1	T = 12 × (0.6–0.4)/0.4 $6 = 0.1v^2/0.6$ $v = 6\ \text{ms}^{-1}$	M1 M1 A1	 [3]	Uses T = λx/L, (=6) N2L 1 force and RA	3
2 (i)	$0.5v\text{d}v/\text{d}x = 0.5\text{g} – 0.015x^2$ $v\text{d}v/\text{d}x = 10 – 0.03x^2$ AG	M1 A1	 [2]	N2L 2 forces	
(ii)	18.3 m	B1	[1]	$\sqrt{(10/0.03)} = 18.257..$	
(iii)	$\int v\text{d}v = \int (10–0.03x^2)\text{d}x$ $v^2/2 = 10x – 0.03x^3/3$ (+c) $v^2/2 = 10 \times 18.3 – 0.03 \times 18.3^3/3$ $v = 15.6\ \text{ms}^{-1}$	M1 A1 M1 A1	 [4]	Attempts to integrate Accept omission of c Uses ans (ii) in formula for v^2	7
3	$\text{Rcos}\theta = 0.5$ g (=5) $\text{Rsin}\theta = 0.5 \times 5^2 \times 0.4$ (= 5) $\tan\theta = (0.5 \times 5^2 \times 0.4)/(0.5\text{ g})$ $\theta = 45°$ AG R = 0.5 g/cos45 R = 7.07 N	B1 M1 M1 A1 M1 A1	 [6]	Resolving vertically Use of N2L horizontally with $\text{acc}^n = w^2r$ Eliminating R $\text{R}^2 = (0.5 \times 5^2 \times 0.4)^2 + (0.5\text{ g})^2$ 7.071..	6
4 (i)	$0.2a = 0.024t – 0.2\text{ g} \times 0.3$ $a = 0.12t – 3$ $\int \text{d}v = \int (0.12t – 3)\text{d}t$, $v = 0.12\text{t}^2/2 – 3t + \text{c}$, $t = 0$, $v = 0.9$ hence c = 0.9 $v = 0.06(t^2 – 50t + 15)$ AG	M1 A1 M1 A1	 [4]	Uses N2L Integrates and finds c	
(ii)	$t^2 – 50t + 15 = 0$ $t = 0.302$	M1 A1	 [2]	Solves 3 term quadratic Smaller +ve root only	

(iii)	$0.024t = 0.3 \times 0.2$ g	M1		Equates tractive force and friction force	
	$t = 25$	A1	[2]		8
5 (i)	$v_v^2 = (15\sin 30)^2 + 2\text{ g} \times 20$	M1		$v_v = 21.3600..$	
	$V^2 = (15\cos 30)^2 + (15\sin 30)^2 + 2\text{ g} \times 20$	M1		V or θ from components, V by energy	
	$V = 25\text{ ms}^{-1}$	A1			
	$\theta (= \tan^{-1} 21.36/(15\cos 30) = 58.7^\circ$	A1	[4]	58.69..	
(ii)	$-20 = (15\sin 30)t - gt^2/2$	M1		M1 maybe gained in **(i)**	
	$2t^2 - 3t - 8 = 0 \Rightarrow t(= 2.866..) = 2.89$	A1		A1 maybe gained in **(i)**	
OR	$t = (15\sin 30)/10 + (25\sin 58.7)/10$	M1		Separating rise and fall times	
	$t = 2.89$	A1			
	$OP^2 = 20^2 + (15\cos 30 \times 2.886)^2$	M1		42.491..	
	$OP = 42.5$ m	A1	[4]		8
6 (i)	0.4 g = 50e/0.8	M1		Uses T = $\lambda \times$/L (e = 0.064)	
	Moves down = 0.044 m	A1		(0.8 + 0.064 – 0.82)	
	$0.4 \times 1.5^2/2 + 0.4\text{ g} \times 0.044 + 50(0.82–0.8)^2/(2 \times 0.8)$ $=0.4v^2/2 + 50 \times 0.064^2/(2 \times 0.8)$	M1 A1		Sets up 2EE/2KE/PE equation	
	$v = 1.6(0)\text{ ms}^{-1}$	A1	[5]		
(ii)	PE gain to reach O = 0.4 g × 0.82	B1		From initial position, (3.28J)	
	$\text{KE} + \text{EE} = 0.4 \times 1.5^2/2 + 50(0.82 - 0.8)^2/(2 \times 0.8)$ Shows by evaluation that insufficient energy	M1 A1	[3]	At initial position, (0.4625J)	8

7 **(i)**	 $\pi \times 0.5^2 \times 0.4 \times 0.2 + \pi \times 0.5^2 \times 0.4 \times 0.5/3$ $= (\pi \times 0.5^2 \times 0.4 + \pi \times 0.5^2 \times 0.4/3)0G$ AG d = 0.275 m	M1 A1 A1	 [3]	Uses table of moments idea	
(ii)	(0.4 + 0.4)F = 0.5 × 60 F = 37.5	M1 A1	 [2]	Takes moments	
(iii)	μ (= 37.5/60) = 0.625	B1 ft	[1]	cv(F)/60	
(iv)	F/R=(60sin30)/(60cos30) (= 0.577..) $0.577 \prec 0.625$ (or μ), no sliding AG $\tan\theta = (0.4 - 0.275)/0.5$ $\theta = 14^\circ$ AG	M1 A1 M1 A1	 [4]	Or quotes $\tan 30 \prec 0.625$ Or 0.5tan30 = 0.288.. $0.4 - 0.29 \prec 0.275$, topples	 10