EDEXCEL FOUNDATION

Stewart House 32 Russell Square London WC1B 5DN

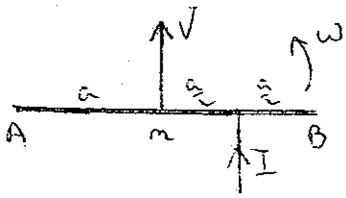
June 2002

Advanced Subsidiary /Advanced Level

General Certificate of Education

Subject **MECHANICS 6682** Paper No. **M6**

Final Version 2/7/02 Geoff Staley

Question number	Scheme	Marks
1. (a)	 Impulse = change in linear momentum	
	$I = mV \Rightarrow V = \frac{I}{m}$	M1A1
	Moment of impulse = change in ang. mom.	
	$\frac{1}{2}aI = \frac{1}{3}ma^2\omega$; $\Rightarrow a\omega = \frac{3I}{2m}$ (or ω = ..)	M1A1;A1
	Speed of $B = V + a\omega$; $= \frac{5I}{2m}$	M1;A1 (7)
(b)	Valid method for x [e.g. $V \pm x\,\omega = 0$]; $x = \frac{V}{\omega} = \frac{I}{m}.\frac{2ma}{3I}$	M1;A1√
	[A1√ dep. on M_1, M_2 and M_4]	
	$= \frac{2}{3}a$	A1 (3) **[10]**
2	$\ddot{y} = 0 \Rightarrow \dot{y} = u \Rightarrow y = ut$	M1A1
	[M for integration but accept with no working]	
	$\ddot{x} = -4y$; $(= -4ut)$	B1
	$\Rightarrow \dot{x} = -2ut^2 + c$	M1A√
	[M for $\int(-4y)\mathrm{d}t$ *with* $y = f(t)$]	
	Using limits correctly or finding "c" $(\dot{x} = -2ut^2 + u)$	M1
	Integrating: $x = ut - \frac{2}{3}ut^3$ [M dep. on prev. two Ms]	M1A1
	Setting x = 0 and solving for t	M1
	$t = \sqrt{\frac{3}{2}}$ s or **1.22 s**	A1 **[10]**

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3. (a)	$\frac{1}{r}\frac{\mathrm{d}}{\mathrm{d}t}\left(r^2\dot{\theta}\right) = 0;\ \Rightarrow\ r^2\dot{\theta} = \text{constant} = h$	M1A1 **(2)**
(b)	$r = a\sec 3\theta \qquad -\frac{\pi}{6} < \theta < \frac{\pi}{6}$	
	$\dot{r} = 3a\sec 3\theta\tan 3\theta.\dot{\theta}$	B1
	Using (a) to eliminate $\dot{\theta}$	
	$= 3r\tan 3\theta.\frac{h}{r^2} = \frac{3h\tan 3\theta}{r}$ (or $\frac{3ah\sec 3\theta\tan 3\theta}{r^2}$ or $\frac{3h\sin 3\theta}{a}$)	M1
	$\ddot{r} = 3h\frac{(r.3\sec^2 3\theta.\dot{\theta} - \tan 3\theta.\dot{r})}{r^2}$ or equivalent	M1A1A1
	[OR $\ddot{r} = 3a\sec 3\theta\tan 3\theta\ddot{\theta} + [9a\sec 3\theta\tan^2 3\theta + 9a\sec^2 3\theta]\dot{\theta}^2$ M1A2,1,0	
	Eliminate $\dot{\theta}$ *and* $\ddot{\theta}$ M1]	
	Complete method to stage $\ddot{r} = f(r)$ *only*	M1
	[e.g. $= \frac{3h}{r^2}\left(3\frac{h}{r}\sec^2 3\theta - 3\frac{h}{r}\tan^2 3\theta\right) = 3\frac{h}{r^2}.3\frac{h}{r}(\sec^2 3\theta - \tan^2 3\theta)$]	
	$\ddot{r} = 9\frac{h^2}{r^3}$	A1
	Mag. of accel. $= \ddot{r} - r\dot{\theta}^2;\ = 9\frac{h^2}{r^3} - \frac{h^2}{r^3} = 8\frac{h^2}{r^3}$ **($k = 8h^2$)**	M1A1√ **(9)**
		[11]

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4. (a)	[s = 20 sin ψ , $\frac{ds}{d\varphi} = 20\cos\psi$ (i), $s = 20\cos\psi\dot{\psi}$ (ii)]	
	Equation of motion approach : $-(m)g\sin\psi = (m)\ddot{s}$ or $(m)v\frac{dv}{ds}$	M1A1
	Arranging to integrable form: [A1√ on omission of – in prev. equation]	M1A1√
	[e.g. $-\int\frac{g}{20}s\,ds = \int v\,dv$ or $-20g\int\sin\psi\cos\psi\,d\psi = \int v\,dv$]	
	Integrate: $-\frac{g}{40}s^2 = \frac{1}{2}v^2 + (C)$ or $5g\cos 2\psi = \frac{1}{2}v^2 + (C)$ or equiv.	M1A1√
	Using limits correctly or finding C	M1
	$\Rightarrow 98\cos 2\psi + 49 = v^2$ *	A1 **(8)**
	[Alternative: Energy approach	
	$\frac{1}{2}mv^2 = mg(7.5 - \text{'y'})$	M1A1
	Finding y	
	$\frac{dy}{ds} = \sin\psi = \frac{s}{20}$ or $\frac{dy}{d\psi} = 20\sin\psi\cos\psi$	M1A1
	$\Rightarrow y = \frac{s^2}{40}$ (+ C) or y = – 5 cos 2ψ (+ C) or equivalent	M1A1
	Using limits correctly	M1
	$v^2 = 49 + 98\cos 2\psi$ * (cso)]	A1
(b)	Along normal: $R - 100g(\cos\psi) = 100\frac{v^2}{\rho}$	M1A1
	$\rho = \frac{ds}{d\psi} = 20\cos\psi$	B1
	$R = 100g + (5\text{x}147) =$ **1715 N** (1720,1700)	A1 **(4)** **[12]**

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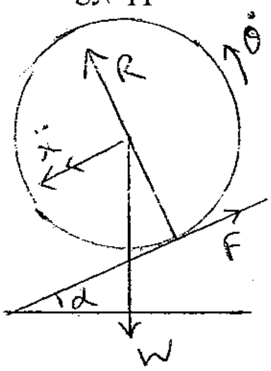
5. (a)	Method to find masses of end "discs" and curved "shell"	M1
	[$M = \rho(2\pi a^2 + 8\pi a^2)$, Masses are $\frac{M}{10}$, $\frac{M}{10}$ and $\frac{8M}{10}$]	
	$I = 2\left(\frac{1}{2}m_1 a^2\right) + m_2 a^2$	M1A1
	$= \frac{9}{10}Ma^2$ * (cso)	A1 **(4)**
(b)	Energy approach:	
		
	KE terms $\frac{1}{2}Mv^2$, $\frac{1}{2}I(\dot\theta)^2$	B1B1
	(Loss in) PE $= Mg\,5a\sin\alpha$	M1
	$v = a\dot\theta$ (seen anywhere)	B1
	Energy equation: $\frac{1}{2}Mv^2 + \frac{1}{2}I(\dot\theta)^2$ = loss in PE (no term in F)	M2
	Substituting for v and I (dep. on M2)	M1
	$\frac{1}{2}Ma^2(\dot\theta)^2 + \frac{1}{2}\frac{9}{10}Ma^2(\dot\theta)^2 = Mg\,5a\sin\alpha$	A1
	$\frac{19}{20}Ma^2(\dot\theta)^2 = Mg\,5a\sin\alpha$; $\dot\theta = 10\sqrt{\frac{g\sin\alpha}{19a}}$	M1;A1 **(10)**
	[Alternative approach:	**[14]**
	$Mg\sin\alpha - F = M\ddot{x}$; $Fa = I\ddot\theta$ M1A1;M1	
	$\ddot{x} = a\ddot\theta$ (seen anywhere) B1	
	Method for $\ddot{x}$: $Mg\sin\alpha - \frac{9}{10}M\ddot{x} = M\ddot{x} \Rightarrow \ddot{x} = \frac{10}{19}g\sin\alpha$ M1A1	
	[M dep. on prev. two Ms]	
	$v^2 = 2\ddot{x}s \Rightarrow v^2 = \frac{100}{19}ga\sin\alpha$ M1A1√	
	$\dot\theta = \frac{v}{a} = 10\sqrt{\frac{g\sin\alpha}{19a}}$ M1A1]	

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Question number	Scheme	Marks
6. (a)	Vertical component of velocity at wall unchanged	
	$\uparrow\ 0 = 14\sin\theta\ t - \frac{1}{2}g t^2$	M1A1
	$= 14\left(\frac{3}{5}\right)t - 4.9t^2$	
	$\Rightarrow\ t = \frac{12}{7}$ s or 1.71 s or $\frac{84}{5g}$	M1A1 (4)
(b)	Time to wall: $4 = 14\cos\theta\ t$; $t = \frac{5}{14}$ (0.357)	M1;A1
	Complete method for time from wall to A: $T = \frac{12}{7} - \frac{5}{14} = \frac{19}{14}$ (1.36)	M1
	Horizontal component of velocity = $14\cos\theta$	B1
	Horizontal component of velocity after rebound = $\frac{1}{2}(14\cos\theta)$	M1
	Distance from wall to A = $\frac{1}{2}(14\cos\theta)$ x $\frac{19}{14}$ = **7.6 m**	M1A1 (7)
	[Marks can be awarded if seen in longer methods for (a)]	
(c)	Vertical component of velocity at A is $14\sin\theta$	B1
	After hitting ground $v\uparrow = \frac{1}{2}(14\sin\theta) = 4.2$ (V)	B1√
	Time from A to B: $0 = Vt - \frac{1}{2}gt^2$; $t = \frac{6}{7}$ s (0.86)	M1A1√;A1
	Distance AB = $\frac{1}{2}(14\cos\theta)$ x $\left(\frac{6}{7}\right)_C$ = **4.8 m**	M1A1 (7)
		[18]