Building the Temperature Sensor

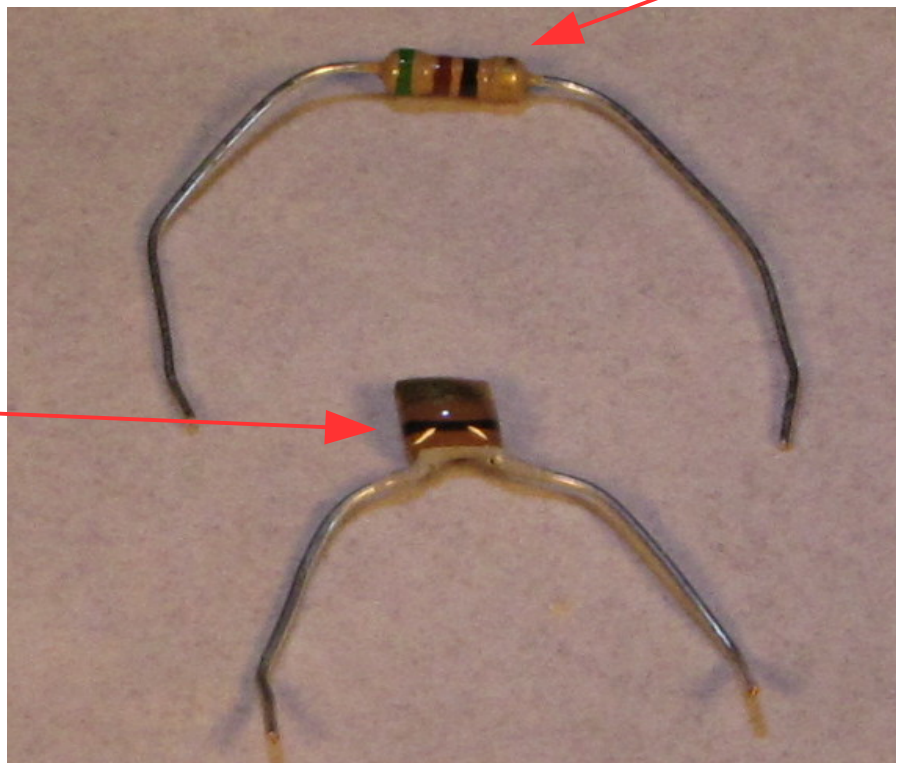
Thermometer Probe

In this exercise we will go through the entire process of building and calibrating a simple digital sensor to read the temperature of an air sample. This sensor is a required component of your air sampling robot.

This exercise will also prepare you to build and calibrate the anemometer and soil conductivity environmental sensors to be used on the robot project.

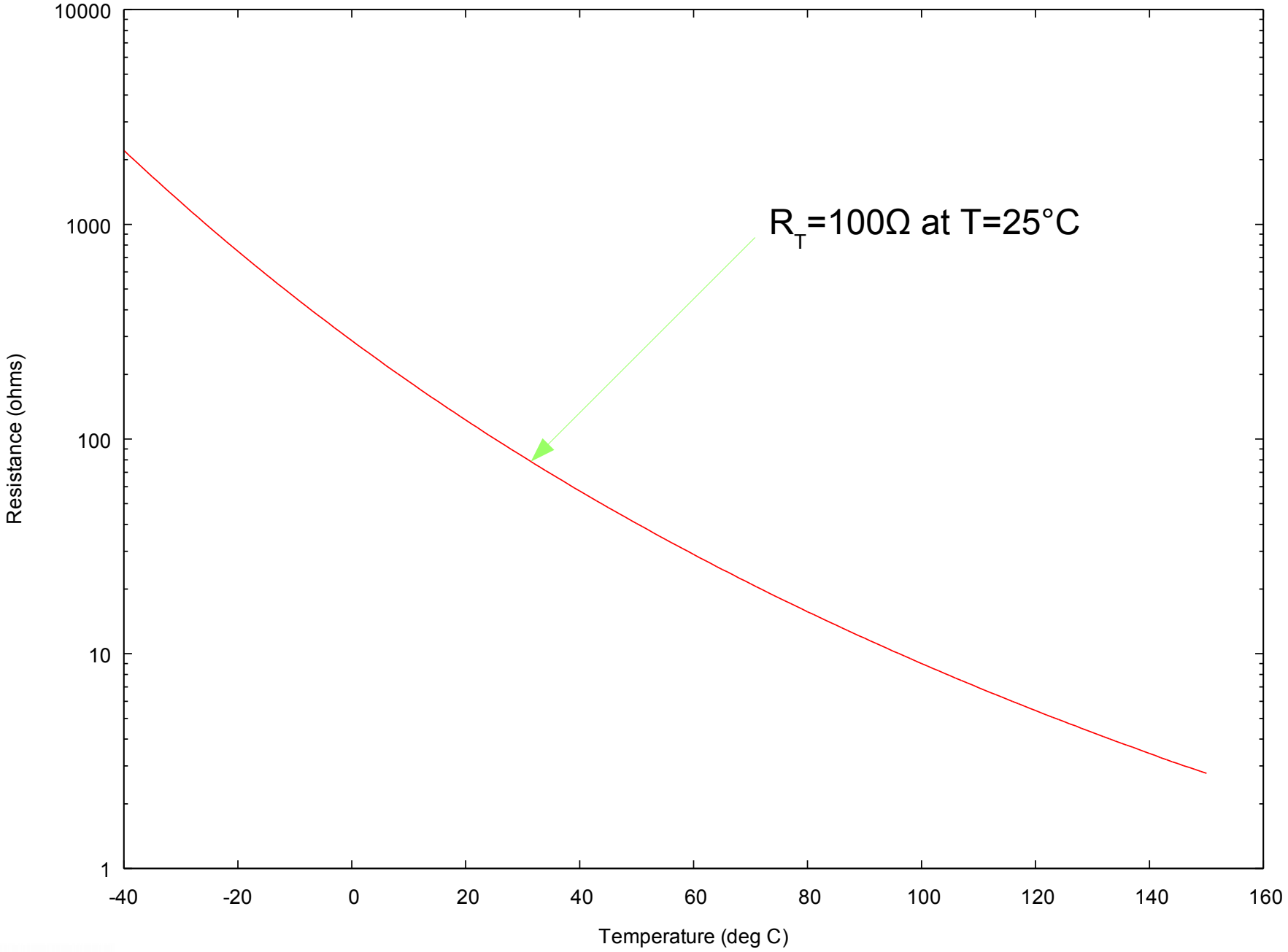
Starting Components

51Ω ±5% fixed resistor



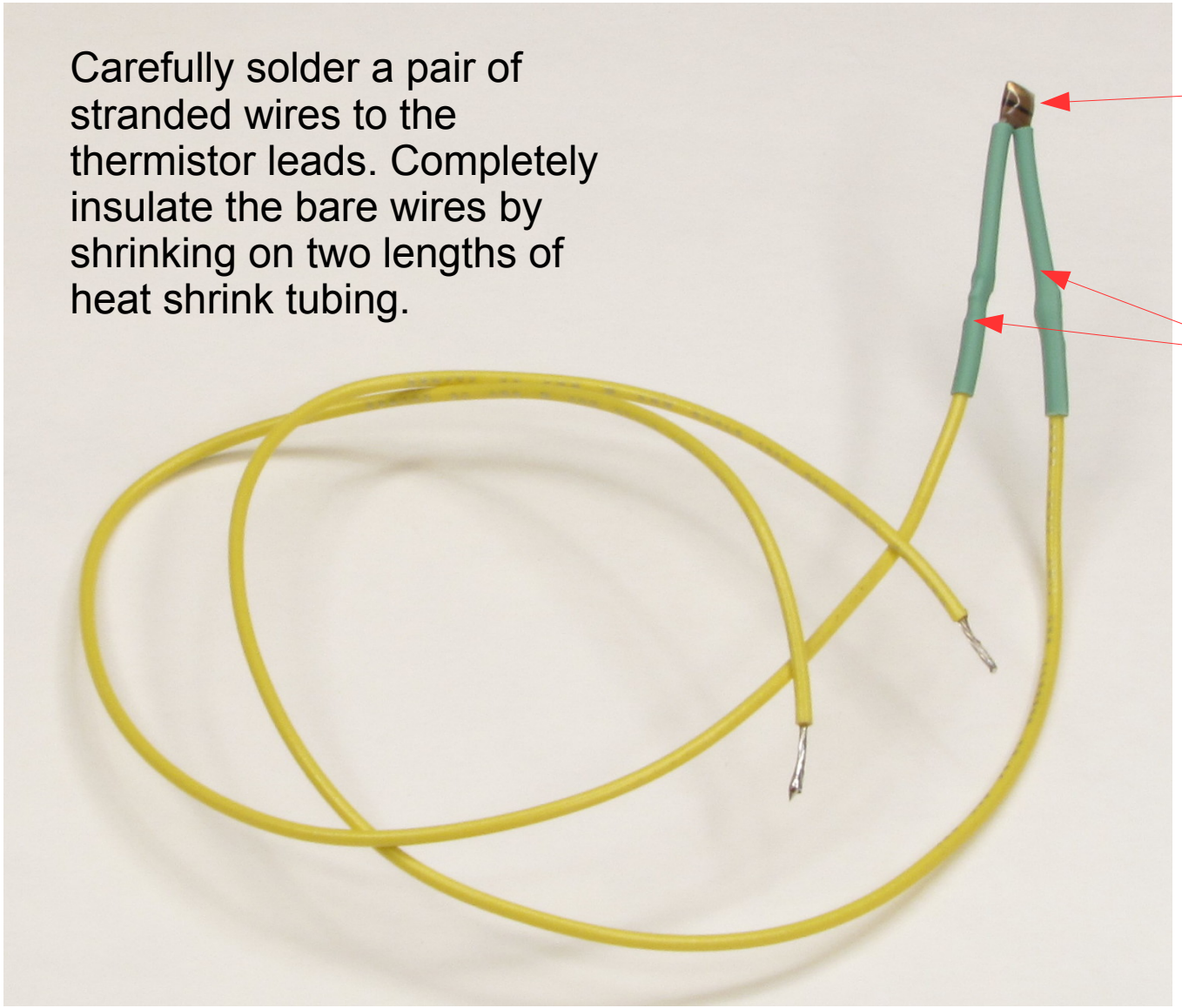
Thermistor (temperature dependent resistor) nominally 100Ω at 25°C

Thermistor Resistance vs. Temperature

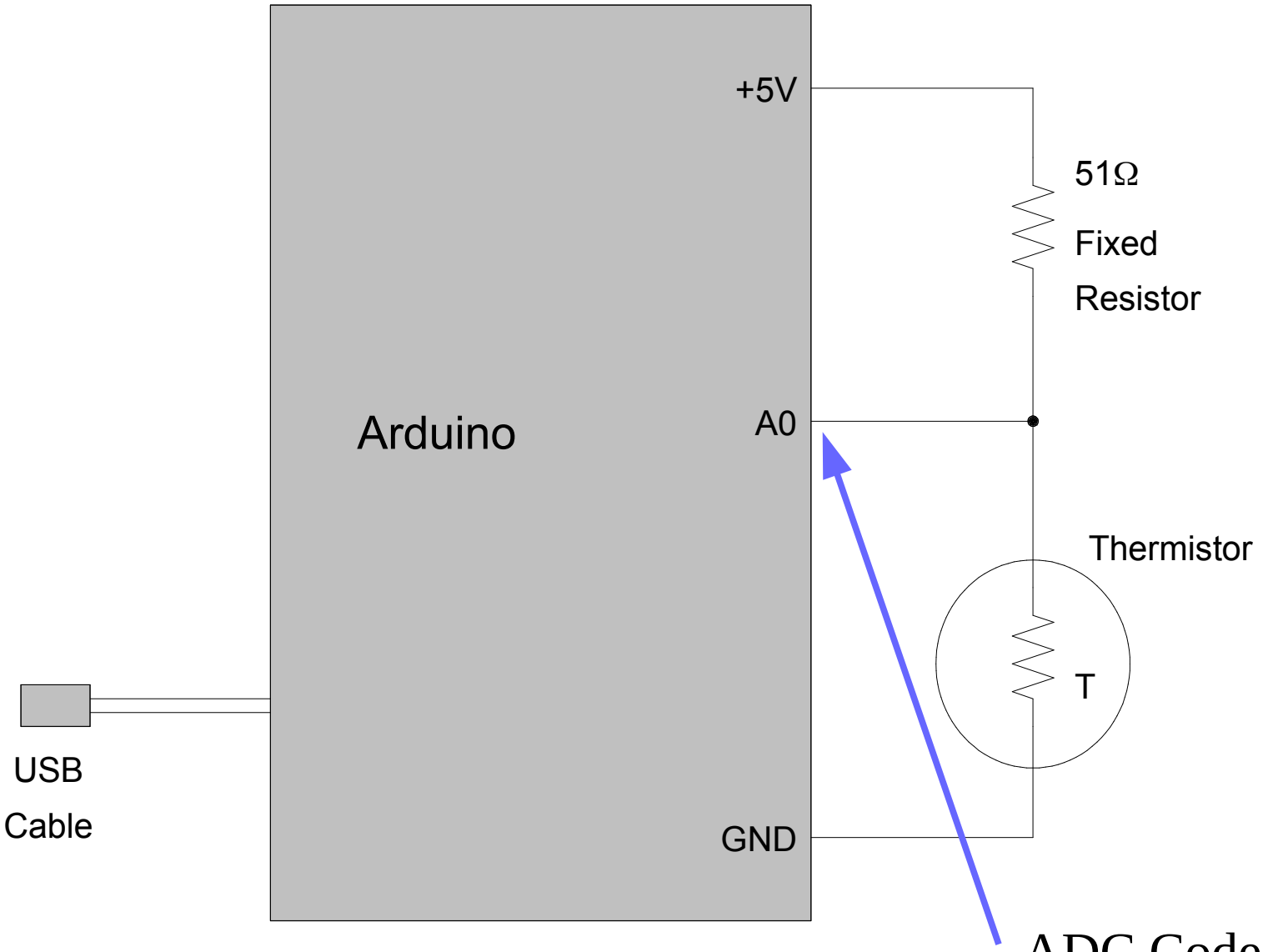


Prepare the Thermistor

Carefully solder a pair of stranded wires to the thermistor leads. Completely insulate the bare wires by shrinking on two lengths of heat shrink tubing.



Temperature Probe Schematic

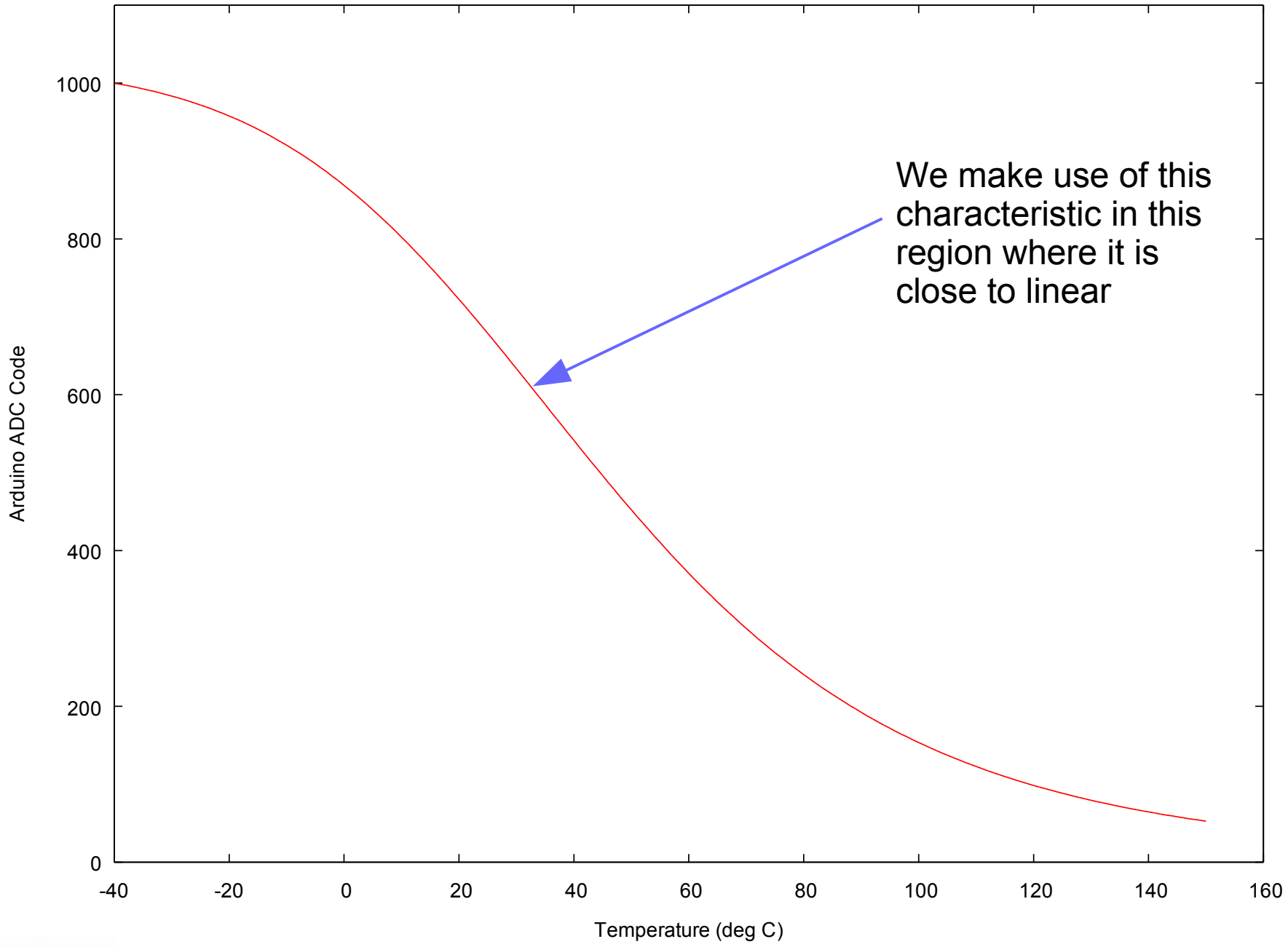


The temperature of the air that the thermistor is immersed in is measured by the Arduino processor by measuring the voltage at the analog input pin A0. The voltage level is converted into a digital code by an analog-to-digital converter in the Arduino.

The resistance of the thermistor is compared with that of the fixed resistor.

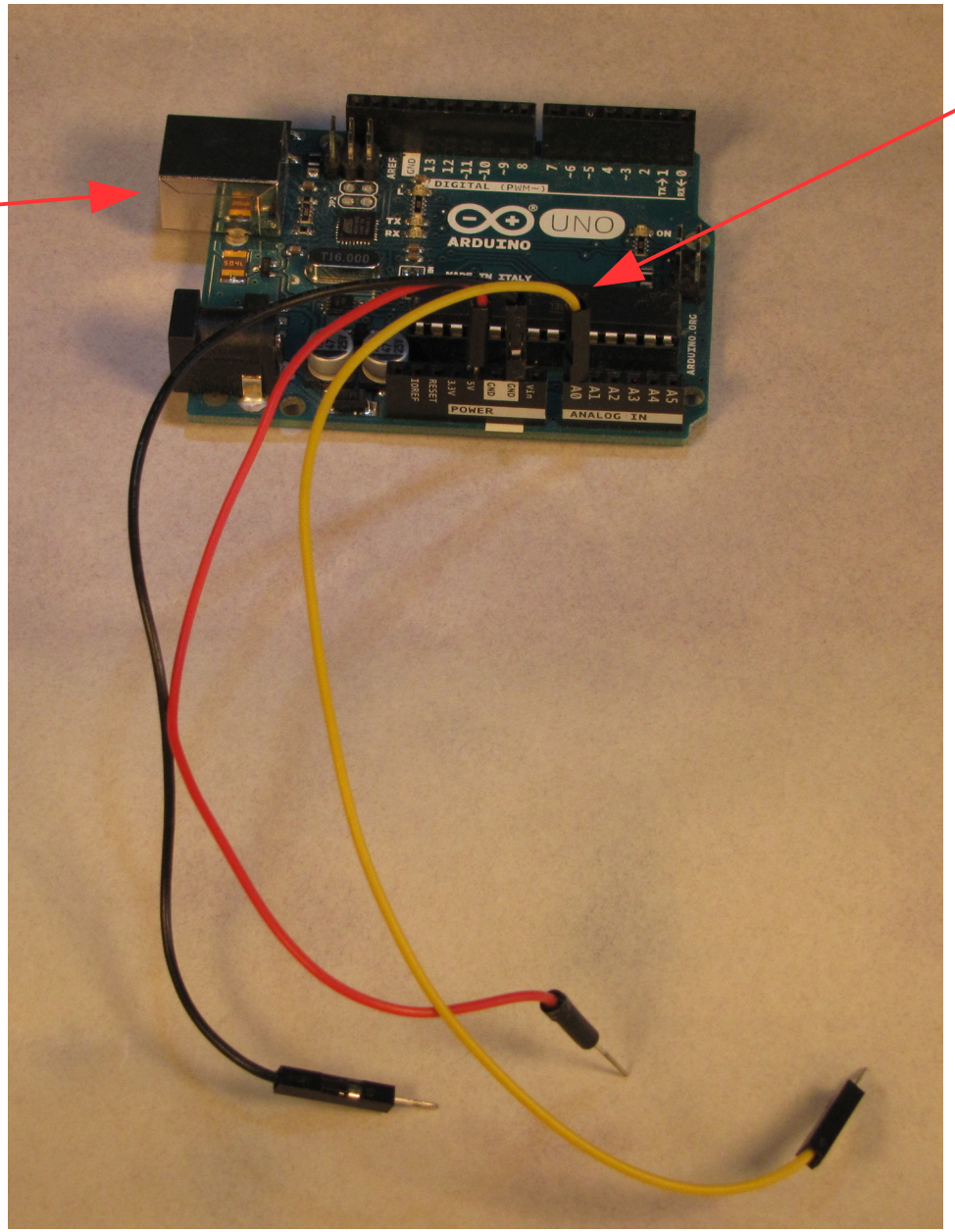
$$\text{ADC Code} = 1023 \cdot \frac{R_T}{R_T + R_{\text{fixed}}}$$

Thermometer ADC vs. Temperature

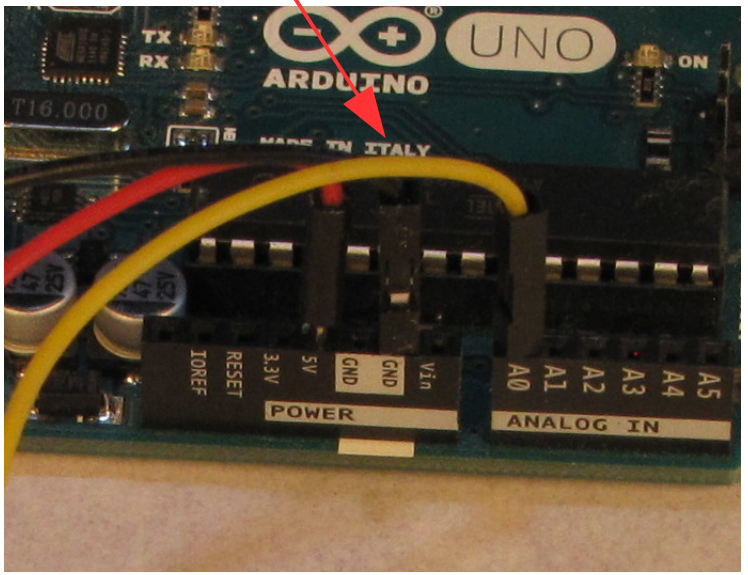


Wire to the Arduino

Leave off the USB connector until wiring is finished and checked!!!

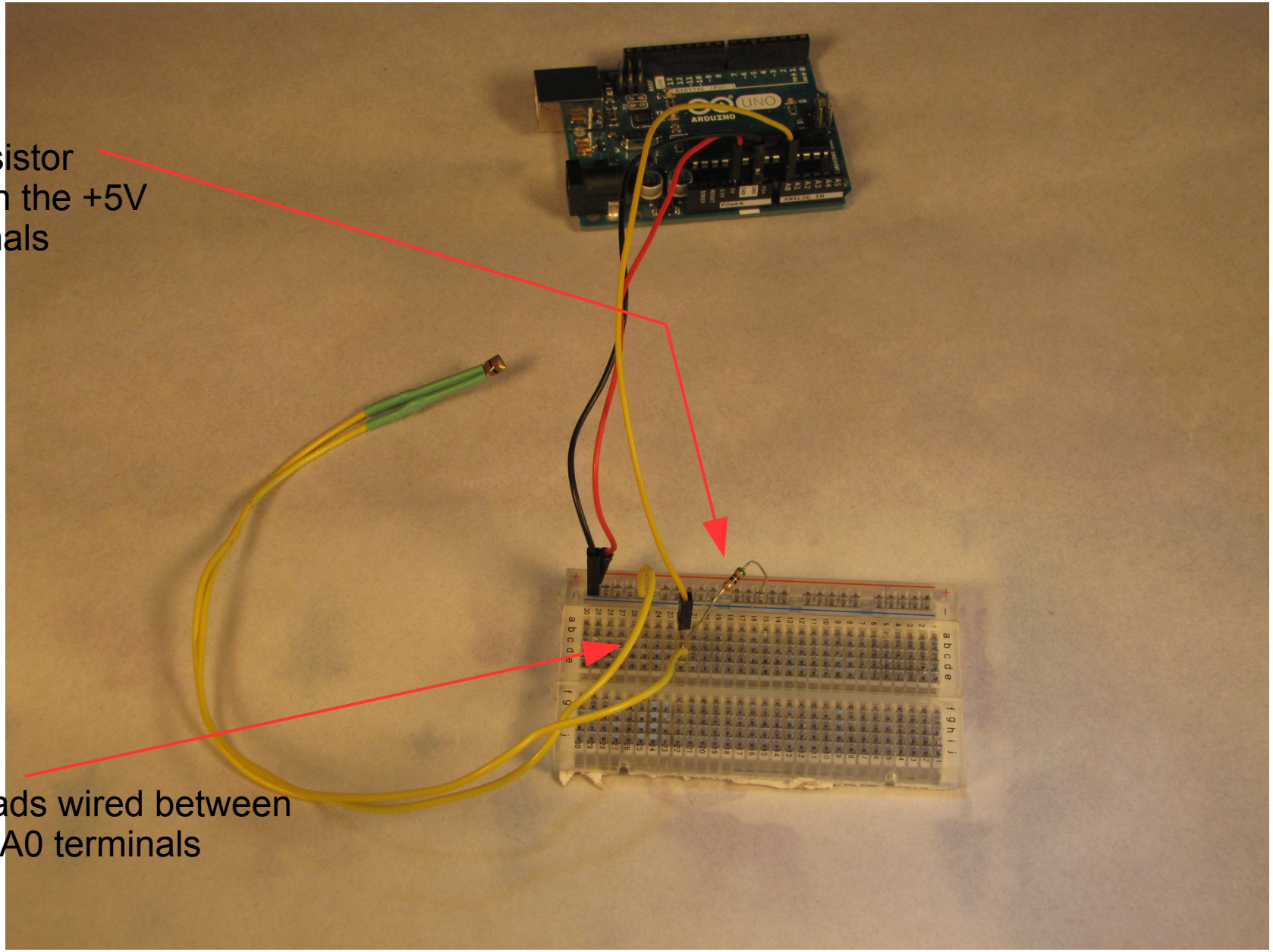


Take +5V, GND and A0 lines from Arduino



Wire to the Arduino

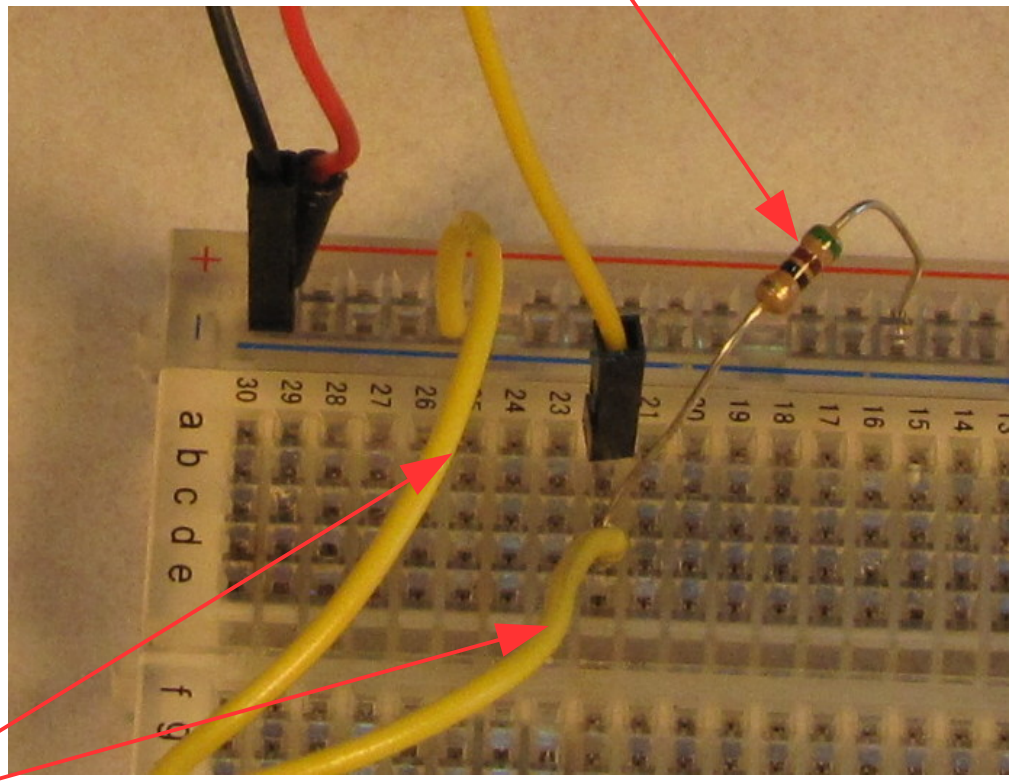
Fixed 51Ω resistor wired between the +5V and A0 terminals



Thermistor leads wired between the GND and A0 terminals

Wire to the Arduino

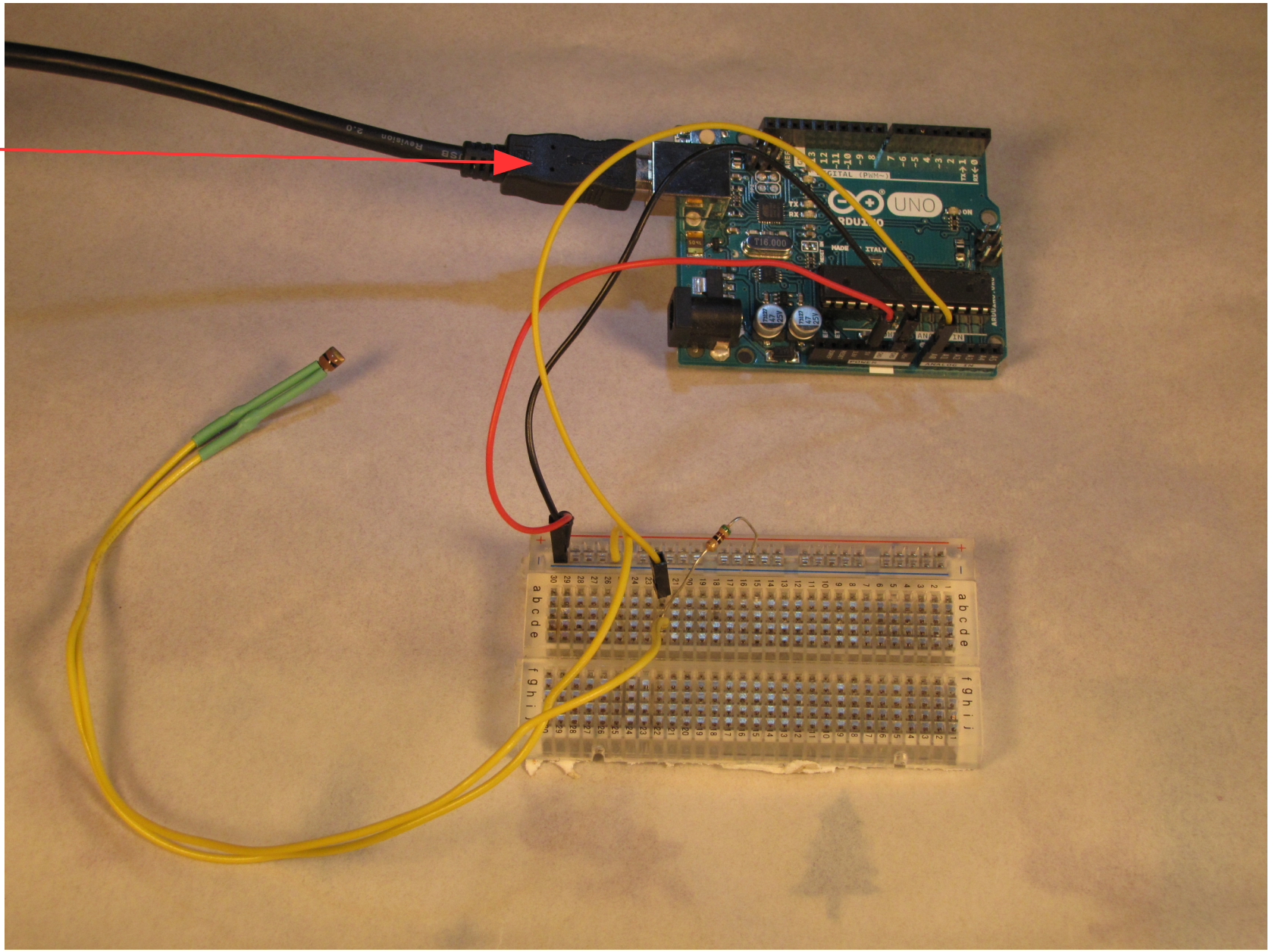
Fixed 51Ω resistor wired between the +5V and A0 terminals



Thermistor leads wired between the GND and A0 terminals

Wire to the Arduino

Finally plug in the USB connector to power up the circuit only when the wiring is checked and double-checked!!!



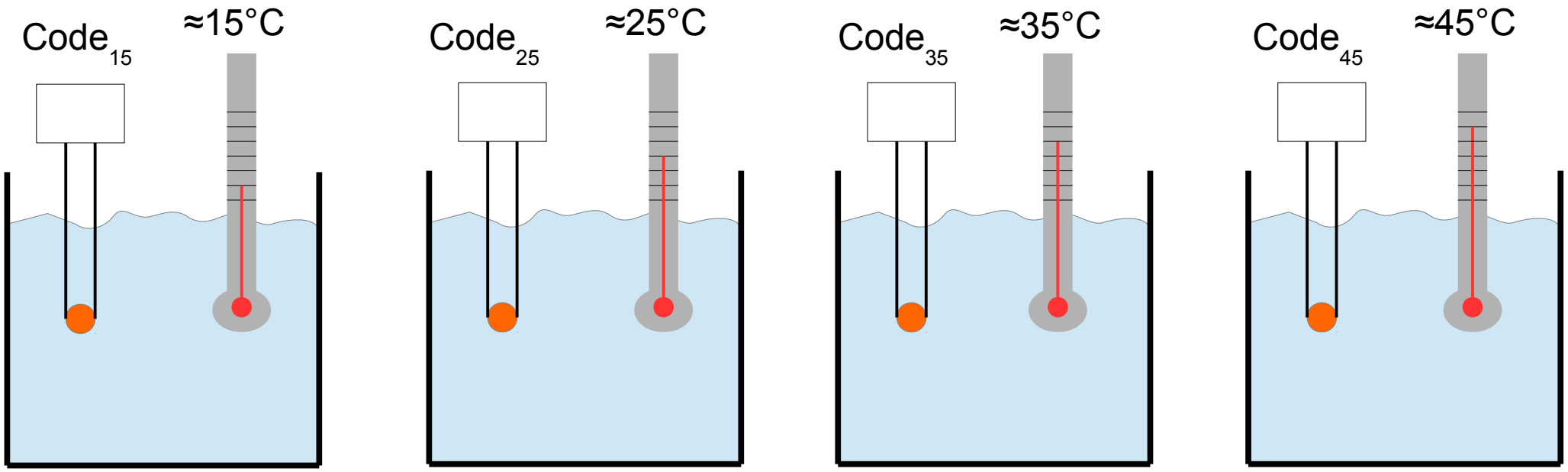
Software to Take ADC Code Readings

```
//This function reads the voltage coming into analog pin 0 ten times
//takes the average, then returns the result.

public static int getThermistorReading() {
    int sum = 0;
    int readingCount = 10;

    //Read the analog pin values ten times, adding to sum each time
    for (int i = 0; i < readingCount; i++) {

       //Refresh the analog pins so we get new readings
        robot.refreshAnalogPins();
        int reading = robot.getAnalogPin(0).getValue();
        sum += reading;
    }

    //Return the average reading
    return sum / readingCount;
}
```

Software to Take ADC Code Readings

```
public static RXTXRobot robot;

//Your main method, where your program starts
public static void main(String[] args) {

    //Connect to the arduino
    robot = new ArduinoUno();
    robot.setPort("COM3");
    robot.connect();

    //Get the average thermistor reading
    int thermistorReading = getThermistorReading();

    //Print the results
    System.out.println("The probe read the value: " + thermistorReading);
    System.out.println("In volts: " + (thermistorReading * (5.0/1023.0)));
}
```

Sensor Calibration



Take four different ADC code readings from the Arduino with the probe immersed in air at four different temperatures. Be sure to allow a few minutes in each air sample for the temperature to stabilize.

Fit Parameters with a Spreadsheet

Enter experimental data points

T deg C	T deg K	measured code
9	282	707
12	285	689
28	301	554
38	311	444
	slope	-9.0138207757
	intercept	794.5506018725

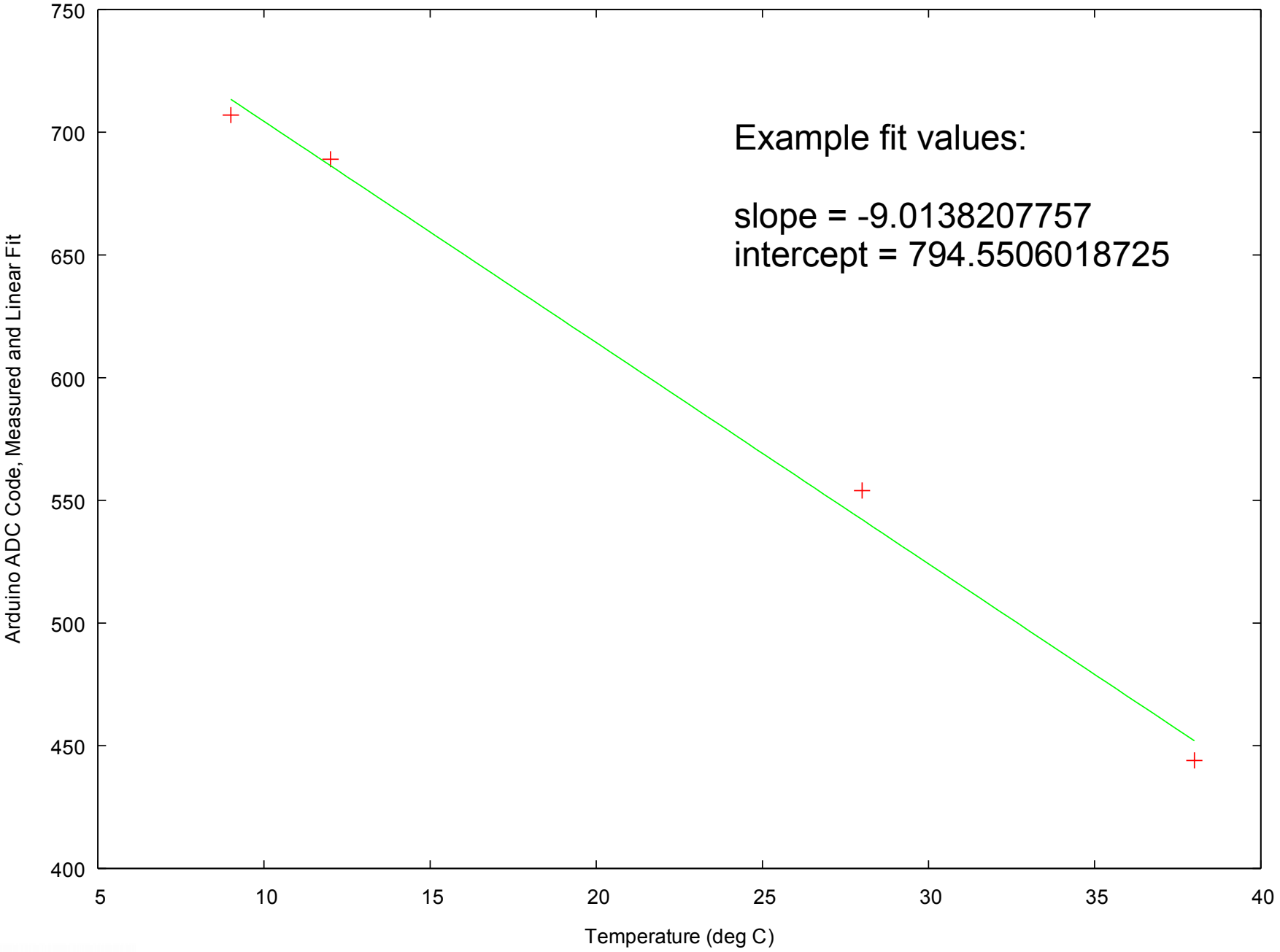
Compute best linear fit with two function calls:

```
=SLOPE($C$3:$C$6,$A$3:$A$6)
=INTERCEPT($C$3:$C$6,$A$3:$A$6)
```

Intermediate points are interpolated by the linear expression

$$\text{ADC Code} = \text{slope} \cdot T + \text{intercept}$$

Linear Fit and Measured Data



Measuring Air Temperature

Once the best fit is determined we will have the ability to measure the temperature of any arbitrary air sample. Your robot will immerse the probe into a air sample and measure the ADC code. Then determine the temperature with the inverse fit formula:

$$T = \frac{\text{ADC Code} - \text{intercept}}{\text{slope}}$$