1 (i)	$(12 + 8)OG =$ $\pm [8 \times 0.6/(\pi/2) - 12 \times (2 \times 0.6)/(3\pi/2)]$	M1 A1		Table of values or equates moments Signs either way round
	$OG = 0$ m	A1	[3]	
(ii)	$(12 + 8) \times 0.6\sin 30 = F(0.6 + 0.6\cos 30)$	M1 A1		Moments about A
	$F = 5.36$	A1	[3]	
2 (i)	$[60 \times 2^2/(2 \times 2)] + 0.6v^2/2 =$ $0.6g(6 - 2 \times 2) + [60 \times 2^2/(2 \times 2)]$	M1		PE/KE(/EE) balance (EE terms may be omitted or wrong but equal)
	$v = 6.32$ ms^{-1}	A1	[2]	$(v = \sqrt{40}\ )$
(ii)	$60e/2 = 60(2-e)/2 \pm 0.6g$	M1		Attempt to find equilibrium position
	Upper ext = 1.1, Lower ext = 0.9	A1		
	Distance from A = 3.1 m	A1		
	$0.6g \times 1.1 + 60(2^2 - 0.9^2)/4$ $= 60 \times 1.1^2/4 + KE$	M1 A1√		Energy balance, descent from A. √ cv upper and lower ext
	KE = 36.3 J	A1	[6]	
	OR			
	$KE - 0.6(6.32)^2/2 = 60 \times 2^2/4$ $-60 \times 1.1^2/4 - 60 \times 0.9^2/4 - 0.6g \times 0.9$	M1 A1ft		Energy balance, descent from A. √ cv upper and lower ext, answer (i)
	KE = 36.3 J	A1		

3 (i)	$t = 2/(25\cos 70)$ (= 0.234)	B1		
	$y = (25\sin 70) \times 0.234 - g \times 0.234^2/2$	M1		
	$y = 5.22$	A1	[3]	
	OR			
	$y = xt\tan 70 - gx^2/2(25\cos 70)^2$	B1		
	$y = 2\tan 70 - g2^2/2(25\cos 70)^2$	M1		
	$y = 5.22$	A1		$s = ut + gt^2/2$ Award if seen in **(i)**
(ii)	$1.2 = (25\sin 70)t - gt^2/2$	B1		
	$5t^2 - 23.5t + 1.2 = 0$	M1		Solves 3 term quadratic for larger root
	$t = 4.65$ s	A1	[3]	
(iii)	$R = 15^2 \sin 2\alpha/10 = 20$	M1		Or solves $(15\sin\alpha)t - 5t^2 = 0$ and $20 = (15\cos\alpha)t$ for α
	$\alpha = 31.4^\circ$	A1	[2]	
4 (i)	$(0.9/2)/r = \tan 45$	M1		
	$r = 0.45$ m	A1	[2]	
(ii)		M1		Take moments about A
	$(\pi 0.9^2 \times 0.9 + \pi 0.45^2 h)OG = \pi 0.9^2 \times 0.9(h + 0.45) + \pi 0.45^2 \text{ h} \times \text{h}/2$	A1√		√ cv(0.45)
	$OG = \dfrac{0.9^3 h + 0.9^3 \times 0.45 + 0.45^2 h^2/2}{0.9^3 + 0.45^2 h}$ $OG = (25h^2 + 180h + 81)/(50h + 180)AG$	A1	[3]	
(iii)	$0.45/OG = \frac{1}{2}$	M1		
	$0.9 = (25h^2 + 180h + 81)/(50h + 180)$	DM1		
	h = 0.545	A1	3	

5 (i)	**(a)** Tcos60 = 7cos60 – 0.2g	M1		Resolves vertically for B
	T = 3 N	A1	[2]	
	(b)	M1		Newton's Second Law with 2 forces resolved horizontally
	7sin60 + 3sin60 = 0.2v^2 /0.6	A1√		√ cv(3)
	v = 5.1(0) ms^{-1}	A1	[3]	
(ii)	T_P cos60 – T_Q cos60 = 0.2g	B1		Resolves vertically for B
	T_P sin60 + T_Q sin60 = 0.2 × 7^2 × 0.6	B1		or RHS = 0.2x(7 × 0.5)^2 /0.5
	T_P – T_Q = 4 and T_P + T_Q =6.78(96..)	M1		Solves 2 SE for T_Q
	T_Q = 1.39 N	A1	[4]	
6 (i)	0.4dv/dt = T–0.4g × 0.5–0.9v	B1		Not awarded for N2L round corner
	0.2dv/dt= 0.2g–T–0.9v	B1		Not awarded for N2L round corner
	0.6dv/dt=0.2g–0.4g × 0.5–1.8v	M1		Awarded for N2L round corner
	dv/dt = – 3v AG	A1	[4]	
(ii)	$\int$ dv/v = $\int$ –3dt	M1		Separates variables, integrates
	ln$v$ = –3t (+ c)	A1		Accurare integrals
	c = ln5	B1		Or $[\ln v]_5^{2.5}$ =$[-3t]_0^t$ implied
	t = 0.231	A1		(ln2)/3
	$\int$ dx = $\int$ e^{c-3t} dt	M1		Attempts integration of v(t)
	x = –[e^{c-3t}]$_0^{0.231}$ /3	A1		Correct integral and limits
	x = 0.833 m	A1	[7]	5/6 m
	OR			
	vdv/dx = –3v, dv/dx = –3 $\int$dv = $\int$– 3dx	M1		Attempts integration
	$[v]_5^{2.5}$ = $[-3x]_0^x$	A1		Correct integral and limits
	x = 0.833m	A1		Accept 5/6m