Gravitational Acceleration

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Newton's Law of Gravitation says that the gravitational force between an object of mass m_1 and an object of mass m_2 whose centers are at a distance r is

$$F = \frac{Gm_1m_2}{r^2}$$

where

$$G = 6.6742 \times 10^{-11} m^3 s^{-2} kg^{-1}$$

If one of the objects is the Earth, then $m_1 \approx 5.972 \times 10^{24}$ kg. Suppose the other is some small (relative to the mass of the Earth) mass m_2 on the surface of the Earth. Then $r \approx 6.378 \times 10^6$ m, and

$$\begin{aligned} F &= m_2 \left(\frac{\left(6.6742 \times 10^{-11}\mathrm{m}^3\mathrm{s}^{-2}\mathrm{kg}^{-1}\right)\left(5.972 \times 10^{24}\mathrm{kg}\right)}{\left(6.378 \times 10^6\mathrm{m}\right)^2} \right) \\ &= m_2 \left(9.798\,\mathrm{m}\,\mathrm{s}^{-2}\right) \end{aligned}$$

which gives the familiar constant of gravitational acceleration.

If a mass is at a height z above the surface of the Earth, so $r = r_E + z$, then $F = mg$, where

$$\begin{aligned} g &= \frac{Gm_E}{(r_E + z)^2} \\ &= \frac{Gm_E}{r_E^2} \cdot \frac{r_E^2}{(r_E + z)^2} \\ &= g_0 \left(\frac{r_E^2}{(r_E + z)^2} \right) \end{aligned}$$

If α is the ratio of z to the radius of the Earth, the right hand side becomes $g_0 \left(\frac{1}{(1+\alpha)^2} \right)$, and we see how g shrinks with α.

The top of Mount Everest is about 8849 meters above the surface of the Earth, giving an $\alpha-$value of .00139, and $g = .997 g_0$. To lower the gravitational constant to 90% of its surface-of-the-Earth value, one would have to be about 4% of an Earth radius (roughly 214 miles) above the surface.