5.2: The Problem Solving Framework

Solving problems in physics can be daunting task. Some solutions appear to be insights from the great beyond, or algebraic tricks that you'd never be able to reproduce on your own. Of course, the reason this appears to be the case is that the field of physics was developed by a bunch of experts on the natural world, who spent their entire lives studying it. They developed both analytical techniques and a general intuitive sense that can almost look like magic to mere mortals. However, the great thing about physics is that it's no mystery where these skills actually came from - the only thing we have to work with are the basic laws of the universe, and there are actually not many of those. For example, one could argue that in this textbook the only laws of the universe we are actually dealing with are the following:

- Conservation of Momentum
- Conservation of Energy
- Newton's three laws
- Kinematic Motion

(In fact, the last example on that list is really just an application of calculus, and perhaps should not be included at all. However, it will end up being a lot of what we do in the second half of this class, so we'll leave it there.)

Such a short list of things to learn! If all of mechanics is covered by that list, why does physics appear to be so hard? Well, that's because we are often applying these laws in situations which are new to us - if they weren't new, we could simply look up the answer, and that doesn't demonstrate any understanding of the physical world. To this end, we'd like to present the **problem solving framework**, which can tackle difficult (and easy!) problems we come across when trying to apply the physical laws we listed above.

The problem-solving framework is a 4-step process to get you from a problem statement to a solution, and is as follows[1]:

1. **Translate:** You might think about this step as "list the knowns and unknows": Take the words on the page and translate them into symbols, as appropriate. For example, "A train of mass 45 kg is traveling at a speed of 67 m/s", means that you can call the variable m the mass, v the speed, and they have particular values as part of the given information. This translation is necessary both because the language of physics is mathematical, and also it will help us organize our solution. This step also includes drawing the situation presented in the problem, and is a critical step that is often skipped by students. *A drawing will always help your thinking* - this is maybe even more true for a bad drawing, because it will be a sign that you do not yet understand the set up of the problem! Walk by the office of any physicist in the world and you will see sketches on a blackboard of whatever they were last working on.
2. **Model:** Decide what physical law you want to use to solve the problem. Sometimes, this is simply picking an equation to use ("this problem is asking us to find the center of mass, so I'm going to use the center of mass formula..."), but more often this step means picking one of the physical laws from the list above to use to solve the problem.
3. **Solve:** Solve! Perform whatever mathematical manipulations needs to be done to find the quantity that you can use to answer the question. Note that in many cases, this can be the longest and most difficult step, but *it also contains no physics!* The physics is done already in step 2, now we are just using math.
4. **Check:** It's critical to check your answer - at least to make sure it *could* be physically reasonable. Sometimes this is just "I found that this car is traveling at 800 mph, is that reasonable?" (no, you did something wrong!) A better way to do this step would be to pick an alternative solution to verify you get the same answer. The classic way to do this is to use Newton's laws if you solved it first with a conservation law, or vice versa. But since this is physics, we are always calculating something about the real world, and we should always be able to see if our calculations roughly match our expectations.

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[1]This framework was inspired by Unit C of Thomas Moore's textbook series *Six Idea That Shaped Physics.*
