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Mark Scheme (Results)
January 2009

GCE

GCE Mathematics (6678/01)

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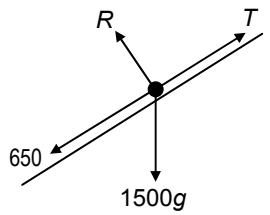
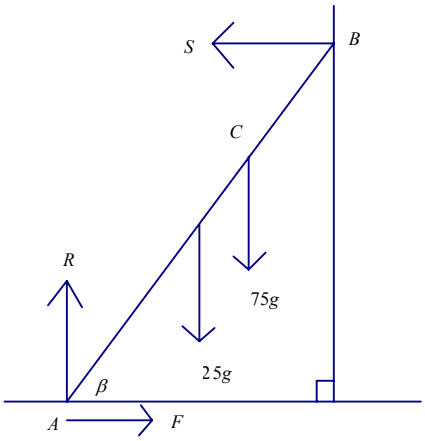
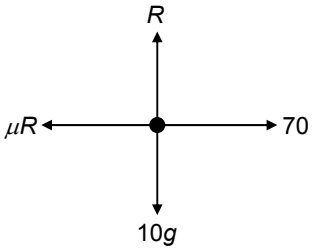
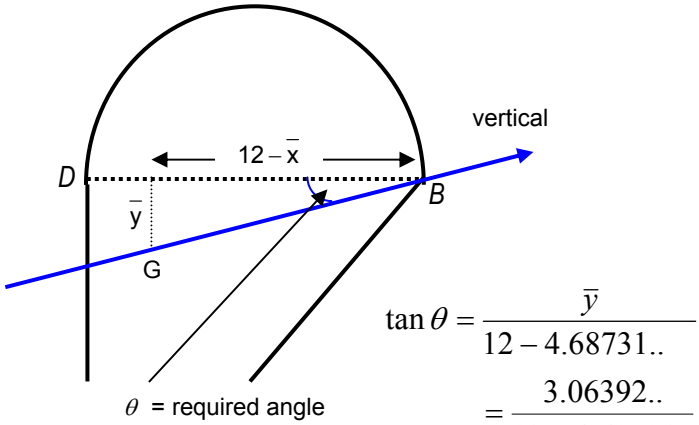
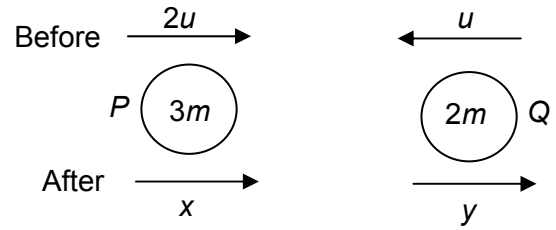
January 2009
6678 Mechanics M2
Mark Scheme

Question Number	Scheme	Marks
1	 F = ma parallel to the slope, $T - 1500g\sin\theta - 650 = 1500a$ Tractive force, 30000 = T x 15 $a = \frac{\frac{30000}{15} - 1500(9.8)(\frac{1}{14}) - 650}{1500}$ $\underline{0.2}$ (m s^{-2})	M1* A1 M1* d*M1 A1 (5) **[5]**
2 (a)	 $R(\uparrow): R = 25g + 75g(=100g)$ $F = \mu R \Rightarrow F = \frac{11}{25}\times 100g$ $= 44g\ (=431)$	B1 M1 A1 (3)
(b)	M(A): $25g\times 2\cos\beta + 75g\times 2.8\cos\beta$ $= S\times 4\sin\beta$ $R(\leftrightarrow): F = S$ $176g\sin\beta = 260g\cos\beta$ $\beta = 56(°)$	M1 A2,1,0 M1A1 A1 (6)
(c)	So that Reece's weight acts directly at the point C.	B1 **[10]**

Question Number		Scheme	Marks
3	(a)	 $R(\updownarrow): R = 10g$	B1
		$F = \mu R \Rightarrow F = \frac{4}{7}(10g) = 56$	B1
		$\therefore$ WD against friction $= \frac{4}{7}(10g)(50)$	M1
		$2800(\text{J})$	A1
			(4)
	(b)	$70(50) - \text{"}2800\text{"} = \frac{1}{2}(10)v^2 - \frac{1}{2}(10)(2)^2$	M1*
			A1ft
		$700 = 5v^2 - 20$, $5v^2 = 720 \Rightarrow v^2 = 144$	d*M1
		Hence, $v = \underline{12}$ (m s^{-1})	A1 cao
			(4)
Or	(b)	$\text{N2L}(\rightarrow): \ 70 - \frac{4}{7}R = 10a$	M1*
		$70 - \frac{4}{7} \times 10g = 10a$, $(a = 1.4)$	A1ft
		$AB(\rightarrow): v^2 = (2)^2 + 2(1.4)(50)$	d*M1
		Hence, $v = \underline{12}$ (m s^{-1})	A1 cao
			(4)
			[8]
4	(a)	$v = 10t - 2t^2$, $s = \int v dt$	M1
		$= 5t^2 - \frac{2t^3}{3}(+C)$	A1
		$t = 6 \Rightarrow s = 180 - 144 = \underline{36}$ (m)	A1
			(3)
	(b)	$\underline{s} = \int v\,dt = \underline{\frac{-432t^{-1}}{-1}}(+K) = \underline{\frac{432}{t}}(+K)$	B1
		$\text{t} = 6, \text{s} = \text{"}36\text{"} \Rightarrow 36 = \frac{432}{6} + K$	M1*
		$\Rightarrow K = -36$	A1
		At $t = 10$, $s = \frac{432}{10} - 36 = \underline{7.2}$ (m)	d*M1
			A1
			(5)
			[8]

Question Number	Scheme	Marks
5 (a)	MR: 108 ▽, 18π ⌓, $108+18\pi$ ◗	B1
	x_i $(\rightarrow)$ from AD: 4, 6, $\bar{x}$ y_i $(\downarrow)$ from BD: 6, $-\frac{8}{\pi}$, $\bar{y}$	B1
	$AD(\rightarrow)$: $108(4)+18\pi(6)=(108+18\pi)\bar{x}$	M1
	$\bar{x}=\dfrac{432+108\pi}{108+18\pi}=4.68731...=\underline{4.69}$ (cm) (3 sf) **AG**	A1
		(4)
(b)	y_i $(\downarrow)$ from BD: 6, $-\frac{8}{\pi}$, $\bar{y}$	B1 oe
	$BD(\downarrow)$: $108(6)+18\pi(-\frac{8}{\pi})=(108+18\pi)\bar{y}$	M1
		A1ft
	$\bar{y}=\dfrac{504}{108+18\pi}=3.06292...=3.06$ (cm) (3 sf)	A1
		(4)
(c)		M1
	$\tan\theta=\dfrac{\bar{y}}{12-4.68731..}$ $=\dfrac{3.06392..}{12-4.68731..}$	dM1 A1
	$\theta=22.72641...=\underline{23}$ (nearest degree)	A1
		(4) **[12]**

Question Number		Scheme	Marks
6	(a)	Horizontal distance: $57.6 = p \times 3$ $p = 19.2$	M1 A1 (2)
	(b)	Use $s = ut + \frac{1}{2}at^2$ for vertical displacement.	M1
		$-0.9 = q \times 3 - \frac{1}{2}g \times 3^2$	A1
		$-0.9 = 3q - \frac{9g}{2} = 3q - 44.1$	
		$q = \frac{43.2}{3} = 14.4$ ***AG***	A1 cso (3)
	(c)	initial speed $\sqrt{p^2 + 14.4^2}$ (with their p)	M1
		$= \sqrt{576} = \underline{24}$ (m s^{-1})	A1 cao (2)
	(d)	$\tan\alpha = \frac{14.4}{p} (= \frac{3}{4})$ (with their p)	B1 (1)
	(e)	When the ball is 4 m above ground:	
		$3.1 = ut + \frac{1}{2}at^2$ used	M1
		$3.1 = 14.4t - \frac{1}{2}gt^2$ o.e $(4.9t^2 - 14.4t + 3.1 = 0)$	A1
		$\Rightarrow t = \frac{14.4 \pm \sqrt{(14.4)^2 - 4(4.9)(3.1)}}{2(4.9)}$ seen or implied	M1
		$t = \frac{14.4 \pm \sqrt{146.6}}{9.8} = 0.023389\ldots$ or $2.70488\ldots$ awrt 0.23 and 2.7	A1
		duration $= 2.70488... - 0.23389...$	M1
		$= 2.47$ or 2.5 (seconds)	A1 (6)
or 6	(e)	M1A1M1 as above	
		$t = \frac{14.4 \pm \sqrt{146.6}}{9.8}$	A1
		Duration $2 \times \frac{\sqrt{146.6}}{9.8}$ o.e.	M1
		$= 2.47$ or 2.5 (seconds)	A1 (6)
	(f)	Eg. : Variable 'g', Air resistance, Speed of wind, Swing of ball, The ball is not a particle.	B1 (1) **[15]**

Question Number		Scheme	Marks
7	(a)	 Correct use of NEL	M1*
		$y - x = e(2u + u)$ o.e.	A1
		CLM ($\rightarrow$): $3m(2u) + 2m(-u) = 3m(x) + 2m(y)$ ($\Rightarrow 4u = 3x + 2y$)	B1
		Hence x = y – 3eu, 4u = 3(y-3eu) + 2y, ($u(9e + 4) = 5y$)	d*M1
		Hence, speed of $Q = \underline{\frac{1}{5}(9e + 4)u}$ **AG**	A1 cso
			(5)
	(b)	$x = y - 3eu = \frac{1}{5}(9e + 4)u - 3eu$	M1#
		Hence, speed P $= \frac{1}{5}(4 - 6e)u = \frac{2u}{5}(2 - 3e)$ o.e.	A1
		$x = \frac{1}{2}u = \frac{2u}{5}(2 - 3e) \Rightarrow 5u = 8u - 12eu, \Rightarrow 12e = 3$ & solve for e	d#M1
		gives, $e = \frac{3}{12} \Rightarrow \underline{e = \frac{1}{4}}$ **AG**	A1
			(4)
Or	(b)	Using NEL correctly with given speeds of P and Q	M1#
		$3eu = \frac{1}{5}(9e + 4)u - \frac{1}{2}u$	A1
		$3eu = \frac{9}{5}eu + \frac{4}{5}u - \frac{1}{2}u$, $3e - \frac{9}{5}e = \frac{4}{5} - \frac{1}{2}$ & solve for e	d#M1
		$\frac{6}{5}e = \frac{3}{10} \Rightarrow e = \frac{15}{60} \Rightarrow e = \frac{1}{4}$.	A1
			(4)
	(c)	Time taken by Q from A to the wall $= \frac{d}{y} = \left\{\frac{4d}{5u}\right\}$	M1†
		Distance moved by P in this time $= \frac{u}{2} \times \frac{d}{y}$ $\left(= \frac{u}{2}\left(\frac{4d}{5u}\right) = \frac{2}{5}d\right)$	A1
		Distance of P from wall $= d - x\left(\frac{d}{y}\right); = d - \frac{2}{5}d = \underline{\frac{3}{5}d}$ **AG**	d†M1; A1 cso
			(4)
or	(c)	Ratio speed P:speed Q = x:y = $\frac{1}{2}u : \frac{1}{5}(\frac{9}{4} + 4)u = \frac{1}{2}u : \frac{5}{4}u = 2:5$	M1†
		So if Q moves a distance d, P will move a distance $\frac{2}{5}d$	A1
		Distance of P from wall $= d - \frac{2}{5}d; = \underline{\frac{3}{5}d}$ **AG** cso	d†M1; A1
			(4)

Question Number	Scheme	Marks
(d)	After collision with wall, speed $Q = \frac{1}{5}y = \frac{1}{5}\left(\frac{5u}{4}\right) = \frac{1}{4}u$ their y	B1ft
	Time for P, $T_{AB} = \frac{\frac{3d}{5} - x}{\frac{1}{2}u}$, Time for Q, $T_{WB} = \frac{x}{\frac{1}{4}u}$ from their y	B1ft
	Hence $T_{AB} = T_{WB} \Rightarrow \frac{\frac{3d}{5} - x}{\frac{1}{2}u} = \frac{x}{\frac{1}{4}u}$	M1
	gives, $2\left(\frac{3d}{5} - x\right) = 4x \Rightarrow \frac{3d}{5} - x = 2x$, $3x = \frac{3d}{5} \Rightarrow x = \underline{\frac{1}{5}d}$	A1 **cao**
		(4)
or (d)	After collision with wall, speed $Q = \frac{1}{5}y = \frac{1}{5}\left(\frac{5u}{4}\right) = \frac{1}{4}u$ their y	B1ft
	speed $P = x = \frac{1}{2}u$, speed P: new speed $Q = \frac{1}{2}u : \frac{1}{4}u = 2:1$ from their y	B1ft
	Distance of B from wall $= \frac{1}{3} \times \frac{3d}{5}; = \frac{d}{5}$ their $\frac{1}{2+1}$	M1; A1
		(4)
2nd or (d)	After collision with wall, speed $Q = \frac{1}{5}y = \frac{1}{5}\left(\frac{5u}{4}\right) = \frac{1}{4}u$ their y	B1ft
	Combined speed of P and $Q = \frac{1}{2}u + \frac{1}{4}u = \frac{3}{4}u$	
	Time from wall to 2nd collision $= \frac{\frac{3d}{5}}{\frac{3u}{4}} = \frac{3d}{5} \times \frac{4}{3u} = \frac{4d}{5u}$ from their y	B1ft
	Distance of B from wall = (their speed)x(their time) $= \frac{u}{4} \times \frac{4d}{5u}; = \underline{\frac{1}{5}d}$	M1; A1
		(4) **[17]**