Question	Answer	Marks	Guidance
1	$\frac{0.3\times 4^2}{2}=\frac{9e^2}{2\times 0.6}$	M1	Set up an energy equation. Note the final velocity is zero.
	$e=0.566$ or $\frac{2\sqrt{2}}{5}$	A1	
	Distance = 1.17 m	A1	
		3	

Question	Answer	Marks	Guidance
2(i)	$V\cos 30=40$	M1	Note V is the velocity of projection
	$V=46.2\ \text{m}\,s^{-1}$	A1	Allow $\frac{80}{\sqrt{3}}$ or $\frac{80\sqrt{3}}{3}$
	$y=23.1t-5t^2$	B1FT	Use $s=ut+\frac{at^2}{2}$ vertically. FT candidates half V but not $V=40$ used
		3	
2(ii)	$y=\frac{23.1x}{40}-\frac{5x^2}{1600}$	M1	Attempt to eliminate t by substituting $t=\frac{x}{40}$ into answer to **part (i)**
	$y=0.577x-\frac{x^2}{320}$ or $y=0.577x-0.003125x^2$	A1	
		2	

Question	Answer	Marks	Guidance
3	$0.5 \times 4 = 0.5g - T$	**M1**	Use Newton's Second Law vertically
	$T = \frac{12e}{0.6}$	**M1**	Use $T = \frac{\lambda x}{l}$
	$e\left(= \frac{3 \times 0.6}{12}\right) = 0.15$	**A1**	
	$\text{EPE} = \frac{12 \times 0.15^2}{2 \times 0.6}$ and distance fallen $= 0.6 - 0.5 + 0.15$	**B1ft**	
	$\frac{0.5v^2}{2} = \frac{0.5 \times 2^2}{2} + 0.5g(0.6 - 0.5 + 0.15) - \frac{12 \times 0.15^2}{2 \times 0.6}$	**M1**	Set up a 4 term energy equation
	$v = 2.85\ \text{m s}^{-1}$	**A1**	
		6	

Question	Answer	Marks	Guidance
4(i)	Velocity component vertically $= \pm (V\sin 60 - 3g)$	**B1**	Use $v = u + at$
	$\tan 30 = \frac{30 - V\sin 60}{V\cos 60}$	**M1**	Use trigonometry of a right angled triangle
	$V = 15\sqrt{3} = 26(.0)\ \text{m s}^{-1}$	**A1**	
		3	

Question	Answer	Marks	Guidance
4(ii)	$y = 26\sin 60 \times 3 - \frac{g \times 3^2}{2}$	**B1FT**	Use $s = ut + \frac{at^2}{2}$ vertically. Their V from **part (i)**
	$D^2 = (26\sin 60 \times 3 - g \times 3^2)^2 + (26\cos 60 \times 3)^2$	**M1**	Use Pythagoras's Theorem
	$D = 45(.0)$ m	**A1**	
		3	

Question	Answer	Marks	Guidance
5(i)	$r = 0.5\sin 30$ (= 0.25 m)	**B1**	
	$T\cos 30 - T\cos 70 = 0.4g$	**M1**	Resolve vertically
	$T = 7.6335..$	**A1**	
	$7.6335\sin 30 + 7.6335\sin 70 = 0.4v^2$ / 0.25	**M1**	Use Newton's Second Law with $a = \frac{v^2}{r}$
	$v = 2.62$ m s^{-1}	**A1**	
		5	

Question	Answer	Marks	Guidance
5(ii)	$A\cos 30 - B\cos 70 = 0.4g$ **and** $A\sin 30 + B\sin 70 = 0.4 \times 12^2 \times 0.5\sin 30$	**M1**	Resolves vertically and uses Newton's Second Law with $a = r\omega^2$
		A1	Both correct
		M1	Attempt to solve for A or B
	$A = 8.82$ N	**A1**	
	$B = 10.6$ N	**A1**	
		5	

Question	Answer	Marks	Guidance
6(i)	$0.2v\dfrac{\mathrm{d}v}{\mathrm{d}x} = 0.09\sqrt{x} - 0.3$	**M1**	Use Newton's Second Law horizontally
	$v\dfrac{\mathrm{d}v}{\mathrm{d}x} = 0.45\sqrt{x} - 1.5$	**A1**	AG
		2	
6(ii)	$0 = 0.45\,x^{\frac{1}{2}} - 1.5$	**M1**	Equate acceleration to zero
	$x = \dfrac{100}{9}$	**A1**	
		2	

Question	Answer	Marks	Guidance
6(iii)	$\int v\,\mathrm{d}v = \int (0.45x^{\frac{1}{2}} - 1.5)\mathrm{d}x$	**M1**	Attempt to integrate
	$\frac{v^2}{2} = \frac{0.45^{\frac{3}{2}}}{\frac{3}{2}} - 1.5x(+c) = 0.3x^{\frac{3}{2}} - 1.5x(+c)$	**A1**	
	$0.3\left(\frac{100}{9}\right)^{\frac{3}{2}} - 1.5\left(\frac{100}{9}\right) + c = 0$	**M1**	
	$c = \frac{50}{9}$	**A1**	
	$x = 0,\ \frac{v^2}{2} > \frac{50}{9}$ so $v > \frac{10}{3}$	**A1**	
		5	

Question	Answer	Marks	Guidance
7(i)	Rectangle: Area $= 1.2 \times 1.8 = 2.16,\ y = \frac{1.8}{2} = 0.9$	**B1**	
	Triangle(s): Area $= 1.2 \times \frac{1.8}{2} = 1.08,\ y = \frac{1.8}{3} = 0.6$	**B1**	
	$(2.16 + 1.08)Y = 2.16 \times 0.9 + 1.08 \times 0.6$	**M1**	Take moments about AD
	$Y = 0.8$ m	**A1**	AG
		4	

Question	Answer	Marks	Guidance
7(ii)	$AG\sin30 = 0.8$	**M1**	Use Trigonometry of a right angled triangle
	$AG = 1.6$ m	**A1**	
		2	
7(iii)	AD makes an angle of 40° or 20° with the vertical	**B1**	
	$W \times AG\sin10 = 7 \times 2.4\cos40$	**M1**	Take moments about A
	$W = 46.3$ N	**A1**	
	$W \times AG\sin10 = 7 \times 2.4\cos20$	**M1**	Take moments about A
	$W = 56.8$ N	**A1**	
		5	