1	EE(B) = $\dfrac{\lambda\times 0.5^2}{2\times 0.7}$ $\left[=\dfrac{5\lambda}{28}\right]$ OR EE = $\dfrac{\lambda\times 0.2^2}{2\times 0.7}$ $\left[=\dfrac{\lambda}{35}\right]$	B1		Correct EE when AP = 1.2 m Correct EE when AP = 0.9 m
	$\dfrac{\Lambda\times 0.5^2}{2\times 0.7}-\dfrac{\lambda\times 0.2^2}{2\times 0.7}=\dfrac{0.3\times 4^2}{2}$	M1		Using EE loss = KE gain
	$\lambda = 16\text{N}$	A1	**[3]**	
2 (i)	$\dfrac{dy}{dx}=1.2-2(0.15x)=0$	M1		Solving trajectory derivative = 0
	$y = 2.4$	A1	**[2]**	From $x = 4$
	OR			
	Greatest height at half range (ii)	M1		Uses $y = 1.2x - 0.15x^2$ with x = distance in **(ii)** ÷ 2
	$y = 2.4$	A1		
(ii)	Twice 'x' for greatest height	M1		Using 'x' from **(i)**
	Distance = 8 m	A1	**[2]**	No ft
	OR			
	$1.2x - 0.15x^2 = 0$	M1		Solves quadratic with $y = 0$
	Distance = 8 m	A1		
3 (i)	$T\sin\theta = m\omega^2 r$	M1		Newton's 2nd law, acceleration = 5^2r and component of T
	$3\omega\sin\theta = \left(\dfrac{\omega}{g}\right)5^2\ (L\sin\theta)$	A1		$3mg\sin\theta = m\ 5^2\ (L\sin\theta)$
	$L = 1.2\text{m}$ AG	A1	**[3]**	
(ii)	$3\omega\cos\theta = \omega$	M1		Resolves vertically for P
	$\theta = 70.53°$	A1		OR $\theta = \cos^{-1}\left(\dfrac{1}{3}\right)$, $\theta = \sin^{-1}\sqrt{\dfrac{8}{9}}$ etc.
	$v = 5\times 1.2\sin\theta$	M1		$v = \omega r$
	$v = 5.66\ \text{ms}^{-1}$	A1	**[4]**	

4 (i)	$x' = 15\cos 30 \quad (= 12.990..)$	B1		
	$y' = 15\sin 30 - 3g \; (= -22.5)$	B1		Or with signs reversed
	$v^2 = (15\cos 30)^2 + (15\sin 30 - 3g)^2$ or $\tan\theta = \dfrac{3g - 15\sin 30}{15\cos 30}$	M1		
	$v = 26(.0) \text{ ms}^{-1}$	A1		
	$\theta = 60°$ to the horizontal	A1	[5]	Or 30° to the vertical
(ii)	$y = 3(15\sin 30) - \dfrac{3^2 g}{2}$	M1		Uses $s = ut + \frac{1}{2}at^2$
	Height = 22.5 m	A1	[2]	N.B. this is also y'
	OR			
	$(-22.5)^2 = (15\sin 30)^2 - 2 \times 10y$	M1		Uses $v^2 = u^2 + 2as$
	Height = 22.5 m	A1		
5 (i)	$0.3g = \dfrac{18e}{0.9}$	M1		Uses $T = \dfrac{\lambda x}{l}$
	$e = 0.15$ m	A1	[2]	
(ii) (a)	$12 = \dfrac{18\text{ext}}{0.9}$ and $ht = 3 - 0.9 - \text{ext}$	M1		Both ideas needed, ext = 0.6
	$ht = 1.5$ m	A1	[2]	
(ii) (b)	$\dfrac{0.3 \times 6^2}{2} - \dfrac{0.3u^2}{2} + 0.3g(0.6 - 0.15)$ $= \dfrac{18 \times 0.6^2}{2 \times 0.9} - \dfrac{18 \times 0.15^2}{2 \times 0.9}$	M1 A1		KE/PE/EE balance up to string breaking
	$\left(\dfrac{0.3u^2}{2} = 3.375\right)$			$u^2 = 22.5$
	$0.3v^2 = 0.3u^2 + 0.3g(3 - 0.6 - 0.9)$ OR $v^2 = u^2 + 2g(3 - 0.6 - 0.9)$	M1		KE/PE balance after string breaks or $v^2 = u^2 + 2g(\text{ht})$ using ht from **(ii)(a)**
	$v = 7.25 \text{ ms}^{-1}$	A1	4	7.2456
6 (i)	$0.1v\dfrac{dv}{dx} = -0.2e^{-x}$ $v\dfrac{dv}{dx} = -2e^{-x}$	M1		Newton's 2nd law, 1 force Must have negative coefficient
	$k = -2$	A1*	[2]	

(ii)	$\int v\,dv = \int -2e^{-x}\,dx$	M1		Integrates
	$\frac{v^2}{2} = 2e^{-x}\ (+c)$	D*A1		Needs first A1 in **(i)**
	$c = \left(\frac{2.2^2}{2} - 2e^0\right) = 0.42$	M1		Or uses limits of 2 and 2.2 for v and x and 0 for x
	$\frac{2^2}{2} = 2e^{-x} + 0.42$ $x = 0.236$	A1	**[4]**	
(iii)	$\frac{v^2}{2} = 2e^{-\infty} + 0.42$	M1		OR finds x when $v = 0.9165$
	$v = 0.917\ \text{ms}^{-1}$ AG	A1	**[2]**	No solution when $v = 0.917$
7 (i)	$d(0.6 \times 0.8 + 0.6^2) =$ $0.4(0.6 \times 0.8) - (0.6/3) \times 0.6^2$	M1 A1		Moments about BAD
	$d = 0.143$ m	A1	**[3]**	Exact 1/7
(ii) (a)	$21 \times 0.143 = 1.2P$	M1		Moments about B
	$P = 2.5(0)$	A1	**[2]**	
(ii) (b)	$F_r = 21\sin45 - 2.5\cos45$ and $R = 21\cos45 + 2.5\sin45$	B1		
		M1		For using $F_r = \mu R$
	$\mu = 0.787$	A1	**[3]**	
(iii)	$P \times 0.6 = 21 \times (0.143 + 0.6)$	M1		Moments about C
	$P = 26(.0)$	A1		
	Required $F_r = 26\sin45 - 21\sin45$	M1		3.5355..
	Max $F_r = 26(.155)$	A1		$0.787 \times (26\cos45 + 21\cos45)$
	As actual $F_r <$ max F_r, no sliding	A1	**[5]**	