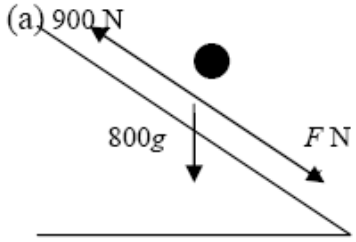
January 2007
6678 Mechanics M2
Mark Scheme

Question Number	Scheme	Marks
1.	(a) $\frac{1}{2}0.8\left(15^2-10^2\right)=50$ (J)	M1 A1 2
	(b) $F=\mu R=\mu 0.8g$	M1
	Work-energy $\mu 0.8g\times 20=50$ ft their (a)	M1 A1ft
	$\mu\approx 0.32$ accept 0.319	A1 4 **6**
	Alternative for (b)	
	$v^2=u^2+2as \Rightarrow a=\frac{15^2-10^2}{2\times 20}=3.125$	M1
	N2L $F=\mu mg=ma=3.125m$	M1 A1ft
	$\mu\approx 0.32$ accept 0.319	A1 4
	Alternative for (b)	
	WE $F=\frac{50}{20}\ (=2.5)$	M1
	$F=\mu R\Rightarrow\frac{50}{20}=\mu 0.8g$ ft their (a)	M1 A1 ft
	$\mu\approx 0.32$	A1 **4**
	The first M1 for *(b)* could be scored in *(a)*:	
	$v^2=u^2+2as\Rightarrow 10^2=15^2-2\times 20\times(-)a\Rightarrow a=(-)\frac{125}{40}$	*(b)*M1
	$F=ma\Rightarrow F=2.5$	
	$WD=F\times d\Rightarrow 2.5\times 20=50J$	*(a)*M1A1

2. (a)



$F + 800g\sin\alpha = 900$	M1	
$F = 573\frac{1}{3}$	A1	
$W = 573\frac{1}{3} \times 15 = 8600$	M1	
$= 8.6$ kW	A1	4

NB. Going up hill is an error, not a Misread

(b) N2L $800 \times 9.8 \times \frac{1}{24} - 900 = 800a$ * M1

$a = -\frac{43}{60}$ awrt -0.72 A1

$0 = 15 - \frac{43}{60}T$ M1

$T \approx 21$ accept 20.9 A1cso 4 **8**

* If they are using their F from (a) then they need to have scored the M1 in (a) in order to score the M1 here.

Alternative for (b)

WD: $573\frac{1}{3}s = \frac{1}{2} \times 800 \times 15^2$

$s = 157$

Use of $v^2 = u^2 + 2as$ M1 for getting as far as an equation in a.

$a = 0.72$ A1

finish as above.

2nd Alternative for (b)

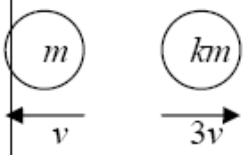
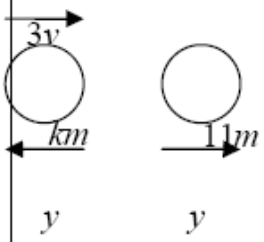
Ft = Change in momentum:

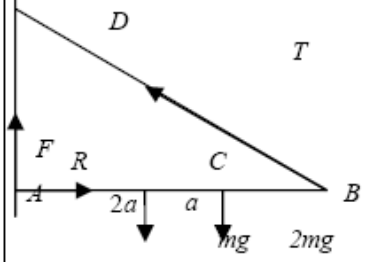
M1 Using the correct F

M1 Use of the method to form an equation

A1 Equation correct unsimplified but fully substituted

A1 $T \approx 21$

Question Number	Scheme	Marks
3.	(a) Large Small Template Mass Ratios 24^2 8^2, 512 anything in ratio 9 : 1 :8 *(c.1810 c.200 c.1610)* M(*A*) $9\times 24 = 16\times 1 + 8\bar{x}$ $\bar{x} = 25$ (cm) exact	B1, B1ft M1* A1 DM1* A1 6
	(b) M(axis) $11M = 12\times\frac{1}{4}m$ ft their $\bar{x}$ ($(36-\bar{x})M = 12\times\frac{1}{4}m$) $M = \frac{3}{11}m$ (o.e.e.)	M1 † A1ft DM1 † A1 4 **10**
4. (a)	  NEL $3v-(-v) = eu$ $u = 8v$	M1 A1 A1 3
(b)	LM $8mv = -mv + 3kmv$ ft their u $(m\times(u) = -mv + 3kmv)$ $k = 3$	M1 A1ft A1 3
(c)	 LM $9mv = -3my + 11my$ ft their k NEL $2y = e\times 3v$ $y = \frac{9}{8}v \Rightarrow e = \frac{3}{4}$ ★ cso	M1 A1ft M1 A1 4
	(d) $y = \frac{9}{8}v > v \Rightarrow$ further collision between P and Q A1 is cso – watch out for incorrect statements re. velocity	M1 A1 2 **12**

Question Number	Scheme	Marks
5.	(a) M(A) $T\sin\theta\times 4a = mg\times 2a + 2mg\times 3a$  $T = \frac{8mg}{4}\times\frac{5}{3} = \frac{10}{3}mg$ Accept 32.7*m*, *33m* (b) $\rightarrow$ $R = T\cos\theta = \frac{10}{3}mg\times\frac{4}{5}$; $= \frac{8}{3}mg$ * cso ft their T (c) $\uparrow$ $F + T\sin\theta = 3mg \Rightarrow F = mg$ ft their T Or: M(B) $F\times 4a = mg\times 2a + 2mg\times a \Rightarrow F = mg$ $F = \mu R \Rightarrow \mu = \frac{3}{8}$ (a) Alternative approach: $\rightarrow$ $R = T\cos\theta$ $\uparrow$ $F + T\sin\theta = 3mg$ M(B) $F\times 4a = mg\times 2a + 2mg\times a (\Rightarrow F = mg)$ $\Rightarrow mg + T\sin\theta = 3mg \Rightarrow T = \frac{2mg}{\sin\theta} = \frac{10mg}{3}$ If they use this method, watch out for F=mg just quoted in (c): M1A1	M1* A1=A1 DM1* A1 5 M1 A1ft; A1 3 M1 A1ft M1 A1 4 **12**

6.	(a) N2L $\left(1.5t^2-3\right)\mathbf{i}+2t\mathbf{j}=0.5\mathbf{a}$		M1
	$\mathbf{a}=\left(3t^2-6\right)\mathbf{i}+4t\mathbf{j}$		A1 2
	(b) $\mathbf{v}=\left(t^3-6t\right)\mathbf{i}+2t^2\mathbf{j}\quad(+\mathbf{c})$		M1 A1
	$t=2\quad -4\mathbf{i}+5\mathbf{j}=-4\mathbf{i}+8\mathbf{j}+\mathbf{c}\qquad(\mathbf{c}=-3\mathbf{j})$		M1
	$\mathbf{v}=\left(t^3-6t\right)\mathbf{i}+\left(2t^2-3\right)\mathbf{j}\qquad\left(\mathrm{m\,s^{-1}}\right)$		A1
	$t=3\qquad \mathbf{v}=9\mathbf{i}+15\mathbf{j}\left(\mathrm{m\,s^{-1}}\right)$ ✱	cso	A1 5
	(c) $\mathbf{Q}=0.5\left(-3\mathbf{i}+20\mathbf{j}-\left(9\mathbf{i}+15\mathbf{j}\right)\right)\quad\left(=0.5\left(-12\mathbf{i}+5\mathbf{j}\right)\right)$		M1
	$\left\|\mathbf{Q}\right\|=0.5\sqrt{\left(5^2+12^2\right)}=6.5$		M1 A1 3
	(d) acute angle is $\arctan\frac{5}{12}\approx 23°$		M1 A1
	or required angle is $\arctan\frac{-5}{12}$		
	or acute angle is $\arccos\frac{12}{13}\approx 23°$		
	or required angle is $\arccos\frac{-12}{13}$		
	required angle is 157°	awrt 157°, 203°	A1 3 **13**

Question Number	Scheme	Marks
7.	(a) Energy $\frac{1}{2}m\left(24.5^2-u^2\right)=mg\times 15$	M1 A1=A1
	$u^2=24.5^2-30g=306.25$	
	$u=\sqrt{306.25}=17.5$ ★ cso	A1 4
	(b) $\rightarrow \quad u_x=u\cos\theta=17.5\times 0.8=14$	B1
	$\psi=\arccos\frac{14}{24.5}\approx 55°$ accept 55.2°	M1 A1 3
	(0.96 rads, or 0.963 rads)	
	(c) $\uparrow \quad u_y=u\sin\theta=17.5\times 0.6=10.5$	B1
	$s=ut+\frac{1}{2}at^2 \Rightarrow -45=10.5t-4.9t^2$	M1 A1
	leading to $t=4.3$, awrt $t=4.3$ or $t=4\frac{2}{7}$	A1
	$\rightarrow \quad BD=14\times 4\frac{2}{7}$ (14 x t) ft their t	M1 A1ft
	$=60$ (m) only	A1 7 **14**
	Alternative for (a)	
	$\rightarrow u_x=u\cos\theta=0.8u$, $\uparrow u_y=u\sin\theta=0.6u$	
	$v_y^2=0.36u^2+2\times 9.8\times 15=0.36u^2+294$	
	$24.5^2=u_x^2+v_y^2=0.64u^2,+0.36u^2+294$	M1 A1,A1
	$u^2=306.25 \Rightarrow u=17.5$ ★ cso	A1 4
	Alternative for (b) $\rightarrow \quad u_x=u\cos\theta=17.5\times 0.8=14$	B1
	$\uparrow \quad v_y^2=u^2\sin^2\theta+2\times 9.8\times 15=404.25$	
	$\psi=\arctan\frac{\sqrt{404.25}}{14}\approx 55°$ accept 55.2°	M1 A1 3
	Alternative for (c) Use of $y=x\tan\theta-\frac{g\sec^2\vartheta}{2u^2}x^2$	M1
	$-45=\frac{3}{4}x$, $-\frac{g}{2\times 17.5^2}\times\frac{25}{16}x^2$	B1,A1
	$x^2-30x-1800=0$ o.e.	A1
	Factors or quadratic formula	M1 A1ft
	BD = 60 (m)	A1