Week 1 Lab Activities:
Basic Electronics

Preparation:

Physical Computing: sensing and controlling the physical world with computers by Dan O'Sullivan and Tom Iqoe.

Read: Introduction, chapter 1, chapter 2 (p. 11-25 only), and chapter 3.

What are we going to use in this workshop?

- **Solderless breadboard**
  !!! When you start to put components on your breadboard, avoid adding, removing, or changing components on a breadboard whenever the board is powered. You risk shocking yourself and damaging your components.
- **LEDs**, or Light Emitting Diodes are diodes that emit light when given the correct voltage. Like diodes, they are polarized, meaning that they only operate when oriented correctly in the circuit. The anode (long leg) of the LED connects to voltage and the cathode connects to ground.
- **Wires**
- **Resistors** limit the current in the circuit.
- **Potentiometers** are variable resistors.
- **Photosensitive resistor (LDR)** are resistors that vary resistance based on the amount of light they sense.
- **(Tact) Switch**es have two states, on/off, and will control the flow of current through the circuit.

Circuit 1: Light a LED

We will use the Arduino board to power up our circuit.
Connect the breadboard to Arduino as shown in the diagram below (don't forget to power the board through a USB cable):
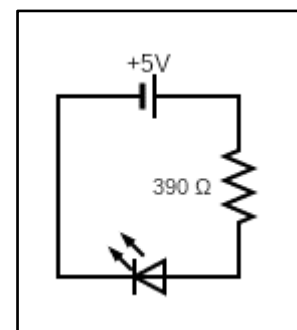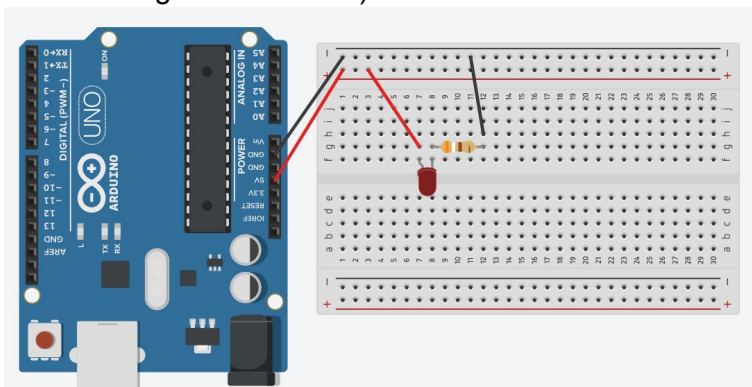
The circuit diagram that corresponds to circuit 1.

- **Task:** Connect the breadboard to the Arduino board as shown in the diagram.
- **Answer:** Why do we add the resistor with the LED?
- **Task:** Use Ohm's law to calculate the current that flows through the LED
- **Note:** You can directly add a LED to pin 13 and GND on the Arduino. This pin has an internal resistor.

Circuit 2: Use a switch to control the state of a LED

Add a button switch to your previous circuit so the LED goes on when you press the button. The button has 4 legs. Can you guess which legs are connected to each other and thus which way the button has to be positioned on the board?

tact switch

- **Task:** Add a switch to the circuit so you can turn the LED on by pressing the button.
- **Task:** Draw the circuit diagram that corresponds to the circuit (see the list of circuit diagram symbols at the end of this document).

Circuit 3: Use a potentiometer to dim a LED

Add a potentiometer to the circuit to add the ability to dim the LED. Insert the potentiometer from your lab kit in your circuit. ***Insert it in series with your 390 Ohm resistor***.

The potentiometer has three pins. Only two need to be connected. Think about how the wiper works within the potentiometer (information from the slides). Can you guess how to connect the potentiometer?


potentiometer

- **Task:** Build the circuit as described above.
- **Task:** Draw the circuit diagram that corresponds to the circuit (see the list of circuit diagram symbols at the end of this document).
- **Answer:** Why do we connect the 390 Ohm resistor in series with the potentiometer?

Circuit 4a: In series

Rebuild Circuit 1 on the left side of the breadboard. On the right side of your breadboard, build a circuit in which a LED is connected in series with two 390 Ohm resistors.
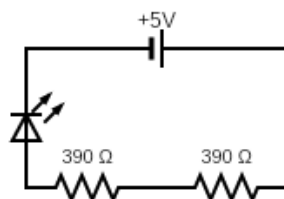
- **Task:** Build both circuits described above.
- **Answer:** What do you observe when you compare circuit 1 and circuit 4a?
- **Task:** Calculate the equivalent resistance of the serial circuit.
- **Task:** Calculate the current flowing through the LED of the serial circuit.

Circuit 4b: In parallel

Remove the series circuit of circuit 4a. Keep circuit 1 on the left side of your breadboard and build a circuit in which we connect two 390 Ohm resistors in parallel on the right side. Use the same LED color as circuit 1.
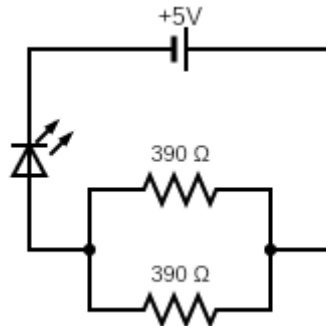
- **Task:** Build the circuit as described above.
- **Answer:** What do you observe when you compare circuit 1 and circuit 4b?
- **Task:** Calculate the equivalent resistance of this parallel circuit.
- **Task:** Calculate the current flowing through the LED in the case of this parallel circuit.

Circuit 5: Use a photosensitive resistor to dim a LED
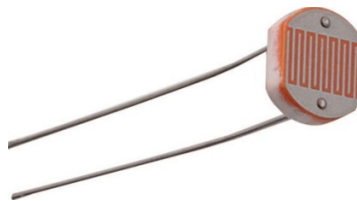
Photosensitive resistor (LDR)

We are going to use our first sensor! Connect the photoresistor to a LED. The resistance of the photoresistor (LDR) changes depending on the light falling on it. The specifications of the LDR change based on the way it is produced. You can look up specifications of every component in the '**Data sheet**' of a component. The Data sheet of this LDR can be found here.

- **Task:** Connect the circuit as described above.
- **Task:** Draw the circuit diagram that corresponds to the circuit (see the list of circuit diagram symbols at the end of this document).
- **Task:** Cover the light sensor with your hand and observe the LED. Then expose the light sensor to bright light (e.g., flashlight) and see what happens to the LED.

Circuit 6: Voltage divider

Voltage divider circuits are circuits that produce an output voltage (V_{out}) that is a fraction of its input voltage (V_{in}). Or in other words: A voltage divider turns a large voltage into a smaller one. These circuits are one of the most fundamental circuits in electronics and it is very important that you understand this concept.
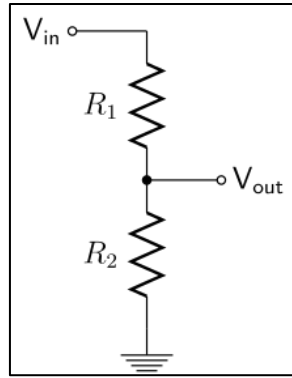
A circuit diagram of a simple
voltage diagram.

The equation:

The voltage divider equation assumes that you know three values of the above circuit: the input voltage (V_{in}), and both resistor values (R1 and R2). Given those values, we can use this equation to find the output voltage (V_{out}):

$$V_{out} = V_{in} \cdot \frac{R_2}{R_1 + R_2}$$

This equation states that the output voltage is **directly proportional** to the **input voltage** and the **ratio of R1 and R2**.

We use these circuits in potentiometers to change the output voltage and create dimmers (think about circuit 3).

- **Answer:** Why do potentiometers have three pins?

Many sensors are simple resistive devices. For example, the photosensitive resistor that we just used, is a variable resistor which produces a resistance proportional to the amount of light it senses. Later in this course, we will use the Arduino to read out these sensors. Arduino and other microcontrollers have difficulty with reading resistance, but voltage is really easy for microcontrollers to measure. So, we use voltage dividers to connect resistive sensors to microcontrollers.
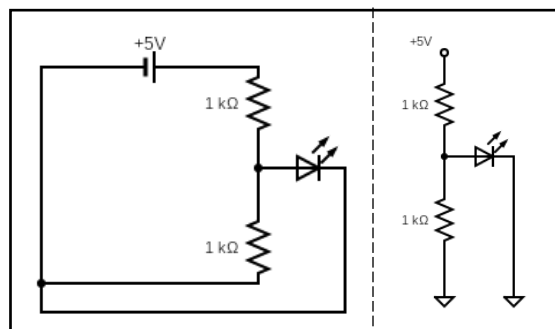
Two ways of drawing the circuit diagram for this circuit. Try to find
all the ways in which the second diagram is simplified.

- **Task:** Build a voltage divider circuit with a LED connected to V_{out}. Use a 1k resistor as R1 and 1k Ohm resistor as R2.
- **Task:** Calculate V_{out} using the voltage divider equation.

List of common circuit diagram symbols:

General remark: Only use the US versions of the components in your circuit diagram drawings. We included the EU versions so you know what they are if you see them in the future.

You can find many symbols on the website: https://www.circuit-diagram.org/. The editor allows you to draw simple circuit diagrams.

1. Resistor:

Note: Always indicate the amount of resistance and the unit symbol for Ohm (Ω)

2. Voltage Source:

Type 1: Ideal voltage source

Type 2: Cell (Battery)
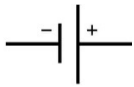
Note: indicate + and – in the schematic. Where the + and – are drawn will influence your whole schematic!

Note: indicate the voltage of the voltage source (e.g., 5V+)

3. GND:

4. Wires:

Wire intersection (not connected):
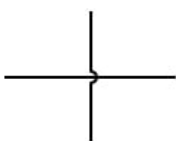
Note: notice the little notch to indicate that the wires are not connected!
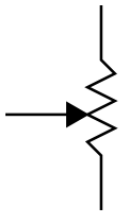
Wire intersection (connected):

Note: if wires are connected, indicate it by a solid dot!

5. Photoresistor (LDR) or 'lightsensor':
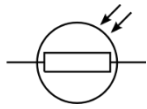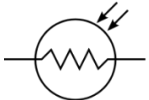
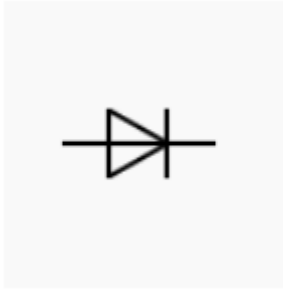Note: it is important to include the two arrows!

6. Potentiometer:
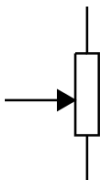
Note 1: Include the total resistance of the potentiometer in the circuit (e.g. 10kΩ)
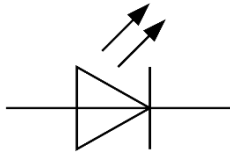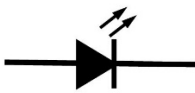
Note 2: This component has 3 connections!

7. Diode:

Note: Component only allows current to flow from its cathode to its anode, so make sure to draw it in the right direction!
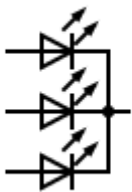
8. LED (Light Emitting Diode):

Note 1: always use the arrows.

Note 2: Component only allows current to flow from its cathode to its anode, so make sure to draw it in the right direction!
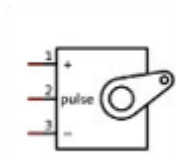
9. RGB LED (common cathode):

Note: Component only allows current to flow from its cathode to its anode, so make sure to draw it in the right direction!
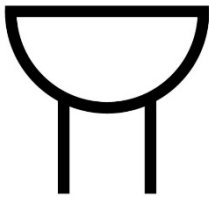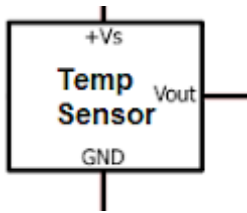
10. Switch:

11. **Servo motor:**

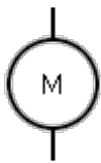Note: Always indicate the names of the pins: +, pulse, and – or VCC, Data and GND.

12. **Piezo buzzer:**

13. **Temperature sensor:**

14. **DC motor:**

15. **Arduino:**