

MARK SCHEME for the May/June 2010 question paper
for the guidance of teachers

9709 MATHEMATICS

9709/51

Paper 51, maximum raw mark 50

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	GCE AS/A LEVEL – May/June 2010	9709	51

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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.
- The symbol $\surd$ implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only. A and B marks are not given for fortuitously “correct” answers or results obtained from incorrect working.
- Note: B2 or A2 means that the candidate can earn 2 or 0.
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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

MR –1	A penalty of MR –1 is deducted from A or B marks when the data of a question or part question are genuinely misread and the object and difficulty of the question remain unaltered. In this case all A and B marks then become “follow through $\sqrt{}$ ” marks. MR is not applied when the candidate misreads his own figures – this is regarded as an error in accuracy. An MR –2 penalty may be applied in particular cases if agreed at the coordination meeting.
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1 c of m of arc = $20\sin(\pi/2)/(\pi/2)$ $(2 + 0.9)\bar{x} = 2 \times 20\sin(\pi/2)/(\pi/2)$ Distance is 8.78cm	B1 M1 A1 A1 [4]	For attempting to take moments about the diameter
2 (i) $\tan 35^\circ = r/7.5$ $r = 5.25$	M1 A1ft A1 [3]	For using the idea that the c.m. is vertically above the lowest point of contact ft using their c of m from the base
(ii) [$\mu mg \cos 35^\circ > mg \sin 35^\circ$] $\mu > \tan 35^\circ \rightarrow$ Coefficient is greater than 0.7	M1 A1 [2]	For using 'no sliding $\rightarrow \mu R > \text{weight component}$ ' Do not allow $\mu \geq 0.7$ AG
3 (i) $mg = T \cos \theta$ $ma = T \sin \theta$ $\tan \theta = a/g = 0.75$ $T = 0.24 \times 10 / \cos \theta = 3$	B1 B1 B1 B1 [4]	SR B1 not B2 for $\tan \theta = v^2/gr$ or a/g used AG For using $T \cos \theta = mg$ to find T
(ii) [$v^2 = 7.5 \times 2 \sin \theta$] Speed is 3 ms^{-1}	M1 A1 [2]	For using $v^2 = ar$ to find v
4 Weight split is 9N:6N For lamina $9 \times 0.75 + 6 \times 0.5$ $= T \times 1.5 \sin 30^\circ$ Tension is 13N Alternatively $[(1.5^2 + \frac{1}{2} 1.5 \times 2) \bar{x} = 1.5^2 \times 0.75 + \frac{1}{2} 1.5 \times 2 \times 0.5]$ $\bar{x} = 0.65$ $15 \times 0.65 = T \times 1.5 \sin 30^\circ$ Tension is 13N	B1 M1 A1ft A1 A1 [5] M1 A1 M1 A1ft A1 [5]	For taking moments about A For using $A\bar{x} = A_1x_1 + A_2x_2$ For taking moments about A

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5	(i) $7 = 16\tan\theta - 10 \times 16^2 / (2 \times 20^2) \cos^2\theta$ $[7 = 16T - 3.2(1 + T^2)]$ $3.2T^2 - 16T + 10.2 = 0$ $T = \frac{3}{4}, 17/4$	B1 M1 A1 A1 [4]	For using $\cos\theta = 1/\sec\theta$ and the given identity to obtain a quadratic in $T(\tan\theta)$ AEF AG
	(ii) $[x = \tan\theta \cos^2\theta / 0.0125 \text{ or } x = 20^2 \sin 2\theta / g]$ For $\tan\theta = 0.75$, distance is 38.4 m For $\tan\theta = 4.25$, distance is 17.8 m	M1 A1 A1 [3]	For solving $y = 0$ for x or for using $R = V^2 \sin 2\theta / g$
	(iii) For sketching two parabolic arcs which intersect once, both starting at the origin, each with $y \geq 0$ throughout, and each returning to the x-axis, the arc for which the angle of projection is smaller having the greater range. The ranges appear significantly greater than x at the intersection, and slightly greater, respectively.	B1 B1 [2]	
6	(i) $[0.35g = 2T\{0.7 / (2.4^2 + 0.7^2)^{1/2}\}]$ Tension is 6.25N $[6.25 = \lambda \times \frac{1}{4}]$ Modulus is 25N	M1 A1 M1 A1 [4]	For resolving forces on P vertically For using $T = \lambda x / L$ AG
	(ii) EE on release $= 25 \times 2^2 / (2 \times 4)$ EE when P is at M $= 25 \times 0.8^2 / (2 \times 4)$ $25 \times 2^2 / (2 \times 4) = 0.35g \times 1.8 + 25 \times 0.8^2 / (2 \times 4) + \frac{1}{2} 0.35v^2$ Speed is 4.90 ms^{-1}	M1 A1 A1 M1 A1 A1 [6]	For using $EE = \lambda x^2 / 2L$ For using $EE \text{ on release} = mgh + EE$ when P is at M $+ \frac{1}{2} mv^2$
7	(i) $[0.25v(dv/dx) = -(5 - x)]$ $[\int v dv = 4 \int (x - 5) dx]$ $v^2/2 = 4(x - 5)^2/2 (+ A)$ $v^2 = 4(x - 5)^2$ Selects correct square root to obtain $v = 10 - 2x$	B1 M1 A1 M1 A1 A1 [6]	For using Newton's second law and $a = v(dv/dx)$ For separating variables and attempting to integrate For using $v(0) = 10$ Any correct expression in x AG
	(ii) $[\int \frac{dx}{10 - 2x} = \int dt]$ $-\frac{1}{2} \ln(10 - 2x) = t(-\frac{1}{2} \ln B)$ $B = 10$ (or equivalent) $x = 5(1 - e^{-2t})$ $0 < e^{-2t} < 1$ for all $t \rightarrow x < 5$ for all t	M1 A1 A1 B1ft B1 [5]	For using $v = dx/dt$ and separating variables ft $x = (B/2)(1 - e^{-2t})$ AG

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2	$X_G = 20/4$ $8 \times 3 = (20/4)mg$ $m = 0.48 \text{ kg}$	B1 M1 A1 A1 [4]	5 Attempt at moments about P
3 (i)	$15 = 40\tan\theta - g40^2/(2 \times 40^2 \cos^2\theta)$ $15 = 40\tan\theta - 5\sec^2\theta$ $\tan^2\theta - 8\tan\theta + 4 = 0$	AG M1 M1 A1 [3]	Substitutes in projectile equation Uses $\sec^2\theta = 1 + \tan^2\theta$
(ii)	$\theta = \tan^{-1}(4 \pm 2\sqrt{3})$ $\theta = 28.2^\circ \text{ or } 82.4^\circ$ $R = 40^2 \sin(2 \times 28.2^\circ)/g \text{ or}$ $R = 40^2 \sin(2 \times 82.4^\circ)/g$ $R = 133 \text{ or } R = 41.9 \text{ (or } 42.0)$ Difference = 91.1 m	M1 A1 M1 A1 A1 [5]	Solves quadratic equation for θ Valid formula for one range $0 = R \tan 28.2^\circ - gR^2/(2 \times 40^2 \cos 28.2^\circ)$ or $0 = R \tan 82.4^\circ - gR^2/(2 \times 40^2 \cos 82.4^\circ)$ Using exact angles. Allow ± 0.2
4 (i)	$d = 2 \times 0.3 \sin(\pi/2)/(3\pi/2)$ $T(0.6 \cos 30^\circ) =$ $0.4g(0.3 \sin 30^\circ + 0.1273 \cos 30^\circ)$ $T = 2 \text{ N}$	AG B1 M1 A1 A1 [4]	$d = 0.1273$ 2.003...
(ii)	$R = \sqrt{(2^2 + (0.4g)^2)} \text{ or } \tan\theta = 2/(0.4g)$ $R = 4.47 \text{ N}$ $\theta = 26.6^\circ \text{ (with vertical)}$	M1 A1 A1 [3]	Either (or $\tan\alpha = 0.4g/2$ with horizontal) $\alpha = 63.4^\circ \text{ (with horizontal)}$
5 (i)	$3T \cos 30^\circ - T \cos 30^\circ = 0.4g$ $T = 2.31$ $0.4 \times 6^2/r = 4T \sin 30^\circ$ $r = 3.12$	M1 A1 M1 A1 [4]	Resolves vertically, 3 terms Newton's 2 nd Law horizontally
(ii)	$T_{PB} = 0$ $T \cos 30^\circ = 0.4g \text{ (} T = 4.62)$ $0.4v^2/3.12 = 4T \sin 30^\circ$ $v = 4.24 \text{ ms}^{-1}$	B1 M1 M1 A1 [4]	Resolves vertically, 2 terms Newton's 2 nd Law horizontally

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6	(i) $0.5v dv/dx = -3v^{1/2}$ $\int v^{1/2} dv = -\int 6dx$ $v^{3/2}/(3/2) = -6x (+c)$ $x = 0, v = 9$ hence $c = 18$ $v^{3/2} = 3(18 - 6x)/2$ $v = (27 - 9x)^{2/3}$	M1 M1 A1 M1 A1 [5]	Newton's 2 nd Law with $a = v dv/dx$ Separates variables and integrates Or uses limits
	AG		
7	(ii) $dx/dt = (27 - 9x)^{2/3}$ $\int (27 - 9x)^{-2/3} dx = \int dt$ $(27 - 9x)^{1/3} / -3 = t (+c)$ $t = 0, x = 0$ hence $c = -1$ $t = 0.5, x = 2.625$	M1 A1ft M1 A1 [4]	$0.5dv/dt = -3v^{1/2}$ $\int v^{-1/2} dv = -\int 6dt$ $v^{1/2} = -3t + c$ $t = 0, v = 9$ hence $c = 3$ and $t = 0.5$, giving $v = 2.25$ $v = 2.25, x = 2.625$
7	(i) $0.4v^2/2 + 24x^2/(2 \times 3)$ $0.4g(3 + x) + 0.4 \times 2^2/2$ $v^2 = 64 + 20x - 20x^2$	AG M1 A2 A1 [4]	PE, EE, KE terms –1 each error to zero
7	(ii) $2v dv/dx = 20 - 40x = 0$ $x = 0.5$ $v = 8.31$	M1 A1ft A1 [3]	$0.4g = 24x/3$
7	(iii) $20x^2 - 20x - 64 = 0$ $x = 2.357$ $T = 24 \times 2.357/3$ $T = 18.9$	M1 A1 M1 A1 [4]	And attempts to solve