Mark Scheme (Results)

January 2008

GCE

GCE Mathematics (6679/01)

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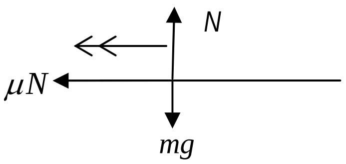
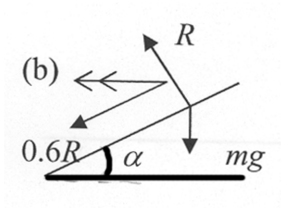
6679 Mechanics M3
Mark Scheme

Question Number	Scheme	Marks
1.(a)	T or $\dfrac{\lambda \times e}{l} = mg$ (even T=m is M1, A0, A0 sp case)	M1
	$\dfrac{\lambda \times 0.16}{0.4} = 2g$	A1
	$\Rightarrow \lambda = \underline{49\text{ N}}$ or 5g	A1 (3)
(b)	Special case $T\sin\theta = mg$ giving θ = 30 is M1 A0 A0 unless there is evidence that they think θ is with horizontal – then M1 A1 A0	
	R(↑) $T\cos\theta = mg$ or $\cos\theta = \dfrac{mg}{T}$	M1
	$49.\dfrac{0.32}{0.4}.\cos\theta = 19.6$ or $4g.\cos\theta = 2g$ or $2mg.\cos\theta = mg$ (ft on their λ)	A1ft
	$\Rightarrow \cos\theta = \frac{1}{2} \Rightarrow \theta = 60°$ (or $\dfrac{\pi}{3}$ radians)	A1 (3)
		6
2. a)	m ‘a’ = $\pm\dfrac{16}{5x^2}$, with acceleration in any form (e.g. $\dfrac{d^2x}{dt^2}$, $v\dfrac{dv}{dx}$, $\dfrac{dv}{dt}$ or a)	B1
	Uses $a = v\dfrac{dv}{dx}$ to obtain $kv\dfrac{dv}{dx} = \pm k'\dfrac{32}{x^2}$	M1
	Separates variables, $k\int v\,dv = k'\int \dfrac{32}{x^2}dx$	dM1
	Obtains $\frac{1}{2}v^2 = \mp\dfrac{32}{x}$ (+ C) or equivalent e.g. $\frac{0.1}{2}v^2 = -\dfrac{16}{5x}$ (+ C)	A1
	Substituting x = 2 if + used earlier or – 2 if – used in d.e. $x = 2$, $v = \pm 8 \Rightarrow 32 = -16 + C \Rightarrow C = 48$ (or value appropriate to their correct equation)	M1 A1
	$v = 0 \Rightarrow \dfrac{32}{x} = 48 \Rightarrow x = \frac{2}{3}$ m (N.B. $-\frac{2}{3}$ is not acceptable for final answer)	M1 A1 cao
		8
	N.B $\dfrac{d}{dx}(\frac{1}{2}mv^2) = \dfrac{16}{5x^2}$, is also a valid approach. Last two method marks are independent of earlier marks and of each other	

Question Number	Scheme	Marks
3.(a)	Large cone small cone S	
	Vol. $\frac{1}{3}\pi(2r)^2(2h)$ $\frac{1}{3}\pi r^2 h$ $\frac{7}{3}\pi r^2 h$ (accept ratios 8 : 1 : 7)	B1
	C of M $\frac{1}{2}h$, $\frac{5}{4}h$ $\bar{x}$ (or equivalent)	B1, B1
	$\frac{8}{3}\pi r^2 h.\frac{1}{2}h - \frac{1}{3}\pi r^2 h.\frac{5}{4}h = \frac{7}{3}\pi r^2 h.\bar{x}$ or equivalent	M1
	$\rightarrow \bar{x} = \frac{11}{28}h$ *	A1 (5)
(b)	tan $\theta = \frac{2r}{\bar{x}} = \frac{2r}{\frac{11}{28}h}, = \frac{2r}{\frac{11}{14}r} = \frac{28}{11}$	M1, A1
	$\theta \approx 68.6°$ or 1.20 radians	A1 (3) **8**
	(Special case – obtains complement by using tan $\theta = \frac{2r}{\bar{x}}$ giving 21.4° or .374 radians M1A0A0)	
	Centres of mass may be measured from another point (e.g. centre of small circle, or vertex) The Method mark will then require a complete method (Moments and subtraction) to give required value for $\bar{x}$). However B marks can be awarded for correct values if the candidate makes the working clear.	

4. (a)	Energy equation with at least three terms, including K.E term $\frac{1}{2}mV^2 + ..$ $+ .. \ \frac{1}{2}.\frac{2mg}{a}.\frac{a^2}{16}, + mg.\frac{1}{2}a.\sin 30, = \frac{1}{2}.\frac{2mg}{a}.\frac{9a^2}{16}$ $\Rightarrow V = \sqrt{\frac{ga}{2}}$	M1 A1, A1, A1 dM1 A1 (6)
(b)	Using point where velocity is zero and point where string becomes slack: $\frac{1}{2}mw^2 =$ $\frac{1}{2}.\frac{2mg}{a}.\frac{9a^2}{16}, -mg.\frac{3a}{4}.\sin 30$ $\Rightarrow w = \sqrt{\frac{3ag}{8}}$ Alternative (using point of projection and point where string becomes slack): $\frac{1}{2}mw^2 - \frac{1}{2}mV_1^2, = \frac{mga}{16} - \frac{mga}{8}$ So $w = \sqrt{\frac{3ag}{8}}$	M1 A1, A1 A1 (4) M1,A1 A1 A1 **10**
	In part (a) DM1 requires EE, PE and KE to have been included in the energy equation. If sign errors lead to $V^2 = -\frac{ga}{2}$, the last two marks are M0 A0 In parts (a) and (b) A marks need to have the correct signs In part (b) for M1 need **one** KE term in energy equation of at least **3 terms** with distance $\frac{3a}{4}$ to indicate first method, and **two** KE terms in energy equation of at least **4 terms** with distance $\frac{a}{4}$ to indicate second method. SHM approach in part (b). (**Condone this method only if SHM is proved**) Using $v^2 = \omega^2(a^2 - x^2)$ with $\omega^2 = \frac{2g}{a}$ and $x = \pm\frac{a}{4}$. Using 'a' = $\frac{a}{2}$ to give $w = \sqrt{\frac{3ag}{8}}$.	M1 A1 A1 A1

5.(a)	 $\frac{mv^2}{r} = \mu N, = \mu mg$ $\mu = \frac{v^2}{rg} = \frac{21^2}{75\times 9.8} = 0.6$ *	M1, A1 A1 (3)
(b)	 R(↑) $R\cos\alpha, \mp 0.6R\sin\alpha = mg$ $\Rightarrow R\left(\frac{4}{5} - \frac{3}{5}.\frac{3}{5}\right) = mg \Rightarrow R = \frac{25mg}{11}$	M1, A1, A1 A1 (4)
(c)	R(←) $R\sin\alpha, \pm 0.6R\cos\alpha = \frac{mv^2}{r}$ $v \approx$ 32.5 m s^{-1}	M1, A1, A1 dM1 A1cao (5) **12**
	In part (b) M1 needs three terms of which one is mg If cos α and sin α are interchanged in equation this is awarded M1 A0 A1 In part (c) M1 needs three terms of which one is $\frac{mv^2}{r}$ or $mr\omega^2$ If cos α and sin α are interchanged in equation this is also awarded M1 A0 A1 If they resolve along the plane and perpendicular to the plane in part (b), then attempt at $R - mg\cos\alpha = \frac{mv^2}{r}\sin\alpha$, and $0.6R + mg\sin\alpha = \frac{mv^2}{r}\cos\alpha$ and attempt to eliminate v Two correct equations Correct work to solve simultaneous equations Answer In part (c) Substitute R into one of the equations Substitutes into a correct equation (earning accuracy marks in part (b)) Uses $R = \frac{25mg}{11}$ (or $\frac{25mg}{29}$) Obtain v = 32.5	M1 A1 A1 A1 (4) M1 A1 A1 M1A1 (5)

6.(a)	Energy equation with two terms on RHS, $\frac{1}{2}mv^2 = \frac{1}{2}m.\frac{5ga}{2} + mga\sin\theta$	M1, A1
	$\Rightarrow v^2 = \frac{ga}{2}(5 + 4\sin\theta)$ *	A1 cso (3)
(b)	R(\\ string) $T - mg\sin\theta = \frac{mv^2}{a}$ (3 terms)	M1 A1
	$\Rightarrow T = \frac{mg}{2}(5 + 6\sin\theta)$ o.e.	A1 (3)
(c)	$T = 0 \Rightarrow \sin\theta, = -\frac{5}{6}$	M1, A1
	Has a solution, so string slack when $\alpha \approx 236(.4)°$ or 4.13 radians	A1 (3)
(d)	At top of small circle, $\frac{1}{2}mv^2 = \frac{1}{2}m.\frac{5ga}{2} - \frac{mga}{2}$ (M1 for energy equation with 3 terms)	M1 A1
	$\Rightarrow v^2 = \frac{3}{2}ga = 14.7a$	A1
	Resolving and using Force = $\frac{mv^2}{r}$, $T + mg = m.\frac{\frac{3}{2}ga}{\frac{1}{2}a}$ (M1 needs three terms, but any v)	M1 A1
	$\Rightarrow T = 2mg$	A1 (6)
		15
	Use of $v^2 = u^2 + 2gh$ is M0 in part (a)	

7.(a)	(Measuring x from E) $2\ddot{x} = 2g - 98(x + 0.2)$, and so $\ddot{x} = -49x$ SHM period with $\omega^2 = 49$ so $T = \frac{2\pi}{7}$	M1 A1, A1 d M1 A1cso (5)
(b)	Max. acceleration = 49 × max. x = 49 x 0.4 = 19.6 m s^{-2}	B1 (1)
(c)	String slack when x = –0.2: $v^2 = 49(0.4^2 - 0.2^2)$ $\Rightarrow v \approx 2.42$ m s^{-1} $= \frac{7\sqrt{3}}{5}$	M1 A1 A1 (3)
(d)	Uses $x = a\cos\omega t$ or use $x = a\sin\omega t$ but not with x = 0 or $\pm a$ Attempt complete method for finding time when string goes slack –0.2 = 0.4 cos 7t $\Rightarrow$ cos 7t $= -\frac{1}{2}$ $t = \frac{2\pi}{21} \approx 0.299$ s Time when string is slack $= \frac{(2)\times 2.42}{g} = \frac{2\sqrt{3}}{7} \approx 0.495$ s (2 needed for A) Total time = 2 x 0.299 + 0.495 ≈ 1.09 s	M1 dM1 A1 A1 M1 A1ft A1 (7) **16**
(a) (b) (c) (d)	DM1 requires the minus sign. Special case $2\ddot{x} = 2g - 98x$ is M1A1A0M0A0 $2\ddot{x} = -98x$ is M0A0A0M0A0 No use of $\ddot{x}$, just a is M1 A0,A0 then M1 A0 if otherwise correct. Quoted results are not acceptable. Answer must be positive and evaluated for B1 M1 – Use correct formula with their ω, a and x but **not** x = 0. A1 Correct values but allow x = +0.2 **Alternative** It is possible to use energy instead to do this part $\frac{1}{2}mv^2 + mg \times 0.6 = \frac{\lambda \times 0.6^2}{2l}$ M1 A1 If they use $x = a\sin\omega t$ with $x = \pm 0.2$ and add $\frac{\pi}{7}$ or $\frac{\pi}{14}$ this is dM1, A1 if done correctly If they use $x = a\cos\omega t$ with x = -0.2 this is dM1, then A1 (as in scheme) If they use $x = a\cos\omega t$ with x = +0.2 this needs *their* $\frac{\pi}{7}$ minus answer to reach dM1, then A1	