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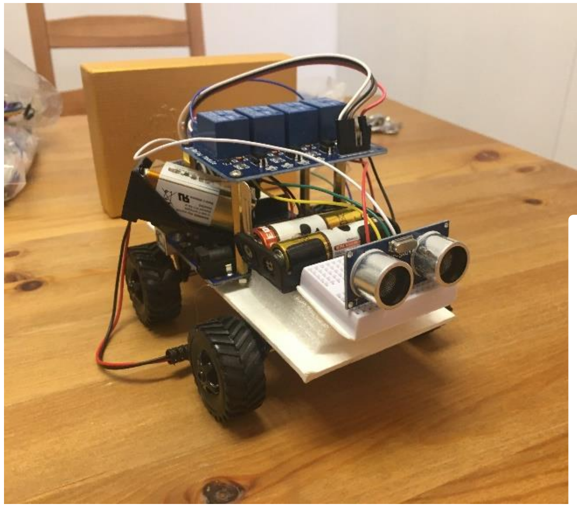

FACULTY OF LIBERAL ARTS AND SOCIAL SCIENCES
博文及社會科學學院

科學與環境學系
Department of Science
and Environmental Studies

ARDUINO WORKSHOP

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The Department of Science and Environmental Studies
The Education University of Hong Kong

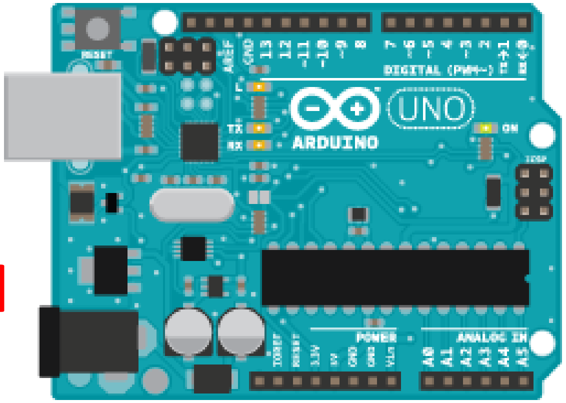
University-School Support Program

Promoting STEM Education using Self-directed Learning as Strategy

Workshop rundown

- **Introduction to Arduino**
- **Operation of Arduino**
- **Part A** – C++ syntax for Arduino coding
- **Part B** – Switch on an LED with simple circuit and coding
  以簡單電路及編碼開啓LED
- **Part C** – Sensors for Arduino, Arduino 感測器
- **Part D** – Controlling motors by Arduino, 以 Arduino 控制馬達
- **Part E** – Arduino as controller by coding with “if”
  以Arduino及”if”編碼作控制器
- **Part F** – Building Smart Devices for the Elderly
  設計長者智能裝置
- **Part G** – Liquid Crystal Display (LCD) as output
  以液晶體顯示屏輸出數據

Arduino microcontroller (微控制器)



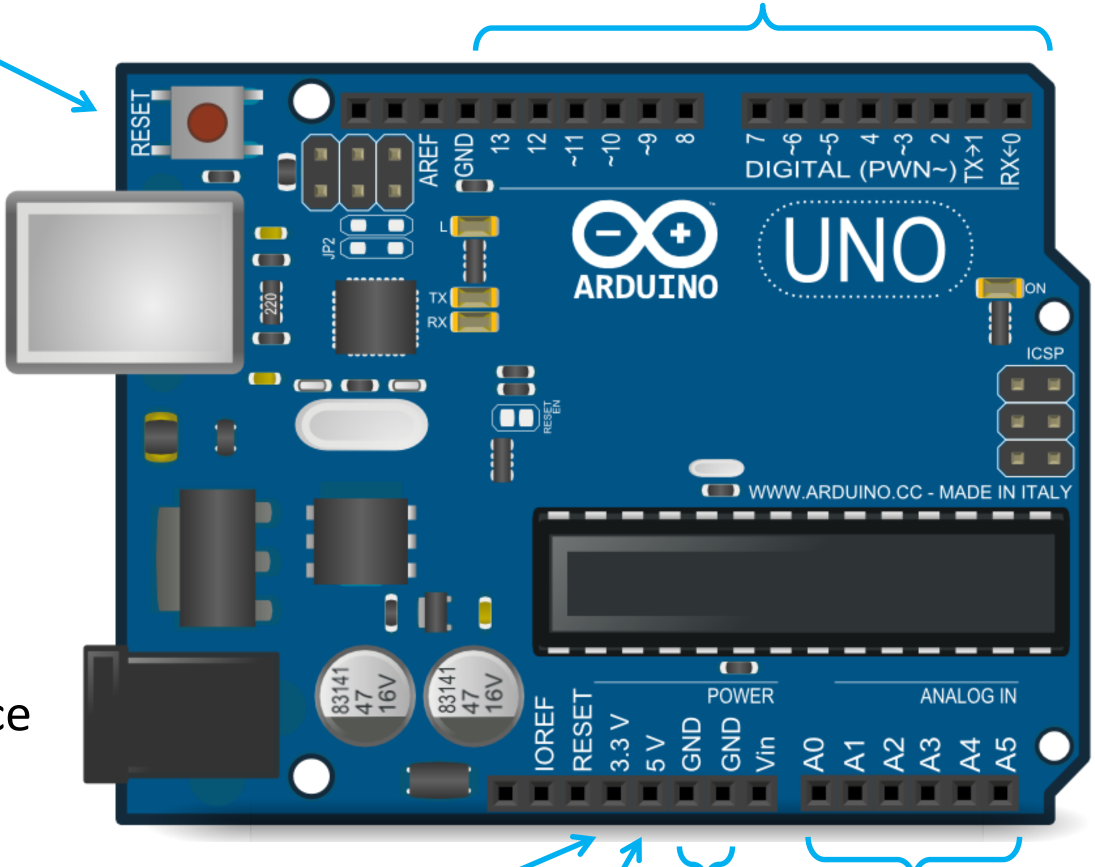
- An **open-source** (開放原始碼) electronics platform based on easy-to-use hardware and software
- A (i) **programmable**, and (ii) **single-board microcontroller** which

1. **reads** inputs, e.g. sensor readings, button states,
2. **processes** the inputs based on instructions, e.g. check with codes and conditions
3. **produces** outputs, e.g. to turn on an LED, activate a motor

- Connection to different hardware - by simple **wiring** (電路)
- Instruction implementation - by the **Arduino Software IDE (**Arduino IDE 軟件**)** and simple programming language

Arduino microcontroller

- The structure on the “**Arduino Uno**” board:



14 digital input and output pins, i.e. high or low

Reset button

USB receptacle

Power source

3V power

5V power

Ground

6 analog inputs
e.g. reading voltage

Photo credit:

Part A - C++ syntax for Arduino Coding

- Arduino IDE software uses **C++** as the coding language
- Nevertheless, there are some functions, e.g. **setup(), loop(),** which are introduced in Arduino IDE but not in other C++ applications
- **Different variable type** in C++:

syntax	Variable types
int	Integer variables e.g. -1, 0, 1
float	Point type variables
double	Point types variables (double precision)
bool	boolean variables (true or false, 1 or 0)
void	a type of function without “return;”

Arduino program structure:

```
void setup() {
        ....
}
```

(initialization)

```
void loop() {
        ....
}
```

(repeating procedures)

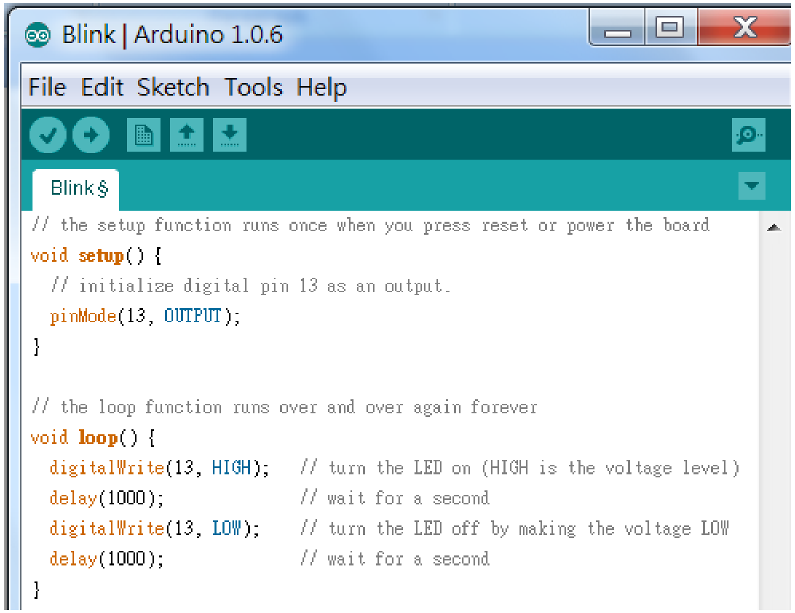
Example to **set up new variables**:

```
int count;
count = 0;
```

Part B - Switching on an LED (開啓LED)

1. Connect the Arduino board to a computer by a USB cable
2. Open “**Device manager**” and **check the port** of the Arduino
3. Open the **Arduino software (IDE)** in “Tools” then “Serial port”, and select the correct port
4. In “Tools” and then “Board”, select the correct board (we are now using “Arduino Uno”)
5. Go to “File” → “Examples” → “Basics” → “Blink” to open examplar file “blink.ino”

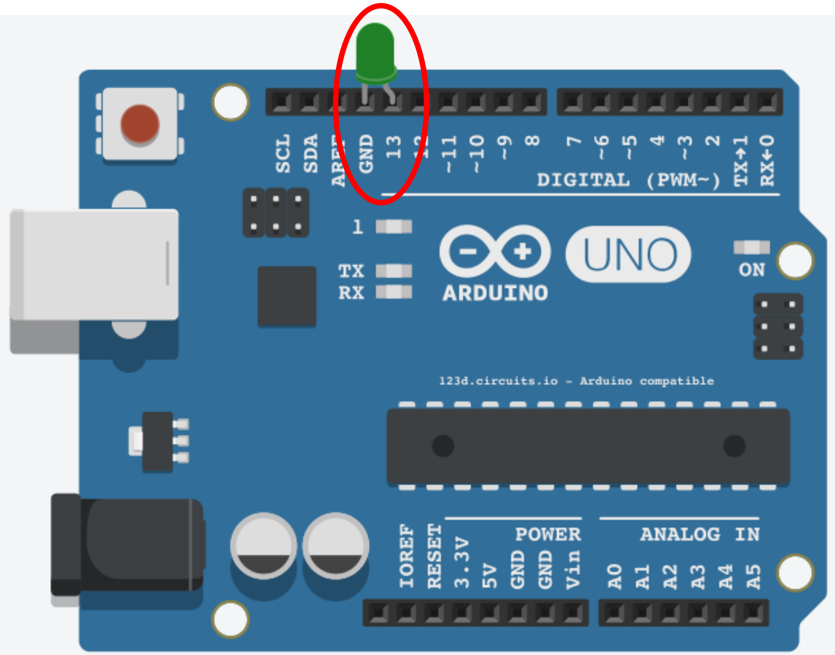
```
void setup() {
        pinMode(13, OUTPUT);
}
void loop() {
        digitalWrite(13, HIGH);
        delay(1000);
        digitalWrite(13, LOW);
        delay(1000);
}
```



```
// the setup function runs once when you press reset or power the board
void setup() {
  // initialize digital pin 13 as an output.
  pinMode(13, OUTPUT);
}

// the loop function runs over and over again forever
void loop() {
  digitalWrite(13, HIGH);   // turn the LED on (HIGH is the voltage level)
  delay(1000);              // wait for a second
  digitalWrite(13, LOW);    // turn the LED off by making the voltage LOW
  delay(1000);              // wait for a second
}
```

Switching an LED (2)

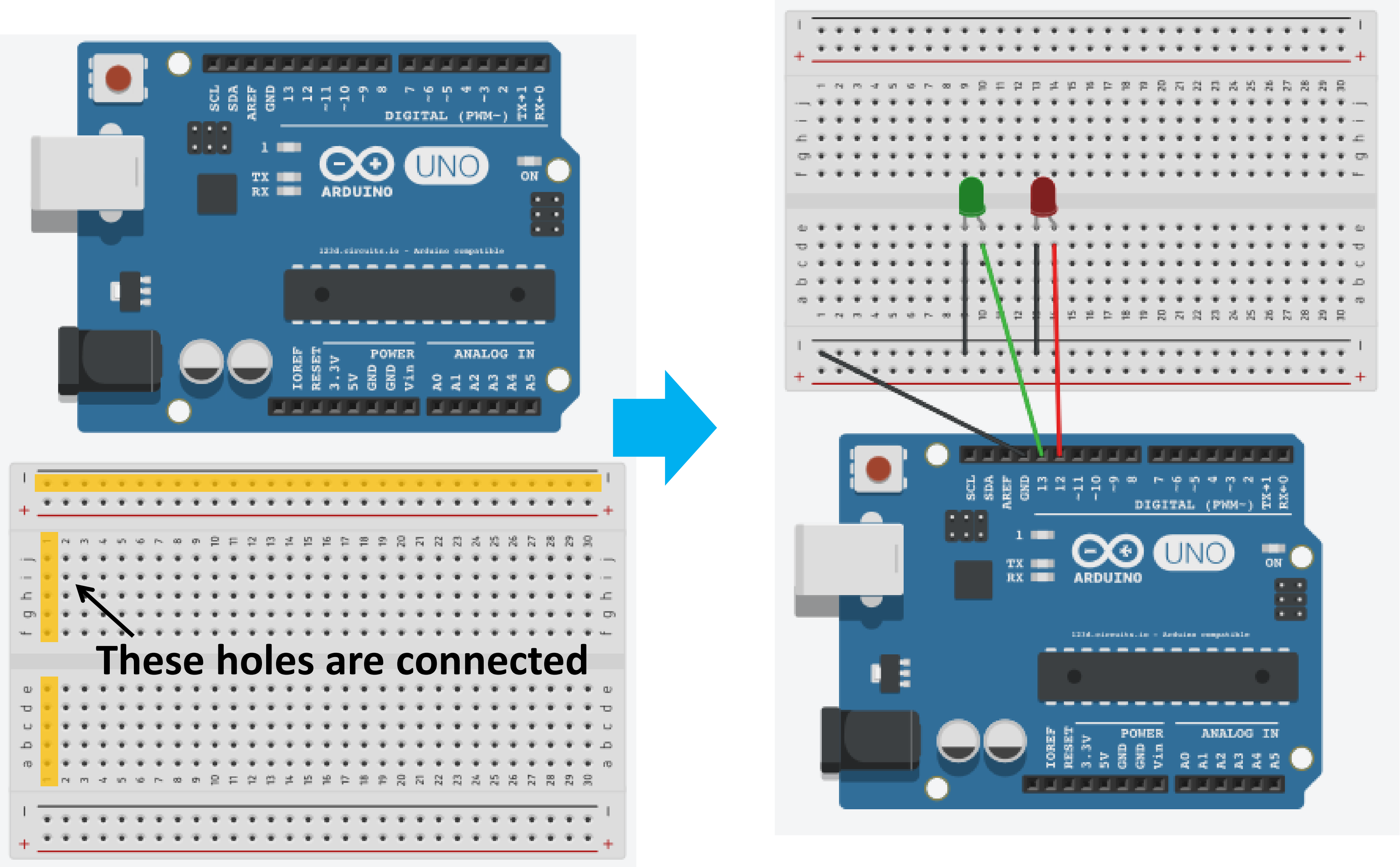
6. Click the **tick** ✓ , the program is checked (compiled)
7. If there is no problem, click the **arrow** ➔ , the program is uploaded to the broad
8. What do you observe for the on-board orange LED?
9. Connect the positive and the negative terminal of a **Green LED** to pin 13 and the ground pin respectively, what do you observe?



Exercise

1. Extend the on-state of the Green LED light to 3s
2. Construct a simple system which simulate the traffic light for pedestrian

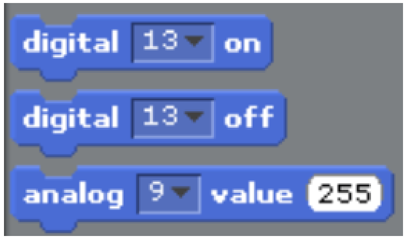
Breadboard (麵包板)



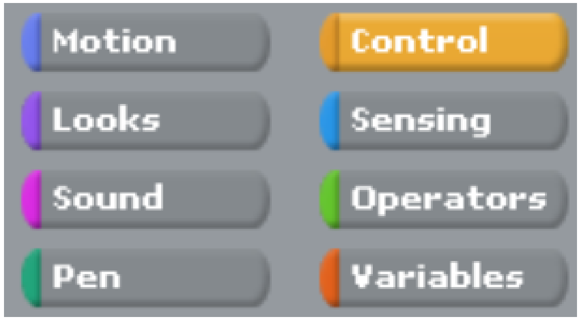
These holes are connected

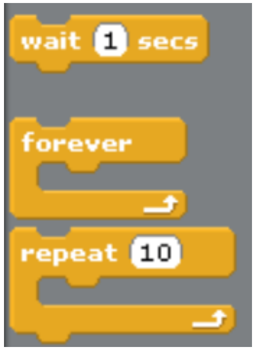
S4A and ArduBlock

- **S4A** is a platform modified from **Scratch** - a graphical programming language developed by MIT which is suitable for youngsters to learn programming
- Another other common block-programming software for Arduino is called **ArduBlock**
- Although script coding is most fundamental, many codes can also be written in S4A and ArduBlock

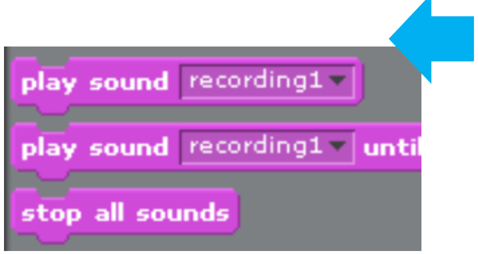


digital 13 on
digital 13 off
analog 9 value 255

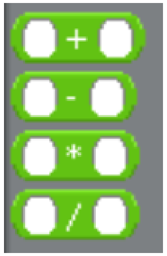




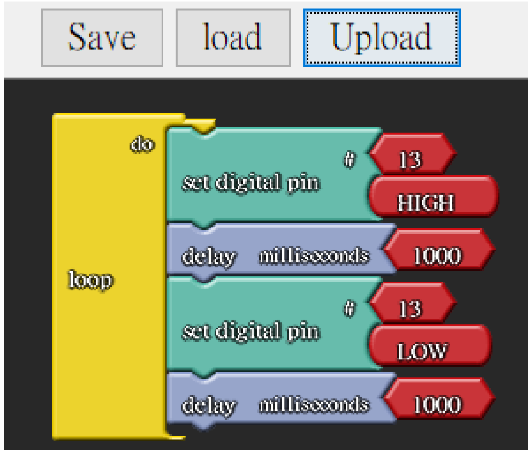
wait 1 secs
forever
repeat 10



play sound recording1
play sound recording1 until
stop all sounds



To upload codes to Arduino, one can use ArduBlock

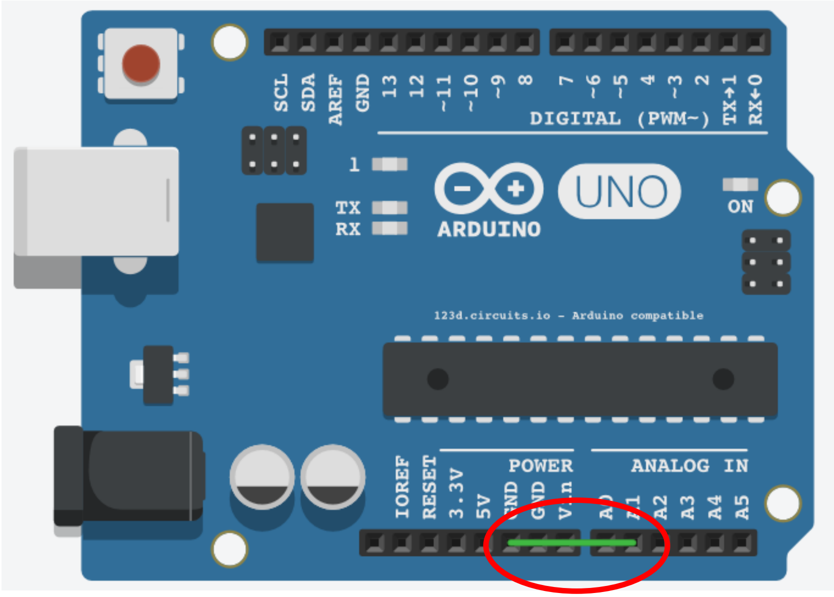


loop do
set digital pin # 13 HIGH
delay milliseconds 1000
set digital pin # 13 LOW
delay milliseconds 1000

Reading data (輸出數據)

- Next, we will use the following code to read data from the Arduino

```
void setup(){
  Serial.begin(9600);
}

void loop(){
   double reading = analogRead(1);
   Serial.print(reading);
   Serial.print("\n");
   delay(2000);
}
```

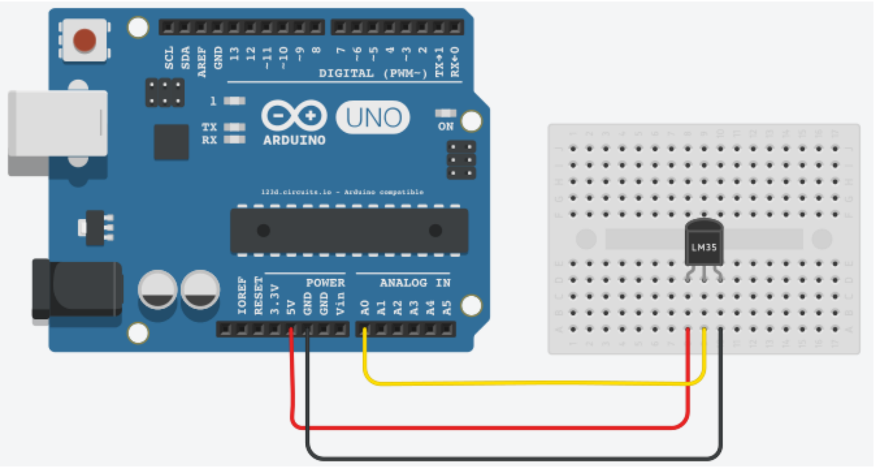


Analog input is a high impedance input, almost draw no current

- **Connect analog pin 1 to the GND pin**, as shown below
- Open “Tools” → “Serial monitor”; observation: ____
- How about **connecting analog pin 1 to the 5V pin**? _______

Part C – Sensor 1: Temperature by LM35

- To measure **temperature,** we can use sensor **LM35**
- Connect the circuit on the left:



- This code displays the sensed temperature in the serial monitor (“Tools”→“Serial Monitor”)

```
void setup(){
                pinMode(0, INPUT);
                Serial.begin(9600);
}
void loop(){
                float temperature =  (analogRead(0)*500.0) / 1024;
                Serial.println(temperature);
                delay(1000);            // output data every second (i.e. 1000ms)
}
```

Sensor 2: Temperature, Humidity by DHT 11

- To measure **temperature and humidity**, we can use **DHT11**
- To use DHT11 sensor, a "**DHT11 library**" has to be installed
- A "**library**" usually include one **.cpp** and one **.h** (header) file, which are useful functions of the sensor
- **Example**: (1) download dht11.cpp and dht11.h from the hyperlink below, (2) go to "My document/Arduino/libraries" (3) create a folder "dht11" and put the .cpp and .h files into the folder

DHT11 library:
http://playground.arduino.cc/Main/DHT11Lib

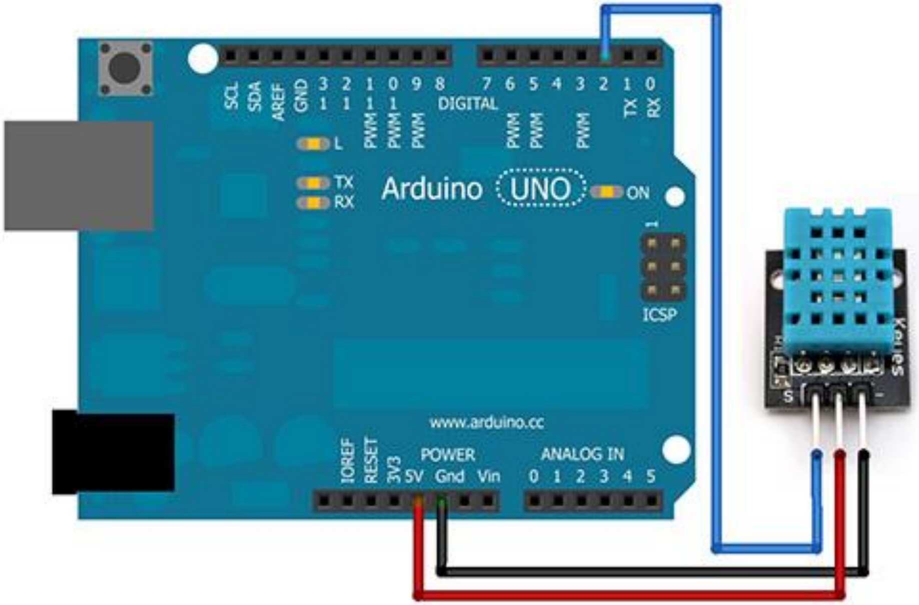


Figure: chioszrobots.com

Temperature and humidity (2)

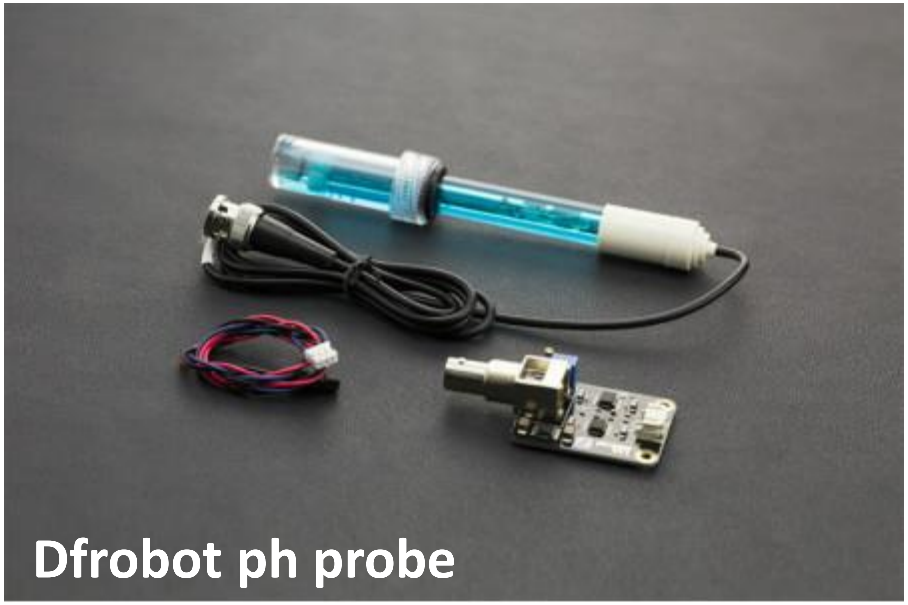
- The following code measures **temperature and humidity by DHT11**

```
#include <dht11.h>
dht11 DHT11;

void setup(){
  Serial.begin(9600);
  DHT11.read(2);  // input at pin 2
}

void loop(){
  Serial.print("Humidity (%): ");
  Serial.print((float)DHT11.humidity, 2);  // to 2 decimal places

  Serial.print("\t Temperature (Deg.): ");
  Serial.println((float)DHT11.temperature, 2);
  delay(2000);
}
```

STEM Challenges: Building a Ph meter

- We will use a **dfrobot ph probe, Arduino**, and **linear equations** in mathematics to construct a Ph meter
- The dfrobot ph probe produces **a roughly linear response** of output voltage as a function of the ph value of the solution
- Connect the ph probe to the Arduino board as follow:

GND → GND, VCC → 5V, Signal → any analog input



Dfrobot ph probe

Calibration

- The code below output the reading of the ph probe on the serial monitor at every 2s interval:

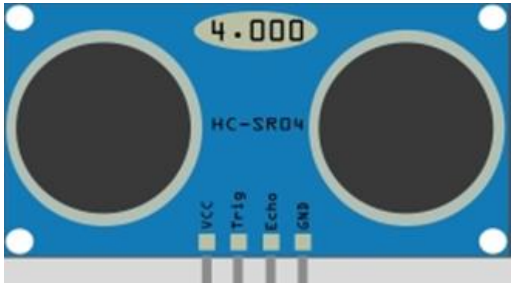
```
int tempin = 3;
void setup() {
  Serial.begin(9600);
  pinMode(tempin, INPUT);
}

void loop() {
  Serial.println(analogRead(tempin));
  delay(2000);
}
```

Challenges

1. Use two solutions with known ph values to calibrate the probe, and convert the reading of the probe into ph values (the formula of **linear equation** has to be applied)
2. Use the probe to measure the ph value of an unknown solution

Sensor 3 - Measuring distance (1)

- To measure **distance**, we can use **ultrasonic sensor HC-SR04 (超聲波距離感測器)**, which consists of one emitter and one receiver of ultrasound
- The **4 pins** of HC-SR04 are as follows:
- Connect the following circuit:



GND – ground pin

Echo – output the signal received at reception

Trigger – trigger the pulse emission

VCC – voltage supply

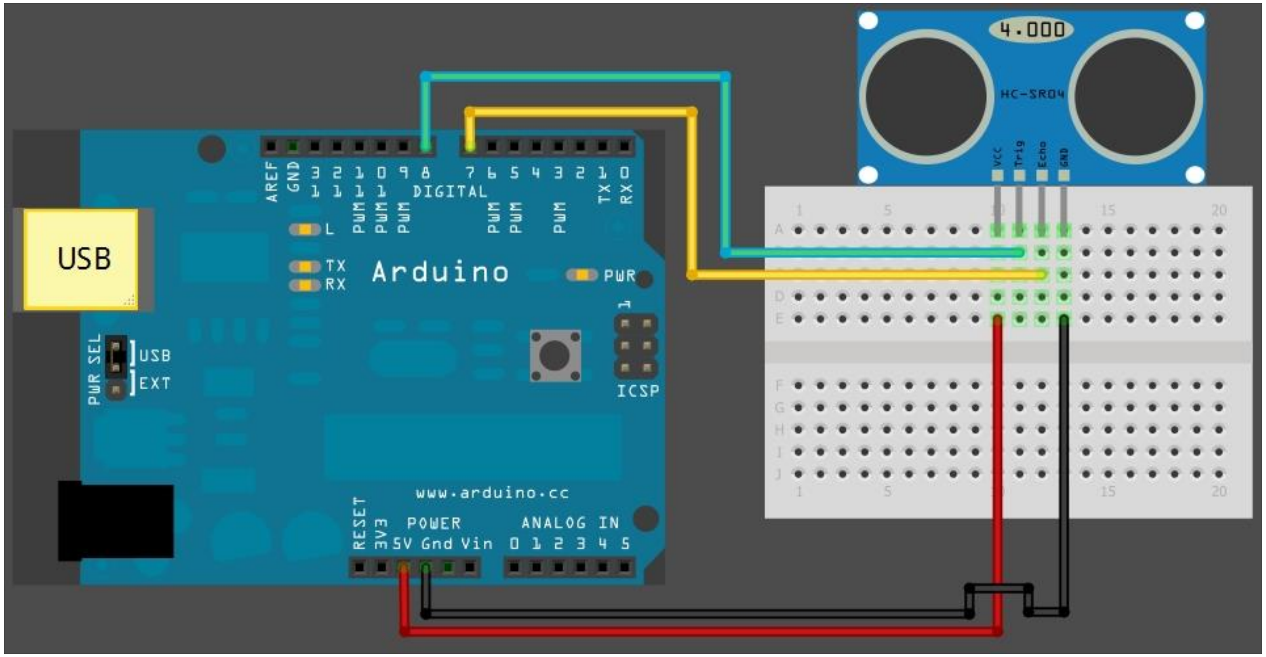


Figure: http://arduinobasics.blogspot.hk/2012/11/arduinobasics-hc-sr04-ultrasonic-sensor.html

Measuring distance (2)

- The following codes **measure distance** of an object by SR04:

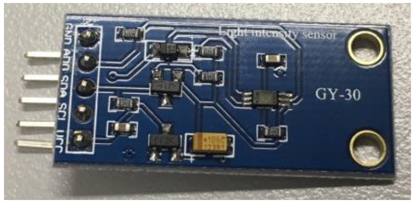
```
int trigPin = 8;
int echoPin = 7;
long duration, distance;

void setup() {
 Serial.begin (9600);
 pinMode(trigPin, OUTPUT);
 pinMode(echoPin, INPUT);
}
```

```
void loop() {
digitalWrite(trigPin, LOW);
 delayMicroseconds(2);

 digitalWrite(trigPin, HIGH);
 delayMicroseconds(10);

 digitalWrite(trigPin, LOW);
 duration = pulseIn(echoPin, HIGH);

 //Calculate the distance (in cm) based on sound speed
 distance = duration/58.2;
 Serial.println(distance);

 //Delay 0.5s before next reading.
 delay(500);
}
```

Exercise: Output the speed of a moving object using SR04

Sensor 4 – Light intensity sensor

- To measure **light intensity**, we can use **GY30**, which measures light intensity in **LUX level**



- To use GY30, the library **BH1750.h** is required
- GY30 uses **I^2C communication mode** on Arduino, where the following connection has to be made

GND → GND, VCC → 5V
SDA (dataline), SDL (clockline):

Board	**I2C / TWI pins**
Uno, Ethernet	SDA → A4 SCL → A5
Mega2560	SDA → A20 SCL → A21
Leonardo	SDA → A2 SCL → A3

This codes output the LUX level sensed by GY30:

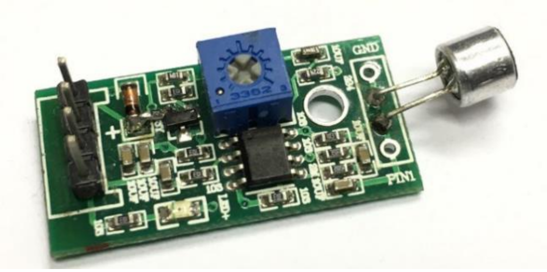
```
#include <Wire.h>
#include <BH1750.h>
BH1750 lightMeter;

void setup(){
  Serial.begin(9600);
  lightMeter.begin();
}

void loop() {
  uint16_t lux = lightMeter.readLightLevel();
  Serial.println(lux);
  delay(1000);
}
```

Other sensors

- **Motion sensor** (by passive infrared) – output “1” when there is a person nearby, and otherwise “0”:

```
void setup(){            // connect output to D10
        pinMode(10, INPUT);
        Serial.begin(9600);
}
void loop(){
        Serial.println((digitalRead(10));
        delay(1000);
}
```

- **Sound sensor** – output either a value of sound level, or output “1” when the sound level is larger than a threshold:

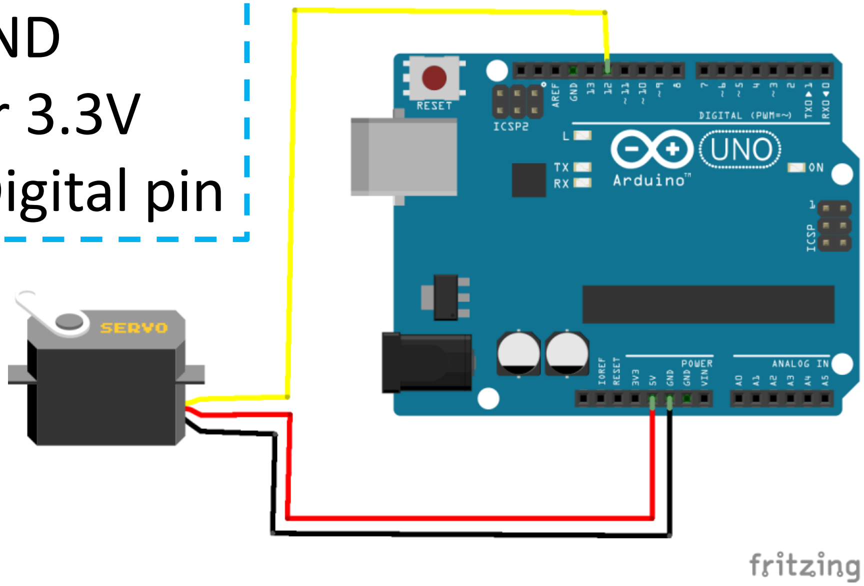


```
void setup(){            // connect output to A0
        pinMode(0, INPUT);
        Serial.begin(9600);
}
void loop(){
        Serial.println((analogRead(0));
        delay(1000);
}
```

Part D - Controlling Servomotors

- **Servomotors** are devices which can rotate to an **precise angle** according to an input signal
- To connect the servomotor to the Arduino board, connect the following circuit:

Brown → GND
Red → 5V or 3.3V
Orange → Digital pin



- To control servomotor, one can download and install the library "**Servo.h**"

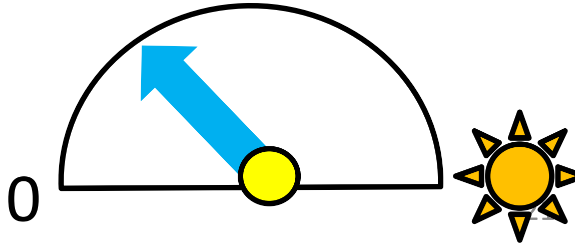
Controlling servomotors (2)

- Use these codes to **control the servomotor** and observe:

```
#include<Servo.h>
Servo servomotor1;
void setup(){           // connect the servomotor to D12
            servomotor1.attach(12);
}
void loop(){
            servomotor1.write(0);
            delay(2000);
            servomotor1.write(90);
            delay(2000);
            servomotor1.write(180);
            delay(2000);
}
```

Exercise

1. Simulate **an automatic door** which opens when it senses a person approaches
2. Construct a device to **display light intensity level** with a rotary indicator



Part E – Arduino as controller by coding with “if” 以Arduino及”if”編碼作控制器

- **Our goal**: a device which alerts a too low or a too high temperature around the classroom

- **Suggestion**: a device which

1. switches on a **green light** when temperature T < 24°
2. switches on a **red light** when temperature T > 30°

- These devices can be distributed around the classroom
- You can have **your own design**!

Build your own device!

- Code for conditional actions:

```
If(temperature < 24)
   Your action;
```

Part F - Smart Devices for the Elderly

- Use "**if … then …** " and various **sensors** and **actuators** to build the following smart devices for the elderly:

1. **Smart cane -** alerts the elderly when the cane is close an obstacle

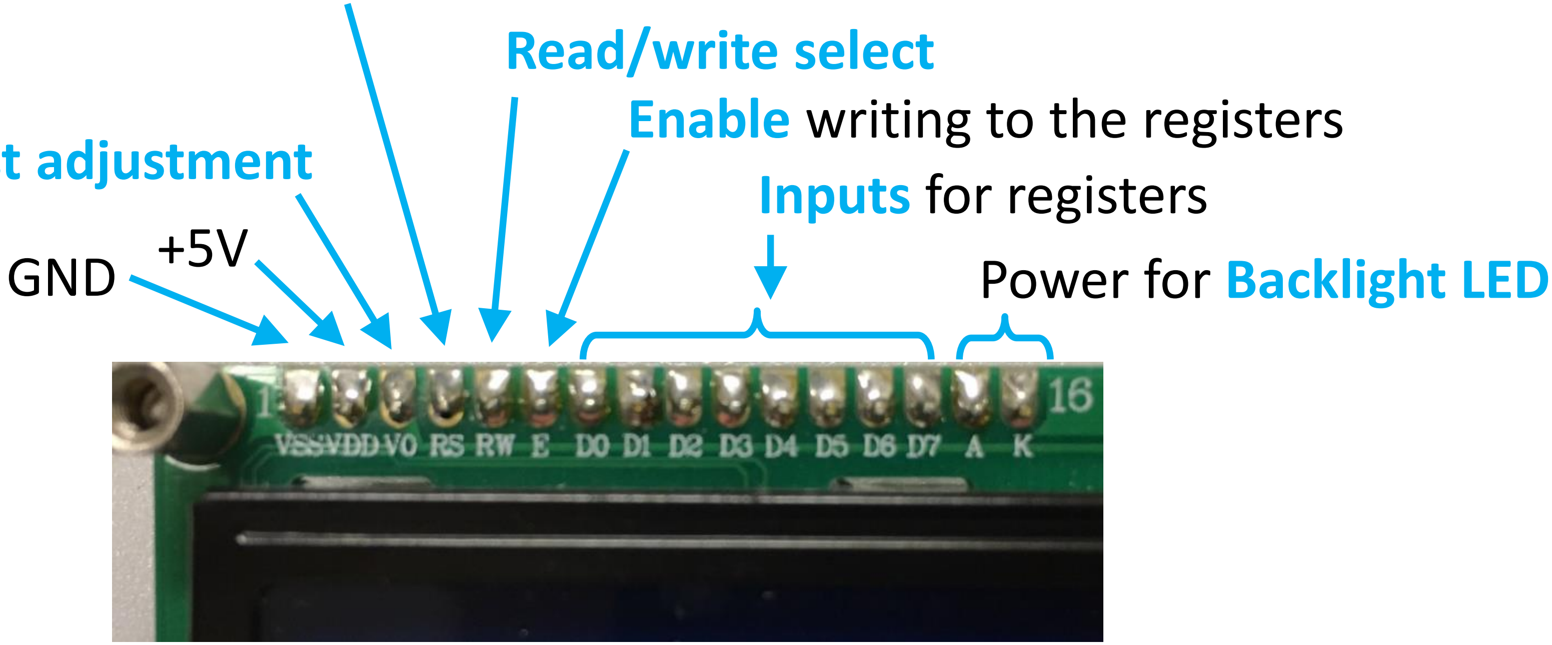
2. **Smart medicine box -** alerts the elderly and open automatically when it is the time for taking medicine

3. **Passenger counters** – counting the number of passengers on the upper deck

Part E - Liquid crystal display (液晶體顯示屏)

- After reading different physical quantities, we will learn to display them using a 1602A **liquid crystal display (LCD)**
- The screen has **2 rows**, each row can display **16 characters**, and there are 16 input pins

Register select (RS) – which can select between data registers (for screen display), or instruction register, which LCD follows instructions



Read/write select

Enable writing to the registers

Contrast adjustment

Inputs for registers

+5V

GND

Power for **Backlight LED**

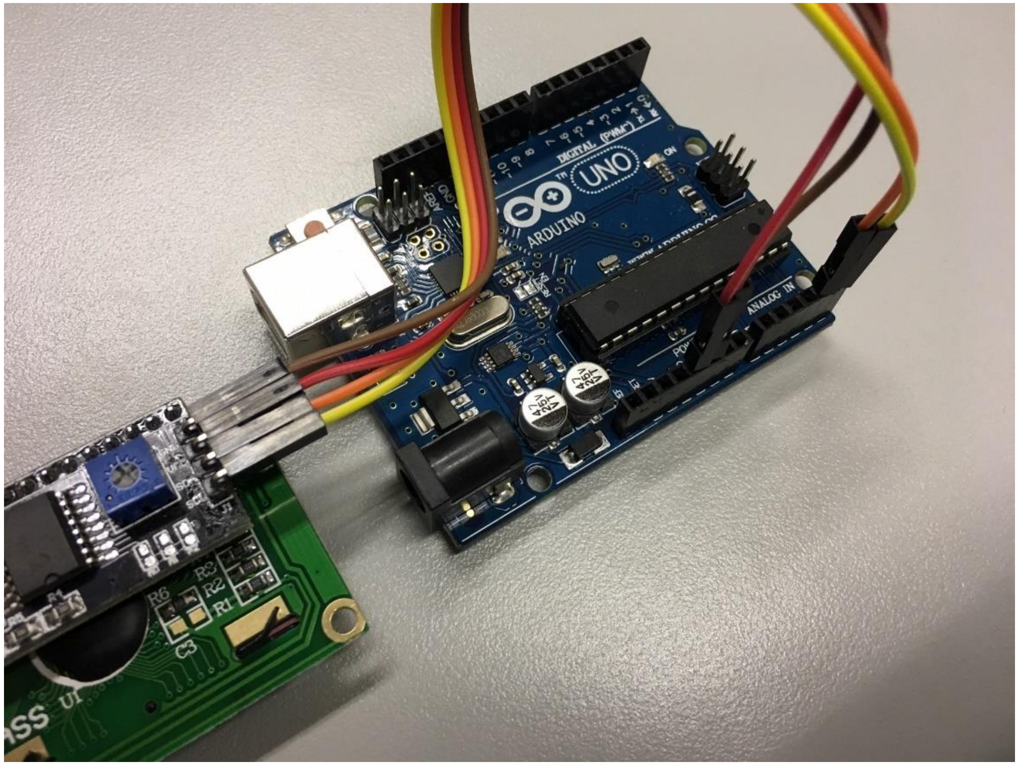
Reference: https://www.arduino.cc/en/Tutorial/HelloWorld

Liquid crystal display (2) & I^{2}C

- We will use a **communication mode** called **I^{2}C** to communicate with the LCD display; library "**Wire.h**" has to be called
- Connect the circuit below:

GND → GND
VCC → 5V

SDA (dataline):
SDL (clockline):



Board	**I2C / TWI pins**
Uno, Ethernet	SDA → A4 SCL → A5
Mega2560	SDA → A20 SCL → A21
Leonardo	SDA → A2 SCL → A3

Reference: https://www.arduino.cc/en/Reference/Wire

Liquid crystal display (3)

- The following codes display some text on the LCD display

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
// Refence: https://bitbucket.org/fmalpartida/new-liquidcrystal/downloads
LiquidCrystal_I2C lcd(0x3F, 2, 1, 0, 4, 5, 6, 7, 3, POSITIVE);  // Try either 0x27 or 0x3F

void setup() {
 lcd.begin(16, 2)     ;              // set up the LCD's number of columns and rows
 lcd.print("hello, world!");      // Print a message to the LCD.
}

void loop() {
 lcd.setCursor(0, 1);                // set the cursor to column 0, line 1
 lcd.print(millis() / 1000);       // print the number of seconds since reset:
}
```

Exercise

- Measure the temperature by LM35 and display the temperature on the screen every 1s (NOTE: lcd.print((char)223) prints the symbol °)

Summary

- We have introduced

1. The **hardware** structure of the Arduino board
2. The use of **Arduino software IDE** to incorporate simple computer programs onto the Arduino board

- Examples **Arduino-based activities** – automated traffic light, smart devices, etc.
- Several different **sensors** are introduced:

1. **LM35** – temperature sensor
2. **DHT11** – temperature and humidity sensor
3. **HC-SR04** – ultrasound distance sensor
4. **GY30** – light intensity sensor

- Others: **display data on LCD**, **relay, remote controller**

Q&A

Thank
you!!