1	$v_{down} = 2g$ $\tan\theta = 2g/12$ $\theta = 59.0°$	B1 M1 A1 [3]	$\tan\alpha = 12/2g$
2	$X_G = 20/4$ $8 \times 3 = (20/4)mg$ $m = 0.48$ kg	B1 M1 A1 A1 [4]	5 Attempt at moments about P
3	**(i)** $15 = 40\tan\theta - g40^2/(2\times40^2\cos^2\theta)$ $15 = 40\tan\theta - 5\sec^2\theta$ $\tan^2\theta - 8\tan\theta + 4 = 0$ AG	M1 M1 A1 [3]	Substitutes in projectile equation Uses $\sec^2\theta = 1 + \tan^2\theta$
	(ii) $\theta = \tan^{-1}(4 +/- 2\sqrt{3})$ $\theta = 28.2°$ or $82.4°$ $R = 40^2\sin(2\times28.2°)/g$ or $R = 40^2\sin(2\times82.4°)/g$ $R = 133$ or $R = 41.9$ (or 42.0) Difference = 91.1 m	M1 A1 M1 A1 A1 [5]	Solves quadratic equation for θ Valid formula for one range $0 = R\tan28.2° - gR^2/(2\times40^2\cos28.2°)$ or $0 = r\tan82.4° - gr^2/(2\times40^2\cos82.4°)$ Using exact angles. Allow +/– 0.2
4	**(i)** $d = 2\times0.3\sin(\pi/2)/(3\pi/2)$ $T(0.6\cos30) =$ $0.4g(0.3\sin30° + 0.1273\cos30°)$ $T = 2$ N AG	B1 M1 A1 A1 [4]	$d = 0.1273$ 2.003…
	(ii) $R = \sqrt{(2^2 + (0.4g)^2)}$ or $\tan\theta = 2/(0.4g)$ $R = 4.47$ N $\theta = 26.6°$ (with vertical)	M1 A1 A1 [3]	Either (or $\tan\alpha = 0.4g/2$ with horizontal) $\alpha = 63.4°$ (with horizontal)
5	**(i)** $3T\cos30° - T\cos30° = 0.4g$ $T = 2.31$ $0.4\times6^2/r = 4T\sin30°$ $r = 3.12$	M1 A1 M1 A1 [4]	Resolves vertically, 3 terms Newton's 2nd Law horizontally
	(ii) $T_{PB} = 0$ $T\cos30° = 0.4g$ ($T = 4.62$) $0.4v^2/3.12 = T\sin30°$ $v = 4.24$ ms^{-1}	B1 M1 M1 A1 [4]	Resolves vertically, 2 terms Newton's 2nd Law horizontally

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 $c = 18$ $v^{3/2} = 3(18 - 6x)/2$ $v = (27 - 9x)^{2/3}$ AG	M1 M1 A1 M1 A1 [5]	Newton's 2nd Law with $a = v\,dv/dx$ Separates variables and integrates Or uses limits
	(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)**	$0.4v^2/2 + 24x^2/(2\times3)$ $0.4g(3 + x) + 0.4\times2^2/2$ $v^2 = 64 + 20x - 20x^2$ AG	M1 A2 A1 [4]	PE, EE, KE terms –1 each error to zero
	(ii)	$2v\,dv/dx = 20 - 40x = 0$ $x = 0.5$ $v = 8.31$	M1 A1ft A1 [3]	$0.4g = 24x/3$
	(iii)	$20x^2 - 20x - 64 = 0$ $x = 2.357$ $T = 24\times2.357/3$ $T = 18.9$	M1 A1 M1 A1 [4]	And attempts to solve