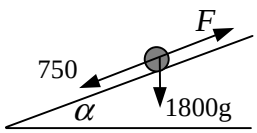
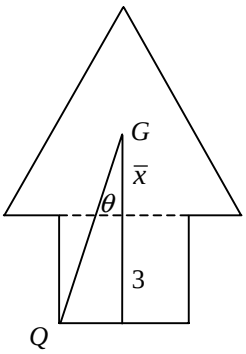
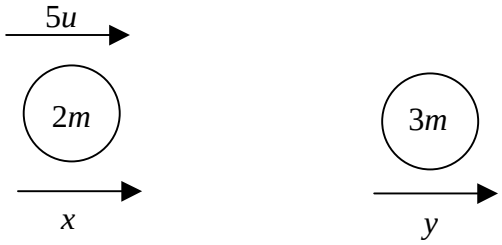
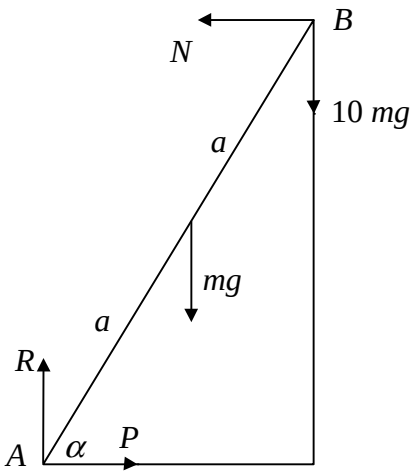
Question Number	Scheme	Marks
1. (a)	$F = \frac{36\,000}{20} \quad (=1800)$	B1
	N2L $\quad \frac{3600}{20} - 750 = 1500a$ ft their F	M1 A1ft
	$a = 0.7 \quad (\text{m s}^{-2})$	A1 4
(b)	 $\nearrow F = 750 + 1500g \times \frac{1}{10} \quad (=2220)$	M1 A1
	P = $2220 \times 20 = 44\,400$	
	Accept also 44000, 44 kW, 44.4 kW	A1 3 **7**
2. (a)	$\mathbf{I} = m\mathbf{v} - m\mathbf{u}$	
	$-4\mathbf{i} + 4\mathbf{j} = 0.2\mathbf{v} - 0.2 \times 30\mathbf{i}$	M1 A1
	$\mathbf{v} = 10\mathbf{i} + 20\mathbf{j} \quad (\text{m s}^{-1})$	A1 <u>3</u>
(b)	$\tan\theta = \frac{20}{10}$	M1
	$\theta = 63.4°$ accept awrt $63°$ or 1.1^c	A1 <u>2</u>
(c)	Final K.E. = $\frac{1}{2} \times 0.2 \times (10^2 + 20^2) \quad (=50)$ ft their $\mathbf{v}$	M1 A1ft
	K.E. lost = $\frac{1}{2} \times 0.2 \times 30^2 - \frac{1}{2} \times 0.2 \times (10^2 + 20^2)$	M1
	= 40 (J) cao	A1 <u>4</u> **9**

Question Number	Scheme	Marks
3. (a)	Rectangle Triangle Decoration	
	Mass Ratio 6 12 18 Ratio 1:2:3	B1
	CM from BG $(-)1\frac{1}{2}$ 2 $\bar{x}$	B1
	$18\times\bar{x}=-6\times1\frac{1}{2}+12\times2$	M1 A1
	$\bar{x}=\frac{5}{6}$ accept exact equivalents	A1 5
(b)		
	Identification and use of correct triangle	M1
	$\tan\theta=\frac{1}{3+\bar{x}}$ ft their $\bar{x}$	M1 A1ft
	$\theta=14.6°$ cao	A1 4 **9**

Question Number	Scheme	Marks
4.	(a) $\mathbf{p} = \left(2t^2 - 7t\right)\mathbf{i} - 5t\mathbf{j}, + 3\mathbf{i} + 5\mathbf{j}$ $= \left(2t^2 - 7t + 3\right)\mathbf{i} + \left(5 - 5t\right)\mathbf{j}$	M1, M1 A1+A1 4
	(b) $\mathbf{q} = \left(2\mathbf{i} - 3\mathbf{j}\right)t - 7\mathbf{i}$	M1 A1
	$\mathbf{j}$: $5 - 5t = -3t \Rightarrow t = 2.5$ equating and solving	M1 A1
	At $t = 2.5$ $\mathbf{i}$: $p_x = 2\times 2.5^2 - 7\times 2.5 + 3 = -2$ $q_x = 2\times 2.5 - 7 = -2$ both	M1
	$p_x = q_x \Rightarrow$ collision cso	A1 6 **10**
	Alternative in (b)	
	$\mathbf{i}$: $2t^2 - 7t + 3 = 2t - 7 \Rightarrow 2t^2 - 9t + 10 = 0$ $t = 2, 2.5$ equating and solving	M1 A1
	At $t = 2.5$ $\mathbf{j}$: $p_y = 5 - 5\times 2.5 = -7.5$ $q_y = -3\times 2.5 = -7.5$ both	M1
	$p_y = q_y \Rightarrow$ collision cso	A1
	In alternative, ignore any working associated with $t = 2$	

Question Number	Scheme	Marks
5.		
	(a) LM $10mu = 2mx + 3my$	M1 A1
	NEL $y - x = 5eu$	B1
	Solving to $y = 2(1+e)u$ * cso	M1 A1 5
	(b) $x = 2u - 3eu$ finding x, with or without $e = 0.4$	M1
	$x = 0.8u$	A1
	$x > 0 \Rightarrow P$ moves towards wall and Q rebounds from wall	
	$\Rightarrow$ second collision ft any positive x	A1 ft 3
	(c) $x = -0.4u$	B1
	Speed of Q on rebound is $3.6fu$	
	For second collision $3.6fu > 0.4u$	M1
	$f > \frac{1}{9}$ ignore $f \mid 1$	A1 3 **11**

Question Number	Scheme	Marks
6.		
	(a) M(A) $N\times 2a\sin\alpha = mg\times a\cos\alpha + 10mg\times 2a\cos\alpha$	M1 A2(1, 0)
	$2N\tan\alpha = 21mg$	
	$N = 7mg$ * cso	M1 A1 5
	(b) $\uparrow\ R = 11mg$	B1
	$F_r = 0.6\times 11mg = 6.6mg$	B1
	For min P $F_r \rightarrow$ $P_{\min} = 7mg - 6.6mg = 0.4mg$	M1 A1
	For max P $F_r \leftarrow$ $P_{\max} = 7mg + 6.6mg = 13.6mg$	M1 A1
	$0.4mg \mid P \mid 13.6mg$ cso	A1 7 **12**
	Note: *In* (a), *if moments are taken about a point other than A, a complete set of equations for finding N is needed for the first* M1. *If this* M1 *is gained, the* A2(1, 0) *is awarded for the moments equation as it first appears.*	

Question Number	Scheme	Marks
7.	(a) Work-Energy $R\times 60 = 80\times 9.8\times 24.4 - \frac{1}{2}\times 80\times 20^2$	M1 A2(1, 0)
	$\left(= 19129.6 - 16\,000 = 3129.6\right)$	
	$R = 52$ (N) accept 52.2	M1 A1 5
	(b) $-8.1 = 20\sin\alpha\times t - \frac{1}{2}gt^2$	M1 A2(1, 0)
	$4.9t^2 - 12t - 8.1 = 0$	M1
	$t = 3$ (s)	A1 5
	(c) $20\cos\alpha\times 3 = 16\times 3 = 48$ (m) ft their t	M1 A1ft 2
	(d) Energy $\frac{1}{2}mv^2 - \frac{1}{2}m\times 20^2 = m\times 9.8\times 8.1$	M1 A2(1, 0)
	$v = \sqrt{\left(558.56\right)} \approx 24 \quad \left(\text{m s}^{-1}\right)$ accept 23.6	M1 A1 5 **17**
	Alternative to (d)	
	$\uparrow \quad v_y = 12 - 3g = -17.4$	M1 A1
	$\rightarrow \quad v_x = 16$	A1
	$v = \sqrt{\left(17.4^2 + 16^2\right)} \approx 24 \quad \left(\text{m s}^{-1}\right)$ accept 23.6	M1 A1 5