INTERMEDIATE LABORATORY II – PHYS 3880

SYLLABUS

Spring 2013

This spring, in addition to two regular Intermediate Lab exercises each student will have the chance to do an Extended Investigation. The objective is to provide students with a chance to do a somewhat more independent, creative and challenging activity that bridges the gap between the more formal laboratory exercises that provide the students with a specific set of equipment and laboratory objective based on specific activity for that equipment and the challenges they will face in their Undergraduate Research project.

Students, working in pairs, will meet with the course instructor ***before*** beginning the Extended Investigation to develop a plan for the investigation. The objective is to establish a clear scientific question to investigate and an outline of a reasonable plan for experiments to be performed. This serves two purposes: (i) to have a clearly established plan of attack on a well focused topic and (ii) to alert the instructors to the required equipment and resources. In planning this, students should carefully consider what can realistically be accomplished in the available time, the available resource including equipment and instructor time, and the need to have a definite conclusion that can be drawn at the end of the Extended Exercise. Specifics include:

- Lab partners and a general topic are chosen on the first day of class.
- A written document (title, 100 word abstract and list of proposed measurements) must be submitted by the first day of the Extended Lab Period and approved before work can begin on the Extended Investigation. A draft of this document is due one week prior to the start of the Extended Investigation.
- A first draft of a joint written report is due the last day of the Extended Lab Period.
- A final draft of the report, revised based on editorial comments, is due one week before the end of the term.

Some Specific Notes

This activity will account for half of the time and half (50%) of the grade for the class.

Reports will require references to at least 5 journal articles. Specific reference to the results of at least one other Intermediate Lab group's work is required. You are also encouraged to cite results of other experimental reports you have done this semester or last.

The extended investigation should have all the components of a good scientific investigation. These include a well defined statement of a problem/question to be addressed (see proposal), a proposed set of experiments that will clearly test the problem, a quantitative model for the experiments, a quantitative assessment of how well the model predicted the outcomes of the experiments, and an analysis of the physics results and their applications.

Some Suggested Possible Topics

General Topic: **Global Warming**
Applicable Intermediate Lab Experiment: Blackbody Radiation, Reflectivity, Spectroscopy
Related Intermediate Lab Experiments: Hydrogen Fuel Cells
Comments*:* Spectroscopic investigations of the solar spectrum and its relation to a blackbody spectrum, absorption lines and emission lines provides an nice starting place. There is a nice simple experiment on the effect of $C0_2$ in warming of gasses from a recent Physics Teacher article. Reflectivity and calorimetry can be related to albedo and angle of incidence.

General Topic: **Plasma Physics**
Applicable Intermediate Lab Experiment: Plasma Physics, Franck-Hertz Experiment,
Related Intermediate Lab Experiments: Spectral Emission, Thermionic Emission, Solar Spectra
Comments: The experiments with the plasma tube provide a tremendous set of investigations into basic plasma physics.

General Topic: **Thermal Effects in Solids**
Applicable Intermediate Lab Experiment: Resistivity, Supeconductivity, Hall Effect, Thermionic Emission, Thermal effects in Diodes
Related Intermediate Lab Experiments: Electron Diffraction (thermal expansion or Debye-Waeler Effect), Velocity and Gravitation (with ball bearings), photoelectric effect
Comments: Since solids are massive collections of atoms, statistical physics (that is, thermal physics) is extremely important to understanding solids. Tracing this link in a number of experiments related to electron transport, atomic position, or energy distributions could be illuminating.

General Topic: **Fourier Optic**
Applicable Intermediate Lab Experiment*:* Spatial Filtering, Holography, Digital Holography, Holographic Interferometry
Related Intermediate Lab Experiments*:* Frensel and Fronhoffer Diffraction, Interferometry, Acoustics
Comments: The use of Fourier Transforms is ubiquitous in optics (and many other places). This can provide a unifying theme for advanced optics investigations.

General Topic: **Interference and Diffraction**
Applicable Intermediate Lab Experiment: Frensel and Fronhoffer Diffraction, Interferometry, Electron Diffraction, Thin Film Interference
Related Intermediate Lab Experiments: Holography, Digital Holography, Spectroscopy, Acoustics, Spatial Filtering
Comments: Interference and diffraction effects of waves is a universal effect. Interferometry shows up in all branches of physics as a tool for precise measurements.

General Topic: **Acoustic Holography**
Applicable Intermediate Lab Experiment: Holography, Interferometry, Frensel and Fronhoffer Diffraction
Related Intermediate Lab Experiments: Spectroscopy
Comments: Investigations of the intensity and phase dependence of acoustic waves, with the goal of recreating the spatial dependence of sound sources.

General Topic: **Molecular Spectroscopy**
Applicable Intermediate Lab Experiment: Atomic and Solar Spectroscopy
Related Intermediate Lab Experiments: Interferometry, Frensel and Fronhoffer Diffraction, Greenhouse Effect
Comments: Using computer controlled spectroscopy in conjunction to investigate the spectra of atomic and molecular sources such as O_2, N_2, CO, CO_2, CH_4. This is rich in quantum theory and applications.

General Topic: **Astronomical Spectroscopy**
Applicable Intermediate Lab Experiment: Atomic and Solar Spectroscopy
Related Intermediate Lab Experiments: Interferometry, Frensel and Fronhoffer Diffraction
Comments: Using computer controlled spectroscopy in conjunction with the telescope to investigate the spectra of astronomical sources such as the moon, planets and stars.

General Topic: **Optical Reflection/Transmission/Absorption Spectroscopy**
Applicable Intermediate Lab Experiment: Atomic Spectroscopy

Related Intermediate Lab Experiments: Interferometry, Frensel and Fronhoffer Diffraction
Comments: Using computer controlled spectroscopy to study the interaction of light with matter through measurements of the reflection/transmission/absorption spectra.

General Topic: **Physical Constants**
Applicable Intermediate Lab Experiment: Thomson elm (elm), Photoelectric Effect (h) Cavendish balance (G), Millikan Oil Drop (e), Blackbody Radiation (h or k_B, Stephan-Boltzmann constant), Hall Effect (e/m), speed of light (c), Fuel Cell (Avagadro's number)
Related Intermediate Lab Experiments: Spectroscopy
Comments: Physical constants are by their very nature universal. Precision measurements of there values have lead to important understanding of basic physics (e.g., c and relativity, k_B and statistical mechanics, *G* and gravity).

General Topic: **Monte-Corlo Methods in Computational Physics**
Applicable Intermediate Lab Experiment: Buffon's Needle Experiment
Related Intermediate Lab Experiments: Plasma Physics, Franck-Hertz, Experiment, Thermionic Emission, Electron Diffraction, Velocity and Gravitational Distributions
Comments: Focuses on computational methods applied to systems of a statistical nature. Use of a computer-aided mathematics program (Mathcad, Mathematica, C++, etc.) is required.

General Topic: **Chaotic Process**
Applicable Intermediate Lab Experiment: Chaotic motion of a compound pendulum, chaotic driven electronic oscillators
Related Intermediate Lab Experiments: Coupled Pendula
Comments: Modeling simple experimental chaotic systems in terms of the mathematics associated with chaos, including strange attractors and Poincaire plots in phase space.

General Topic: **Electron Interactions with Matter**
Applicable Intermediate Lab Experiment: Electron Diffraction, Thermionic emission, Franck-Hertz, Hall Effect Photoelectric effect
Related Intermediate Lab Experiments: Plasma, Resistivity, Superconductivity, Scanning tunneling microscopy, Spectroscopy
Comments: The mechanisms for energy transfer from electrons to matter is a central theme in many fields, including, solid state physics, atomic physics, spectroscopy, plasma physics and astronomy.

General Topic: **Thermodynamics and Kinetic Theory**
Applicable Intermediate Lab Experiment: Velocity and Gravitational Distributions
Related ***Intermediate Lab Experiments:*** Atomic and Solar Spectroscopy, Blackbody Radiation, Thermionic Emission, Avagadro's Number
Comments: Using computer controlled spectroscopy in conjunction with the telescope to investigate the spectral of astronomical sources such as the moon, planets and stars.

General Topic: **Ultrasonics**
Applicable Intermediate Lab Experiment: SpinTronics Labs
Related ***Intermediate Lab Experiments:*** Microwave labs
Comments: USU has a new ultrasonics apparatus. The "canned" labs provide a nice introduction to the field and a jumping off point for creative extensions.

General Topic: **Muon Detection and Cross Sections**
Applicable Intermediate Lab Experiment: New equipment modeled on ALPHA workshop
Related ***Intermediate Lab Experiments:*** Thomson e/m, Electron diffraction
Comments: This experiment proposes to measure the absolute angular cross section on muons created in the upper atmosphere by high energy cosmic rays. This is based on experiments introduced at the AAPT Beyond the First Year summer workshop and has immediate applications to ongoing work at USU.