1	$\frac{dv}{dt} = e^{-0.5v}$ $\int \frac{1}{e^{-0.5v}} dv = \int dt$		**M1**		Separates the variables and attempts to integrate
	$\frac{e^{-0.5v}}{0.5} = t(+c)$		**A1**		
	$t = 0$, $v = 2$ so $c = 2e$		**M1**		$c = 5.4365\ldots$ or use of limits
	$v = 2.4(0)$ when $t = 1.2$		**A1**	4	
2	**(i)** $T = \frac{20(0.8\sin\theta)}{0.8}$	AG	**B1**	1	Hence $20\sin\theta$
	(ii) No friction (so perpendicular)	AG	**B1**	1	Or ring smooth
	(iii) $20\sin\theta(0.8\cos\theta) =$ $8(0.6\sin\theta) + 2(1.2\sin\theta)$		**M1** **A1**		Moments about A (3 terms) All terms correct
	$\theta = 63.3°$		**A1**	3	Accept 1.1 radians
3	**(i)** $0.3v\frac{dv}{dx} = -2x$		**M1**		
	$k = -\frac{20}{3} = -6\frac{2}{3}$		**A1**	2	
	(ii)		**M1**		Integrates acceleration
	$\int_8^0 v\,dv = -\frac{20}{3}\int_0^x x\,dx$		**M1**		Uses limits or finds constant of integration
	$x = 3.1(0)$		**A1**	3	
4	**(i)** $T\cos30 - T\cos45 = 0.3g$		**M1**		Resolves vertically
	$T = 18.9$		**A1**		$T = 6\sqrt{3} + 6\sqrt{2}$
	$18.9\sin30 + 18.9\sin45 = \frac{0.3v^2}{0.6}$		**M1** **A1**		Resolves horizontally, Acceleration = v^2/r
	$v = 6.75\ \text{ms}^{-1}$		**A1**	5	
	(ii) $L = \frac{0.6}{\sin 30} + \frac{0.6}{\sin 45}$		**B1**		2.0485…
	$0.3\times3^2\ (2.05\sin\theta) = T\sin\theta$		**M1**		
	$T = 5.53\,\text{N}$		**A1**	3	

5	**(i)**	$0.2g = R + 21 \times \dfrac{0.05}{0.75}$	**M1**		
		$R = 0.6\,\text{N}$	**A1**	2	
	(ii)	$21\left(\dfrac{0.8}{\cos\theta - 0.75}\right) / (0.75\cos\theta) = 0.2g$	**M1** **A1**		θ = angle of string with vertical Comp of tension = weight $\theta = 13.7(291\ldots)$
		$e = 0.0735$	**A1**	3	$e = 0.8/\cos\theta - 0.75 = 0.073529\ldots$
		OR			
		$\dfrac{21e}{0.75} \times \dfrac{0.8}{(e + 0.75)} = 0.2g$	**M1** **A1**		e = extension Comp of tension = weight
		$e = 0.073529\ldots$	**A1**		
	(iii)	$\dfrac{0.2(3)^2}{2} + \dfrac{21(0.05)^2}{(2 \times 0.75)} = \dfrac{0.2v^2}{2} + \dfrac{21 \times 0.0735^2}{1.5}$	**M1** **A1**		Uses EE/KE balance
		$v = 2.93\,\text{m s}^{-1}$	**A1**	3	
6	**(i)**	Mass of disc $= \pi(1.2^2 - 0.4^2 - 0.3^2)$	**B1**		1.19π (or in (ii))
		$0 = \pi(1.2^2 - 0.4^2 - 0.3^2)y - (0.4^2) \times 0.7$	**M1** **A1**		LHS $= \pi(1.2^2 - 0.3^2) \times 0$
		$y = 0.0941$ m	**A1**	4	
	(ii)	$0 = \pi(1.2^2 - 0.4^2 - 0.3^2)x - \pi(0.3^2).5$	**M1** **A1**		LHS $= \pi(1.2^2 - 0.4^2) \times 0$
		$x = 0.0378\,\text{m}$	**A1**	3	
	(iii)	$\tan\theta = \dfrac{0.0941176}{0.0378151}$	**M1**		
		$\theta = 68.1°$	**A1**	2	

7 (i)	$(x =)\ V\cos 45t = V\cos 60(t+1)$	**M1** **A1**		Equates horizontal distances Terms correct
	$t = 2.414$ AG	**A1**	3	
(ii)	$(y =)\ V\sin 45t - \frac{gt^2}{2} =$ $V\sin 60(t+1) - \frac{g(t+1)^2}{2}$	**M1** **A1**		Equates vertical distances Terms correct
	$V\{\sin 60(3.414) - \sin 45(2.414)\} =$ $5\{(3.414)^2 - (2.414)^2\}$	**M1**		Gathers terms correctly
	$V = 23.3$	**A1**	4	23.32...
(iii)	Greatest $H = \frac{23.32^2 \sin^2 60}{(2g)}$	**B1**√		20.39, ft cv$(23.3)^2 \times 3/80$
	$h = 23.3\sin 60(3.414) - \frac{g(3.414)^2}{2}$	**M1**		
	$h = 10.67$	**A1**		
	Falls 9.72 m	**A1**	4	