There are two equations for the force of gravity. Know when to use them:

- $F_g = \frac{Gm_1m_2}{r^2}$ is always true. Yes, typically we use this equation for planet sized objects and larger, however, you could use this for an object on the surface of a planet.
- $F_g = mg$ is true where the gravitational field is constant. In the thin plane of existence where humans live on the surface of the Earth, the gravitational field strength is considered to be constant with negligible error.
    - Realize this force, like all other forces, is an interaction between two masses. On the surface of the Earth, the two masses are the Earth and whatever object's mass you are substituting into that equation.
- You can set the two equations equal to one another to solve for the acceleration due to gravity on any planet.
    - $F_g = \frac{Gm_{\text{object}}m_{\text{planet}}}{r^2} = m_og \Rightarrow g = \frac{Gm_{\text{planet}}}{r^2}$
    - Remember "r" is the distance between centers of mass of the two objects.
        - For an object near the surface of a planet, or orbiting a planet: $r = R_{\text{planet}} + \text{Altitude}_{\text{object}}$

Do not assume the force of static friction is always equal to its maximum value. Remember the force of static friction adjusts to prevent an object from sliding relative to the surface it is resting on.

- $F_{sf} \le \mu_s F_N$
- I dedicated several questions in my video Friction - AP Physics 1: Unit 2 Review Supplement to this concept, and there are many multiple-choice questions in my Ultimate Review Packet and Ultimate Exam Slayer which make sure you understand this. Please, please, please take the time to understand static friction!

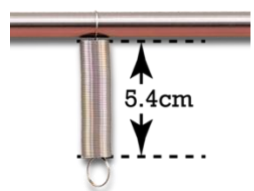
The force of friction is independent of surface area. This is considered to be true in all the AP Physics courses. This is the standard model for friction between two surfaces. Yes, it really is true.

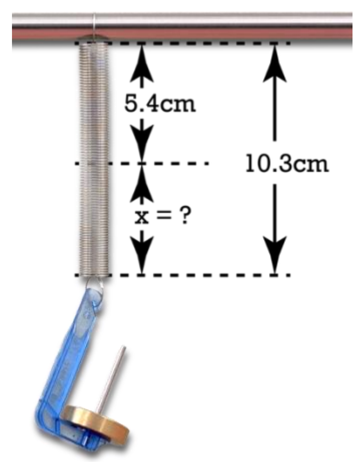
- $F_{sf} \le \mu_s F_N$ & $F_{kf} = \mu_k F_N$
- There is no surface area in either of those equations.

- When at least one of the surfaces is deformable, then the force of friction *does* depend on surface area; however, we do not consider that case in the AP Physics curriculum.
  - Yes, car tires are deformable and therefore surface area does affect the force of friction.
    - This is all for my Formula 1 fans out there. You are welcome.
- Please do not assume the normal force equals the force of gravity in the force of friction equations. We just discussed that!

The force of friction always opposes sliding motion. Yeah, I also made an entire video about this. Please make sure you understand it!

Do not confuse the natural length of a spring with "x" in Hooke's law: $F_s = -kx$





- The "x" in Hooke's law is the displacement of the spring from equilibrium position.
- The natural length of the spring is the length of the spring with no forces acting on the spring.
  - A spring with a natural length of 5.4 cm is hung vertically. A mass is placed on the spring and lowered slowly until the mass is at rest when the length of the spring is 10.3 cm.
    - The displacement of the spring from equilibrium position, x, is 4.9 cm.
      - Knowns: $L_i = 5.4cm;\ L_f = 10.3cm;\ x = ?$
      - $L_f = L_i + x \Rightarrow x = L_f - L_i = 10.3cm - 5.4cm = 4.9cm$

An object moving in a circle at a constant linear speed ***is*** *accelerating.*

- Velocity is a vector; it has both magnitude and direction.
  - The magnitude of the linear velocity is not changing.
  - The direction of the linear velocity is changing.
    - Therefore, the object does have a linear acceleration.
    - That linear acceleration is centripetal acceleration: $a_c = \frac{v_t^2}{r}$

The centripetal force is the net force in the in-direction on the object which causes the centripetal acceleration of the object which causes the change in direction of the velocity of the object.

- $$\sum F_{in} = ma_c \ \& \ a_c = \frac{{v_t}^2}{r} \Rightarrow \sum F_{in} = m\left(\frac{{v_t}^2}{r}\right)$$
- The Centripetal Force is not a new force. The centripetal force is the net force in the in-direction. So, the centripetal force is never, ever in a free-body diagram.