Solving Dynamics Problems (3rd reference): Newton's Second Law

"Once is happenstance. Twice is coincidence. Three times begins to seem like a message to be ignored at one's peril".
*– The Orphan's of Raspay*

Setup State: Sketch a Free-Body Diagram

1. Isolate the object being analyzed.
   Identify ALL forces that act ON the object; NOT the forces it exerts on its surroundings.

2. Draw a *convenient* coordinate system.

3. Represent the object as a dot at the origin (particle model).

4. Draw vectors representing each of the identified forces. (Tail of force vector on the object. Illustrate angles.)

[new]

5. Illustrate the direction of the acceleration near the FBD (not on the center dot).
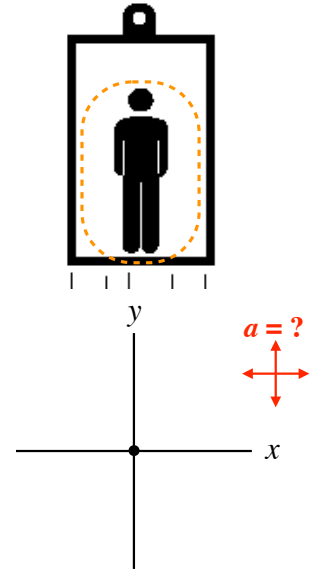
Analysis Stage: Apply Newton's Laws (i.e. "Read" the free-body diagrams).

▶ Similar to Newton's 1st Law problems, **EACH STEP IS GRADED**.

- **Physics Principle:** Write the relevant Newton's Law(s) equations(s) *independently* for each direction (axis). i.e: Newton's 2nd Law ($\Sigma F = ma$)

   example:

   $$\sum \vec{F}_y = m\vec{a}_y$$

- **Application:** Write the explicit sum of the vectors or component vectors along that direction. Note: there must be a variable for every force (arrow) in the FBD.

   $$\vec{F}_{1y} + \vec{F}_{2y} + ... + \vec{F}_{Ny} = m\vec{a}_y$$

- **Sign Convention:** Separate magnitude and direction. Use +/– signs to represent the direction of the force vectors **and** the acceleration vector. Note: the variables are now magnitudes, so no arrow caps; the direction is described by the +/– signs.

   $$F_{1y} - F_{2y} + ... - F_{Ny} = +ma_y$$

- Write the components in terms of the original magnitudes and functions of the angles (sin or cos), when applicable. If the angle is not known, you may leave it as a component.

   $$F_1 \cos\theta_1 - F_2 \sin\theta_2 + ... = +ma_y$$

- Identify and solve for the desired quantity.

Suggestion: Do not carry out algebraic steps until the direction is represented with +/– signs.