Course Description and Goals

The exploratory physics lab tries to teach students how to investigate physical phenomena from an experimental standpoint.

The understanding of physical phenomena consists of a closed feedback cycle that begins for example with the observation of a phenomenon that is not entirely understood and that is possibly surprising. Using our knowledge of physics we then formulate several hypotheses that may describe the observation. In order to test these hypotheses we need to devise various experiments that would demonstrate which of the hypotheses is consistent with the initial observations. Throughout this experimental exploration one often encounters additional surprising phenomena that were not anticipated and the process repeats itself.

During this lab course students will experience this investigative cycle. Through close and continuous interaction with the lab instructors students will be able to hypothesize what the underlying physics behind various phenomena are and then test the validity of their hypotheses. During each experiment the students are required to identify the relevant experimental variables, suggest ways to measure them and implement these ideas in the lab. Once a successful model is found, the students may use it to predict yet another phenomenon and test experimentally if the predicted behavior is observed. Since there are many ways to explore a single phenomenon, the lab is set up to enable students to follow their individual creativity and initiative in their experimental endeavor.

Throughout the lab course students will explore at most three or four phenomena. Topics include mechanics, electromagnetism, buoyancy, surface tension and more. The experiments performed in this lab course are not at the forefront of present day research. Rather, the experiments are chosen to match the student’s background level in physics and math. Already with a course in mechanics and electromagnetism (can be taken concurrently with the lab course) students will have the necessary background and tools to understand the underlying physics, read the required literature and write mathematical models for the system at hand.

The experiments will be carried out in groups of three students. The lab will meet twice a week for 3 hours each time. There will be considerable amount of work required between each lab session in order to prepare for the next lab, comparable in time to that necessary to do a problem set for an upper level physics course. This will include reading literature, inventing measurement schemes and writing mathematical models. Therefore in addition to the two 3 hour lab sessions per week each group will have a 1 hour tutoring session with the lab instructor during which all aspects of the experiments will be discussed. The lab is taught by a physics professor and takes place in a single room where often the instructor will interrupt the experimental work to engage in an interactive discussion with the entire class about various aspects of the experiments or the theory behind it.
At the end of each lab, students will be required to write a short lab report comparable in length to a short publication in physical review summarizing their hypotheses and experimental findings. In addition, each student will be required twice during the course to give an oral presentation about their work.

This is a graded course. We do not allow students to take it pass/fail. The number of students per class will be limited to 18. The course will be graded according to the following composition:

- Performance in lab – 40%
- Preparing for each lab – 30%
- Lab reports – 15%
- Presentations – 15%

Course Syllabus:
During the course of the lab the following topics will be discussed:

- Conservation laws – energy and momentum
- Types of forces – conserving and non conserving
- Relation between force work and energy
- Types of equilibrium – stable and unstable
- Coupled pendulum
- Buoyancy
- Solenoids and Faraday’s induction law
- Boyle law of ideal gases
- The meaning of experimental errors and measurement uncertainties
- Making ball-park estimates of physical quantities