Laser Harp Build Instructions

This is a simplified version of the Laser Harp project built by the Artisan's Asylum hackerspace in Somerville, Massachusetts, and winners of the RadioShack East Vs. West Hackerspace Challenge.

The Artisan's Asylum version of the harp is quite large and involved a considerable amount of construction. It has 12 strings, uses an Arduino Mega and communicates with a PC, which plays the audio samples. Plucking the strings also triggers cool lighting effects.

This version has been scaled down a bit to make it a great beginner project, but the basic functionality is the same: a set of laser pointers are aimed at a series of photoresistors, which are hooked up to the input pins on an Arduino. The Arduino is running a program that detects any interruptions in the beams and plays the note corresponding to that sensor. The harp is played by "plucking" the laser strings; i.e., blocking the path of the laser.

For this version, the Arduino itself produces the audio, and a small piezo speaker is connected directly to the Arduino. These instructions describe how to build a three-string harp, which allows us to use the smaller Arduino Uno. Adding more strings is easy: the Uno can handle up to five sensors; more than that will require an Arduino with more input pins, such as the Mega.

Parts

Note: the parts for this simplified version of the project are different than what appears in print in the magazine, which lists the parts used in the full-size version.

Arduino Uno:
http://www.radioshack.com/product/index.jsp?productId=12268262

Laser pointer device, e.g.:
http://www.radioshack.com/product/index.jsp?productId=4344500
or:
http://www.radioshack.com/product/index.jsp?productId=2103037

3 photoresistors:
http://www.radioshack.com/product/index.jsp?productId=2062590

3 10k resistors
http://www.radioshack.com/product/index.jsp?productId=2062347

Piezo speaker:
http://www.radioshack.com/product/index.jsp?productId=2062402

Potentiometer:
http://www.radioshack.com/product/index.jsp?productId=2062354&filterName=Type&filterValue=Potentiometers

Solid-core hookup wire:
http://www.radioshack.com/product/index.jsp?productId=2049743

Solderless breadboard:
http://www.radioshack.com/product/index.jsp?productId=2882885

Jumper wire kit:
http://www.radioshack.com/product/index.jsp?productId=2103801

Getting Started

Install Arduino Software
Download Arduino software from the Arduino website: http://arduino.cc

If you've not used an Arduino before, you'll want to spend some time familiarizing yourself with the basics. Check out the Arduino website (above) for some great beginner tutorials.

Install the Tone Library
For this project, you'll need to install the "Tone" library, which can be downloaded here:
http://code.google.com/p/rogue-code/wiki/ToneLibraryDocumentation

When you unzip the downloaded file, it will create a "Tone" folder. This folder should be moved to the "Libraries" folder, which is in your Arduino sketchbook folder. If you're not sure of your sketchbook folder location, it can be found in your Arduino preferences. If the "libraries" folder doesn't exist, create it, then copy the "Tone" folder to that location. Restart your Arduino application. You should now see "Tone" when you select from the menu bar:

Sketch > Import Library... (look under "Contributed")

For more information, see "Contributed Libraries" on the page: http://arduino.cc/it/Reference/Libraries

How it Works

Photo Sensors

The laser-detecting circuits use a photoresistor paired with a resistor to create a *voltage divider*. A change in *resistance* in one of the resistors creates a change in *voltage*. The photoresistor's resistance changes according to the intensity of the light hitting it; the brighter the light, the lower the resistance.

Each sensor circuit is hooked up to an analog input pin. The pin reads variations in voltage and translates them to a value from 0 to 1023, which can be read by the Arduino program (or *sketch*) running on the device. Depending on the value, the sketch will determine if the laser is hitting the sensor.

Calibration

Because the photoresistors will behave differently depending on various ambient lighting conditions, we need a way to calibrate the sensors. We'll calibrate manually using a potentiometer as an input. The potentiometer also acts as a voltage divider and will be hooked up to one of the analog input pins. Turning the potentiometer sends a value from 0 to 1023 to your Arduino sketch. This will be used to dial in the calibration (more on this later).

The Sketch

Download the "LaserHarpJr" sketch from here:

http://www.radioshack.com/graphics/uc/rsk/Support/ProductManuals/RS_DIY_LaserHarpJr.ino.zip

Unzip it and open the "LaserHarpJr.ino" file with your Arduino software. You don't need to understand everything about the sketch to build this project, but familiarizing yourself with it is a great way to learn about programming an Arduino. It's also a good starting point for customization.   For example, if you want to add more sensors or change the notes played by the harp, find the following chunk of code, which defines the analog input pin and the musical note for each sensor:

```
sensor[0].pin = A0;
sensor[0].note = NOTE_G3;
sensor[1].pin = A1;
sensor[1].note = NOTE_D4;
sensor[2].pin = A2;
sensor[2].note = NOTE_A4;
```

If you want to change the sequence of notes from this arpeggio to the first three notes of the C-major scale, simply change "NOTE_G3" to "NOTE_C4" and "NOTE_A4" to "NOTE_E4". Note that if you want to add "strings," you'll need to change the following line as well, towards the top of the sketch:

```
const int SENSOR_COUNT = 3;
```

More information about the tone library can be found here:
http://code.google.com/p/rogue-code/wiki/ToneLibraryDocumentation

Building the Circuit

This is an easy circuit to assemble using a solderless breadboard. Hook up the resistors, photoresistors and piezo speaker as shown in the illustration below, using jumper wires to connect each sensor circuit to the analog inputs on your Arduino. You'll need to solder hookup wire to the solder tabs on the potentiometer in order to make the connections. While stranded wire is more flexible, it's easier to connect solid-core wire to the solderless breadboard.
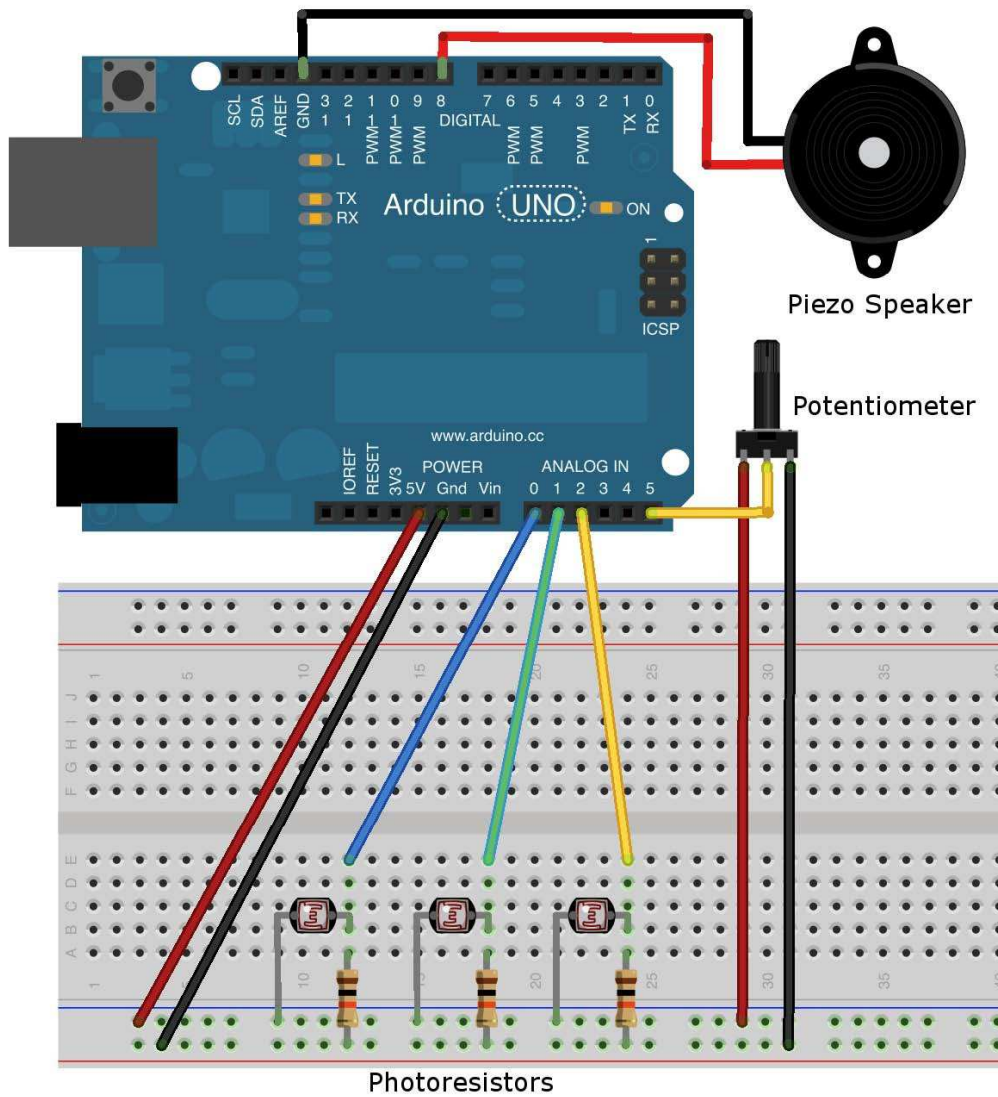
When assembled, it should look something like this.
No need to worry about setting up the lasers just yet!

Programming the Arduino

Next we'll upload the Arduino sketch to the device. Connect your Arduino to your computer using a USB A/B cable, and make sure the right board and serial port are selected (see the appropriate "Getting Started" section for your operating system: http://arduino.cc/en/Guide/HomePage).
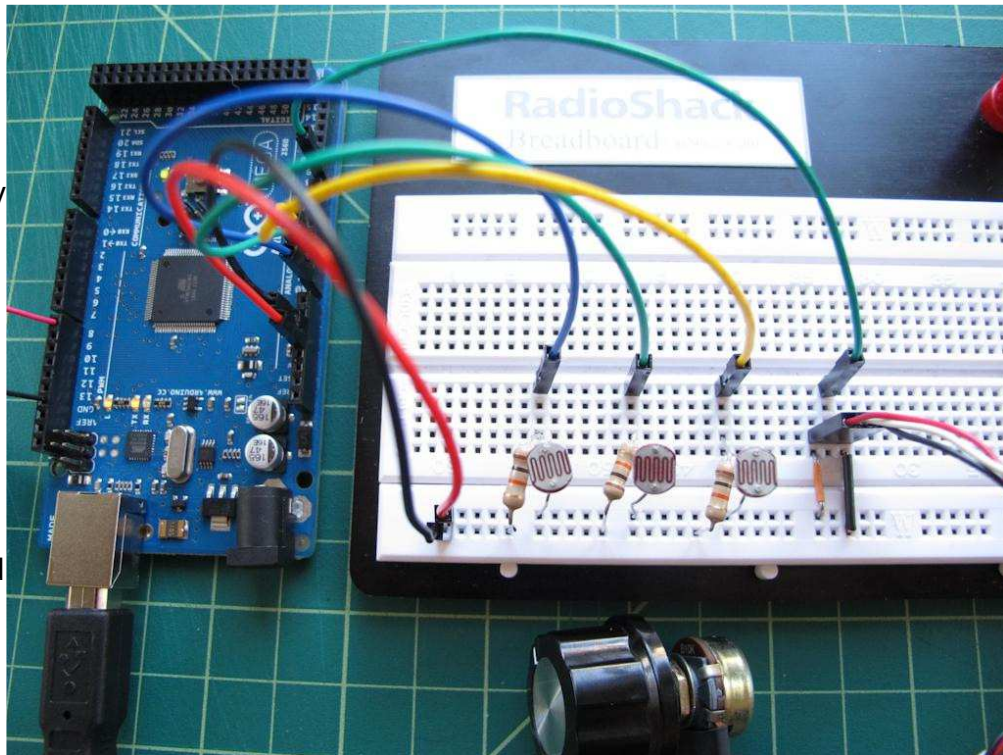
Open the "LaserHarpJr.ino" file with your Arduino software and click the right-arrow button (next to the check button). Some LEDs should blink on the Arduino board, and after a few moments, you should see "Done Uploading" in the console area of the Arduino software. Your sketch should now be running!

Testing Without a Laser

Using only the ambient light in the room, we can test the harp's sensors before setting up the lasers. However, the sensors will need to be calibrated first.

Calibration
You may or may not hear a tone coming from the speaker; slowly turning the potentiometer should cause the tone to turn on (or off) at some point. The trick is to turn

it just past the point where the tone turns off; at this point, any reduction in light falling on the sensor should trigger it, causing the tone for that sensor to sound.

Test
When you're done calibrating, test each sensor (one at a time) by putting a finger over it:
When a sensor is blocked, you should hear a tone. When you remove your finger, the tone should
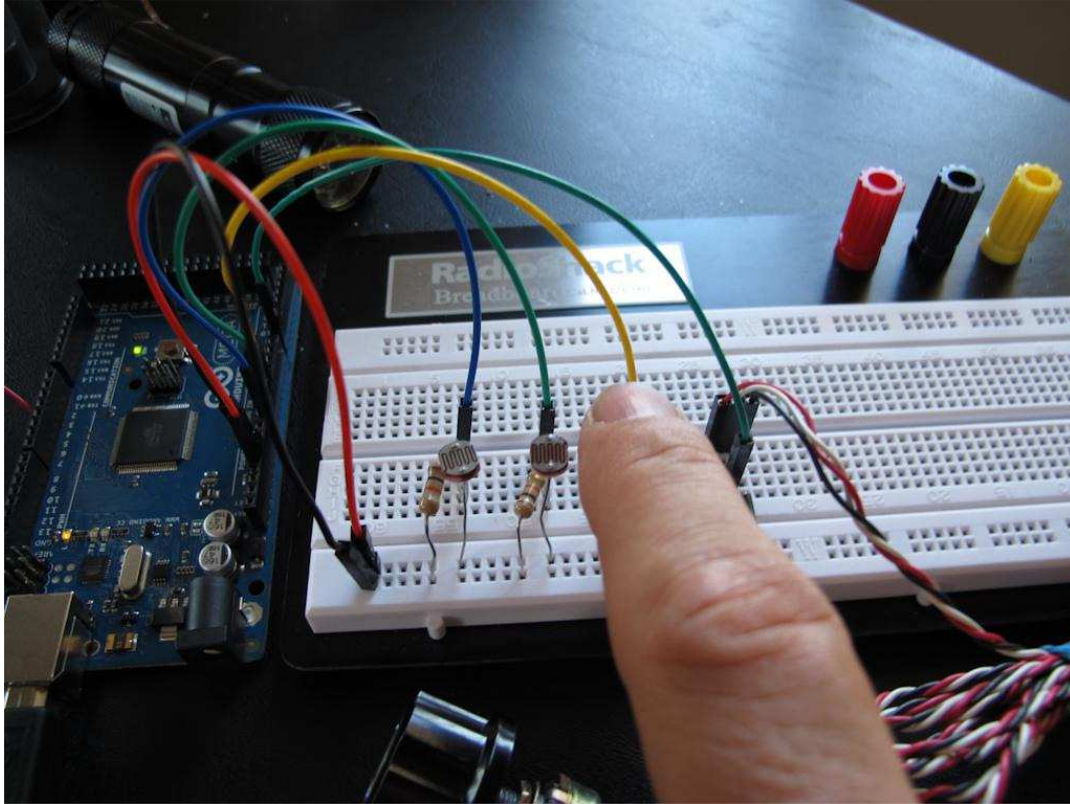
stop. Move your finger from sensor to sensor. You should hear a series of notes (a different note for each sensor).

Troubleshooting
If it's not working...
• Check all connections. Make sure all components and jumper wires are in the appropriate rows in the solderless breadboard. Make sure you've connected to the correct pins on the Arduino.
• Use a multimeter to test your circuit. Hook it up in voltage testing mode to test the voltage coming from each photoresistor (In the illustration and photo above, you would test the blue, green and yellow wires coming from each sensor. Unplug each wire in turn from the Arduino and test the voltage across the wire and ground. The voltage should vary as you block and unblock the sensor).
• Use a multimeter to test the resistance of the photoresistors. A fully blocked photoresistor should be in the same ballpark as the fixed (non-photo) resistor in the

voltage divider circuit. If the resistance is significantly different (e.g., 10K vs. 100K), try to find a photoresistor in the correct range. Otherwise, replace the fixed resistor with one of a similar value as the blocked photoresistor.

If you want to see what's going on in the Arduino program, turn on debug input in the sketch by changing this line:

```
const boolean DEBUG = false;
```

To this:

```
const boolean DEBUG = true;
```

Turn on the Serial Monitor in Arduino while the program is running, keeping the USB cable connected. This will print some interesting information to the screen as you play your harp, but it will negatively affect its performance; there will be a lag as you block and unblock the beams.

Laser Time!

Once you have everything working, it's time to set up the lasers. (You might want to power down the Arduino for now by unplugging its USB cable.)

There is any number of ways to position the lasers, as long as each beam points at one of the sensors. I happened to have a microphone boom stand kicking around, so I used that as a horizontal bar onto which I clamped the three laser pointers, using three small spring clamps and some gaffer's tape:

However, the endless! For example, position the pointers staircase so that melodies play when and down the stairs! require some additional course).

possibilities are you could along a different people walk up (This will wiring, of
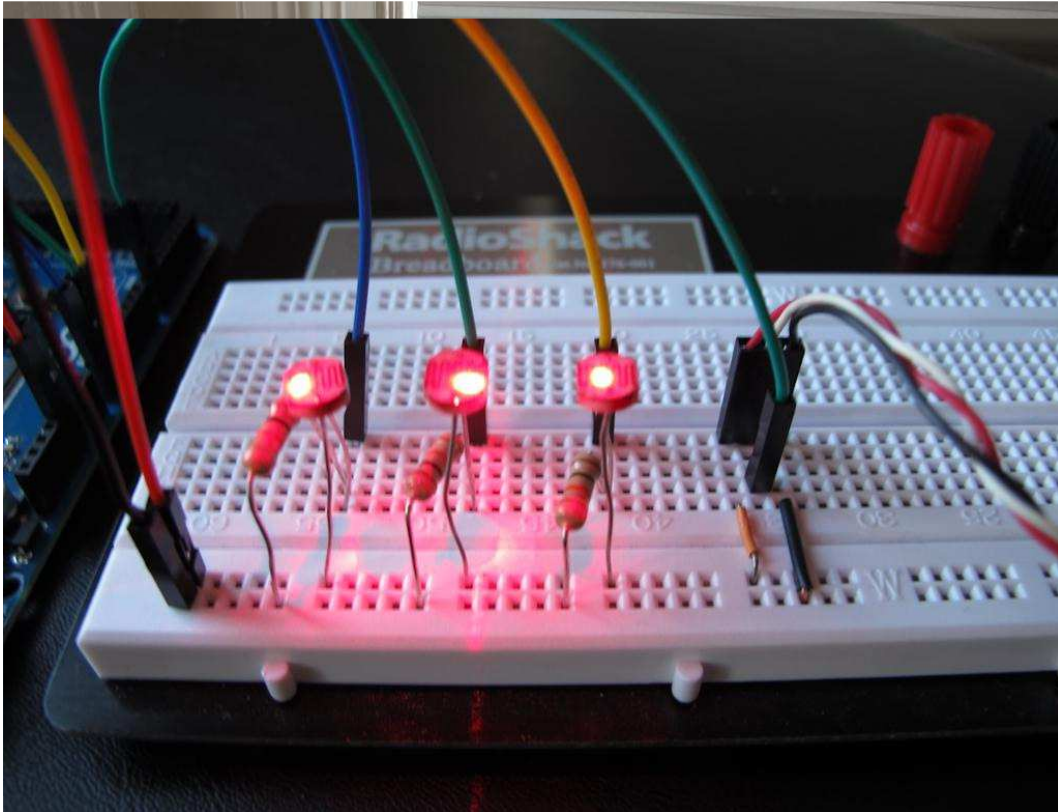
In any case, the lasers must be aimed carefully so that they hit each photoresistor, and you will need to re-calibrate. Power on the Arduino by plugging in the USB cable (you can also use a 9V battery, plugged in using a barrel connector). With all three lasers hitting the sensors, turn the potentiometer just past the point where you stop hearing a tone.

Play Your Harp

Place your hand in the path of one of the three lasers. You should hear a note play. When you move it out of the path, the note should stop. As you move your hand from beam to beam, you should hear a series of notes, with each laser "string" playing a different note.