FOR THE INSTRUCTOR

I believe strongly in the value of conceptual exercises for any physics class at any instructional level. I am also of an equally strong opinion that our standard method for presenting conceptual exercises leaves much to be desired. In fact, if we observed someone present a word problem to a class the way we accept the presentation of a conceptual exercise, there would be many raised eyebrows.

Imagine an instructor reading a medium-level difficulty problem from a standard physics textbook, looking up at the class and saying, “Okay, what’s the answer?” A group of bewildered students look around at each other and shrug. “Twenty-two?” someone calls out from the back of the room. “No,” says the instructor, “It’s pi over two.” And he then begins to zip through a number of equations on the board with his back turned toward the class the whole time. Did he really expect anyone in the class to give a meaningful answer to his question? Did he really want one?

Here is my short list of what I believe are the main errors we make when teach students using conceptual exercises. Notice I said “we” – I make my share of mistakes as well, all the time. [And if you put yourself in a category of experienced instructors who have learned to overcome these instructional weakness, more power to you.]

1. We choose demonstrations, exercises and brain teasers that are ambiguous or prone to wrong thinking on the part of our students. That is good, since it introduces a provocative or ‘teachable’ moment. But then we don’t provide the set-up, background, or physics principles to the students *at the same time* so that a normal, thinking person could have even a chance to get it right. Therefore, the message we are sending to students is, “I know more than you do, and I’m cleverer than you are. I know this stuff; you never will: get used to it.”

2. We accept guesses. This, in my opinion, is our biggest error, and something we would never, *ever* accept if we were presenting a word problem. In my opinion, a guess without a reason behind it represents no thinking on the part of the student at all. If we are willing to accept blind guesses, then we might as well just give up asking conceptual questions at all and return to straight lecture. I would rather do that then send the message to my students that it is okay to go through life pulling answers out of the air to the difficult questions in life, hoping that maybe once in a while you guessed right and thing may turn out okay.

3. We don’t train our students how to think reasonably and logically. We have become masters at showing, demonstrating, and cajoling our students on the steps needed to successfully solve an algebraic word problem. We repeat them, again and again, chapter after chapter, hoping that maybe *this* time they won’t make the same simple mistakes they have made in the previous three chapters. But at least we have a plan! Maybe we accept blind guesses because we just don’t know how to train our students to think through a conceptual exercise in a reasonable, logical manner.

4. Our use of conceptual exercises is almost exclusively focused on the content we are trying to teach. In my mind, that is like accepting our student's point of view that the most important part of solving an algebraic word problem is getting the right numerical answer. By focusing on the correct choice – A, B, C, or D – we miss an opportunity by not asking the most important question: "*Why* do you think that is the correct answer?" If we took the time to explore *how* our students think, we would have the knowledge about them in our possession that we need to *change* the way they think. But that takes up valuable class time. And it is also a lot of hard work on our part.

5. The conceptual exercises we present to students are haphazard and unsystematic. Choose any topic of an introductory physics course, and odds are that nine out of ten physics instructors will write down the same set of key equations that they expect students to learn and master after the unit is completed. Can we say the same thing about the key concepts of that unit? In my opinion, if an idea or principle is worth knowing, then it can be expressed as a written statement. It is also my opinion that at least one conceptual exercise can be created to assess a student's understanding of any physics principle expressed in writing. I have made my own attempts to create an accurate and complete 'concept standard' for introductory physics, but not even I have attempted to create an encyclopedia of conceptual exercises to assess student understanding of *all the* key concepts of general physics.

This workbook is an attempt to correct at least some of these problems. First, I have tried to create a set of exercises with a consistent tone and methodology for all topics introduced in a technical physics course. Second, I have tried to write exercises that minimized blind guessing by often providing students with the correct answer. In that way, I have tried to focus on the thought processes that lead from a set of basic physics principles applied to a set of conditions to a unique and reasonable outcome instead of the outcome itself. Third, I have created examples of 'reasonable' arguments that our student might develop on their own as answers for these demonstrations. I have done this so that your students can learn *how* to construct a conceptual argument, and also learn how to construct a *better* argument by examining the flaws in the incorrect ones that I have invented.

Finally, it was my intention to develop a set of exercises using the current textbook model for algebraic word problems. Each type of exercise comes in sets of three or six. I intended having a complete solution to the first third of each type of problem in the book as part of the problem itself. This would be similar to the 'Solved Problems' approach within the chapter of a physics textbook. The second third would have had a solution at some other location in the workbook, to encourage students to solve the problem on their own but also giving them a way to check if their answers were right or not. The final third set of exercises, without any solutions provided, could then be used as graded homework.

Only a few of the Conflicting Contentions exercises are 'solved' problems. Perhaps my last goal will be accomplished by the next edition of the workbook. However, I hope that you will still consider using this approach when teaching with these exercises. I haven't prepared written solutions, but because the majority of the situations described in the exercises are ‘classics’ we use regularly in class, anyway, you could probably give your students the correct solution during class time as you go over them without too much preparation.

With respect to my other goals for this workbook, I will let you decide to what extent I have met with success.

Christopher Wozny
Associate Professor of Chemistry and Physics
Waycross College