# 3.3 The Dynamics Protocol

"The Protocol" (as we call it) for dynamics is a method for understanding and solving a dynamics problem. You are not required to follow this protocol completely, but your protocol should include the basic steps in some order.

## Step 0 Identication

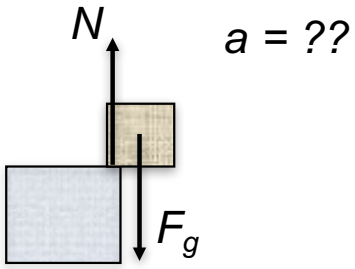
Before using any lens, you have to identify the most effective lens or lenses and provide motivation for it. Start by becoming familiar with the scenario you're exploring. Close your eyes and imagine it happening. Consider if you have any experience with anything like it. What was the outcome? Draw a good picture and indicate any relevant parameters. What's going on?

If the problem involves forces and mentions (zero or non-zero) acceleration or change in momentum, then dynamics is often a good lens to look at the problem.

## Step 1 Write $\sum \vec{F} = m\vec{a}$,

From formula F = ma, we know that if you apply a force to something it will accelerate. If you have several forces *acting on that single body*, you add these forces like vectors to get a *resultant force*. This resultant force causes the body to acceleration *in the same direction as the resultant force.* Thus, we must identify the forces *acting on the body* and the acceleration of the body.

## Step 2 Make a Free Body Diagram, and indicate acceleration




Make a simple diagram of the body showing all the force vectors acting on the body ONLY. That is, don't include forces that the body puts on a different body. Make the forces start from the point they are acting from. For instance, in the FBD for the smaller block at right, we can draw the force of gravity coming from the center of mass but the normal force is drawn from the place where the two blocks are in contact, *where the normal force is being applied. Off to one side,* indicate the direction of acceleration, or if the acceleration is zero if you know. Do not make the acceleration vector attach to the body – the acceleration is not a force. The acceleration *is caused by the resultant force.*

## Step 3 Add the Forces like vectors!

Add the forces "nose to tail" like vectors and make a *resultant vector* from the very beginning to the very end. If you know the direction of the acceleration, this resultant vector must be in the same direction of the acceleration. If it isn't, then something is not correct. If the body is in equilibrium, a = 0 and end of the last vector should be at the beginning of the first force vector, or "the snake bites its tail."

## Step 4 Define the positive direction.

In order to do the math correctly, you'll have to make sure you define a positive direction as in the diagram above. Forces in the opposite direction are negative. Prove to yourself that this is the right way to do it.

## Step 5 Substitute values to $\sum \vec{F} = m\vec{a}$ and solve

Example 1
You are in an elevator that is accelerating upwards at 2 m/s$^2$. Using your own mass, how much force is the elevator putting on you? Remember, it's not the answer, but rather following all the steps of the protocol that I wish to see.

Example 2
You are in an elevator and your mass is 50 kg. However, you find yourself standing upside down on the ceiling with the scale under you reading 100 N. What's the direction and magnitude of your acceleration? Remember, it's not the answer I want here, but the protocol. Can you follow it exactly until you have memorized it.

Disclaimer
No, you don't have to follow this protocol exactly. However, whichever protocol you use, it should be clear that you understand how to arrive at the solution. You will certainly need to identify all the forces in a drawing and identify the existence