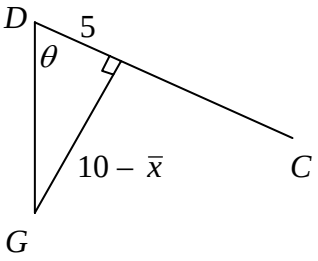
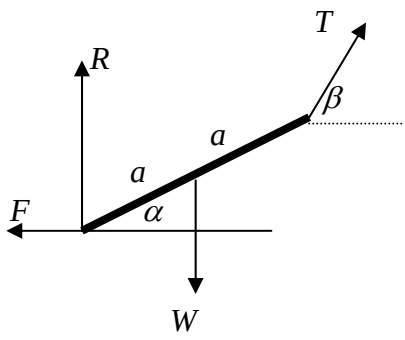
Question Number		Scheme	Marks
1.	(*a*)	Differentiating: $\mathbf{a} = 3\mathbf{i} - 5\mathbf{j}$ (sufficient)	M1A1 **(2)**
	(*b*)	Integrating : $\mathbf{r} = (\frac{3}{2}t^2 - 2t)\mathbf{i} - \frac{5}{2}t^2\ \mathbf{j}\ (+C)$	M1A1
		Using initial conditions to find C ($3\mathbf{i}$); $\mathbf{r}\ (t = 2) = 5\mathbf{i} - 10\mathbf{j}$	M1; A1
		Distance = $\sqrt{\{5^2 + (10)^2\}}$; = $5\sqrt{5}$ or 11.2 or 11.18 (m)	M1; A1 **6)**
			(6 marks)
2.	(*a*)	$0 \le t \le 3$ $v = 2t^2 - \frac{1}{3}t^3\ (+C)$ Evidence of integration for M1	M1 A1
		$t = 3 \Rightarrow v = 9$ m s^{-1}	A1 **(3)**
	(*b*)	$t \ge 3$ $v = -\frac{27}{t}\ (+C)$	B1
		Using $t = 3$ and candidates' $v = 9$ to find C; $C = 18$	M1; A1 ft
		Substituting $t = 6$ in expression for v ; $v = 13.5$ m s^{-1}	M1; A1 **(5)**
			(8 marks)
3.	(*a*)	Change in KE: $\frac{1}{2} \times 80 \times (8^2 - 5^2)$ [loss: 2560 – 1000 = 1560 J]	B1
		Change in PE: $80 \times g \times (20 - 12)$ [loss: 15680 – 9408 = 6272 J]	B1
		WD by cyclist = 20×500 – (loss in K.E. + P.E.)	M1 A1 ft
		= 2168 Nm (allow 2170 and 2200)	A1 **(5)**
	(*b*)	Equation of motion: $F - 20 = 80 \times 0.5$ [M1 requires three terms]	M1 A1
		Power = $F_c \times 5$; = 300 W	M1 A1
			(9 marks)

(ft = follow through mark)

Question Number		Scheme			Marks
4.	(*a*)	Shape	Square	Semi-circle	Lamina *L*	
		Relative masses	100	$12\frac{1}{2}\pi(39.3)$	$100 - 12\frac{1}{2}\pi(60.7)$	M1 A1
		Centre of mass from *AB*	5	$\frac{20}{3\pi}$ (2.12)	$\bar{x}$	B1 B1
		Moments about *AB*: $100 \times 5 - 12\frac{1}{2}\pi \times \frac{20}{3\pi} = (100 - 12\frac{1}{2}\pi)\bar{x}$				M1 A1
		Answer: 6.86 cm				A1 (cao) **(7)**
	(*b*)				Correct angle, diagram sufficient	M1
					Method to find θ [or $(90 - \theta)$]	M1
					$\tan\theta = \frac{10 - \bar{x}_c}{5}$	A1 ft
					Answer: 32.1°	A1 (cao) **(4)**
						(11 marks)
5.	(*a*)	$x = u\cos\alpha\, t$; $y = u\sin\alpha\, t - \frac{1}{2}gt^2$				B1; B1
		Eliminating *t* : $y = u\sin\alpha \frac{x}{u\cos\alpha} - \frac{1}{2}g\frac{x^2}{(u\cos\alpha)^2}$				M1
		$y = x\tan\alpha - \frac{gx^2}{2u^2\cos^2\theta}$				M1
		$y = x\tan\alpha - \frac{gx^2}{2u^2}(1+\tan^2\alpha)$ *				A1 **(5)**
	(*b*)	$-2 = x\tan 45° - \frac{9.8\times x^2}{2\times 14^2}(1 + \tan^2 45°)$				M1 A1
		Simplifying "correctly" to quadratic of form $ax^2 + bx + c = 0$ (may be implied, e.g. $x^2 - 20x - 40 = 0$; $-0.05x^2 + x + 2 = 0$; $4.9x^2 - 98x - 196 = 0$)				M1
		Solving for *t* (2.205 s), $x = 14\cos 45°\, t$, $x = 21.8$ m				M1 A1 **(5)**
	(*c*)	$21.8_c = 14\cos 45°\, t$; $t = 2.2$ s				M1 A1 (cao) **(2)**
						(12 marks)

(ft = follow through mark; cao = correct answer only; cso = correct solution only;
* indicates answer is given on the examination paper)

Question Number	Scheme	Marks
6. (*a*)	$\leftarrow v_1$ $\rightarrow v_2$ $\rightarrow u$ 0 A ○ B ○ m 3m CoM: $mu = -mv_1 + 3mv_2$ $\Rightarrow \quad u = -v_1 + 3v_2$ NEL: $e\,u = v_2 + v_1$	M1 A1 M1 A1
	Solving : $v_1 = \frac{1}{4}(3e-1)u$ $v_2 = \frac{1}{4}(1+e)u$	M1 A1 A1 **(7)**
	Speed of B after hitting wall $= \pm\frac{3}{16}(1+e)u \quad (v_2^*)$	B1 ft
	For second collision $v_2^* > v_1$; $\frac{3}{16}(1+e)u > \frac{1}{4}(3e-1)u$	M1
	Solving, $e < \frac{7}{9}$	M1 A1
	Finding lower bound using $v_1 > 0$; $e > \frac{1}{3}$	M1
	Complete range: $\frac{1}{3} < e < \frac{7}{9}$	A1 (cso) **(6)**
		(13 marks)
7. (*a*)	 $F = 0.6R$ (seen anywhere) Moments about B: $R \times 2a\cos\alpha + F \times 2a\sin\alpha = W \times a\cos\alpha$ Using $\cos\alpha = \frac{12}{13}$ and $\sin\alpha = \frac{5}{13}$ Solving for R $\frac{24}{13}R + \frac{6}{13}R = \frac{12}{13}W \Rightarrow 30R = 12$ $\Rightarrow \quad R = \frac{2}{5}W$ *	M1 M1 A1 M1 M1 A1 **(6)**
(*b*)	Resolve $\leftrightarrow$: $T\cos\beta = F$; $= 0.6R = \frac{6}{25}W$ Resolve $\updownarrow$: $T\sin\beta + R = W$ $\quad T\sin\beta = \frac{3}{5}W$ Complete method for β [e.g $\tan\beta = 2.5$] ; $\quad \beta = 68.2°$ Complete method for T: substitute for β or $\sqrt{\{(0.6W)^2 + (0.24W)^2\}}$ $T = 0.646...W \Rightarrow \quad k = 0.65$ or 0.646	M1 A1 M1 A1 M1; A1 **(6)** M1 A1 **(2)**
		(14 marks)