

# PROBLEM SOLVING GUIDELINES

Effective problem solving *can be learned!* The ability to learn physics and then apply it to the solving of problems is greatly facilitated by acquiring good problem solving habits. The techniques listed below are employed by *all experienced scientists* - in nearly *every* problem! (This remarkable fact surfaced unexpectedly in recent American Physical Society studies of the 'problem solving process'.) I would like you to exercise these techniques and ask that any piece of written work you submit contain them - even if only in an "ever-so-abbreviated" form.

1. Draw a picture of the physical situation (before and after if appropriate). The picture should be about a half page in size – anything smaller is *useless*. Often, an accurately drawn picture will immediately clear up your questions without further inquiry.
2. Identify your symbols - either by words or some reference (e.g. arrows) to your picture.
3. Identify your goal - i.e. a brief (even telegraphic !) description of what you're trying to achieve.
4. Identify all basic pertinent equations. Start from fundamental equations only - not special cases.
5. **Work the problem with symbols only.** Find a simplified *symbolic answer* - then - *only at the end*- substitute in numerical values for each symbol.
6. Check for correct units in your symbolic answer.
7. Check that your answer **MAKES SENSE**. This is usually done by sticking in values for the symbols in your symbolic answer for which the outcome is (roughly) known - and then observing that your solution does indeed give the expected result.

**REMEMBER!** Physics is about *relationships*. The *whole point* of modern science is that there are *very few* basic relationships and that... *all other relationships spring from them!* Thus, what we are interested in here is not just "some numerical outcome or other" ... but rather the understanding of how one arrives at the solution of any specific problem by starting from those (*few!*) basic fundamental relationships. Accordingly, the derivation and the algebraic form representing the final *relationship* are *much* more important than the simple numerical outcome. You are not "done" with a problem until your mind sees how that derivation proceeds. This is what we will mean by "completing a problem" and it is what I am looking for in your homework solutions and on exams. **The answer is the *relationship* ... not the number!!!**

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**FORMAT:** Please use quadrille ruled engineering paper for all your solutions and use one side of each sheet only! On the first page include your name, the date and the problem set number. Number all sheets in the upper right-hand corner using a "ratio" notation i.e. (page-number) / (total pages). Include at least your initials in the upper right corner as well. In general, each problem will require at least one full side (and often more) to include all the above steps - don't stint on space!! - spread out. You are responsible for stapling your sheets together before class -! ... *Don't come to me asking for a stapler!*

**Grading homework problems.** I use the 2 point grading scheme: 1-point is given for an accurate picture and correct assessment of the "kind" of problem at hand and for writing down the correct **fundamental** equations pertinent to this problem. The second point is given for correctly applying the general equations of physics to the specifics of the problem at hand and for successfully bringing the problem to algebraic completion. A final "difficulty multiplier" indicated by the number of stars e.g. ★★ will be applied to the individual problem score.

**Grading problems on exams.** I use the 1-2-4-3 grading scheme: 1-point is given for an accurate picture and correct assessment of the "kind" of problem at hand, 2-points are given for writing down the correct **fundamental** equations pertinent to this problem, 4-points are given for correctly applying the general equations of physics to the specifics of the problem at hand, 3-points are given for successfully bringing the problem to algebraic completion. **NB!** If you should "miraculously" produce the correct numerical outcome of any problem but without the foregoing work being listed in detail...your answer will be accorded no points. Conversely, if you should correctly work your way through the algebraic solution but then carelessly substitute incorrect numerical values at the end, that solution will be accorded full (or nearly full) credit.

# THE LAB NOTEBOOK

A good lab notebook is a useful and permanent working document. It may not be as polished as other pieces of work which you write several times before submitting - nonetheless, it should be characterized by a completeness, readability, and sturdiness of organization which allows profitable reference to it even after the passage of time. Once again, building good habits is the key - all successful scientists have them.

## I. General Physical Description

✓ We ask that you use a spiral notebook with 8 1/2" x 11" quadrille ruled paper and that you number your pages for easy reference. Be sure to print your name, section number, *and* chosen lab time on the front of your lab book.

✓ Start the lab book off with a table of contents which you should update each time you undertake a new lab exercise. List the labs in order by title and the page numbers they occupy. Be sure to include the date you performed the data taking. You have completed a lab when I assign a permanent grade next to the lab listing in your table of contents.

## II. The Lab Write-Up

Each lab will be represented by your *Rough Pages* and your *Formal Write-up*.

**Rough Pages:** Start each lab with a few 'rough pages' containing the **raw data** and **sketches** entered during the actual performance of the lab exercise. The rough pages are an important part of the lab book. The lab write-up proper will process this 'raw information' to produce your 'finished product' . . .

◆→ Now start the lab write-up proper with: ✓ the formal title of the lab, ✓ the date on which you wrote it up, and ✓ the names of the lab partners at your particular lab station with whom you performed the lab.

A good formal write-up will contain:

- a) **An Abstract:** Your abstract will, in general, tell what "physical theory" is being placed under scrutiny and the general scheme of how you intend to do that (usually the demonstrated validity of some proposed relationship/equation). (1 point)
- b) **Theory Section:** In this section you will *derive* the working equations (the equations you actually use) from fundamental equations. In the later labs you will also *derive* your working uncertainty formulae from fundamental expressions. It is important, here, to clearly point out *exactly* where the act(s) of comparison between theory and measurement will take place. (2 points)
- c) **Procedure and Apparatus:** Include rough but complete sketches of apparatus and a brief description of how you took data. I suggest that, at this point, you also include necessary sizes and masses etc. in your sketches. (1 point)
- d) **Data Tables:** A record of relevant data taken - written in table form. Include units and make your tables spacious. (2 points)
- e) **Analysis:** Analysis of the data along with estimation of uncertainties. This is the place you employ your working equations and present your results in a form available for easy comparison. In many cases you will include either a graph with multiple curves or a final table with the most crucial values to be compared placed side by side (2 points)
- f) **Evaluation and Conclusion:** In general this will be the comparison between measured and predicted results – and the evaluation. The prime question to answer each time is: *Did the predictions agree with the measurements **within uncertainty**?* You will, *almost always*, want to summarize the pivotal comparison values in a small final table. (2 points)

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10 points total

Lab #	<i>Title</i>	<i>Page #s in lab-book</i>	<i>Lab-date &amp; Writeup date</i>	<i>Lab-grade</i>	<i>Class-grade</i>
1	<b>Intro to Lab</b>				
2	<b>Intro to Motion</b>				
3	<b>Freefall</b>				
4	<b>Projectiles</b>				
5	<b>Newton's 2nd</b>				
6	<b>Friction</b>				
7	<b>Circular Motion</b>				
8	<b>Work Energy</b>				
9	<b>Impulse &amp; Momen.</b>				
10	<b>Conservation</b>				
11	<b>Moment of Inertia</b>				
12	<b>Static Equilibrium</b>				
13	<b>Simple Harmonic</b>				
14	<b>Ballistic Pendulum</b>				
15					