Research Proposal:

Advanced Labs with a Lock-In Amplifier and LabVIEW

General Goal: In this project I hope to design one or more upper division lab experiments in which students are required to use a lock-In amplifier to find a desired signal within a ‘noisy’ signal. To help find the wanted signal, students will be utilizing the computer program LabVIEW. Using LabVIEW students will construct a program capable of controlling the lock-in amplifier and also use it to collect data.

Motivation: The lock-in amplifier is an extremely useful and resourceful measurement tool. Because of its numerous applications, it is important for undergraduate physics students to have firsthand experience using the lock-in and to understand just how valuable a tool it can be. The lock-in is essentially designed to “lock” onto a desired signal and cut out the noise that surrounds it with great precision. In addition to finding signals, a lock-in can be used to make numerous measurements, such as finding the resistance through a tiny wire, the determination of the velocity of sound in air based on phase measurements, the detection of weak optical signals, and much more. In the real world, when one attempts to find or examine a specific signal there exists quite a bit of noise with that signal. By first supplying a reference signal, a signal similar to the signal desired, the lock-in filters and amplifies this signal which it uses to set the operating frequency. With the locked reference and a pre-processed input signal the lock-in amplifier then manipulates the signals digitally to produce the desired output.

LabVIEW is a signal processing and waveform analysis tool. It is an industry standard programming language that can be used to control lab instruments and then collect the data from these instruments. LabVIEW also has the advantage of being a graphical programming environment. That is, programs on LabVIEW are written by simply attaching icons together unlike programming languages such as C or FORTRAN which rely on pure text-based programming. As a result students are usually more at ease using LabVIEW to create functioning programs. Using LabVIEW's easy-to-use functions students can efficiently create programs aimed with such uses as signal acquisition, processing, and analysis.

By creating experiments that utilize both a lock-in amplifier and LabVIEW students will be able to improve several skills at once. Not only will students be exposed to new tools and resources, but they will also be able to further skills they already possess such as programming and precise measurement.

Context: Because of both the lock-in and LabVIEW's extreme versatile nature, several different experiments exist using the two tools. One such experiment is to use a crystal formed from alternating masses attached at regular intervals on a vibrating wire and by measuring the amplitude of vibration, scan the driving frequency in the wire, and determine the resonant angular frequencies of the "phonons" allowed in the wire.

Creating similar labs for physics students at Redlands will help prepare them for research level positions elsewhere. It is important for students to be aware of the different types of techniques that can be employed in solving a particular problem, and the lock-in amplifier and LabVIEW are two tools that will prove to solve many challenges. One such challenge is the utilization of a lock-in amplifier and LabVIEW to examine Faraday's Rotation theory.

Procedure & Timeline:

- **Summer-July 4, 2012-August 6, 2012:**

  - Learn Basic LabVIEW- reading LabVIEW manual &constructing sample programs
  - Learning lock-in theory
  - Learning the basics about the lock-in, using teach spinlock-in to perform basic experiments
  - Exploring experiment options-surveying literature to see what experiments use lock-ins
  - Selecting sample experiments and testing.
  - Optimizing chosen experiment(s) + LabVIEW control
  - Developing advanced lab appropriate instructions & readings
- September-December 2012- Acquisition of any additional data/ finalizing any work not finished over the summer
- February 1, 2013- Thesis Outline
- March 8, 2013- First draft of completed thesis
- March 22, 2013- Thesis revision
- March 27, 2013- Senior Symposium
- March 30, 2013- Thesis revision
- April 18, 2013- Final draft of thesis

References:

- **Graphical computing in the undergraduate laboratory: Teaching and interfacing with LabVIEW**

  P. J. Moriarty, B. L. Gallagher, C. J. Mellor, and R. R. Baines

- **A basic lock-in amplifier experiment for the undergraduate laboratory**

  K. G. Libbrecht, a) E. D. Black, and C. M. Hirata

- **Physics 300B Laboratory Manual**

  Dr. Eric Ayars

  California State University, Chico

- **MODEL SR830**

  DSP Lock-In Amplifier (Manual)

- **Lock-in detection with DataStudio**

  Yaakov Kraftmakhera_

  Department of Physics, Bar-Ilan University, Ramat-Gan 52900, Israel

- Ph 77 — ADVANCED PHYSICS LABORATORY

Lab 2 - Small-Signal Detection Using the Lock-In Amplifier (Caltech)

- **Automation of the Franck–Hertz experiment and the Tel-X-Ometer x-ray machine using LABVIEW**

  W. Fedak, a) D. Bord, C. Smith, D. Gawrych, and K. Lindeman

  Department of Natural Sciences, University of Michigan–Dearborn, Dearborn, Michigan 48128

- **Optical Faraday rotation**

  P. R. Berman

  Department of Physics and Michigan Center for Theoretical Physics, University of Michigan, Ann Arbor, Michigan 48109-1040

- **A simple experiment for determining Verdet constants using alternating current magnetic fields**

  Aloke Jain, Jayant Kumar, Fumin Zhou, and Lian Li

  Department of Physics, Center for Advanced Materials, University of Massachusetts Lowell, Lowell, Massachusetts 01854