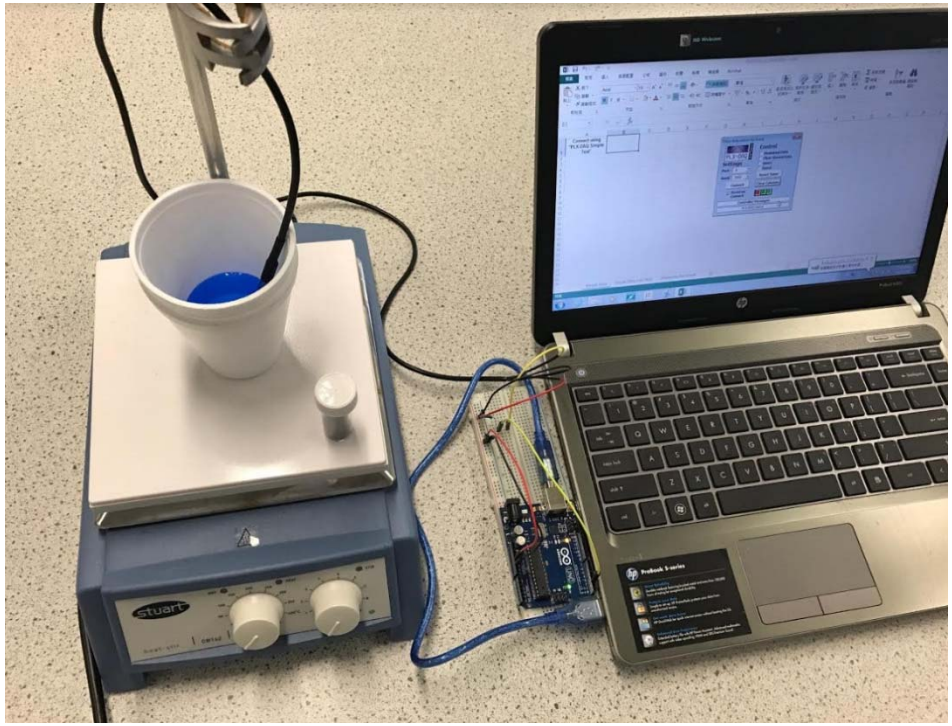
Hands on Experiment : Determining the enthalpy change of a reaction with the use of Arduino system

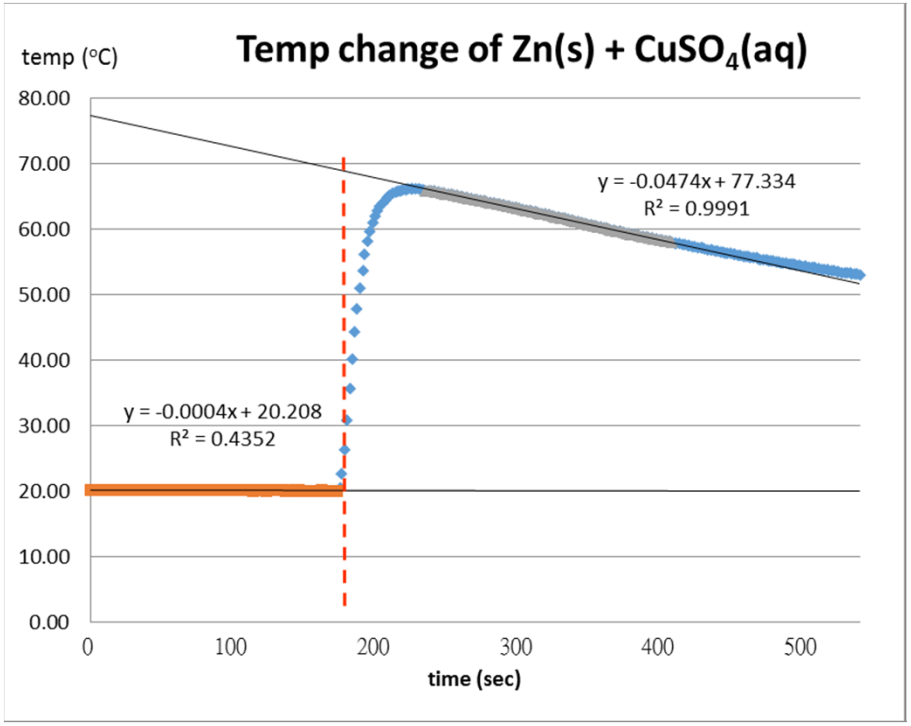
Setup for the Experiment

Determining the enthalpy change of metal displacement reaction

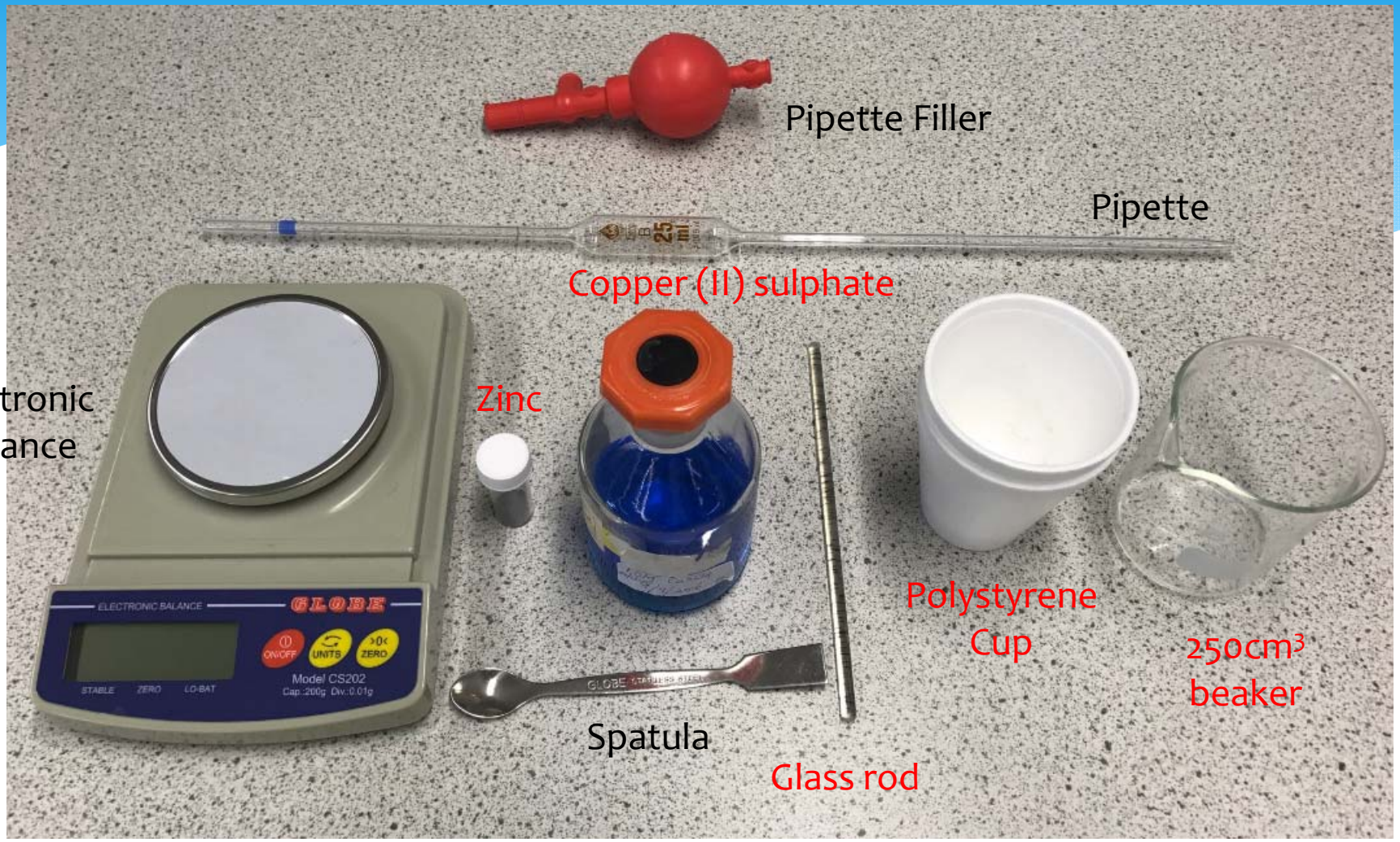
$$Zn(s) + CuSO_4(aq) \longrightarrow Cu(s) + ZnSO_4(aq)$$

Using Arduino system with temperature sensor to record the temperature change during the reaction





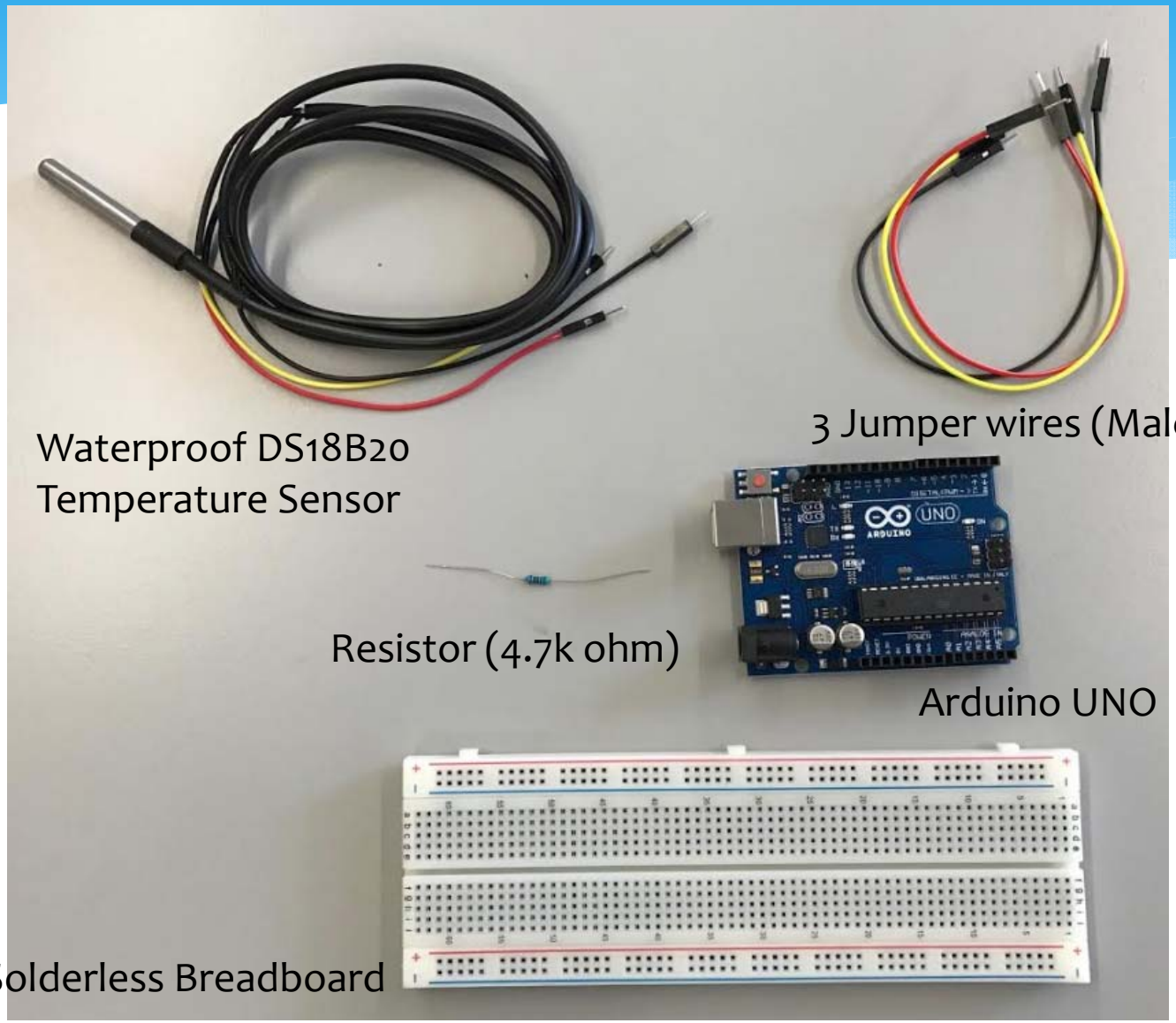
Equipment required for Experiment



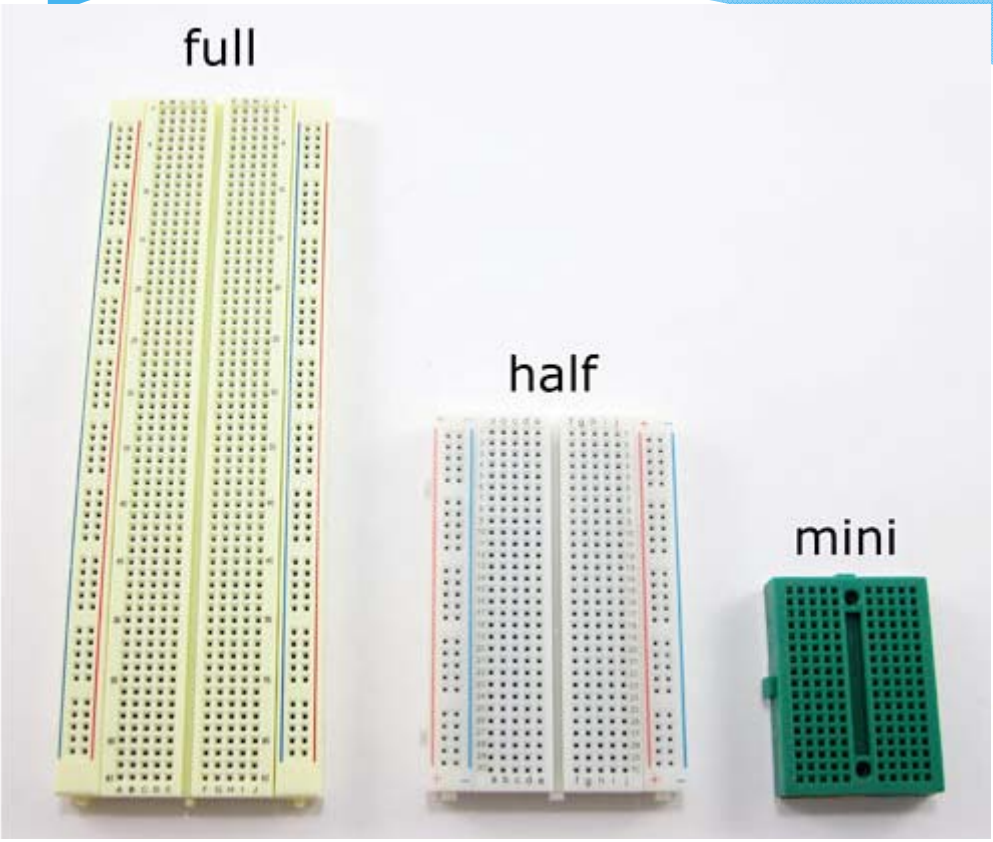
Zinc powder 

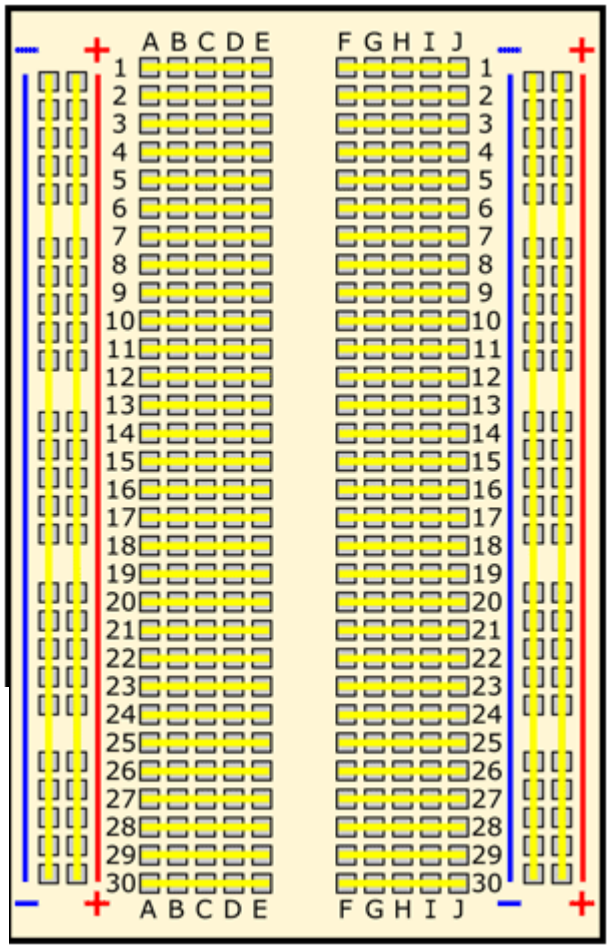
Copper (II) sulphate 

Equipment required for Arduino system

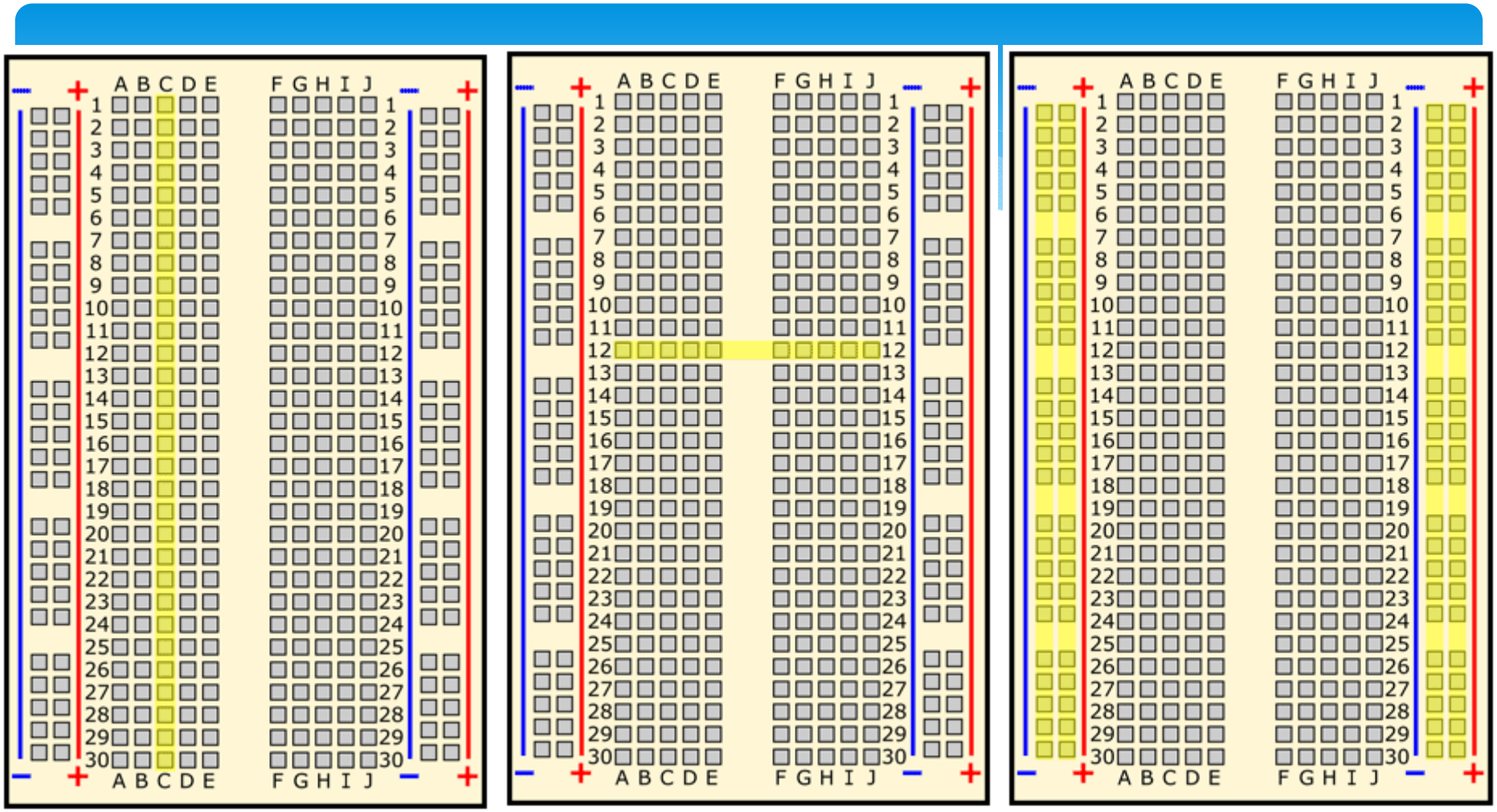


Basic : Solderless breadboard(麵包板)





http://www.sciencebuddies.org/science-fair-projects/how-to-use-a-breadboard.shtml

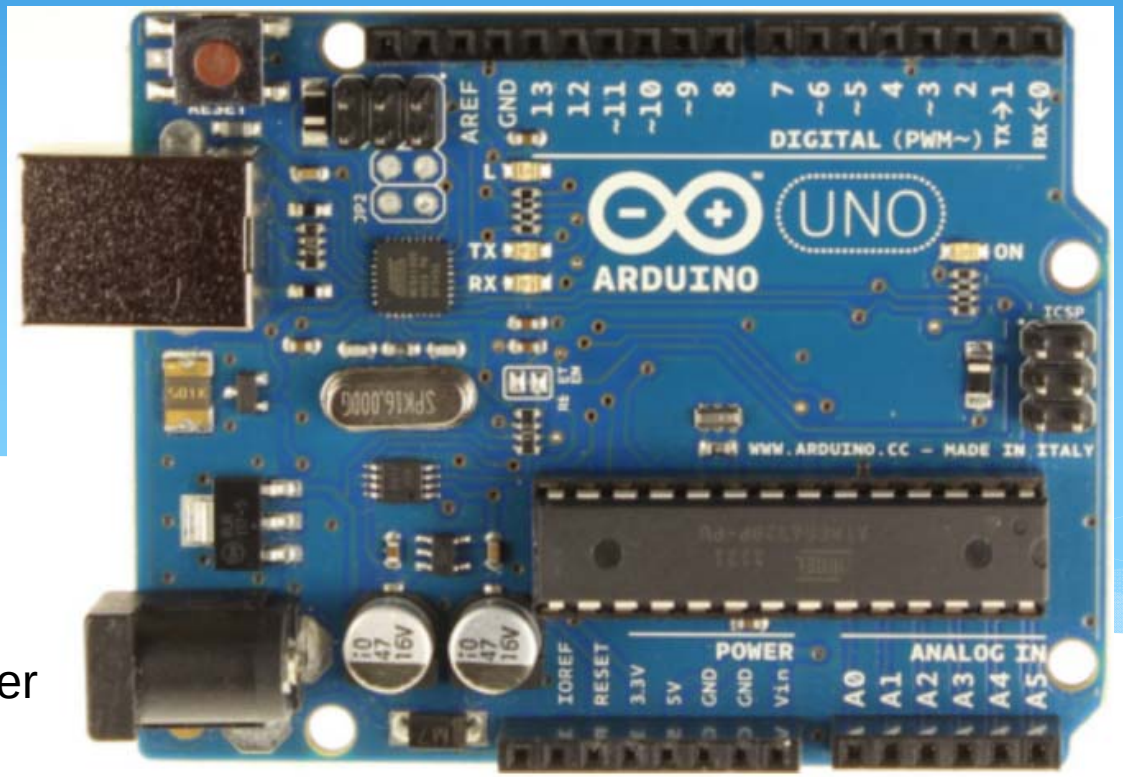


Positive	Negative
Power	Ground
Plus sign (+)	Minus sign (-)
Red	Blue or black

Basic : Arduino UNO board

Digital Input / Output

USB

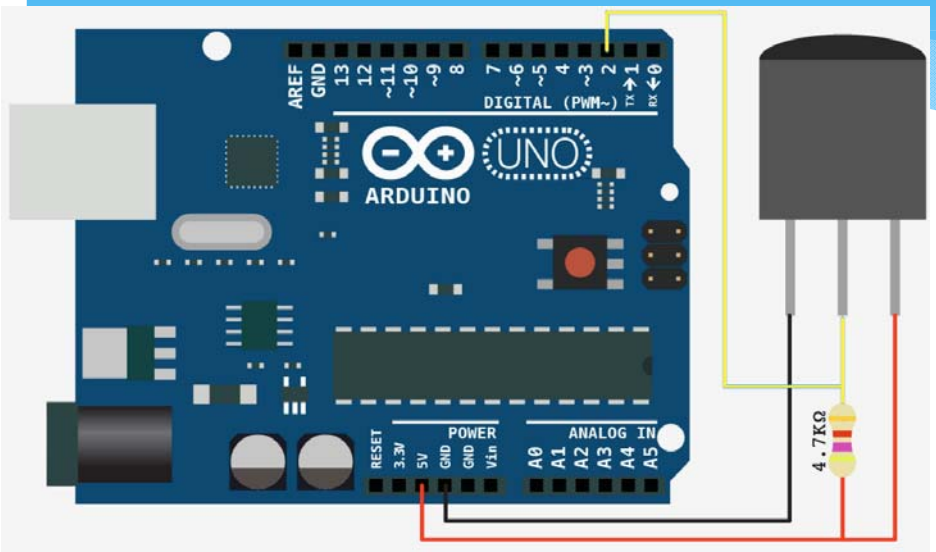


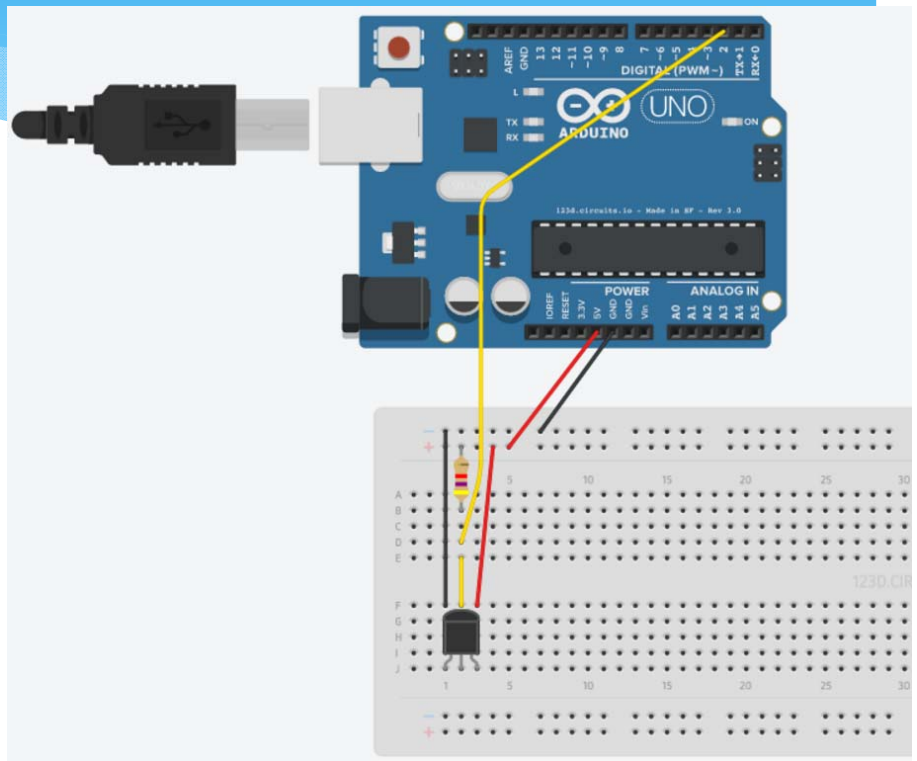
9V Power

Power

Analog Input /Output

Operation of the Arduino system
1. Wiring of temperature sensor in Arduino system

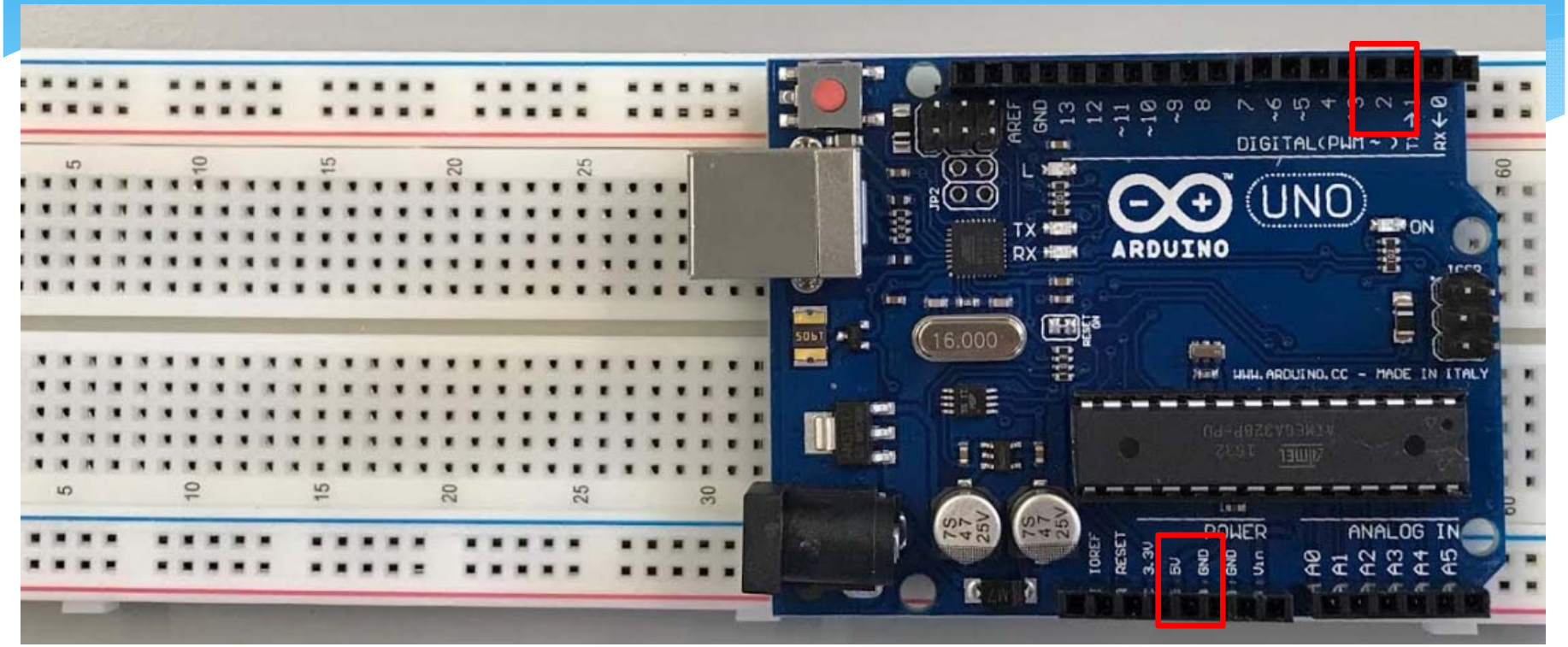




https://create.arduino.cc/projecthub/TheGadgetBoy/ds18b20-digital-temperature-sensor-and-arduino-9cc806

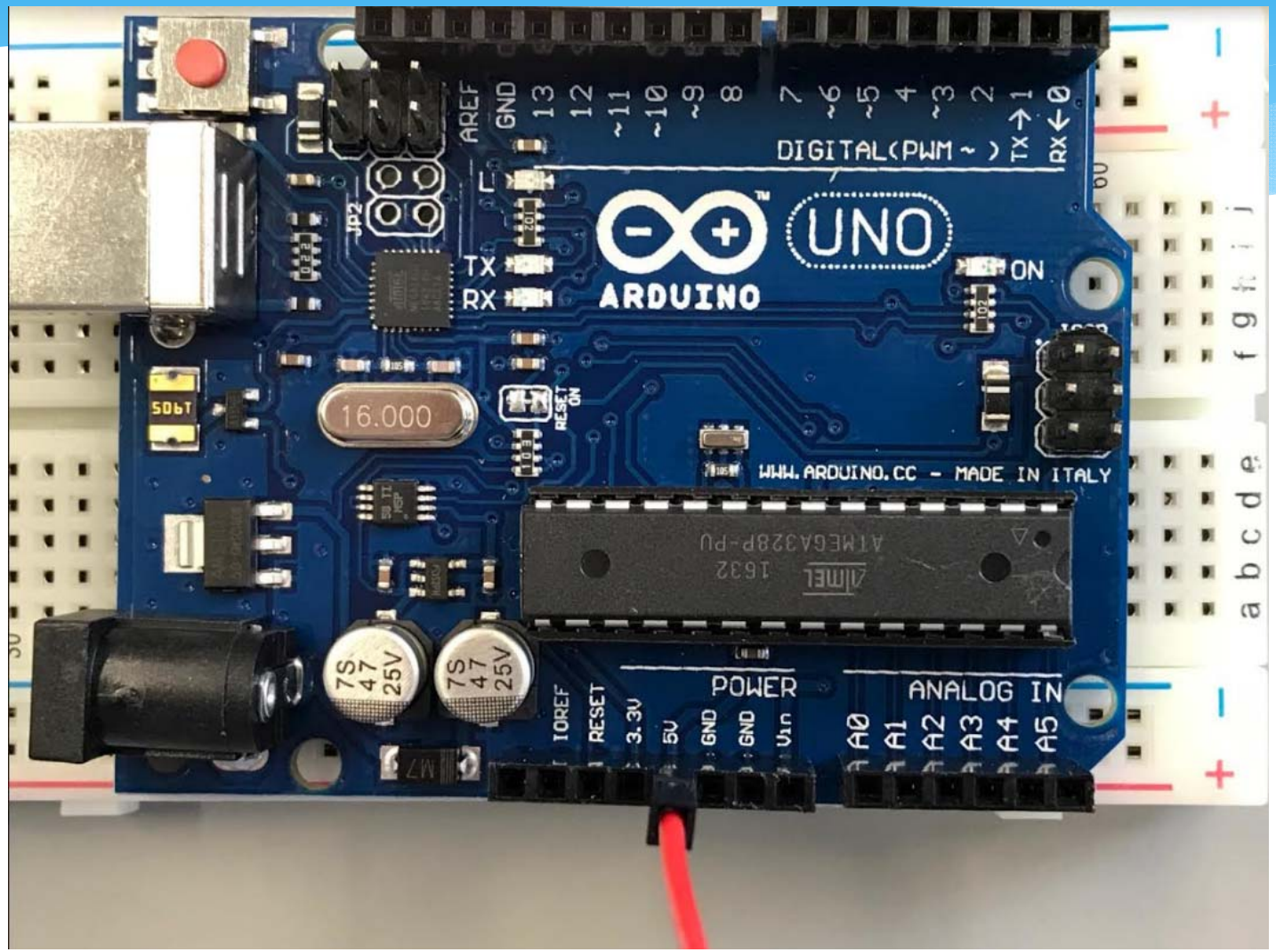
Identify the pins

Signal : 2

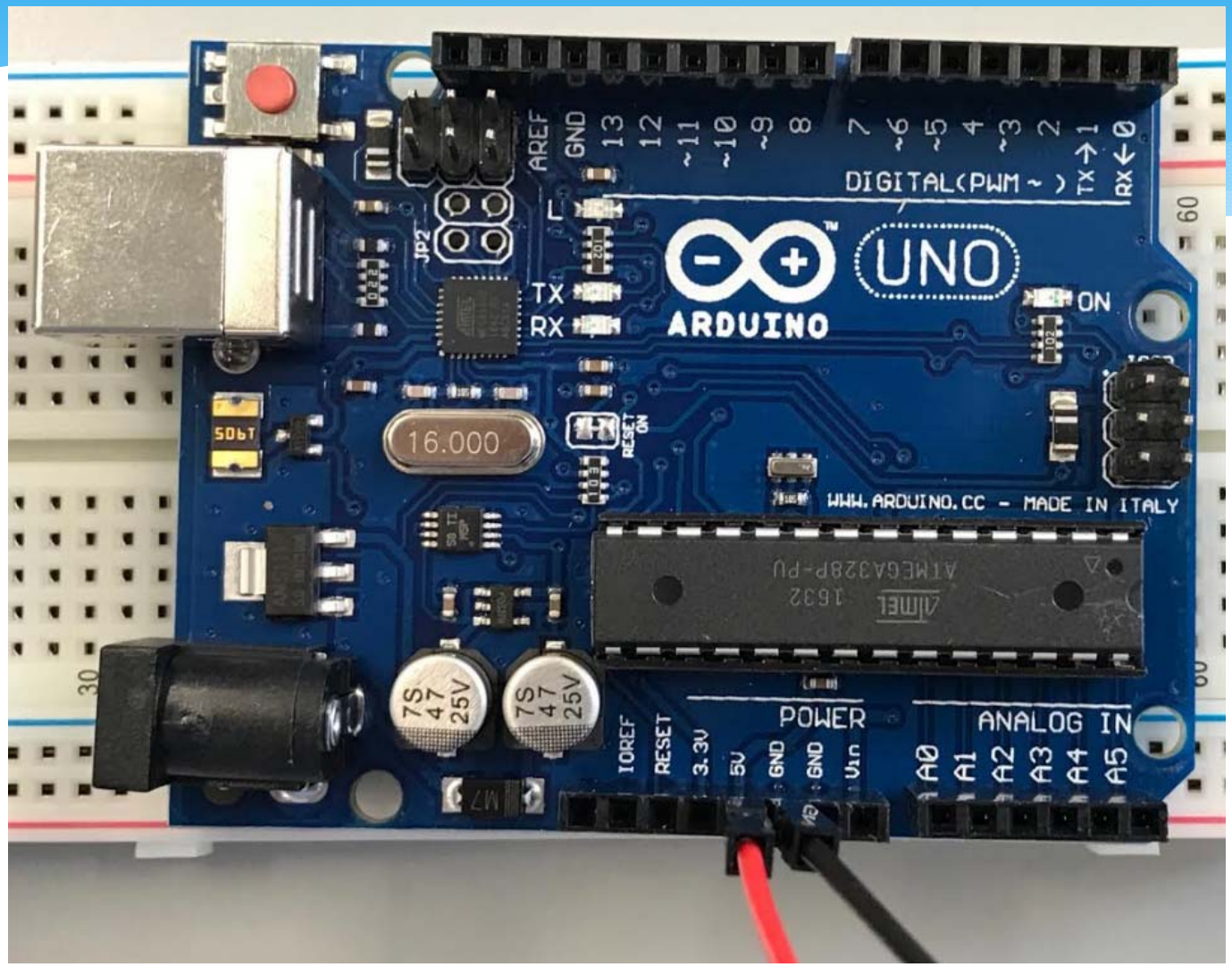


Power : 5V (+)
GND (-)

Connect red jumper wire to 5V

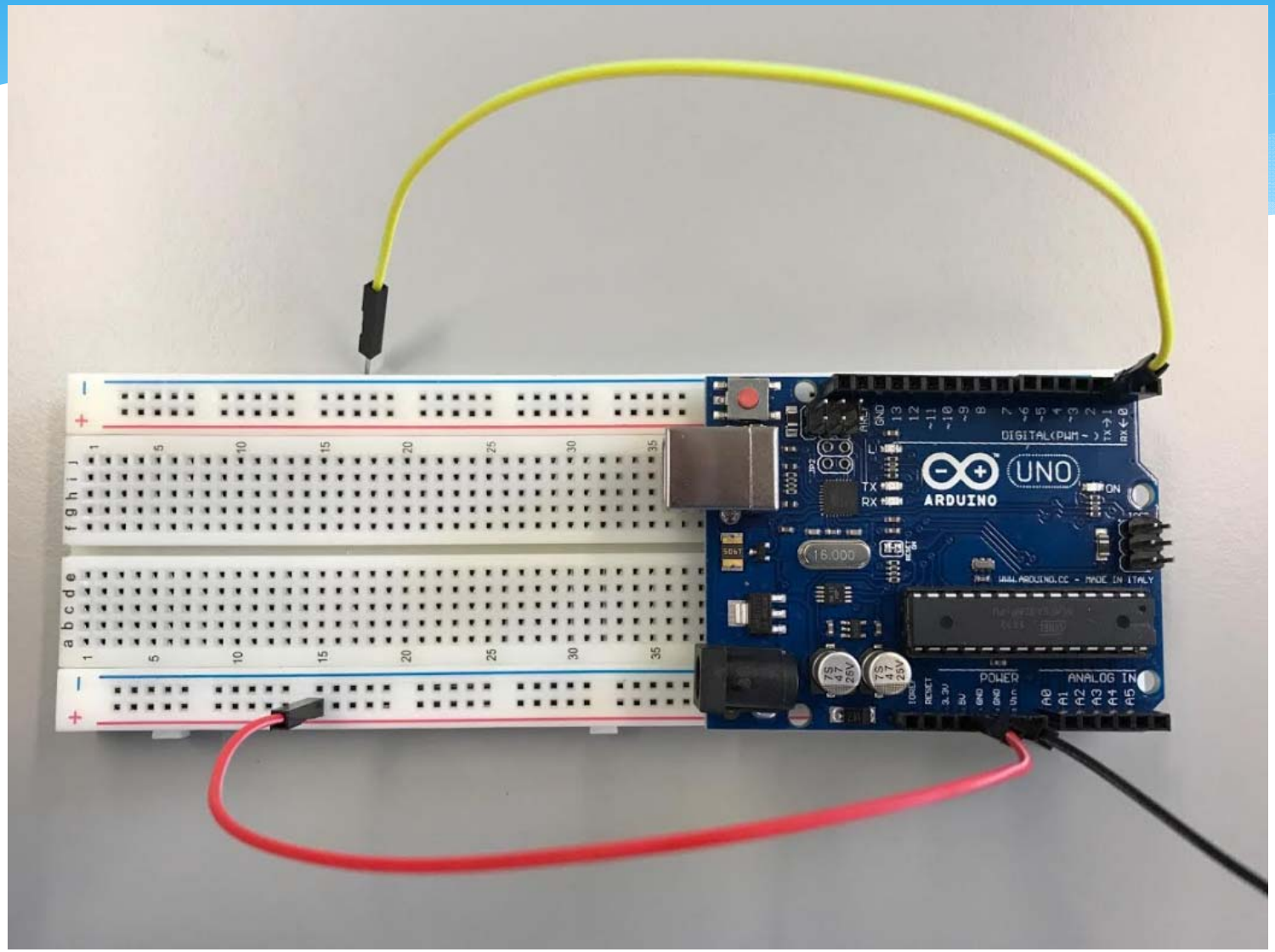


Connect black jumper wire to GND

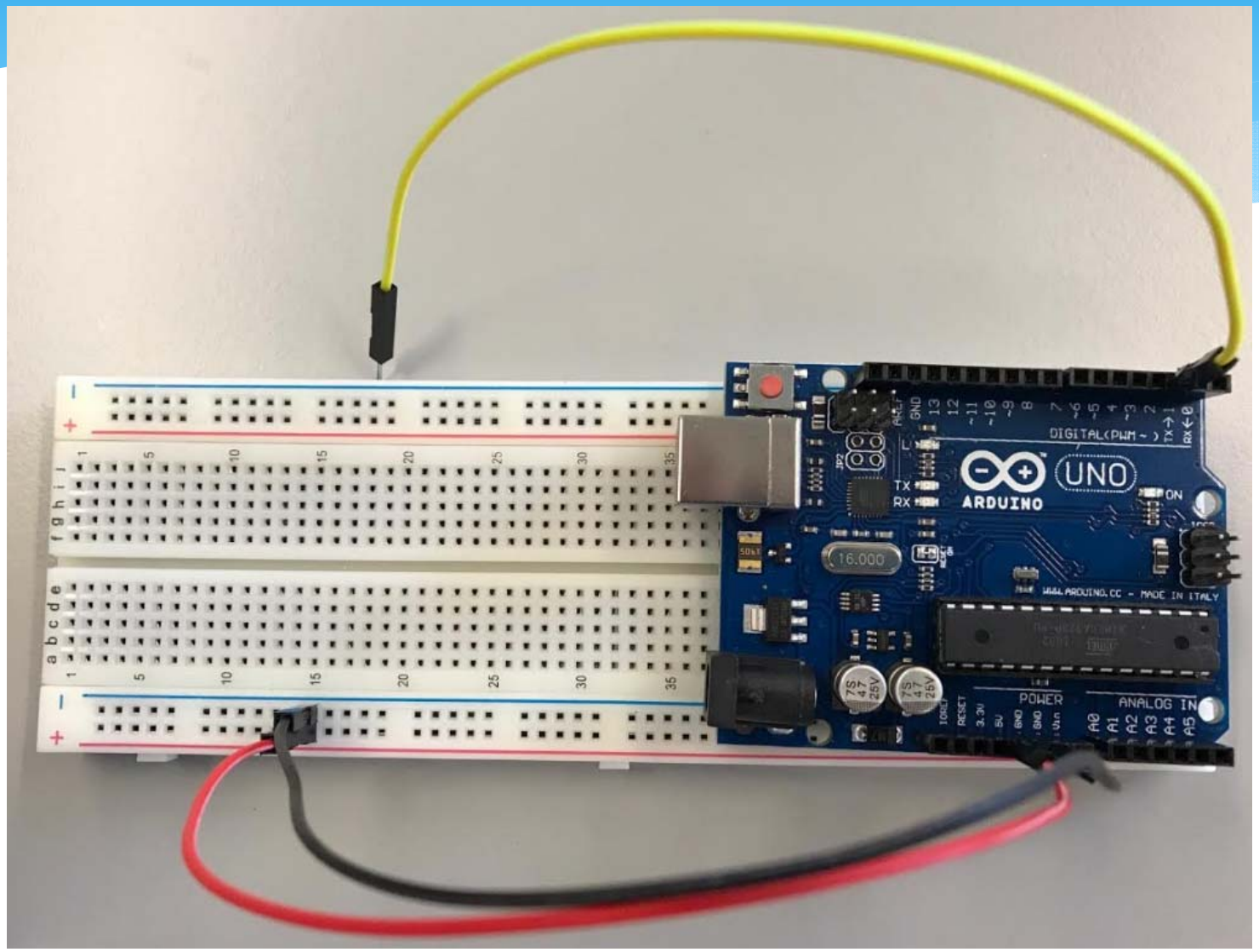


Connect Yellow jumper wire to 2

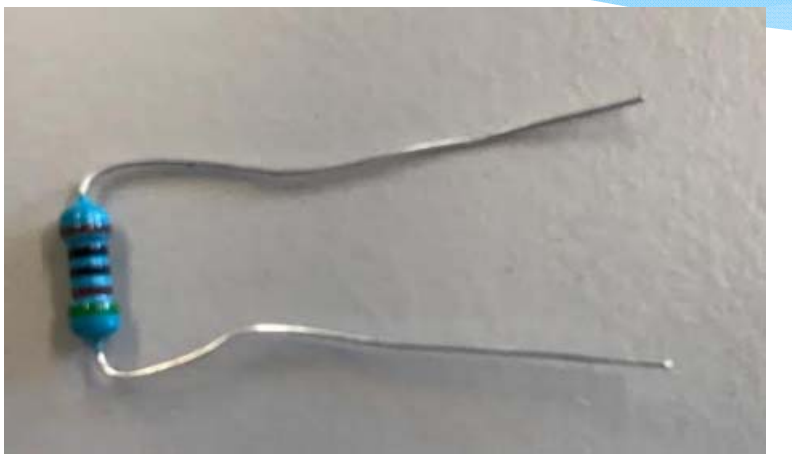
Connect another end of red jumper wire to breadboard +



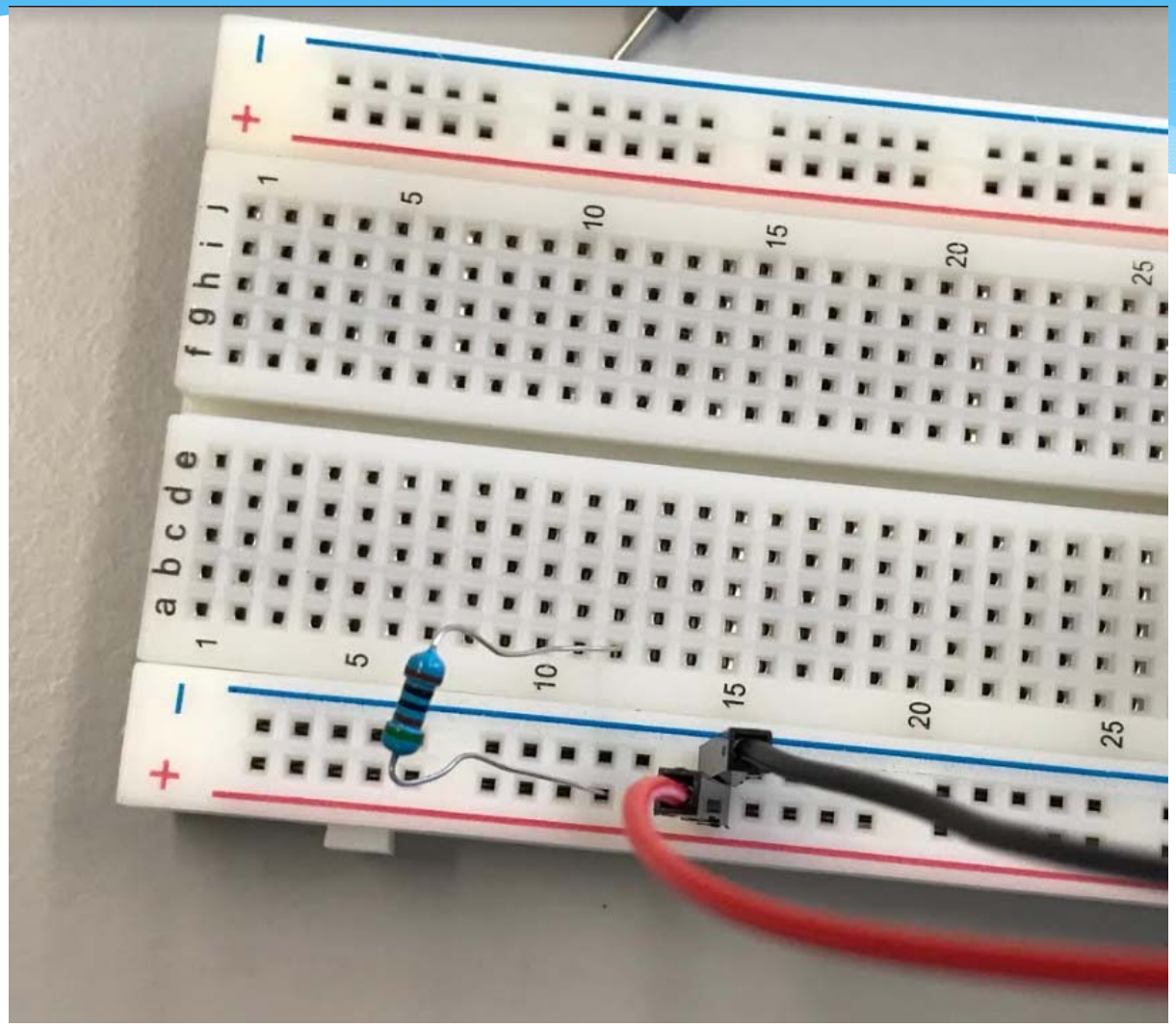
Connect another end of black jumper wire to breadboard -



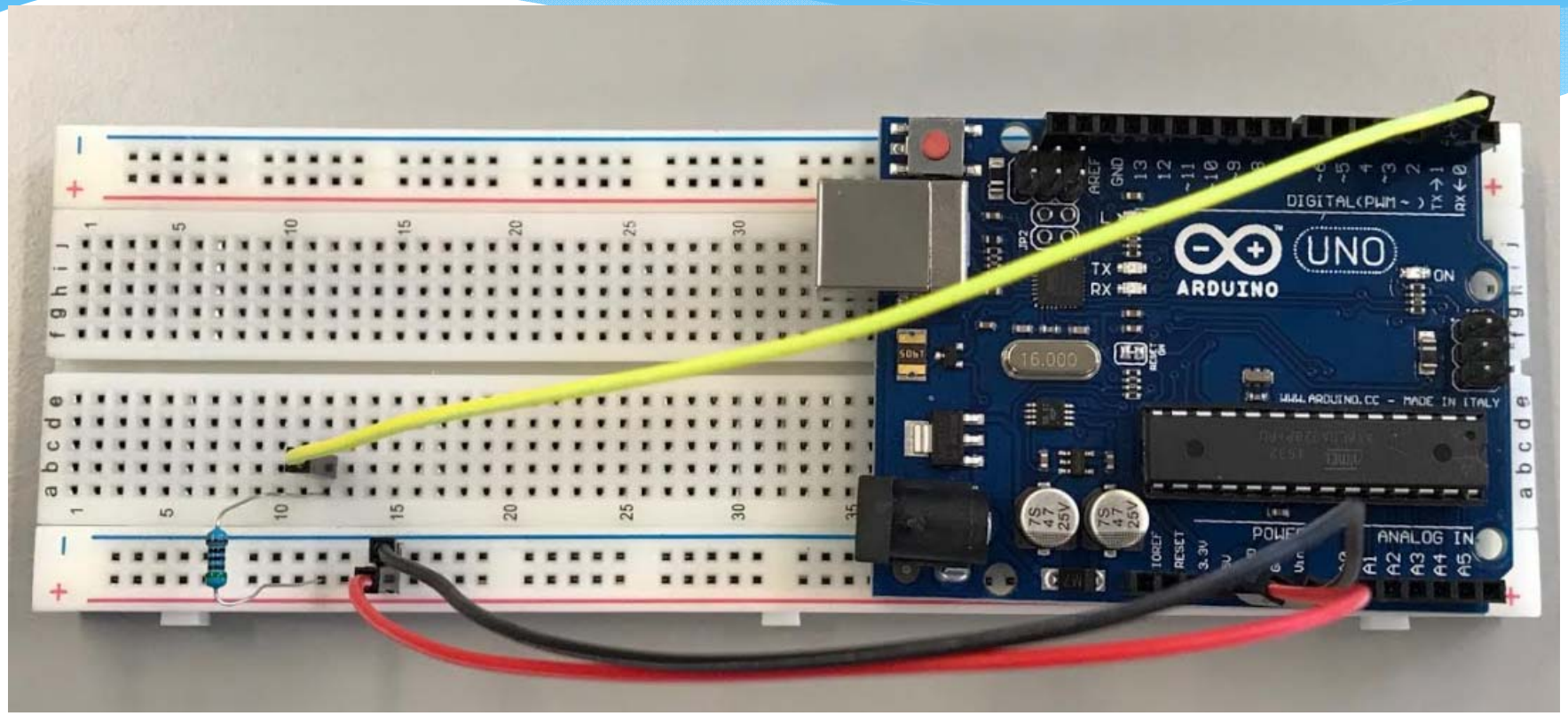
Bend the 4.7k ohm resistor to “C” shape



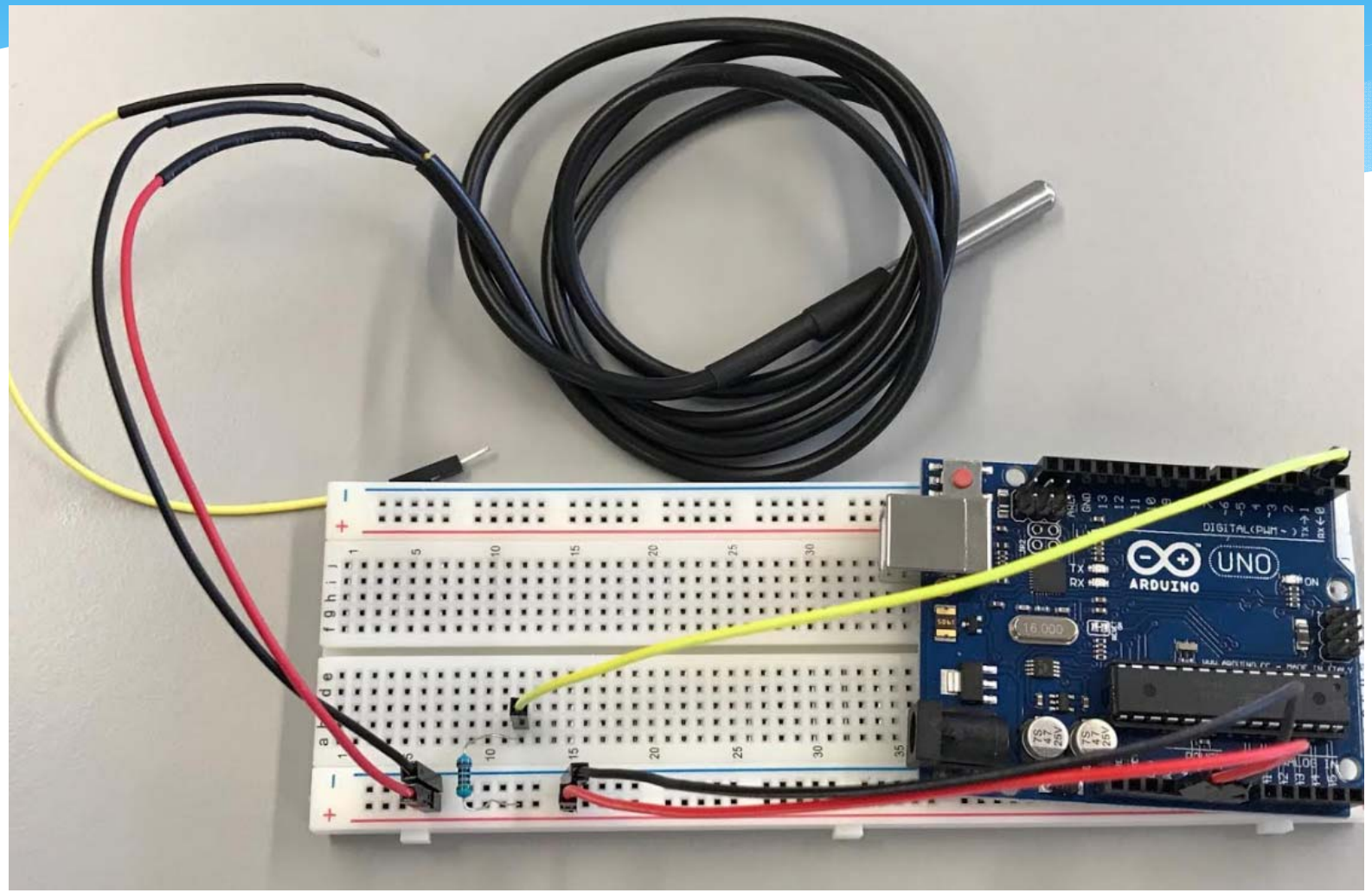
Connect the bended resistor to breadboard + and A12



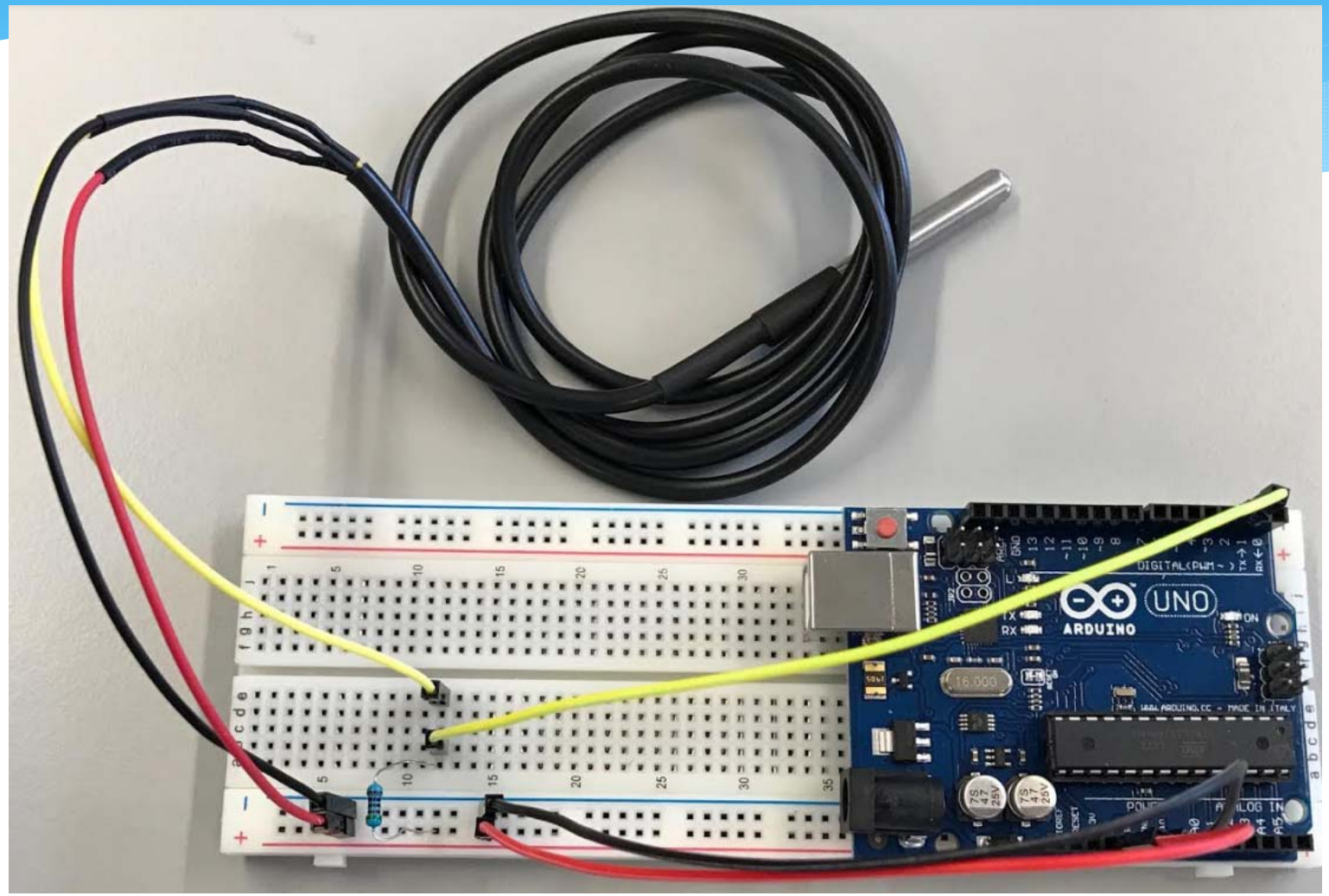
Connect another end of yellow jumper wire to breadboard B12



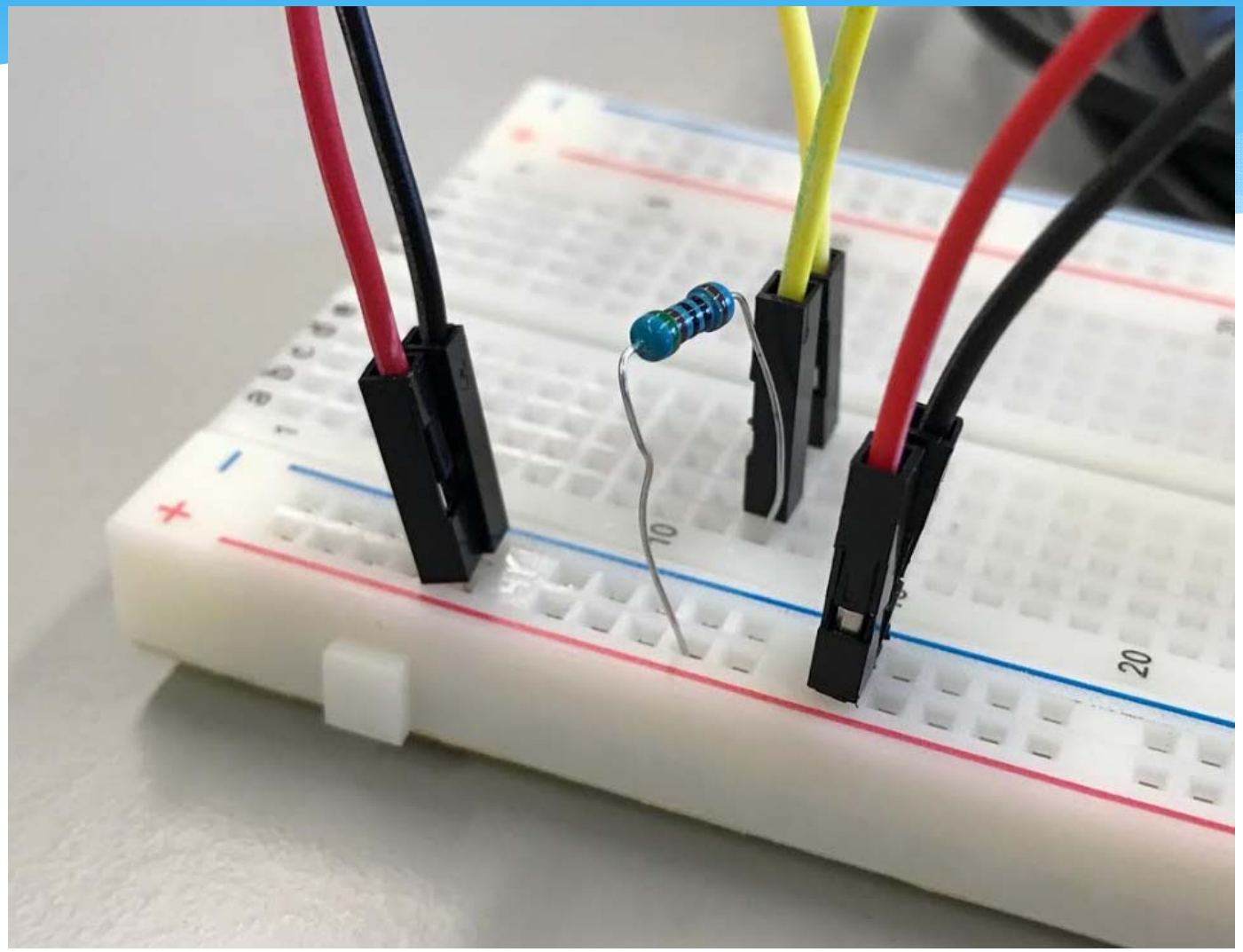
Connect red and black wire of temp sensor to breadboard + and - respectively



Connect yellow wire of temp sensor to breadboard E12



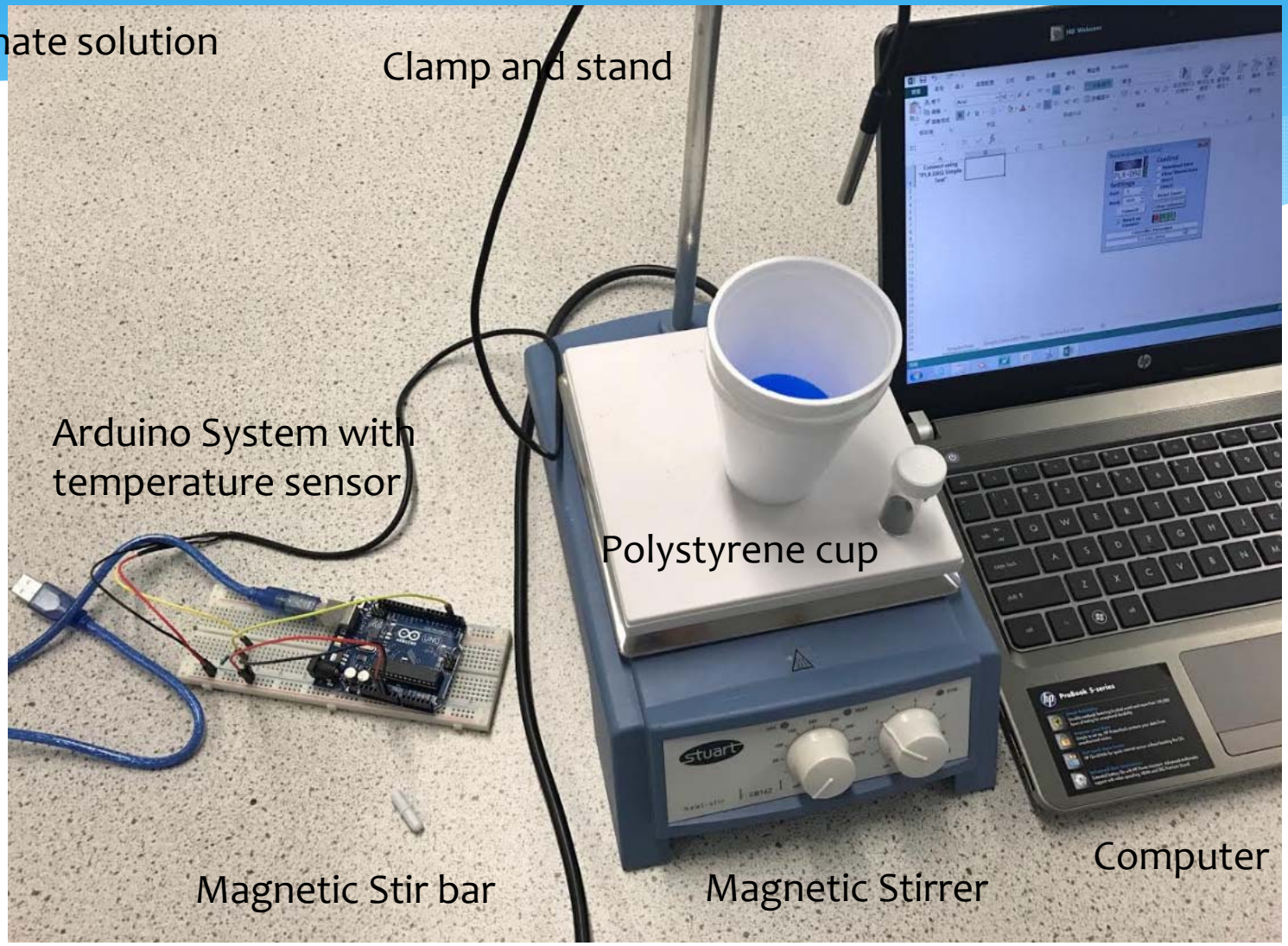
Check all wires and resistor to see all are firmly secured on Arduino and breadboard



https://www.youtube.com/watch?v=p6AN6rPWzfI

Experimental Setup

Copper(II)sulphate solution
Zinc powder



Points to note

Avoid glass rod from contact with temp sensor

Magnetic Stir bar should not to contact with temp sensor

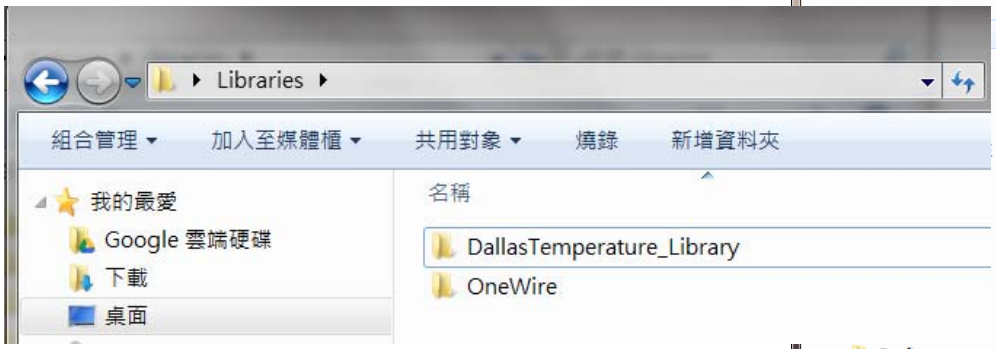
2. Copy the following into Arduino Libraries

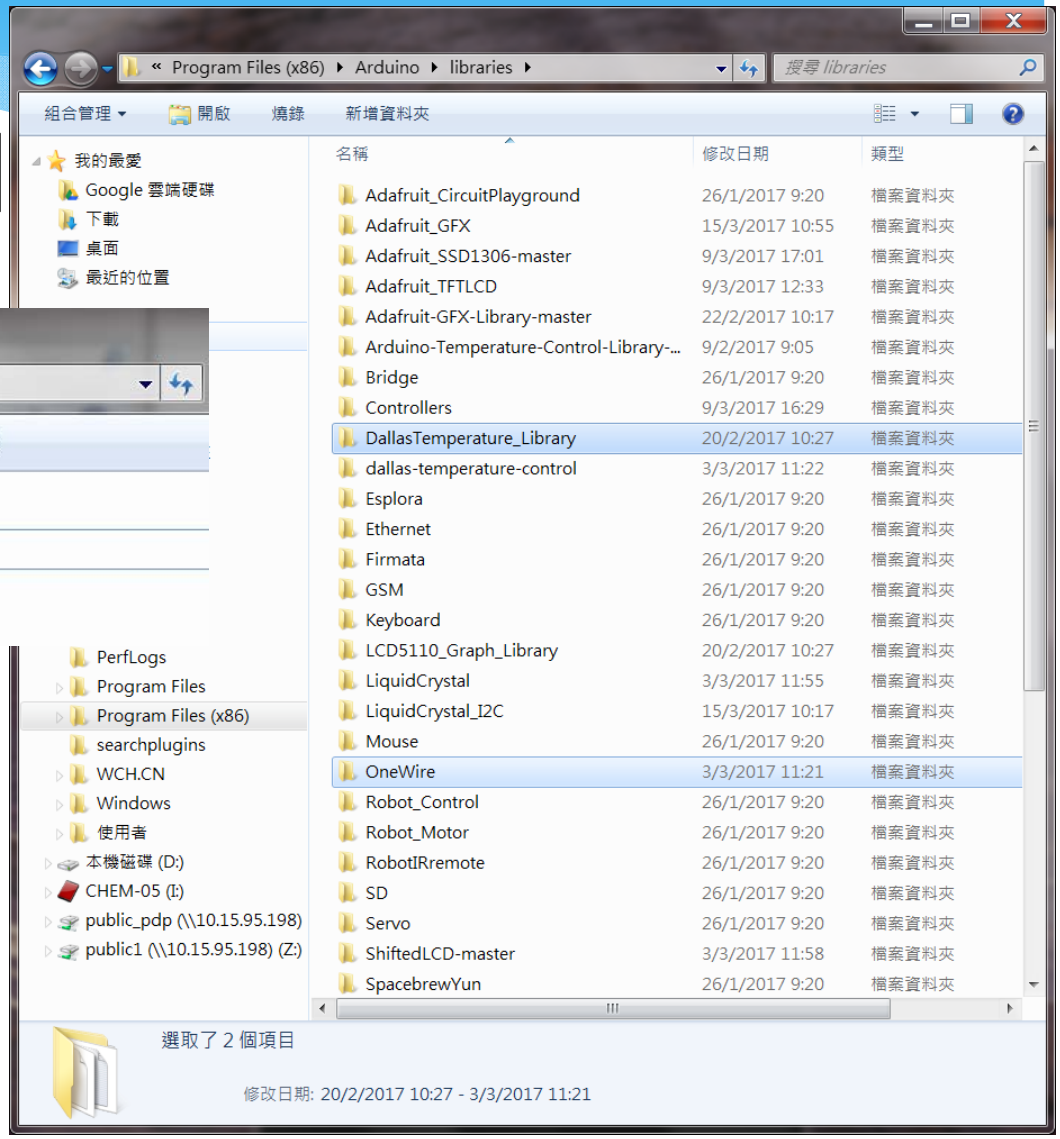
One Wire

Dallas Temperature_Library

Waterproof DS18B20
Temperature Sensor

Program Files (x86)>Arduino>libraries





3. Upload Arduino code

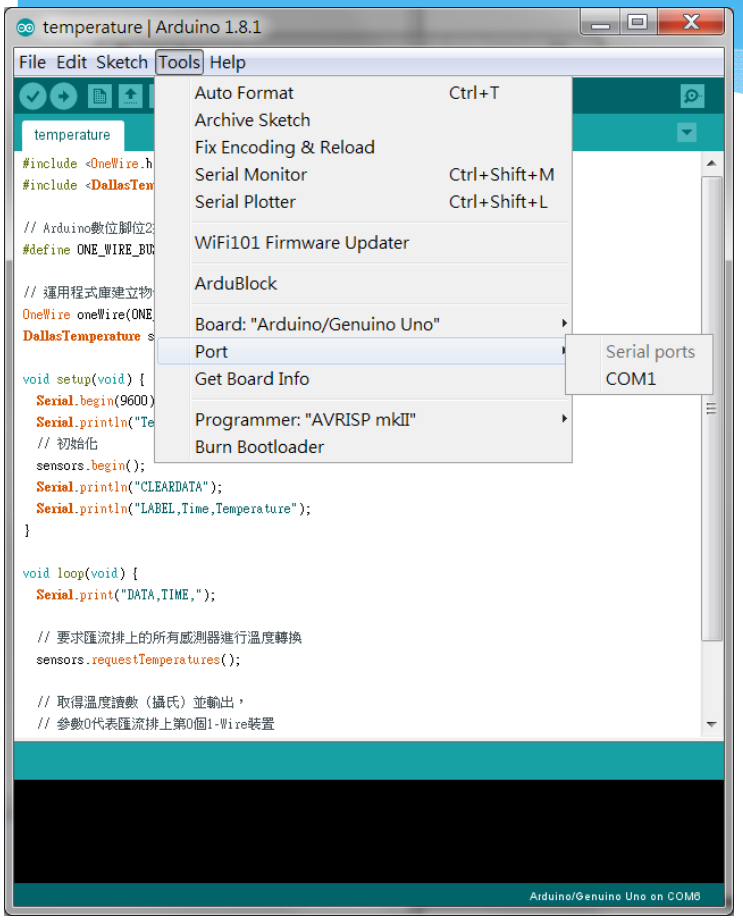
Waterproof DS18B20
Temperature Sensor

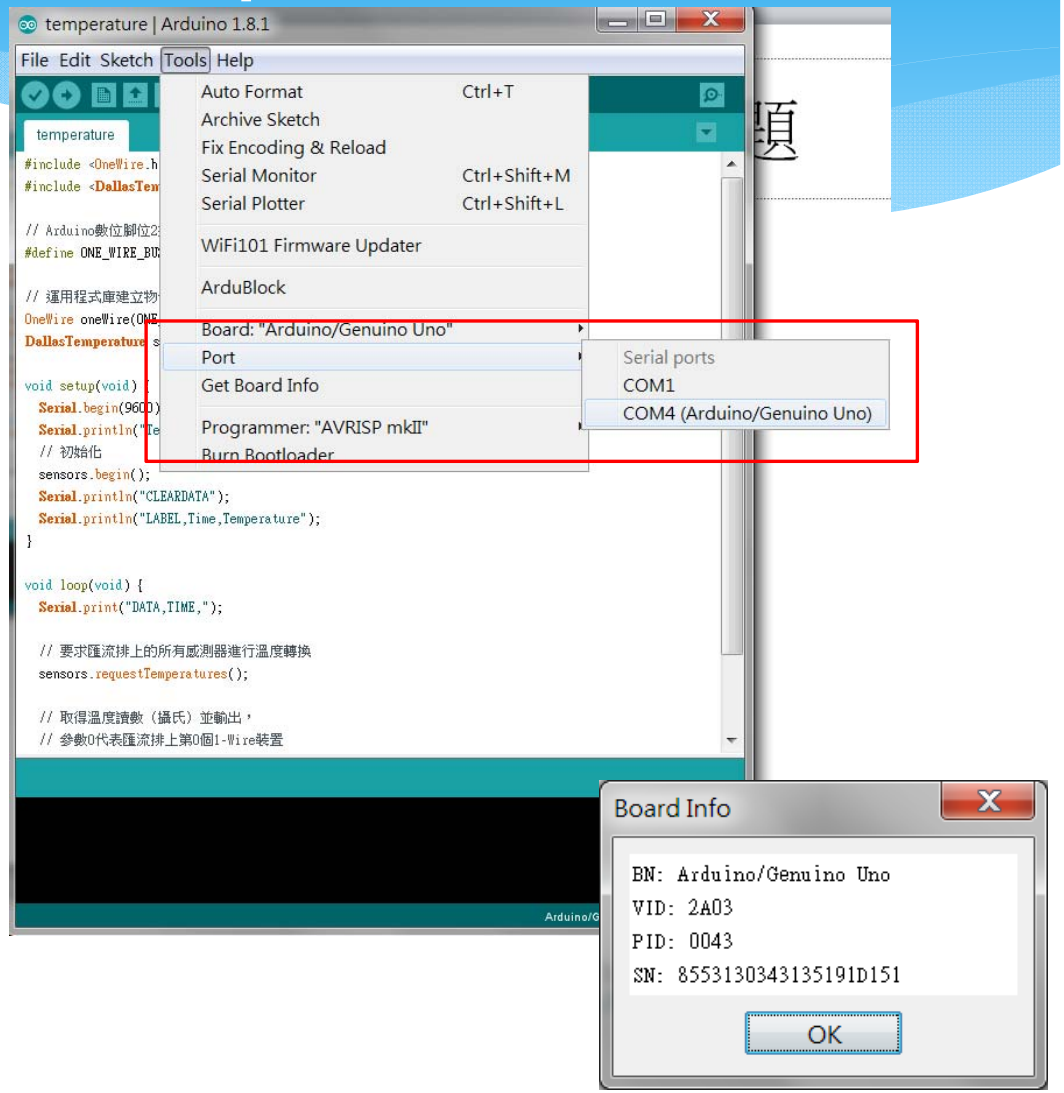
Open Arduino IDE software

Copy the code into Arduino IDE

Save the Arduino Sketch as “temp”

4. Checking the port of Arduino system to record the temperature data





5. Uploading of code into Arduino Board

temperature | Arduino 1.8.1

File Edit Sketch Tools Help

Upload

temperature

```
#include <OneWire.h>
#include <DallasTemperature.h>

// Arduino數位腳位2接到1-Wire裝置
#define ONE_WIRE_BUS 2

// 運用程式庫建立物件
OneWire oneWire(ONE_WIRE_BUS);
DallasTemperature sensors(&oneWire);

void setup(void) {
  Serial.begin(9600);
  Serial.println("Temperature Sensor");
  // 初始化
  sensors.begin();
  Serial.println("CLEARDATA");
  Serial.println("LABEL,Time,Temperature");
}

void loop(void) {
  Serial.print("DATA,TIME,");

  // 要求匯流排上的所有感測器進行溫度轉換
  sensors.requestTemperatures();

  // 取得溫度讀數（攝氏）並輸出，
  // 參數0代表匯流排上第0個1-Wire裝置
```

Arduino/Genuino Uno on COM4

temperature | Arduino 1.8.1

File Edit Sketch Tools Help

temperature

```
#include <OneWire.h>
#include <DallasTemperature.h>

// Arduino數位腳位2接到1-Wire裝置
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  sensors.requestTemperatures();

  // 取得溫度讀數（攝氏）並輸出，
  // 參數0代表匯流排上第0個1-Wire裝置
```
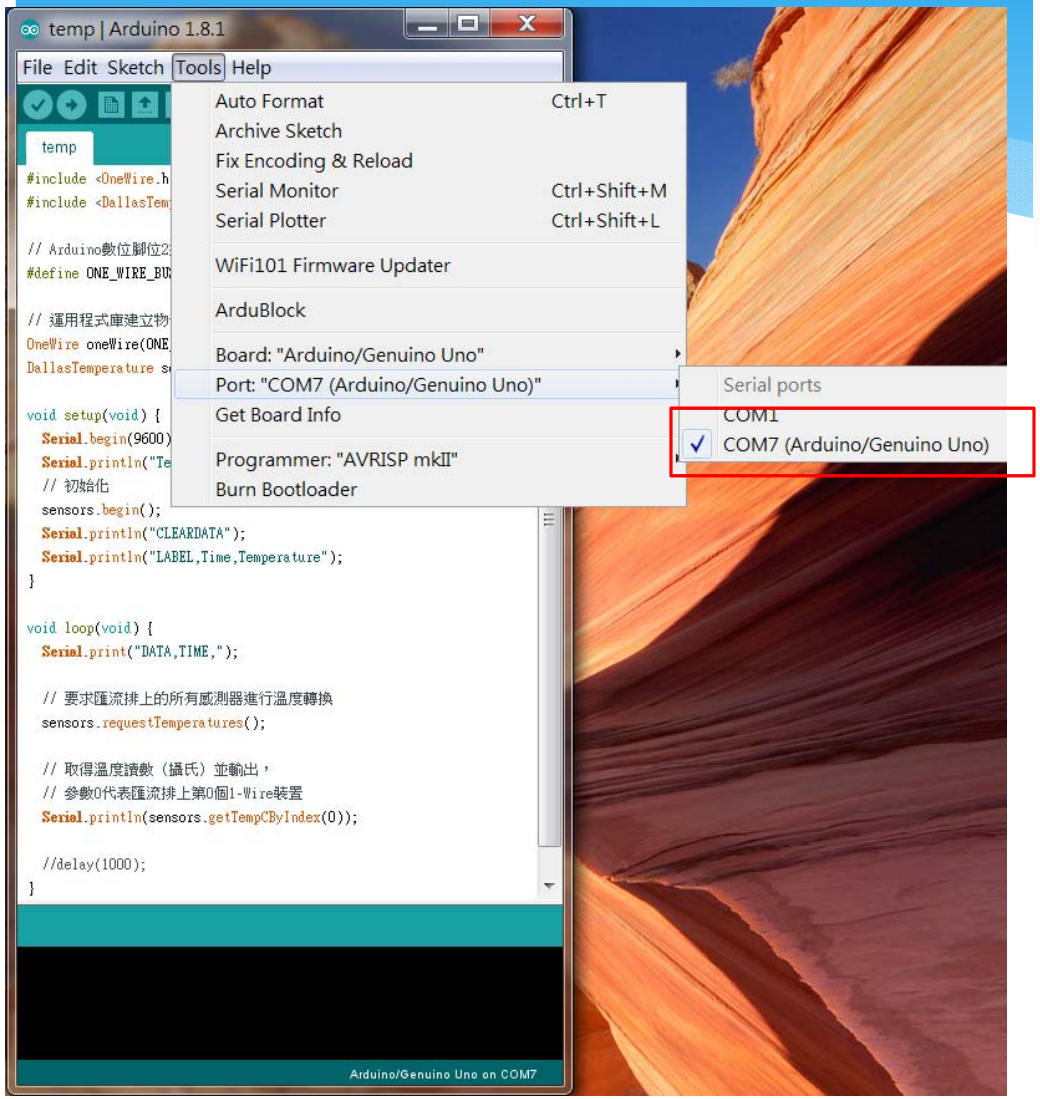
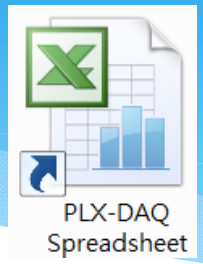

Done uploading.

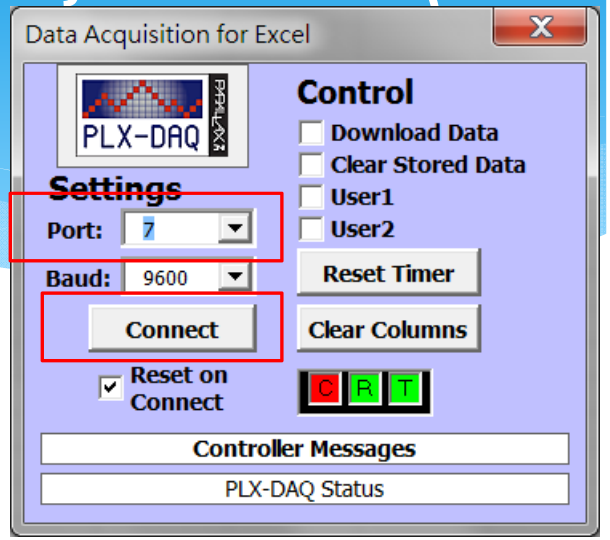
```
Sketch uses 5566 bytes (17%) of program storage space. Maximum is 32256 bytes.
Global variables use 299 bytes (14%) of dynamic memory, leaving 1749 bytes for local variables. Maximum
```

Arduino/Genuino Uno on COM4

6.Checking the port of Arduino system to start record the temperature data by PLX-DAQ



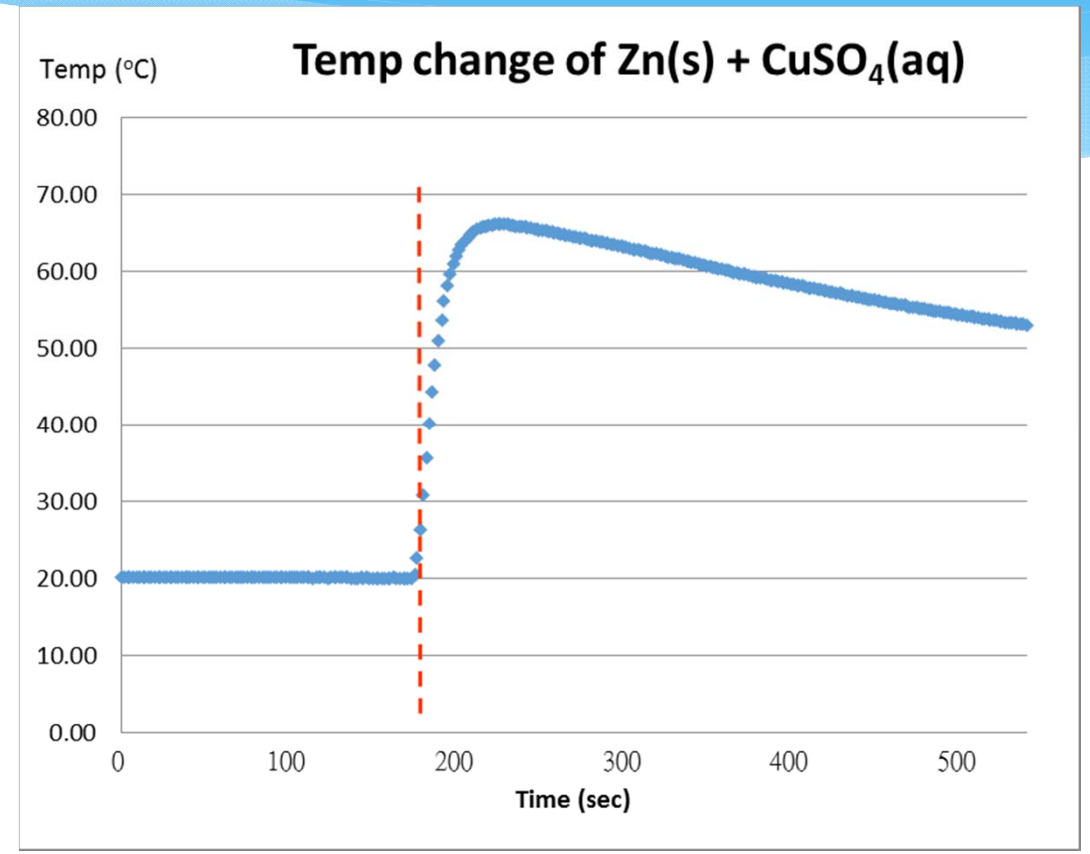




	A	B	C
1	Time	Temperature	
2	9:11:51	24.06	
3	9:11:51	24.06	
4	9:11:51	24.06	
5	9:11:51	24.06	
6	9:11:51	24.06	
7	9:11:51	24.06	
8	9:11:52	24.06	
9	9:11:52	24.06	
10	9:11:52	24.06	
11	9:11:52	24.06	
12	9:11:52	24.00	
13	9:11:52	24.00	
14	9:11:52	24.00	
15	9:11:53	24.06	
16	9:11:54	24.00	
17	9:11:54	24.06	

7.Data Collection by Excel plug-ins

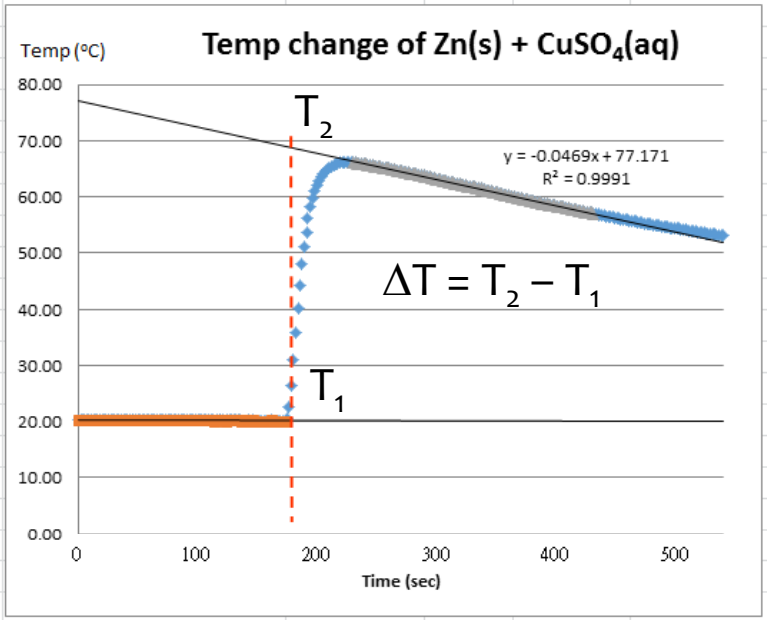
	A	B
1	Time	Temperature
2	上午 10:11:43	20.19
3	上午 10:11:45	20.19
4	上午 10:11:47	20.19
5	上午 10:11:48	20.19
6	上午 10:11:50	20.19
7	上午 10:11:52	20.19
8	上午 10:11:54	20.19
9	上午 10:11:56	20.19
10	上午 10:11:57	20.19
11	上午 10:11:59	20.19
12	上午 10:12:01	20.19
13	上午 10:12:03	20.19
14	上午 10:12:05	20.19
15	上午 10:12:06	20.19
16	上午 10:12:08	20.19
17	上午 10:12:10	20.19
18	上午 10:12:12	20.19
19	上午 10:12:13	20.19
20	上午 10:12:15	20.19
21	上午 10:12:17	20.19
22	上午 10:12:19	20.19
23	上午 10:12:21	20.19
24	上午 10:12:22	20.19
25	上午 10:12:24	20.19



Total duration : 540 seconds 540 data

8.Data analysis by using Microsoft Excel

Actual Time	Time diff	Duration (sec)	Temp	Initial T	Decrease T
10:11:43	0:00:00	0	20.19	20.19	
10:11:45	0:00:02	2	20.19	20.19	
10:11:47	0:00:04	4	20.19	20.19	
10:11:48	0:00:05	5	20.19	20.19	
10:11:50	0:00:07	7	20.19	20.19	
10:11:52	0:00:09	9	20.19	20.19	
10:11:54	0:00:11	11	20.19	20.19	
10:11:56	0:00:13	13	20.19	20.19	
10:11:57	0:00:14	14	20.19	20.19	
10:11:59	0:00:16	16	20.19	20.19	
10:12:01	0:00:18	18	20.19	20.19	
10:12:03	0:00:20	20	20.19	20.19	
10:12:05	0:00:22	22	20.19	20.19	
10:12:06	0:00:23	23	20.19	20.19	
10:12:08	0:00:25	25	20.19	20.19	
10:12:10	0:00:27	27	20.19	20.19	
10:12:12	0:00:29	29	20.19	20.19	
10:12:13	0:00:30	30	20.19	20.19	
10:12:15	0:00:32	32	20.19	20.19	
10:12:17	0:00:34	34	20.19	20.19	
10:12:19	0:00:36	36	20.19	20.19	
10:12:21	0:00:38	38	20.19	20.19	
10:12:22	0:00:39	39	20.19	20.19	
10:12:24	0:00:41	41	20.19	20.19	
10:12:26	0:00:43	43	20.19	20.19	
10:12:28	0:00:45	45	20.19	20.19	
10:12:29	0:00:46	46	20.19	20.19	
10:12:31	0:00:48	48	20.19	20.19	
10:12:33	0:00:50	50	20.19	20.19	
10:12:35	0:00:52	52	20.19	20.19	
10:12:37	0:00:54	54	20.19	20.19	
10:12:38	0:00:55	55	20.19	20.19	
10:12:40	0:00:57	57	20.19	20.19	



Temperature Data Collected by Arduino UNO

Date of Expt: 13/2/2017

Sample Rate : 1 second

Reaction Enthalpy

Zn(s) + CuSO4(aq) → ZnSO4(aq) + Cu(s)

Data Collection :

Metal : Zinc

Solution : Copper (II) sulphate

Time for adding zinc: 173 Sec

Maximum Temp

y = -0.0469 x + 77.171

T2 = 69.06

Initial Temp

T1 = 20.19

Calculations :

mass of solution (m) =	50	g
Sp Heat Cap of solution (c)=	4.18	$J\ g^{-1}\ K^{-1}$
Temp Diff (ΔT)	48.87	°C
heat capacity of container (c')	0	$J\ K^{-1}$

Number of mole

zinc	0.0616	mol
Copper (II) sulphate	0.0500	mol
Limiting number of mole	0.0500	mol

Sample Data | Sample Data Analysis | Procedure | Data Analysis

Scientific Inquiry opportunity

To investigate the enthalpy change of neutralization