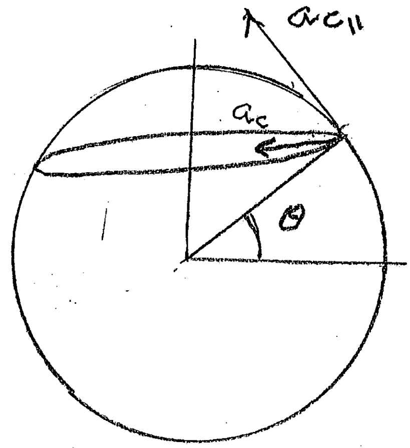
Answers – Week 6

6-1. No, as soon as you start driving on a curve, the pendulum bob starts going in a circle and so the string must tilt to provide the centripetal force. As long as the road is straight the system is <u>inertial</u>, but once you go on a curve the built in acceleration causes the pendulum to tilt at $\tan\theta = \dfrac{V^2}{Rg}$.

6-3. Because the Earth rotates about an axis through its poles a pt. at latitude θ has centripetal acceleration $\underset{\rightarrow}{a_c} = -R_E\omega_E^{\,2}\cos\theta\,\hat{r}_\theta$ $\perp$ radius of ⊕ 'at θ.



At the poles $\theta = \dfrac{\pi}{2}$, $a_c = 0$

Equator $\theta = 0$, $a_c = -R_E\omega_E^{\,2}\hat{r}$ $\perp$ radius of Earth at another θ, $\underset{\rightarrow}{a_c}$ has a component, $a_{c_\parallel}$, parallel to the Earth's surface.

Pendulum must tilt to provide force for $a_{c_\parallel}$.

6-5. The minus sign tells us that this force is pulling M_1 and M_2 toward one another. It is an attractive force.

6-7. For a hollow sphere of radius R_{shell}

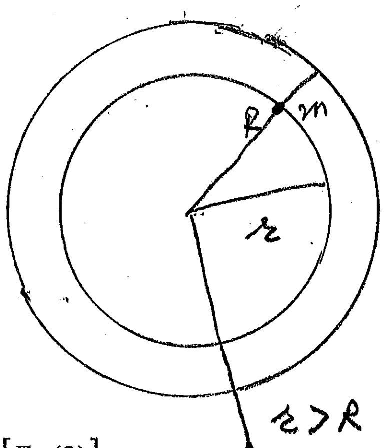
$\underset{\rightarrow}{F_G} = 0$ (1) $r < R_{shell}$

$$\underset{\rightarrow}{F_G} = \frac{-GM_{shell}m}{r^2} \quad (2)$$

$r > R_{shell}$

Solid sphere density

$$\rho = \frac{M}{\frac{4\pi}{3}R^3}$$



Frist put m at r < R. All the "shells" Lying between r and R give no force on M. All those between 0 and r give the force $[Eq(2)]$.

So r < R
$$\underset{\rightarrow}{F_G} = -G\frac{4\pi}{3}\rho r^3\frac{m}{r^2}\hat{r}$$
$$= -\frac{4\pi}{3}G\rho m r\hat{r}$$

For r > R, all the mass contributes so

$$\underset{\rightarrow}{F_G} = -\frac{GMm}{r^2}\hat{r}$$

6-9. By Kepler's law for Earth satellites

$$T_E^2 = \frac{4\pi^2}{GM_E} r_E^3$$

For satellites of Jupiter

$$T_J^2 = \frac{4\pi^2}{GM_J} r_J^3$$

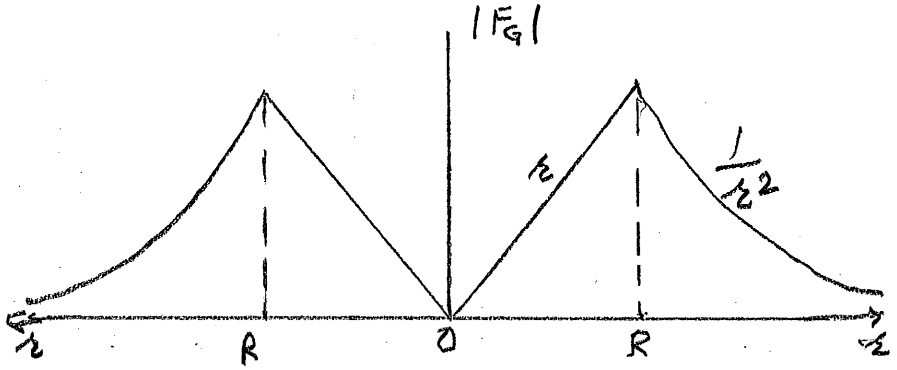
$$\frac{M_E}{M_J} = 3.13 \times 10^{-3}$$

6-11. $$T^2_{sun} = \frac{4\pi^2}{GM_{galaxy}} R^3_{sun} \qquad G = 6.7 x 10^{-11} \frac{N-m^2}{(kg)^2}$$

$T_{sun} = 6.3 \times 10^{14}$sec

Speed = 3×10^6m/s

6-13. As we learnt in problem 6-7 the magnitude of gravitational force at a distance r from the center of a solid sphere of radius R_E will look like



So force will be $\frac{mg}{4}$ at $r = \frac{R_E}{4}$, $2R_E$

It will be $\frac{mg}{2}$ at $r = \frac{R_E}{2}$, $\sqrt{2} R_E$