} = (-)1.37(2)$ $v^2 = 17.1(5)^2 + 1.37(2)^2$ $v = 17.2 \text{ ms}^{-1}$ $\tan \alpha = 1.37(2)/17.1(5)$ $\alpha = 4.6^\circ$ below the horizontal		M1	A1	A1		Sets up and solves a 3 term quadratic equation
				A1		Ignore smaller root if shown
				A1		From $v = 20\sin 31 - 10t$
		M1				Or uses method in (ii) above
						17.1(5) is horizontal velocity component
		A1				
		M1				
		A1	[7]			4.57°
						[10]