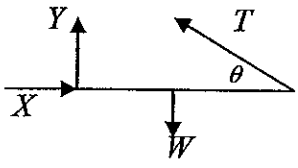
January 2005

6678 Mechanics M2
Mark Scheme

Question Number	Scheme	Marks
1.	 (a) $M(A)$ $W\times 4a = T\times 8a\sin\theta$ Using a value of $\sin\theta$ and solving $T=\frac{5}{6}W$ * cso (b) $\rightarrow$ $X = T\cos\theta$ $=\frac{2}{3}W$	M1 A1 M1 A1 4 M1 A1 A1 3 **7**
2.	(a) Mass ratios: circle 9π; rectangle 200; plate $200-9\pi$ Centres of mass: circle 6; rectangle 10; plate $\bar{x}$ $9\pi\times 6+(200-9\pi)\bar{x}=200\times 10$ $\bar{x}\approx 10.7$ (cm) cao (b) $\tan\theta=\frac{5}{10.7}$ ft their $\bar{x}$ $\theta\approx 25°$ cao	B1; B1ft B1 M1 A1 5 M1 A1ft A1 3 **8**

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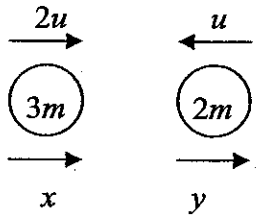
3.	(a) KE lost is $\frac{1}{2}\times 0.6\times\left(10^2-9^2\right)$ $\left(=5.7\text{ J}\right)$		B1
	PE lost is $0.6\times 9.8\times 12\sin 30°\left(=35.28\text{ J}\right)$		B1
	Total loss in energy is 41.0 (J)	accept 41	M1 A1 4
	(b) $R=0.6\times 9.8\times\cos 30°\left(\approx 5.09\right)$		B1
	WE $40.98=\mu\times 0.6\times 9.8\times\cos 30°\times 12$	ft their (a)	M1 A1ft
	$\mu\approx 0.67$ or 0.671		M1 A1 5 **9**
	Alternative for (b)		
	$a=\dfrac{9^2-10^2}{2\times 12}\left(=(-)\dfrac{19}{24}\right)$	awrt 0.79	B1
	N2L $mg\sin 30°-\mu mg\cos 30°=m\left(-\frac{19}{24}\right)$	ft their a	M1 A1ft
	$\mu\approx 0.67$ or 0.671		M1 A1 5
4.	(a) $\ddot{\mathbf{r}}=6\mathbf{i}+(2t+3)\mathbf{j}$		B1
	$\mathbf{F}=0.4(6\mathbf{i}+11\mathbf{j})$	0.4×something obtained by differentiation, with $t=4$	M1
	$\lvert\mathbf{F}\rvert=\sqrt{\left(2.4^2+4.4^2\right)}$	modulus of a vector	M1
	≈ 5.0	accept more accurate answers	A1 4
	(b) $\mathbf{r}=\left(3t^2+4t\right)\mathbf{i}+\left(\frac{1}{3}t^3+\frac{3}{2}t^2\right)\mathbf{j}\,(+\mathbf{C})$		M1
	Using boundary values, $\mathbf{r}=\left(3t^2+4t-3\right)\mathbf{i}+\left(\frac{1}{3}t^3+\frac{3}{2}t^2+4\right)\mathbf{j}$		A1
	$t=4$, $\mathbf{r}=61\mathbf{i}+49\frac{1}{3}\mathbf{j}$		A1
	$OS=\sqrt{\left(61^2+49\frac{1}{3}^2\right)}\approx 78$ (m)	accept more accurate answers	M1 A1 5 **9**

Question Number	Scheme	Marks
5.	(a) $50\,000 = F \times 25 \ (F = 2000)$ or equivalent	M1
	$\rightarrow \quad F = R + 750$	M1
	$R = 1250$ * cso	A1 3
	(b) N2L $1500 + 2000 = 2500a$ ignore sign of a	M1 A1
	$a = 1.4 \ (\text{m s}^{-2})$ cao	A1 3
	(c) Trailer: $T + R = 1500 \times 1.4$ *or* Car: $T - 1500 - 750 = 1000 \times -1.4$	M1
	$T = 850 \ (\text{N})$	A1 2
	(d) $25^2 = 2 \times 1.4 \times s \ (s = 223.2...)$	M1
	$W = 1500 \times s$ ft their s	M1 A1ft
	$= 335$ (kJ) accept 330	A1 4
	(e) Resistances vary with speeds	B1 1 **13**
6.	 (a) LM $6mu - 2mu = 3mx + 2my$	M1 A1
	NEL $y - x = 3eu$	B1
	Solving to $y = \frac{1}{5}u(9e+4)$ * cso	M1 A1 5
	(b) Solving to $x = \frac{2}{5}u(2-3e)$ oe	M1 A1
	$x < 0 \ \Rightarrow \ e > \frac{2}{3}$	M1 A1
	$\frac{2}{3} < e \mid 1$ ft their e for glb	A1ft 5
	(c) $2m\left[\frac{1}{5}u(9e+4)+u\right] = \frac{32}{5}mu$	M1 A1
	Solving to $e = \frac{7}{9}$ awrt 0.78	M1 A1 4 **14**

Question Number	Scheme	Marks
7.	(a) $\uparrow\ u_y = 32\times\frac{3}{5}\ (=19.2)$	B1
	$-20 = 19.2t - 4.9t^2$	M1 A2(1, 0)
	$t \approx 4.8$ or 4.77 (s)	A1 5
	(b) $\rightarrow\ u_x = 32\times\frac{4}{5}\ (=25.6)$	B1
	$d = 25.6\times 4.77...$	M1
	≈ 120 or 122 (m)	A1 3
	(c) $\uparrow\ v_y^2 = 19.2^2 + 2\times 9.8\times 4\ \left[v_y^2 = 447.04,\ v_y \approx 21.14\right]$	M1
	$V^2 = 447.04 + 25.6^2$	M1 A1
	$V = 33$ or $33.2\ (\text{m s}^{-1})$	A1 4
	(d) $\tan\theta = \dfrac{21.14}{25.6}\quad \left(\text{or } \cos\theta = \dfrac{25.6}{33.2}, ...\right)$ ft their components or resultant	M1 A1ft
	$\theta \approx 40°$ or $39.6°$	A1 3 **15**
	Alternative for (c)	
	$\frac{1}{2}m\left(V^2 - 32^2\right) = mg\times 4$	M1 A1
	$V^2 = 1102.4$	M1
	$V = 33$ or $33.2\ (\text{m s}^{-1})$	A1 4
	There is a maximum penalty of one mark per question for not rounding to appropriate accuracy.	