

## Virtual and Traditional Lab Experiments in General Physics Courses

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In our Department of Engineering and Physics, we offer 5 different introductory physics courses that require accompanying laboratories. For our majors in Engineering Physics, and some of the students from Chemistry and Mathematics departments, we have two calculus-based physics courses. The first class, PHYSCIS 235 is basically the Newtonian mechanics plus a very brief introduction to heat and thermodynamics. This is the first freshman level physics class for science and engineering majors. This class has its lab as co-requisite which we call PHYICS 236.

The second calculus based introductory physics class that we offer; PHYSICS 255 covers the electricity and magnetism which also include a cursory introduction to optics. The lab that accompanies this course is referred to as PHYSICS 256. Our algebra-based introduction to physics courses, PHYSICS 130 and PHYSICS 132 classes are basically mirrored the PHYSICS 235 & PHYSICS 255 courses in content but differ in mathematical treatment and depth. The complexity of problems treated in these two courses differs from the calculus based classes. The labs that go along with PHYSCIS 130 and PHYSICS 132 are PHYSICS 131 And PHYSICS 133 respectively.

In addition we offer one condensed introductory class, PHYSICS 125 which is a shorter version of PHYSICS 130 and 132 combined. These entire five courses require laboratories that support the lectures. In a typical semester we have over 200 students in these classes. Providing laboratory space and equipments and managing all these individual labs are quite challenging. Since we don't have a graduate program in our Department, we cannot easily find enough undergraduate students as teaching assistants who are able and willing to help in these laboratories. Scheduling labs with skilled manpower traditionally has been a problem for us. Now that the State has been cutting our budgets and the fact that we have not had any increase in our operating expenses for years, only has exacerbated our situation.

We have tried to redesign our labs and lab projects by adding virtual experiments to the list of lab experiments that students do in a semester. It is still a unanimous opinion in our department that student must get some form of hand-on experience in physics laboratories. And all online lab or entirely virtual lab experiments is not an option. Recently we have experimented with a hybrid plan that divides the lab projects to 50 percent virtual lab experiments and the other half as tradition lab projects. We have implemented this plan only in our algebra based physics classes.

The list of lab projects for PHYSICS 131 consists of:

Introduction to Physics Lab

**Measurement, Modeling, Graphing, and Use of Data Studio Software**

Lab Experiment One  
**One-Dimensional Motion with Constant Acceleration**

Lab Experiment Two  
**Projectile Motion**

Lab Experiment Three  
**Newton's Second Law and the Definition of Mass**

Lab Experiment Four  
**Work and Energy**

Lab Experiment Five  
**Conservation of Momentum**

Lab Experiment Six  
**Rotational Motion and Moment of Inertia**

Virtual Experiment One  
**Position, Velocity, Acceleration and Free Fall**

Virtual Experiment Two  
**Projectile Motion**

Virtual Experiment Three  
**Masses on Inclines**

Virtual Experiment Four  
**One- and Two-Dimensional Collisions**

Virtual Experiment Five  
**Basic Torque**

The above list was implemented in Fall of 2009. However the order in which these project were carried out was different for lab sections. We have implemented a similar idea in PHYSICS 133 which its list follows:

Lab Experiment One  
**Electrostatics**

Lab Experiment Two  
**Capacitors and Ohm's Law**

LE3. Lab Experiment Three  
**Series Circuits and Power**

Lab Experiment Four

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## Electrical Circuits

Lab Experiment Five

**Induced Effects and Electromagnetic Forces**

Lab Experiment Six

**Reflection and Refraction and Simple Lenses**

Virtual Experiment One

**Coulomb Forces and Electric Fields**

Virtual Experiment Two

**Cathode Ray Tube and Parallel Plate Capacitors**

Virtual Experiment Three

**Resistive Circuits**

Virtual Experiment Four

**Trajectory in E & B Fields, Magnetic field of a Bar Magnet**

Virtual Experiment Five

**Snell's Law and Simple Lenses**

We have only recently implemented this plan and one single semester may not be sufficient to draw a solid conclusions. Nevertheless, the result that we have gotten so far has not been very satisfactory. To begin with, students have had the usual software complains such as the compatibility of the virtual lab and the operating systems. The windows are constantly been updated and Microsoft has a new version of its operating system. As a result, we have computers with three different operating systems, i.e. Windows XP, Windows Vista, and Windows 7. More importantly, students were complaining about the lack of continuity in labs and the gap between virtual labs verses the hands-on experiments. They liked the idea of not showing up at a regular time and being able to finish the virtual lab experiments at their convenient time. But it seems far from being clear that they are getting the experiences that were intended for these laboratories. There are many reasons for having introductory physics laboratories. However, the main goal for experimental projects has been the idea of letting students to understand and comprehend the physical concepts reviewed in the lectures. By participating in different experimental projects in the laboratories, students are supposed to prove those concepts and see how theories are applied in real life experiments.

Currently we are debating how to proceed in implementing introductory physics laboratories in our Department. Due to the lack of resources and at the same time trying to uphold the integrity of these labs and their intended objectives, have left us with very limited choices. These options include that whether we should continue with the current plan in its limited form or to expand this hybrid combination of the traditional and virtual lab projects to our other introductory calculus-based physics courses, i.e. PHYCIS 236 and PHYSICS 256. A few of us in the Department are also thinking about all online laboratories. Time is short and we need to implement something in our introductory laboratories before the Fall semester.