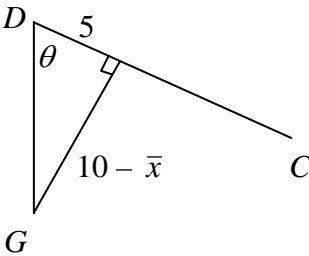
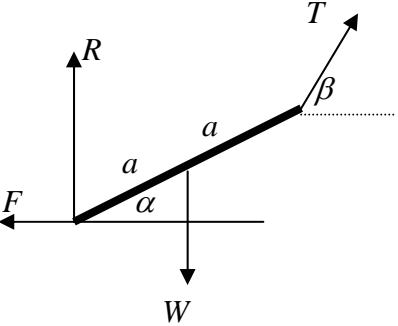


Question Number	Scheme	Marks
<p>1. (a)</p> <p>(b)</p>	<p>Differentiating: $\mathbf{a} = 3\mathbf{i} - 5\mathbf{j}$ (sufficient)</p> <p>Integrating: $\mathbf{r} = \left(\frac{3}{2}t^2 - 2t\right)\mathbf{i} - \frac{5}{2}t^2\mathbf{j} (+ C)$</p> <p>Using initial conditions to find C ($3\mathbf{i}$); $\mathbf{r}(t=2) = 5\mathbf{i} - 10\mathbf{j}$</p> <p>Distance = $\sqrt{5^2 + (10)^2}$; = $5\sqrt{5}$ or 11.2 or 11.18 (m)</p>	<p>M1A1 (2)</p> <p>M1A1</p> <p>M1; A1</p> <p>M1; A1 (6)</p> <p>(6 marks)</p>
<p>2. (a)</p> <p>(b)</p>	<p>$0 \leq t \leq 3$ $v = 2t^2 - \frac{1}{3}t^3 (+ C)$ Evidence of integration for M1</p> <p>$t = 3 \Rightarrow v = 9 \text{ m s}^{-1}$</p> <p>$t \geq 3$ $v = -\frac{27}{t} (+ C)$</p> <p>Using $t = 3$ and candidates' $v = 9$ to find C; $C = 18$</p> <p>Substituting $t = 6$ in expression for v; $v = 13.5 \text{ m s}^{-1}$</p>	<p>M1 A1</p> <p>A1 (3)</p> <p>B1</p> <p>M1; A1 ft</p> <p>M1; A1 (5)</p> <p>(8 marks)</p>
<p>3. (a)</p> <p>(b)</p>	<p>Change in KE: $\frac{1}{2} \times 80 \times (8^2 - 5^2)$ [loss: $2560 - 1000 = 1560 \text{ J}$]</p> <p>Change in PE: $80 \times g \times (20 - 12)$ [loss: $15680 - 9408 = 6272 \text{ J}$]</p> <p>WD by cyclist = $20 \times 500 - (\text{loss in K.E.} + \text{P.E.})$</p> <p style="padding-left: 40px;">= 2168 Nm (allow 2170 and 2200)</p> <p>Equation of motion: $F - 20 = 80 \times 0.5$ [M1 requires three terms]</p> <p>Power = $F_c \times 5$; = 300 W</p>	<p>B1</p> <p>B1</p> <p>M1 A1 ft</p> <p>A1 (5)</p> <p>M1 A1</p> <p>M1 A1</p> <p>(9 marks)</p>

(ft = follow through mark)

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

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

Question Number	Scheme	Marks
<p>6. (a)</p>	<div style="display: flex; justify-content: space-between;"> <div style="width: 30%;"> <p> $\leftarrow v_1$ $\rightarrow v_2$ $\rightarrow u$ 0 A ○ B ○ m 3m </p> </div> <div style="width: 60%;"> <p>CoM: $mu = -mv_1 + 3mv_2$</p> <p>$\Rightarrow u = -v_1 + 3v_2$</p> <p>NEL: $e u = v_2 + v_1$</p> </div> </div> <p>Solving : $v_1 = \frac{1}{4}(3e - 1)u$</p> <p>$v_2 = \frac{1}{4}(1 + e)u$</p> <p>Speed of B after hitting wall = $\pm \frac{3}{16}(1 + e)u$ (v_2^*)</p> <p>For second collision $v_2^* > v_1$; $\frac{3}{16}(1 + e)u > \frac{1}{4}(3e - 1)u$</p> <p>Solving, $e < \frac{7}{9}$</p> <p>Finding lower bound using $v_1 > 0$; $e > \frac{1}{3}$</p> <p>Complete range: $\frac{1}{3} < e < \frac{7}{9}$</p>	<p>M1 A1</p> <p>M1 A1</p> <p>M1 A1</p> <p>A1 (7)</p> <p>B1 ft</p> <p>M1</p> <p>M1 A1</p> <p>M1</p> <p>A1 (cso) (6)</p> <p>(13 marks)</p>
<p>7. (a)</p>	 <p>$F = 0.6R$ (seen anywhere)</p> <p>Moments about B:</p> <p>$R \times 2a \cos \alpha + F \times 2a \sin \alpha = W \times a \cos \alpha$</p> <p>Using $\cos \alpha = \frac{12}{13}$ and $\sin \alpha = \frac{5}{13}$</p> <p>Solving for R</p> <p>$\frac{24}{13}R + \frac{6}{13}R = \frac{12}{13}W \Rightarrow 30R = 12W$</p> <p>$\Rightarrow R = \frac{2}{5}W^*$</p>	<p>M1</p> <p>M1 A1</p> <p>M1</p> <p>M1</p> <p>A1 (6)</p>
<p>(b)</p>	<p>Resolve \leftrightarrow: $T \cos \beta = F; = 0.6R = \frac{6}{25}W$</p> <p>Resolve \uparrow: $T \sin \beta + R = W$ $T \sin \beta = \frac{3}{5}W$</p> <p>Complete method for β [e.g $\tan \beta = 2.5$]; $\beta = 68.2^\circ$</p> <p>Complete method for T: substitute for β or $\sqrt{\{(0.6W)^2 + (0.24W)^2\}}$</p> <p>$T = 0.646...W \Rightarrow k = 0.65$ or 0.646</p>	<p>M1 A1</p> <p>M1 A1</p> <p>M1; A1 (6)</p> <p>M1</p> <p>A1 (2)</p> <p>(14 marks)</p>