1	$0.6v\mathrm{d}v/\mathrm{d}x = 0.3x$	M1		Newton's Second Law with $a = v\mathrm{d}v/\mathrm{d}x$
	$0.6v^2/2 = 0.3x^2/2(+c)$	A1		From $\int 0.6v\mathrm{d}v = \int 0.3x\mathrm{d}x$
	$[x^2/2]_0^8 = [v^2]_2^v$	M1		Uses limits of finds constant
	$v = 6\,\mathrm{ms}^{-1}$	A1	[4]	**[4]**
2	**(i)**	M1		Table of values or moment equation
	$12 \times 3 \times 0.2/8 - 8 \times 0.2/2 = (8 + 12)d$	A1		$0.9 - 0.8 = 20d$
	$d(= 0.1/20) = 0.005\,\mathrm{m}$ AG	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			
		M1		Moments about point of contact
	$F \times (2 \times 0.2) + 8 \times 0.1 = 12 \times 0.075$	A1		
	$F = 0.25$	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)
	$v = 2.47\,\mathrm{ms}^{-1}$	A1	[3]	**[7]**

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

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