To get a rough estimate of the effects of the tidal field consider a pefectly smooth, spherical Earth completely covered w/ an ocean that responds immediately to the field. So, the height of the ocean $h(\theta)$ is an equipotential surface completely in balance b/w the Earth's & Moon's grav. pull

$$g_E h(\theta) = \frac{Gmr^2}{a^3}\left(\frac{3}{2}\cos^2\theta - \frac{1}{2}\right)$$

where $g_E = \frac{GM}{r^2}$

$$\therefore h(\theta) = h_0\left(\frac{3}{2}\cos^2\theta - \frac{1}{2}\right) \quad \text{where } h_0 = \frac{mr^4}{Ma^3}$$

for the Moon this is $h_0 \simeq 0.36\,m$ & for the Sun $h_0 \simeq 0.16\,m$

These are approx. the right magnitudes for the tidal bulges in the deep oceans. Coastal tides depend strongly on local topography & resonance may also enhance tides.

Two-Body Problems

Collisions

We are interested in 2 bodies interacting through very rapid internal forces that are only large when to bodies are close together (External forces like gravity are assumed to affect each particle equally & can be ignored).

As these are internal forces they are equal & opposite so the total linear momentum of the system is conserved:

$$\vec{p}_1 + \vec{p}_2 = \text{constant} \quad \text{where } 1 \text{ \& } 2 \text{ are the } 2 \text{ bodies}$$

or $m_1\vec{u}_1 + m_2\vec{u}_2 = m_1\vec{V}_1 + m_2\vec{V}_2$ $(\vec{u}_1, \vec{u}_2)$ before collisions
$(\vec{V}_1, \vec{V}_2)$ after collision

Most collision forces are conservative (e.g. electrostatic repulsion) so can write energy conservation:

$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1V_1^2 + \frac{1}{2}m_2V_2^2 + Q$$

when Q is the net gain or loss in KE that occurs in the collision.

If $Q = 0 \rightarrow$ elastic collision
$Q > 0$, energy loss
$Q < 0$, energy gain (say, an explosion during collision)

Direct Collisions:

Collisions that occur on a single straight line

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