校園發明大賽

INVENTION FOR SCHOOLS CONTEST

Basic Arduino
Arduino 入門

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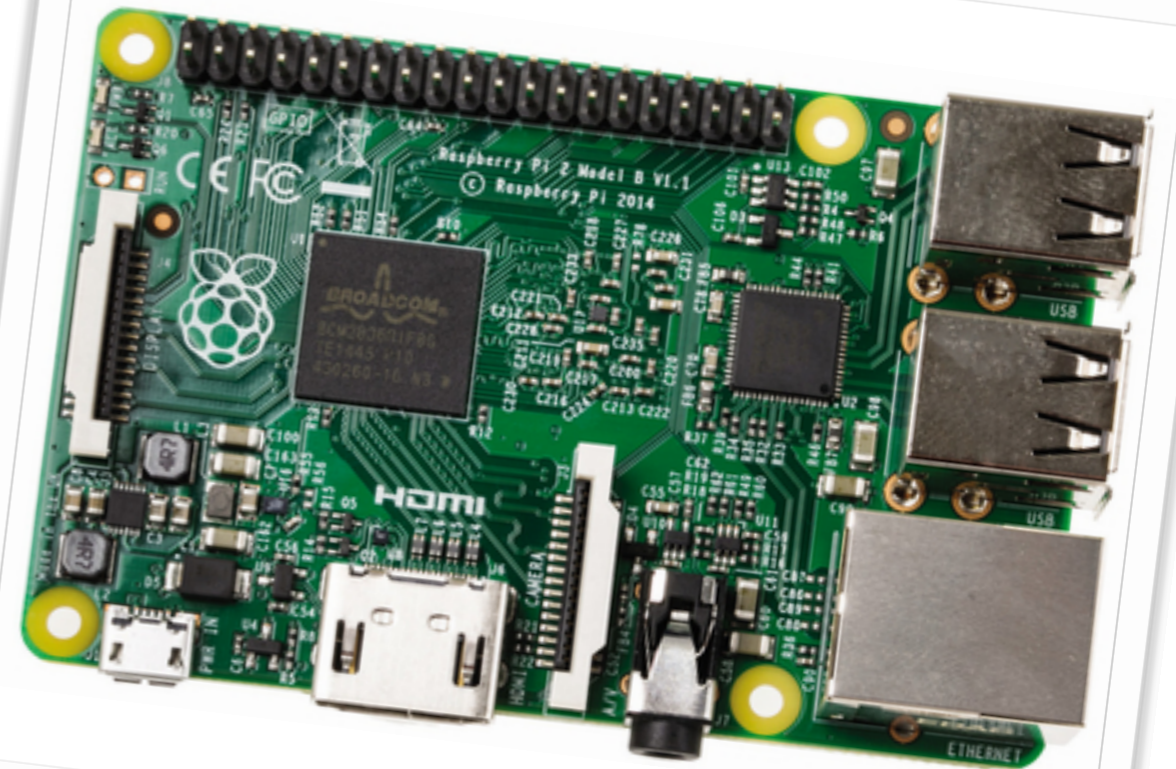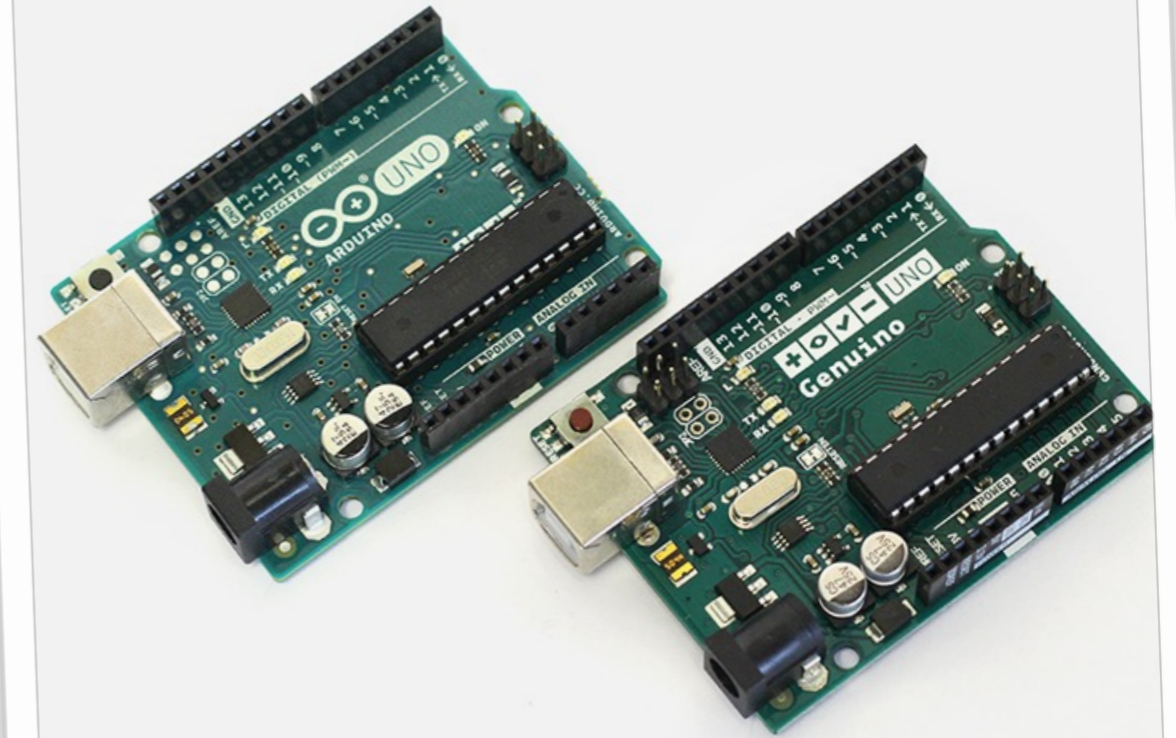香港大學工程學院 葉志立博士

Topics to cover...
內容...

- Credit-card sized computers 卡片式電腦

- Arduino: overview　Arduino 概探

- Setting up Arduino　設置 Arduino

- Software development environment for Arduino
  為 Arduino 而設的軟件開發環境

- Interfacing with the real world 與世界接軌

Credit-card sized computers

卡片式電腦

Why credit card-sized computers?
為什麼使用卡片式電腦?

- Low cost 便宜

- Small 小巧

- Portable 易攜

- Programmable 可編寫程式

- Can be used as a desktop computer
  可作桌面式電腦使用

- Can be connected to other electronic components to make different
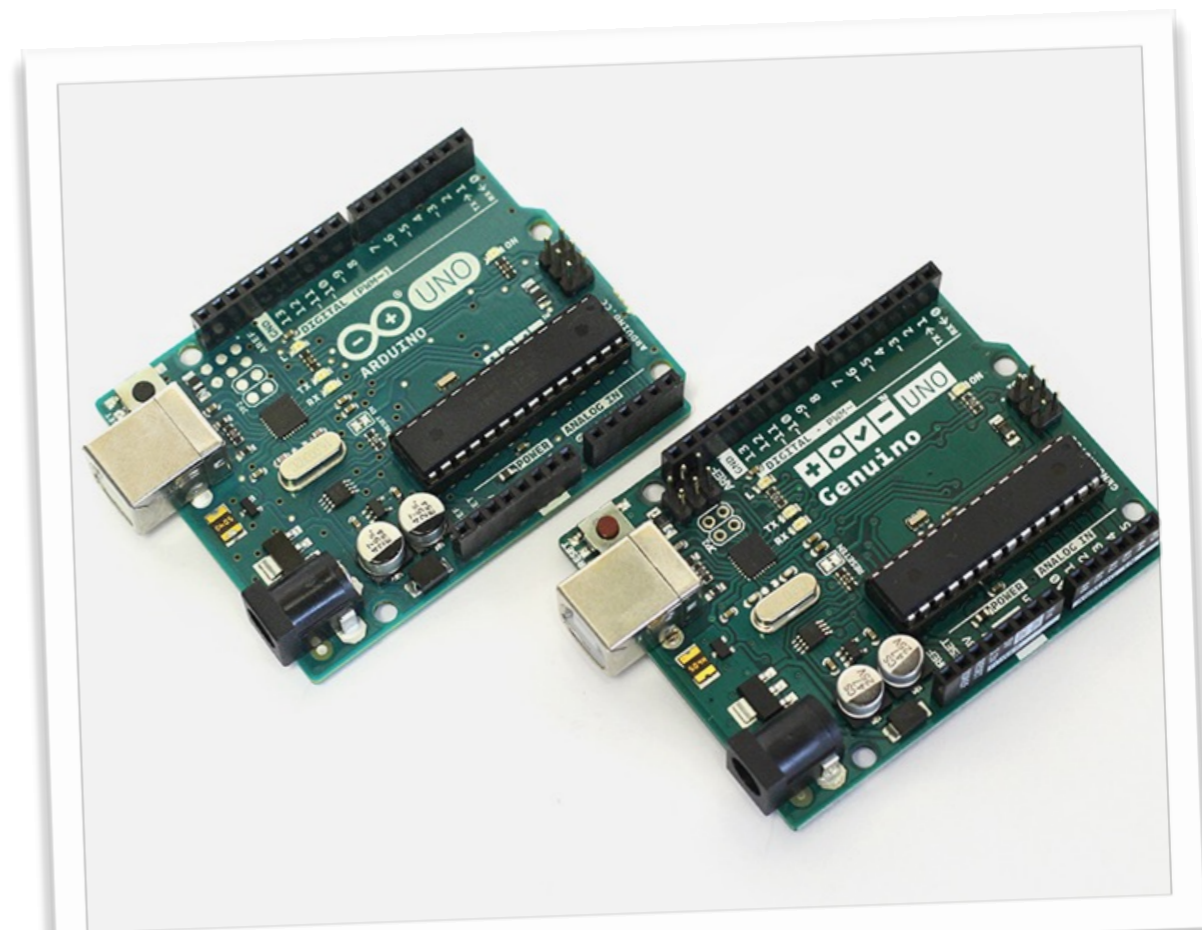 devices 可連接到其他電子零件去製作出不同的裝置

Arduino: overview

Arduino 概探

Image source:
- https://www.arduino.cc

What is Arduino?
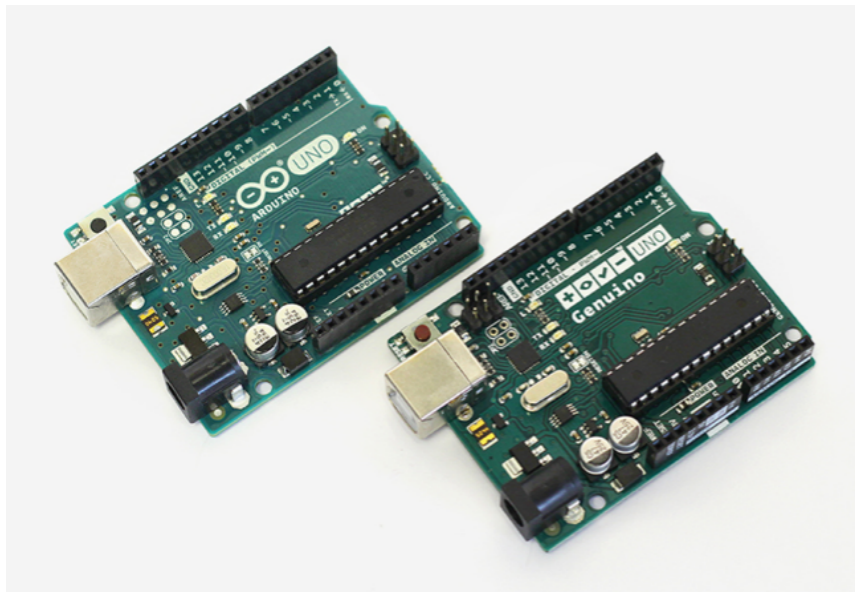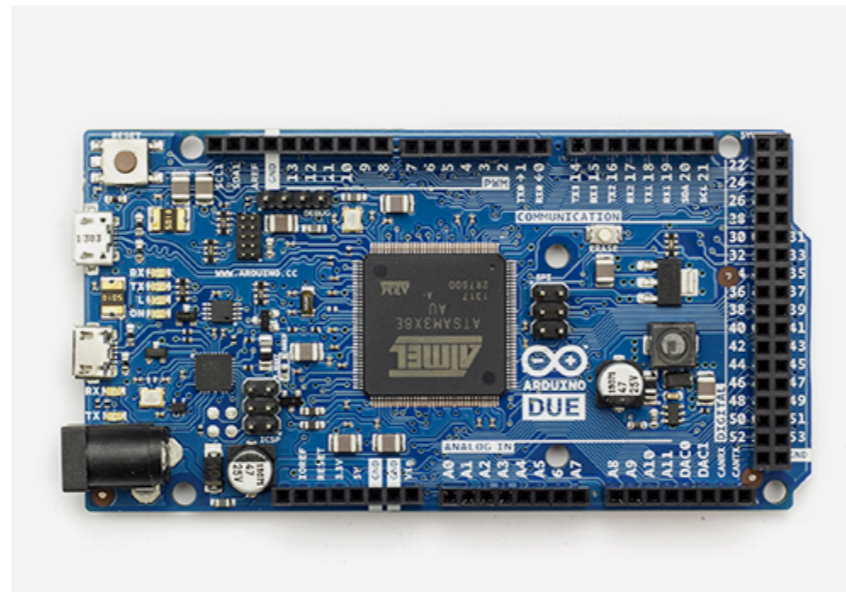# 什麼是 Arduino？

- An open-source prototype platform based on easy-to-use hardware and software.
  一套易用且建基於開放源碼平台的硬件和軟件。

- Can be connected to other electronics components to make different devices.
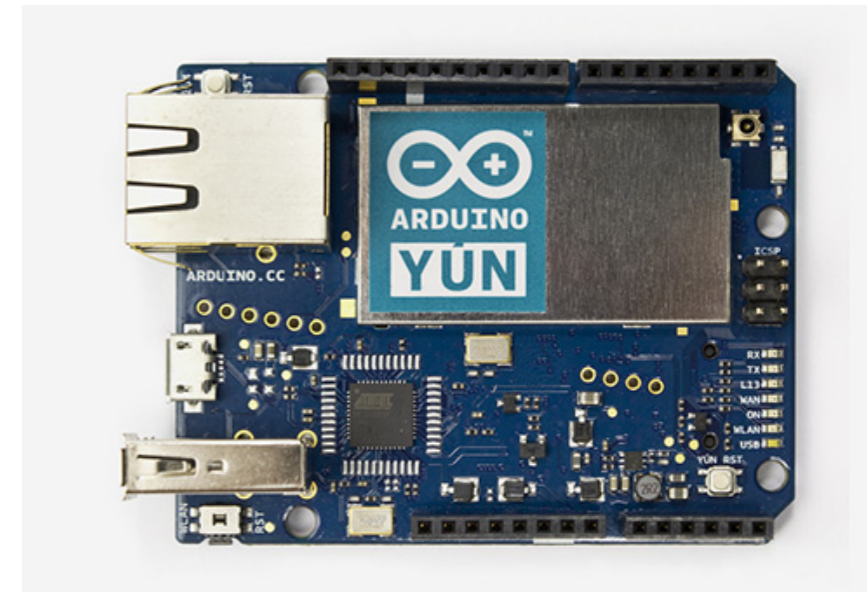 可連接到其他電子零件去製作出不同的裝置。

Some of the Arduino models
部分的 Arduino 類型
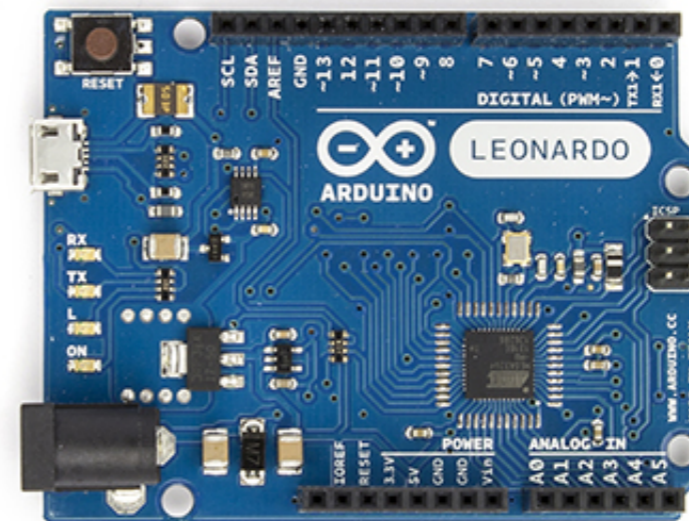

Arduino UNO / Genuino UNO
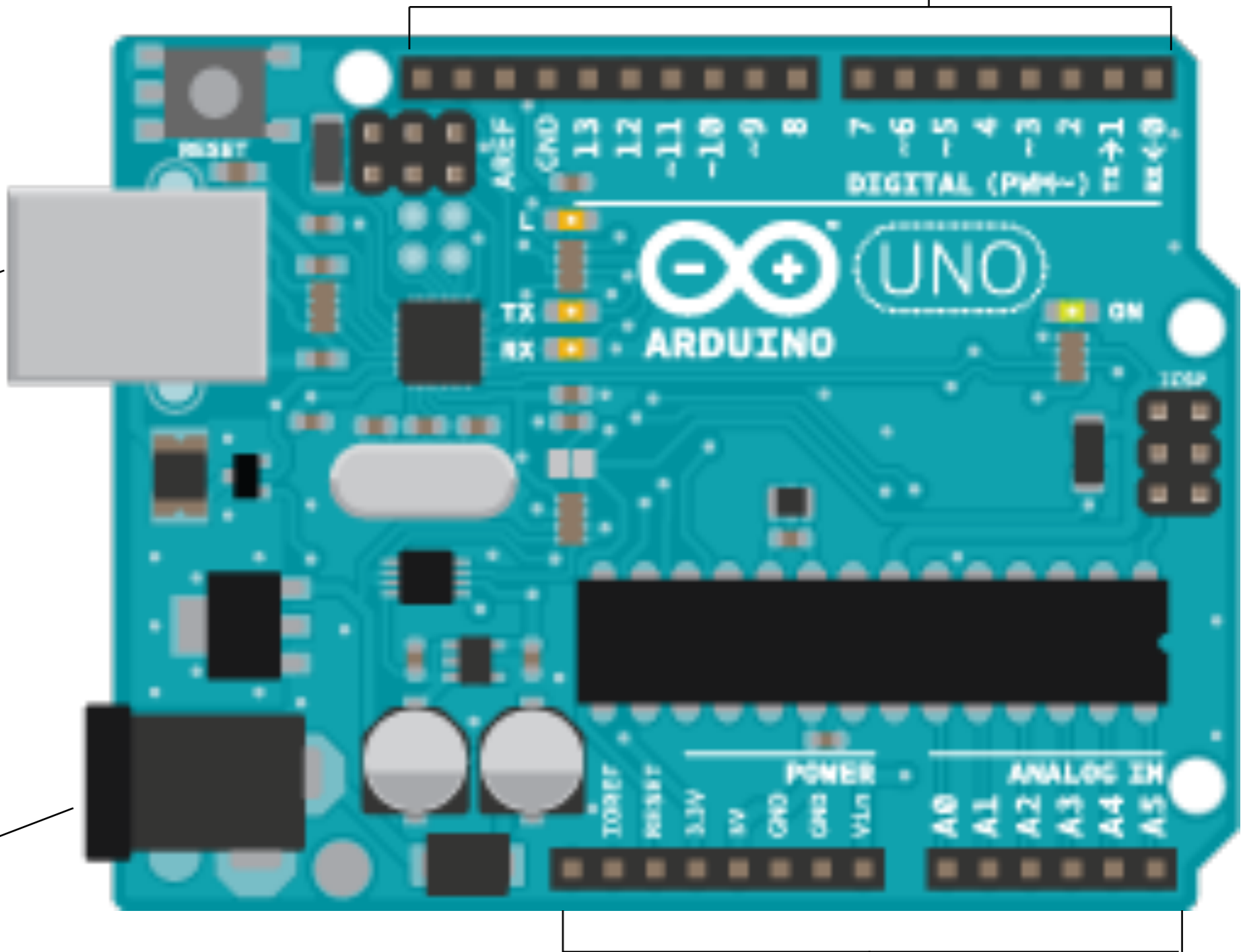

Arduino Due

Arduino Yun

Arduino Zero

Arduino Leonardo

Comparison 比較：
https://www.arduino.cc/en/Products/Compare

Sockets for connecting the Arduino to other electronics
用以接駁電子零件

USB connector used to load programs on to Arduino from computer USB
插頭，用以上載程式到 Arduino

Power connector
接駁電源

Sockets for connecting the Arduino to other electronics
用以接駁電子零件

Image source:
- https://www.arduino.cc

What can Arduino be used for?
Arduino 可以用來做什麼？

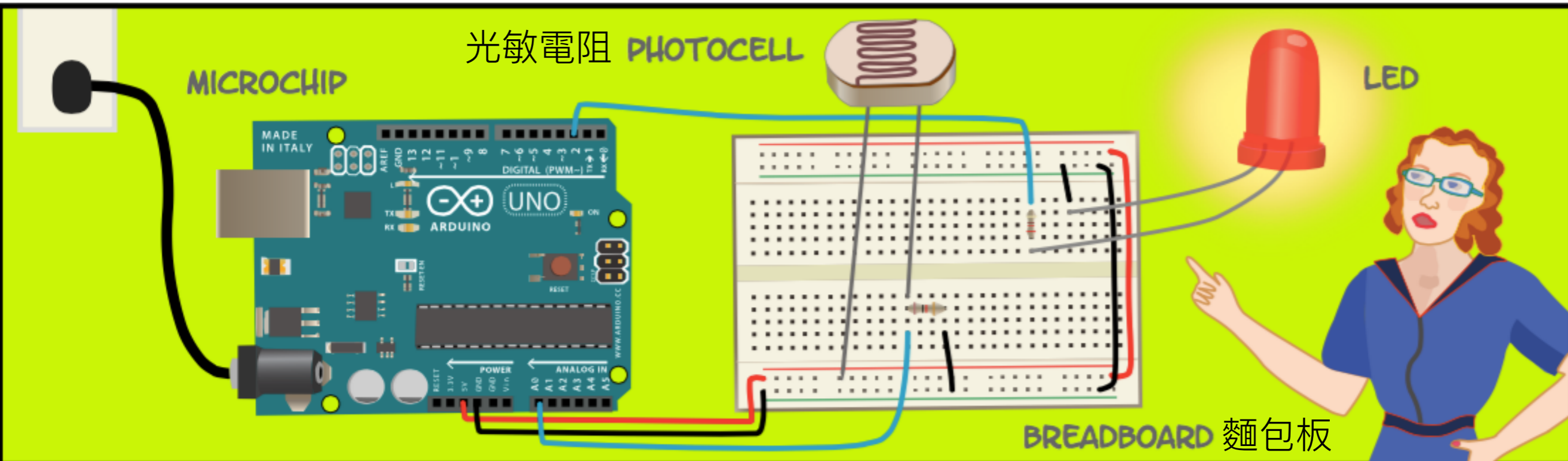- Able to read inputs, such as light on sensor, a finger on a button, or a Twitter message.
  能夠讀取各種輸入如：感應器偵測到光線、手指按動按鈕、或一個Twitter訊息。

- Generate an output such as activating a motor, turning on an LED, publishing something online.
  變成輸出如：啟動摩打、點亮LED燈或在網上發佈信息等。

What can Arduino be used for?
Arduino 可以用來做什麼？

光敏電阻 PHOTOCELL
MICROCHIP
LED
BREADBOARD 麵包板

AN ARDUINO CONTAINS A **MICROCHIP**, WHICH IS A VERY SMALL COMPUTER THAT YOU CAN PROGRAM. YOU CAN ATTACH SENSORS TO IT THAT CAN MEASURE CONDITIONS (LIKE HOW MUCH LIGHT THERE IS IN THE ROOM). IT CAN CONTROL HOW OTHER OBJECTS REACT TO THOSE CONDITIONS (ROOM GETS DARK, LED TURNS ON).

Arduino 內有一微控制器，是一可讓你編寫程式的小電腦，你可以接駁感應器去量度不同的環境狀況（如室內環境的光暗度），再由Arduino 變成輸出（如房間太暗則點亮LED燈）

Image source:
- http://playground.arduino.cc/Main/ArduinoComic

Setting up Arduino
設置 Arduino

Setting up Arduino
設置 Arduino

- What you need 你需要的:

  - Power supply.　電源供應器。

  - A male type A USB to male micro USB cable.
    一條 Type-A USB 至 micro USB 公對公連接線。

  - A software development environment for Arduino.
    一個為 Arduino 而設的軟件開發環境。

Main reference:
- Setting up your Raspberry Pi. Quick Start Guide. https://www.raspberrypi.org/help/quick-start-guide/

Power supply
電源供應器

- Use a 5V micro USB power supply.
  使用5V micro USB 電源供電。

- Power bank for mobile phone.
  可携式電源。

- Computer USB port.
  電腦的 USB 端口。

- USB power supply.
  USB 電源供應器。

- A male type A USB to male micro USB cable.
  一條 Type-A USB 至 micro USB 公對公連接線。

Image sources:
- http://hken.rs-online.com/web/p/plug-in-power-supply/8226373/
- http://hken.rs-online.com/web/p/power-banks/7757508/
- https://www.facebook.com/orico.hk/photos/a.644756615659662.1073742025.147921822009813/644756678992989/

Software development environment for Arduino
為 Arduino 而設的軟件開發環境

Programming the Arduino
Arduino 編程

- Visual programming 可視化編程: Scratch for Arduino

  - Easy to learn. 容易學習。

- Writing code on the Arduino IDE.
  用 Arduino IDE 寫程式碼。

  - Nearly identical environment for Processing programmers.
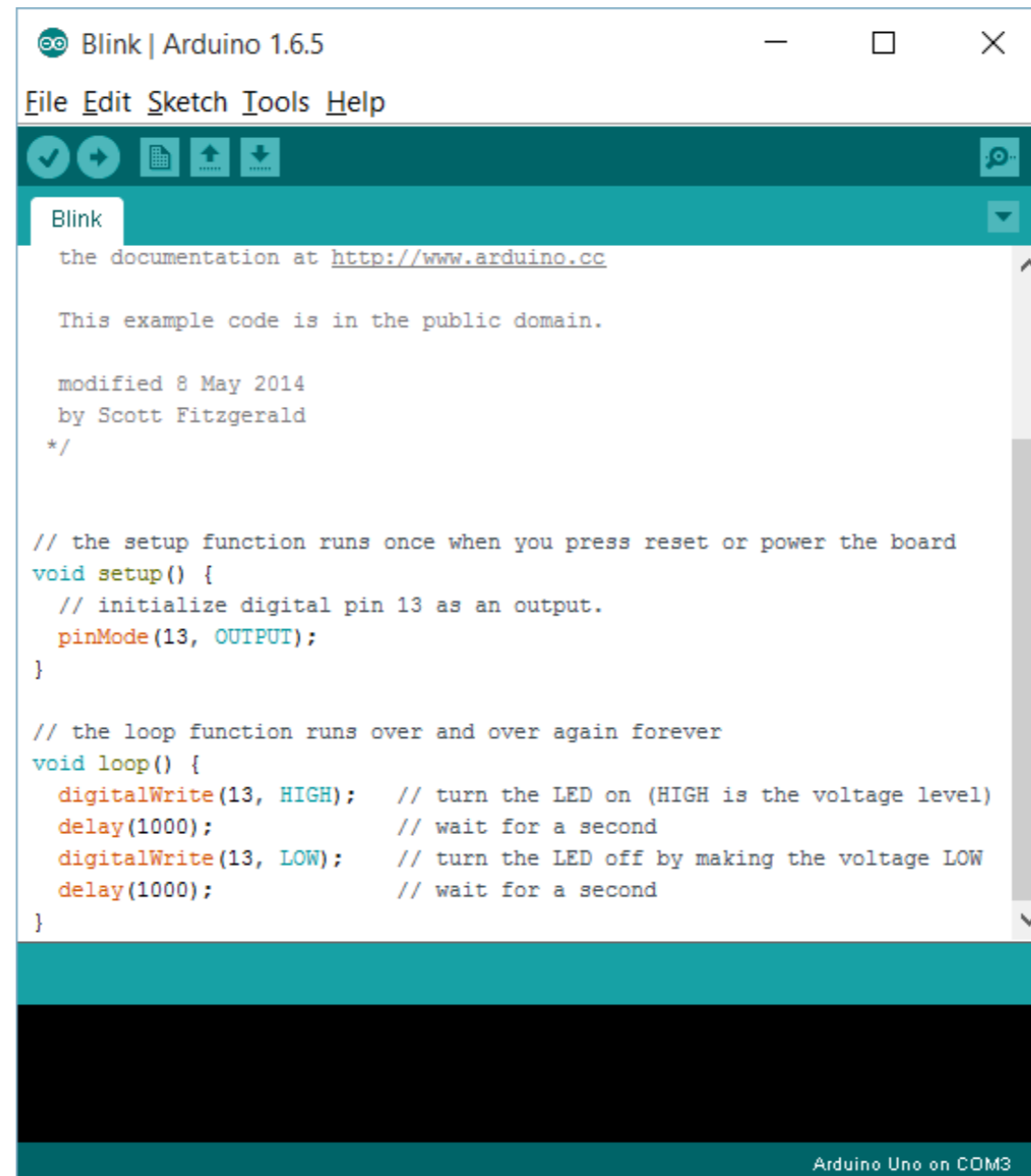   和 Processing 的開發環境幾乎完全一樣。

Main references:
- https://www.raspberrypi.org/documentation/usage/

Programming the Arduino: Scratch for Arduino
編寫程式以控制 Arduino: Scratch for Arduino

Image source:
- http://s4a.cat

Programming the Arduino: Arduino IDE
編寫程式以控制 Arduino: Arduino IDE

Image source:
- https://www.arduino.cc

Installing the Arduino IDE
安裝 Arduino 的整合開發環境

- Download from 在此下載：
  https://www.arduino.cc/en/Main/Software

- Install the software 安裝軟件。

- The Arduino Integrated Development Environment (IDE) looks like this after successful installation.
  成功安裝後 Arduino 的整合開發環境 (IDE) 看來像這樣。

References:
- https://www.arduino.cc/en/Guide/HomePage
- https://www.arduino.cc/en/Main/Software
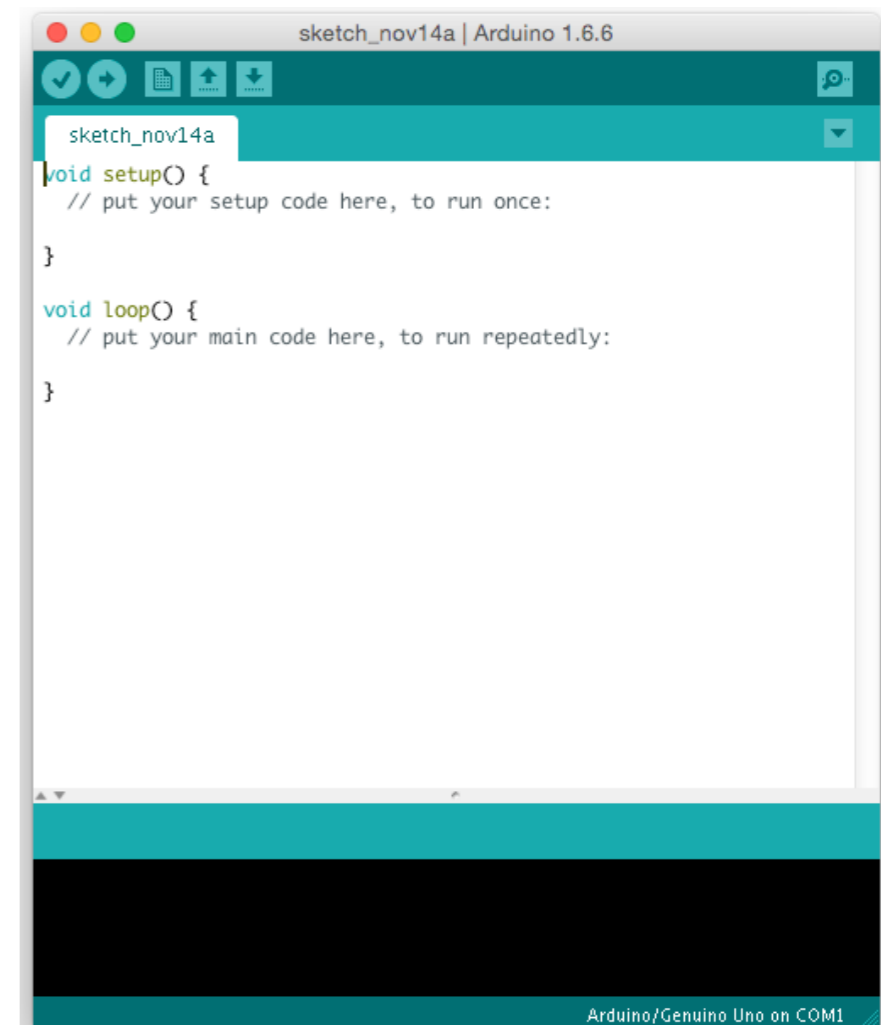
Scratch for Arduino

- A visual programming tool which allows the user to create animations and games with a drag-and-drop interface.
  用拖放界面的可視化編程工具，可寫動畫和遊戲。

- Scratch is an MIT project:
  Scratch 由麻省理工開發：https://scratch.mit.edu/

- Scratch for Arduino (S4A) is a modified version of Scratch to be used with Arduino.
  Scratch for Arduino (S4A) 是 Scratch 的修改版，使之可用於 Arduino。

- Web site 網頁：http://s4a.cat/

Installing Scratch for Arduino

- Install Arduino IDE first. 先裝 Arduino 整合開發環境。

- Download Scratch for Arduino from here 在這裏下載：
  http://s4a.cat/#downloads
  Install the software. 安裝軟件。

- Download the firmware. 下載韌體。

  - Save the file linked by "Download our firmware from here" at http://s4a.cat/#downloads (direct link at http://vps34736.ovh.net/S4A/S4AFirmware16.ino)
    下載在 http://s4a.cat/#downloads 中 "Download our firmware from here" 所連結的檔案。 (或直接取 http://vps34736.ovh.net/S4A/S4AFirmware16.ino)

Installing Scratch for Arduino

- Make sure Scratch for Arduino is not open.
  確定 Scratch for Arduino 不在執行。

- Connect Arduino to the computer using a USB cable.
  將 Arduino 用 USB 線連到電腦。

- Open Arduino IDE.
  執行 Arduino 整合開發環境。

- Open the firmware file S4AFirmware16.ino in the IDE.
  在 Arduino 整合開發環境內開韌體檔 S4AFirmware16.ino。

Installing Scratch for Arduino

- In the Tools menu, select the board version and the serial port where the board is connected.
利用 Tools 菜單選擇 Arduino 板種和連接的串流埠。

- Load the firmware into your board through File > Upload
用 File > Upload 上載韌體。

- Close Arduino IDE. 關閉 Arduino 整合開發環境。

- Start Scratch for Arduino, it should be able to find your Arduino board.
執行 Scratch for Arduino，它應可找到你的 Arduino 板.

Installing Scratch for Arduino

- Microsoft Windows users may need to install the Arduino drivers, available at http://s4a.cat/#drivers. (Direct link http://vps34736.ovh.net/S4A/drivers.zip)
  微軟視窗用戶可能需要安裝 Arduino 驅動程式，可在 http://s4a.cat/#drivers下載。（於此直接下載：http://vps34736.ovh.net/S4A/drivers.zip）

- To avoid confusion, do not run Scratch for Arduino and Arduino IDE at the same time.
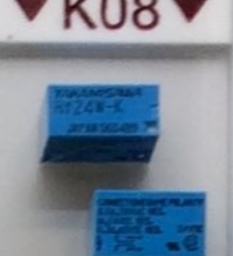 為避免混亂，Scratch for Arduino 和 Arduino 勿同時開啟。

Interfacing with the real world
與世界接軌

You need some electronic components...
你要些電子零件⋯⋯

07-01-3005
TAKAMISAWA RY-5W-K
DC5V/1A 2P2T 8 Pin
Relay, 167Ω

07-01-3006
TAKAMISAWA RY-6WK
DC6V/1A 2P2T 8 Pin
Relay,

07-01-3012
TAKAMISAWA RY-12WK
DC12V/1A 2P2T 8 Pin
Relay,

07-01-3024
TAKAMISAWA RY-24W-K
DC24V/1A 2P2T 8 Pin
Relay,

07-08-1412
MASSUSE ME-15M-012-HTS
DC12V 12A 1P1T 4 Pin Relay,

07-08-9017
MASSUSE ME-25-012-HS
DC12V (617Ω/ 8A 250V)

Dae Yang DYR-MY-4C
4P2T 3A/DC 24V Relay

ME-2-24
2P2T 8 Pin Relay,

07-10-1822
Dae Yang DYR-LY-2CMA
2P2T 10A/ AC220V Relay

07-01-3205
TAKAMISAWA JY-5H-K
DC5V/5A 1P1T 4 Pin
Relay,

07-01-3212
TAKAMISAWA JY-12H-K
DC12V/5A 1P1T 4 Pin
Relay,

07-01-3224
TAKAMISAWA JY-24H-K
DC24V/5A 1P1T 4 Pin
Relay,

07-01-3103
TAKAMISAWA SY-3K DC
3V/2A 1P2T 6 Pin Relay,
15Ω

07-08-1506
1P2T 5 Pin Relay,

07-08-1509
MASSUSE ME-15M-009-TS
DC9V 12A 1P2T 5 Pin Relay,

07-08-1512
MASSUSE ME-15M-012-TS
DC12V 12A 1P2T 5 Pin Relay,

MASSUSE ME-13F-012-
2Z2
DC12V 2P2T 8 Pin Relay,

MASSUSE ME-13F-02-4-
DC24V 2P1T 8 Pin Relay,
650Ω

07-01-3105
TAKAMISAWA SY-5-K DC
5V/2A 1P2T 6 Pin Relay,
167Ω

07-01-3109
TAKAMISAWA SY-9-K DC
9V/2A 1P2T 6 Pin Relay,
540Ω

07-01-3112
TAKAMISAWA SY-12K
DC12V/2A 1P2T 6 Pin
Relay,

07-01-3124
TAKAMISAWA SY-24K
DC24V/2A 1P2T 6 Pin
Relay,

ME-1A-05B
1A 1P2T 5 Pin Relay,

07-08-5012
MASSUSE ME-1A-12B
DC12V 2A 1P2T 5 Pin Relay,
400Ω

07-08-5024
MASSUSE ME-1A-24B
DC24V 2A 1P2T 5 Pin Relay,
1600Ω

07-024-2Z1
MASSUSE ME-13F-012-1Z1
DC12V 1P2T 8 Pin Relay,
160Ω

MASSUSE ME-13F-A240-
1Z1 AC240V 1P2T 8 Pin Relay,

07-01-4005
TAKAMISAWA A-5W-K DC
5V/2A 2P2T 10 Pin Relay,
178Ω

07-01-4012
TAKAMISAWA A-12W-K
DC12V/2A 2P2T 10Pin
Relay,

07-01-3305
TAKAMISAWA NY-5W-K
DC5V/5A 1P1T 4 Pin
Relay,

07-01-3312
TAKAMISAWA NY-12W-K
DC12V/5A 1P1T 4 Pin
Relay,

ME-3-005-1Z5
1P2T 6 Pin Relay,

07-08-6012
MASSUSE ME-3-012-1ZS
DC12V 1A 1P2T 6 Pin Relay,
720Ω

07-08-9007
MASSUSE ME-12-12
12V DC 2P2T 10 Pin Relay,
1028Ω

MASSUSE ME-28A-012-1H1
5A 20VDC
5A 250VAC

07-08-9003
MASSUSE ME-28A-012-1
AC240V 8 Pin Relay,

07-01-3324
TAKAMISAWA NY-24W-K
DC24V/5A 1P1T 4 Pin

07-08-5303
MASSUSE ME-4-L1-3
DC3V 1 Coil Latch 2P2T 8

07-08-5305
MASSUSE ME-4-L1-5B
DC5V 1 Coil Latch 2P2T

07-08-5312
MASSUSE ME-4-L1-12B
DC12V 1 Coil Latch 2P2T 8

MASSUSE ME-11
2A 1P2T 5 Pin Relay,

MASSUSE ME-11-024-
DC24V 12A 1P2T 5 Pin Relay,
360Ω

07-08-5312
MASSUSE ME-11-024-12
DC24V 12A 1P2T 5 Pin Relay,
1440Ω

Know the components:
  Light Emitting Diodes (LEDs)
認識元件：發光二極管
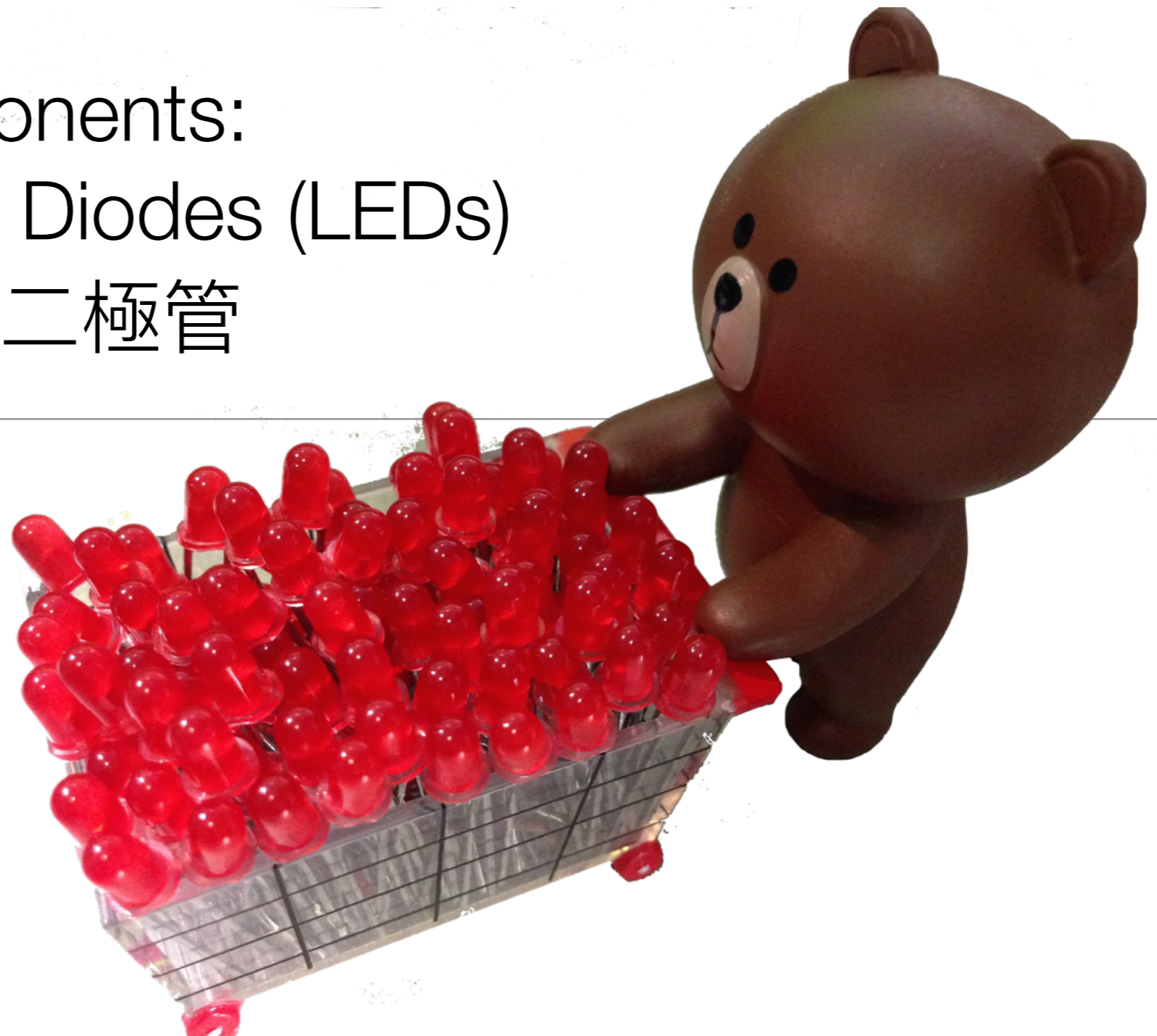
Light Emitting Diode 發光二極管

- An LED is a semiconductor component.
  發光二極管是半導體元件。

- LED is a special kind of diode, which is a component that allows one-way flow of current only.
  發光二極管是一種特別的二極管。 在二極管內，電流只能單向流動。

- What makes LED different from a normal diode is that when there is current flow, it lights up.
  發光二極管特別的是，電流通過時，它會發光。

- Usually, a resistor is needed to limit the current flow through an LED so it would not be burnt.
  通常，發光二極管要用電阻以限流，以免被燒壞。

Light Emitting Diode 發光二極管

- Since an LED allows unidirectional current flow only, it is polarized.
  正因發光二極管只能讓電流單向流動，它是有極性的元件。

- The direction of current flow is along the triangle in the circuit diagram.
  電流由符號中三角形那邊的正極流往粗線那邊的負極。

- The side current enters is marked as positive using the + symbol, and the other side negative using the – symbol.
  正極可用正號 + 表示，負極則用負號 –。

- The lead on the positive side of a new LED is often longer.
  新的發光二極管正極腳會長些。

Light Emitting Diode 發光二極管

- The polarity of an LED can also be determined by looking at the transparent or translucent LED itself.
其實，我們可以從透明或半透明的發光二極管的結構，得知其引線的極性。

- Inside an LED, one side is larger in size than the other. The larger side connects to the negative (–) terminal.
發光二極管中，金屬大些的那邊為負極。

- Which is the positive terminal in this LED?
這隻發光二極管哪邊是正極？

LED quiz!　LED問答！

- What are the polarities of the LEDs Cony is holding?
  兔兔拿着兩個發光二極管，極性是甚麼？

Know the components: Resistors
認識元件：電阻

Resistors 電阻

- In a circuit diagram, the zig-zag symbol correspond to resistors.
  電路圖上鋸齒形的符號代表電阻。

- Resistors limit current flow and its values are measures in ohms, with the greek letter Ω (Omega) as symbol.
  電阻減低電流，單位為「歐姆」Ohm,利用希臘字母Ω代表。

- Resistors are non-polar. That is, unlike batteries, installing a resistor one way of another does not matter.
  電阻是無極性元件。 即是說，不像電池，正反來安裝也沒所謂。

- Resistors look like those in the picture.
  電阻的外觀如圖。
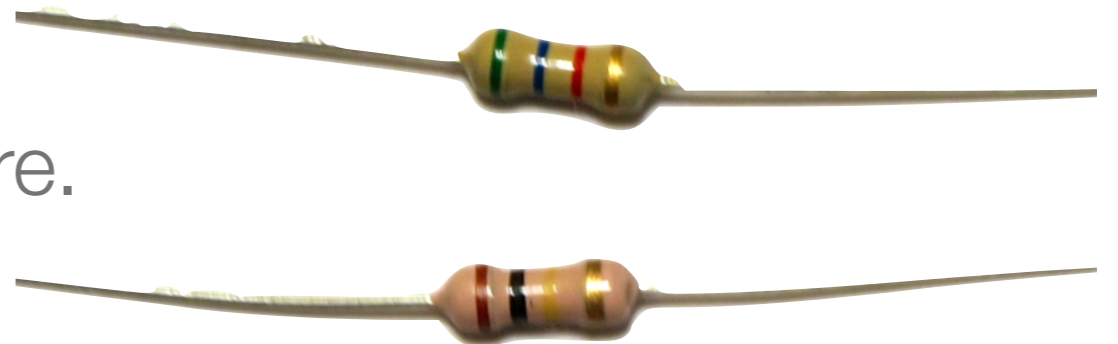
Ohm's law 歐姆定律

- The larger the value the resistor, the smaller will be the current flow given the same voltage.
電阻值越大，施加同樣電壓時電流越小。

- With a resistor value of R and a voltage of V, the current I=V/R. This is called the Ohm's law and can be remembered as V=IR.
若電壓為 V,電阻值為 R, 電流 I 就等於 V/R。 此公式為歐姆定律，可以 V=IR 記之。

- Many components like light emitting diodes (LEDs) cannot bear too much current, and resistors are used in series with them to limit the current so as not to damage them.
很多電子元件如發光二極管不能承受太多電流，故會串連電阻限流，以免燒壞。

Colour coding 色碼

- Resistors and some other components are colour coded. 電阻和一些電子零件都會用色碼記錄數值。

12345678901234567890123456789012345 67890
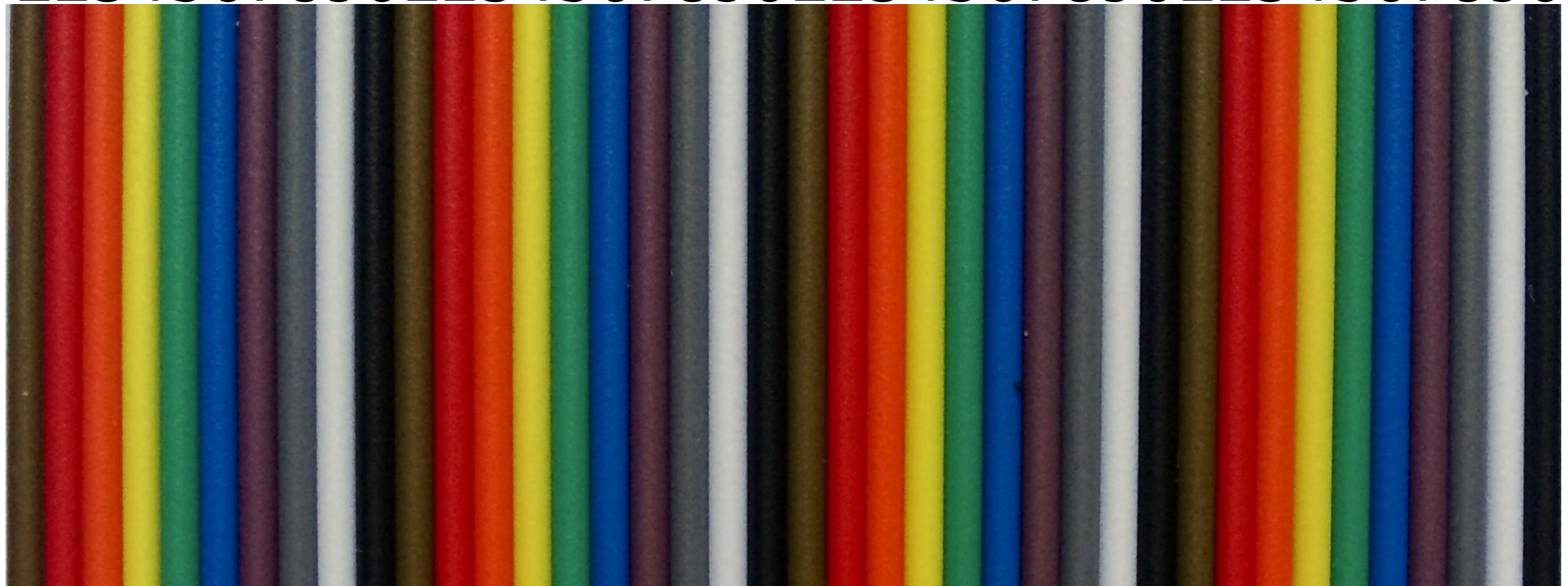
Colour code table 色碼表

- Four color bands are used for resistors with ±5% or ±10% tolerance.
  誤差值為 ±5% 和 ±10% 的電阻通常有四個色環。

- Five color bands are used for resistors with ±1% tolerance.
  誤差值為 ±1% 的電阻通常有五個色環。

Colour 顏色	Value 數值	Multiplier 倍數	Tolerance 誤差
Black 黑	0	$\times 10^0$	
Brown 啡	1	$\times 10^1$	±1%
Red 紅	2	$\times 10^2$	
Orange 橙	3	$\times 10^3$	
Yellow 黃	4	$\times 10^4$	
Green 綠	5	$\times 10^5$	
Blue 藍	6	$\times 10^6$	
Violet 紫	7	$\times 10^7$	
Grey 灰	8	$\times 10^8$	
White 白	9	$\times 10^9$	
Gold 金		$\times 10^{-1}$	±5%
Silver 銀		$\times 10^{-2}$	±10%

To read resistor values 讀電阻數值

- First, identify the tolerance band. If there is a gold or silver band at the end of the resistor, it must be the tolerance band. Otherwise, probably your resistor has five colour bands, and a brown band at one end, which could be a bit separated from other bands or very much near the end of the resistor, is the tolerance band.
首先要確定哪個是誤差色環。 如其一尾端之色環是金色或銀色,那肯定是誤差色環。 如沒有,那電阻很可能是有五個色環,而其中一尾環會是啡色的誤差色環。

- The colour band besides the tolerance band is the multiplier band. Other colour bands are value bands.
它通常會距離其他色環較遠,或該環較近尾部。 誤差色環旁的,就是倍數色環。 其他的,就是代表數值的色環。

Reading resistor colour code 讀電阻色碼

- From the opposite side of the tolerance band, start reading the value bands. This would form a two- or three-digit number. The value of the resistor is the number, multiplied by the multiplier indicated by the multiplier band, in ohms. 要讀電阻值，先由不是誤差色環的那面開始，讀數值色環的數值。 這會得出一個兩位或三位數。 將此數乘以倍數色環所代表的值，便會得出電阻值，單位為歐姆。

$$5\ 6\ 2\ (5\%) => 56 \times 10^2 = 5600\Omega = 5.6k\Omega$$

$$1\ 0\ 4\ (5\%) => 10 \times 10^4 = 100000\Omega = 100k\Omega$$

What are their resistance values?
它們的阻值是甚麼？

$4\ 7\ 1\ 5\% => 47 \times 10^1 = 470\Omega$

$3\ 0\ 1\ 0\ 1\% => 301 \times 10^0 = 301\Omega$

$4701\ 1\% => 470 \times 10^1 = 4.7k\Omega$

$104\ 5\% => 10 \times 10^4 = 100k\Omega$

Image source:
- Yet another picture of resistors. By Omegatron. https://commons.wikimedia.org/wiki/File:Resistors.jpg

Preferred values 標準阻值

- Resistor values may have errors, and tolerance values tell their range.
電阻值會有誤差，誤差值告訴用者阻值範圍。

- Preferred values, derived from tolerance values, are used to make mass production of resistors easier.
為使更易大量生產電阻，有利用誤差值計出來的標準阻值。

- E-12 series, most commonly used, designed for resistors with 10% tolerance:
最常用的 E-12 系列，設計給誤差值 10% 的電阻：
10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82

- E-24 series, often available in resistors with 5% and 1% tolerance:
E-24 系列，誤差值 5% 和 1% 的電阻常用：
10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82, 91

References:
- https://www.youtube.com/watch?v=jSPNvJ0XYCQ
- http://www.resistorguide.com/resistor-values/

Resistor quiz!　電阻問答！

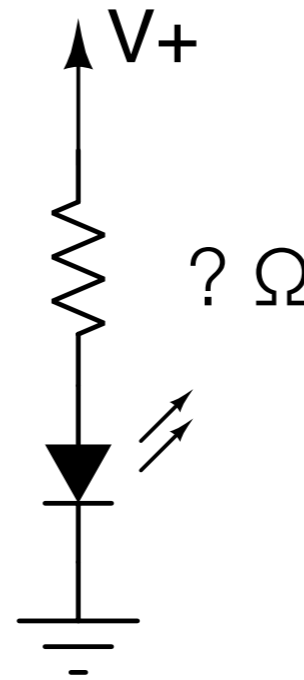- What's the resistance of the resistors Cony is holding? 兔兔拿着兩支電阻，阻值是多少？

Ohm's law: example 歐姆定律：例子

- An LED operates at 1.5V and can take up at most 5mA of current. What should the series resistor value be when the power supply is 5V?
  一工作電壓為1.5V 的發光二極管能承受不多於 5mA 的電流。當電源電壓為 5V，串連的限流電阻阻值應是多少？

V+

? Ω

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- Answer 答案: (5V-1.5V)/5mA = 3.5V/0.005A = 700Ω

- Higher resistance limits the current more, so a rule of thumb is to use a value slightly more than 700Ω, e.g., 820Ω.
電阻阻值大，限流更多，故可用經驗法則，用稍大於700Ω 的阻值，例如 820Ω。

V+

700Ω
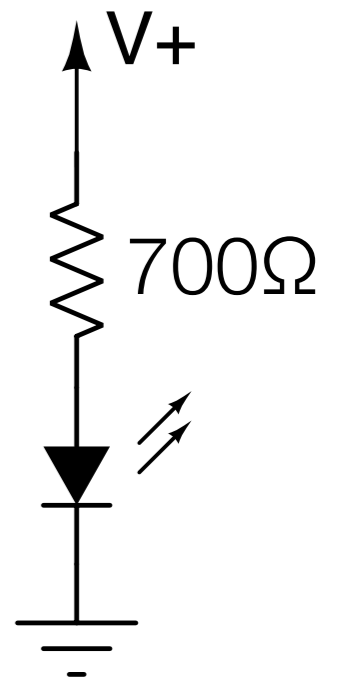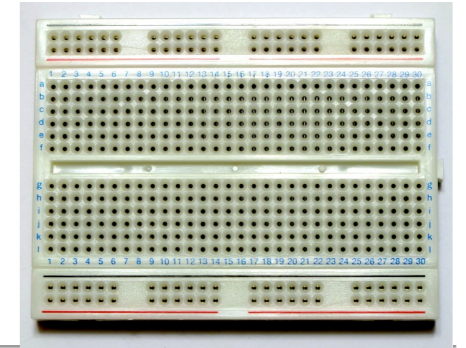
Connecting to the real world
# 連接現實世界

Breadboard 麵包版

- A breadboard is a board with internal connections and holes for placing components.
  麵包版上有孔洞以安插電子電件,而內部有金屬連接各洞。

- Usually, there are connected holes on the two sides for power supply connections (black for ground, red for positive voltage), and those in the middle are connected every row, though rows on the two sides are not connected.
  通常,麵包版兩邊有兩行洞用來連接電源(紅正黑負),而中間的洞就每行相桵,但兩邊的洞並不相連。

Breadboard: internal connections
麵包版：內裏連接例

- The power connections are marked on the surface of this board. 這麵包版上有電源行的連接標記。
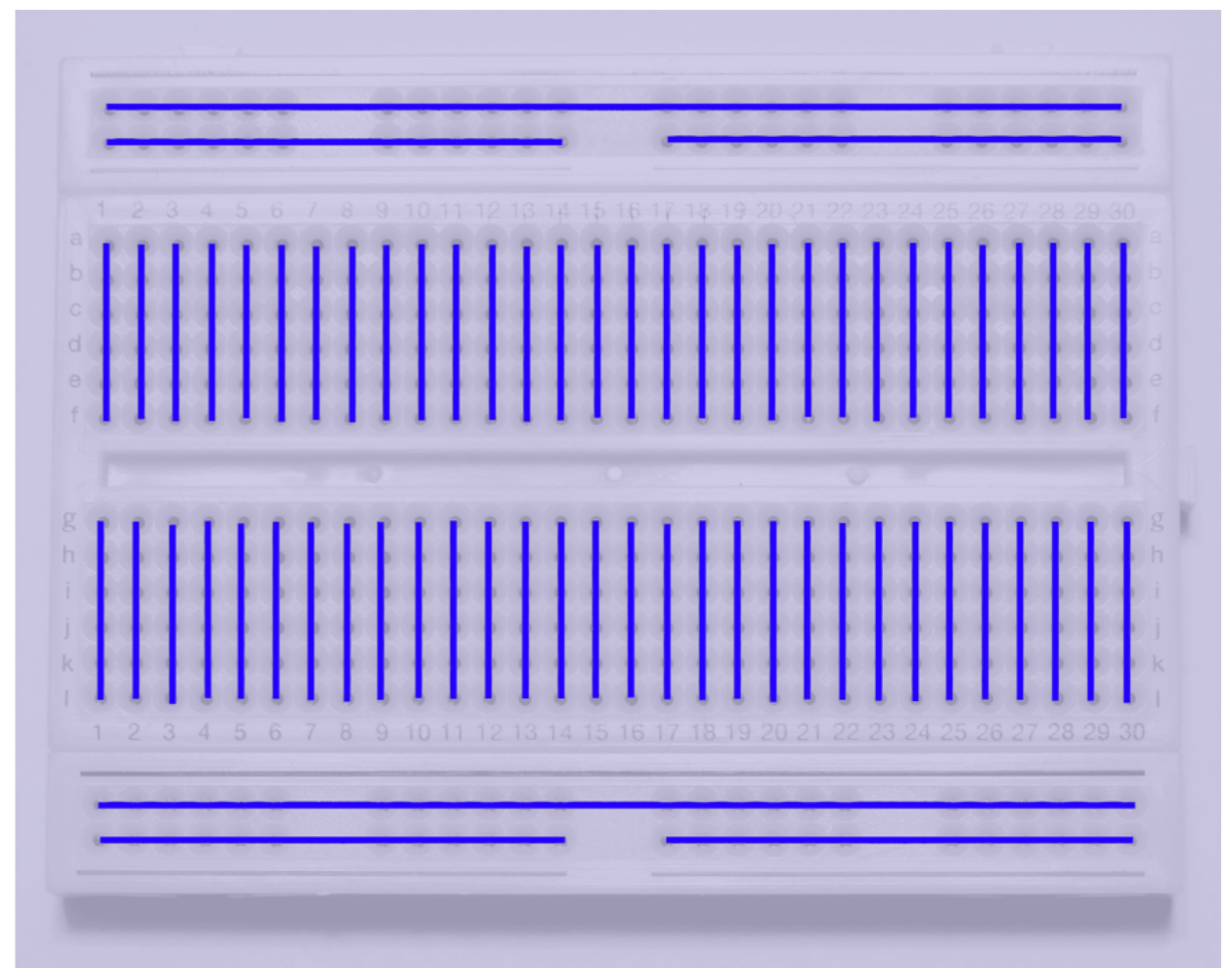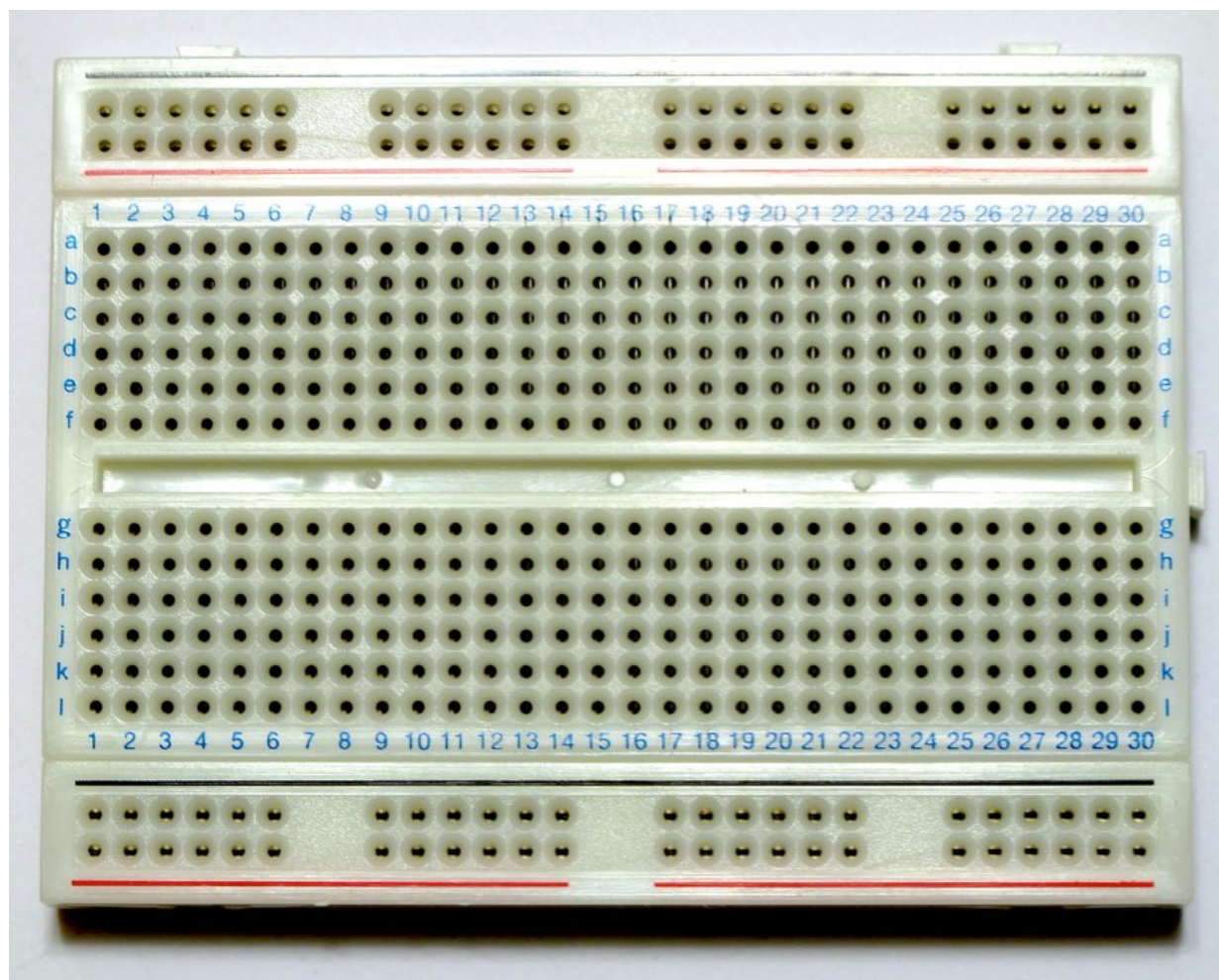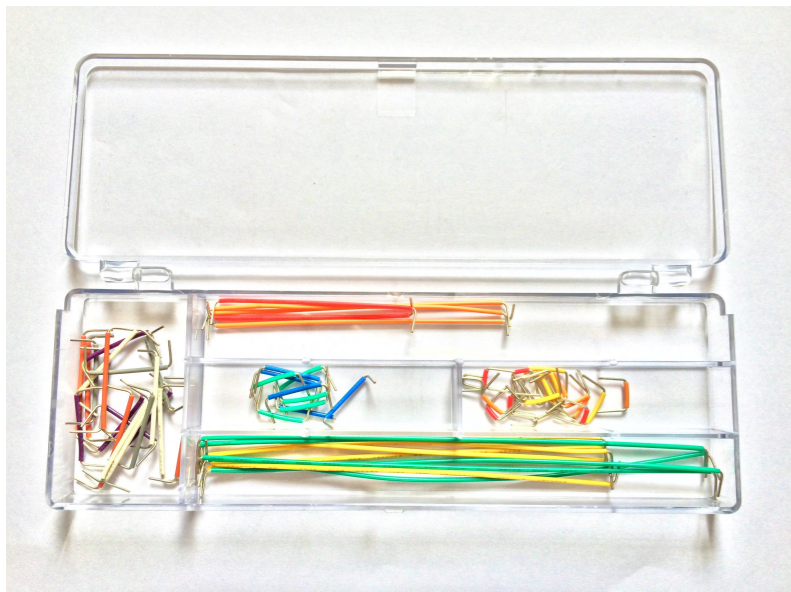
Connecting components 連接零件

- Electronic components are connected using wires on a breadboard.
  電子零件用電線在麵包版上連接。

Jumper cables
跳線

Jumper wire roll
單枝電線卷

Flat cable with connectors
杜邦彩排線

A S4A program
一個 S4A 程式

- Components have to be connected to the Arduino in a particular way.
  電子零件要用特定方法連接 Arduino。

- S4A allows for:
  S4A 可支援：

  - 6 analog inputs (analog pins) 六個模擬輸入（模擬引腳），

  - 2 digital inputs (digital pins 2 and 3) 兩個數碼輸入（數碼引腳 2 和 3），

  - 3 analog outputs (digital pins 5, 6 and 9) 三個模擬輸出（數碼引腳 5, 6 和 9），

  - 3 digital outputs (pins 10, 11 and 13) and 三個數碼輸出（數碼引腳 10, 11 和 13）

  - 4 special outputs to connect Parallax continuous rotation servomotors (digital pins 4, 7, 8 and 12).
    還有四個特別的輸出，用作連接 Parallax 連續旋轉伺服摩打（數碼引腳 4, 7, 8 和 12）

Reference:
- http://s4a.cat/

A Scratch program
一個 Scratch 程式

- To switch on or off a digital output on an Arduino board, use the digital on or off block.
利用 digital on 或 off 模塊控制數碼輸出的電位。

- To output an analog value, use the analog value block.
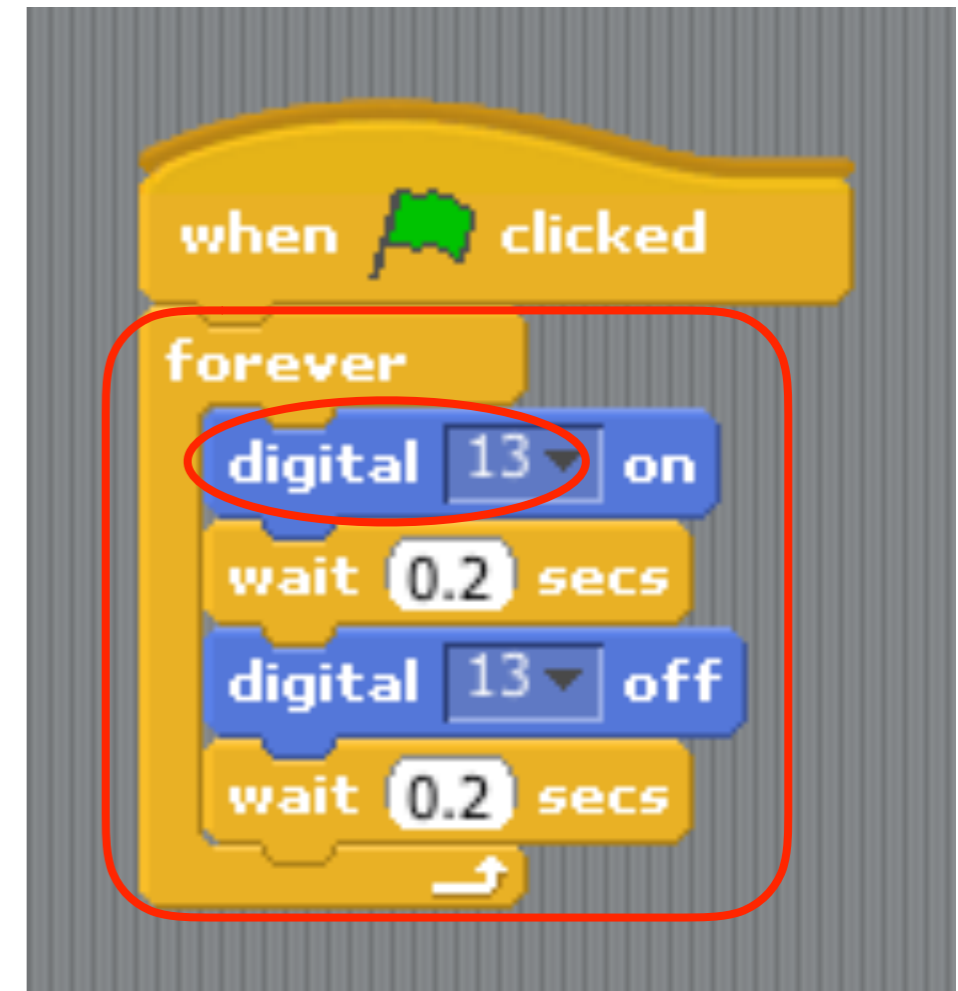利用 analog value 模塊控制模擬輸出的電位。

A S4A program
一個 S4A 程式

- Which output pin does the program use?
  這程式用哪個輸出端子？

- Digital pin 13. 數碼輸出，引腳 13.

- What does it do? 這程式做甚麼？

- Repeatedly turn on digital output 13
  for 0.2 seconds, then turn it off
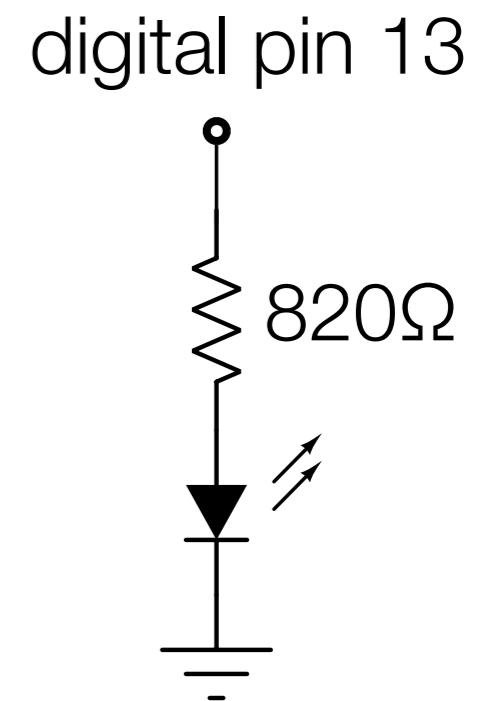 for 0.2 seconds.
  不斷將數碼輸出引腳 13 開 0.2 秒關 0.2 秒。

S4A Blinking light
S4A 閃燈

- What should the circuit be if the program
  is to control an LED?
  如要用這程式控制一顆發光二極管，電路應是怎樣？

- Remember how the circuit to light up an LED looks like?
  記得點亮發光二極管的電路是怎樣的嗎？

- It's like this. 是這樣的。

- How to use digital output pin 13 to control
  the LED?
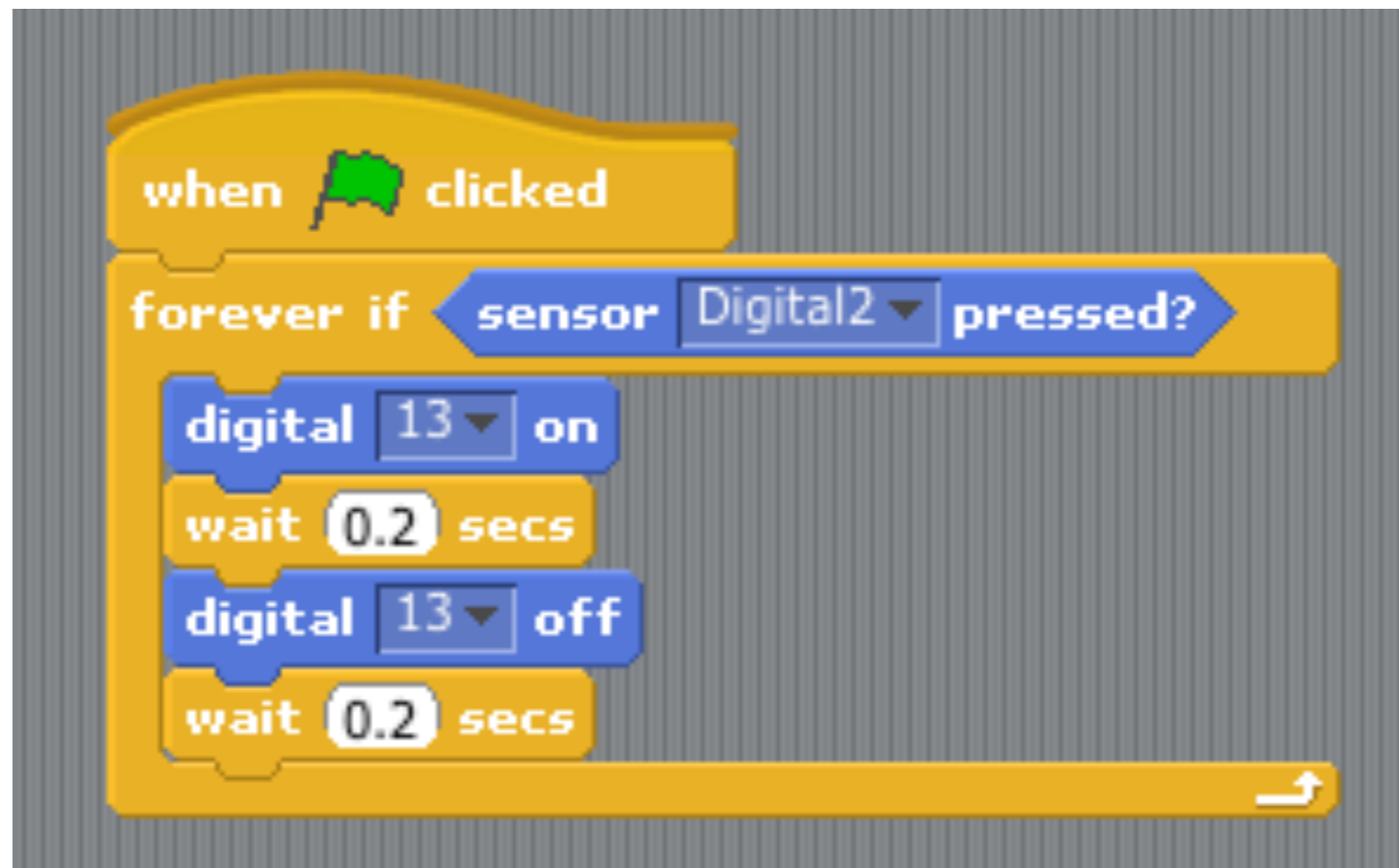 如何用數碼輸出引腳 13 控制發光二極管？

- This works. 這就行了。

digital pin 13
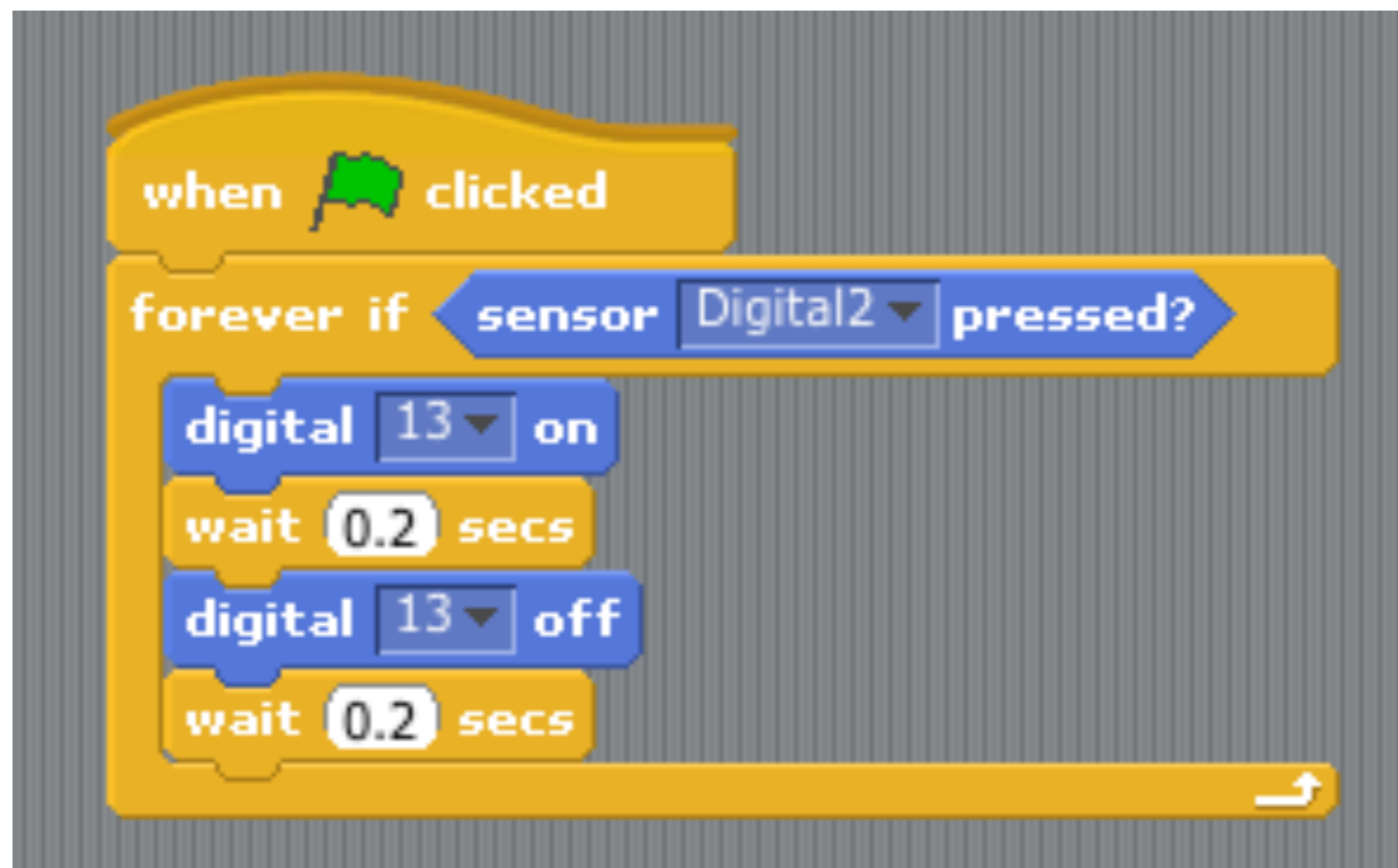
820Ω

A new program......
一個新的程式……

- Which part is different? 有哪部分不同？

What does this program do? 這程式做甚麼？

- The loop runs, and thus the LED blinks, only when digital input 2 is high.
 迴環只在數碼輸入 2 是高電位時才有效，發光二極管才會閃。

And the circuit is... 電路是⋯⋯

- We need to connect digital pin 2 to power through a push button. A pull down resistor is also needed because when the button is not pressed, the input voltage is in high impedance state and is prone to noise.
我們要給數碼輸入引腳 2 上經按鈕接電源，亦要下拉電阻，因沒按按鈕時引腳處於高阻抗狀態，容易被噪音影響。

- Pull down resistor value is typically one to a few kΩ. 下拉電阻阻值通常為一至幾千歐姆。
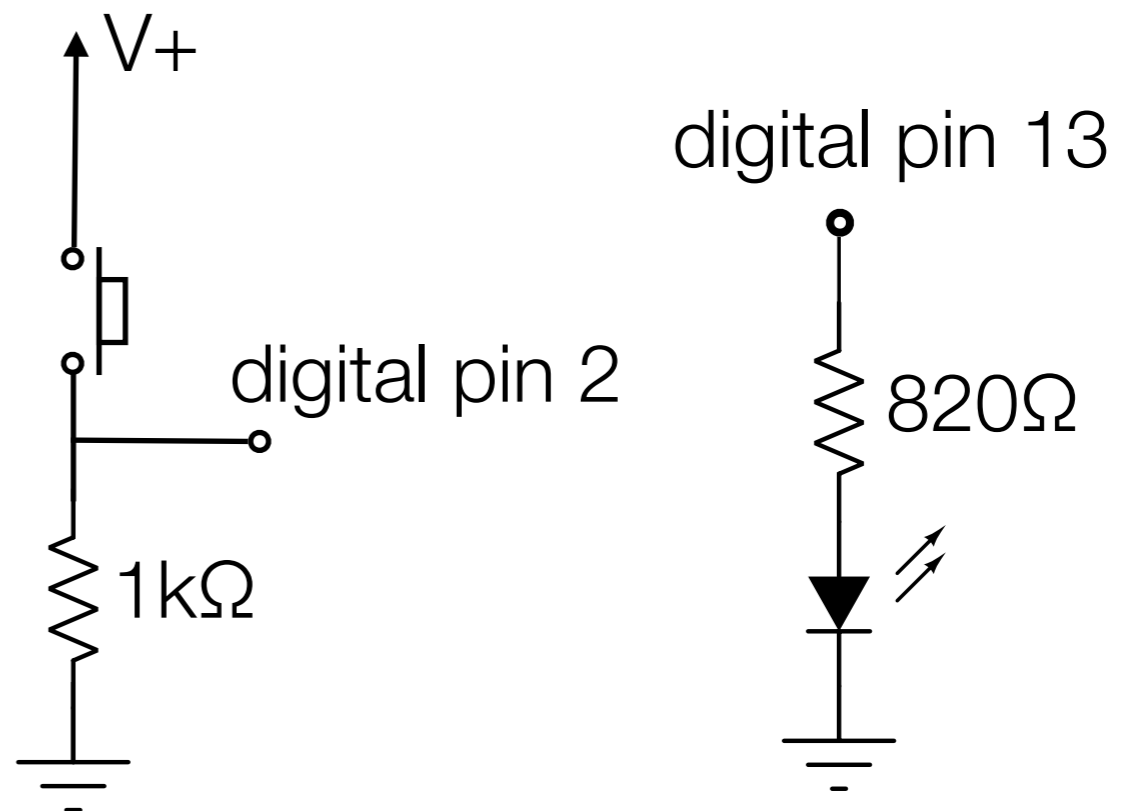
Programming in Arduino IDE
Arduino 整合開發環境下編程

- Code inside `setup()` is run once at start of program.
  `setup()` 內的程式碼會於程式開始時執行一次。

- Code inside `setup()` is run periodically, many times a second.
  `setup()` 內的程式碼會不斷執行，每秒多次。

Reference:
- https://www.arduino.cc/en/Reference/HomePage

A few useful functions
幾個有用的函數

- `pinMode(`pin, mode`)` sets the mode of a pin.
  mode can be `INPUT`, `OUTPUT`, or `INPUT_PULLUP`.
  用來控制引腳是輸入、輸出，還是有拉上電阻的輸入。

- `digitalWrite(`pin, value`)` outputs a `HIGH` or `LOW` value to a digital
  pin. 輸出高或低電位予數碼輸出引腳。

- `digitalRead(`pin`)` reads the value from a specified digital pin, either
  `HIGH` or `LOW`. 讀數碼輸入引腳的電位，是高還是低。

- `delay(`ms`)` pauses the program for ms milliseconds.
  暫停 ms 毫秒。

Reference:
- https://www.arduino.cc/en/Reference/PinMode
- https://www.arduino.cc/en/Reference/DigitalWrite
- https://www.arduino.cc/en/Reference/DigitalRead
- https://www.arduino.cc/en/Reference/delay

The two programs in Arduino IDE
Arduino 整合開發環境下的兩個程式
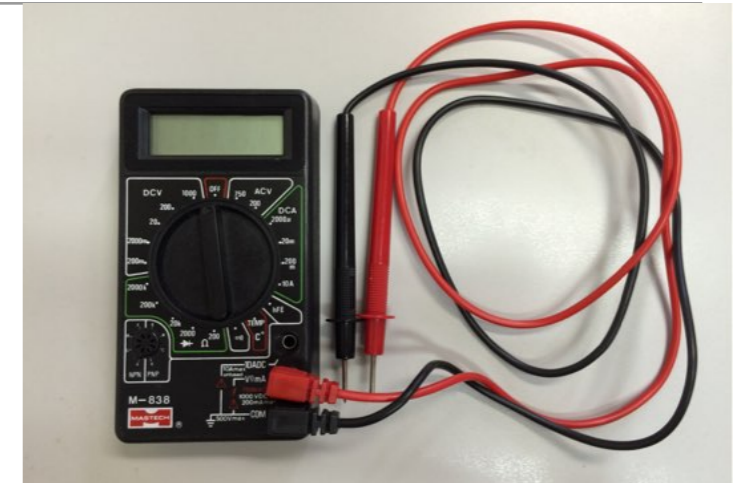
Reference:
- https://www.arduino.cc/en/Reference/HomePage

Tools 工具

- Multimeter 萬用表

  - For testing components 用來測試零件

- Cutter pilers 剪鉗

  - For cutting component leads short 用來剪短零件腳

Thank you 謝謝

Questions? 問題?