Basics of Arduino
EPICS Workshop

Arduino (RedBoard), Breadboard, LEDs
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What is an Arduino/RedBoard?

Arduino Uno (and the Sparkfun RedBoard version) are single board computers (called microcontrollers) that can sense and control things in the real physical world.

Arduino was developed by some folks in Italy and was made open source so everyone could use them. This has led to their wide use and adoption for lots of applications.
Sparkfun RedBoard: Microcontroller based on the Arduino Uno

- **PWR IN**
- **USB** (to Computer)
- **RESET**
- **SCL/SDA** (I2C Bus)
- **POWER** 5V / 3.3V / GND
- **Analog INPUTS**
- **Digital I/O** PWM(3, 5, 6, 9, 10, 11)
RedBoard (Analog, Digital, Power Header)

The **digital pins** are the digital inputs and outputs of the Arduino. These are what you connect to buttons, LEDs, sensors, etc. to interface the Arduino with other pieces of hardware. Pins marked with a tilde (~) can also serve as analog outputs, which you can use to dim LEDs or run servo motors (PWM).

There are six **analog inputs** on the analog header. These pins all have analog-to-digital converters, which can be used to read in an analog voltage between 0 and 5V. These are useful if you need to read the output of a potentiometer or other analog sensors. All six analog pins can also serve as digital inputs and outputs.

The **power header** is mostly full of voltage supply pins. These pins are traditionally used as power sources for other pieces of hardware (like LEDs, potentiometers, and other circuits). The ‘3.3V’ and ‘5V’ pins are regulated 3.3V and 5V voltage sources. The ‘GND’ pins are the common ground – the 0V reference for those voltage supplies. ‘VIN’ is the input voltage, it’ll be equal to the voltage of your input supply if you have a wall adapter connected. If nothing is connected to the barrel jack, and you’re powering the board via USB, VIN should be around 5V.
Some Sensors in the Toolbox.....

<table>
<thead>
<tr>
<th>Name</th>
<th>Image</th>
<th>Type</th>
<th>Function</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Push Button</td>
<td></td>
<td>Digital Input</td>
<td>Switch - Closes or opens circuit</td>
<td>Polarized, needs resistor</td>
</tr>
<tr>
<td>Trim potentiometer</td>
<td></td>
<td>Analog Input</td>
<td>Variable resistor</td>
<td>Also called a Trimpot.</td>
</tr>
<tr>
<td>Photoresistor</td>
<td></td>
<td>Analog Input</td>
<td>Light Dependent Resistor (LDR)</td>
<td>Resistance varies with light.</td>
</tr>
<tr>
<td>Relay</td>
<td></td>
<td>Digital Output</td>
<td>Switch driven by a small signal</td>
<td>Used to control larger voltages</td>
</tr>
<tr>
<td>Temp Sensor</td>
<td></td>
<td>Analog Input</td>
<td>Temp Dependent Resistor</td>
<td></td>
</tr>
<tr>
<td>Flex Sensor</td>
<td></td>
<td>Analog Input</td>
<td>Variable resistor</td>
<td></td>
</tr>
<tr>
<td>Soft Trimpot</td>
<td></td>
<td>Analog Input</td>
<td>Variable resistor</td>
<td>Careful of shorts</td>
</tr>
<tr>
<td>RGB LED</td>
<td></td>
<td>Dig &amp; Analog Output</td>
<td>16,777,216 different colors</td>
<td>Ooh... So pretty.</td>
</tr>
</tbody>
</table>
Other equipment in the toolbox...

- Jumper Wire: Various Colors (x30)
- LED (5mm): Light Emitting Diode (x10, x10, x1)
- Photo Resistor (x1)
- 330Ω Resistor (x25)
- 10KΩ Resistor (x25)
- Temp. Sensor (TMP36) (x1)
- Push Button (x2)
- DC Motor (x1)
Prototyping Circuits
Solderless Breadboard
Breadboard

An electronics breadboard is actually referring to a solderless breadboard. These are great units for making temporary circuits and prototyping, and they require absolutely no soldering.
Breadboard

Tops of the metal clips have clips that allow you to stick a wire or the leg of a component into the exposed holes on a breadboard.
**Breadboard**

**Power rails** are metal strips that are identical to the ones that run horizontally and provide lots of easy access to power.

Ravine isolates both sides of a given row from one another and they are not electrically connected.
Solderless Breadboard

- Each row (horiz.) of 5 holes are connected.

- Vertical columns – called power bus are connected vertically.
The power rails on either side are not connected, so if you want the same power source on both sides, you will need to connect the two sides with some jumper wires. Remember, the marking are there just as a reference.

There is no rule that says you have to plug power into the + rail and ground into the – rail, though it is good practice to keep everything in order.
Continuity – Is it a Circuit?

The word “circuit” is derived from the circle. An Electrical Circuit must have a continuous LOOP from Power \( (V_{cc}) \) to Ground \( (GND) \).

Continuity is important to make sure portions of circuits are connect.
Measuring Electricity – Voltage

Voltage is a measure of potential electrical energy. A voltage is also called a potential difference – it is measured between two points in a circuit – across a device.

![Diagram of voltage measurement](image_url)
Measuring Electricity -- Current

Current is the measure of the rate of charge flow. For Engineers, it is consider to be the movement of electrons.

In order to measure this – you must break the circuit.
Measuring Electricity -- Resistance

Resistance is the measure of how much opposition to current flow is in a circuit.

Components should be removed entirely from the circuit to measure resistance. Note the settings on the multi-meter. Make sure that you are set for the appropriate range.
Using Serial Communication

Method used to transfer data between two devices.

Data passes between your computer and RedBoard through the USB cable. Data is transmitted as zeros (‘0’) and ones (‘1’) sequentially.

RB dedicates Digital I/O pin # 0 to receiving and Digital I/O pin #1 to transmit.
Concepts: Analog vs. Digital

• Microcontrollers are **digital** devices – ON or OFF (True/False, HIGH/LOW). Also called – discrete (as opposed to continuous)

• **analog** signals are continuous (think temperature)
PWM

- A few pins on the Arduino allow for us to modify the output to mimic an analog (continuously variable) signal

- This is done using a technique called:
  - **Pulse Width Modulation (PWM)**

* Refer to LED fade Demo (PWM) [https://www.sparkfun.com/products/12062](https://www.sparkfun.com/products/12062)
analogWrite() 

To create an analog signal, the microcontroller uses a technique called PWM. By varying the duty cycle, we can mimic an “average” analog voltage.

analogWrite(pin, value)

![Pulse Width Modulation (PWM)](image_url)
Digital Sensors

digitalWrite()  digitalRead()

- Digital signals are either HIGH (1, true, 5volts) or LOW (0, false, 0 volts)

- Voltage signal for HIGH will be a little less than 5V on your Uno
  - range is

- Voltage signal for LOW will be about 0 volts on most systems
  - actually on the ATMEG 328  $V_{OL} \leq 0.9$ volts  {for 5V system}
  - $V_{OH} \geq 4.2$ volts {for 5V system}
Using the Breadboard to build a simple circuit

• Use the breadboard to wire up a single LED with a 330 Ohm Resistor (Orange-Orange-Brown).

Note: the longer leg on the LED is the positive leg and the shorter leg is the negative
Example 1: Watch LED video
Breadboard Circuit

• What happens when you break the circuit?
• What if you wanted to add more than one LED?
Adding control – let’s use the Arduino and start programming!!!
Concepts: INPUT vs. OUTPUT

**Inputs** is a signal / information going into the board.  

**Output** is any signal exiting the board.
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**Inputs** is a signal / information going into the board.  
**Output** is any signal exiting the board.

| Examples: Buttons, Switches, Light Sensors, Flex Sensors, Humidity Sensors, Temperature Sensors... | Examples: LEDs, DC motor, servo motor, a piezo buzzer, relay, an RGB LED |
Remember, your sensor is only outputting a voltage that will be input into the RedBoard and read through the program you created. All sensors output a voltage, just some have digital and some have analog signals.
Getting Started with the RedBoard

• Install the Arduino IDE
  • Go to arduino.cc
    • Download