Introduction
At this station you will find a selection of components, breadboards, and power supplies with which for you to play. Feel free to build what inspires you. If you are a new to breadboarding, read on.

Breadboarding Primer
The solderless breadboard is a convenient rapid prototyping substrate.

A breadboard consists of an array of holes that can accept a wire. The core of the array, denoted as rows A-J in the text on the edges of the breadboard, consist of columns of five holes that are electrically tied together: any wire or component inserted into one of these five holes will be shorted together. The top and bottom periphery of the array consists of rows of 25 holes that are similarly connected together. The top and bottom periphery rows are intended for the purpose of power distribution, hence the extended connectivity of these rows.
To use the breadboard, insert a wire or component into a hole, as shown above. In order to strip a wire, use a combo wire cutter/stripper tool, as shown below:

The combo wire cutter/stripper tool may take a little bit of practice to use, so if you are frustrated, try using some of the pre-cut wire scraps sitting around on the table to get you started.

**Beginner Level: The LED Circuit**

To get you familiar with the breadboarding environment, we will build the simplest circuit—an LED that is powered off of the power supply.

To start with, gather the following components:

- One LED
- One 220 ohm resistor

An LED looks something like the following image:
Note that an LED is polarized, which means that it matters how you plug it in. In this case, the side with the longer lead should go toward the positive power supply. If you look at the dome of the LED, there is a small flat on one side as well. The flat denotes the side that goes toward the negative power supply. If you connect it in the other direction, the LED will not light up.

A resistor will look something like the following image:

![Resistor Image]

A resistor is not polarized, so you can plug it in either way and it will work fine. All resistors are color coded. To read the color code, orient the resistor so that the gold band is to the right (the gold band corresponds to the resistor’s tolerance, or the manufacturing accuracy of the resistance value. In this case, gold means within 5% accurate). Read the colors from left to right. The first two colors form a two-digit value, and the third color is the exponent on the multiplier. Colors correspond to numbers as follows:
<table>
<thead>
<tr>
<th>Color</th>
<th>Value</th>
<th>Exponent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>0</td>
<td>$10^0 = 1$</td>
</tr>
<tr>
<td>Brown</td>
<td>1</td>
<td>$10^1 = 10$</td>
</tr>
<tr>
<td>Red</td>
<td>2</td>
<td>$10^2 = 100$</td>
</tr>
<tr>
<td>Orange</td>
<td>3</td>
<td>$10^3 = 1,000$</td>
</tr>
<tr>
<td>Yellow</td>
<td>4</td>
<td>$10^4 = 10,000$</td>
</tr>
<tr>
<td>Green</td>
<td>5</td>
<td>$10^5 = 100,000$</td>
</tr>
<tr>
<td>Blue</td>
<td>6</td>
<td>$10^6 = 1,000,000$</td>
</tr>
<tr>
<td>Violet</td>
<td>7</td>
<td>$10^7 = 10,000,000$</td>
</tr>
<tr>
<td>Gray</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

Thus, Red-Red-Brown corresponds to $22 \times 10^1 = 220$ ohms. Likewise, Brown-Black-Red corresponds to $10 \times 10^2 = 1,000$ ohms.

Now, you will connect the circuit up as described in the following schematic diagram:

![Schematic Diagram]

When you are completed building the circuit, the breadboard should look something like this:
If you have having trouble building the circuit, please consult the instructional video or ask bunnie for help!

**Intermediate Level: An Acoustic Oscillator**

In this project, you will build a circuit that makes an adjustable tone on a speaker. It is a fundamental starting point for a number of other circuits, ranging from alarms to analog music synthesizers to timing circuits for various applications. The core circuit is the 555 timer, a true classic circuit from back in 1971, and still being made in quantities of billions of units per year today.

In order to build this circuit, gather the following parts:

![Components](image)

From left to right, these are:

- Two 0.1uF capacitors (marked with “104” on the package)
- A 10k-ohm resistor (brown-black-orange)
• A 555 timer chip (in an 8-leaded package)
• A 50k-ohm potentiometer
• A speaker

Note that the 555 timer **must** be inserted in the proper direction and all the pins wired up exactly as described in the schematic. Permanent damage and lots of smoke will come out of the if you do not do this! See the diagram below for how to identify the pins on the 555 timer relative to the notch on the part:

Now, wire the circuit up according to the following schematic. Good luck, and feel free to ask bunnie for help! Before plugging in the power, see bunnie and he’ll check your wiring to prevent any meltdowns.
When you are finished, the circuit should look something like the following:

![Circuit Diagram](image)

Turn the knob on the potentiometer, and you will hear the that the pitch of the tone on the speaker goes up and down. There are a lot of quick variations you can make on this circuit to make it more complex; you can use the reset pin (pin 4), for example, as a “trigger” for the timer circuit and turn it into an alarm. You can also cascade several timers and use them to trigger each other to create more complex tones and patterns of sounds, and you can combine it with various op-amps to provide feedback and filtering functions. Datasheets for the 555 timer are provided to help you explore.

**Advanced Level: Voice Recorder/Playback**

In this project, you will build a circuit that can record sounds via a microphone and play them back. It's a fun little project that takes about a half hour to complete if you are
reasonably adept with a breadboard. If you are still a bit shaky on breadboarding, I’d suggest budgeting an hour, or asking for help from bunnie—if you are lucky, there will be some partially wired circuits around that can reduce the amount of effort it’ll take you to finish this project.

Before starting the project, gather the following components:

Clockwise, starting at the top left, these components are:

- 4.7 uF capacitor (polarized, pay attention to how it is inserted!)
- 220 uF capacitor (polarized, pay attention to how it is inserted!)
- Microphone
- Two pushbutton switches
- The ISD1416 or 1420 voice recorder/playback IC (the 16 version does 16 seconds of record/playback, and the 1420 does 20 seconds)
- Four 0.1uF capacitors (marked with “104”)
- Two 10k resistors (brown black orange)
- One 1k resistor (brown black red)
- Three 100k resistors (brown black yellow)
- One 5.1k resistor (green brown red)
- One 470k resistor (yellow violet yellow)

In addition, you will also need a speaker, not shown above.

Note that the larger capacitors (the larger can-type capacitors) are sensitive to which way they are inserted. Be sure to insert the side marked with the “-“ sign toward the ground side of the circuit. One can see the “-“ sign in the photo below:
If inserted backwards, a capacitor can rupture and cause damage to surrounding circuits, or worse yet, you!

Now, wire up the circuit according to the diagram below.

When you are finished, the circuit should look something like the following:
When you push the record button (connected to pin 27 of the ISD1416), speak into the microphone; to play back, push the play button and hold down for the duration of the play.

Happy hacking!