Introduction

We are all experienced users of many sorts of mechanical systems, from swings on a playground to bicycles to can openers. On the other hand, the application of basic mechanical principles to the devices that we use is much less familiar than the devices themselves. It is the purpose of this laboratory to begin the process of developing awareness of various physical principles at work in various situations. This will be accomplished by a series of "encounters" with various sorts of apparatus -- all of which you will be seeing in lecture demonstrations and/or in laboratory situations. This is the least formal of the lab exercises we will do this term, but it may be among the more important educationally; it gives you some things to be curious about, and curiosity is by far the best force to motivate learning.

In the laboratory room you will find a number of "stations" each with a description/instruction sheet. Follow the instructions on these sheets to work with the apparatus; be sure to record all requested information in your laboratory notebook and be sure that you visit all of the stations. You need not visit the stations in any particular order.
Angular Momentum Conservation

1) Sit on the stool with your feet on the floor (so that the stool seat cannot rotate); start the bicycle wheel rotating as rapidly as you can. Hold the rotating wheel by its axis and lift your feet off the floor.

Turn the axis of the bicycle wheel around. Can you find any relationship between the orientation of the bicycle wheel axis of rotation and the motion of your stool seat?

2) With your feet on the floor to prevent the stool seat from rotating, again start the bicycle wheel spinning as rapidly as you can. Hold the axis of rotation of the wheel in a vertical position and then lift your feet from the floor. Now turn the axis of the wheel 180 degrees so that it is vertical again but the wheel is now spinning the other way from your vantage point. What happens? Turn the wheel back to its original position and pay very close attention to what your body "feels". You should feel a "force" trying to push you around so that you change your state of rotation on the stool seat. Where does the force come from?

Later in the term we will learn to analyze situations like this in terms of a quantity called "angular momentum."
**STATION # 2**

**Precession**

Look carefully at how this bicycle wheel is mounted in the frame that holds it. Move the axis of the wheel in the two directions permitted by the way that the wheel is mounted. Now start the wheel spinning about its axis as rapidly as you can.

1) By exerting forces on the wooden frame, change the direction of the axis of the wheel's rotation and observe what the wheel does. This is another example of the conservation of angular momentum that you experienced at Station # 1.

2) With the wheel still spinning rapidly, hang the weight provided from the small metal "eye" on the axis of the wheel's rotation. What happens? If you hang more or less weight how is the behavior of the spinning wheel altered?

The motion of the axis of rotation that results when a weight is hung from the axis in the way that you have done it at this station is called "precession." The planet earth is undergoing such a precessional motion although very slowly, completing a full cycle in 25000 years. The twisting force (torque) which drives the earth's precession comes from the gravity of the moon and the sun.
STATION # 3

The Bernoulli Effect

1) Turn on the air supply and direct the hose straight up in the air. Place the ball in the center of the air stream so that the air "supports" the ball and then withdraw your hand.

Now tilt the hose so that the stream of air is no longer directed straight up. The ball does not fall! How close to horizontal can you direct the stream of air and still suspend the ball?

With the air at some angle to the vertical, move the end of the hose so that the ball follows in a horizontal circle. The stream of air is not only able to support the weight of the ball, it can cause it to swing around so as to "follow" the direction of the air stream.

2) Tear or cut a strip of paper from your lab notebook paper. The strip should be about 11 inches long and an inch or so wide (exact dimensions are not important.

Now hold one end of the strip under your lower lip; let the other end hang down. Blow a gentle stream of air from your mouth over the strip. The strip rises.

During the term you will learn how all of these effects may be explained by the Bernoulli equation of hydrodynamics.
Which Way Will the Floats Move?

Two flasks nearly full of water have fishing floats inside anchored to the stoppers of the flasks. Notice the air bubbles at the tops of the flasks too. These flasks are mounted at either end of a piece of wood which can spin about a central axis.

Suppose you start the wooden piece spinning about its axis. What direction will the fishing floats move with respect to the flasks? Guess and then try it to see if you have guessed correctly.

To understand what is going on here, you will need notions of rotational motion and fluid mechanics which we will discuss later.
Resonance of a Drumhead

1) The piece of rubber stretched over the cardboard cylinder may be thought of as representing the drumhead of a kettledrum. Behind the stretched rubber is a rather large loudspeaker that is designed to reproduce low-frequency sounds (such speakers are sometimes called "woofers").

The speaker is connected to an amplifier and an electronic "sound" generator (actually it is called an "audio oscillator" or "signal generator"). Turn on the signal generator and set its dial to read 20 Hz (or 20 cycles per second or "cps"). Now turn on the strobe light and set the control so that the light blinks 1200 times per minute. Now slowly vary the frequency (the "pitch") of the signal generator. You should find a setting of the signal generator control such that the motion of the drumhead is at a maximum.

This is called a "resonant frequency" of the drumhead.

2) Now set the signal generator to a frequency of 40 Hz and set the strobe light to blink 2400 times a minute. Again vary the frequency of the signal generator until the motion of the drumhead is maximum. You have just found a second resonant frequency of the drumhead. What is different about this second resonance in terms of the motion of the drumhead?

3) Try to find yet a third resonance of the drumhead. Set the signal generator to 60 Hz and the strobe light to 3600 blinks per minute. Once again vary the frequency of the signal generator until you find a resonance. How does this resonance differ from the previous two (in terms of the pattern of motion of the drumhead)?

Rather late in the term we will study sound waves and various sorts of mechanical resonance.
STATION # 6

How Does It Work?

Twirl the axle in your fingers to set the axle and the wheel spinning and then let the axle rest against the spiral metal spring at the top of the wooden frame.

Why does the axle move along the spring and follow its curve on BOTH sides of the spiral?

We will discuss a quantity called "torque" that explains what you are seeing here.
1) On the floor you will find a bucket partly filled with water; inside the bucket is a funnel with a rubber tube attached. Remove the funnel from the bucket (keeping the tube attached) and while you hold the funnel right-side up, pour the water from the bucket that you found on the floor into the top bucket. Replace the empty bucket on the floor, but keep holding the funnel.

2) Dip the 500 ml beaker into the top bucket so that the beaker has about 300 ml of water in it.

3) Raise the funnel with the hose attached as high above the level of the glass sphere as you can (at least 2 feet) and then slowly pour the 300 ml of water from the beaker into the funnel. It will take the water in the funnel some time to leave the funnel; be patient, and slowly add water from the beaker to the funnel until all 300 ml has gone down.

4) When the last of the 300 ml of water has left the funnel, pinch the tube attached to the funnel tightly between your thumb and index finger and, keeping the tube tightly pinched, lower the funnel into the bucket on the floor. Now stop pinching the tube.

5) Stand back and watch.

You'll be able to figure out just how this thing works when we study fluid statics and dynamics.
The Oscilloscope

1) The microphone is connected to a device called an "oscilloscope". You can ignore its inner workings and regard it as a device that displays time variations of various sorts.

   For example, sing, squawk, burp or otherwise make some noise in the microphone while you watch the oscilloscope screen. A representation of the sound waves coming from your mouth is displayed on the screen.

2) The second oscilloscope is connected to two audio oscillators of the sort you used with the drumhead at station #5. Turn the controls that vary the frequency (or "pitch") being generated and observe the pattern on the screen. This is the result of combining wave motion simultaneously in two dimensions.