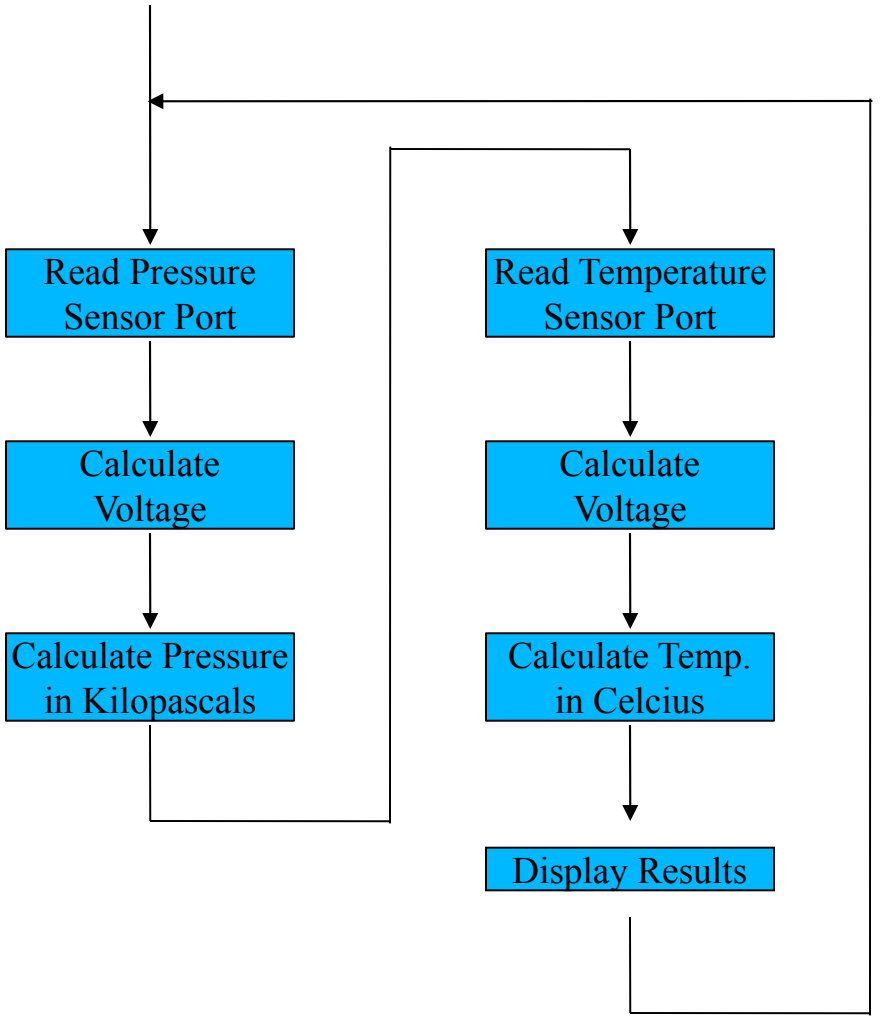
Working With Sensors

In This Section, You Will Start Using the Sensors, This Section Will Cover:

- Writing Software to Collect Sensor Data
- Writing Software to Process Sensor Data
- Testing the Sensor Data
- Requirements:
  - Hair Dryer
  - Thin Rubber or Soft Plastic Hose

Mission Software

- In this section, you will develop software to process the sensor data.
- There are several things that need to be done to get the needed results. The flow chart on the right shows what needs to be done. This section will describe each step in detail.



What Is an Analog-to-Digital Converter?

- In Order to Collect Data From the Sensors, Signals From the Sensors Must Be Converted Into Units That the Processor Can Handle
  - Sensors Generate an 'Analog' Voltage That Varies Based on What Is Measured and the Processor Cannot Understand It
    - Remember, the Processor Is 'Digital' So It Only Understands Ones and Zeros (i.e., Binary Data)
- An Analog-to-Digital Converter (ADC) Allows a Processor to Measure Voltages
  - It's an Analog World Outside the Processor
    - Measurements Do Not Have Discrete Steps (i.e., On/Off, High/Low, One/Zero)
    - An ADC Allows the Processor to Measure the Analog World
- As An Example, Look at a Temperature Sensor
    - A Temperature Sensor Converts the Measured Temperature to a Voltage That Corresponds to the Temperature
    - The ADC Measures the Voltage and Converts It to a Digital Number That the Processor Can Use
    - The Processor Take The Digital Number and Processes It to Calculate the Temperature
    - You Will Do This With the *CanSat*

Reading the Sensors

- The Processor Has an Interface Component Called an Analog-to-Digital Converter (ADC)
  - The ADC Converts a Voltage to an Integer Number
  - The Integer Number Is Used to Calculate the Measured Voltage
  - The Microcontroller Has a 10-Bit ADC
    - This Gives an Integer Range of 0 to 1023 Covering 0 to 5 Volts
    - The Following Equation Determines the Voltage Measured:

      Voltage = Measured / 1023 * 5
- If the ADC Generated an Integer Number Value of 512, Then the Voltage Is 512 / 1023 * 5 = 2.5 Volts Which Is Half the Voltage Range and Half the ADC Range
- 1024 Is the Number Values That the ADC Can Generate
  - With an ADC Value of 512, the Voltage Is Half the Maximum Voltage Which Is 2.5 Volts
- There Are Three ADC Channels Available

analogRead() Function

- The Function to Read the ADC Is Called `analogRead()`

```
value = analogRead(channel);
```

- The analogRead() Function Requires One Parameter:
  - Channel is an integer that is 0, 1, or 2 to select the analog port.
  - Value is an Integer Variable That Holds the Value of the ADC
    - Remember That the Variable Has to Be Declared the Proper Size
    - Since the ADC Can Generate a Value From 0 to 1023, It Needs a Variable Declared int Which Allows a Range From 0 to 65535

Reading the Pressure Sensor

- Enter the following program to read the pressure sensor and display it. Make the program continuously print the data.
- The value displayed is the raw number from the ADC. It will need to be processed to a useful value.

```
Void setup()
{
    Serial.begin(38400);
}

void loop() {
    int pressure;
    pressure = analogRead(0);
    Serial.println(pressure);
}
```

Reading the Pressure Sensor

- The previous program displayed the number out of the ADC. Now modify the program to convert the ADC value to a voltage value. Remember the equation V = ADC/1023.0 * 5.0
- The program below shows how to do it.
- Remember to add the Printfloatln() function to the top of your program

```
Void setup()
{
    Serial.begin(38400);
}

void loop() {
    int pressure;
    float voltage;
    pressure = analogRead(0);
    voltage = (float)pressure / 1023.0 * 5.0;
    Serial.println(voltage,2);
}
```

Calculating Air Pressure Value

- The Pressure Sensor Measures the Atmospheric Pressure and Generates a Voltage Proportional to the Air Pressure
  - The Higher the Air Pressure, the Higher the Voltage
- An Equation Is Provided by the Manufacturer:

  $V = 5.0(0.009P - 0.095)$

- V Is the Voltage and P Is the Air Pressure in Kilopascals
- The Equation for the Pressure Sensor Needs to Be Solved for P

$$V = 5.0(0.009P - 0.095)$$
$$V = (5.0 * 0.009 * P) - (5.0 * 0.095)$$
$$V = 0.045 * P - 0.475$$
$$V + 0.475 = 0.045 * P$$
$$(V + 0.475)/0.045 = P$$
$$P = (V + 0.475) * 22.222$$
$$P = 22.222 * V + 10.556$$

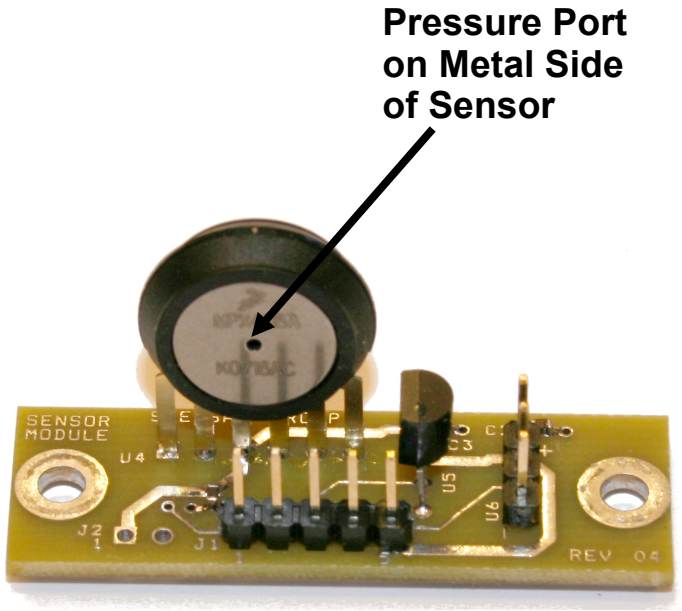
Working With the Pressure Sensor Calculating the Pressure Value

- Given P = 22.222 * V + 10.556, Modify the Program That Calculated Voltage and Add This Equation to Calculate Pressure
  - Remember to Include More Variables As Needed and the Variables Need to Be Declared at the Top of the Program
  - The Pressure Calculation Needs to Be Done With Floating Point Math
- The Result Should Be Around 100.0 to 102.0

```
void loop() {
    int pressure;
    float voltage;
    float kpa;
    pressure = analogRead(0);
    voltage = (float)pressure / 1023.0 * 5.0;
    kpa = 22.222 * voltage + 10.556;
    Serial.println(kpa,2);
}
```

Testing the Pressure Sensor

- You Will Need a Straw
- Run the Program That Continuously Displays the Pressure Readings
- Looking at the Sensor Board, Place One End of the Straw Over the Hole on the Metal Side of the Sensor
- With the Free Side of the Straw, Suck the Air Out With Your Mouth
  - You Should See the Pressure Reading Drop
  - If Not, Readjust the Straw on the Pressure Sensor Until You Have a Better Seal, Make Sure the End of the Straw Is Flat and Smooth
  - If the results are being displayed too fast, insert a pause command in the loop to slow the program down



Working With the Temperature Sensor

- For the Temperature Sensor, the Equation Is:

  V = 0.01 * C + .5

- V Is the Voltage and C Is the Temperature in Celsius
- Solve for C

  V – 0.5 = 0.01 * C

  100 * V – 50 = C

  C = 100.0 * V - 50.0

Reading the Temperature Sensor

- **The Temperature Sensor Is Connected to Port 1 So the Command to Read the ADC Is:**

```
value = analogRead(1);
```

- **Write a Program to Read the Temperature Sensor and Calculate the Temperature in Celsius**

```
void loop()
{
    int temperature;
    temperature = analogRead(1);
    Serial.println(temperature);
}
```

Processing Temperature Data

- The next step is to calculate the voltage just like the pressure sensor

```
void loop() {
    int temperature;
    float voltage;
    temperature = analogRead(0);
    voltage = (float)temperature / 1023.0 * 5.0;
    Serial.println(celcius,2);
}
```

Calculate the Temperature

- Now that the voltage has been calculated, it is time to calculate the temperature in Celcius

```
void loop() {
    int temperature;
    float voltage;
    float celcius;
    temperature = analogRead(0);
    voltage = (float)temperature / 1023.0 * 5.0;
    celcius = temperature * 100.0 - 50.0;
    Serial.println(voltage,2);
}
```

- Run the program and use a blow drier to heat up the temperature sensor and see the results. If the numbers are being displayed too quickly, insert a pause command in the loop to slow the program.

Summary

- In This Section, You Should Have Written Two Programs to Read the Pressure Sensor and Temperature Sensor, Calculated the Air Pressure and Temperature, and Displayed the Results on the Computer

- You Should Have Tested the Pressure Sensor and Temperature Sensor