1	(i)	$T\sin30° = 0.4g$ $T = 8N$	M1 A1 [2]	Resolves vertically
	(ii)	$T\cos30° = 0.4v^2 / 0.2$ $(= 0.4\omega^2 \times 0.2)$ $v = 1.86$ ms^{-1}	M1 A1ft [2]	Newton's Second Law radially ft only on T from part (i)
2	(i)	$20 = gt^2 / 2$ $(t = 2)$ $x = 15 \times 2$ $x = 30$	M1 DM1 A1 [3]	$y = -gx^2 /(2 \times 15^2)$ use of trajectory equation $-20 = -10x^2 / (2 \times 15^2)$
	(ii)	$v = (g \times 2) = 20$ $v = \sqrt{(15^2 + 20^2)}$ $v = 25$	B1 M1 A1 [3]	
3	(i)	 $F \times 0.4\sin20° = 12 \times (0.4 / 2)\cos20°$ $F = 16.48$ AG	M1 A1 A1 [3]	Moments about O
	(ii)	$R = -16.48 + 12 + W$ $-16.48 + 12 + W = 0$ $W = 4.48$	B1 M1 A1 [3]	Equates forces vertically Works with R = 0
4	(i)	$e = \sqrt{(0.6^2 + 0.32^2)} - 0.4$ $(= 0.28)$ $0.3g \times 0.32 = 2[\lambda (0.28^2 - 0.2^2)] / (2 \times 0.4)$ $\lambda = 10$	B1 M1, A1 A1 [4]	Extension of half string = 0.28 m PE loss = EE gain
	(ii)	$e = \sqrt{(0.6^2 + 0.25^2)} - 0.4$ $0.3g \times 0.25 = 0.3v^2 / 2 +$ $2[10(0.25^2 - 0.2^2) / (2 \times 0.4)]$ $v = 1.12$	B1 M1 A1ft A1 [4]	Extension of half string = 0.25 m PE loss = KE gain + EE gain N.B. 0.25 is extension of half string ft on candidates λ only
5	(i)	$T = 6e / 0.3$ $0.2 \times 5^2 (0.3 + e) = 6e / 0.3$ $e = 0.1$	B1 M1, A1 A1 [4]	Newton's Second Law radially
	(ii)	$0.2\omega^2 (0.3 + e) = 6e / 0.3$ $e = 0.06\omega^2/(20 - 0.2\omega^2)$ $20 - 0.2\omega^2 > 0$ $(0 <) \omega < 10$	M1 A1 M1 A1 [4]	Newton's Second Law radially Other forms acceptable Uses denominator > 0 Disregard lower limit

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6	(i)	$0.2a = -0.2g0.5 - 0.4/x^2$	M1	Uses Newton's Second law
		$v\,dv/dx = -(5 + 2x^{-2})$ AG	A1 [2]	
	(ii)	$\displaystyle\int v\,dv = -\int(5 + 2x^{-2})dx$	M1	Separates variables and integrates
		$v^2/2 = -5x + 2/x\ (+c)$	A1	
		$3^2/2 = -5 \times 0.5 + 2/0.5 + c$	M1	Hence $c = 3$, or $[v^2/2]_3^0 = [-5x + 2/x]_{0.5}^x$
		$x = 1$	A1	From $0 = -5x + 2/x = 3$
		Travels $(= 1 - 0.5) = 0.5$m	A1	
		F towards O (0.4) less than maximum	M1, A1	Compares 0.5×0.2g and $0.4/1^2$
		friction $(= 1)$	[7]	
7	(i)	$OG_{quadrant} = 2\sin(\pi/4)/(3\pi/4)$	B1	$8/(3\sqrt{2}\ \pi)$
		$a^2(a\sqrt{2}/2) = \pi/4[2\sin(\pi/4)/(3\pi/4)]$	M1	–1 each error, min zero
		$\qquad\qquad +(a^2 - \pi/4)x$	A2	There must be 3 moment terms
		$x = 2\sqrt{2}(3a^3 - 2)/(12a^2 - 3\pi)$	A1 [5]	Other forms acceptable
	(ii)	$x\cos45° > 1$	B1	
		$(6a^3 - 4)/(12a^2 - 3\pi) > 1$	M1	
		$3a^2(2 - a) < 3\pi/2 - 2$ AG	A1	
		True when $a = 1.68$, not when $a = 1.67$ AG	B1 [4]	RHS = 2.712.. compared with LHS = 2.709.. and 2.76.. respectively