EKG and Sound

I. Before coming to lab
- Read this handout and the supplemental.
- Visit the following website: http://www.blaufuss.org/ then click on the "START" button next to "Heart Sounds Tutorial." Do not worry so much about the text. Pay attention to how the various heart sounds correspond to the plots and animations.
- A video of the vocal cords in action can be found at the following URL. It may be helpful in understanding the first part of the lab. Be warned, this is a video of an actual person's vocal cords as seen through trans-nasal endoscopy – a medical procedure where a camera is fed through a person's nostrils and down their throat. It is interesting, but not for the overly squeamish. Here's the URL:
  http://www.youtube.com/watch?v=TcR8MwOhpUM

II. Learning Objectives
In this lab, you'll hear and "see" acoustical signals and learn how to interpret them. You'll apply various transformations to them and measure sound frequencies. Finally, you'll apply this knowledge to heart sounds, both on a sample of normal and abnormal heart sound recordings and then on your own heart.

III. Materials
Tuning fork
This is a tuning fork that is designed to oscillate at a given frequency (printed on the base of the fork). To avoid damaging the tuning fork, don't bang it against anything hard. You can strike it against your hand or against the carpeted lab chairs or the rubber sole of your shoe.

Balloon
It's a balloon.

Vernier microphone

This is a simple microphone whose output can be read by Logger Pro.

Stethoscope
This is a standard medical stethoscope that has been modified so that one earpiece is now connected to a microphone whose input goes directly into the computer. The other end of the stethoscope is the one that goes against your chest.

Vernier EKG probe

The EKG sensor plugs into one of the sockets on the left side of the Lab Pro. It has three alligator clips, colored red, black, and green.

V. Procedure
Tell us who you are. (Picture, names, and emails please)
A:

Vocal sounds
Using the Lab2Sound.cmbl file in Logger Pro, sing a high note into the microphone. Without stopping, gradually lower your pitch until the note is as low as you can sing. **What do you observe happening in the FFT plot?**
A:

Collect data for your singing the high note again. Click "Stop" to freeze the screen. **Paste screenshots of the "High Note" time signal and FFT graphs here:**
A:

Now, sing the low note again. Collect data and then click "Stop" to freeze the screen. **Paste screenshots of the "Low Note" time signal and FFT graphs here:**
A:

Tuning Fork
Click "Collect" to start taking data. Hold the tuning fork by the stem and lightly hit the tuning fork on something **soft** (*e.g.* your knee, shoe sole, back of chair, *etc.*). If you hold the tuning fork up to your ear, you should be able to hear a tone. Have the microphone collect the tuning fork sound. Click "Stop" once you have a nice signal. **What is the frequency written on the tuning fork?**
Frequency =

Qualitatively describe the resulting audio signal and FFT plots. How do these compare to the singing plots?
A:

Using the "Examine" function in Logger Pro, determine the period and frequency of the tuning fork sound wave:
Period =
Frequency =

How does your measured frequency compare to the frequency written on the tuning fork?
A:

Fit the audio signal to a sine wave. **Paste a screenshot of the audio signal with the fit clearly displayed:**
A:

What is the frequency from your fit? (Note: Be careful of units here!)
Frequency =

Does the fit frequency match the frequency written on the tuning fork? Explain.
A:

Click on the FFT plot. Fit the main feature of the FFT plot to a Gaussian. **What is the mean of the Gaussian? What does this value correspond to?**
Mean =
A:

Paste a screenshot of the FFT with the fit clearly displayed:
A:

Balloon
Here you will use a balloon as a physical model of how humans produce sound. You will collect data using the Logger Pro file Lab2Balloon.cmbl.

Blow up a balloon and pinch it closed. Press "Collect" in Logger Pro and slowly let the air out such that it makes a squealing sound. (You know how to do this...it's just difficult to describe in words.) **Paste a screenshot of the audio signal and FFT of the high-pitched squeal:**
A:

Now try to decrease the pitch of the squeal. **What do _you_ have to change in order to accomplish this?**
A:

What (specific) part(s) of the human anatomy is modeled by the squealing balloon?
A:

Explain how the balloon produces a sound wave and why this is, therefore, a good model for your answer to the previous question:
A:

Heart Murmurs
In this part of the lab you will use the Logger Pro file Lab2Murmur.cmbl to hear a normal heartbeat (normalheart.wav) and a heart murmur (diamondshapedsystolicmurmur.wav). To do this, open the .wav files in Quicktime and point the microphone to the computer's speakers while collecting data on Logger Pro. More detailed instructions are found in the Procedures section of this write-up.

First, play the normal heartbeat sound file. Listen to the heartbeats. You should hear a repeated "lub-dub" sound. The "lub" is called S1 and the "dub" is called S2. Collect the sound data for this heartbeat. Measure the time between S1's and use it to calculate the frequency of the signal (i.e. heart rate):
Time between an S1 and the next S1 =
Heart rate in beats per minute =

Now look at a single S1. It looks like just a blip, but zoom in very close on it. You should see some actual structure—not quite a sine wave, but definitely something that looks somewhat periodic, at least for a few oscillations. **Estimate the frequency of these very fast oscillations:**
A:

Is this frequency related to the heart rate you calculated above?
A:

Now go back and zoom in on an S2. **How does the waveform look compared to an S1?**
A:

Does it appear to be roughly the same frequency as the S1?
A:

Before moving on, store this data run in Logger Pro, so you can see data from the normal heartbeat you just took and the heartbeat with at murmur, which you will take next, at the same time. Play the heartbeat with a murmur audio file. Listen to the heartbeat.

Hit Command+L in LoggerPro to save the first recording. As before, collect the "Heart Murmur" sound in Logger Pro by holding the microphone up to the computer speakers. **How does it (qualitatively) sound different from the normal heart sound?**
A:

In order to compare the frequency spectra of both the "Normal Heart" sound and the "Heart Murmur" sound you will need to double-click on the "FFT 2" window. On the right side of the window under "FFT Definition", deselect "Offset" from "Run 1". (It should correspond to the red square.) Now double-click on the "FFT" window and deselect "Offset" from "Latest". (This one should be a blue circle.) **How does the frequency spectrum of the murmur compare to the spectrum of the "normal" sounds?**
A:

How is this useful in diagnosing heart murmurs?
A:

Paste a screenshot of the audio signals and FFT plots of the normal and heart murmur sounds:
A:

EKG and Sound

<u>Listen to your heart with a stethoscope</u>
In this part of the lab you will listen to your own heart and collect the sound data using the file Lab2Heart.cmbl on Logger Pro.

Select one group member to be the "patient" (and also the doctor, since you will be listening to your own heart). Put on the stethoscope with one ear bud in your ear and the other attached to the microphone. You may want to use an earplug in your other ear to damp out surrounding noises.

IMPORTANT NOTE: The equipment you'll be using in this part of the lab is for educational purposes only. It is **not** intended to be used for medical diagnosis. As paranoid as you might be, don't assume that you have a heart disorder based on anything you measure in the physics lab. This isn't real medical equipment, and you're not a real doctor. Chances are, you are perfectly healthy.

Using the diaphragm side of the stethoscope, find your heartbeat and listen to it. Record the sound in Logger Pro by collecting data for a few seconds. If you don't see an audio signal, check the setting on the stethoscope. **Paste a screenshot of your heart sound here:**
A:

Identify the S1 and S2 on your heart signal (there will be more noise than in the heart sounds you saw in the previous section). Zoom in close on an S1. **Determine your pulse rate:**
Pulse rate =

Select the time interval corresponding to S1 and try to fit a sine wave to the acoustic signal. (The fit will not be great, of course, since the amplitude isn't very constant, but you can at least get an idea of the frequency this way.) **What is the frequency from the fit?**
A:

Paste a screenshot of your S1 signal with fit:
A:

Do the same thing for S2:
Frequency from fit =

Paste a screenshot of your S2 signal with fit:
A:

Does S2 overall look similar to S1 or substantially different?
A:

Record your heartbeat again, except this time, while the recording is occurring, knock on your sternum with your knuckles a few times.
What do the knocks look like in the waveform?
A:

Paste a screenshot of your signal here:
A:

Zoom in on a knock and measure the frequency of the knocking noise in the same way you did for S1 and S2. **Estimated frequency from fit =**
Frequency=

How does the knocking frequency compare to the S1 and S2 frequencies? What do you think it is about your anatomy that is responsible for this frequency?
A:

Now turn to page 2 of the Logger Pro file. Connect the "patient" with EKG leads as described in the

materials section. This time, record both your heart sounds (using the stethoscope/microphone) and your heart's electrical activity (using the EKG) simultaneously. **Paste a screenshot of both graphs here:**
A:

What do you notice about the relative timing of the electrical and acoustical signals? Why do think this happens?
A:

VI. Conclusion
When you have finished listening to your heart, wipe off the ear bud of the stethoscope using an alcohol swab so that the next person has a clean stethoscope. Throw away used alcohol swabs, earplugs, and EKG patches.

What is the most important thing you learned in lab today?
A: