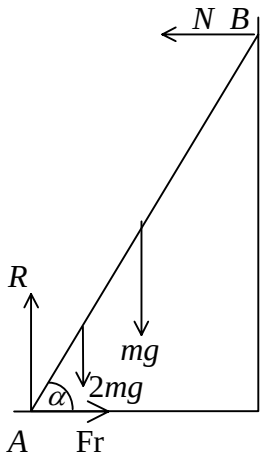
Question number	Scheme	Marks
1. (*a*)	Use of $(8 + \lambda)m$	B1
	i: $3m \times 4 + \lambda m \times 4 = (8 + \lambda)m \times 2$	M1
	Solving to $\lambda = 2$ (*)	M1 A1 (4)
	j: $5m \times (-3) + 2m \times 2 = 10m \times k$	M1 A1
	$k = -1.1$	A1 (3)
		(7 marks)
2. (*a*)	$T_r = \frac{24000}{12}$ (= 2000)	M1
	N2L: $T_r - 1200 = 1000 \times f$	M1 A1ft
	$f = 0.08$	A1 (4)
(*b*)	Work Energy $\frac{1}{2} \times 1000 \times 14^2 = 1200d$	M1 A1
	$d = 81\frac{2}{3}$ awrt 81.7	A1 (3)
(*c*)	Resistances may *vary* with speed	B1 (1)
		(8 marks)

Question number	Scheme	Marks
3.		
	$(\uparrow)$ $R = 3mg$	B1
	M(B) $mga\cos\alpha + 2mg \times \frac{3}{2}a\cos\alpha + \text{Fr} \times 2a\sin\alpha = R \times 2a\cos\alpha$	M1 A2 1,0
	Solving to Fr = $\frac{3}{4}mg$	M1 A1
	$\text{Fr} \le \mu R \Rightarrow \frac{3}{4}mg \le \mu 3mg$	M1
	$\mu \ge \frac{1}{4}$ (least value is $\frac{1}{4}$)	M1 A1 (9)
		(9 marks)
4. (a)	  	
	MR $48a^2$ $12a^2$ $60a^2$	B1, B1ft
	CM $4a$ $(-)\frac{1}{3} \times 4a$ $\bar{x}$	B1
	$48a^2 \times 4a - 12a^2 \times \frac{4}{3}a = 60\bar{x}$	M1 A1
	Solving to $\bar{x} = \frac{44}{15}a$ (*)	A1 (6)
(b)	$\lambda M \times 4a = M \times \frac{44}{15}a$	M1 A1
	$\lambda = \frac{11}{15}$	A1 (3)
		(9 marks)

Question number	Scheme	Marks
5. (*a*)	$v = \int a\,dt = 2t^2 - 8t \ (+c)$	M1 A1
	Using $v = 6$, $t = 0$; $v = 2t^2 - 8t + 6$	M1 A1 (4)
	$v = 0 \Rightarrow 2t^2 - 8t + 6 = 0, \Rightarrow t = 1,3$	M1 A1
	$S = \int (2t^2 - 8t + 6)\ \mathrm{d}t = \left[\frac{2}{3}t^3 - 4t^2 + 6t\right]$	M1 A2, 1, 0
	$= 0 - 2\frac{2}{3}$	M1
	Distance is $(\pm)2\frac{2}{3}$ m	A1 (7)
		(11 marks)
6. (*a*)	L.M. $2u = 2x + y$	M1 A1
	NEL $y - x = \frac{1}{3}u$	M1 A1
	Solving to $x = \frac{5}{9}u$ (*)	M1 A1
	$y = \frac{8}{9}u$ (*)	A1 (7)
(*b*)	$(\pm)\ \frac{8}{9}eu$	B1
	L.M $\frac{10}{9}u - \frac{8}{9}eu = w$	M1 A1
	NEL $w = \frac{1}{3}\left(\frac{5}{9}u + \frac{8}{9}eu\right)$	M1 A1
	Solving to $e = \frac{25}{32}$ accept 0.7812s	M1 A1 (7)
(*c*)	*Q* still has velocity and will *bounce back* from wall colliding with *stationary P*.	B1 (1)
		(15 marks)

Question number	Scheme	Marks
7. (*a*)	$\mathbf{I} = 0.4(15\mathbf{i} + 16\mathbf{j} + 20\mathbf{i} - 4\mathbf{j})$ $(= 0.4(35\mathbf{i} + 12\mathbf{j}) = 14\mathbf{i} + 4.8\mathbf{j})$	M1
	$\lvert\mathbf{I}\rvert = \sqrt{(14^2 + 4.8^2)}$ *or* $0.4\sqrt{(35^2 + 12^2)}$ M1 for any magnitude	M1 A1
	$= 14.8$ (Ns)	A1 (4)
(*b*)	Initial K.E. $= \frac{1}{2}m(15^2 + 16^2)$ $(= 240.5m = 96.2$ J)	M1
	$\frac{1}{2}mv^2 = \frac{1}{2}m(15^2 + 16^2) = m \times 9.8 \times 1.2$ –1 each incorrect term	M1 A2, 1,0
	$v^2 = 504.52$	M1
	$v = 22$ (m s^{-1}) accept 22.5	A1 (6)
(*c*)	$\arccos \frac{15}{22.5} = 48°$ accept 48.1°	M1 A1 A1 A1 (4)
(*d*)	Air resistance Wind (problem not 2 dimensional) Rotation of ball (ball is not a particle) any 2	B1, B1 (2)
		(16 marks)
Alt (*b*)	Resolve ↑ with 16 and 9.8	M1
	(↑) $v_y^2 = 16^2 + 2 \times (-9.8) \times (-1.2)$	M1 A1
	$(v_y^2 = 279.52, v_y \approx 16.7\ldots..)$	
	$v^2 = 15^2 + 279.52$	M1 A1
	$v = 22$ (m s^{-1}) accept 22.5	A1 (6)
Alt (*c*)	$\arctan \frac{16.7}{15} = 48°$	M1 A1 A1 A1 (4)