Problem 13.12

Determine the *mass density ratio* between the moon and earth given that the acceleration of gravity on the moon is 1/6 that of the earth's.

This is an odd problem in the sense that it's main claim to fame is that it makes you *think.* An object's volume density is such that multiplying it by the body's volume give you its mass. Using that with N.S.L. and the acceleration information yields:

$$\frac{Gm_m \cancel{m_{you}}}{R_m^2} = \cancel{m_{you}} a_m$$

$$\Rightarrow \quad a_m = \frac{G\left(\rho_m\left(\frac{4}{3}\pi(R_m)^3\right)\right)}{R_m^2}$$

$$\Rightarrow \quad a_m = \frac{4}{3}\pi G\rho_m R_m$$

As for the earth:

$$\frac{Gm_e \cancel{m_{you}}}{R_e^2} = \cancel{m_{you}} a_e$$

$$\Rightarrow \quad a_e = \frac{G\left(\rho_e\left(\frac{4}{3}\pi(R_e)^3\right)\right)}{R_e^2}$$

$$\Rightarrow \quad a_e = \frac{4}{3}\pi G\rho_e R_e$$

Relating the accelerations and adding the radius relationship, we can write:

$$\left(\frac{1}{6}\right)a_e = a_m$$

$$\left(\frac{1}{6}\right)\left(\cancel{\frac{4}{3}}\cancel{\pi}\cancel{G}\rho_e \cancel{R_e}\right) = \left(\cancel{\frac{4}{3}}\cancel{\pi}\cancel{G}\rho_m\left(.250\cancel{R_e}\right)\right)$$

$$\Rightarrow \quad \frac{\rho_e}{\rho_m} = \frac{3}{2}$$