

# INTERMEDIATE LABORATORY - PHYX 3870-3880

## *Description of Experiments*

### MECHANICS

#### **M1. *Kater's Pendulum***

A straightforward lab using a reversible physical pendulum to measure the local acceleration of gravity,  $g$ , to less than 0.01%. Emphasis is given to detailed error analysis and error propagation and to high precision measurements. Computer interfacing with photogates and motion sensors. A good beginning lab.

#### **M2. *Coupled Pendulum***

Investigation of two pendulums coupled by a spring between them. Lab emphasizes comparison of measured results of the periods and damping to values derived from a theoretical model using differential equations. Completion of Analytical Mechanics is recommended. Computerized data collection with voltage probes and motion sensors and data reduction are used.

#### **M3. *Cavendish Balance***

Determines the universal gravitational constant,  $G$ , using a torsion balance to measure the attraction between known masses. Emphasis is on fitting the data with a detailed model and extracting results by correlating the fitting parameters with the physical model. A good beginning lab.

### ELECTRICITY & MAGNETISM

#### **E1. *Millikan's Oil Drop Experiment***

Demonstrates the quantized nature of the electric charge and measures a value of the fundamental constant  $e$ . This classic experiment led to the first Nobel prize for an American physicist. Emphasizes experimental design and statistical analysis methods using large data sets.

#### **E2. *Thompson's $e/m$ Experiment***

Measures the ratio of the charge to mass of an electron ( $e/m$ ) by investigating the trajectory of electrons in electric and magnetic fields. The British physicist J. J. Thompson received a Nobel prize for the experiment. Good preparation for *Electron Diffraction from a Crystal Lattice* and subsequent Advanced Laboratory experiments. Emphasis is on determining the interdependence of experimental parameters (e.g., accelerating voltage, magnetic field, radius, charge) through the Lorentz Force Law. A good beginning lab.

#### **E3. *Measurement of Plasma Parameters***

Uses a Langmuir probe to study the properties of a charged plasma of gas. Provides an excellent background for space and atmospheric physics, as well as plasma physics. Emphasis is on understanding the nuances of the plasma environment and on complex voltage measurements. Automated data collection uses voltage probes and programable power supplies.

### OPTICS

#### **O1. *Microwaves***

A largely phenomenological lab investigates the propagation of microwaves. Includes examples of reflection, refraction, transmission, absorption, diffraction, interference, polarization and attenuation. A good first lab of optics topics.

## **O2. Polarization**

Explores the nature of polarized light and polarizing materials. A straightforward procedure. Emphasis on fitting data to non-linear functions. A good lab to begin with.

## **O3. Geometrical Optics and Computer Ray Tracing**

*Under development.*

## **O4. Holography**

Explores the basics of holographic photography. Students record holographic images on film using a darkroom.. Provides good experience with lasers, optics elements, interferometry, and an optics bench. Emphasizes experimental technics in optics. Procedure is involved and time-consuming, but the end product is exciting.

## **O5. Fresnel and Fraunhofer Diffraction**

Investigates diffraction from single and double slits in the Fresnel and Fraunhofer limits. Computerized data collection is used. Detailed analytical and numerical data analysis. *Under development.*

## **O6. Michelson and Fabry-Perot Interferometry**

Introduction to interferometric technics. A number of experiments are possible including investigation of the index of refraction of a gas as a function of pressure, resolution of atomic spectral doublets, and hyperfine splitting. Provides good experience with optics elements and light sources.

## **ELECTRONICS**

*The Electronics Experiments should be done in order for the best understanding of the principles.*

## **L0. Basic Electronics**

Covers basic concepts in electronics. Treats passive components including resistor and capacitors. Emphasizes the use of tools in electronic including reading schematics, multimeters, power supplies, and oscilloscopes. Essential background for subsequent labs.

## **L1. The Diode and Its Applications**

Investigates the nature of a p-n junction. Gives examples of common uses of the diode. A basic introduction to electronics with practice in building circuits. Emphasis on the statistical mechanics underlying semiconductor charged carriers. It is assumed that the student has completed the sophomore labs in Ohm's Law and Test Equipment, The Oscilloscope, RL Circuits, and RLC circuits.

## **L2. The Transistor and Its Applications**

Investigates the nature of the p-n-p and n-p-n junction. Emphasizes the practical use of transistors in applications circuits.

## **L3. The Operational Amplifier and its Applications**

A basic introduction to linear integrated circuits with practice in building circuits. Gives examples of common uses of the op amp.

## **L4. Digital Electronics**

A basic introduction to common digital integrated circuits and Boolean algebra. Uses AND, OR, NAND, NOR, and XOR gates, inverters, latches, decade counters and other common digital integrated circuits to build basic circuits. Also build some circuits with practical applications. *Under development.*

**L5. Computer Interfacing**

*Under development.*

**L6. Transducers and Interfacing**

*Under development.*

**L7. Electronics Project**

*Under development.*

**THERMODYNAMICS/STATISTICAL MECHANICS**

**T1. Velocity and Gravitational Distributions**

An excellent introduction to the kinetic theory of gases. Uses an air table to investigate the statistical distribution of the velocity of particles. Compares the results with Statistical Mechanics velocity distribution functions. Also explores the effect of an external field (gravity) on the statistical distribution of particles. Emphasizes statistical modeling. Computer interfacing uses a video camera.

**T2. Avagadro's Number: Electrolysis and Brownian Motion**

*Under Development* Investigates the use of hydrogen fuel cells, energy conversion and efficiency through a series of closely related experiments. Uses studies of hydrolysis and Brownian motion to determine Avagadro's number. Emphasizes simple modeling and error analysis.

**T3. Blackbody Radiation.**

Measurements of the intensity and spectrum of a blackbody radiator as a function of temperature. Theoretical curves from the Wein and the Stefan-Boltzmann  $T^4$  laws will be compared to measurements. Emphasis on non-linear curve fitting and high temperature techniques.

**ATOMIC PHYSICS**

**A1. Franck-Hertz Experiment**

Classic experiment which demonstrates the quantized nature of atomic electron orbitals. Good practice in use of electronics test equipment. Emphasizes experimental design and data analysis methods. Extensive computerized data collection.

**A2. Photoelectric Effect**

Explores the interaction of light with matter through the photoelectric effect. Determines the dependence of the photo current on the physical parameters of the experiment. A very simple experiment. Emphasizes determination of the relation of the experimental parameters in Planck's relation.

**A3. Speed of Light**

The first part measures the speed of light using the pulsed laser method. The second part measures the propagation time of a light pulse through a fiber optic cable and compares this with the propagation time of an electron pulse through a wire. A third part uses rotating mirrors to measure the speed of light. Emphasis is on contrasting different methods to determine the same physical quantity. A simple experiment.

**A3. Atomic Spectra**

*Under development.*

## NUCLEAR PHYSICS

### **N1. *Introduction to Radiation and Nuclear Physics***

Introduction to statistics for nuclear counting. Uses Geiger tube to investigate the basic principles of half life, absorption coefficient, and types of radiation. Discusses types of detectors. A prerequisite for the *Gamma Spectroscopy* experiment.

### **N2. *Particle Detectors***

*Under development*

### **N3. *Gamma Spectroscopy***

Measures the gamma spectra of several elements. Determines the composition of an unknown from its gamma spectrum. Investigates the attenuation of gamma rays. Uses a multi-channel analyzer interfaced with a computer, a solid state detector, and other modern equipment.

### **N4. *Compton Scattering***

*Under development*

## SOLID STATE PHYSICS

### **S1. *Hall Effect***

Determines the sign and concentration of charge carriers in semiconductors by studying carrier mobility in magnetic and electric fields. Provides good background for *The Diode and Its Applications* and *Electron Paramagnetic Resonance*. Emphasizes physical principles of semiconductor physics. Computer automation of data collection.

### **S2. *Electron Diffraction from a Crystal Lattice***

Investigates the diffraction of electrons from a thin polycrystalline carbon film. Analysis of diffraction pattern allows determination of the crystal structure and lattice spacings of graphite. A suggested prerequisite for the *X Ray Diffraction* Advanced Laboratory experiment. Emphasizes diffraction physics principles and determination of the experimental parameters related to Bragg's Law.

### **S3. *High Temperature Superconductivity***

Develops temperature measurement techniques using thermocouples and cryogenic techniques for handling liquid nitrogen. Explores the qualitative aspects of the Meissner Effect and magnetic levitation. Measures the resistance as a function of temperature to determine the critical temperature, critical magnetic field, and critical current. Measures the persistent current in a superconductor. Emphasis on the physical principles of superconductors.

### **S4. *Electron Spin Resonance***

Uses the response of bound electrons in a solid to rapidly varying magnetic fields to investigate the nature of solids. This is an important technique in many fields such as non-destructive testing and medicine. Experiment is mostly qualitative and emphasizes physical principles. *Under development.*