香港天文台
HONG KONG OBSERVATORY

USER GUIDE

BASIC ARDUINO TRAINING

(Exercise: Automatic Weather Station)

Version	:	**1.0**
Date	:	**September, 2019**
Prepared by	:	**Jeffrey Chang - Intern (R3/F3)**

Hong Kong Observatory

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1. INTRODUCTION

1.1 What is Arduino

Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of **digital** and **analog input/output (I/O)** pins that may be interfaced to various expansion boards or breadboards (shields) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The microcontrollers can be programmed using **C and C++ programming languages**. In addition to using traditional compiler toolchains, the Arduino project provides an **integrated development environment (IDE)** based on the Processing language project.

1.2 Digital Signals

Digital pins are used mainly as **output pins**. You can connect various devices (LEDs, buzzer, LCD) on the digital pins and turn them on/off by **writing HIGH or LOW on the respective pins**. Check out digitalWrite() command. Before using a digital pin, you have to set it in input/output mode using pinMode() command.

You can use a digital pin in input mode as well, especially when using interrupts in your code. Digital pins 2 and 3 of UNO can be used for interrupt detection. In general, you can check the status (on or off) of a device (or a switch) connected to a digital pin by using that pin in input mode. The command used is digitalRead().

Applications: LED Flash, LCD Monitor, Fan (On/Off)

1.3 Analog Signals

Analog pins are the ADC (analog to digital converter) input pins. They are used for **reading analog voltage** (between 0-5V on arduino, by default). Check out the sample program for analogRead() command.

Applications: Sensors (Signal by measuring voltage difference)

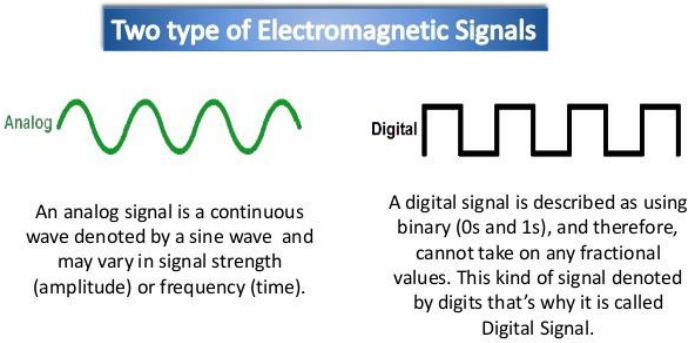


Figure 1. Analog and Digital Signals

1.4 I2C Communication

The I2C communication bus is very popular and broadly used by many electronic devices because it can be easily implemented in many electronic designs which require communication between a **master** and **multiple slave devices or even multiple master devices**. Each device has a preset ID or a unique device address so the master can choose with which devices will be communicating.

The two wires, or lines are called **Serial Clock (or SCL – Pin A4)** and **Serial Data (or SDA – Pin A5)**. The SCL line is the clock signal which synchronize the data transfer between the devices on the I2C bus and it's generated by the master device. The other line is the SDA line which carries the data.

The two lines are "open-drain" which means that pull up resistors needs to be attached to them so that the lines are high because the devices on the I2C bus are active low.

Applications: Real-time Clock, Sensors

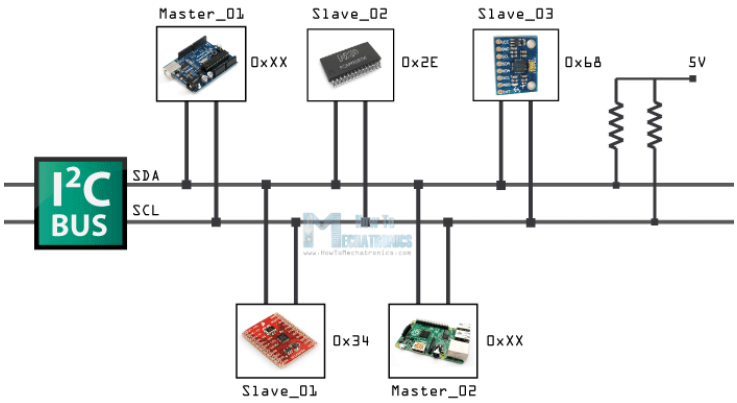
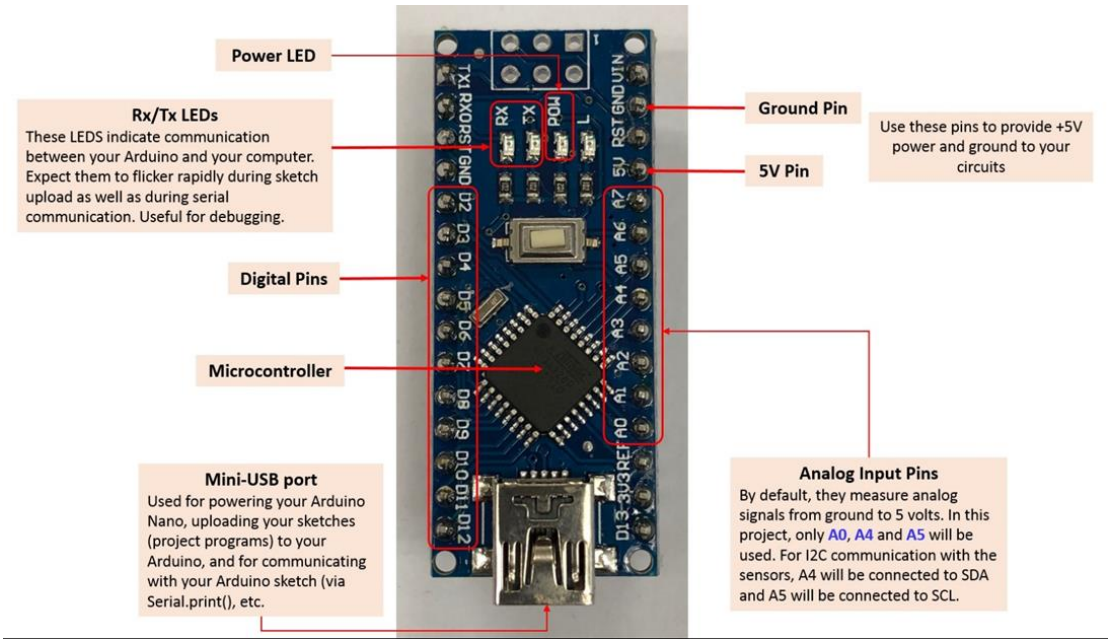
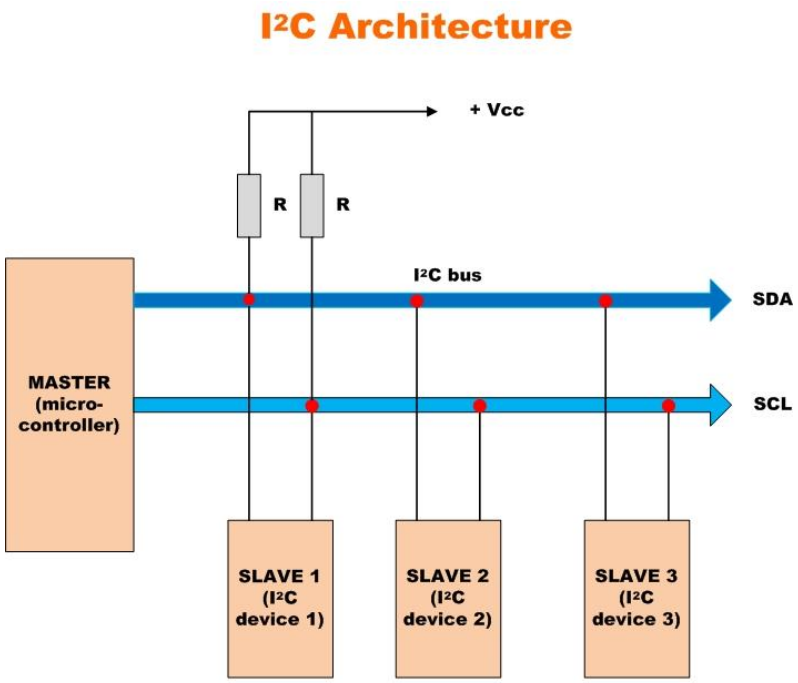


Figure 2. I2C Communication Example

2. GETTING STARTED

2.1 The Arduino Nano Board





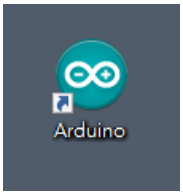
Multiple devices on common I²C bus

Serial data (SDA)
Serial clock (SCL)

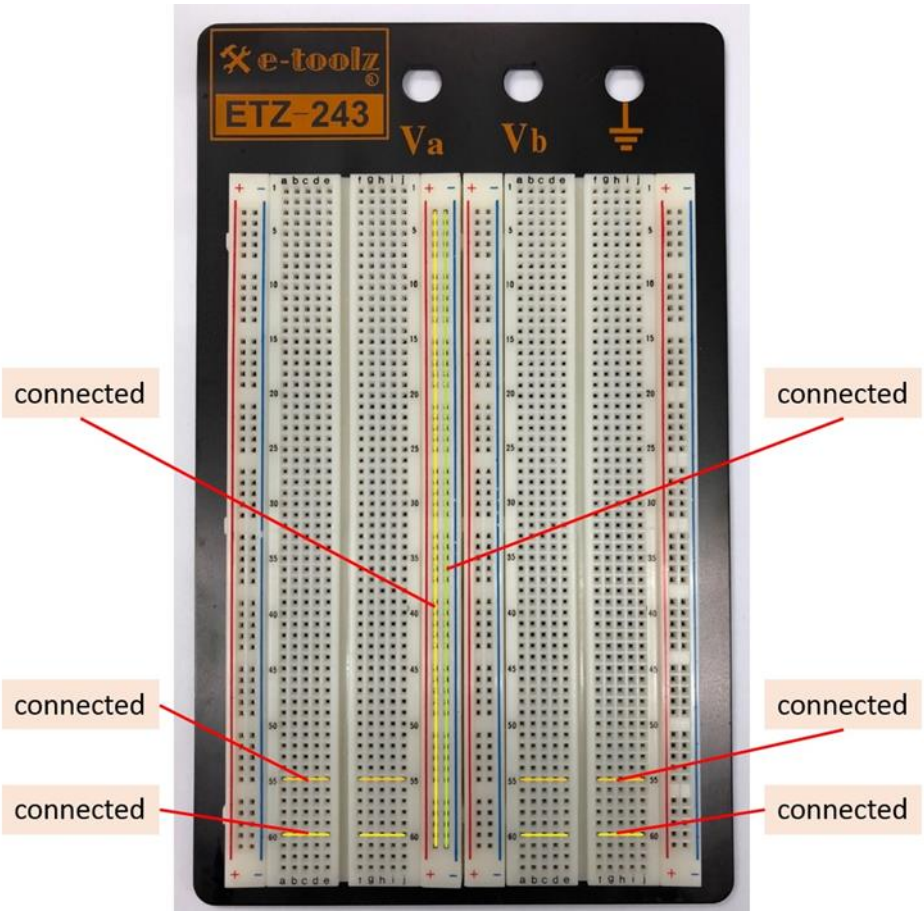
2.2 The Arduino IDE

Before you start controlling the world around you using the Arduino, you'll need to download the Arduino IDE (Integrated Development Environment). The Arduino IDE allows you to write programs and upload them to your Arduino. You can download the latest version of the IDE from:
https://www.arduino.cc/en/Main/Software

In this workshop, the Arduino IDE has been downloaded and installed for you. The link to start your Arduino IDE is shown as an Arduino icon on the desktop of your PC (see below).

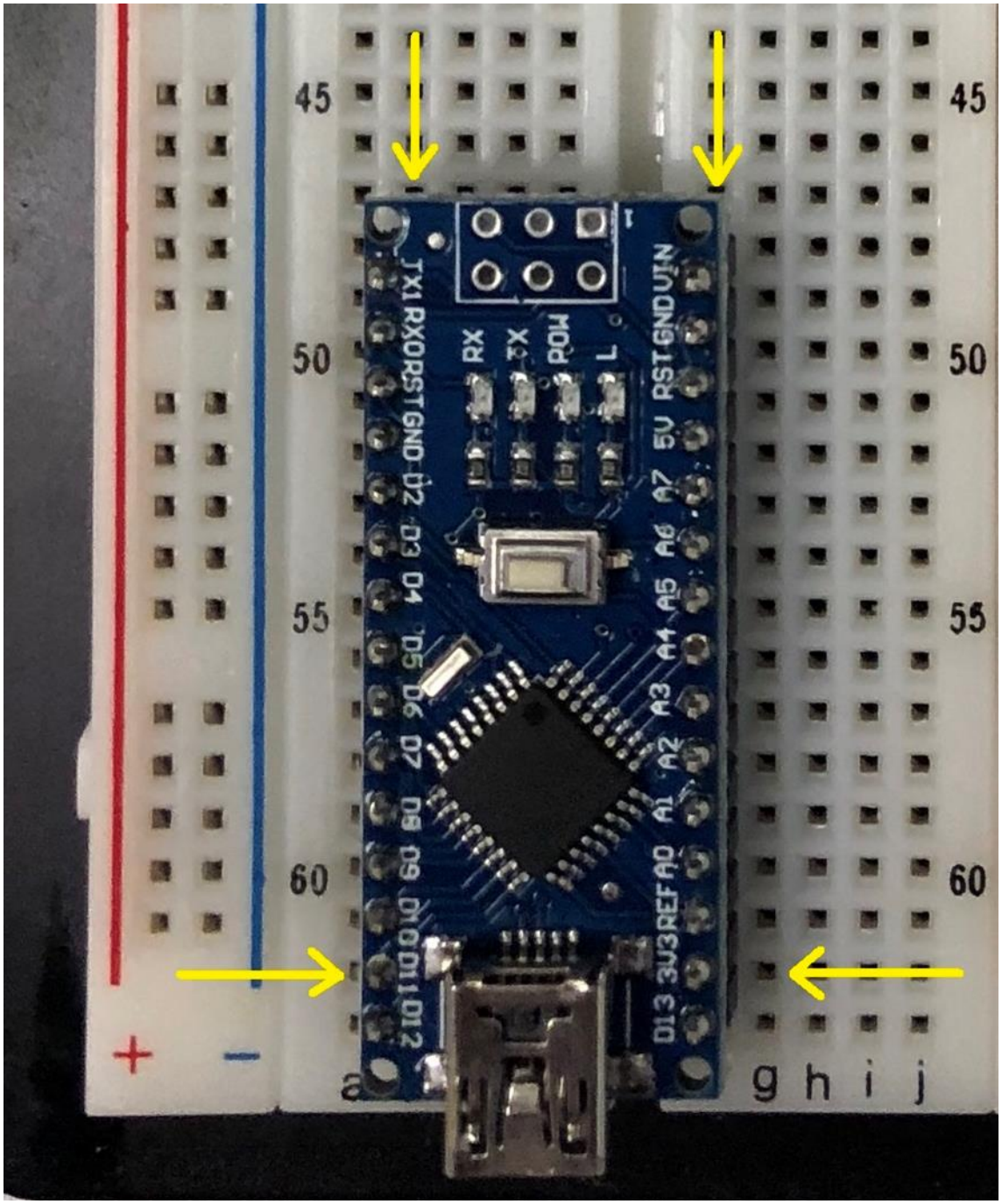


2.3 Basic information about the Breadboard used in this workshop



2.4 Connecting your Arduino Nano to a PC

Insert the Arduino Nano on the breadboard as shown below and connect it to your PC using a mini-USB cable

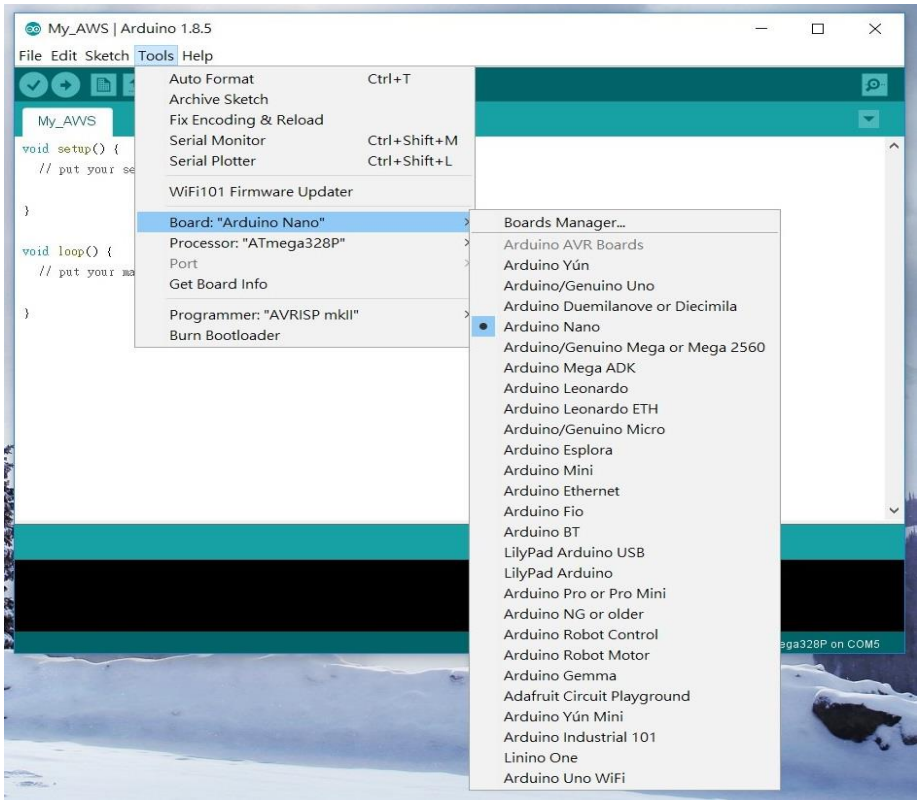


3. CREATING YOUR FIRST ARDUINO PROJECT

3.1 Running the Arduino IDE

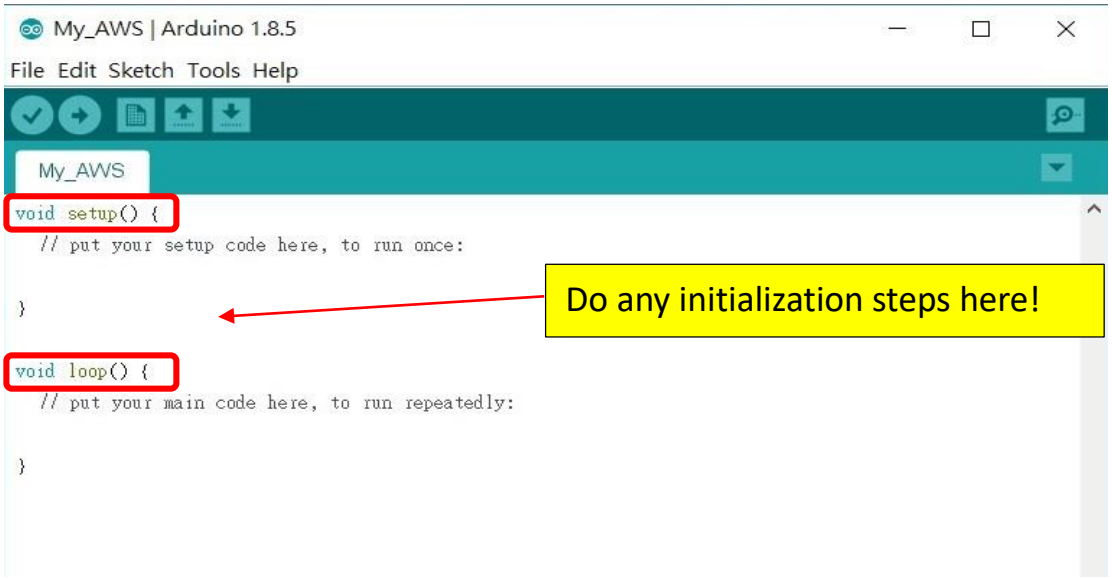
Double click on the Arduino icon on the desktop of your PC to start running the Arduino IDE.

3.2 Selecting a proper Arduino board



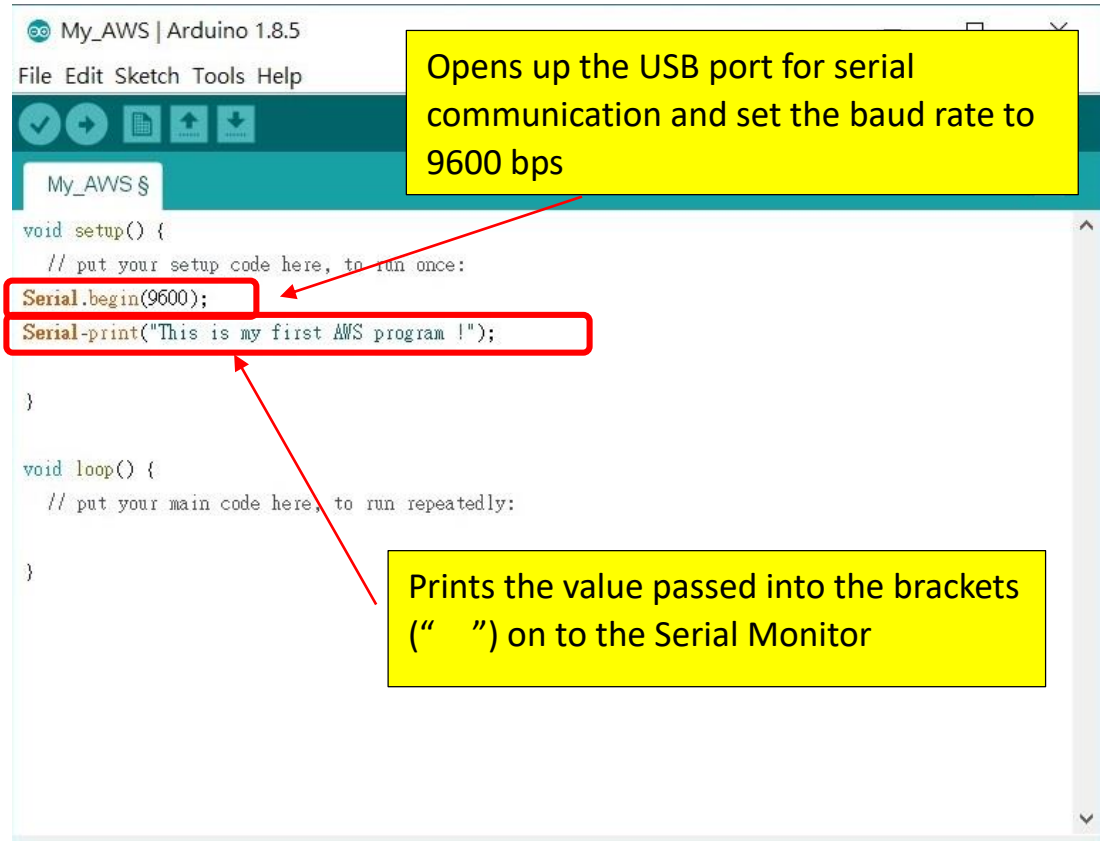
3.3 Creating a new project file

The basic structure of a new project file is shown below:



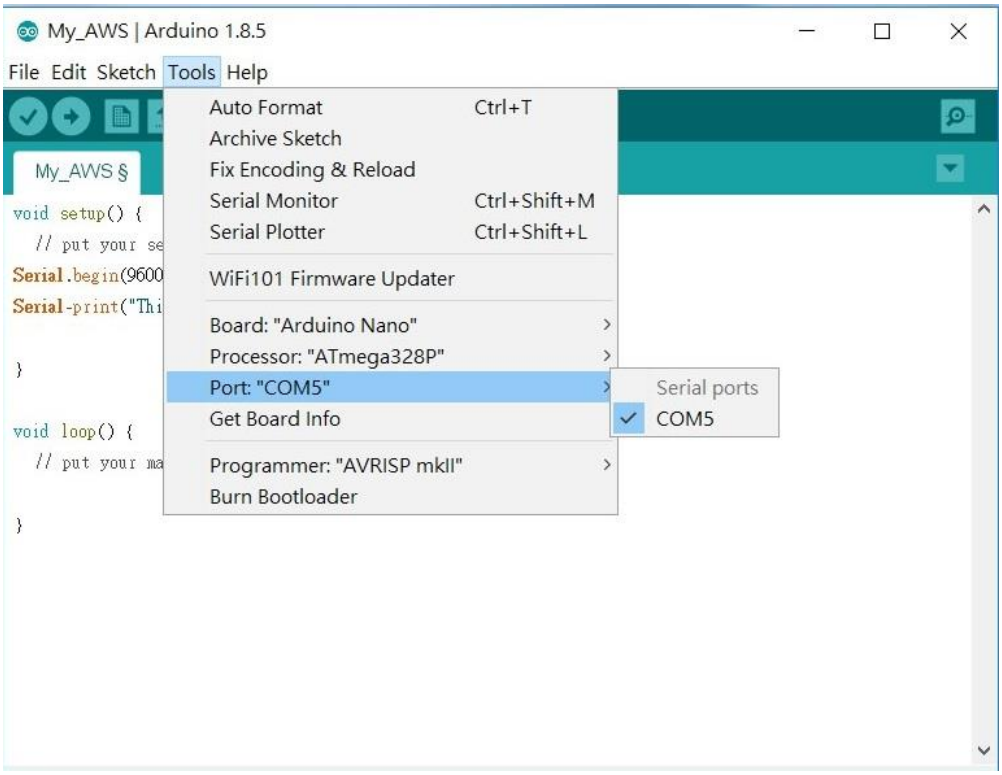
Type the following in the setup() section:

```
Serial.begin(9600);
Serial.print(" This is my first AWS program! " );
```

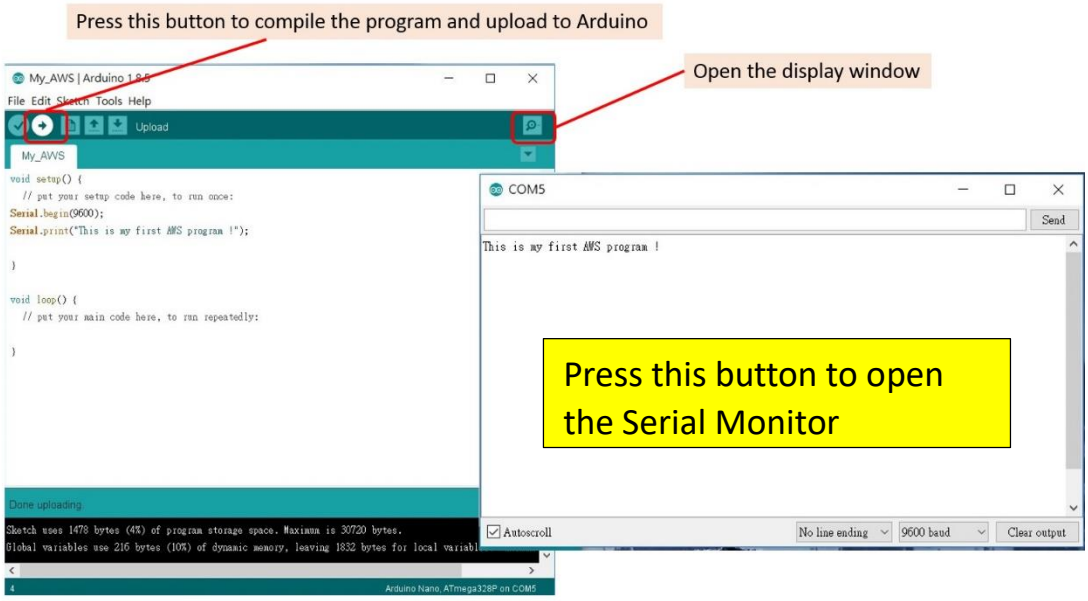


3.4 Setting up an appropriate Communication Port

Set up an appropriate COM port for displaying the information:
select **COM5 or COM4** in some PCs.



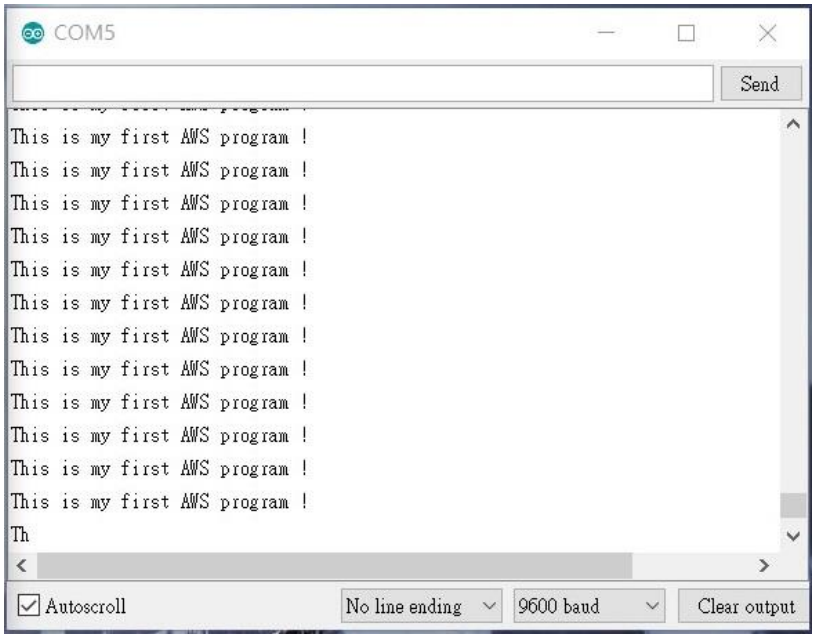
3.5 Compiling and uploading a program to your Arduino



3.6 Using the loop() function

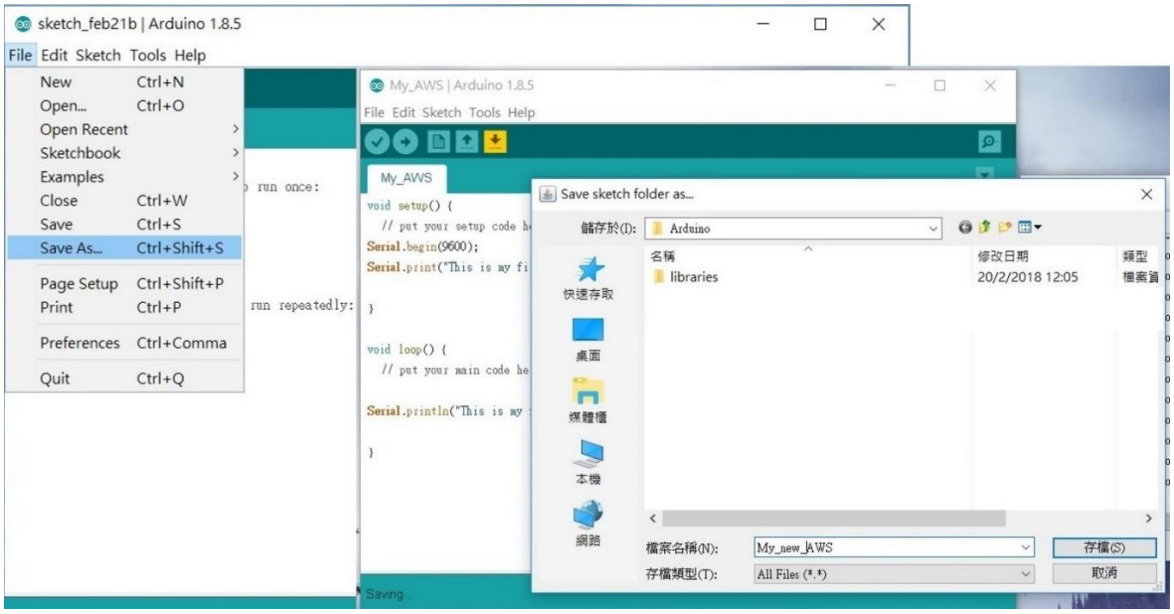
In the loop() section, type Serial.print("This is my first AWS program! ") and see the result.

Try using Serial.println("This is my first AWS program! ") instead of Serial.print("This is my first AWS program! ") and recompile your program and see the result.



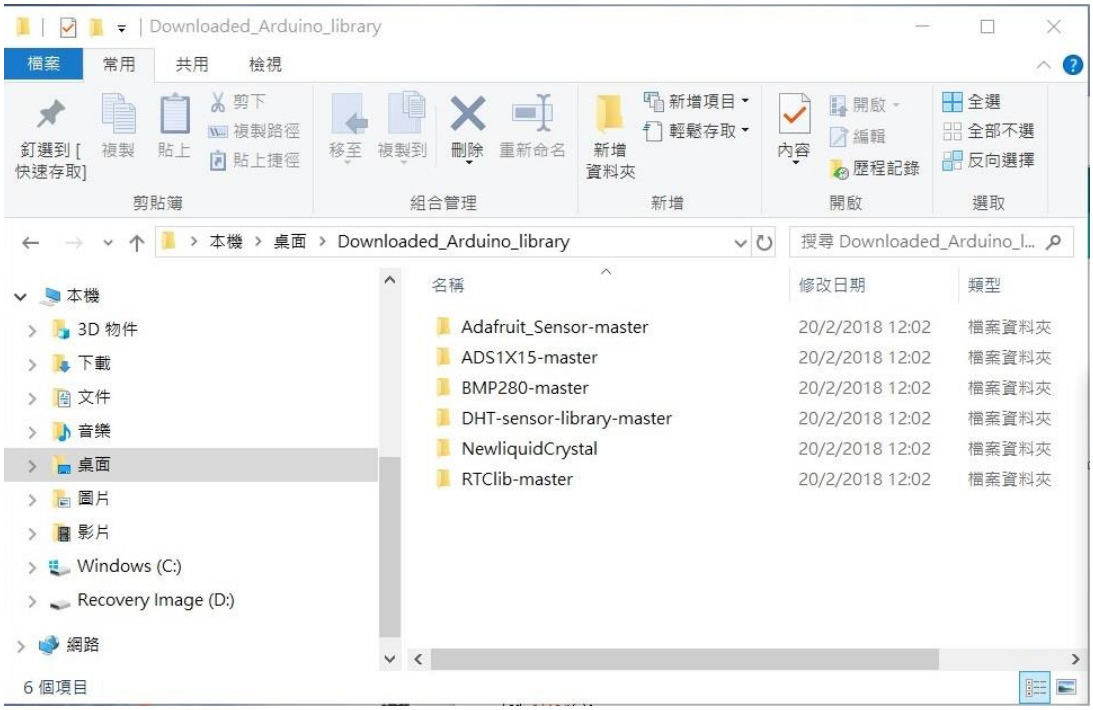
3.7 Saving your first project file

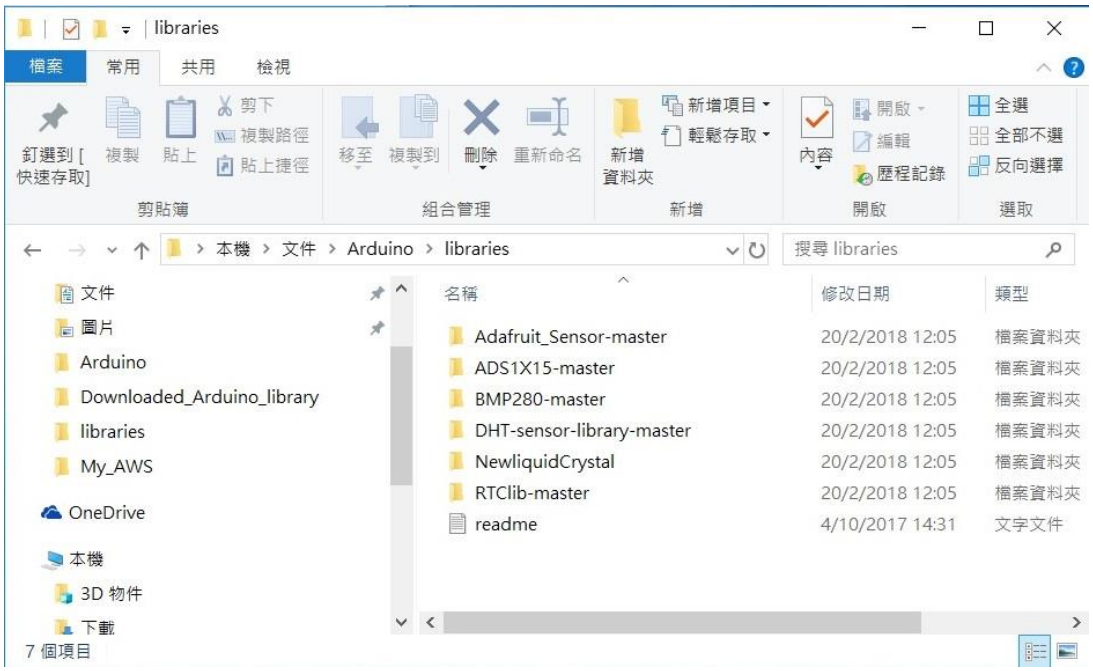
Save the program as My_new_AWS.



3.8 Downloading library files for different sensors for your Arduino projects

When you purchase different sensors, you need to download the appropriate library files and put them in the proper directory for Arduino IDE to access the files. The following is an example of a list of library files downloaded and stored under the folder 'Downloaded_Arduino_library'. They should be copied to the folder 'document>Arduino>libraries' as shown below:



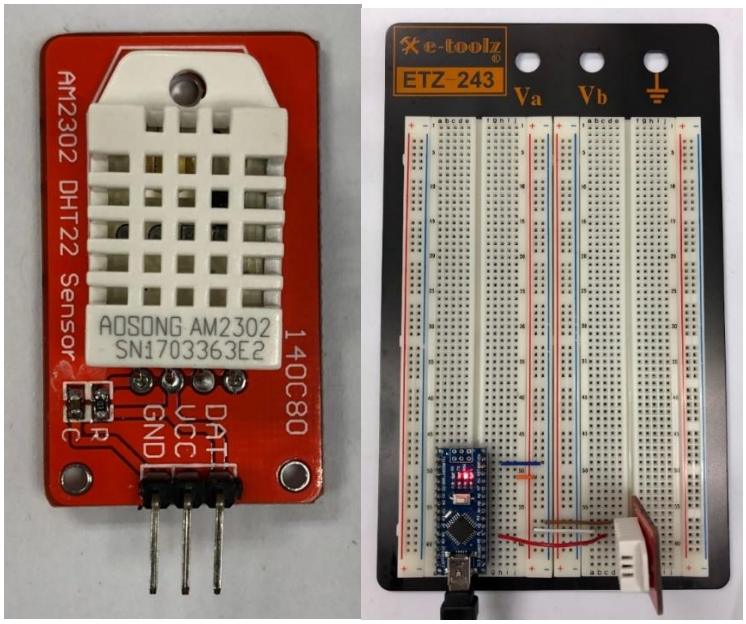


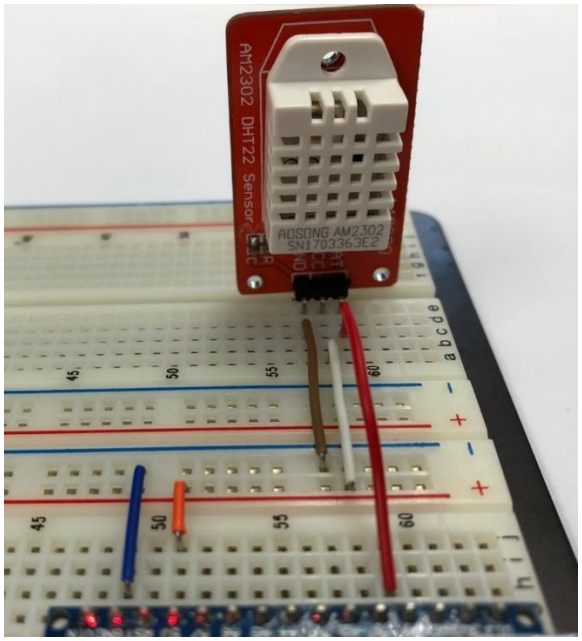
4. INSTALLING TEMPERATURE AND HUMIDITY SENSOR

- DHT22 MODULE

4.1 Wiring

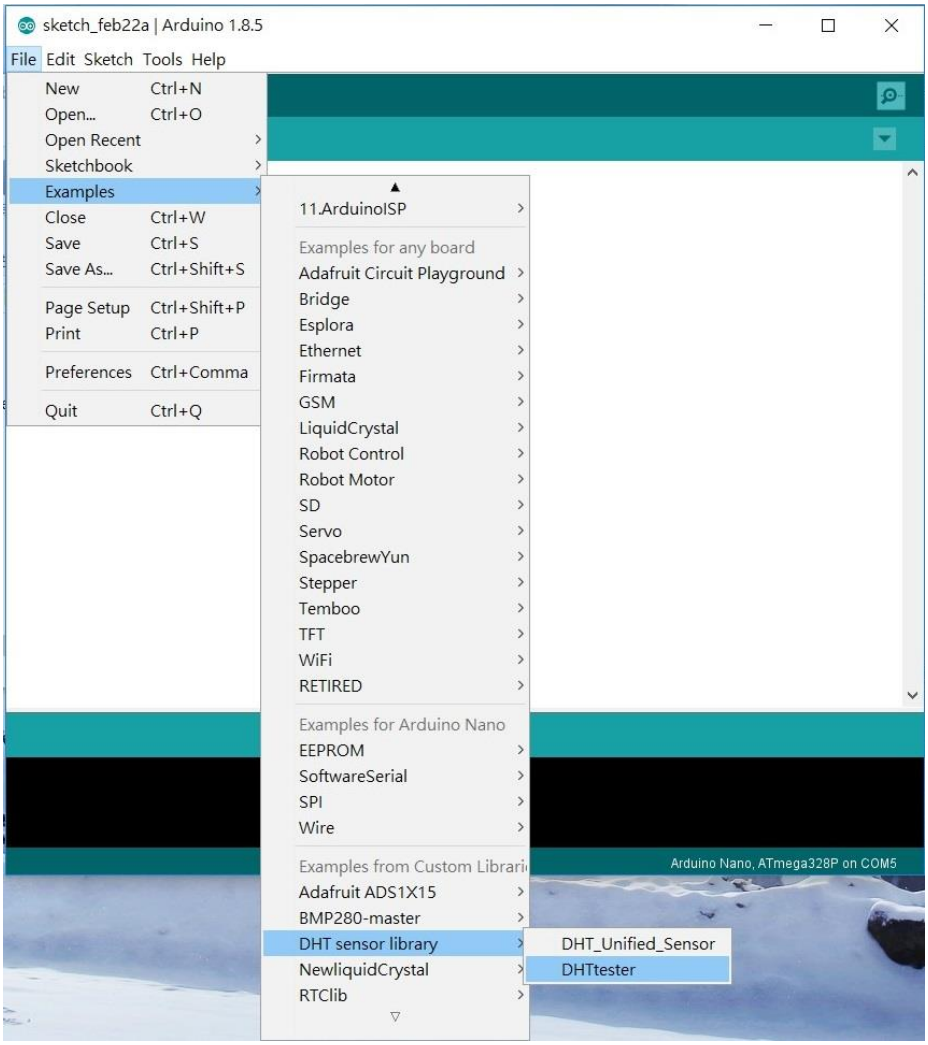
1. Connect GND and VCC of DHT22 to the **GND** and **5V** pins of Arduino Nano respectively
2. Connect DAT of DHT22 to **A0** pin of Arduino Nano





4.2 Choosing an Example file in the DHT sensor library

Choose the **DHTtester file** from the DHT sensor library as shown below:



4.3 Modifying the Analog input pin to display correctly

Modify the **analog input pin from 2 to A0** as shown below:

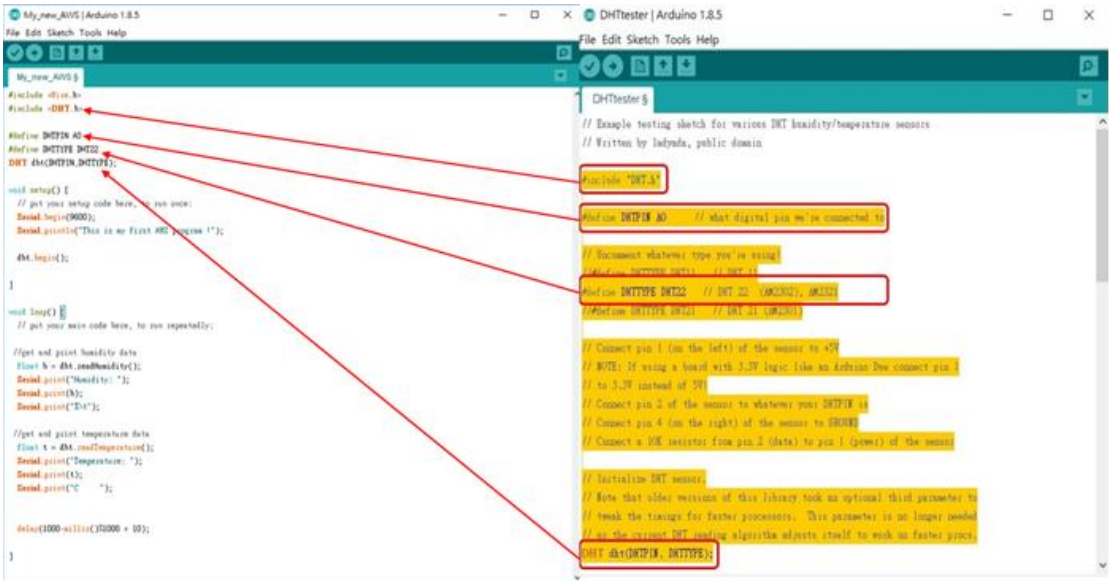
Compile and upload the program again and see the results.

4.4 Modifying the My_new_AWS file to include the DHT22 sensor program

Open the My_new_AWS file side by side with the DHTtester file.

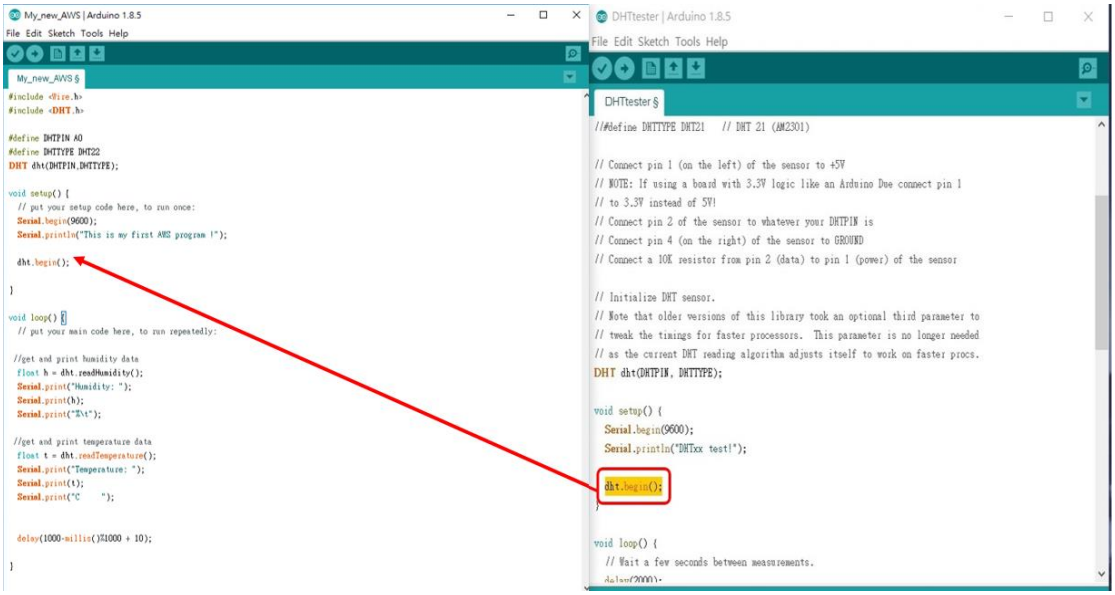
Copy the following 4 lines to header section of My_new_AWS program:

```
#include "DHT.h"
#define DHTPIN A0          // what digital pin we're connected to
#define DHTTYPE DHT22      // DHT 22  (AM2302), AM2321
DHT dht(DHTPIN, DHTTYPE);
```

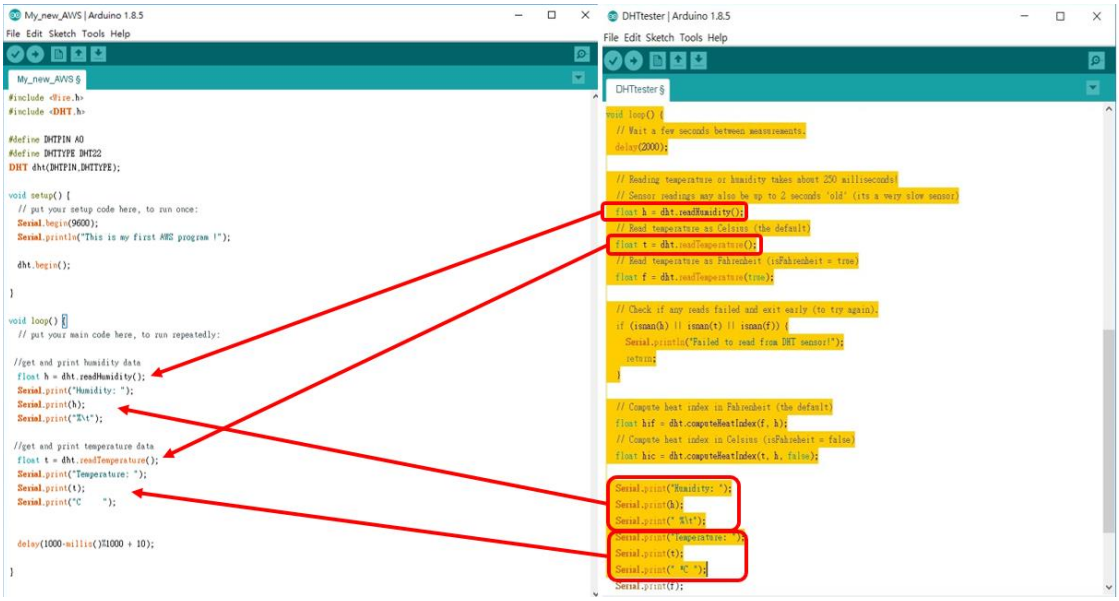


Copy the following line to the setup section of My_new_AWS program:

dht.begin(); as shown below:

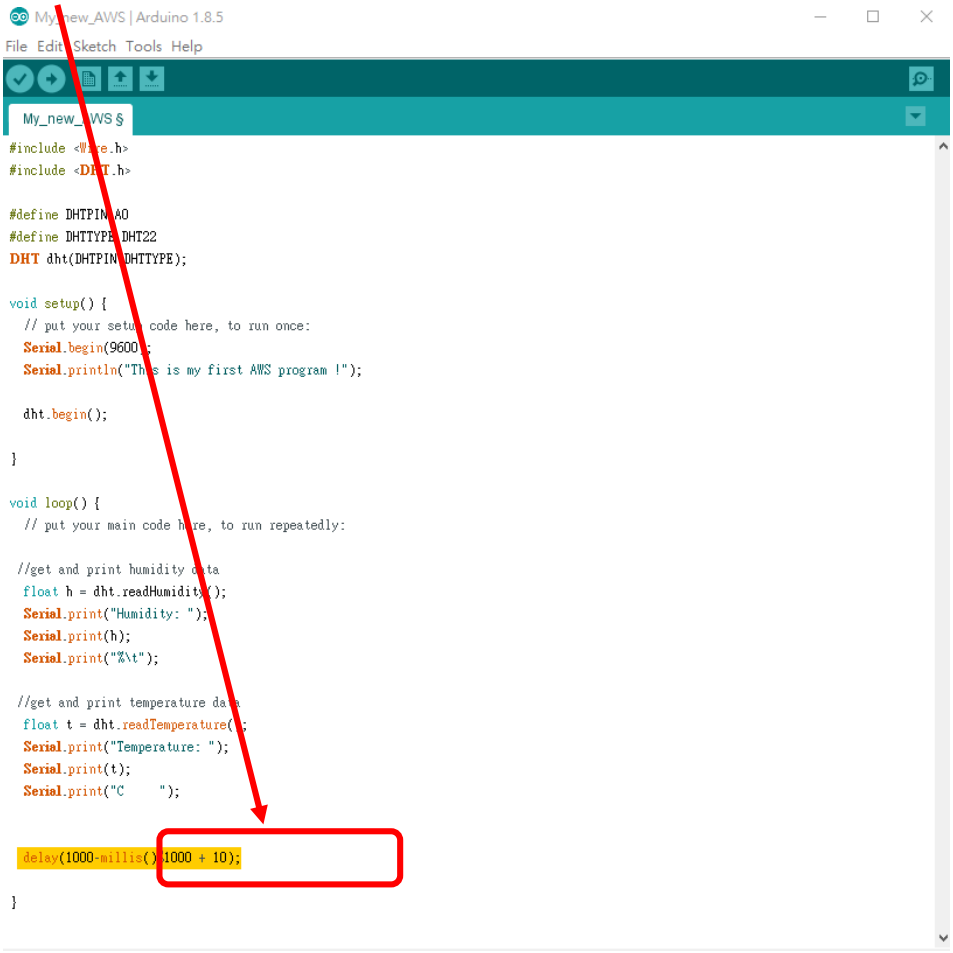


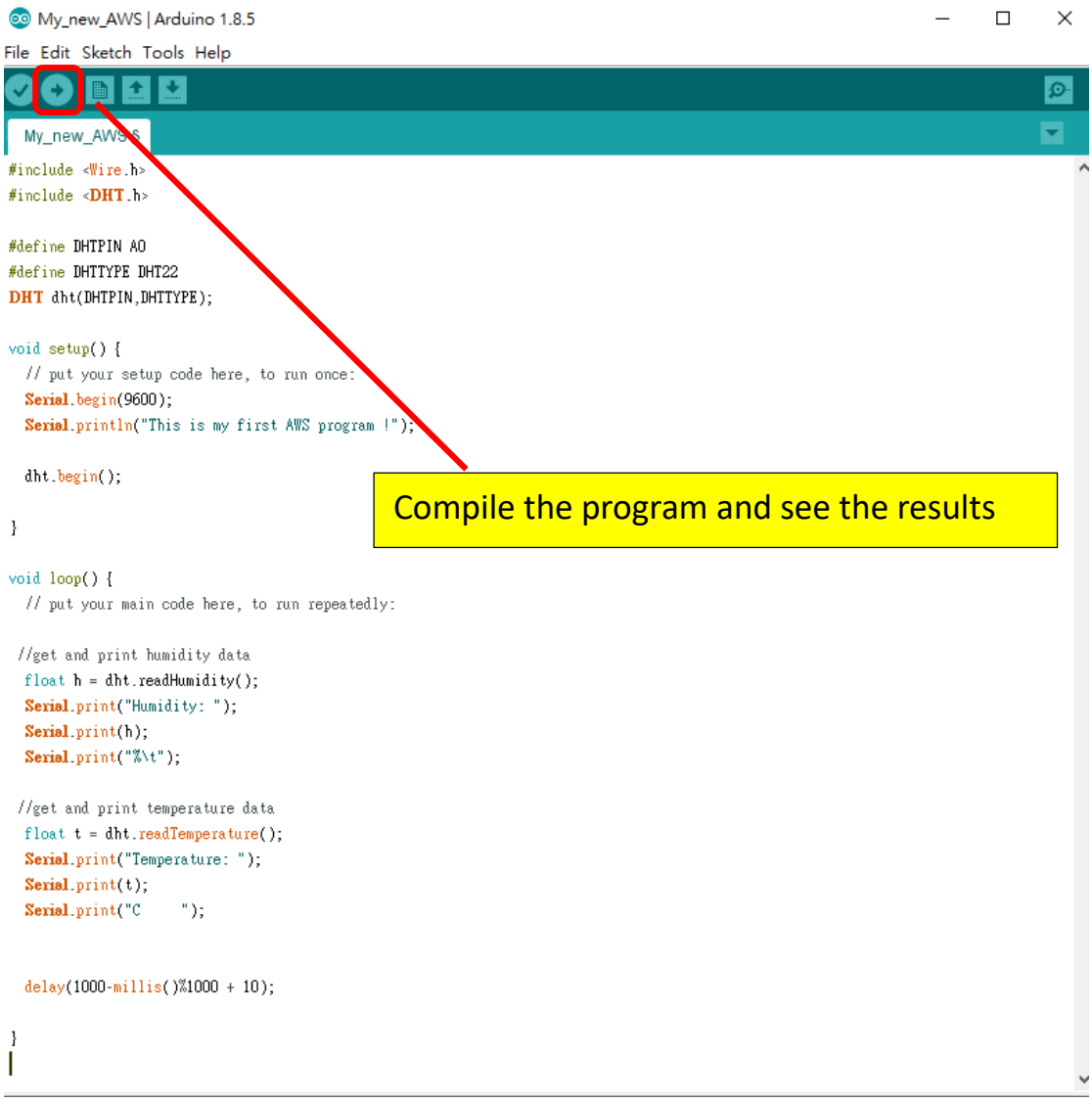
Copy the loop() section of DHTtester to My_new_AWS and modify them as shown below:

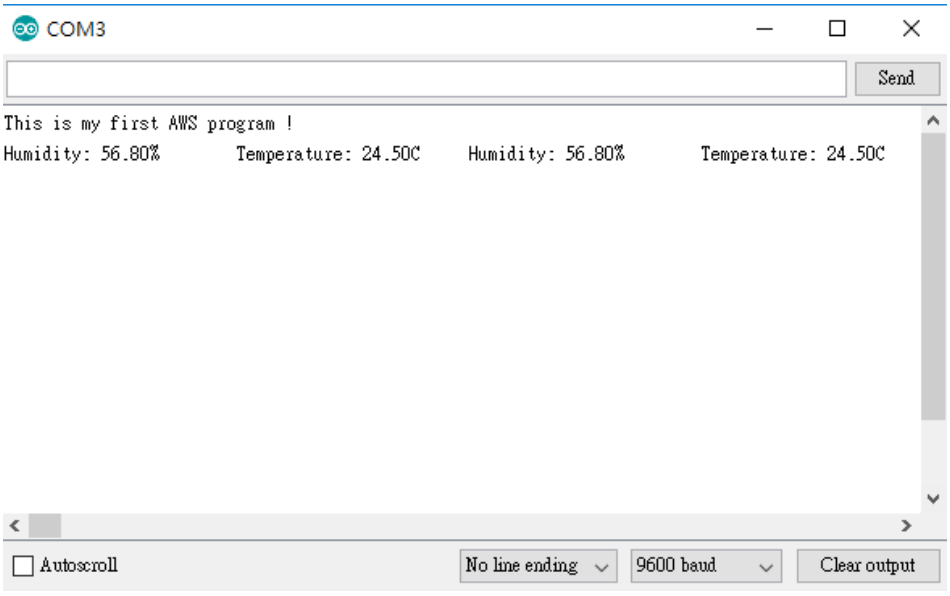


Add a time delay for ensuring printing a data record every second.

delay(1000-millis()%1000 + 10);




My_new_AWS | Arduino 1.8.5
File Edit Sketch Tools Help
My_new_AWS
#include <Wire.h>
#include <DHT.h>
#define DHTPIN A0
#define DHTTYPE DHT22
DHT dht(DHTPIN,DHTTYPE);
void setup() {
// put your setup code here, to run once:
Serial.begin(9600);
Serial.println("This is my first AWS program !");
dht.begin();
}
void loop() {
// put your main code here, to run repeatedly:
//get and print humidity data
float h = dht.readHumidity();
Serial.print("Humidity: ");
Serial.print(h);
Serial.print("%\t");
//get and print temperature data
float t = dht.readTemperature();
Serial.print("Temperature: ");
Serial.print(t);
Serial.print("C ");
delay(1000-millis()%1000 + 10);
}
Compile the program and see the results


COM3
Send
This is my first AWS program !
Humidity: 56.80% Temperature: 24.50C Humidity: 56.80% Temperature: 24.50C
Autoscroll
No line ending
9600 baud
Clear output

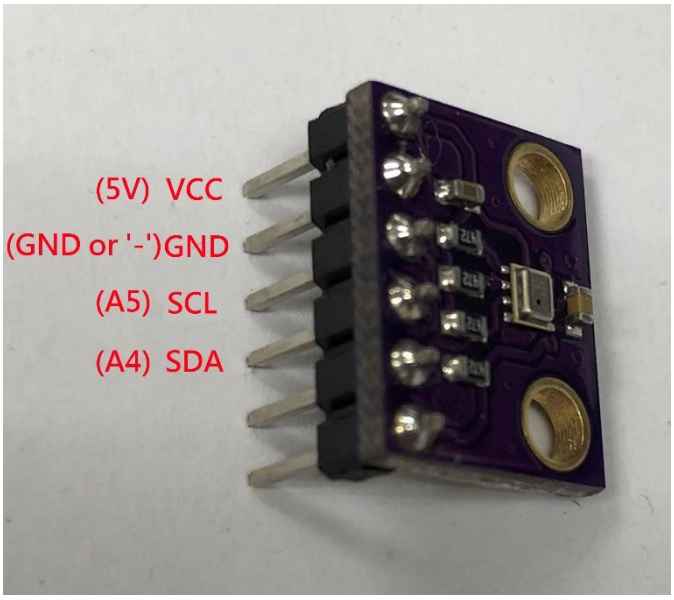
5. INSTALLING PRESSURE SENSOR - BMP280 MODULE

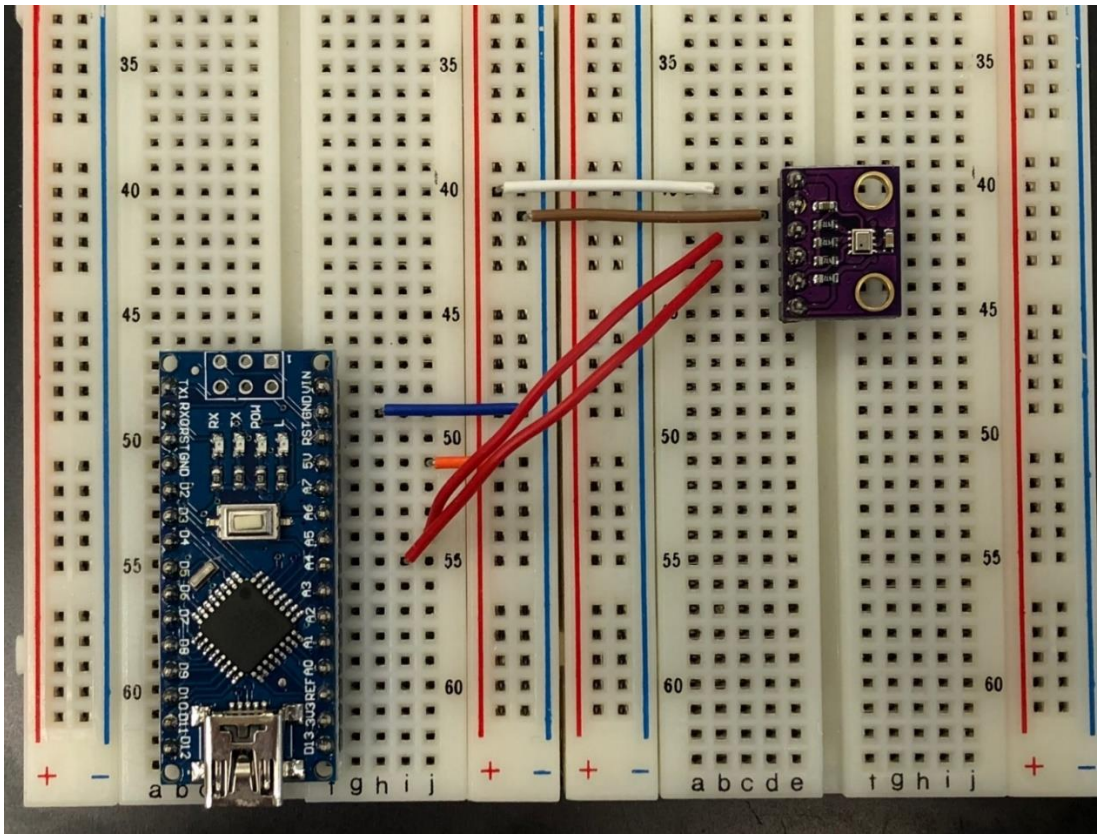
5.1 Wiring

1.Connect BMP280 **VCC** to **5V** and **GND** to **ground** respectively

2.Connect BMP280 **SCL to Adruino A5**

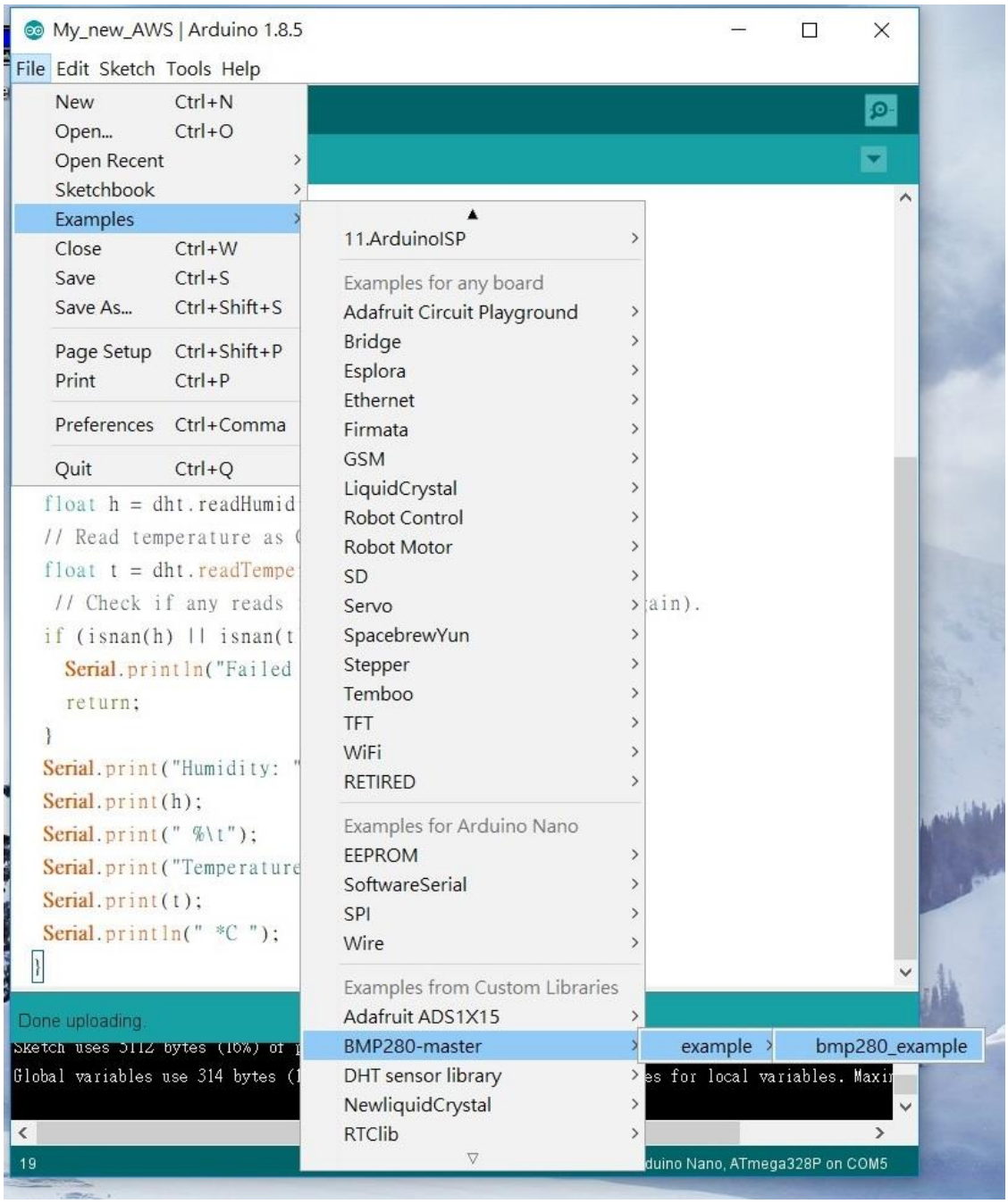
3.Connect BMP280 **SDA to Adruino A4**



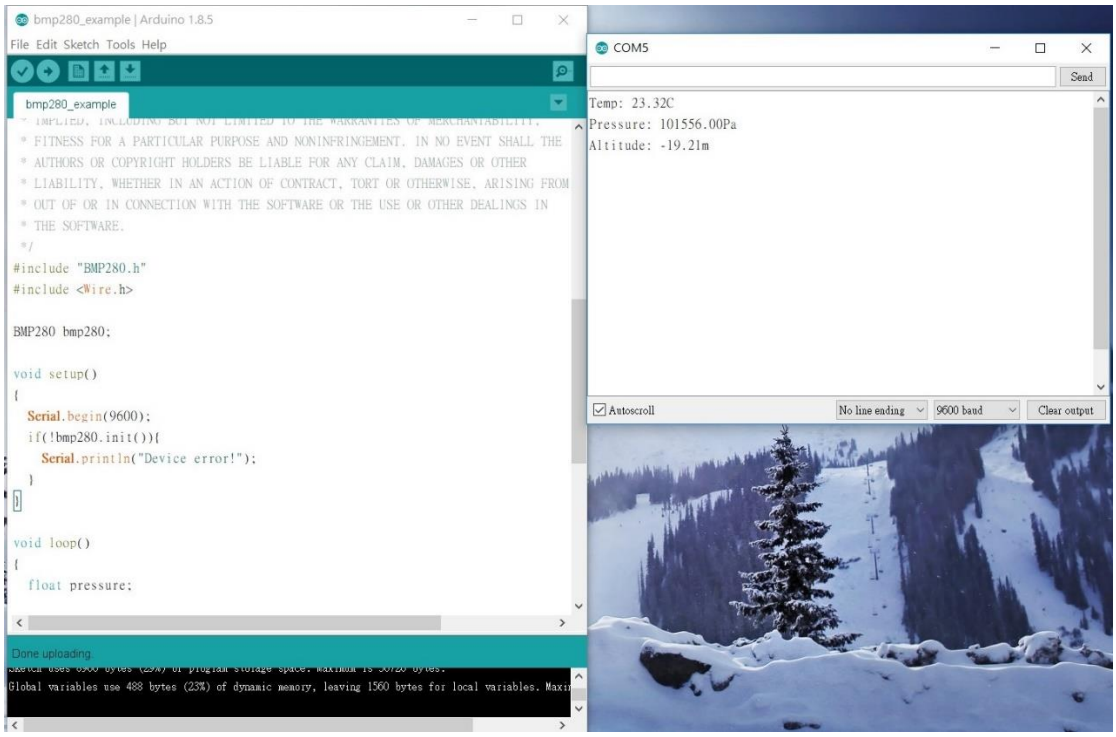


5.2 Choosing an Example file in BMP280 library

Choose the bmp280_example file from the BMP280-master library as shown below:

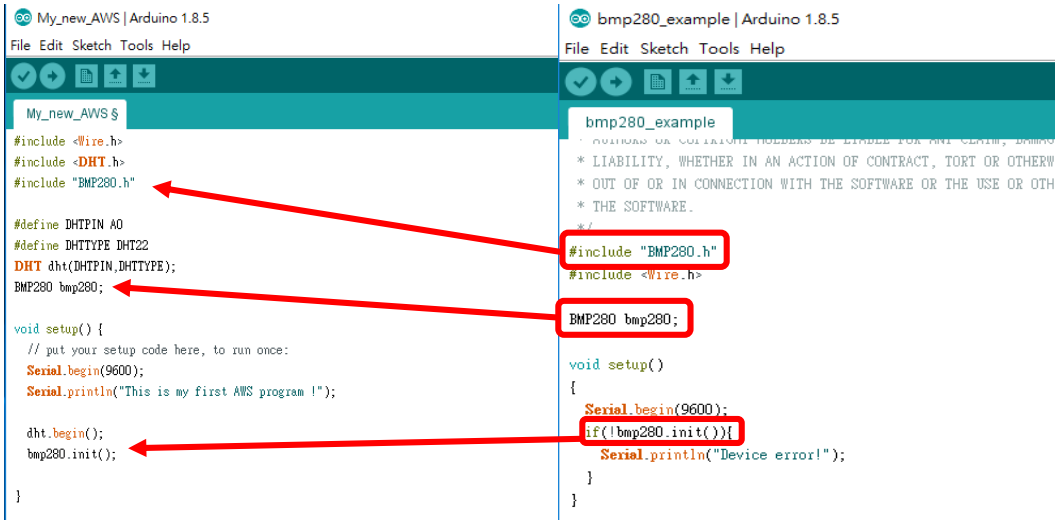


Compile and upload the program to Arduino Nano and see the results.



5.3 Modifying My_new_AWS file to include the BMP280 sensor program

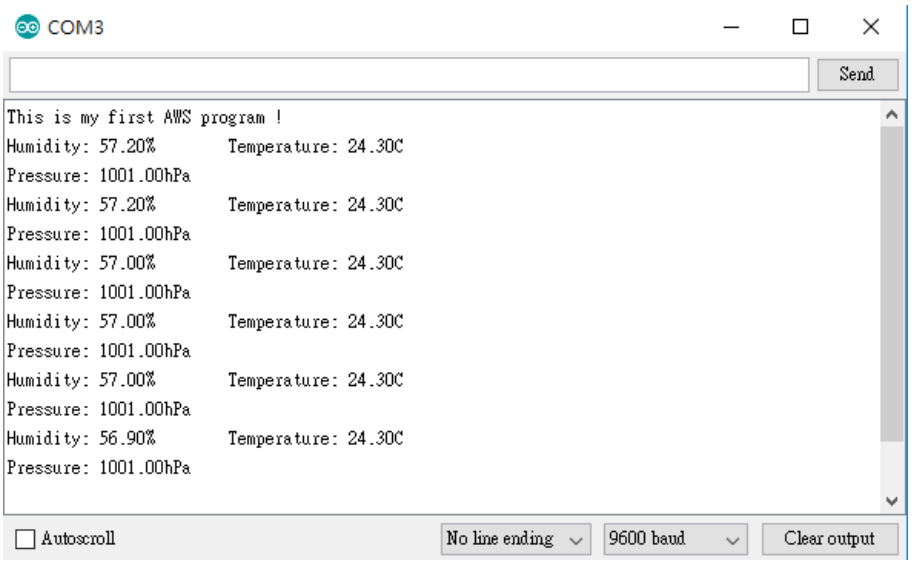
Open My_new_AWS file and copy the below lines from bmp280_example file to the file. In setup(), add bmp.init(); as shown.



```
void loop() {
  // put your main code here, to run repeatedly:

 //get and print humidity data
  float h = dht.readHumidity();
  Serial.print("Humidity: ");
  Serial.print(h);
  Serial.print("%\t");

 //get and print temperature data
  float t = dht.readTemperature();
  Serial.print("Temperature: ");
  Serial.print(t);
  Serial.println("C     ");

  //get and print atmospheric pressure data
  float p = bmp280.getPressure()/100;
  Serial.print("Pressure: ");
  Serial.print(p);
  Serial.println("hPa");
  delay(1000-millis()%1000 + 10);

}
```

```
void loop()
{
  float pressure;

  //get and print temperatures
  Serial.print("Temp: ");
  Serial.print(bmp280.getTemperature());
  Serial.println("C"); // The unit for  Celsius because original arduino don't support speical symbols

  //get and print atmospheric pressure data
  Serial.print("Pressure: ");
  Serial.print(pressure = bmp280.getPressure());
  Serial.println("Pa");

  //get and print altitude data
  Serial.print("Altitude: ");
  Serial.print(bmp280.calcAltitude(pressure));
  Serial.println("m");

  Serial.println("\n");//add a line between output of different times.
```

Compile and upload the program to see the results! Remember to save your My_new_AWS file again!



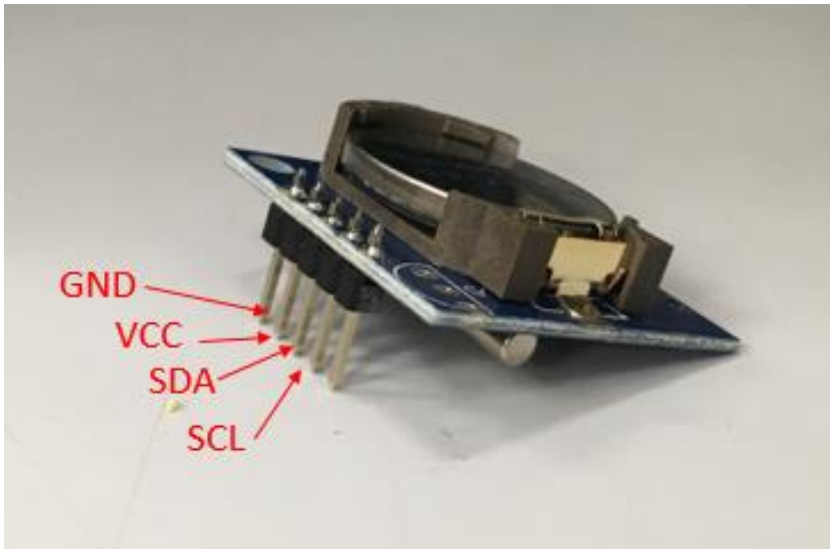
6. INSTALLING REAL-TIME CLOCK - RTC1307 MODULE

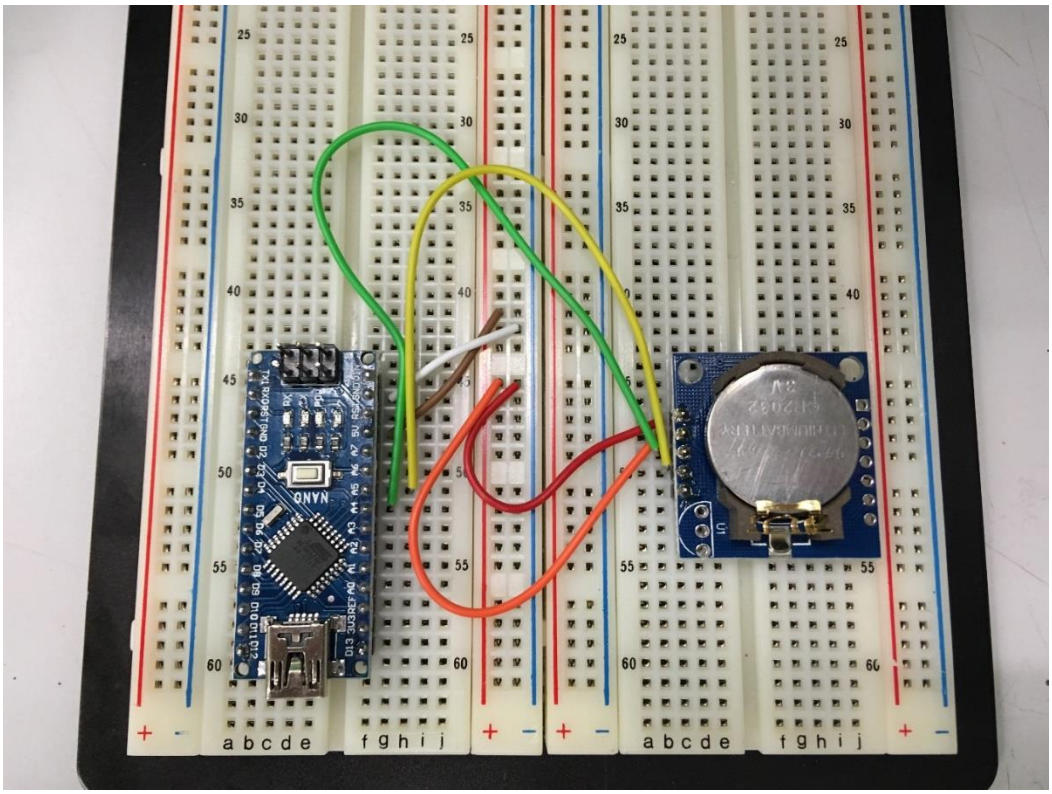
6.1 Wiring

1.Connect DS1307 **VCC** to **5V** and **GND** to **ground** respectively

2.Connect DS1307 **SCL to Adruino A5**

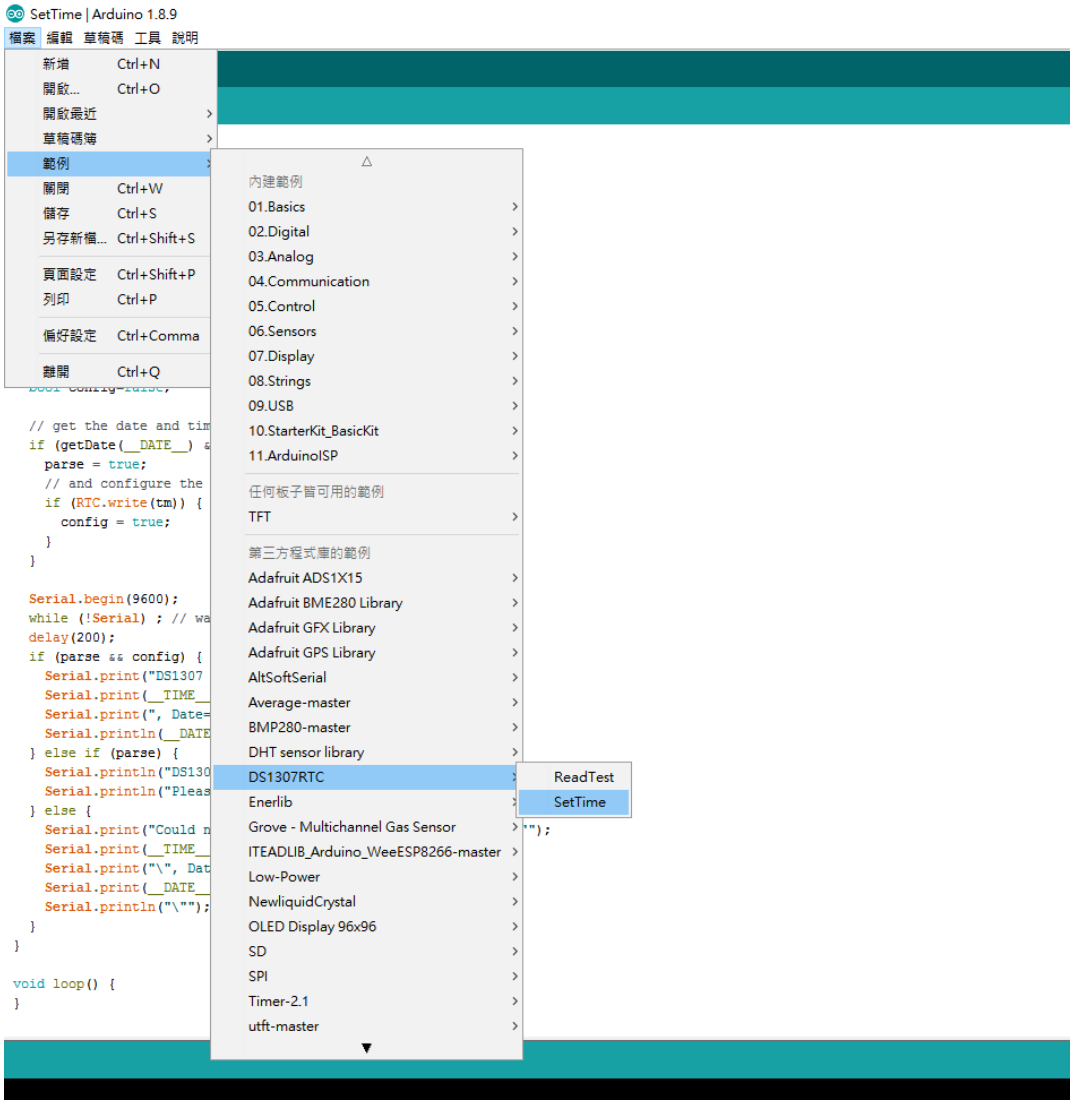
3.Connect DS1307 **SDA to Adruino A4**





6.2 Choosing an Example file in RTC library (Set Time)

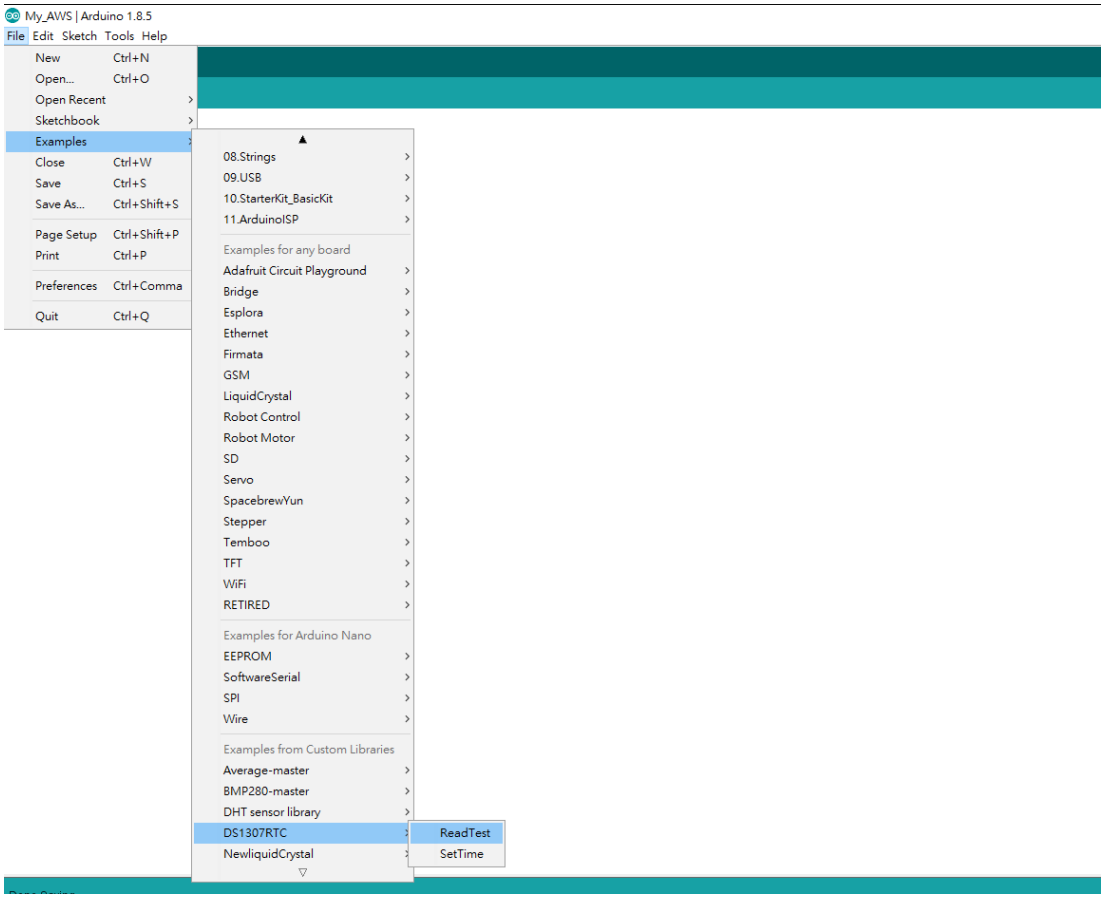
Since the clock may not be synchronizing with local time, we can run this script in synchronizing the time with computer. Choose the SetTime file from the DS1307RTC library as shown below.



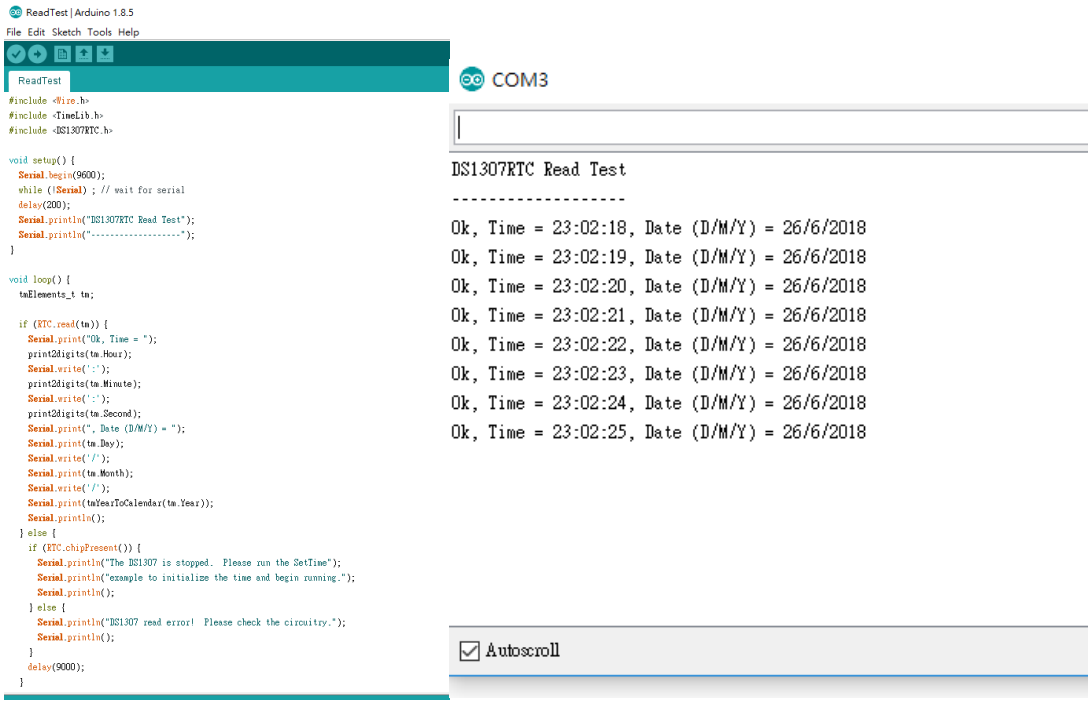
Compile and upload the program to Arduino Nano and see the results.

6.3 Choosing an Example file in RTC library (Read Time)

Choose the ReadTest file from the DS1307RTC library as shown below:



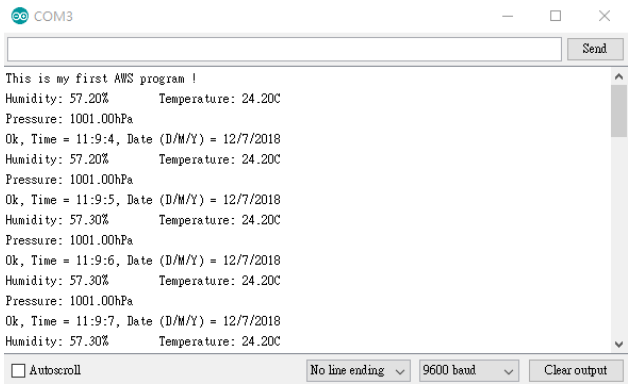
Compile and upload the program to Arduino Nano and see the results.



6.4 Modifying My_new_AWS file to include the RTC ReadTest program

Open My_new_AWS file and copy the below lines from ReadTest file to the file, minor modification from print2digits to Serial.print would be needed for simplifying the code.

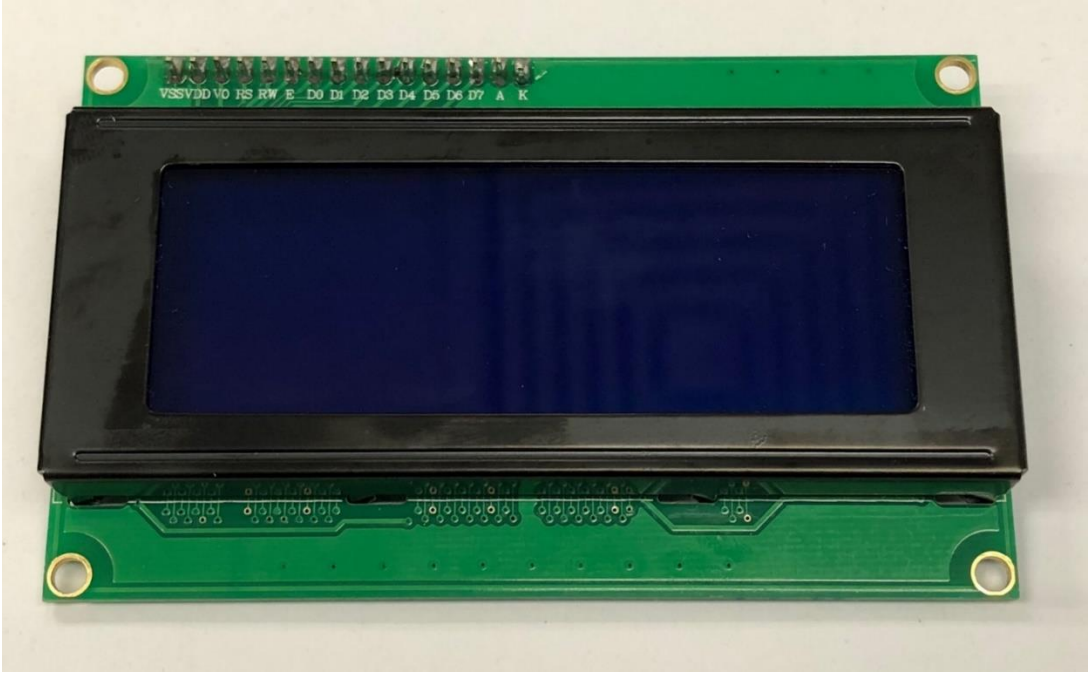
Compile and upload the program to see the results! Remember to save your My_new_AWS file again!



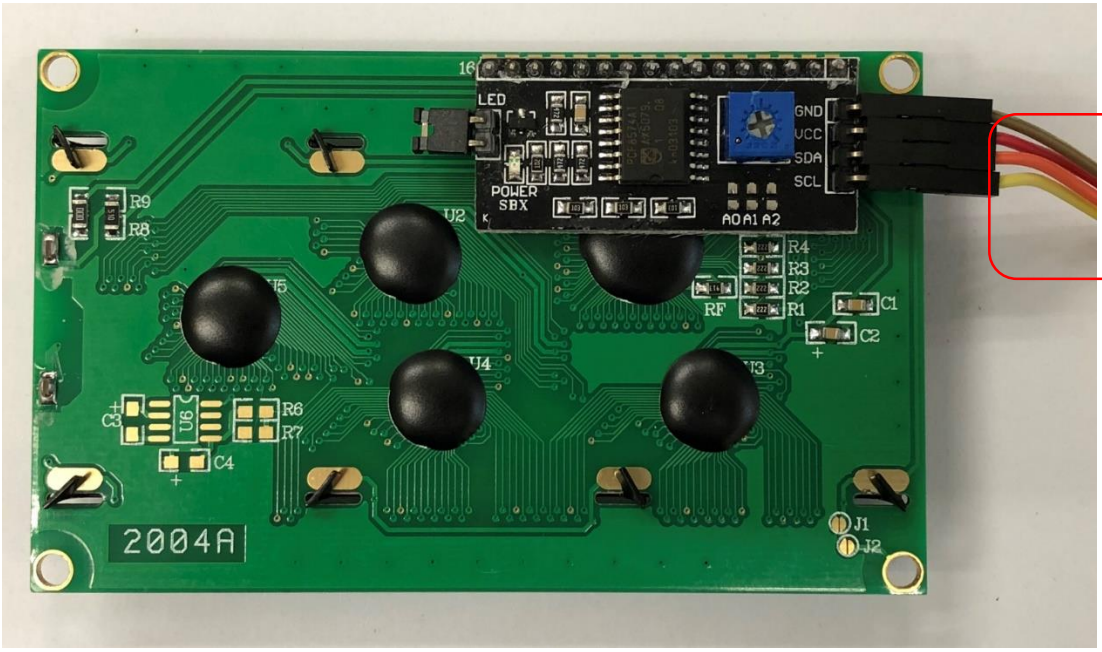
7. INSTALLING LCD DISPLAY

- LCD I2C 2004A DISPLAY

Front view

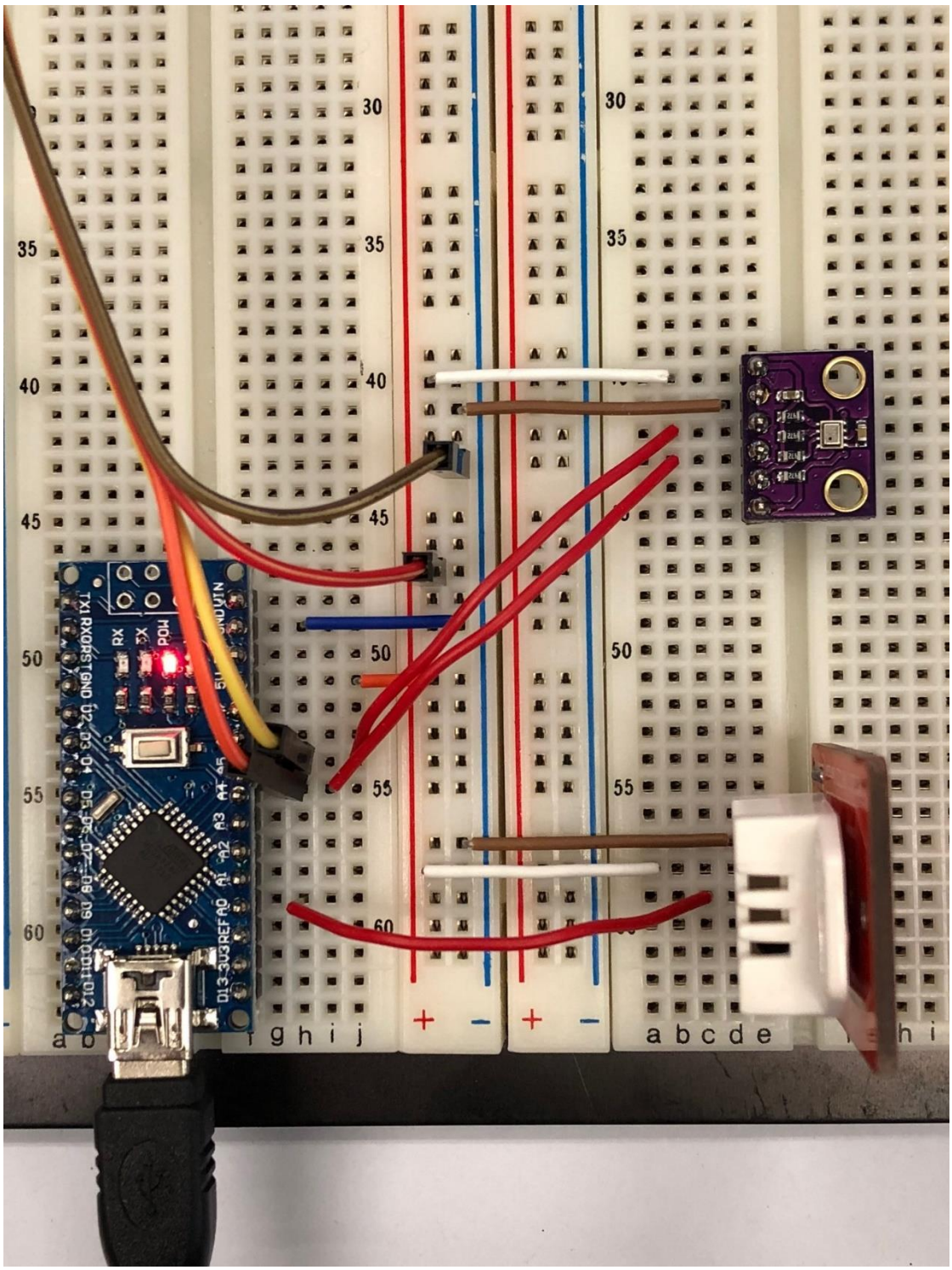


Rear view



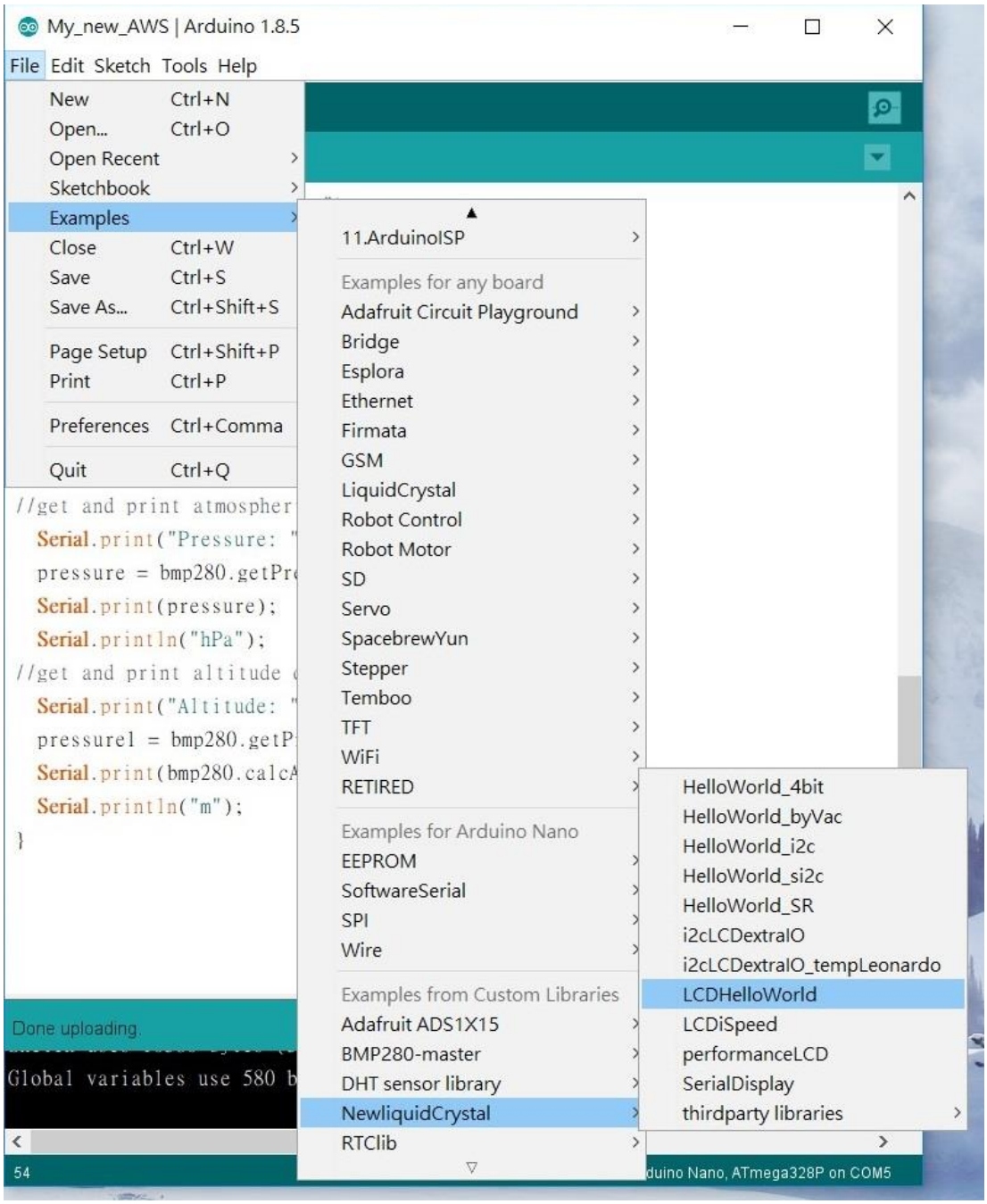
7.1 Wiring

1. Connect LCD **VCC** to **5V** and **GND** to **ground** respectively
2. Connect LCD **SCL to Adruino A5**
3. Connect LCD **SDA to Adruino A4**

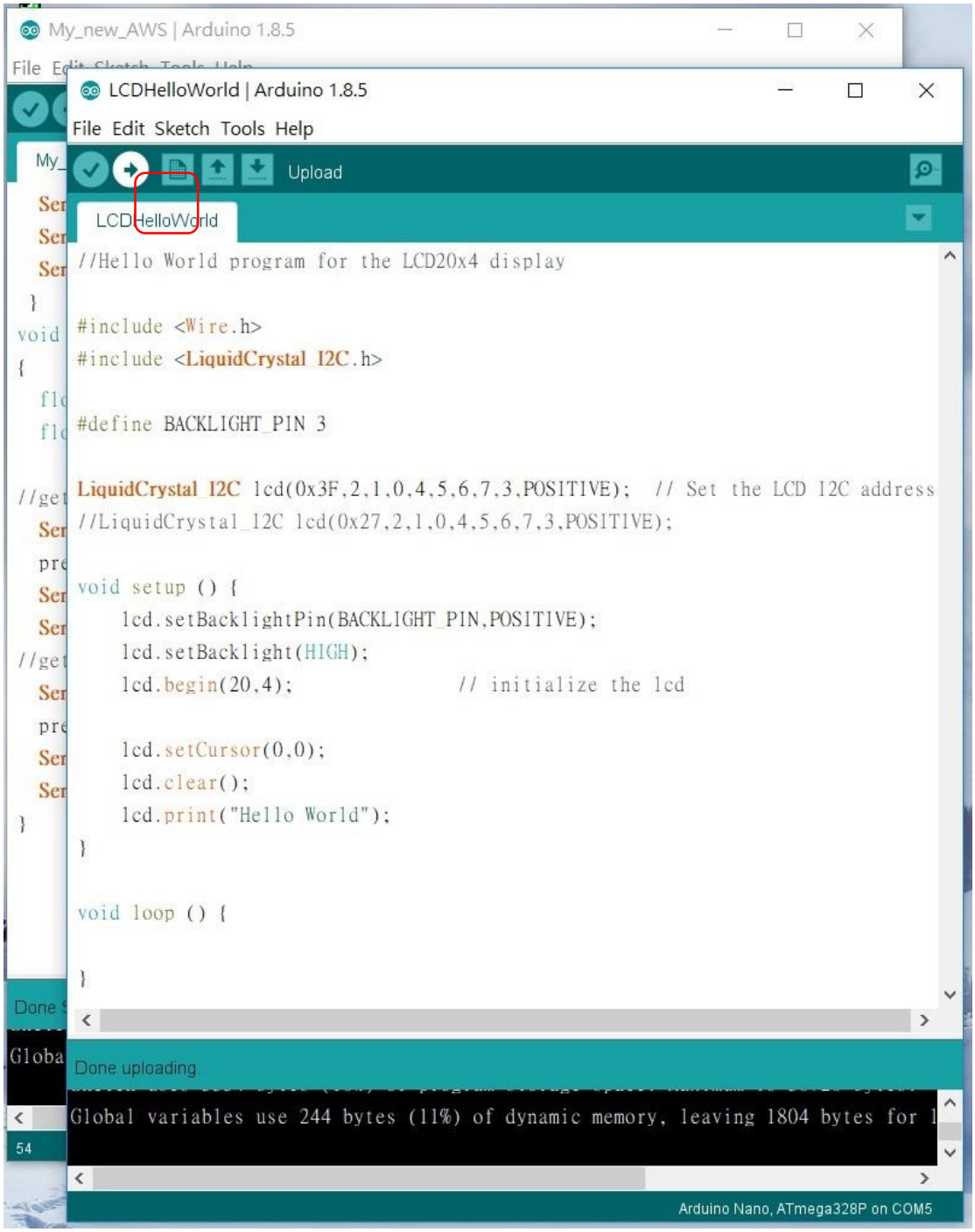


7.2 Choosing an Example file in the NewliquidCrystal library

Choose the LCDHellowWorld example file from the NewliquidCrystal library as shown.

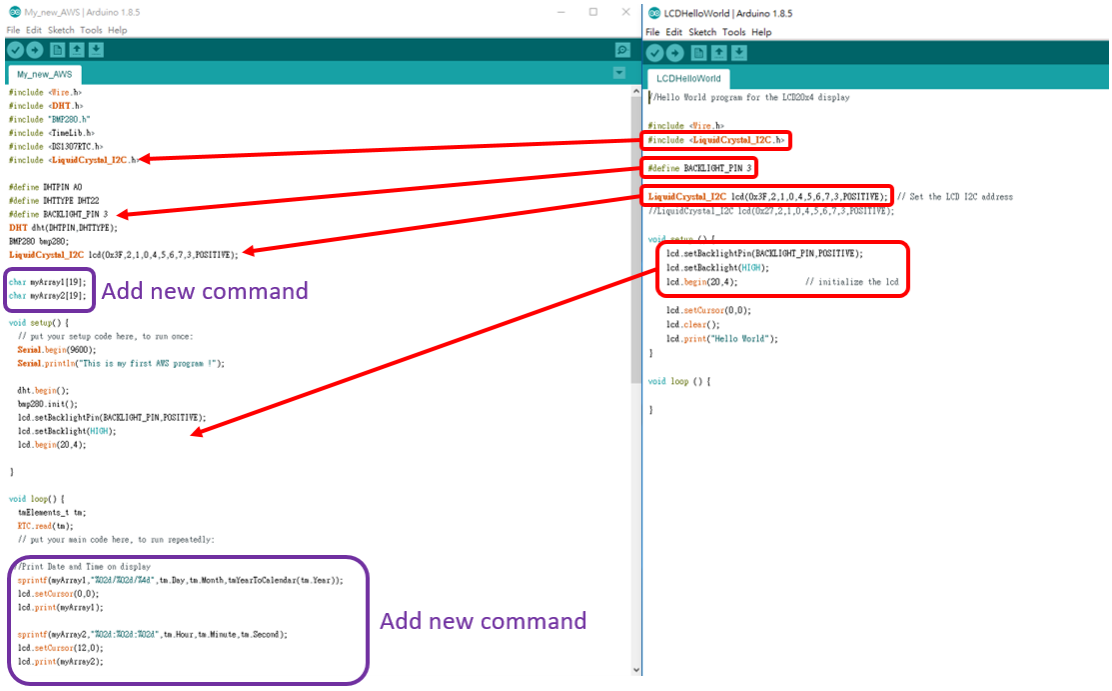


Compile and upload the LCDHelloWorld program to Arduino Nano and see the output shown on the LCD display.



7.3 Modifying the My_new_AWS file to display information on the LCD display

Copy the highlighted lines in the header and setup() sections from LCDHellowWorld to the My_new_AWS. Add 2 new commands into the script in having the time format as XX:YY:ZZZZ HH:MM:SS, since if we print the date out directly, when having a single digit time (i.e. 10:09:04, the display will show 10:9:4 instead of 10:09:04), therefore we need to add a command in keeping the format.



My_new_AWS | Arduino 1.8.5

File Edit Sketch Tools Help

My_new_AWS §

```
  tmElements_t tm;
  RTC.read(tm);
  // put your main code here, to run repeatedly:

 //Print Date and Time on display
  sprintf(myArray1,"%02d/%02d/%4d",tm.Day,tm.Month,tmYearToCalendar(tm.Year));
  lcd.setCursor(0,0);
  lcd.print(myArray1);

  sprintf(myArray2,"%02d:%02d:%02d",tm.Hour,tm.Minute,tm.Second);
  lcd.setCursor(12,0);
  lcd.print(myArray2);

//Abbreviation setup
  lcd.setCursor(0,1);
  lcd.print("Temp: ");
  lcd.setCursor(0,2);
  lcd.print("RH: ");
  lcd.setCursor(0,3);
  lcd.print("Pres: ");
```

// Integrate the abbreviation setting on display

```
//Print Temperature information on display
  float t = dht.readTemperature();
  lcd.setCursor(6,1);
  lcd.print(t,1);
  lcd.setCursor(18,1);
  lcd.print("C");
```

// Showing temperature info. on display

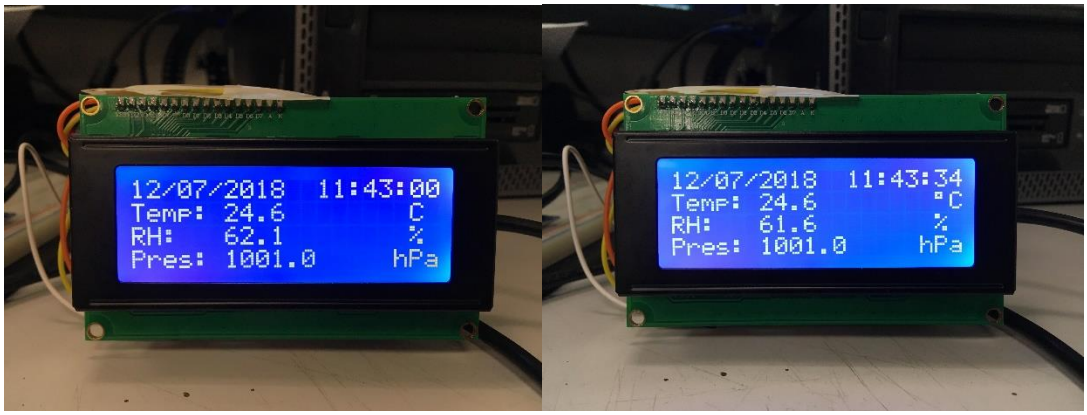
```
//Print Humidity information on display
  float h = dht.readHumidity();
  lcd.setCursor(6,2);
  lcd.print(h,1);
  lcd.setCursor(18,2);
  lcd.print("%");
```

// Showing humidity info. on display

```
//Print Pressure information on display
  float p = bmp280.getPressure()/100;
  lcd.setCursor(6,3);
  lcd.print(p,1);
  lcd.setCursor(17,3);
  lcd.print("hPa");
  delay(1000-millis()%1000 + 10);
}
```

// Showing pressure info. on display

If you want to output the degree symbol ºC, try to change the command lcd.print(“C”); to lcd.print(“\337C”) in temperature module command;



8. SENSORS COMPARISON

Since sensors may have their initial errors in measurement, calibration and testing are required. A script was developed to compare the DHT22 sensors in a parallel circuit.

```
// Example testing sketch for various DHT humidity/temperature sensors
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include "DHT.h"

#define DHTPIN1 A0         // what digital pin we're connected to
#define DHTPIN2 A1
#define DHTPIN3 A2
#define BACKLIGHT_PIN 3

#define DHTTYPE1 DHT22      // DHT 22    (AM2302), AM2321
#define DHTTYPE2 DHT22
#define DHTTYPE3 DHT22

DHT dht1(DHTPIN1, DHTTYPE1);
DHT dht2(DHTPIN2, DHTTYPE2);
DHT dht3(DHTPIN3, DHTTYPE3);
LiquidCrystal_I2C lcd(0x3F,2,1,0,4,5,6,7,3,POSITIVE);

void setup() {
   Serial.begin(9600);
   Serial.println("DHT22 test!");
   lcd.setBacklightPin(BACKLIGHT_PIN,POSITIVE);
   lcd.setBacklight(HIGH);
   lcd.begin(20,4);                        // initialize the lcd

   dht2.begin();
   dht3.begin();
}
```

```
void loop() {
  // Wait a few seconds between measurements.
  delay(2000);

  // Reading temperature or humidity takes about 250 milliseconds!
  // Sensor readings may also be up to 2 seconds 'old' (its a very slow sensor)
  float h1 = dht1.readHumidity();
  float h2 = dht2.readHumidity();
  float h3 = dht3.readHumidity();
  // Read temperature as Celsius (the default)
  float t1 = dht1.readTemperature();
  float t2 = dht2.readTemperature();
  float t3 = dht3.readTemperature();

  lcd.setCursor(0,0);
  lcd.print("T1:");
  lcd.setCursor(0,1);
  lcd.print("T2:");
  lcd.setCursor(0,2);
  lcd.print("T3:");
  lcd.setCursor(4,0);
  lcd.print(t1);
  lcd.setCursor(4,1);
  lcd.print(t2);
  lcd.setCursor(4,2);
  lcd.print(t3);
  lcd.setCursor(0,0);
  lcd.print("T1:");
  lcd.setCursor(0,2);
  lcd.print("T2:");
  lcd.setCursor(0,2);
  lcd.print("T3:");
  lcd.setCursor(4,0);
  lcd.print(t2);
  lcd.setCursor(4,1);
  lcd.print(t2);
  lcd.setCursor(4,2);
  lcd.print(t3);
```

```
    lcd.setCursor(10,0);
    lcd.print("RH1:");
    lcd.setCursor(10,1);
    lcd.print("RH2:");
    lcd.setCursor(10,2);
    lcd.print("RH3:");
    lcd.setCursor(15,0);
    lcd.print(h1);
    lcd.setCursor(15,1);
    lcd.print(h2);
    lcd.setCursor(15,2);
    lcd.print(h3);

    lcd.setCursor(10,0);
    lcd.print("RH1:");
    lcd.setCursor(10,2);
    lcd.print("RH2:");
    lcd.setCursor(10,2);
    lcd.print("RH3:");
    lcd.setCursor(15,0);
    lcd.print(h2);
    lcd.setCursor(15,1);
    lcd.print(h2);
    lcd.setCursor(15,2);
    lcd.print(h3);
}
```