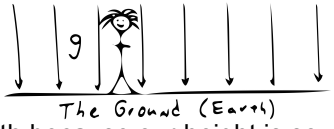
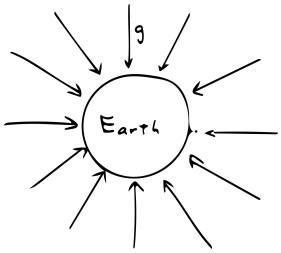
Flipping Physics Lecture Notes:
AP Physics 1 Review of *Universal Gravitation*

- Newton's Universal Law of Gravitation: $F_g = \frac{Gm_1m_2}{r^2}$
  - Universal Gravitational Constant: $G = 6.67\times10^{-11}\frac{N\cdot m^2}{kg^2}$
  - r is not defined as the radius, it is defined as the distance between the centers of mass of the two objects which can be confusing because sometimes it does work out to be the radius. ☺
  - $\vec{F}_g = m\vec{g}$ is planet specific.
  - $F_g = \frac{Gm_1m_2}{r^2}$ is universally true.
  - We can combine the two to solve for the acceleration due to gravity on Earth (or any large, celestial body): $F_g = m_o g = \frac{Gm_o m_E}{\left(R_E + alt\right)^2} \Rightarrow g = \frac{Gm_E}{\left(R_E + alt\right)^2}$

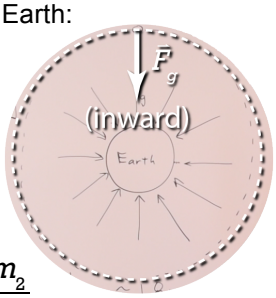


- The gravitational field is approximately constant on the surface of the Earth because our height is so small compared to the radius of the Earth. $h_{mr.p} \approx 1.8$ m, $R_E \approx 6{,}370{,}000$ m
- The gravitational field is not constant from a global perspective and decreases as altitude increases, this can be shown using a vector field diagram.



- Solving for the speed of the satellite in orbit around the Earth:
  - $\sum F_{in} = F_g = m_s a_c = \frac{Gm_s m_E}{r^2} = m_s\frac{v_t^2}{r}$

    $\Rightarrow v_t = \sqrt{\frac{Gm_E}{r}} = \sqrt{\frac{Gm_E}{\left(R_E + alt\right)}}$



- Universal Gravitational Potential Energy: $U_g = -\frac{Gm_1m_2}{r}$
  - The equation used to find gravitational potential energy in a non-uniform gravitational field.
  - $U_g \le 0$: The zero line is infinitely far away. $U_{g_\infty} = -\frac{Gm_1m_2}{\infty} \approx 0$
  - A single object can *not* have Universal Gravitational Potential Energy. Universal Gravitational Potential Energy is defined as the Gravitational Potential Energy that exists between *two* objects.
    - Technically Gravitational Potential Energy in a constant gravitational field: $PE_g = mgh$, is the gravitational potential energy that exists between the object and the Earth. So even PE_g requires two objects.