



### THE EXPERIMENTS

#### ***Experiment 2: A Simple Resonant System***

A thorough introduction to the procedures and techniques you will come to master as you complete the sophomore experimental physics lab sequence. Specifically, you conduct spectral and time domain analyses of a RLC resonant circuit. You are required to complete this experiment before attempting any of the others.

[http://www.sophphx.caltech.edu/Physics\\_6/Experiment\\_02.pdf](http://www.sophphx.caltech.edu/Physics_6/Experiment_02.pdf)

#### ***Experiment 7: The Kelvin Absolute Voltmeter***

By measuring the force between two parallel metal plates as a function of the voltage difference between them you may determine the electrical permittivity of space and thus the speed of light. The apparatus was designed and built many years ago by the renowned physicist Wolfgang Panofsky; it includes a beautiful, century-old analytic balance.

[http://www.sophphx.caltech.edu/Physics\\_6/Experiment\\_07.pdf](http://www.sophphx.caltech.edu/Physics_6/Experiment_07.pdf)

#### ***Experiment 9: A Mass Spectrometer***

In this experiment you will use a simple mass spectrometer to observe the various isotopes of several alkali metals and halogens, testing the applicability of the Lorentz force law to individual ions of both positive and negative charge, and you will determine the ratio of the electron charge to the atomic mass unit (AMU).

[http://www.sophphx.caltech.edu/Physics\\_6/Experiment\\_09.pdf](http://www.sophphx.caltech.edu/Physics_6/Experiment_09.pdf)

#### ***Experiment 12: Electron Diffraction***

The discovery of the wave-like nature of electrons by the American physicists Davisson and Germer in 1927 and by G. P. Thompson in 1928 earned Louis de Broglie, the theorist who proposed this idea, the 1929 Nobel Prize; Davisson and Thompson later shared the 1937 prize for those experiments. Our experiment, similar to Thompson's, examines the quite spectacular diffraction of electrons by crystals of graphite and aluminum, providing a precise determination of Planck's constant.

[http://www.sophphx.caltech.edu/Physics\\_6/Experiment\\_12.pdf](http://www.sophphx.caltech.edu/Physics_6/Experiment_12.pdf)

### ***Experiment 13: The Solid State Diode***

The PN junction semiconductor diode is a staple of modern electronics. The condensed matter theory describing its behavior is relatively modern, fascinating, and rich in detail. Understanding how the diode works requires a synthesis of facts from electromagnetism, statistical mechanics, and multi-particle quantum theory. This experiment investigates the accuracy of a simplified version of William Shockley's 1950 theory of the ideal PN junction diode (Shockley shared the 1956 Nobel Prize with J. Bardeen and W. Brattain for their invention of the transistor).

[http://www.sophphx.caltech.edu/Physics\\_6/Experiment\\_13.pdf](http://www.sophphx.caltech.edu/Physics_6/Experiment_13.pdf)

### ***Experiment 14: Lumped-Parameter Delay Line***

The apparatus consists of a 1-dimensional resonant cavity constructed from a 10-cell set of strongly-coupled LC resonators. The resulting transmission line is dispersive, and its spectrum of resonances is particularly rich. You will find that its behavior varies slightly from the predictions of the most straightforward theory, hinting at the existence of an additional high-frequency resonance well beyond its cutoff frequency.

[http://www.sophphx.caltech.edu/Physics\\_6/Experiment\\_14.pdf](http://www.sophphx.caltech.edu/Physics_6/Experiment_14.pdf)

### ***Experiment 15: Sound Waves in a Cavity***

The apparatus is essentially a two-dimensional resonant cavity using air as the transmission medium of sound waves introduced by a speaker in a cavity wall. Analysis of the very rich spectrum of resonances provides the dispersion relation for sound waves in air and yields a very accurate determination of the speed of sound.

[http://www.sophphx.caltech.edu/Physics\\_6/Experiment\\_15.pdf](http://www.sophphx.caltech.edu/Physics_6/Experiment_15.pdf)

### ***Experiment 16: Analog Fourier Analysis***

Using a high-Q resonant filter to selectively amplify particular harmonics of a periodic input signal allows you to measure the Fourier component amplitudes and phases of the input waveform. Comparing your results with the mathematical calculation of these values will provide some interesting insights into the relationship between these particular abstract mathematical constructs and actual physical behavior.

[http://www.sophphx.caltech.edu/Physics\\_6/Experiment\\_16.pdf](http://www.sophphx.caltech.edu/Physics_6/Experiment_16.pdf)

**Experiment 19: The Index of Refraction of Gasses**

Using a modern, research-grade implementation of Albert Michelson's famous interferometer design you will fairly accurately determine the indices of refraction of various gasses (air, CO<sub>2</sub>, He) at two wavelengths. Combining your results with a simple microscopic theory of the atomic origin of the refractive index provides some insight into the response of an atom's electrons to an oscillating external electromagnetic field.

[http://www.sophphx.caltech.edu/Physics\\_6/Experiment\\_19.pdf](http://www.sophphx.caltech.edu/Physics_6/Experiment_19.pdf)

**Experiment 24: The Temperature Dependence of Resistance**

Good conductors have a resistance which is very nearly proportional to temperature — why is that? Pure semiconductor materials, on the other hand, have a resistance which decreases exponentially with increasing temperature — again, why? As with the behavior of the PN junction diode (Experiment 13), the answers lie deep in the complex and subtle behaviors of the outer (valence) electrons of the atoms in the solid. This experiment tests some basic but important models derived from condensed matter theory, which synthesizes basic laws of electrodynamics, statistical mechanics, and quantum theory.

[http://www.sophphx.caltech.edu/Physics\\_6/Experiment\\_24.pdf](http://www.sophphx.caltech.edu/Physics_6/Experiment_24.pdf)

**Experiment 25a: Balmer Lines of Hydrogen**

Using a high-quality, research-grade spectrometer to accurately measure the emission line spectrum of a high-temperature hydrogen gas, you will test the accuracy of a very simple quantum model of the electron energy levels in a hydrogen atom (a charged particle in an attractive Coulomb field). Your results will should also provide a very precise measurement of a fundamental constant of nature, the (reduced mass) *Rydberg constant*.

[http://www.sophphx.caltech.edu/Physics\\_6/Experiment\\_25a.pdf](http://www.sophphx.caltech.edu/Physics_6/Experiment_25a.pdf)

**Experiment 27: The Normal Zeeman Effect**

The presence of an external magnetic field causes the individual spectral lines emitted by a hot gas to split, although the splitting may be very small. This phenomenon is called the *Zeeman effect* after the physicist who first observed it around 1896. A model for the source of the splitting was first proposed by Lorentz, who shared the 1902 Nobel Prize with Zeeman. Your careful measurements of the line splitting as a function of magnetic field strength will provide an accurate estimate of the electron's charge/mass ratio.

[http://www.sophphx.caltech.edu/Physics\\_6/Experiment\\_27.pdf](http://www.sophphx.caltech.edu/Physics_6/Experiment_27.pdf)