

AP Physics C – Gravity, acceleration due to gravity and potential energy due to gravity

So we will expand upon these two ideas

$F = ma$, $w = mg$ Use weight as mg on the surface of Earth, but when you are elsewhere, use

$F_g = G \frac{m_1 m_2}{r^2}$ This is true for anywhere, including the surface of the Earth. G is the universal gravitational constant = $6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$

A few things to remember about the force due to gravity:

1. always attractive (best looking force out there)
2. all matter is attracted together due to gravity no matter how small or far away
3. IMPORTANT – the force is directly proportional to each mass
4. IMPORTANT – the force is directly proportional to the square of the inverse of the distance apart (called the inverse square law – remember this and understand it!!)
5. the distance is measured from center to center of each object.

Since

$F_g = G \frac{m_1 m_2}{r^2} = mg$ if we divide out the mass of the object, we are left with the equation for g

$g = G \frac{m_2}{r^2}$ this is commonly called the gravitational field strength. You plug in the mass that you are “falling” toward and the distance away that you want to know the acceleration.

Potential energy:

$U_g = mgh$, $U_g = -G \frac{m_1 m_2}{r}$ the negative sign is assigned because the scientific community decided that when you are furthest away (infinitely far) that would be called 0 Joules of energy. So, everything below that point would be less energy and therefore negative

$$W = \int F dx \cos\theta$$

$$W = -\Delta U$$

$U_g = -\int -G \frac{m_1 m_2}{r^2} dr$ the negative sign on the force comes from the force point the opposite way r is measured. (F is toward the planet, r is away from the planet)

Artificial gravity:

If you spin a space station, the objects within the station will travel in a circle...you know what that means, centripetal force. The force required to move the objects in a circle will feel like gravity on earth if the speed and distance are right. To calculate the artificial gravity, just solve for the centripetal acceleration and compare that to the acceleration due to gravity on Earth. (EX. if $a_c = 10 \text{ m/s/s}$, then that feels like 1 g (one Earth gravity))

$$F_c = \sum F_r, \quad F_c = ma_c, \quad F_c = m \frac{v^2}{r}, \quad F_c = m\omega^2 r$$