TEACHING

David J. Hilton
Associate Professor, UAB

TEACHING PHILOSOPHY

My teaching philosophy is based on the Socratic dialog. One goal of physics education is to provide students with a clear idea of the process that one uses to solve complex problems, which lends itself well to the traditional classroom lecture methods. A purely passive environment, however, does not succeed. The focus in that passive environment can quickly become "Which equations do I need to use to solve these problems?", which reduces physics to a formula lookup exercise instead of a set of fundamental principles that govern the physical world. In the past five years, my teaching style has evolved to combat this problem and my embrace of the Socratic method is a clear consequence of this.

In any physics class, it is critical to separate the *principles* from the *process*. Fundamentally, both are important; the process often involves learning the mathematical steps needed to solve equations, but the principles explain why this process works. The principles are the basic concepts (momentum, energy) that are critical to the understanding of this science. Both pieces are critical and must be at the core of any good course design. I plan my lectures so that I am not the only one speaking. I always cultivate an environment where students question my methods and we all focus on the steps needed to answer these questions. I regularly stop and have students participate in the discussion of the next step in a particular derivation or turn entire derivations over to the class to complete.

Education in the 21st century will involve a wide array of new tools that were not available when I was an undergraduate in the mid-1990's. Since coming to UAB, I have taught the introductory graduate Electricity and Magnetism for all but one year. This class focusses on the complex problems that a functioning physicist must be able to analyze and understand in this branch of physics. Where we were once only able to solve a handful of problems using analytical methods, advances in computer analysis software make numerical solutions widely available and relatively easy to implement. With this growing dependence on numerical methods, it is critical that our methods of teaching advanced physics classes also advance, but to do so in a way that provides students with the skills that they need to function in the workforce. The process that we must teach to solve these problems must change, but we need to determine the best methodologies that will allow us to continue teach the principles.

Given the complexity of the kinds of problems in advanced classes, my classes are structured in a three stage process. First, there is often a new mathematical concept to be introduced. This math was often discovered when trying to solve that specific physics problem, so this leads, in many cases, to a the second step, which is a direct discussion of the fundamental physics problem. I strive to demonstrate how the principles in this particular problem relates to prior problems, both in my class and in their prior undergraduate classwork in this subject. The third step engages the class in a guided Socratic dialog where they apply this new method to a similar problem. Since the class sizes for PH750 and 751 have been under ten students, this allows me to engage each student on nearly all of these dialogs so that I receive feedback from each student on their progress towards understanding both the process and principles. Homework problems and exam questions in this class are designed to give the student the same challenge: do they understand both the process and the principle that is needed to master this topic? With feedback from students to guide me, I believe that this method has proved successful in this class.

CURRICULAR DEVELOPMENT

I received support from the National Science Foundation CAREER program to redevelop the graduate sequence in Electricity and Magnetism with strong statements from my reviewers that they also viewed this as a critical need. I proposed a modification to the curriculum to expose students to the rapidly evolving numerical tools that can help them solve more advanced problems in Electricity and Magnetism. These tools can help advance the conceptual understanding of the principles of this subject in a way that was not possible in the classical method. In electrostatics, students use numerical models to study the methods of solving electrostatic problems taught in class by developing models of the analytical solutions from their homework. These tools also allow me to reverse problems - giving them the final charge distribution and asking them to calculate the electrostatic potential instead of the standard question of calculating the charge distribution from the potential - which is a key indicator of *conceptual* understanding in physical problems. We must not train a generation of students to be dependent on a software package to solve problems, but we also cannot train a generation that is ignorant of these new tools. I believe that these tools must always supplement the principles of the subject, but that these provide with new and innovative methods to test the conceptual understanding of these principles.