PHYSICS 2 SUMMER 2008
MIDTERM SOLUTIONS

Multiple Choice Questions

1. $\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & 3 & 0 \\ 1 & 0 & -1 \end{vmatrix} = -3\hat{i} + 2\hat{j} - 3\hat{k}$ C

2. $F = \frac{Gm_1 m_2}{d^2}$ $m_1 \to 2m_1$ and $m_2 \to 2m_2 \Rightarrow F \to 4F$ D

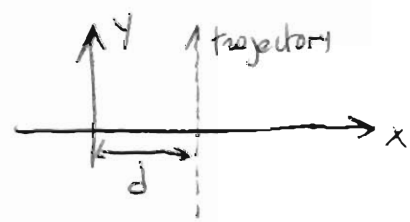
3. $F = \frac{GMm}{d^2}$ $d: R \to R + 3R = 4R \Rightarrow W \to \frac{1}{16} W = \frac{200}{16} N = 12{,}5\,N$

   $\frac{1}{16} = \left(\frac{1}{4}\right)^2$ A

4. Consider torque about hinge
   Torque due to string $= TL$
   Torque due to rod $= \frac{WL}{2}$
   $\Rightarrow TL = \frac{WL}{2} = 40\,Nm$ D

5. Angular momentum constant. $L = I\omega$. I decreases, therefore ω increases. A

6. Since $\vec{L} = \vec{r} \times \vec{p}$ and $\vec{L} \neq 0$ and $\vec{L}$ is conserved. $\vec{r}$ cannot be zero



   d = distance of closest approach
   $d = \frac{L}{p} = 4\,m$ B

7. $\vec{L} \perp \vec{r}$, $\vec{L} \perp \vec{p} \Rightarrow \vec{L} \perp (yx)$ plane $\Rightarrow$ A

8 $V_{CM} = \omega R = 10 \cdot 3 \frac{cm}{sec} = 30$ cm/sec E

9 $\frac{mv^2}{r} = \frac{GmM}{r^2} \Rightarrow v^2 = \frac{GM}{r} \Rightarrow v = \sqrt{\frac{GM}{r}}$ C

10 $F = -kx$ A

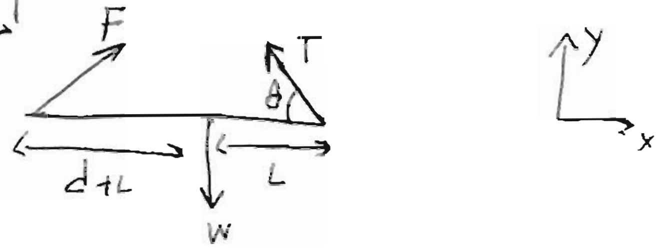
11 KE maximum as body goes through equilibrium (2)
EPE maximum when spring is stretched or compressed the most (3)
GPE maximum when object is highest (1) D

12 $\frac{F_\perp/A}{\Delta L/L} = Y$ $\Delta L = \frac{F_\perp}{A} \frac{L}{Y} \Rightarrow \Delta L$ largest when A smallest
B

13 At the highest point, bob has $\vec{v} = 0 \Rightarrow$ D
(like letting it fall from rest)

Problem 1

FBD



$\Sigma \vec{F} = 0$

$$\begin{cases} F_y + T\sin\theta = W & (1) \\ F_x - T\cos\theta = 0 & (2) \end{cases}$$

$\Sigma \vec{\tau} = 0$ take torques about hinge $\quad W(d+L) = T\sin\theta(d+2L) \quad (3)$

$$\boxed{T = \frac{W(d+L)}{\sin\theta\,(d+2L)}}$$

From equation (1) $\quad F_y = W - T\sin\theta = W - \frac{W(d+L)}{\sin\theta(d+2L)}\sin\theta$

$$F_y = W - \frac{W(d+L)}{(d+2L)} \qquad \boxed{F_y = \frac{WL}{d+2L}}$$

From equation (2) $\quad F_x = T\cos\theta \implies \boxed{F_x = \frac{W(d+L)}{\tan\theta\,(d+2L)}}$

Problem 2

(a) Let g = acceleration of gravity on planet

At the top, time ~~tmax~~ $= \frac{1}{2}t \qquad (t = 10\text{ sec})$

$$0 = v_0 - g\left(\frac{t}{2}\right) \implies \boxed{g = \frac{2v_0}{t}}$$

C = circumference $= 2\pi R = 10^8$ m

$$R = \frac{C}{2\pi} = \frac{10^8}{2\pi} = 1.59\ 10^7 \text{ m}$$

Grevity Force $F = \frac{GMm}{R^2} = mg$

$g = \frac{GM}{R^2}$

$\cancel{g = \sqrt{\frac{GM}{R^2}}}$

$$M = \frac{R^2 g}{G} = \frac{C^2}{4\pi^2} \frac{1}{G} \frac{2v_0}{t} \qquad \boxed{M = \frac{C^2 v_0}{2\pi^2 G t}}$$

$$M = \frac{(10^8)^2\, 10}{2\pi^2\, 6.67\, 10^{-11}\, 10}\, Kg = \frac{10^{27}}{2\pi^2\, 6.67}\, Kg = \underline{\underline{7.6\ 10^{24}\, Kg}}$$

(b) $F_{centripetal} = m\omega^2 (R+h) = \frac{GMm}{(R+h)^2}$ $\qquad h = 5\ 10^7\, m$

$\omega = \frac{2\pi}{T}$

$$\frac{4\pi^2}{T^2}(R+h) = \frac{GM}{(R+h)^2}$$

$$T^2 = \frac{4\pi^2 (R+h)^3}{GM} \qquad \boxed{T = 2\pi \sqrt{\frac{(R+h)^3}{GM}}}$$

$$T = 2\pi \sqrt{\frac{((1.59+5)\,10^7)^3}{6.67\ 10^{-11} \cdot 7.6\, 10^{24}}} = 1.49\ 10^5\, sec$$