陽明交大
NYCU

物聯網裝置與平台
IoT Devices and Platforms

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National Yang Ming Chiao Tung University

	日期	主題
1	9/17	(加退選9/13-27) 課程介紹, arduino簡介
2	9/24	物聯網裝置: Arduino basic introduction
3	10/1	物聯網裝置: Arduino Digital Interface
4	10/8	物聯網裝置: Arduino Analog Interface
5	10/15	sensor介紹 part 1
6	10/22	sensor介紹 part 2
7	10/29	sensor介紹 part 3
8	11/5	(期中考周11/1-5) sensor介紹 part 4
9	11/12	期中考
10	11/19	Sensor介紹; 通訊模組 Bluetooth, Lora
11	11/26	Sensor介紹; 通訊模組 wifi
12	12/3	Proposal
13	12/10	物聯網平台 - IoT Cloud Platform
14	12/17	AI應用 (SVM)
15	12/24	(期末考周 12/24-30) Project 準備周
16	12/31	(國定假日)
17	1/7	(彈性補充教學) Final demo
18	1/14	(彈性補充教學) Final demo part 2 (如果需要兩周進行)

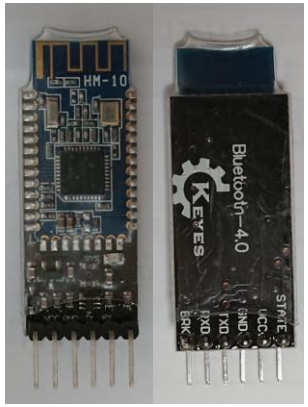
Important date

- **Find your team member (each group: 2~4 persons)**
  - Total: 15 groups
- (12/3) Project proposal
  - Prepare slide (2 pages are enough) with 5 min introduction
    - P0. Project title
    - P1. Your idea/motivation
    - P2. What do you need (ex: sensors)
  - We will discuss and provide suggestions to each team
- (1/7, 1/14) Final project demo (via Teams)
  - Prepare both slide and live demo
  - Upload slide and demo video to e3
  - **Each team has 10 minute, so we might only need one week.**

Last week

- Magnetometer (3-axis compass): 磁力計
  - I2C sensor
  - measure the earth's magnetic field in three axes
- Communication module: Bluetooth
  - Use Bluetooth to transmit data between Arduino and smart phone

HMC5883L



HM-10

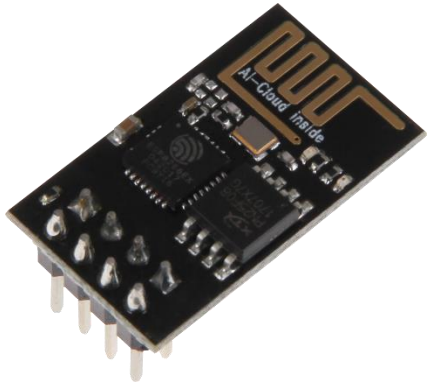
This week

- Dust Sensor: Use PPD42NS to measure Particulate Matter level (PM level) in the air.
- Water Level Sensor: Read the current water level value
- Wi-Fi module: Use ESP8266 WiFi module to upload sensing data to IoT cloud platform

PPD42NS

Dust Sensor

Water Level Sensor



ESP8266

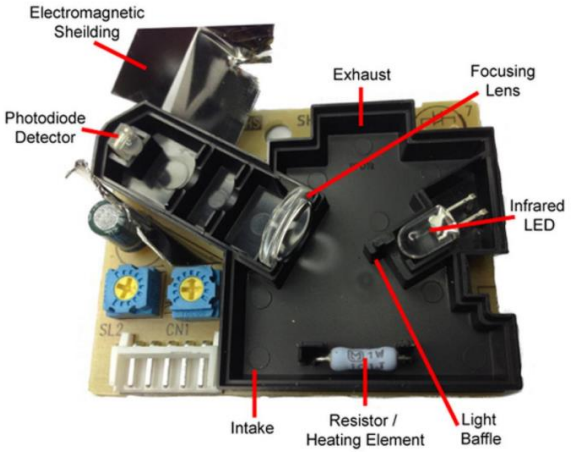
Dust Sensor

Use PPD42NS to measure Particulate Matter level (PM level) in the air.

https://wiki.seeedstudio.com/Grove-Dust_Sensor/
https://files.seeedstudio.com/wiki/Grove_Dust_Sensor/resource/Grove_-_Dust_sensor.pdf
https://www.mouser.com/datasheet/2/744/Seeed_101020012-1217636.pdf

Dust Sensor

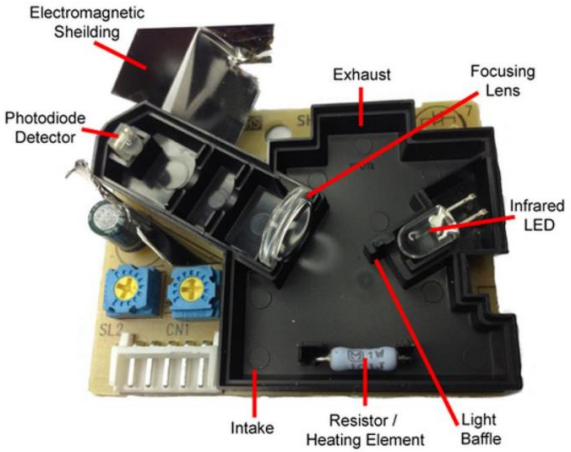
- The Unit of the PPD42NS is **pcs /0.01cf** or **pcs/liter** (升)
- Pcs / 0.01cf means how many particulate matter in 0.01 cubic feet (立方英呎)
  - 0.01cubic feet = 283 mL (毫升)
- Technical Details:
  - Detectable particle size: approx. 1µm (minimum.)
  - Detectable range of concentration 0~28,000 pcs/liter (0~8,000pcs/0.01 CF=283ml)
  - Operating Temperature Range 0~45°C
  - Operating Humidity Range 95%rh or less (without dew condensation)



https://aqicn.org/sensor/shinyei/

Dust Sensor

- There is a Infrared LED and Photodiode Detector.
- Dust particles modify the signal received by the detector from the light source by collecting the emitted light diffused by the dust particles.
- A power resistor heats the air in the optical chamber and generates a flow between two apertures putted in the plastic cover



https://aqicn.org/sensor/shinyei/

PM2.5 空污偵測的網路公民科學

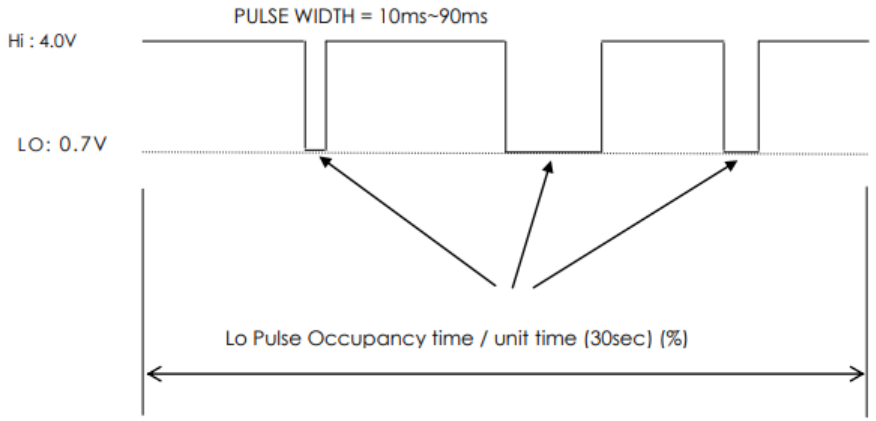
- PM2.5 感測器主要的偵測原理是靠光的散射作用。
  - PM2.5: 直徑小於或等於 2.5 微米
  - PPD42NS: Detectable particle size approx. 1μm (minimum.)

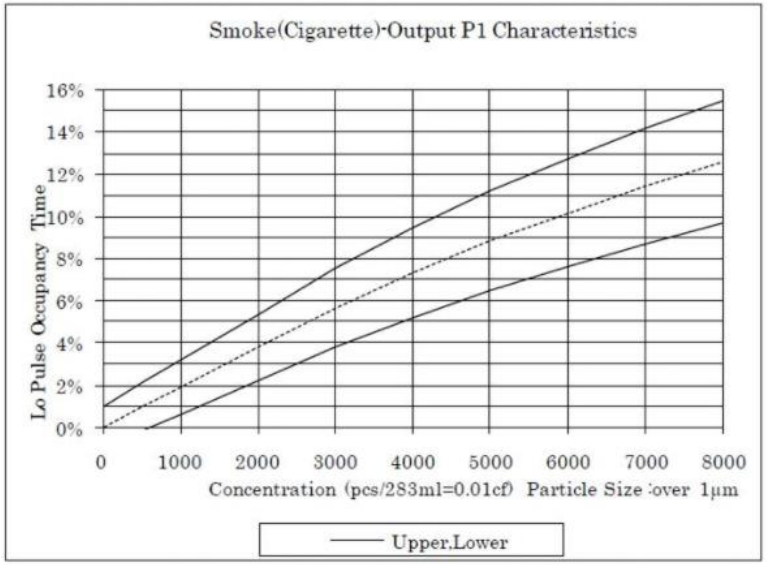
- 感測器內部有發光 LED 和接收器，當空氣中的細懸浮微粒進入感測器，受到光線照射後，產生**米氏散射(Mie scattering）**，細懸浮微粒越多，散射越厲害，接收器記錄的散射光越強

https://esep.colife.org.tw/journal_pdf/308.pdf

Dust Sensor

- Counting the Low Pulse Occupancy time (LPO time) in given time unit. **LPO time is proportional to PM concentration**.





https://files.seeedstudio.com/wiki/Grove_Dust_Sensor/resource/Grove_-_Dust_sensor.pdf

Dust Sensor

- Goal: Use PPD42NS to measure Particulate Matter level (PM level) in the air
- Hardware Required
  - PPD42NS dust sensor
  - Arduino

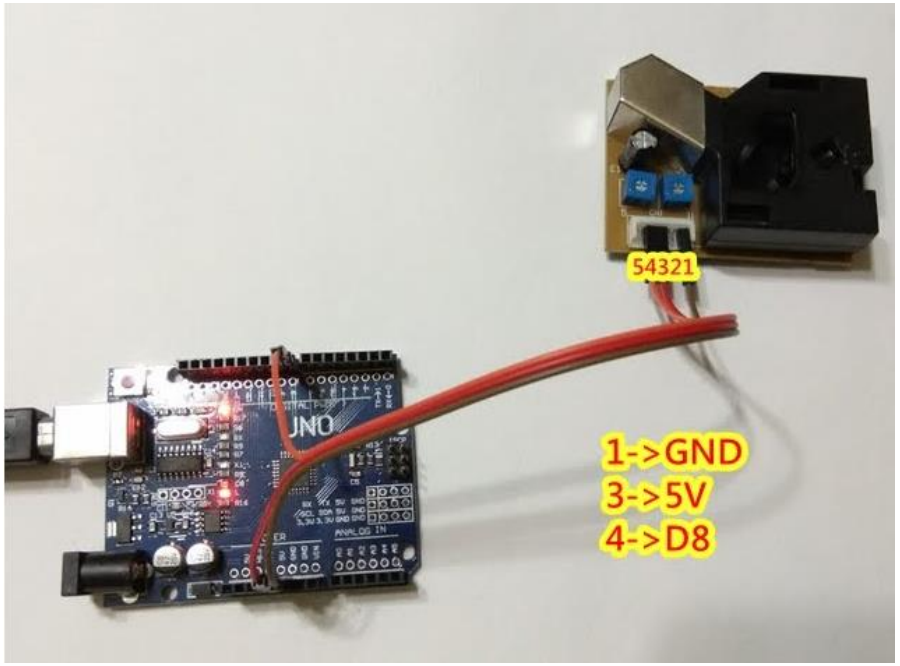
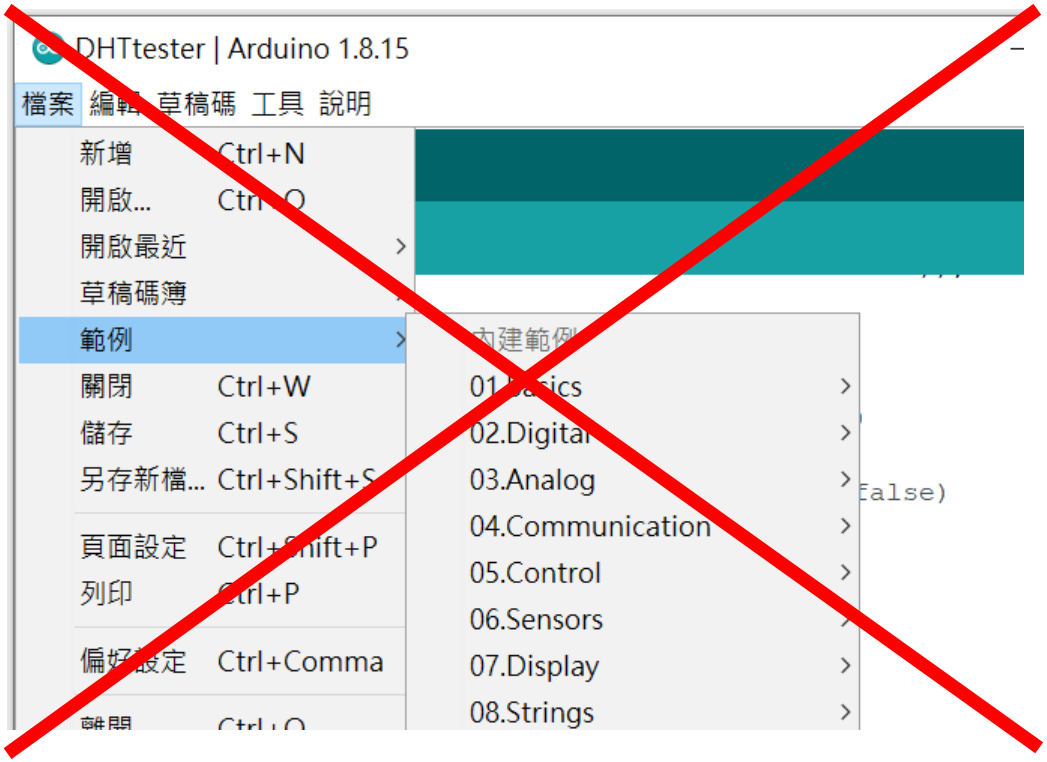


Figure from: https://sites.google.com/site/wenyumaker/03-pm2-5%E7%81%B0%E5%A1%B5%E5%82%B3%E6%84%9F%E5%99%A8/05-ppd42ns

Lab1. Dust Sensor

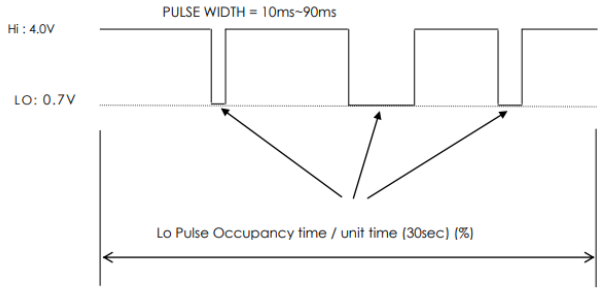
Arduino IDE

- No build-in example
- Try to write the code by yourself (Refer to the slides)

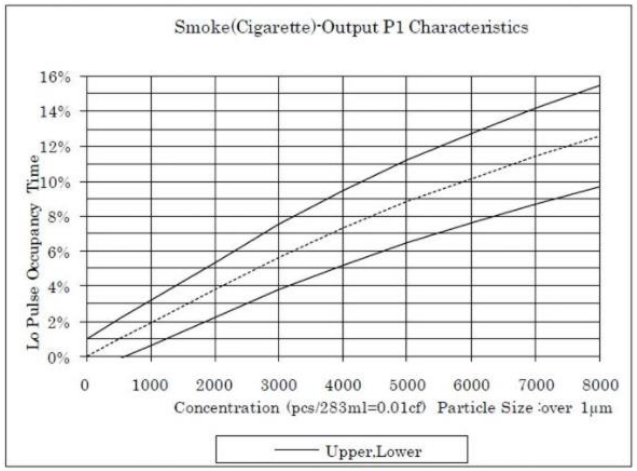


Sample code

```
int pin = 8;
unsigned long duration;
unsigned long starttime;
unsigned long sampletime_ms = 30000;  //sample 30s
unsigned long lowpulseoccupancy = 0;
float ratio = 0;
float concentration = 0;

void setup() {
  Serial.begin(9600);
  pinMode(8,INPUT);
  starttime = millis();                    //get the current time;
}
```

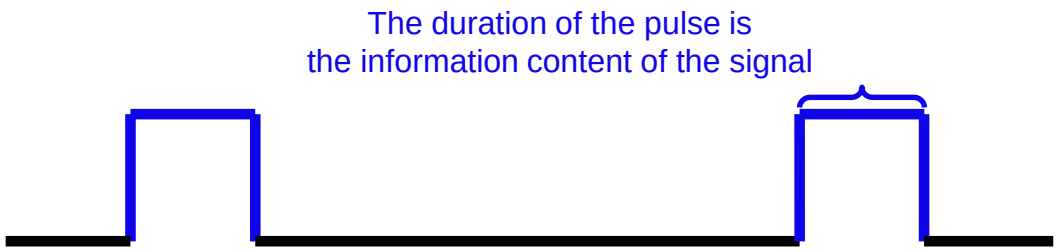



```
void loop() {
   duration = pulseIn(pin, LOW);
   lowpulseoccupancy = lowpulseoccupancy+duration;

   if ((millis()-starttime) >= sampletime_ms) //if the sampel time = = 30s
   {
      ratio = lowpulseoccupancy/(sampletime_ms*10.0);  // Integer percentage 0~100
      concentration = 1.1*pow(ratio,3)-3.8*pow(ratio,2)+520*ratio+0.62;
      // using spec sheet curve
      Serial.print("concentration = ");
      Serial.print(concentration);
      Serial.println(" pcs/0.01cf");
      Serial.println("\n");
      lowpulseoccupancy = 0;
      starttime = millis();
    }
}
```



Syntax

- Syntax
  - pulseIn(pin, value)
  - pulseIn(pin, value, timeout)
- Description
  - Reads a pulse (either HIGH or LOW) on a pin. Returns the length of the pulse in microseconds.
  - For example, if value is HIGH, pulseIn() waits for the pin to go HIGH, starts timing, then waits for the pin to go LOW and stops timing.



Syntax

- Syntax
  - pow(base, exponent)
- Description
  - Calculates the value of a number raised to a power. pow() can be used to raise a number to a fractional power. This is useful for generating exponential mapping of values or curves.
- Parameters
  - base: the number. Allowed data types: float.
  - exponent: the power to which the base is raised. Allowed data types: float.
- Example
  - z = pow(x, y);

Discussion 1

- Why it uses sampletime_ms*10.0?

```
ratio = lowpulseoccupancy/(sampletime_ms*10.0); // Integer percentage 0~100
```

- Rewrite the code to show the measurement in the unit of pcs/liter. Upload your code (PrtScr) to e3.
  - Hint: 0.01cf = 0.2832 liter

Quiz 1

- Air monitor with color notification
  - 1. Use the dust senor and RGB LED to show the PM level.
  - 2. Turn the green light when concentrate < 500
  - 3. Turn the yellow light when 500 < concentrate < 1000
  - 4. Turn the red light when concentrate > 1000

Lab2. Water level sensor

Use Water Level Sensor to measure current water level

Water Level Sensor

- The sensor has a series of ten exposed copper traces, five of which are power traces and five are sense traces.
- These traces are interlaced so that there is one sense trace between every two power traces.
- Usually these traces are not connected but are bridged by water when submerged.

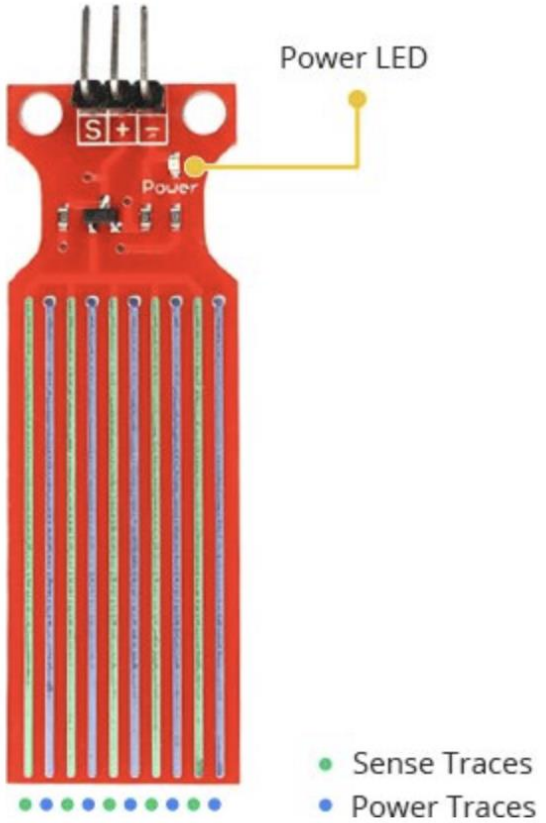


Figure from: https://lastminuteengineers.com/water-level-sensor-arduino-tutorial/

Water Level Sensor (cont.)

- The series of exposed parallel conductors, together acts as a variable resistor (just like a potentiometer) whose resistance varies according to the water level.
- The change in resistance corresponds to the distance from the top of the sensor to the surface of the water.

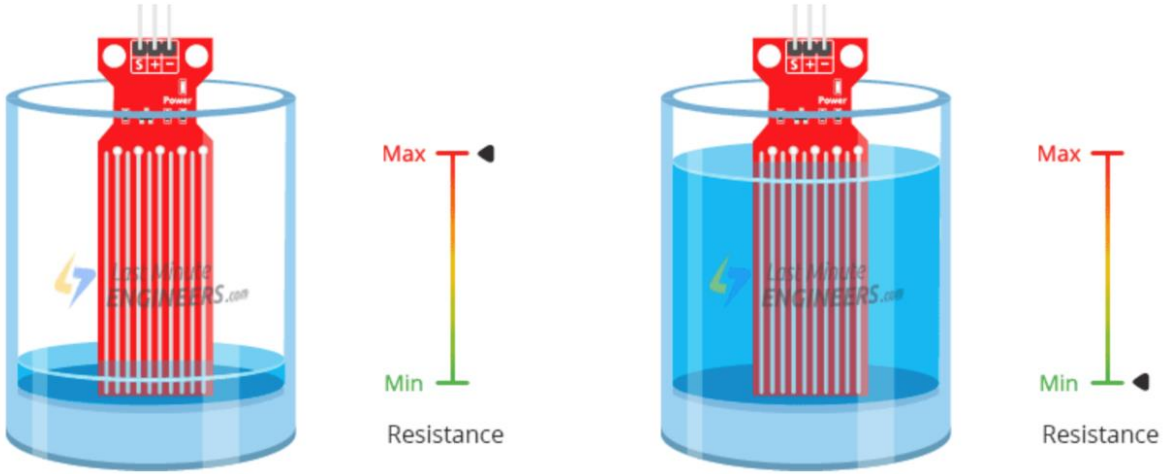
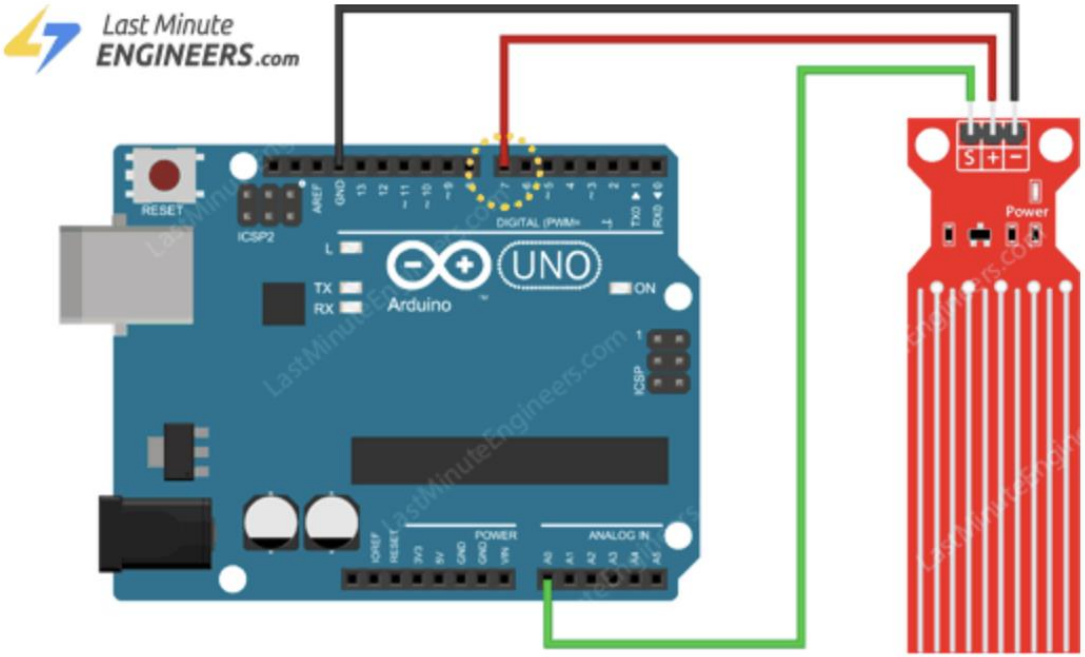


Figure from: https://lastminuteengineers.com/water-level-sensor-arduino-tutorial/

Water Level Sensor

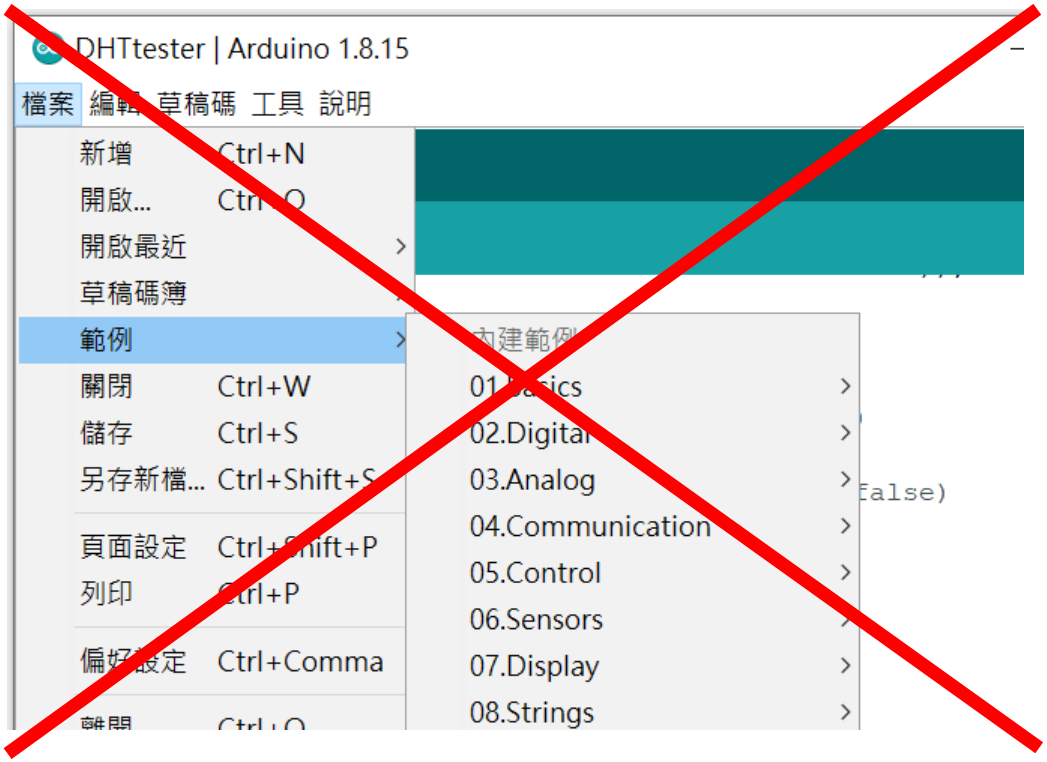
- Goal: Use Water Level Sensor to measure current water level
- Hardware Required
  - Water Level Sensor
  - Arduino Uno



Lab2. Water Level Sensor

Arduino IDE

- No build-in example
- Try to write the code by yourself (Refer to the slides)



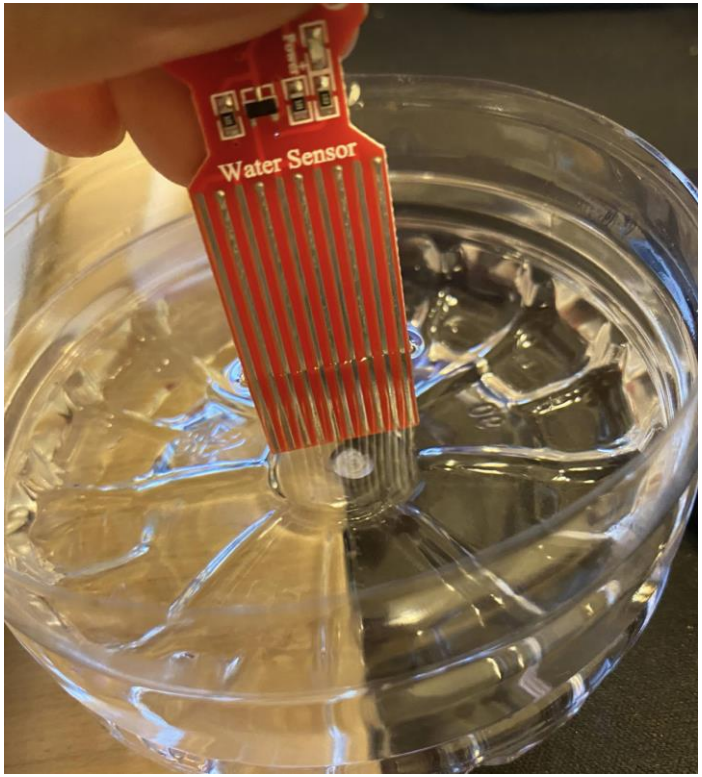
Sample code

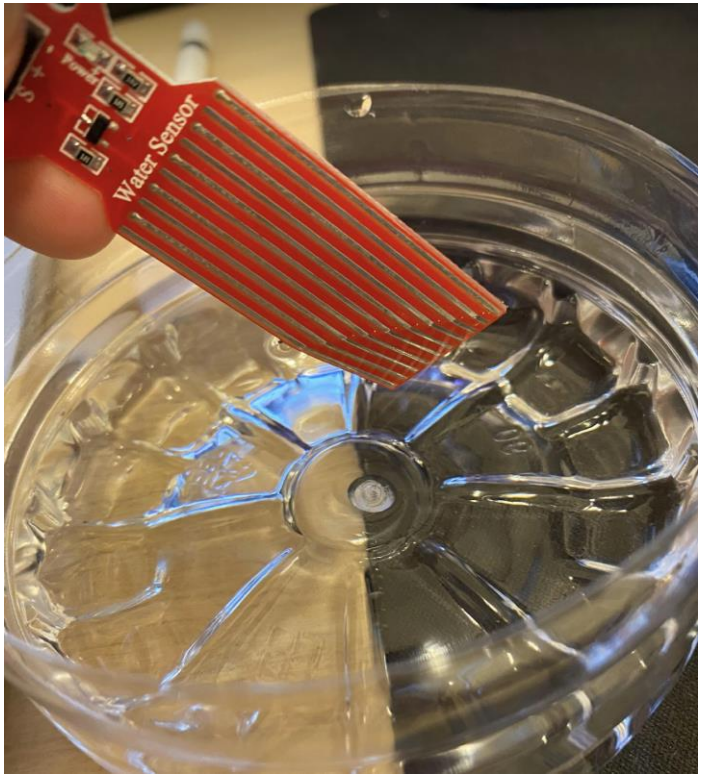
```
// Sensor pins
#define sensorPower 7
#define sensorPin A0

// Value for storing water level
int val = 0;
void setup() {
        // Set D7 as an OUTPUT
        pinMode(sensorPower, OUTPUT);

        // Set to LOW so no power flows through the sensor
        digitalWrite(sensorPower, LOW);
        Serial.begin(9600);
}
```

```
void loop() { //get the reading from the function below and print it
        int level = readSensor();
        Serial.print("Water level: ");
        Serial.println(level);
        delay(1000);
}

//This is a function used to get the reading
int readSensor() {
        digitalWrite(sensorPower, HIGH);    // Turn the sensor ON
        delay(10);                          // wait 10 milliseconds
        val = analogRead(sensorPin);        // Read the analog value form sensor
        digitalWrite(sensorPower, LOW);     // Turn the sensor OFF
        return val;                         // send current reading
}
```

Discussion 2

- Let the sensor tilt, does it make the result different?





Quiz 2

- Imitate a water pump
  - 1. Let the Servo keep sweeping when water level is not full.
  - 2. Stop the Servo when water level is full.
  - 3. We want to simulate the machine that can keep working until full of water.
  - 4. Use map() function to map the sensor value between 0-100, and show it in Serial Monitor
- Hint: You need to do the Calibration.

Lab3. ESP-01 WIFI Module

Use ESP-01 WIFI Module to transmit sensor data to cloud platform

Esp8266 WiFi Module

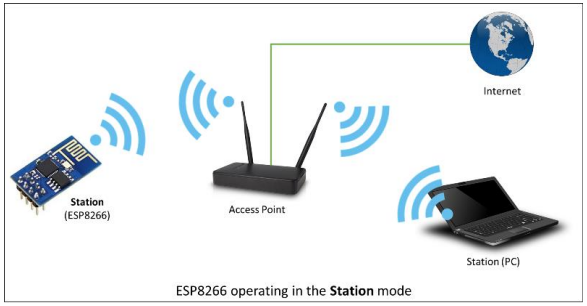
- ESP8266
  - 是一款可以作為微控制器使用的成本極低且具有完整TCP/IP協議的Wi-Fi IoT控制晶片，具有 AP (Access Point網路基地台模式)、STA (Station工作站模式) 、AP + STA(共存模式)
  - 使用UART通訊界面(Universal Asynchronous Receiver/Transmitter，通用非同步收發傳輸器)，包括了RS232、RS449、RS423、RS422和RS485等標準規範
  - ESP8266 family:

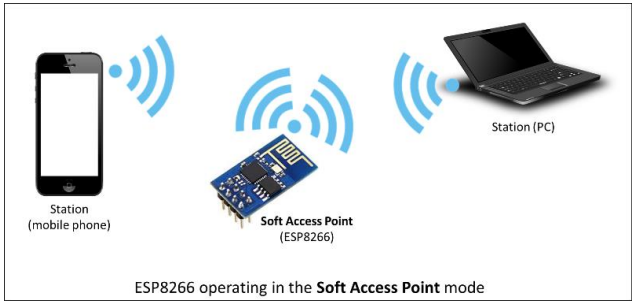
https://en.wikipedia.org/wiki/ESP8266
https://blog.jmaker.com.tw/esp8266-esp01/

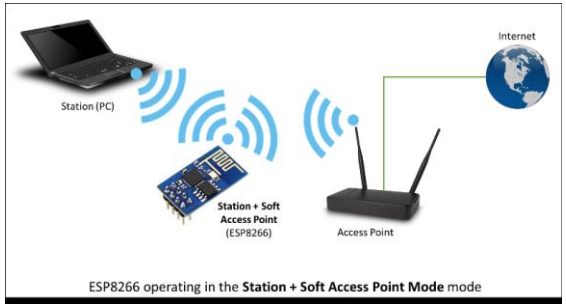
Esp8266 WiFi Module

- AP，也就是無線接入點，無線網路的建立者，是網路的中心節點。即一般家庭或辦公室使用的無線路由器。

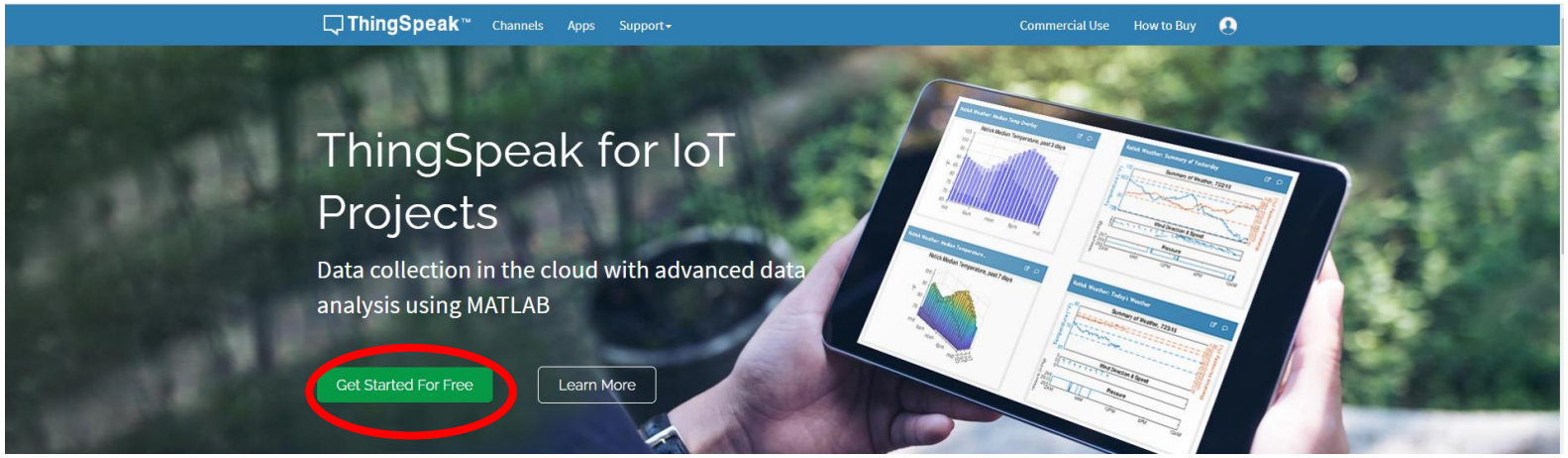
- STA，每一個連線到無線網路中的終端節點，如筆記型電腦、手機以及其它可以連網的裝置。

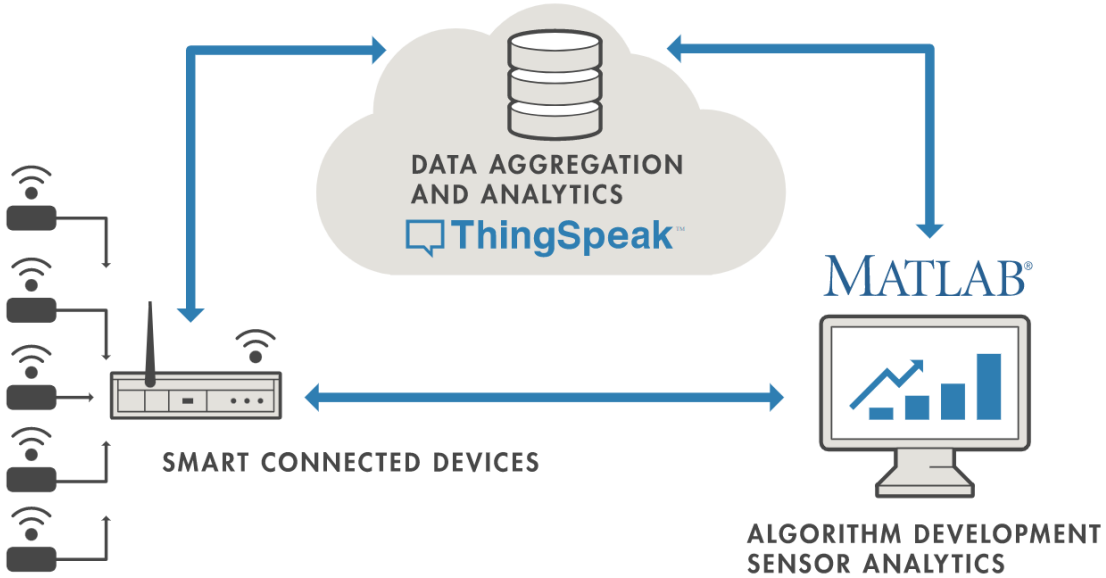






ThingSpeak (IoT雲端平台)





https://thingspeak.com/

ThingSpeak

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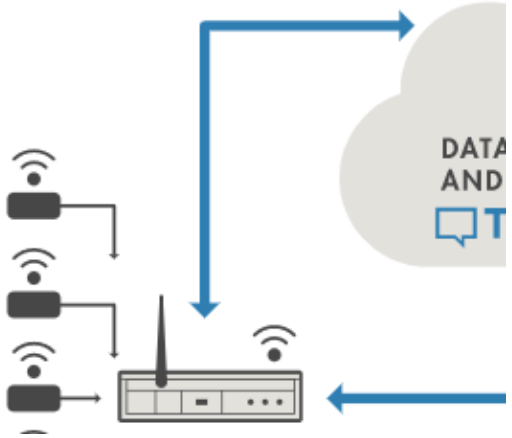
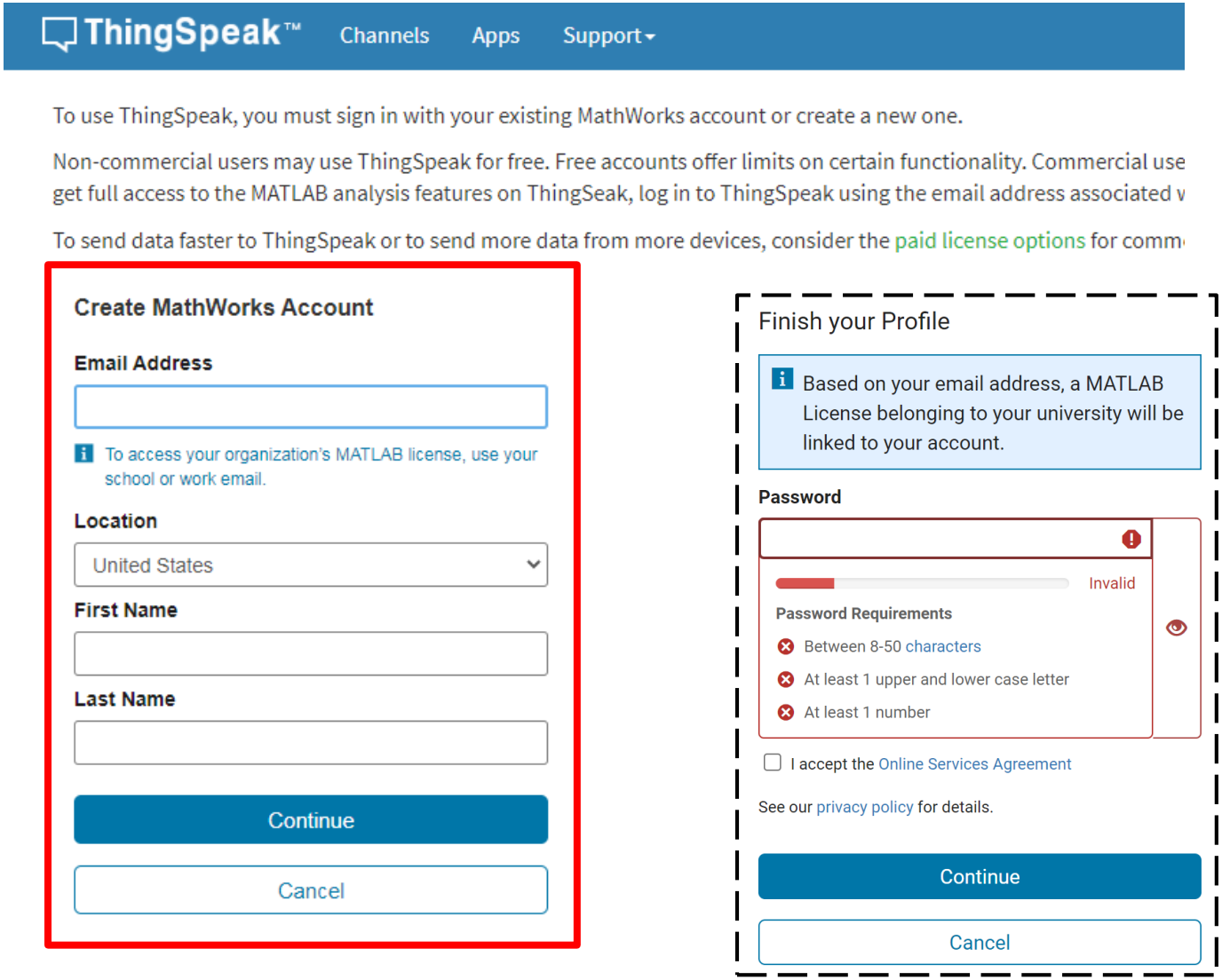


ThingSpeak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Password Requirements
Between 8-50 characters
At least 1 upper and lower case letter
At least 1 number
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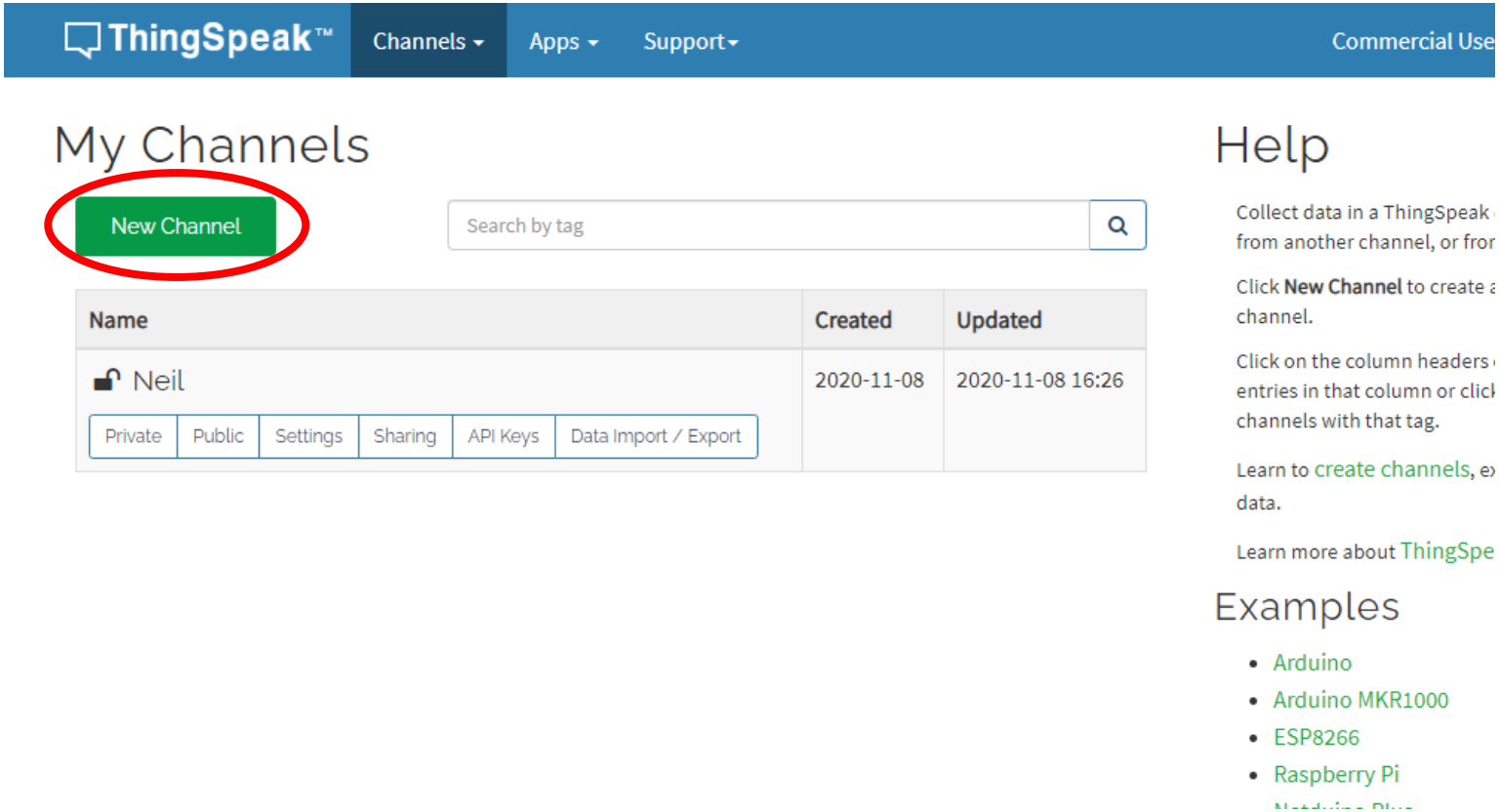
ThingSpeak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Updated
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2020-11-08
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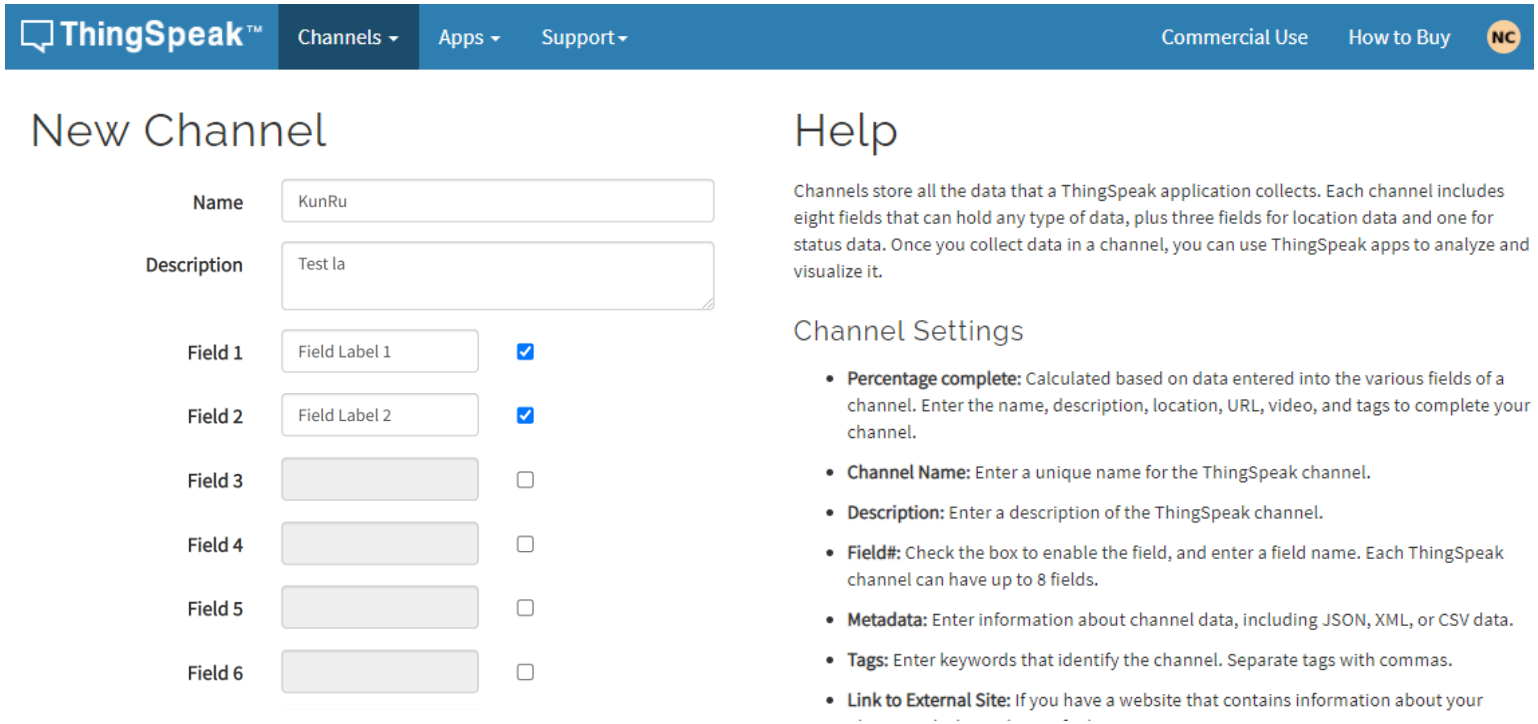
Private
Public
Settings
Sharing
API Keys
Data Import / Export
Help
Collect data in a ThingSpeak
from another channel, or fror
Click New Channel to create a
channel.
Click on the column headers
entries in that column or click
channels with that tag.
Learn to create channels, ex
data.
Learn more about ThingSpe
Examples
Arduino
Arduino MKR1000
ESP8266
Raspberry Pi

ThingSpeak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Field Label 2
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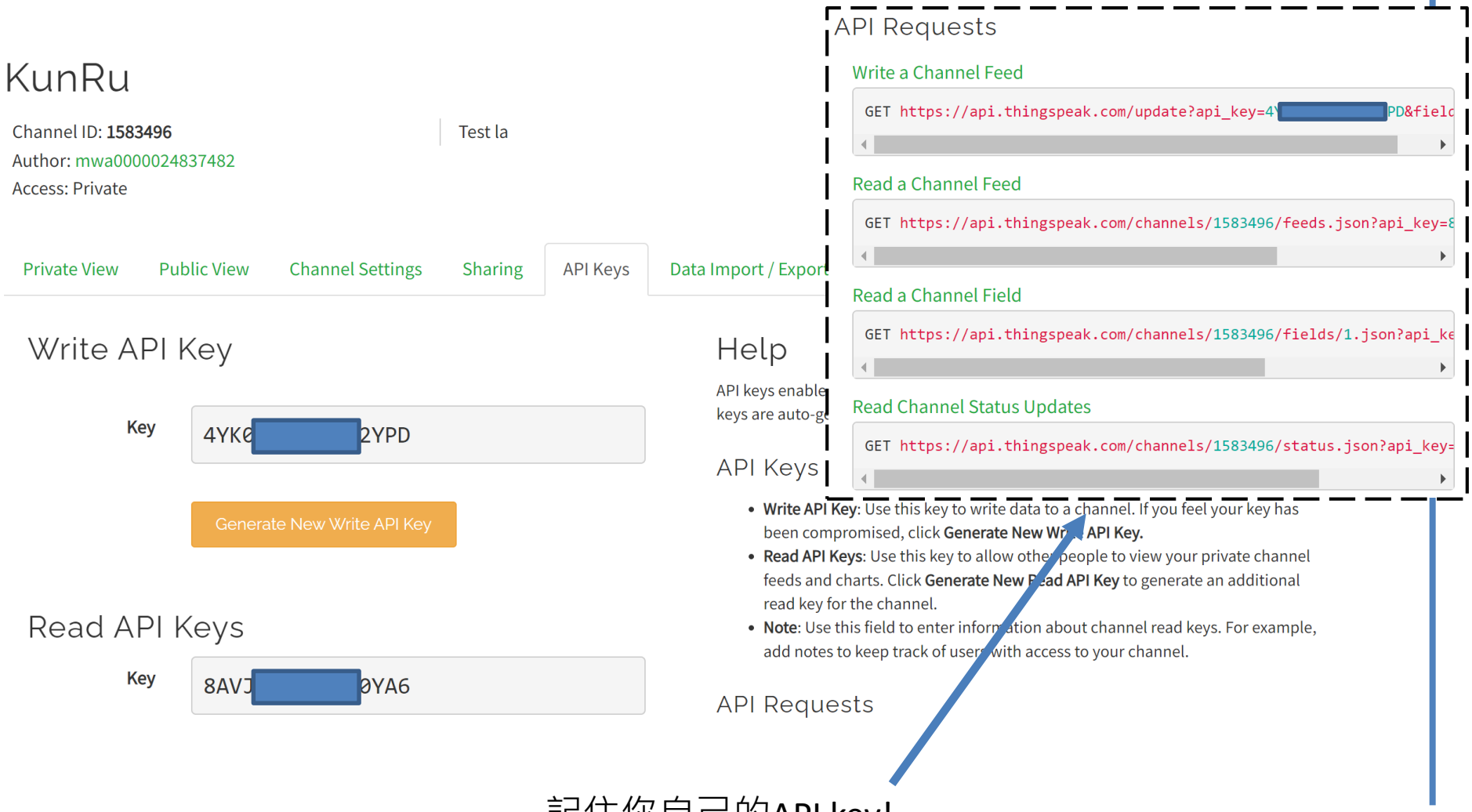
Channels store all the data that a ThingSpeak application collects. Each channel includes eight fields that can hold any type of data, plus three fields for location data and one for status data. Once you collect data in a channel, you can use ThingSpeak apps to analyze and visualize it.
Channel Settings
Percentage complete: Calculated based on data entered into the various fields of a channel. Enter the name, description, location, URL, video, and tags to complete your channel.
Channel Name: Enter a unique name for the ThingSpeak channel.
Description: Enter a description of the ThingSpeak channel.
Field#: Check the box to enable the field, and enter a field name. Each ThingSpeak channel can have up to 8 fields.
Metadata: Enter information about channel data, including JSON, XML, or CSV data.
Tags: Enter keywords that identify the channel. Separate tags with commas.
Link to External Site: If you have a website that contains information about your

ThingSpeak

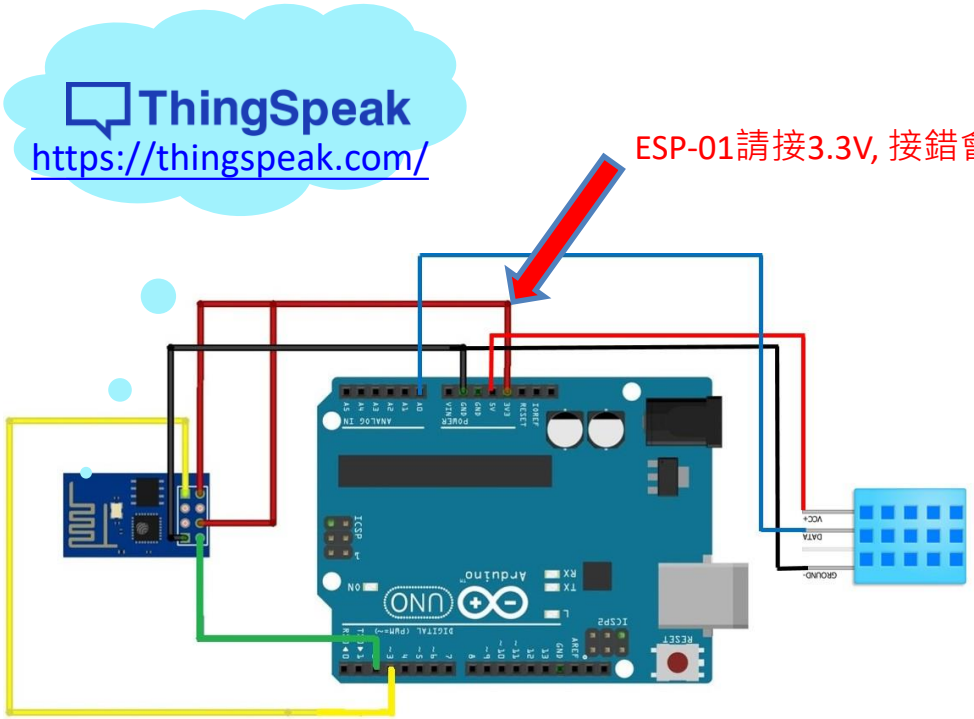


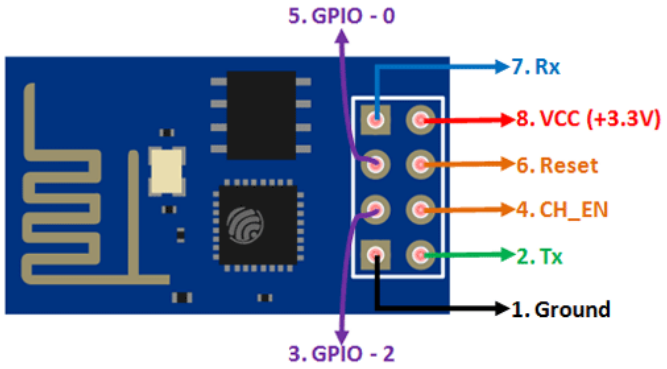
記住你自己的API key!

ESP-01 WiFi Module

- Goal: Use ESP-01 WIFI Module to transmit sensor data to cloud platform
- Hardware Required
  - Arduino UNO
  - ESP-01 WIFI module
  - DHT-11 sensor

ThingSpeak
https://thingspeak.com/

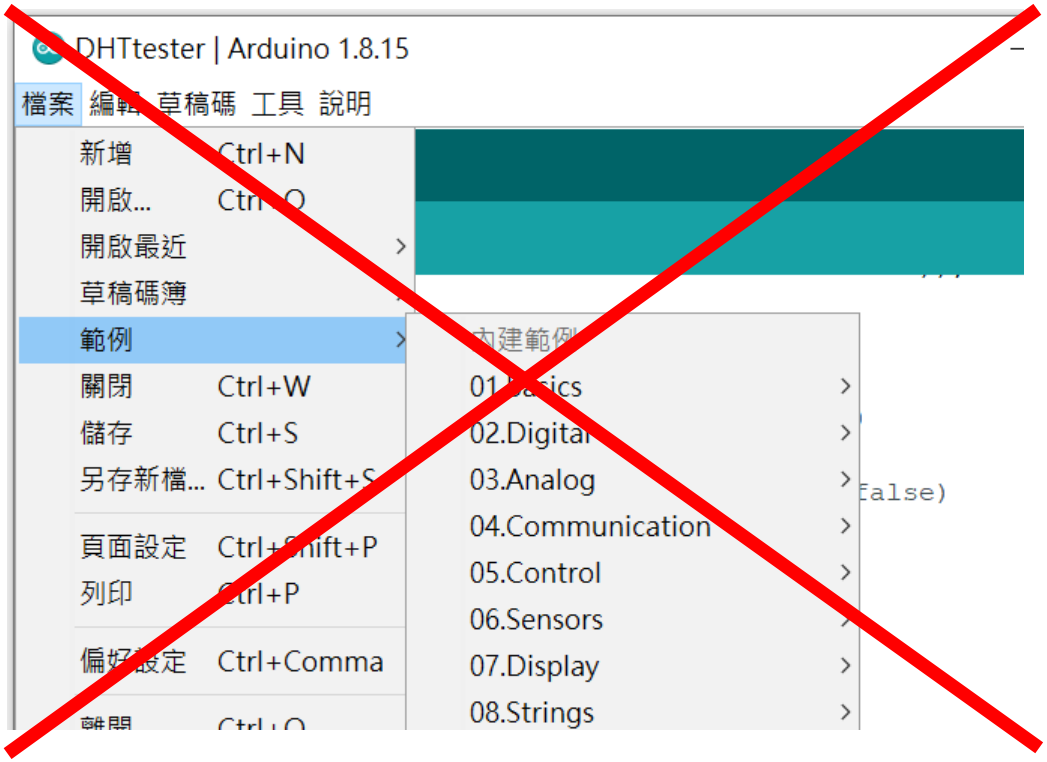




Lab3. ESP-01

Arduino IDE

- No build-in example
- Try to write the code by yourself (Refer to the slides)



Sample code

```
#include <SoftwareSerial.h>
#define WiFi_TX 2
#define WiFi_RX 3
SoftwareSerial WiFi_Serial(WiFi_TX,WiFi_RX);

// 請輸入自己WiFi熱點的名稱
#define SSID "your_SSID"

// 請輸入自己WiFi熱點的密碼
#define PASS "your_password"

#define IP "api.thingspeak.com"
// GET /update?key=[THINGSPEAK_KEY]&field1=[data 1]&filed2=[data 2]...;

String GET = "GET /update?key=1234567890123456";
// 請將key=之後的16碼改為自己的API key
```

```
void setup() {
  Serial.begin(9600);
  WiFi_Serial.begin(115200);
  WiFi_Send("AT");                          // AT command
  delay(1000);
  if(WiFi_Serial.find("OK")){
    Serial.println("RECEIVED: OK");
    WiFi_Send("AT+CIPMUX=0");               //設定為單連線型態
    delay(1000);
    if(WiFi_Serial.find("OK")){
      Serial.println("RECEIVED: OK");
    }

    while(!connectWiFi());                  //將Wi-Fi模組連上可連至外網的Wi-Fi AP
  }
  else{
    Serial.println("NO RESPONSE!");         // Wi-Fi模組沒有回應
  }
}
```

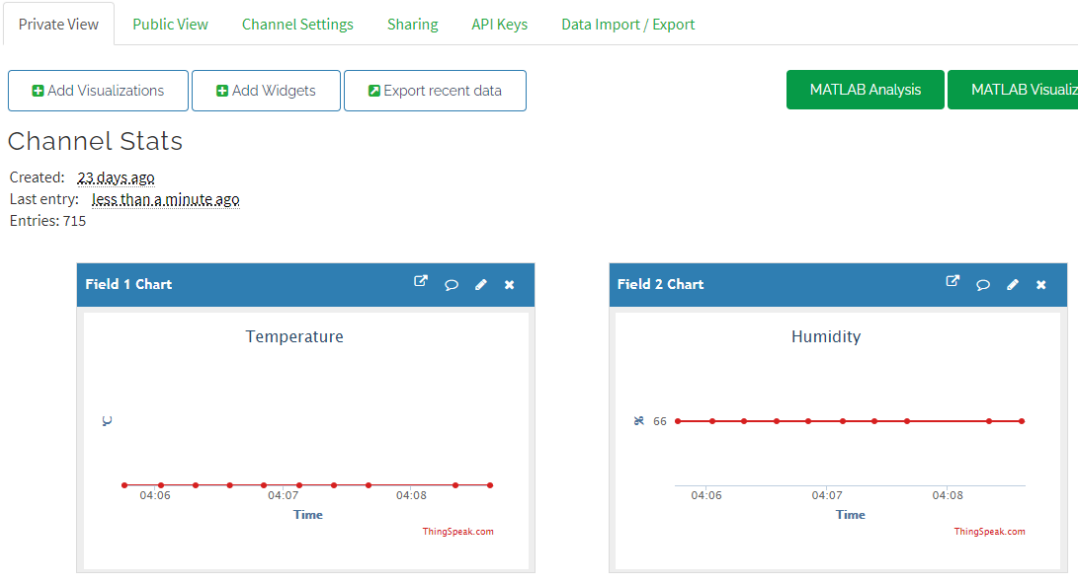
```
boolean connectWiFi(){
  WiFi_Serial.println("AT+CWMODE=1");       //WiFi 應用型態為Station型態
  delay(1000);
  String cmd="AT+CWJAP=\"";                 //輸入WiFi帳密, 與WiFi AP連線
  cmd+=SSID;
  cmd+="\",\"";
  cmd+=PASS;
  cmd+="\"";
  WiFi_Send(cmd);
  delay(1000);
  if(WiFi_Serial.find("OK")){
    Serial.println("RECEIVED: OK");
    return true;
  }
  else{
    Serial.println("RECEIVED: Error");
    return false;
  }
}
```

```
void loop() {
  double Hum = 66;                                  // 假設一個濕度數值
  double Temp = 20.5;                               // 假設一個溫度數值
  if (isnan(Hum)||isnan(Temp)){                     // 如果溫濕度值不存在
    Serial.println("Failed to read from DHT sensor!");
    return;
  }

  else{
    String HH,TT;
    HH=String(Hum);                 //將濕度值轉換成字串型態的資料
    TT=String(Temp);                //將溫度值轉換成字串型態的資料

    updateDHT11(TT,HH);             //將溫濕度資料傳至雲端平台

    Serial.print("Humidity: ");
    Serial.print( HH );
    Serial.print(" %\t");
    Serial.print("Temperature: ");
    Serial.print( TT );
    Serial.println(" *C\t");
  }
  delay(5000);
}
```

```
void updateDHT11(String T, String H){
  String cmd = "AT+CIPSTART=\"TCP\",\"";     //建立TCP連線
  cmd += IP;
  cmd += "\",80";
  WiFi_Send(cmd);
  delay(1000);
  if(WiFi_Serial.find("ERROR")){
    Serial.println("RECEIVED: TCP Connect Error");
    return;
  }
  cmd = GET + "&field1=" + T + "&field2=" + H +"\r\n";
  WiFi_Serial.print("AT+CIPSEND=");              //傳送資料的指令
  WiFi_Serial.println(cmd.length());            //資料的長度
```

```
 if(WiFi_Serial.find(">")){            //確定WiFi模組有接收到指令
   Serial.print(">");
   Serial.print(cmd);
   WiFi_Serial.print(cmd);            //傳送資料
   delay(1000);
   if(WiFi_Serial.find("OK")){
     Serial.println("RECEIVED: SEND OK");
   }
   else{
     Serial.println( "RECEIVED: SEND Error_2" );
   }
 }
 else{
   Serial.println( "RECEIVED: SEND Error" );
 }
}

void WiFi_Send(String cmd){
 Serial.print("SEND: ");
 WiFi_Serial.println(cmd);
 Serial.println(cmd);
}
```

Results


Private View
Public View
Channel Settings
Sharing
API Keys
Data Import / Export
Add Visualizations
Add Widgets
Export recent data
MATLAB Analysis
MATLAB Visualiz
Channel Stats
Created: 23 days ago
Last entry: less than a minute ago
Entries: 715
Field 1 Chart
Temperature
04:06
04:07
04:08
Time
ThingSpeak.com
Field 2 Chart
Humidity
66
04:06
04:07
04:08
Time
ThingSpeak.com

COM34
SEND: AT
RECEIVED: OK
SEND: AT+CIPMUX=0
SEND: AT+CWJAP="Neil_2","09121021"
RECEIVED: OK
SEND: AT+CIPSTART="TCP","api.thingspeak.com",80
RECEIVED: SEND Error
Humidity: 66.00 % Temperature: 20.50 *C
SEND: AT+CIPSTART="TCP","api.thingspeak.com",80
>GET /update?key=U5RQ8FIUOS89J7RK&field1=20.50&field2=66.00
RECEIVED: SEND OK
Humidity: 66.00 % Temperature: 20.50 *C
SEND: AT+CIPSTART="TCP","api.thingspeak.com",80
>GET /update?key=U5RQ8FIUOS89J7RK&field1=20.50&field2=66.00
RECEIVED: SEND OK
Humidity: 66.00 % Temperature: 20.50 *C
SEND: AT+CIPSTART="TCP","api.thingspeak.com",80
>GET /update?key=U5RQ8FIUOS89J7RK&field1=20.50&field2=66.00
RECEIVED: SEND OK
Humidity: 66.00 % Temperature: 20.50 *C
SEND: AT+CIPSTART="TCP","api.thingspeak.com",80
>GET /update?key=U5RQ8FIUOS89J7RK&field1=20.50&field2=66.00
RECEIVED: SEND OK
Humidity: 66.00 % Temperature: 20.50 *C
SEND: AT+CIPSTART="TCP","api.thingspeak.com",80
>GET /update?key=U5RQ8FIUOS89J7RK&field1=20.50&field2=66.00
RECEIVED: SEND OK
Humidity: 66.00 % Temperature: 20.50 *C

ESP-01 WIFI 工作流程

- AT // AT command
- AT+CIPMUX=0 // Configures the multiple connections mode
- AT+CWMODE=1 // Set Station mode
- AT+CWJAP=SSID+PW // Access to the internet by WiFi (set SSID and PW)
- AT+CIPSTART=TCP... // Establishes TCP Connection, UDP Transmission or SSL Connection
- AT+CIPSTART=<type>,<remote IP>,<remote port>[,<TCP keep alive>]
- AT+CIPSEND=cmd.length() // Sends Data with single connection (+CIPMUX=0)

- 已知問題:
  - 不建議使用iphone熱點分享 (無法連線)
  - 請勿使用NYCU校園wifi (需要瀏覽器認證)

ESP8266 AT 指令
https://iottalk.vip/static/iottalk/01/ESP8266UsersGuide.pdf
https://www.espressif.com/sites/default/files/documentation/4a-esp8266_at_instruction_set_en.pdf

Quiz 3

- We use dust sensor, water level sensor and Wi-Fi module today
- Send the sensing value from dust sensor and water level sensor to ThingSpeak
  - In the sample code, the sensing value is a fixed number
  - Replace it with sensing value

```
void loop() {
  double Hum = 66;                    // 假設濕度數值
  double Temp = 20.5;                 // 假設溫度數值
```

Summary

Summary

- **“請記得填寫”教室座位實聯制**
  - https://docs.google.com/spreadsheets/d/1k4q-JP9Pk9cLGY70V04Nbc6XbUbBdYu_TXqJtHF6rGk
- **Practice Labs by yourself**
- **Write Answers for Discussion**
  - Upload to e3 before next class
- **Quiz: Write code for quiz, then demonstrate to TAs**
  - Quiz 1. Air monitor with color notification
  - Quiz 2. Imitate a water pump
  - Quiz 3. Send the sensing data to ThingSpeak