Miami Plan Principles

The diverse educational communities of a comprehensive university have a common interest in liberal learning: it nurtures capabilities for creatively transforming human culture and complements specialized work by enlarging one's personal and vocational pathways. Liberal education involves thinking critically, understanding contexts, engaging with other learners reflecting and acting, habits that extend liberal learning through a lifetime to benefit both the individual and society.

THINKING CRITICALLY

Thinking critically promotes imagination and intuition along with reasoning and evaluation. These diverse abilities contribute to achieving perspective, constructing and discerning relationships, and gaining understanding. Confidence in working with data and materials, skepticism in analyzing arguments or presentations, persistence in engaging complex problems and facility in communicating about technical matters are central to thinking critically. A skillful use of written and spoken languages, and informed use of mathematics and an ability to employ contemporary information sources are integral to thinking critically.

UNDERSTANDING CONTEXTS

Liberal learning cultivates the perspective that present cultural circumstances are an historical and a changing situation. Decisions about what is to be studied, the forms in which knowledge appears and the ways reasoning develops are to be continually examined. Ways of knowing need active attention: gender, class, racial identity, ethnicity, economic status and regional identity condition our understanding; temporal and spatial relationships, institutional traditions, religious commitments, philosophic perspectives, and political objectives shape our assumptions; influences originating beyond geographic and social boundaries affect what we know. Crucial to our future is knowledge of the conceptual frameworks and achievements of the arts, sciences, and technology, as well as understanding of the earth’s ecosystem and the character of global society.

ENGAGING WITH OTHER LEARNERS

A healthy exchange of conflicting ideas and differing viewpoints encourages rethinking of accepted perspectives; it requires making choices and taking risks. Diversity among learners, a supportive atmosphere of group work, active listening, opportunities for presenting and criticizing the results of inquiry and creative effort encourage learning, aid growth and stimulate imagination. Thoughtful and systematic inquiry about the learning process supports shared efforts, and positive advising situations and experiences outside the classroom reinforce them.

REFLECTING AND ACTING

Thinking critically and understanding contexts for knowledge in an engaging learning situation lead to reflection and informed action. Making thoughtful decisions and examining their consequences enhance personal moral commitment, enrich ethical understanding, and strengthen civic participation.
Relation of PHY 191, 192 to the Miami Plan for Liberal Education

The Miami Plan for Liberal Education identifies four key aspects of liberal education: thinking critically, understanding contexts, engaging with other learners, and reflecting and acting. In what ways does PHY 191, 192 seek to fulfill these expectations?

• Critical thinking

Physics has a rich tradition of fostering critical thinking. The student will learn how to make ‘order of magnitude’ calculations. An order of magnitude approach answers questions like ‘will it fly?’, or ‘can we afford to build it?’ instead of ‘what will be its top speed?’ or ‘exactly how much will this cost?’. In an era when United States Senators can’t grasp the concept of an order of magnitude calculation of the differential cost of the Gulf War effort, it is comforting to know that a freshman ‘graduate’ of PHY 191 readily comprehends the idea and could make such an estimate.

Students learn how to approach problems in a systematic way. They learn by example and by drill how to translate a literal statement of a problem into a quantitative formulation. They learn how to identify the given and unknown parameters, and how systematically to construct a solution.

• Understanding contexts

A recurring theme in physics is that its ‘laws’ are merely approximations that adequately describe a body of knowledge only for a limited time. Experimental advances that follow theoretical breakthroughs may yield results that point out the inadequacy of the theory that led to their inception. For example, the quantum theory of Schrodinger, initially hailed for its ability to predict the wavelengths of light emitted by atoms with great precision, was ultimately found lacking in precision and was superseded by a relativistic quantum theory. Experimental advances and theoretical breakthroughs form a cat-that-catches—its—tail sequence of increasingly refined approximations.

Every generation of physicists has witnessed changes in the laws of nature. A retiring colleague once expressed this very succinctly. In overstating the changing nature of physics he said, ‘All of the physics I knew when I received my PhD is now wrong’. Of course he didn’t mean ‘all’ but his point was not lost on his listeners. The changing nature of physics is made evident in PHY 191, 192 by including contemporary physics such as quantum mechanics and statistical physics. Topics of current concern that receive attention include high-temperature superconductivity, the scanning—tunneling electron microscope, and the role of capacitors in computer memory chips.

• Engaging with other learners

The introductory calculus based physics course often presents the first intensive experience where science students face a rigorous experience in abstract modelling of real systems. To be successful, such a course must include the development and understanding of concepts, the transfer of content, as well as careful attention to context. While the knowledge transfer required is considerable, the conceptual frameworks developed in physics represent the original model upon which scientific inquiry is based. For many students, the development and understanding of conceptual frameworks and the structure that they create in development of critical and analytical thinking provide the greatest challenge. This arises primarily from students’ Aristotelean preconceptions of the nature of the world around them, as well as inexperience in thinking critically and analytically about phenomena they observe and experience. While one of
the major objectives of this redesign is to provide students a more modern and useful knowledge base, the structure, content, and mode of instruction of the course are being changed to address more successfully the conceptualization and critical thinking perspectives.

Success in addressing conceptualization and critical thinking clearly requires engaging with other learners. This means providing opportunities for discussion of the paradigm of scientific rationalization as well as the careful examination of new concepts and the contexts in which they exist and are valid. This redesign provides for an enriched opportunity to attack these points. First the “information transfer” portion of the course has been designed as basically a three “lecture” hour core. (It should be stressed that in no instance do we just “lecture”. Each such class meeting involves student questioning and discussion as well as a significant number of demonstrations, simulations, etc. This is legitimately engaging with other learners from the perspective of novice learners engaging with expert learners). This core is enhanced by the fourth hour for which we have coined the term “X—days” for want of a better one. These days provide a relatively unstructured time for a number of activities specifically designed to enhance students’ experiences, understanding of concepts, and provide for learner—learner interaction. In past contexts it was common to have “recitation” sections which were primarily directed at developing students’ problem solving skills. However, our X—days go much beyond the normally understood recitation format. They include opportunities for hands on experience with demonstration equipment and computer simulations as well as problem solving techniques. We have also been experimenting with ways in which we can establish formal study groups in this course.

Another example of learners engaging with one another is in the laboratory portion of the course. This is a more formal vehicle which enables students to formulate their personal conceptions based on exchanges of ideas. The primary goal of the lab experience is to help the students form concepts and examine them, not to teach technology. In general, the laboratory exercise involves the student in a team format; addressing a specific physical problem or concept, performing an experiment related to that concept, collecting and analyzing data, and comparing these results to previously developed models or developing models from their observations. In most instances, experiments are designed to elucidate and confirm concepts currently being developed in the classroom. In other cases the experiments provide experiences which the students subsequently bring into the classroom for discussion and further development.

Our conservation of energy experiment is a good example of how concepts can be reshaped by a lab experience. Students learn early on that the kinetic energy \( E \) of a mass in is related to its speed \( V \) by the equation \( E = \frac{1}{2}mv \) They also learn the principle of conservation of energy, and that the gravitational potential energy of a raised mass can be converted into an equal amount of kinetic energy. They then verify the conservation of energy by dropping a pool ball and measuring its speed after it falls a measured distance. This high—precision measurement confirms their expectation that energy is conserved. They then perform a variation of the first experiment. The pool ball is allowed to roll down a smooth incline. Its speed is again measured and they compare the energy \( E = \frac{1}{2}mv \) with the change in its gravitational potential energy. Try as they may they cannot make them equal! They wrestle with three choices: i) energy is not always conserved, ii) energy is converted into heat by the force of friction on the rolling ball, iii) we failed to account for another form of kinetic energy. Opinions vary! There is a healthy exchange of ideas. Differing viewpoints based on prior experiences are expressed. This engagement of learners takes place with a spirit of cooperation.
Examples of the discovery approach, where material is introduced prior to their theoretical development, are the initial laboratories on motion and equilibrium in the first semester, and those on logic gates and electrical circuits, in the second semester.

- **Reflecting and acting**

Knowledge is neither good or bad but it is helpful in making informed rather than purely emotional decisions. PHY 191, 192 has no particular ax to grind in environmental issues such as nuclear waste or moral and political issues such as star wars weaponry, but it does encourage a questioning attitude and a scientific approach to such issues.

Experience in making order of magnitude calculations is perhaps the most useful skill a student will carry away from PHY 191, 192. This skill might be brought to bear in matters such as a local school board budget. Which is better, an informed citizen, or an informed citizen who can make order of magnitude judgments?