GEAR has in inventory Sharp brand IR distance sensors. In this short lesson you will learn how to connect a sensor to Arduino and send distance measurements via the serial port. These are analog sensors and cannot be connected to the digital GPIO pins of a Raspberry Pi. You could interface the sensor to RPi with an A/D (analog to digital) chip. However, since we have Arduinos to work with, why not use an Arduino, which has built-in A/D electronics?

Connect the signal wire of the sensor to analog pin A0 of the Arduino. The sensor red wire connects to +5 volts on Arduino and the black wire to ground on the Arduino. [Note: in my testing with an Arduino Leonardo, I found that about 10% of distance measurements varied significantly from the rest at any specific target distance. When the sensor was powered by a separate battery supply, there was very little variation in measurements at any given distance.]

Open the Arduino IDE on your Raspberry Pi and enter the code below. Verify the code and upload to the Arduino. Then open the Serial Monitor in the Arduino IDE software. Place your hand near the sensor and vary the distance between your hand and sensor. You should see a distance read out on the monitor in centimeters.

```
// Sharp IR GP2Y0A21YK0F Distance Test

void setup() {
Serial.begin(9600); // start the serial port
}

void loop() {

float value = analogRead(0); // sensor connected to A0 pin on Arduino
float volts = (value / 1023.0) * 5.0;
float distance = (25.3) * pow(volts, -1.15);
delay(1000); // pause for one second
if (distance <= 80 && distance >= 10){

Serial.println(distance); // print the distance
}
else {
Serial.write("distance out of range of sensor");
Serial.write("\n");
}
}  // end of loop, now make the next measurment
```

Explanation of the code

```
float volts = (value / 1023.0) * 5.0;
```

The Arduino has a 10 bit analog to digital (A/D) chip that converts the voltage from the sensor to a 10 bit number. A 10 bit number can store a number range of 0 to 1023. You can confirm this by calculation. Using a calculator in scientific mode, enter the number 2, then press the X^Y button, then enter 10, then press the equals button. The answer will be 1024 (there are 1024 numbers in the range 0 to 1023). Remember that computers use binary numbers and if you raise the number 2 to a power of 10, then the number in base 10 is 1024. The Arduino A/D chip can assign one of 1024 values to the input voltage. If the voltage input is 0, then the number 0 is assigned. If the input is 5.0 volts, then the number assigned is 1023. Now take a look at the Arduino code line listed above. Here we can see that the value assigned to the input voltage is divided by 1023.0 and then multiplied by 5.0. Suppose the input voltage was 5.0. Then the A/D chip would assign a value of 1023. And the code above would result in this equation:

$$(1023 / 1023.0) * 5.0 = 5.0 \text{ volts}$$

Suppose the input voltage was 2.25 volts. Then the A/D chip would assign a value according to this equation:

$$(2.25 / 5.0) * 1023 = 460$$

To convert a A/D value of 460 to voltage:

$$(460 / 1023.0) * 5.0 = 2.25 \text{ volts}$$

The next line of code:

```
float distance = (25.3) * pow(volts, -1.15);
```

Here we are using the equation of a curved calibration line to convert a voltage reading to a distance in centimeters. We are using a built-in Arduino function named **pow()**, which stands for power. The function takes two arguments: the value and the exponent. The equation can be expressed like this:

$$\text{distance in centimeters} = (25.3) * \text{volts}^{-1.15}$$

The above equation was derived by graphing voltage vs. distance of a sensor in a calibration test. If you use a spreadsheet program like MS Excel or Google Sheets, the software can graph and calculate the line equation. To learn how to do this, see the lesson on calibrating the sensor. In preparing the data for graphing, you should take multiple readings at several distances and then average the readings for each distance. For example, in my tests, I made 20 distance readings at each of the following distances: 8, 10, 12, 14, 16, 18, 20, 25, 30, 35, 40, 50, 60, 70, 80, 100 centimeters (320 measurments total). Graph the average voltage readings against the distances to obtain an equation.