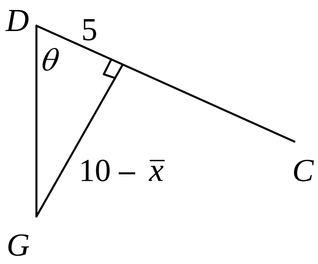
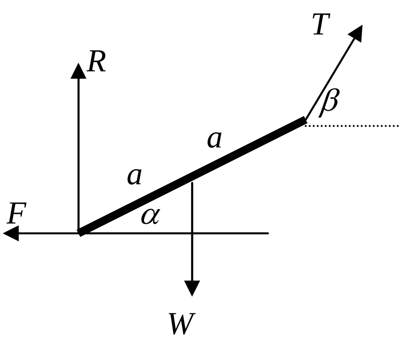
EDEXCEL MECHANICS M2 (6678) – JUNE 2002 **PROVISIONAL MARK SCHEME**

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**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 × 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: $mu = -mv_1 + 3mv_2$	M1 A1
	$\Rightarrow u = -v_1 + 3v_2$	
	NEL: $e\,u = v_2 + v_1$	M1 A1
	Solving : $v_1 = \frac{1}{4}(3e - 1)u$	M1 A1
	$v_2 = \frac{1}{4}(1 + e)u$	A1 **(7)**
	Speed of *B* after hitting wall $= \pm\frac{3}{16}(1 + e)u$ $(v_2{}^*)$	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)	M1
		
	Moments about *B*: $R \times 2a\cos\alpha + F \times 2a\sin\alpha = W \times a\cos\alpha$	M1 A1
	Using $\cos\alpha = \frac{12}{13}$ and $\sin\alpha = \frac{5}{13}$	M1
	Solving for *R*	
	$\frac{24}{13}R + \frac{6}{13}R = \frac{12}{13}W \Rightarrow 30R = 12$	M1
	$\Rightarrow R = \frac{2}{5}W$ *	A1 **(6)**
(*b*)	Resolve $\leftrightarrow$: $T\cos\beta = F$; $= 0.6R = \frac{6}{25}W$	M1 A1
	Resolve $\updownarrow$: $T\sin\beta + R = W$ $T\sin\beta = \frac{3}{5}W$	M1 A1
	Complete method for β [e.g $\tan\beta = 2.5$] ; $\beta = 68.2°$	M1; A1 **(6)**
	Complete method for *T*: substitute for β or $\sqrt{\{(0.6W)^2 + (0.24W)^2\}}$	M1
	$T = 0.646...W \Rightarrow k = 0.65$ or 0.646	A1 **(2)**
		(14 marks)