The Ten Steps to Problem Solving[†]

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An important part of mastering physics is to learn the skill of problem solving. Physics is quantitative, and for many of the questions we ask we seek quantitative answers. The following steps will help you organize your thoughts and take a systematic approach to solving problems on both homeworks and tests.

1. *Read the problem carefully at least twice.* After that, if you don't understand what the problem is about and what physical situation is being considered, read it again.

2. *Write down the list of known quantities given in the problem.* Be sure to include the appropriate units. It is helpful to use standard notations for variables, *i.e.* m for mass. If there is more than one mass, consider using subscripts. Also include any physical constants that you think might be helpful.

3. *Write down the list of unknown quantities that the problem asks you to find.* Essentially, what are you looking for? Assign those quantities variable names, and put '= ?' by each.

4. *Draw a picture.* Visualization can be a powerful aid in determining what physical principles are being explored. It also helps illuminate relationships between quantities. Be sure to label the diagram with both the known and unknown quantities. It is often useful to introduce a coordinate system. If you do so, make sure to label the axes.

5. *Be sure that all quantities are in the same system of units.* If not, do the appropriate conversions to a common system of units. Much of the time, incorrect answers can be attributed to lack of care here.

6. *Write down any physical, mathematical or logical relationships among variables that might be of use.* These can be physical relationships, *e.g.*, Newton's Second Law, Conservation of Momentum, etc; or just mathematical ones like the Pythagorean Theorem. Asking yourself what physical principle is being illustrated by the problem can give valuable clues.

7. *Check to see that you have as many equations as unknowns.* The problem isn't solvable if there aren't as many constraints on the unknowns as there are unknowns. If there aren't enough constraints, consider what other physical or mathematical principles might restrict the unknowns.

8. *Solve the system of equations for the unknowns.* You may need to solve simultaneous equations, or it may be that a single equation has only one unknown. It is often helpful here to make sure that your equations are dimensionally correct. That is, the units on one side of the equation should match the units on the other side. If they do not, then you need to retrace your steps, as you should suspect that there is a mistake. It is also a good idea to ask yourself what happens when when one of the variables approaches a limiting value, say goes to zero or becomes very large. Do you get the behavior that you'd expect?

9. *Insert numerical values for the known quantities into the expressions for the unknowns to get numerical values for the unknowns.* Do not insert numerical values into an equation until you have solved for the unknown quantity in terms of known quantities. Be sure to attach the correct units to any answer. I often put the final answer for the unknowns in square brackets [. . .] beside the question marks in step 3. The reason we wait until this step to insert numerical values is that it may be that some factors cancel out, and it is usually good to know the functional dependence of the unknowns on the knowns. Also, use the appropriate significant figures!

10. *Ask yourself: Do these answers make sense?* If the result of your calculation is that a standard $8'' \times 11.5''$ piece of paper weighs two pounds, then consider the possibility that you've made a mistake. That is, the answer should have the correct order-of-magnitude. If not, retrace your work and search for errors.

[†]I first encountered these steps written out explicitly in this form by Chris Wright, physics teacher extraordinaire at Camden High School, Camden SC. This document is available at `http://www.wissenplatz.org/materials/StepsToProblemSolving.pdf` and may be freely distributed, as long as it is done so in its entirety.

Wow! That seems like A LOT of work! You're probably tired just reading through it all. Well, why should you solve problems this way, you ask? There are several reasons.

1. I've been solving physics problems longer than you have, and in my experience these steps actually make the entire process easier. In fact, it can become second nature to do so. In short, it works!
2. When you come to review the problems that you've solved, having the solution in this format will make it easier to follow. Really. Trust me—you don't want pages of scribbling with the answer magically appearing at the bottom.
3. If you come to visit me during office hours, and claim to have difficulty solving a problem, I'm going to ask you to show me how far you've gotten in these steps. Guaranteed to happen. If you don't have anything written out, I might suspect that you haven't thought about the problem very much.
4. The above should really be enough to convince you. But if you need more, let me give you one last reason: Exam and quiz problems will be graded according to how well you follow these steps. Yes, just writing down the knowns and unknowns, and drawing a picture is worth partial credit! And if you make a mistake in solving the problem, you are much more likely to receive only a small penalty. If the grader can't figure out where you went wrong, you'll lose more points. And, if you have the correct answer, but no discernible path to that answer—you didn't show your work—then you get no credit! Ouch. I am much more interested in how you approach problems—*how you think about physics*—than I am in the actual answer.

Not all of these steps are appropriate for every problem, but they should be seen as the default, and you should try to included each step when possible.