1		$V\sin\theta = 2g$ (= 20)	**B1**		Using vertical motion to greatest height
		$V\cos\theta = 30/2$ (= 15)	**B1**		Using horizontal motion
		$V^2 = 15^2 + 20^2$ or $\tan\theta = 20/15$	**M1**		Using Pythagoras or trigonometry
		$V = 25$ ms^{-1}	**A1**		
		$\theta = 53.1°$	**A1**	5	
2	**(i)**	$60(3 \times 0.8/8) \times 0.28 = P(0.8 - 0.8 \times 0.28)$	**M1** **A1**		An attempt at taking moments
		$P = 8.75$ AG	**A1**	3	
	(ii)	$\mu = 8.75/60$	**M1**		
		$\mu = 0.146$	**A1**	2	
3		$V_h = 9\cos60$	**B1**		
		$V_v = (\pm)4.5$	**B1**		Or $9\cos60$
		$-4.5 = 4.5 - gt$	**M1**		
		$t = 0.9$	**A1**		
		Distance = 4.05	**A1**	5	From $0.9 \times 9\cos60$
4	**(i)**	$2 \times 0.56 \times 0.28 + 1.2^2(0.56 + 1.2/2) = h(2 \times 0.56 + 1.2^2)$	**M1**		Moments about BC
		$h = 0.775$	**A1**		
		$2 \times 0.56 \times 1 + 1.2^2(1.2/2) = v(2 \times 0.56 + 1.2^2)$	**M1**		Moments about BAG
		$v = 0.775$	**A1**	4	
	(ii)	45°	**B1**	1	
	(iii)	$\tan\theta = (0.56 + 1.2 - 0.775) / (1.2 - 0.775)$	**M1**		
		$\theta = 66.7°$	**A1**	2	
5	**(i)**	$24e/0.8 = 0.2g$	**M1**		
		$e = 0.2$	**A1**	2	
	(ii)	$24 \times 0.2^2 / (2 \times 0.8)$ (= 0.6)	**B1**√		ft(cv0.2) Initial EE
		$0.6 \times 4.5^2/2 + 0.6gd + 24 \times 0.2^2/(2 \times 0.8)$	**M1**		PE/EE/KE balance attempt
		$= 0.6 \times 3.5^2/2 + 24 \times (0.2 + d)^2/(2 \times 0.8)$	**A1**		d = distance particle falls
		$d = 0.4$ so AP (= 0.8 + 0.2 + 0.4) = 1.4m	**A1**	4	
	(iii)	$24 \times 0.2^2/(2 \times 0.8) + 0.6 \times 4.5^2/2 = 0.6v^2/2 + 0.6g \times 0.5$	**M1** **A1**		PE/EE/KE balance, 4 terms. Award B1ft for initial KE if not already seen in part ii
		$v = 3.5$ ms^{-1}	**A1**	3	
6	**(i)**	$0.2v\mathrm{d}v/\mathrm{d}x = 0.2g\sin30 - 0.1x^2(0.2g\cos30)$	**M1**		N2L parallel to the slope
		$2v\mathrm{d}v/\mathrm{d}x = 10 - (\sqrt{3})x^2$ AG	**A1**	2	

(ii)	$2\int v dv = \int(10 - \sqrt{3}x^2)\,dx$	**M1**		Integrates acceleration
	$v^2 = 10x - \sqrt{3}x^3/3$	**A1**		No need to show c = 0
	$0 = 10 - \sqrt{3}x^2$	**M1***		Solves accn =0 (x = 2.4028..)
	$v^2 = 10 \text{ x } 2.4 - \sqrt{3} \text{ x } 2.4^3/3$	**dep M1***		Puts solution of accn = 0 in v^2 (x)
	Max v = 4(.002)	**A1**	5	
(iii)	$0 = 10x - \sqrt{3}x^3/3$	**M1**		
	x = 4.16	**A1**	2	
7 (i)	Rcos60 + Tcos30 = 0.2 g	**M1**		Resolving vertically
	R + T$\sqrt{3}$ = 4 AG	**A1**	2	g = 10 must be used
(ii)	Tsin30 – Rsin60 = 0.2 ω^2 × 0.6sin60	**M1**	2	N2L horizontally with accn= ω^2 r
	(T – R$\sqrt{3}$ = 0.12 $\omega^2\sqrt{3}$)	**A1**		Accept with trig ratios
(iii) (a)	Rcos60sin30 + Rsin60cos30 = 2sin30–0.2 × 2^2 × 0.6sin60cos30	**M1**		Substitutes ω=2 and eliminates T from **(i)** and **(ii)**
	R = 0.64 N	**A1**	2	Accept answers between 0.639 and 0.641 inclusive
	OR			
	R + 3R = 4 – 0.12 × 2^2 × 3	**M1**		
	R = 0.64	**A1**		
(b)	Tcos30 = 2	**M1**		
	T = 2.31	**A1**		When R = 0, T = 4$\sqrt{3}$ /3 or 4/$\sqrt{3}$
	2.31sin30 = 0.2 ω^2 × 0.6sin60 AND v = ω × 0.6sin60	**M1**		
	v = 1.73 m s^{-1}	**A1**	4	
	OR			
	2.31sin30 = 0.2 v^2 /(0.6sin60)	**M1**		
	v = 1.73 m s^{-1}	**A1**		Final pair of marks