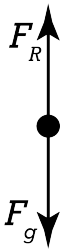
Flipping Physics Lecture Notes:

AP Physics C: Dynamics Review (Mechanics)
https://www.flippingphysics.com/apc-dynamics-review.html

- Newton's 1st Law: When viewed from an inertial reference frame, an object at rest will remain at rest and an object in motion will remain at a constant velocity unless acted upon by a net external force.
  - An inertial reference frame is where the acceleration of the reference frame zero.
  - A non-inertial reference frame is where the acceleration of the reference frame is not zero.
  - Also called the "Law of Inertia".
    - Inertia is the tendency of an object to resist acceleration.
- Newton's 2nd Law: $\sum \vec{F} = m\vec{a}$ on the equation sheet it is $\vec{a} = \frac{\sum \vec{F}}{m} = \frac{\vec{F}_{net}}{m}$.
- Newton's 3rd Law: $\vec{F}_{12} = -\vec{F}_{21}$
- $\sum \vec{F} = m\vec{a} \Rightarrow newtons, N = \frac{kg \cdot m}{s^2}$
- The basic forces with which we begin dynamics:
  - Force of Gravity also called Weight. $F_g = mg$
    - The force of gravity is caused by the interaction between the object and the planet.
    - The force of gravity is always down.
    - The acceleration due to gravity, g, her on planet Earth is +9.81 m/s^2.
    - Sometimes the symbol is W.
    - The force of gravity acts on the center of gravity of the object. (Which is the same as the center of mass in a constant gravitational field like the one we live in.)
  - Force Normal, F_N: A pushing force caused by a surface.
    - The force normal is normal to (perpendicular to) the surface.
    - The force normal is always a push. (Never a pull. A surface can't "pull".)
    - The force normal acts on the contact point between the two surfaces.
  - Force of Tension, F_T: The force caused by a rope, cable, wire, string, etc.
    - Always in the direction of the rope, cable, wire, string, etc.
    - Always a pull. (Never a push. You can't "push" with a rope.)
    - Sometimes the symbol is T.
  - Force Applied, F_a: The force of one object pushing or pulling on another object.
  - Force of Friction, F_f: The force caused by the interaction between two surfaces.
    - With regards to the direction of the Force of Friction. F_f always:
      - is parallel to the surface.
      - opposes motion (opposes sliding between the two surfaces)
      - is independent of the direction of the Force Applied.
    - General formula on the equation sheet: $\left|\vec{F}_f\right| \le \mu \left|\vec{F}_N\right|$
    - Static friction is when the two surfaces do NOT slide relative to one another.
      - $\vec{F}_{sf} \le \mu_s \vec{F}_N$ & $\vec{F}_{sf_{max}} = \mu_s \vec{F}_N$
    - Kinetic friction is when the two surfaces DO slide relative to one another.
      - $\vec{F}_{kf} = \mu_k \vec{F}_N$

        - The coefficient of friction, μ, is an experimentally determined, dimensionless number which depends on the materials of the two interacting surfaces.
            - General range is 0 – 2:
                - However, μ can get up to 4 in extreme circumstances.
            - $\mu_s > \mu_k$ (For the same two interacting materials.)
- Free Body Diagrams or Force Diagrams. The five steps are …
    1. Draw the Free Body Diagram(s).
    2. Break forces in to components.
    3. Redraw the Free Body Diagram(s).
    4. Sum the forces.
    5. Sum the forces (in a direction perpendicular to the direction in step 4).
        - Only forces are drawn in Free Body Diagrams.
        - When on an incline we will often break the force of gravity in to it's parallel and perpendicular components and sum the forces in the parallel and perpendicular directions. $F_{g_\perp} = mg\cos\theta$ & $F_{g_\parallel} = mg\sin\theta$
        - Always draw the Free Body Diagram without breaking forces into components first and then redraw the Free Body Diagram. These are specific instructions from The AP CollegeBoard!
        - When summing the forces you must identify:
            - Positive directions, especially for pulleys!
            - Which object(s) you are summing the forces on.
            - Which direction you are summing the forces in.
        - You can only sum the forces on multiple objects at the same time if they all have the same acceleration.
- Translational equilibrium.
    - Translational motion simply means moving from one location to another.
    - Translational Equilibrium means the net force acting on the object is zero, $\sum \vec{F} = 0$.
    - An object in translational equilibrium is not accelerating.
        - $\sum \vec{F} = 0 = m\vec{a} \Rightarrow \vec{a} = 0$.
            - The object moves with a constant velocity or is at rest.
- The Drag Force or the Resistive Force, F_R: The force caused by the interaction of an object and the fluid the object is moving through.
    - Sometimes the symbol is R or F_D.
    - Opposite the direction of motion of the object.
    - For "small" objects moving at "slow" speeds, $\vec{F}_R = -b\vec{v}$.
        - The resistive force equals the negative of, b, the proportionality constant times the velocity of the object.
    - For all other objects (and more generally applicable), $\vec{F}_R = \frac{1}{2} D\rho A v^2$.
        - D is the Drag Coefficient of the object, has no dimensions, is experimentally determined, and depends on the shape and surface texture of the object.
        - ρ is the density *of the medium* through which the object is moving.
        - A is the cross sectional area of the object normal to the direction of motion.
        - v is the velocity of the object.

- Terminal velocity is when an object moving through a fluid has reached translational equilibrium. Force example an object which is falling downward in the Earth's atmosphere has a free body diagram with the force of gravity down and the resistive force up.



  - $\sum F_y = F_R - F_g = ma_y \Rightarrow \frac{1}{2} D\rho A v^2 - mg = ma_y \Rightarrow a_y = \frac{\frac{1}{2} D\rho A v^2 - mg}{m} = \frac{D\rho A v^2}{2m} - g$
    - In other words, in the absence of air resistance, $a_y = -g$!!!
  - With $a_y = 0 \Rightarrow 0 = \frac{D\rho A v^2}{2m} - g \Rightarrow \frac{D\rho A v^2}{2m} = g \Rightarrow \boxed{v_{terminal} = \sqrt{\frac{2mg}{D\rho A}}}$
  - Note: This equation is only true for "an object which is falling downward in the Earth's atmosphere". A rocket moving upward will have a different equation for terminal velocity because the free body diagram is different.