Physics 360
Description of Experiments

1. Biopack Experiments

This set of three exercises combines nicely into a single laboratory set of experiments. Electrocardiography, Electromyography, and Nerve Conduction Speed all make use of electronic signals either propagating along nerve fibers or generated by muscle contraction. These experiments are constructed around "Biopac Systems", a commercially produced set of experiments that use *EKG* electrodes and computer-aided data collection.

2. Quadrupole Mass Spectrometer System

The quadrupole mass spectrometer system consists of an ultra-high vacuum pumping station, a quadrupole mass analyzer and a special inlet system that allows mass analysis of gases at atmospheric pressure. In addition to learning about the principles of ultra-high vacuum, several biophysics laboratory experiments are being developed:

a) **Alcohol Fermentation:** Quadrupole mass spectrometry offers scientists sufficiently sensitive instrumentation to monitor and analyze the metabolism of microorganisms. Specifically, Saccharomyces cerevisiae represents the ideal model organism for experimentation in alcohol fermentation. Work with commercial products demonstrates the strong preference for anaerobiosis and immense fermentative capacity of distiller's yeast – so-called “turbo” yeast. Residual gas analysis, coupled with simple population growth models, can confirm the one-to-one stoichiometric approximation of anaerobic catabolic glucose conversion models. Lastly, ethanol inhibition permeates all levels of high-alcohol fermentation and requires further research to fully understand yeast as a model organism and as a key component of modern industry.

3. Diffusion

Diffusion plays an important role in many processes in biology. The physical mechanism underlying diffusion is random displacement due to collisions occurring on a molecular scale, also known as Brownian motion or random walk. In this lab you will explore the mathematics of random walks using simple models and Matlab-based computer simulations.

4. Ultrasonics

In this experiment we examine the physics underlying the use of ultrasound as an interrogation probe for the determination of ultrasonic and mechanical properties of tissue. The speed of propagation, the attenuation, and the backscatter of ultrasonic waves are three indices commonly employed to ascertain the inherent mechanical properties of tissue by a noninvasive means. In this experiment you will measure the density, longitudinal signal velocity, acoustic impedance, and frequency-dependent attenuation coefficient of tissue-mimicking phantoms using a broad-band ultrasonic measurement system.

5. Electrophysiology (Chara)

This lab illustrates electrical properties of cell membranes while introducing basic principles of intracellular electrophysiological recording. Specifically, you will learn the two-electrode voltage clamp technique and examine the properties of ion channels and the ionic basis of the membrane potential. The alga Chara corallina are the cells of choice in ion channel research and will be provided for this experiment. In this experiment, you will stimulate action potentials in a freshwater alga and investigate their characteristics. You will see that these action potentials have very different properties from the animal action potentials with which you are now familiar.

6. Dynamics and Thermodynamics of Microscale Objects (Optical Tweezers)

The motion of small objects, such as proteins in cells, at length scales of nanometers to micrometers has a very different feel from the motion of the larger objects seen in everyday life at length scales of centimeters to meters or more. The motions of larger objects are typically close to deterministic, in the sense that they follow regular, well-defined paths. They are also strongly affected by inertia, in the sense that a car will travel a long distance before it is stopped by friction. Motions of small objects in liquid or gaseous environments are very different. Random effects arising from thermal forces make motion quite unpredictable; furthermore, inertia is often almost entirely irrelevant. This experiment allows you to see these effects up-close by watching and analyzing the motion of micron-size beads in a liquid, and then trapping the beads in an optical force field and watching the thermal dynamics of their motion. This project involves seven specific tasks:

1) Build a microscope using an oil-immersion lens.
2) Use it to watch Brownian motion of the beads and quantify it by evaluating their diffusion coefficient.
3) By evaluating the average deterministic part of the beads motion obtain an estimate of Boltzmanns constant - the fundamental number relation temperature to energy and force.
4) Align the laser to form a trap.
5) Directly observe the thermal fluctuations of micron-size beads and quantify them via their mean-squared displacement
6) Evaluate the strength of the laser trap by dragging beads out of the trap
7) Use trap to measure the viscosity of a biomimetic material (gelatin) at various concentrations of gelation