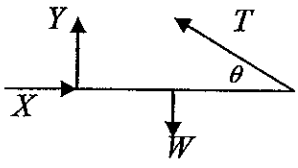
# January 2005

## 6678 Mechanics M2
## Mark Scheme

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

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| 3. | (a) KE lost is $\frac{1}{2}\times 0.6\times\left(10^2-9^2\right)$ $(=5.7\text{ J})$ | B1 |
| | PE lost is $0.6\times 9.8\times 12\sin 30°\,(=35.28\text{ J})$ | B1 |
| | Total loss in energy is 41.0 (J) accept 41 | M1 A1 4 |
| | (b) $R=0.6\times 9.8\times\cos 30°\,(\approx 5.09)$ | 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 |
| | $\approx 5.0$ 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 |

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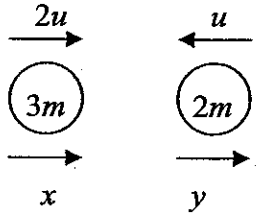
| **5.** | (a) $50\,000 = F \times 25 \ (F = 2000)$ or equivalent | M1 |
| | $\rightarrow \quad F = R + 750$ | M1 |
| | $R = 1250$ * cso | A1 3 |
| | (b) N2L $1500 + 2000 = 2500a$ ignore sign of $a$ | M1 A1 |
| | $a = 1.4 \ (\text{m s}^{-2})$ cao | A1 3 |
| | (c) Trailer: $T + R = 1500 \times 1.4$ *or* 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 |
| | $\frac{2}{3} < e \leqslant 1$ 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 |
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| 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 |
| | $\approx 120$ or $122$ (m) | A1 3 |
| | (c) $\uparrow\ v_y^2 = 19.2^2 + 2\times 9.8\times 4\quad [v_y^2 = 447.04,\ v_y \approx 21.14]$ | M1 |
| | $V^2 = 447.04 + 25.6^2$ | M1 A1 |
| | $V = 33$ or $33.2$ $(\text{m s}^{-1})$ | A1 4 |
| | (d) $\tan\theta = \frac{21.14}{25.6}\quad \left(\text{or } \cos\theta = \frac{25.6}{33.2}, ...\right)$ 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.* | |