Sensing for Science

Level 2

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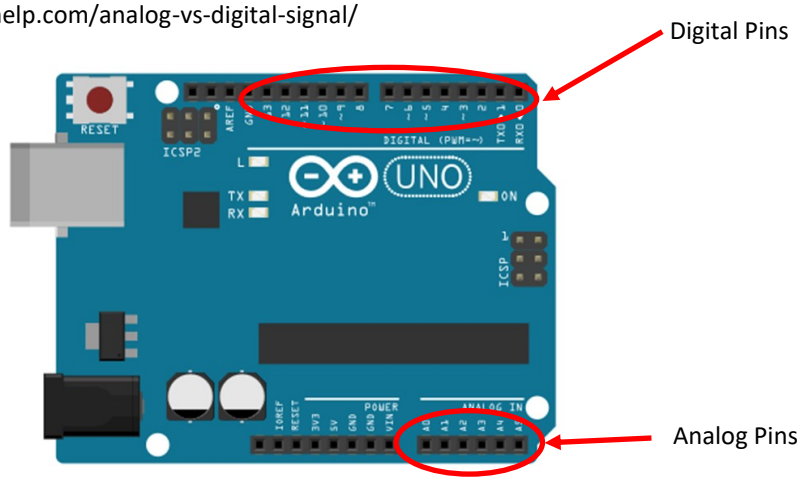
Introducing Sensors

A sensor is a device that takes a input from the environment and converts it into data for us to interpret. Sensors can be complex (dissolved oxygen) or simple (temperature sensor). When working with sensor on a Arduino board, most sensors will be setup the same way. We will explore two sensors in this level that will translate to more complex sensors.

All sensors will need to be connected to an input pin on our Arduino board. These inputs can be analog (number value ranging 0 to 1023) or digital (on or off). Both have their advantages and disadvantages, these can be found at:

https://www.softwaretestinghelp.com/analog-vs-digital-signal/



A potentiometer is a 3-pin variable resistor. The two outside pins are connected to the ground and power. The middle pin is the wiper, this pin's value changes when you turn the knob, giving us a different voltage value. Potentiometers are sensors, they convert the physical rotation of the nob to an electrical input that we can send to the Arduino and get a numerical value for us to interpret. The pins on a potentiometer are very delicate so be careful when trying to place them on the breadboard.

Potentiometers are used anywhere you see a nob, such as a volume control and speed control. They come in many types and configurations.

In the first circuit, we will be creating a circuit that will read analog data from the potentiometer and output an analog signal to a LED. Let's get the code written out first. This code will introduce new commands for us to use.
Variables—before the void setup we can place lines of code here to create variables. We use variables to give the data in or out a name that we can use for interpreting. There are many variables we can create, we will be using the "int" variable. Typing "int" before setting a variable, tells the code that the variable is an integer. Variable names are case-sensitive. Keep variables simple and easy to recognize what data they are holding. The variables we will be setting are shown below. "sensor value" will be the data coming from our sensor (potentiometer) and "output value" we be our output (LED). We could given pins a variable name as well, but it is not required for this circuit.

```
int sensorValue = 0;
int outPutValue = 0;

void setup() {
```

Void setup

This circuit we will be using the void setup area to start up our serial monitor. The serial monitor is a addition in the Arduino IDE that allows us to see data read by the Arduino board for visual inspection of data, calibrating sensors, and debugging issues that we may have with the board. As we continue through the different levels of Sensing for Science we will be using the serial monitor. To start the serial monitor we will put Serial.begin (9600); This tells the Arduino board to start the serial monitor when the board is restarted and the serial monitor is opened. Our code for void setup should look like the code below.

```
void setup() {

  Serial.begin(9600);

}
```

This is the speed of communications between the board and the computer.

The Loop code

In level one we had pretty simple loop code, but now this area will start getting complex. But we will take it one line at a time and understanding which each command does for us.

```
sensorValue = analogRead(A0);
```

Calling the variable we created earlier

analogRead is a command that tells the board to read the data coming in from A0 pin

```
outPutValue = map(sensorValue, 0, 1023, 0, 255);
```

Calls the variable we created earlier

The map commands takes values from one range and converts it to another range. So the values from our sensorValue variable has a range from 0 to 1023 (the range analog pins read) and converts it to a range of 0 to 255 (the range of the digital pin output)

```
analogWrite(9, outPutValue);
```

This command will take the outPutValue and write it as an analog signal through a digital pin (9).

This command tells us to print onto the serial monitor. Using quotes creates text in the monitor. Writing a variable name or a pin, will show the value in the serial monitor.

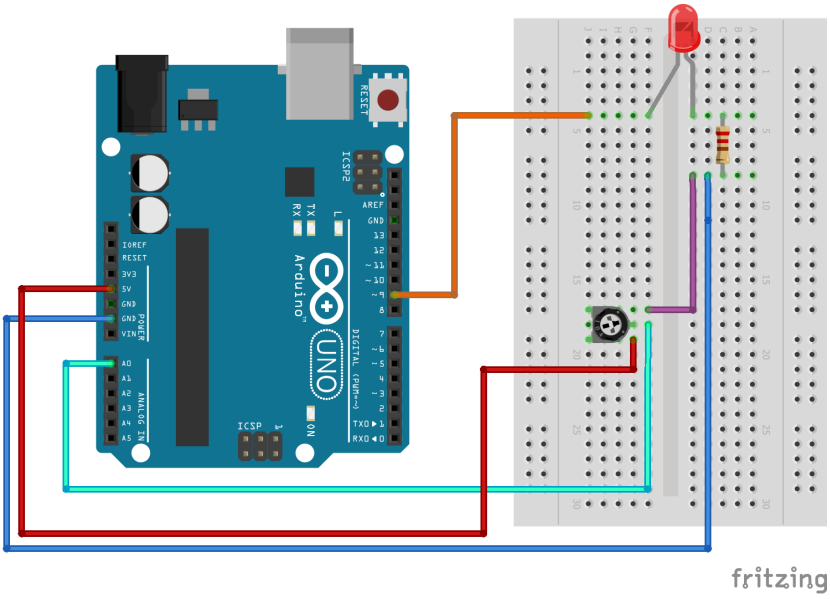
```
Serial.print ("sensor =");
Serial.print (sensorValue);
Serial.print ("\t ouput =");
Serial.println (outPutValue);

delay (2);
```

Delay allows time for the data values to settle when there are changes

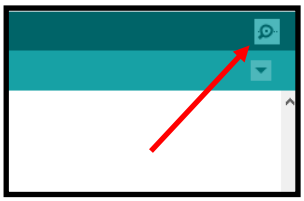
Adding the "ln" to the end of print will create a new line in the monitor.

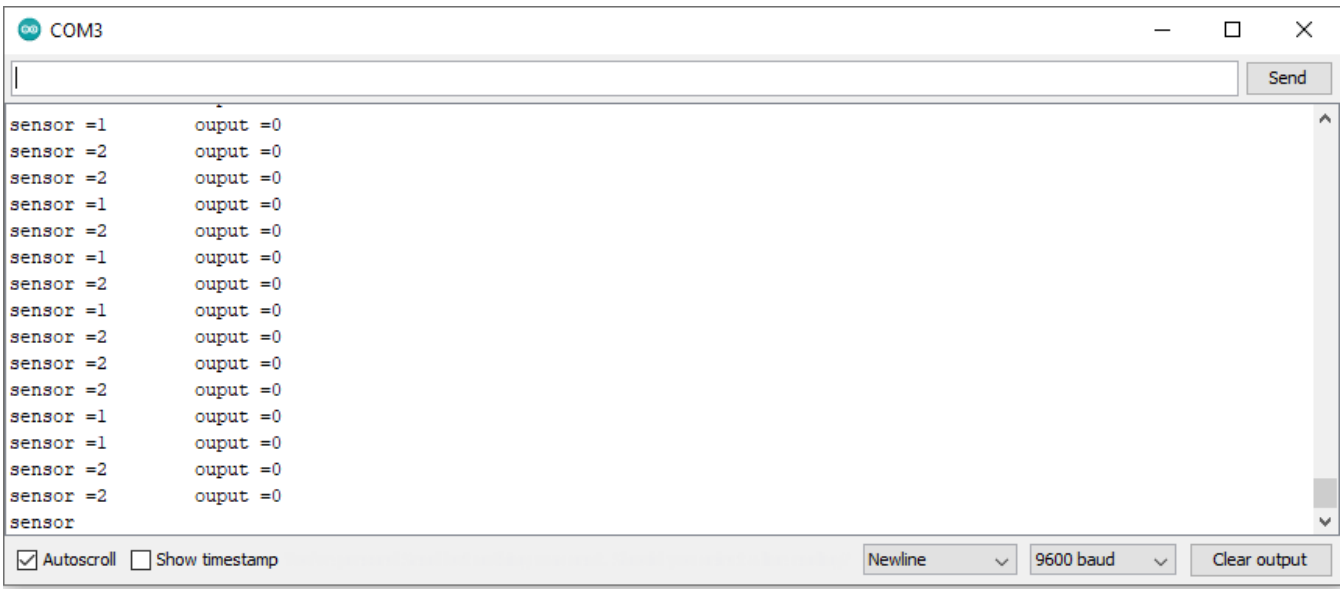
That is all the code for this circuit. There will be a complete code at the end of this packet. At this time it would be good verify your code to see if you missed anything. Remember it is not the end of the world if you get an error message. Most likely if you do it would be a missed semicolon or you have a character not the right case in your variables.

Construct the circuit below using the diagram. When you are finished connect your board to the USB cable and upload your code from IDE.



Once you have successfully uploaded your code to the Arduino board, keep the USB plugged in and open the serial monitor in the IDE. The serial monitor is in the upper right hand corner and looks like a spy glass. A dialog box should open and within a few seconds you should start seeing you data roll in. When you turn the knob on the potentiometer you should see the values change on the serial monitor and your LED change in brightness. We have completed our first sensor circuit. Play around with this one before moving onto the next circuit for this level.





The second circuit we will be creating at this level is a light sensor. We can see this sensor used in automated greenhouses and newer cars that turn on headlights automatically. This sensor will be constructed with two components, a standard resistor, and a photoresistor. A photoresistor is a resistor that changes its resistor value based on the level of ambient light. We are going to use the change in value for our sensor. Photoresistors do not have polarity and be used in either orientation.

Just like the previous circuit, let's look at the code we will need for the circuit.

```
int lightLevel;
int threshold = 300;

void setup() {

  Serial.begin(9600);

}

void loop() {

lightLevel = analogRead(A0);

if(lightLevel < threshold){
  digitalWrite(9,HIGH);
  }
 else{
  digitalWrite(9,LOW);
  }
Serial.print("light level =");
Serial.println(lightLevel);

delay(200);

}
```

This will the placeholder for the data coming from the light sensor

This is the level we set as a threshold. It is used to decide when the circuit will light up the LED

Tell the board that analog data from A0 is the lightLevel.

Starting the serial port for monitoring data and calibrating.

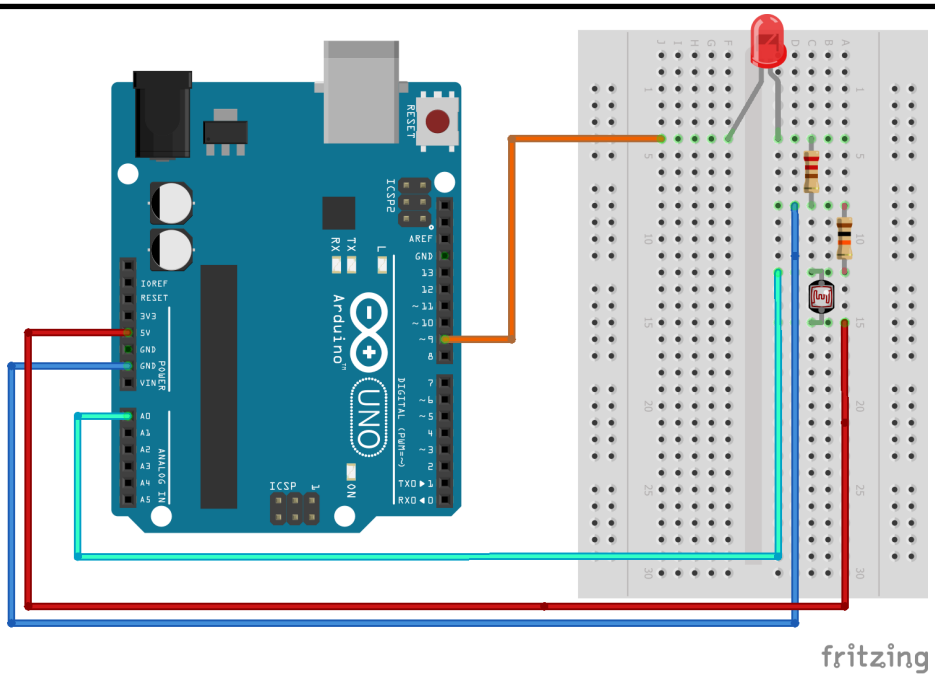
Digitalwrite is either off or on, unlike analogwrite which can vary from 0 to 255.

If else statements are logic commands that runs a certain code "if " the condition is true. Otherwise, use the other code. This code is saying if the lightLevel value is less than (<) 300, turn LED on, otherwise keep LED off.

This command writes the lightLevel value in the serial monitor for us to inspect

This delay allows time for us to debug the serial monitor but allows the code to repeat fast enough to change output with changes to input

After you have verified your code and fixed any errors, it is time to build the circuit. Use the diagram in aid of the construction of the circuit.



Once you have confirmed you have constructed the circuit correctly, upload the code to the Arduino board. Once it is finished uploading, open the serial monitor and observe the values. Using your finger, cover and uncover the photoresistor and take note of the values. Also, take note of the LED, does it turn off and on? All photoresistors have some variant in them and the threshold might have to be changed for the circuit to work correctly. Play around with the threshold and the delay to see how the circuit reacts. You take components or lines of code from circuit 1 and use them in circuit 2.

Troubleshooting guide:

- My LED doesn't turn on when I cover the photoresistor -> check connections -> check serial monitor to see if you are reaching thresholds -> replace LED
- Serial monitor going in a straight line not entering down -> missing a 'ln' in the last line of the serial print.
- Serial monitor showings nothing -> check you port
- Serial monitor values are not changing with the photoresistor -> bad photoresistor try another one
- Values are not changes when turning the nob of the potentiometer -> pins are not in the breadboard-> misaligned the pins of the potentiometer->damaged potentiometer try another one

Sources:

Analog Vs Digital Signal - What Are The Key Differences. (n.d.). www.softwaretestinghelp.com. https://www.softwaretestinghelp.com/analog-vs-digital-signal/

Jost, Danny. "What Is a Sensor?" FierceElectronics, 2019, www.fierceelectronics.com/sensors/what-a-sensor.

SparkFun Inventor's Kit for Arduino. Vol. 4.0, SparkFun electronics, Inc., 2017.

Potentiometer Code

```
int sensorValue = 0;
int outPutValue = 0;

void setup() {

  Serial.begin(9600);

}

void loop() {

sensorValue = analogRead(A0);

outPutValue = map(sensorValue, 0, 1023, 0, 255);

analogWrite(9, outPutValue);

Serial.print ("sensor =");
Serial.print (sensorValue);
Serial.print ("\t ouput =");
Serial.println (outPutValue);

delay (2);

}
```

Light Sensor Code

```
int lightLevel;
int threshold = 300;

void setup() {

  Serial.begin(9600);

}

void loop() {

lightLevel = analogRead(A0);

if(lightLevel < threshold){
  digitalWrite(9,HIGH);
  }
 else{
  digitalWrite(9,LOW);
  }
Serial.print("light level =");
Serial.println(lightLevel);

delay(200);

}
```