1	c of m of arc = $20\sin(\pi/2)/(\pi/2)$ $(2 + 0.9)\,\bar{x} = 2\times20\sin(\pi/2)/(\pi/2)$ Distance is 8.78cm	B1 M1 A1 A1 [4]	 For attempting to take moments about the diameter
2	**(i)** $\tan35° = r/7.5$ $r = 5.25$	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) [$\mu mg\cos35° > mg\sin35°$] $\mu > \tan35° \rightarrow$ Coefficient is greater than 0.7	M1 A1 [2]	For using 'no sliding $\rightarrow \mu R >$ weight component' Do not allow $\mu \geqslant 0.7$ 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 $3ms^{-1}$	M1 A1 [2]	For using $v^2 = ar$ to find v
4	Weight split is 9N:6N For lamina $9 \times 0.75 + 6 \times 0.5$ $= T \times 1.5\sin30°$ Tension is 13N **Alternatively** [$(1.5^2 + \frac{1}{2}\,1.5\times2)\ \bar{x} = 1.5^2\times0.75 + \frac{1}{2}\,1.5\times2\times0.5$] $\bar{x} = 0.65$ $15 \times 0.65 = T \times 1.5\sin30°$ 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

5	**(i)**	$7 = 16\tan\theta - 10\times16^2/(2\times20^2)\cos^2\theta$ $[7 = 16T - 3.2(1 + T^2)]$ $3.2T^2 - 16T + 10.2 = 0$ $T = ¾, 17/4$	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)	$[x = \tan\theta\cos^2\theta/0.0125$ or $x = 20^2\sin2\theta/g]$ 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 $R = V^2\sin2\theta/g$
	(iii)	For sketching two parabolic arcs which intersect once, both starting at the origin, each with $y \geqslant 0$ 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 $[6.25 = \lambda \times ¼]$ 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 $= 25\times2^2/(2\times4)$ EE when P is at M $= 25\times0.8^2/(2\times4)$ $25\times2^2/(2\times4) = 0.35g\times1.8 + 25\times0.8^2/(2\times4) + ½\ 0.35v^2$ Speed is $4.90ms^{-1}$	M1 A1 A1 M1 A1 A1 [6]	For using $EE = \lambda x^2/2L$ For using EE on release = mgh + EE when P is at M + $\frac{1}{2}mv^2$
7	**(i)**	$[0.25v(dv/dx) = -(5 - x)]$ $[\int vdv = 4\int(x - 5)dx]$ $v^2/2 = 4(x - 5)^2/2$ (+ 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