

紫外線

測量及應用設計比賽

Ultraviolet Radiation

Measurement & Application Design Competition

<http://www.cs.hku.hk/~uv/>

DIY Ultraviolet Radiation
Measurement Device
自製紫外線測量器

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DIY Ultraviolet Radiation Measurement Device

自製紫外線測量器



What to expect

有甚麼期待

- Participants are expected to exercise their creativity to design and implement a solution to the UV measurement problem.
參賽者應運用他們的創造力來設計和實施紫外線測量問題的解決方案。
- No complete solution will be presented in this talk.
這次講座將不會提供完整的紫外線測量方案。
- Yet, the techniques presented are relevant.
然而，我們將簡介相關的技術。

We are a group of geniuses, the project is done!
我們是天才，做完了！

It's time to test our ultraviolet application!
要測試我們應用紫外線的發明了！

What are the light sources?
光源呢？

Light sources 光源

- Torches 火把
- Flashlight 電筒
- Fluorescent light tubes 光管
- Compact fluorescent light bulbs 慳電膽
- Incandescent lamps 白熾燈
- Light-emitting diode (LED) light bulbs LED 燈泡

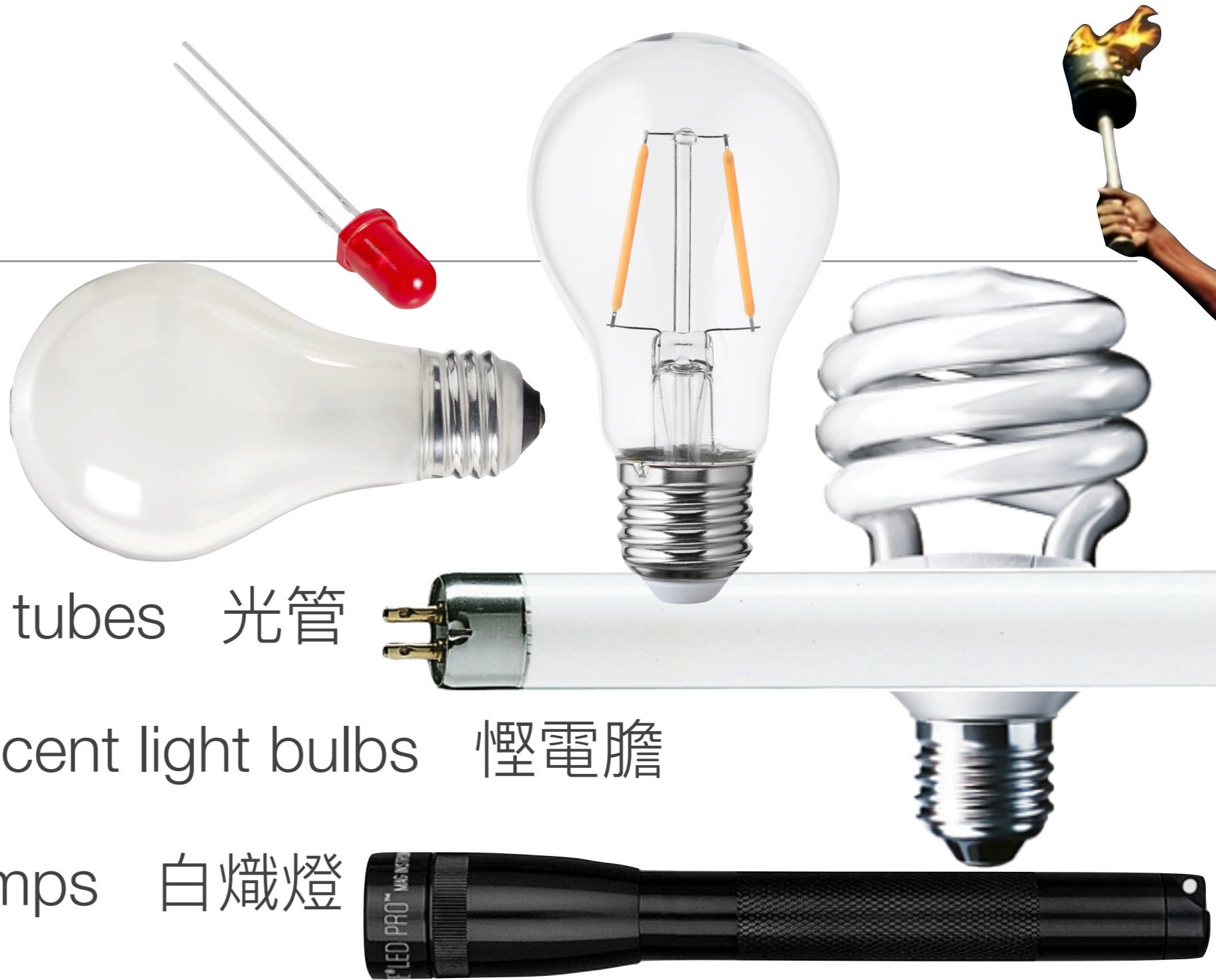


Image sources 圖片來源：

http://www.lighting.philips.com/main/prof/conventional-lamps-and-tubes/fluorescent-lamps-and-starters/tl-miniature/tl-mini-consumer-products/928001008213_EU/product

<http://www.lighting.philips.com/main/prof/conventional-lamps-and-tubes/compact-fluorescent-integrated/energy-saver-twister-shape/tornado>

http://www.lighting.philips.com/main/prof/conventional-lamps-and-tubes/incandescent-lamps/gls-specialties/rough-vibration-service/920586334302_EU/product

<http://www.ikea.com/hk/en/catalog/products/70382185/>

http://maglite.com/shop/media/catalog/product/cache/1/image/655x/040ec09b1e35df139433887a97daa66f/m/m/mm_pro_led_blk_640_5_1.jpg

<https://hken.rs-online.com/web/p/visible-leds/2285988/>

Do they generate UV?
它們會發紫外線嗎？

Ultraviolet light sources

紫外線光源

- Torches 火把
- Flashlight 電筒
- Fluorescent light tubes 光管
- Compact fluorescent light bulbs 慳電膽
- Incandescent lamps 白熾燈
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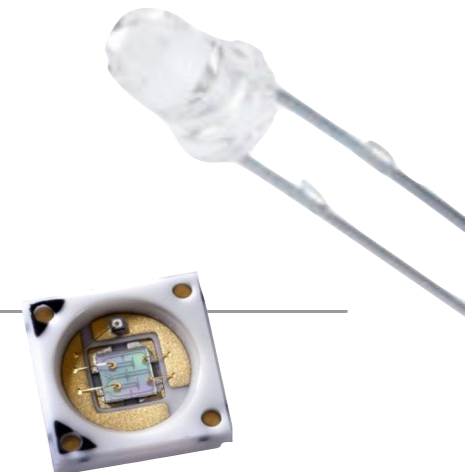


Image sources 圖片來源 :

<https://www.amazon.co.uk/Manta-Ray-Detector-Blacklight-Flashlight/dp/B01N66L1BO>

http://www.exo-terra.com/download/high_res/products/images/PT2189_Reptile_UVB150.jpg

<https://www.lightbulbsdirect.com/hallincbl/60abl>

http://www.lighting.philips.com/main/prof/conventional-lamps-and-tubes/special-lamps/purificationwater-and-air/commercial-and-professional-air/tuv-t8/928039504005_EU/product

<https://hken.rs-online.com/web/p/uv-leds/8903948/>

<https://hken.rs-online.com/web/p/uv-leds/8801494/>

<https://hken.rs-online.com/web/p/uv-leds/7135024/>

Who likes UV? 誰喜歡紫外線？



Bearded Dragon
Pogona vitticeps



Image sources 圖片來源：
http://www.exo-terra.com/en/explore/uv_rating_index.php
Yip Chi Lap [Beta] beta at acm dot org

Any more?

還有沒有？

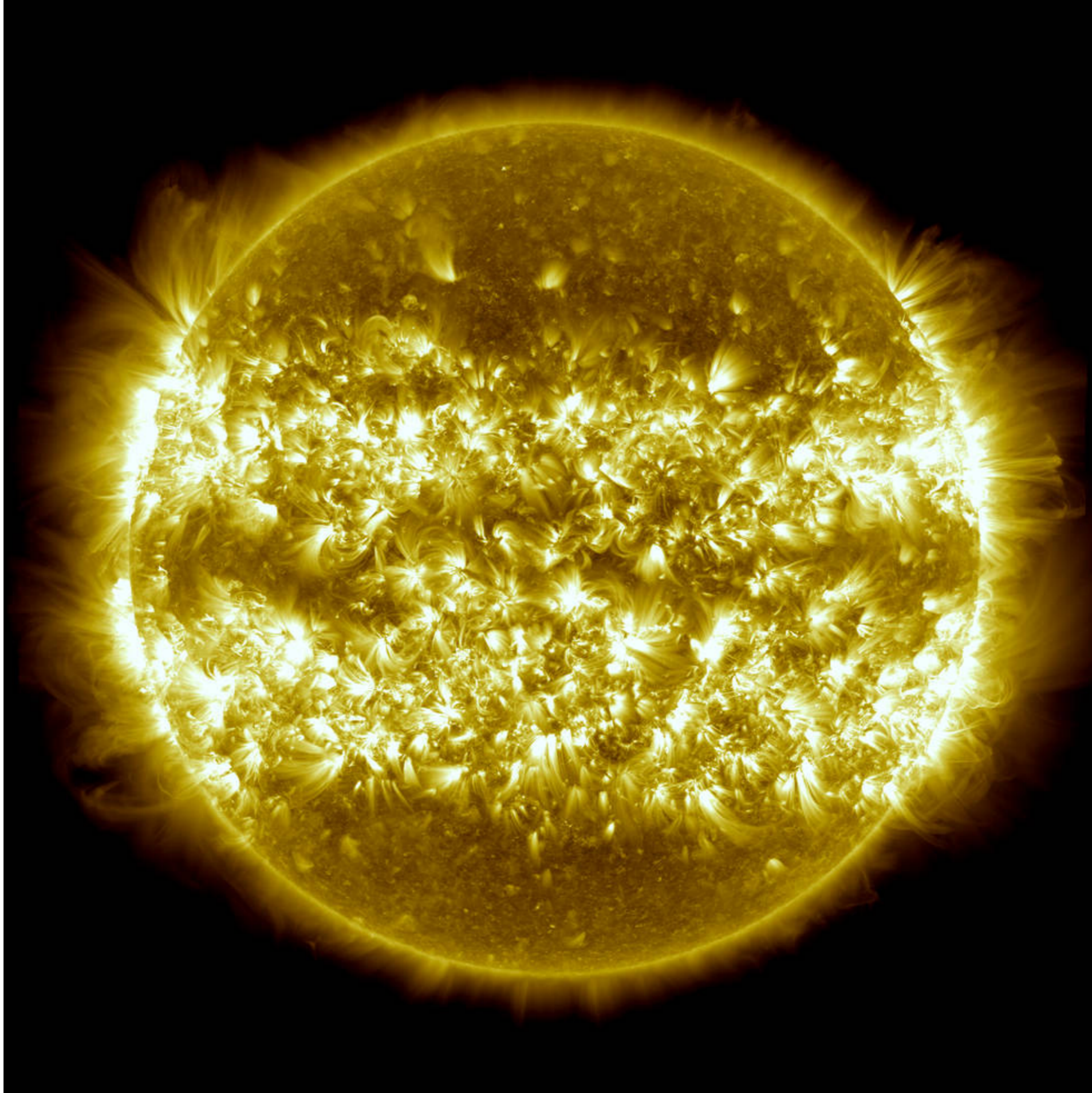


Image sources 圖片來源 : https://www.nasa.gov/mission_pages/sdo/news/first-light-3rd.html

Ultraviolet Radiation Measurement & Application Design Competition

How fluorescent light tubes work

光管的原理

- A fluorescent light is a type of gas discharge tube.
光管是一種氣體放電管。
- The nearly vacuum tube contains some inert gas and mercury vapour.
幾乎真空的管內有少量惰性氣體和汞（水銀）蒸氣。
- A short period of high voltage on the two sides of the tube is applied to start electric discharge which ionises the mercury vapour, making the gas conductive.
點光管時，管兩側施以短暫高電壓，使汞氣離子化，因而導電。
- The filaments on the two sides of the tube produce electrons that continually excite the mercury atoms afterwards.
之後，燈管兩側的燈絲產生電子，不斷激發水銀原子。

How fluorescent light tubes work

光管的原理

- When an electron in an atomic orbital at a higher energy level falls to one at a lower energy level, some of the difference energy is released as photons.
當電子由能階較高的軌域下降至能階較低的軌域，其能量差有一部分會以光子的形式釋放出來。
- Different atoms have orbitals at different set of orbitals at different energy levels, thus the set of possible energy jumps are characteristic of the atom.
不同的原子有不同的能階的軌域，因此電子在不同軌域跳躍時的可能的能量差會有所不同，亦成為該原子的特徵。
- A fluorescent light tube, which is a mercury discharge tube, emits lights characteristic of mercury, such as UV light.
利用汞氣放電的光管，會發出水銀特有的光（例如紫外線）。
- Fluorescent materials line the inside of a tube, converting UV light to visible light.
管的內部有熒光材料，將紫外光轉換為可見光。

Wavelength of light emitted by mercury discharge lamps

水銀放電燈發出的光的波長

- What are the wavelengths of light emitted by a mercury discharge tube?
水銀放電燈會發出甚麼波長的光？
- Let's look it up! 要查表了！
<https://physics.nist.gov/PhysRefData/Handbook/Tables/mercurytable3.htm>
- 1 Angstrom = 1 Ångström = $1\text{Å} = 10^{-10}\text{ m} = 0.1\text{ nm}$
- There are many pictures and videos in this site:
這網站有很多圖片和片段：
<http://www.edisontechcenter.org/Fluorescent.html>

Quiz time!

問答時間！

- What are the three strongest wavelengths, in nanometers, a mercury discharge lamp produce?
以納米計，水銀放電燈發出最強光的三個波長是甚麼？
- In which spectral range (e.g., infrared, visible light) is each of them?
它們分別是在光譜的哪個範圍（如紅外線、可見光）？

Oh, my invention does not respond
to the UV light source.

噢，我們的發明對紫外線沒有反應。

How can I know it's not the problem
of the UV light source itself?

我怎知不是紫外線光源的問題？



Size(mm):
163w x 81.5h



Size(mm):
163w x 81.5h



Size(mm):
158w x 79h



Size(mm):
158w x 79h



Size(mm):
153w x 76.5h



Size(mm):
153w x 76.5h



Size(mm):
148w x 74h



Size(mm):
148w x 74h



Size(mm):
143w x 71.5h



Size(mm):
143w x 71.5h



Let's try...
試試看……

Then how to test for UV?
那怎麼測紫外線？

Let's do a simple experiment...
做個小實驗吧……

Experimenting with UV-sensitive beads 紫外線變色珠寶實驗



UV sensitive beads

紫外線變色珠

- Ultraviolet light-sensitive plastic beads are generally white, but turn colours when exposed to ultraviolet light.
紫外線變色珠原是白色的，受到紫外光照射後會變成不同顏色。



UV sensitive beads

紫外線變色珠


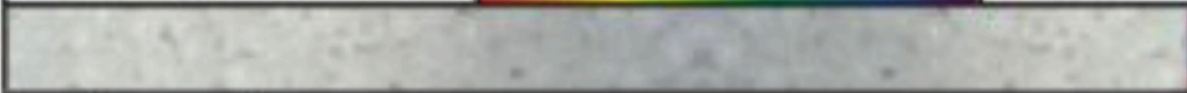

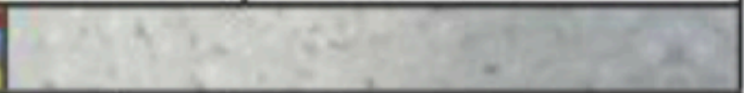
<p>Infrared 2500 - 700 nm</p> <p>Infrared light makes our skin feel warm and can be detected by certain animals such as rattlesnakes.</p>	<p>Visible 700 - 400 nm</p> <p>Visible light can be seen by our eyes. It includes all the colors of the visible rainbow.</p> 	<p>UV-A 400 - 320 nm</p> <p>Too much exposure to Ultraviolet A can result in the same damage as UV-B, but to a lesser degree.</p>	<p>UV-B 320 - 280 nm</p> <p>Ultraviolet B light is needed for Vitamin D synthesis in our body, but is a major cause of reddening of the skin, sunburn, skin cancer, cataracts, suppression of the immune system, and photo-aging.</p>	<p>UV-C 280 - 1 nm</p> <p>Ultraviolet C light is extremely dangerous, but completely absorbed by the ozone in the earth's atmosphere and does not reach the earth's surface.</p>
				
<p>Beads are white 2500 - 360 nm</p>		<p>Beads are colors 360 - 300 nm</p>	<p>Beads are white 300 - 1 nm</p>	

Image source: http://cdn.teachersource.com/downloads/lesson_pdf/UV-AST.pdf

UV sensitive beads: what is the theory behind?

紫外線變色珠：背後有甚麼理論？

- What is this effect called?
這特性叫甚麼？
- Photochromism.
光變色性。
- Is it physical reaction, chemical reaction, or others?
是物理反應，化學反應還是其他？
- Light-induced chemical reaction.
光致化學反應。

Photochromism: references

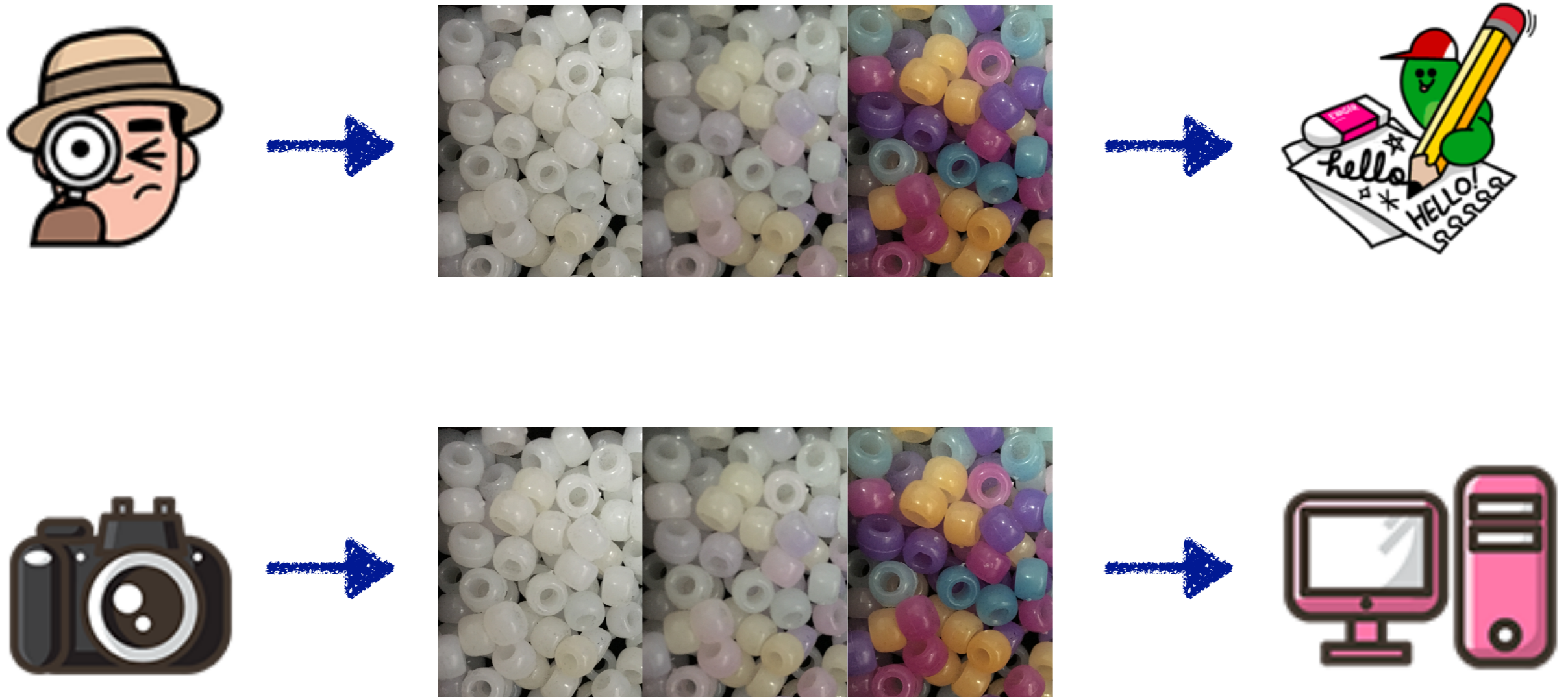
光變色性：參考資料

- Organic photochromism (IUPAC Technical Report)
H. Bouas-Laurent, Heinz Dürr
Pure and Applied Chemistry 73, 639–665
<https://old.iupac.org/publications/pac/2001/pdf/7304x0639.pdf>
- 光變色性物質 (Photochromic Materials)
臺北市立永春高級中學化學科蔡曉信老師
科學Online. 國立臺灣大學. 2013-10-12.
<http://highscope.ch.ntu.edu.tw/wordpress/?p=48341>
- Chemistry of Ultraviolet Detecting Beads with Video
Ron Perkins. Educational Innovations. 2009-11-13 0142.
<http://blog.teachersource.com/2009/11/13/chemistry-of-ultraviolet-detecting-beads-video/>

The strength of UV 紫外線強度



Can we detect the color change automatically? 可不可以自動探測顏色轉變？



Digital image representation

數碼圖像表示

- A picture is a two-dimensional matrix of picture elements (pixels).

一幀圖片是一個二維的像素矩陣。

- Screen coordinate system:

x-axis goes to the right, y-axis goes downwards.

屏幕坐標系統：x 軸指向右，y 軸指向下。

- Top left-hand corner has coordinates (0,0)

左上角坐標為 (0,0)。

- The values of a pixel at an (x,y) position tells the colour shade.

在矩陣 (x,y) 的數目代表顏色深淺。

	0	1	2	3	4	→ x
0	255	255	0	255	255	
1	255	0	127	0	255	
2	0	127	255	127	0	
3	255	0	127	0	255	
4	255	255	0	255	255	
↓ y						

Representing colours 顏色表示法

- Familiar? 熟悉嗎?

Grayscale 灰階圖像

255	255	0	255	255
255	0	127	0	255
0	127	255	127	0
255	0	127	0	255
255	255	0	255	255

RGB image RGB 圖像
Red plane Green plane Blue plane





255	255	0	255	255
255	0	127	0	255
0	127	255	127	0
255	0	127	0	255
255	255	0	255	255

255	255	0	255	255
255	0	127	0	255
0	127	255	127	0
255	0	127	0	255
255	255	0	255	255



255	255	0	255	255
255	0	127	0	255
0	127	255	127	0
255	0	127	0	255
255	255	0	255	255



Color representation in computer...

電腦中的顏色表示...

	R: 187 G: 187 B: 177
	R: 106 G: 75 B: 132
	R: 175 G: 126 B: 66
	R: 121 G: 49 B: 89



	R: 65 G: 96 B: 108
	R: 169 G: 153 B: 157

	R: 155 G: 157 B: 147
	R: 173 G: 163 B: 135

Color representation in computer...

電腦中的顏色表示...

- Any other possibilities?
還有其他可能性嗎？
- How can you select colours in a computer?
你如何在電腦上選色？

Some colour models

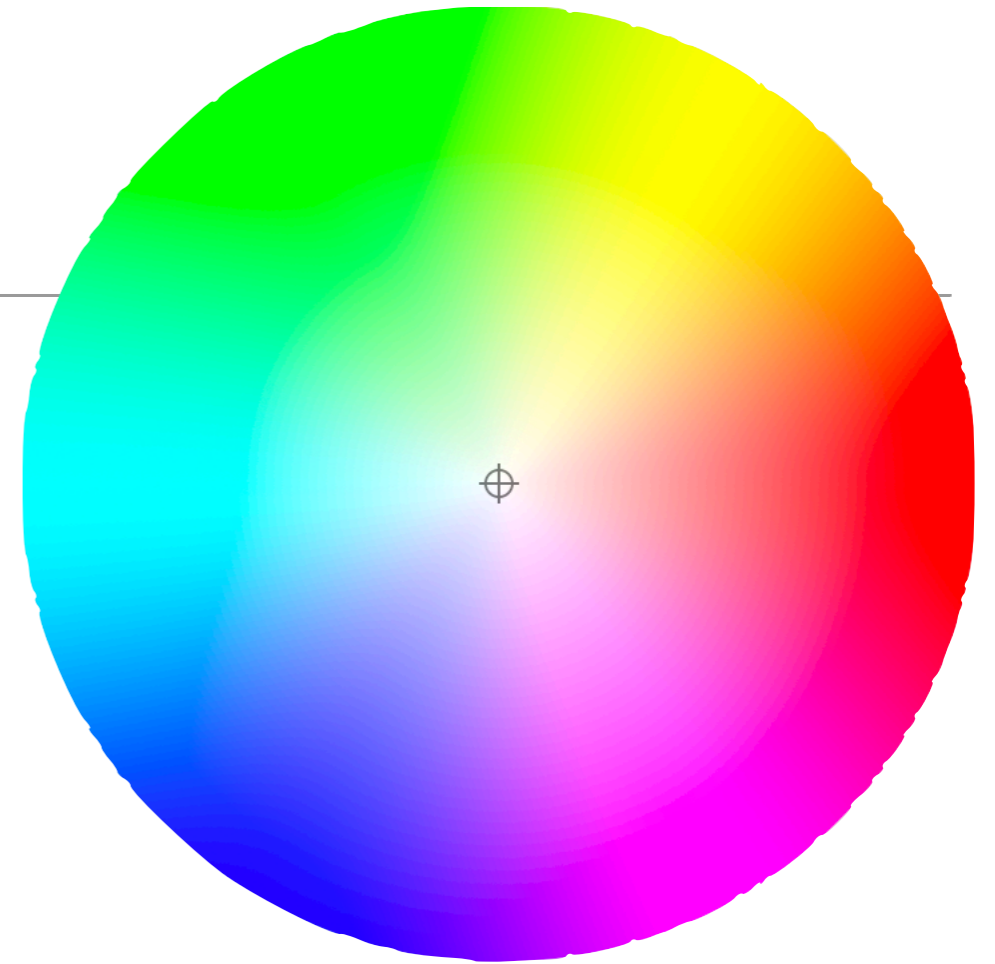
一些顏色模型

- RGB: Red-Green-Blue. Addition of coloured light sources
RGB: 紅、綠、藍。色加法，三源色光源疊加
- CMY: Cyan-Magenta-Yellow. Addition of colour dyes;
subtraction of reflected lights.
CMY: 青、洋紅、黃。色減法，三顏色染料混合，減反射光。
- CMYK: Cyan-Magenta-Yellow-Black. CMY with black dye
for better black and save of coloured dyes.
CMY: 青、洋紅、黃、黑。CMY加黑色，更易控制的黑色，省顏色染料。

Some colour models: HSB

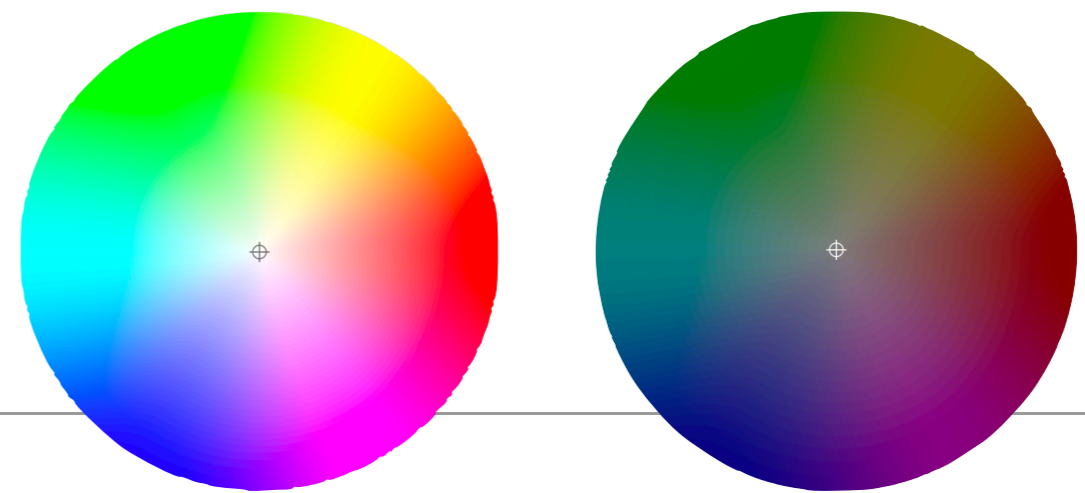
一些顏色模型：HSB

- HSB: Hue-Saturation-Brightness.
HSB: 色調，飽和度，亮度。
- Hue is colour as an angle.
 0° , 60° , 120° , 180° , 240° , 300°
correspond to
Red, Yellow, Green, Cyan, Blue, and Magenta respectively.
色調用角度表示。
 0° , 60° , 120° , 180° , 240° , 300°
分別代表
紅、黃、綠、青、藍、和洋紅色。



Some colour models: HSB

一些顏色模型：HSB



- Saturation is about how pastel the colour is. The more saturated, the less pastel. Hot red is saturated, pink is less saturated (or more pastel) red, and white has a saturation of zero. Paints become less saturated by adding white.
飽和度說明顏色有多粉色。越飽和，越不粉色。大紅色飽和度高，粉紅色飽和度沒那麼高，白色飽和度是零。顏料加白，飽和度減低，變粉色。
- Brightness is how bright the colour is. Pink can become dark pink by lowering brightness. Brown is a yellow with a low brightness. Paints become less bright by adding black.
亮度就是感覺有多光。粉紅色亮度低了就是深粉紅，而啡色其實是低亮度的黃色。顏料加黑，亮度減低，變深色。

RGB: quiz

RGB: 問答

- Is the amount of green component increasing or decreasing to the right? 
綠色的成分向右是增加還是減少了？
- Is the amount of blue component increasing or decreasing to the right? 
藍色的成分向右是增加還是減少了？

CMY: quiz

CMY: 問答

- Is the amount of yellow component increasing or decreasing to the right? 
黃色的成分向右是增加還是減少了？
- Is the amount of yellow component increasing or decreasing to the right? 
黃色的成分向右是增加還是減少了？

HSB: quiz

HSB: 問答

- Is the amount of saturation increasing or decreasing to the right?
飽和度向右是增加還是減少了？
- Is the amount of brightness component increasing or decreasing to the right?
亮度的成分向右是增加還是減少了？

Colour: references

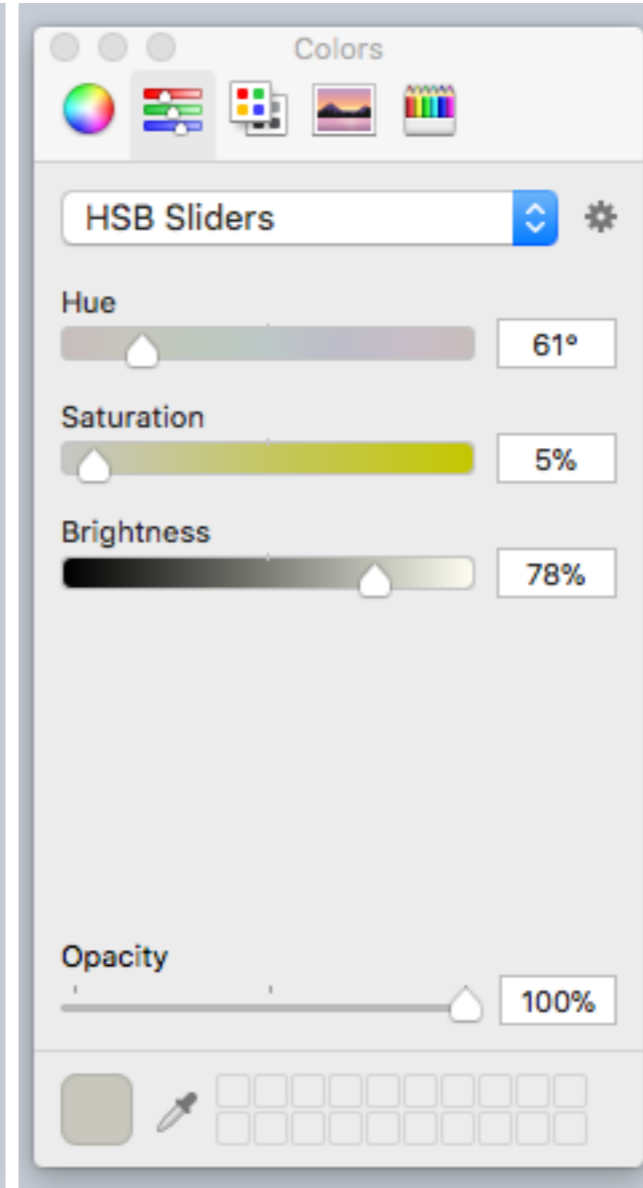
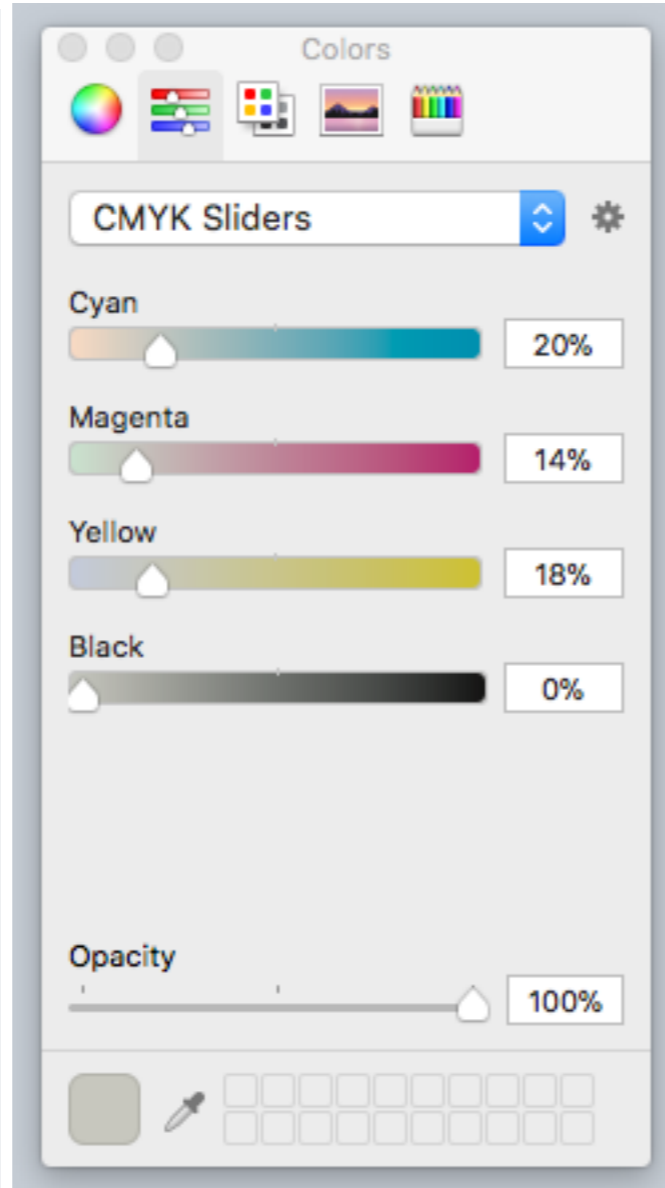
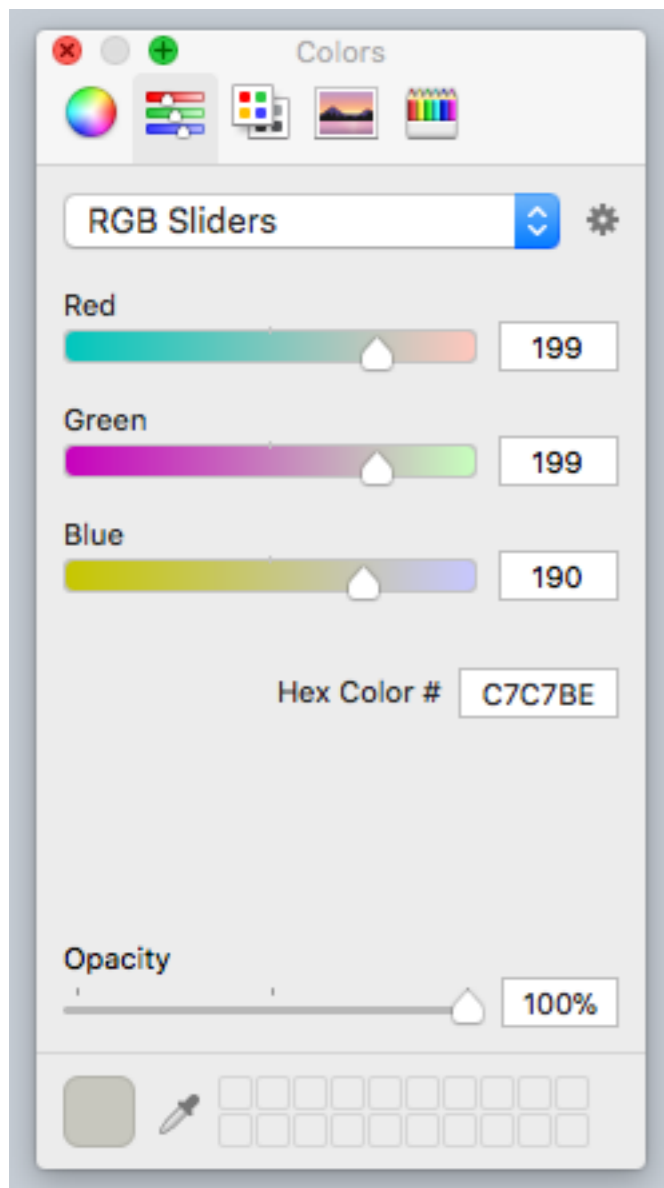
顏色：參考資料

- Frequently Asked Questions about Colour
Charles Poynton. 2009-10-19.
<http://poynton.ca/ColorFAQ.html>
- A Guided Tour of Color Space
Charles Poynton. 1997-08-19.
http://poynton.ca/papers/Guided_tour/abstract.html

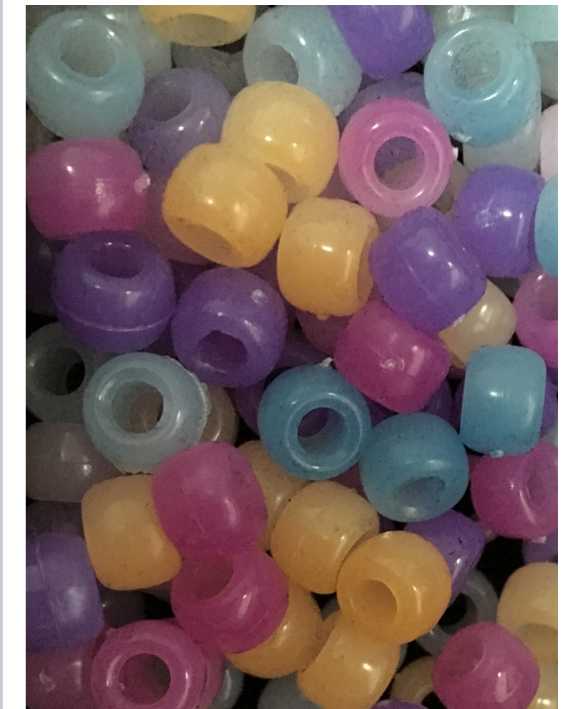
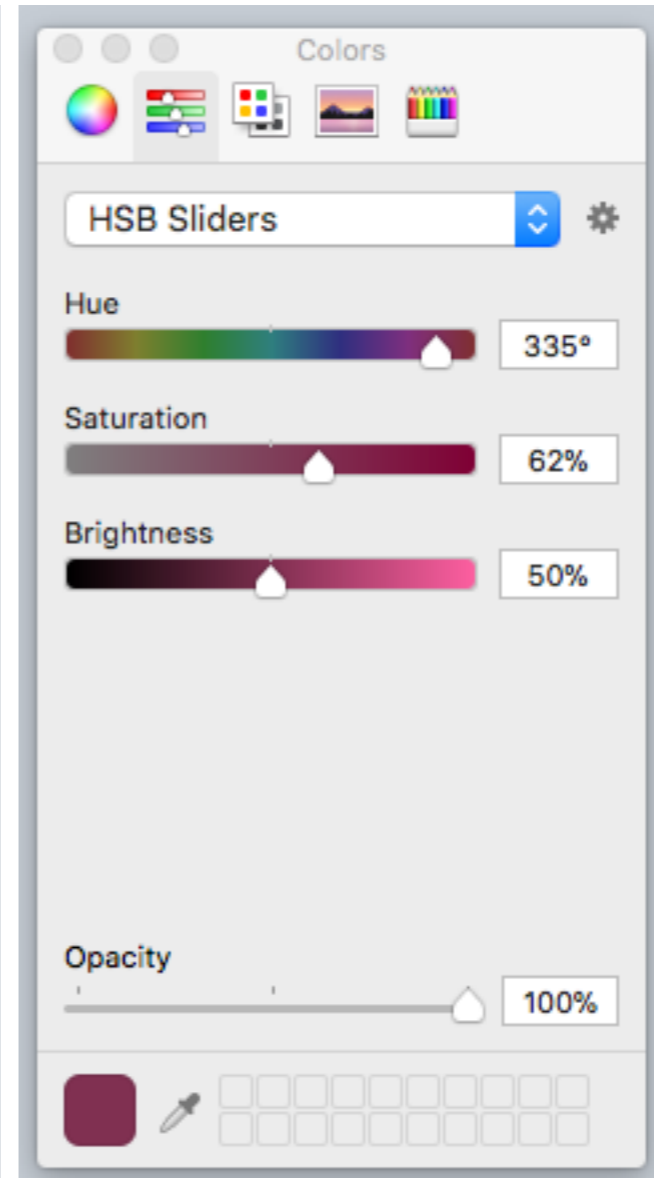
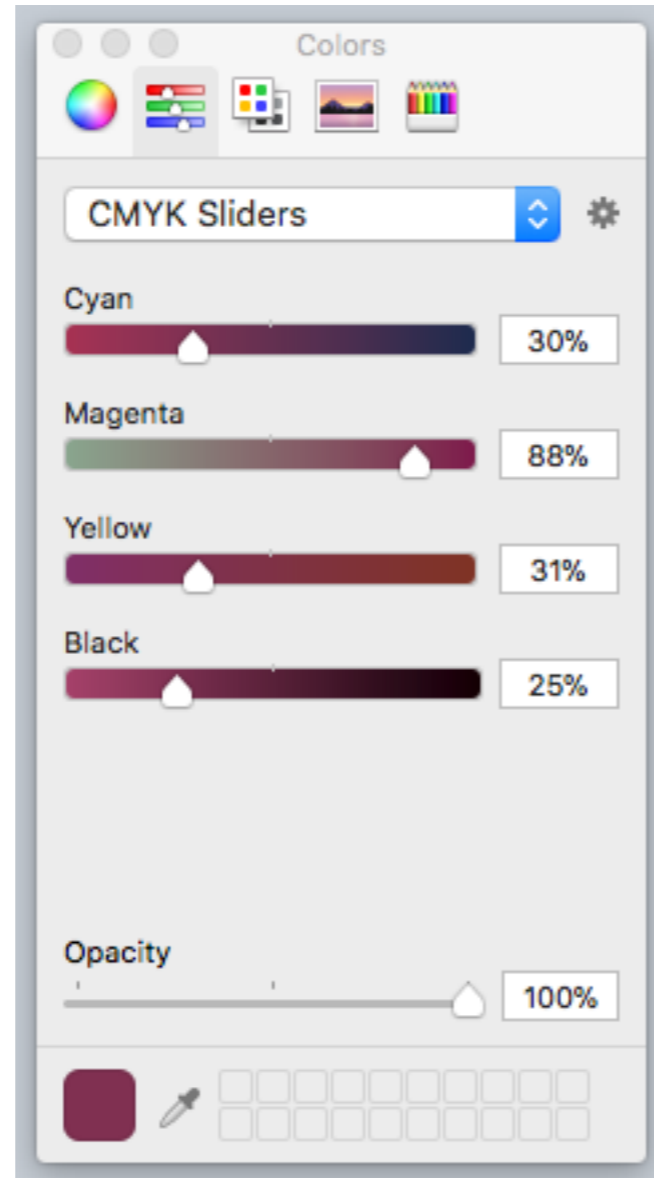
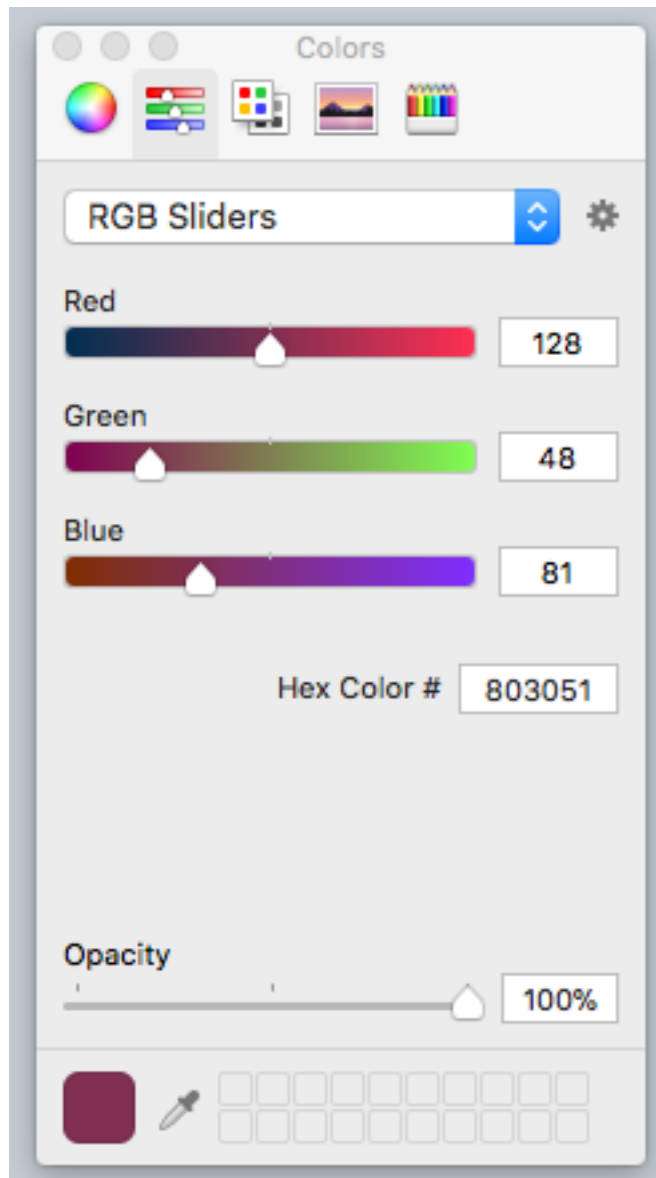
What should we look at?
我們應該看甚麼？



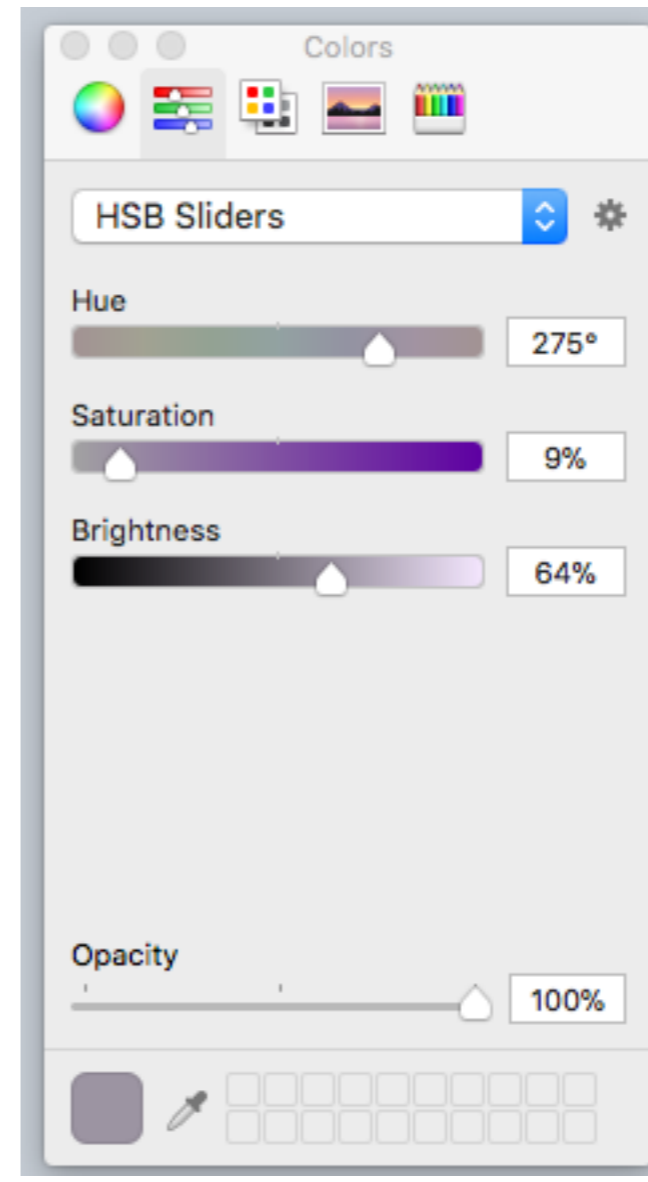
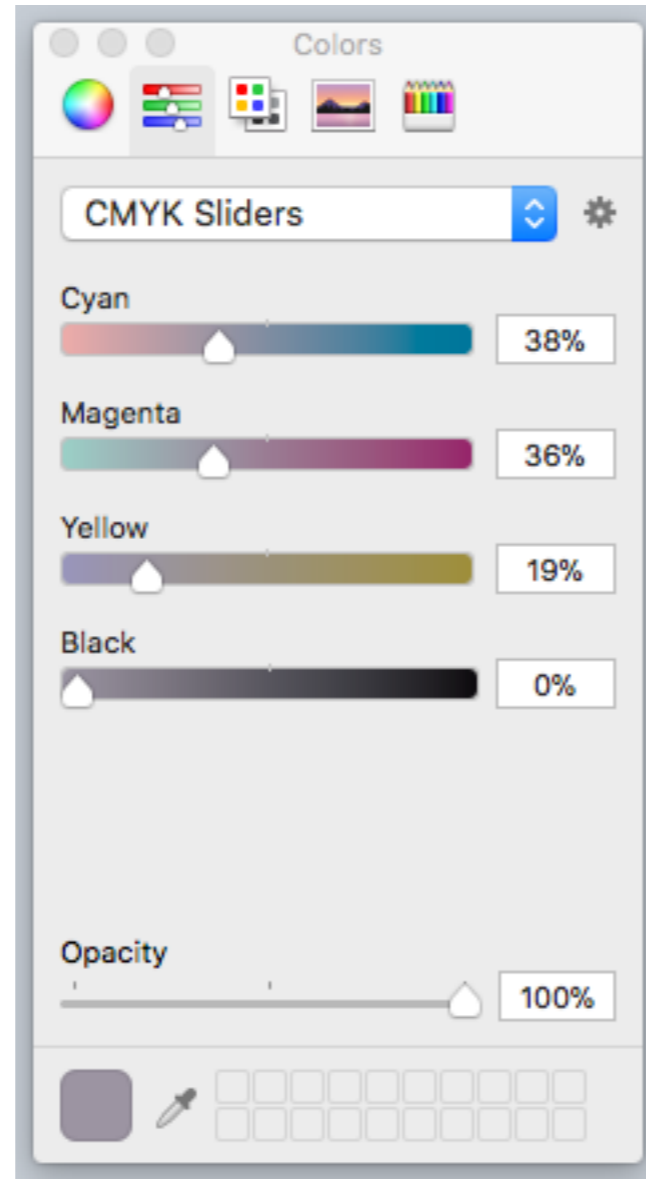
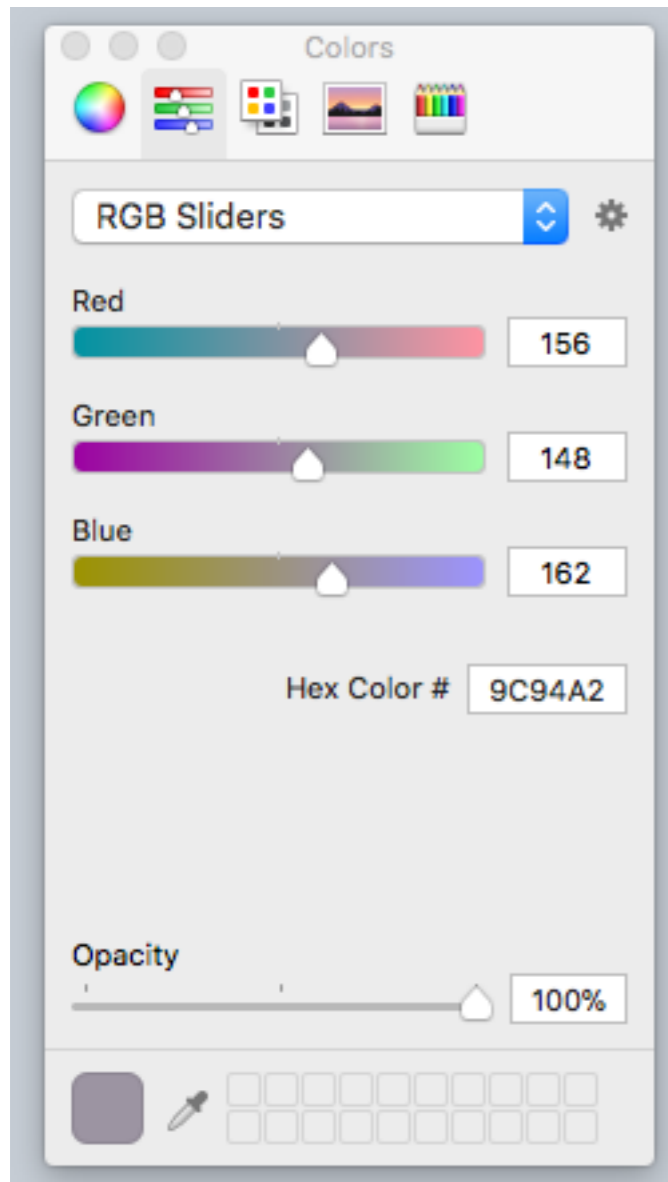
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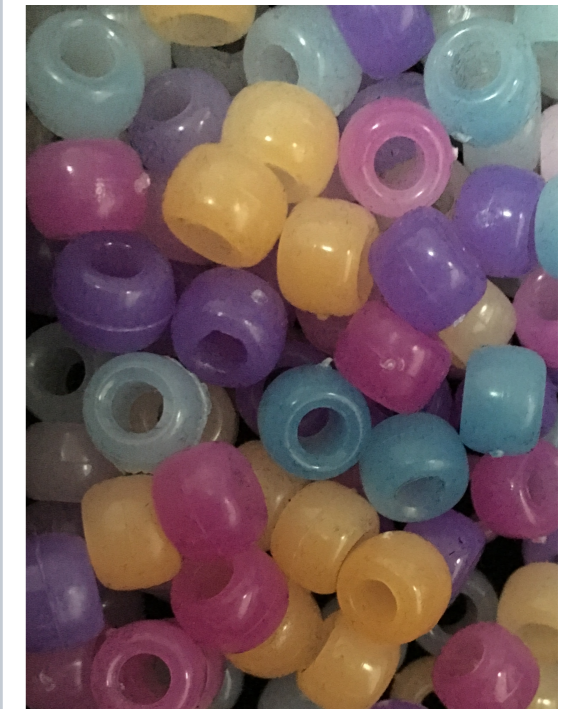
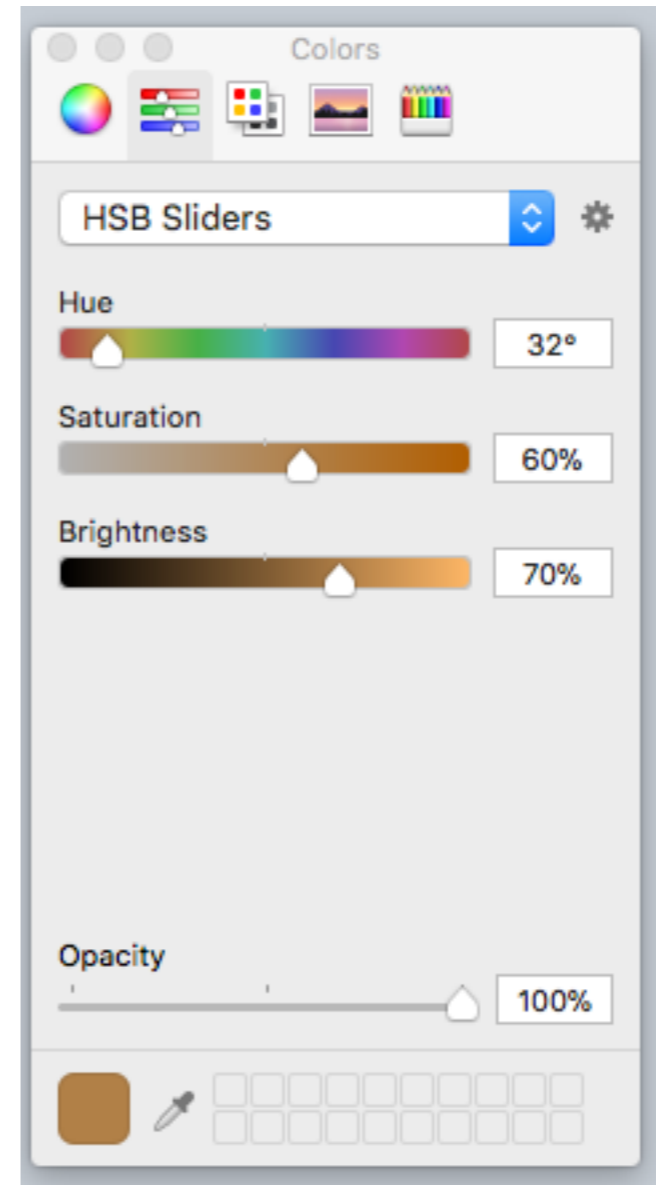
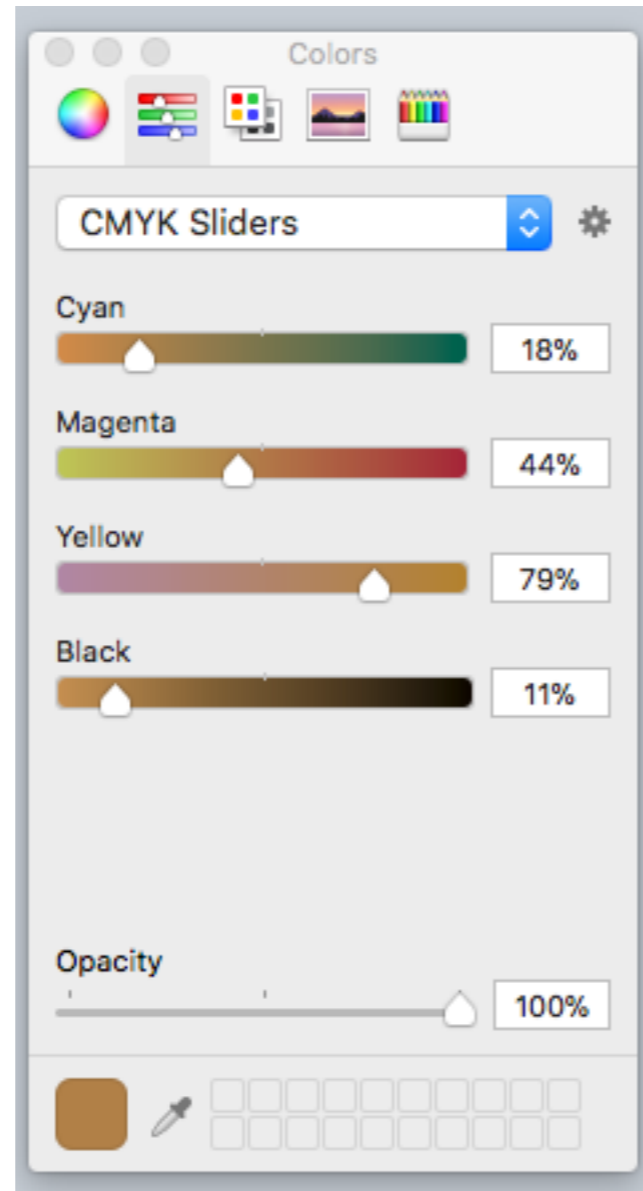
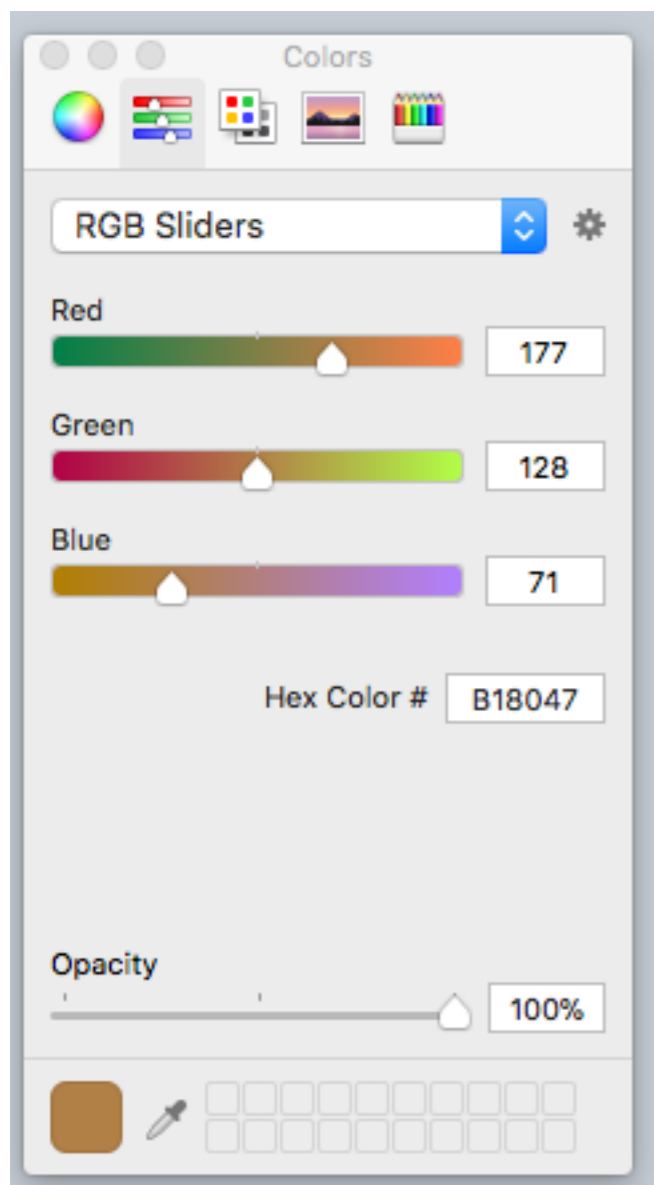
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What should we look at? 我們應該看甚麼？



What should we look at? 我們應該看甚麼？



Programming: Processing

編程：Processing

- Software environment: Processing.
軟件開發環境為 Processing.
<https://processing.org/>
- Most updated version: version 3.3.6, released 2017-09-04
最新版本：2017-09-04 更新的 3.3.6.
- It is cross-platform and can run on the OS X, Windows, and Linux.
它是個跨平台的軟件開發環境，可在OS X，Windows，和Linux運行。
- We will be using Processing to process video / photo from a digital video camera / digital camera.
我們會用 Processing 處理和分析視頻資訊。
- Note that the tool and environment are quite general, and are not limited to do what we are going to introduce.
這些工具和環境並非只能做到我們將要介紹的東西。



More about Processing

關於 Processing

- Processing is a programming environment for manipulating images, animations, and interactions. Processing 可用作處理圖像，動畫和人機互動設計。
- It integrates with the programming languages Java and JavaScript, and can be deployed as Java applications, on the web with HTML5 and WebGL support, or as Android applications.
它利用Java和JavaScript的編程語言，可產生出獨立運作的Java應用程式、在支援HTML5和WebGL的瀏覽器上使用的網頁、或Android應用程式。

Learning Processing

學習 Processing

- Tutorials

<https://processing.org/tutorials/>

- Reference

<https://processing.org/reference/>

Time to program!

編程時間！

Can it be simpler?
可以簡單些嗎？

UV sensor module 紫外線感測器模組

- There are modules for interface to credit card-sized computers.
有供卡片式電腦用的紫外線感測器模組。



UV-1 使用說明

主要用途：

紫外線測試儀、戶外紫外線監測設備和殺菌燈設備等

概述：

專為需要高可靠性和精確性測量紫外線指數 (UVI) 的場合所設計；

適合測量太陽光紫外線強度總量；

對照世界衛生組織紫外線指數分級標準

檢測 UV 波長：200-370nm；

回應極快、全互換性；

規格：

工作電壓：3.3V~5V

輸出電壓：DC 0~1V (對應 UV 指數 0~10 級)

測試精度：±1UV 指數

響應波長：200nm ~ 370nm

環境溫度：-20°C ~ 85°C

響應時間：< 0.5sec

工作電流：典型值 0.06mA，最大值 0.1mA

尺寸：19.8mm x 15mm

接線方式：

VCC：為電源正極輸入口，接入 3.3V-5V 的電壓

GND：為電源負極輸入口

OUT：為模擬信號輸出口，鏈接 MCU 的 I/O 口

注意：Arduino 玩家應該設置 MCU 的 I/O 口為輸入模式/接收模式，否則無法使用。其他 MCU，或者更為高級的控制板如 ARM 這些，若需設置 I/O 口為輸入輸出模式，都必須設置為輸入模式/接收模式，否則無法使用。51 系列單片機可直接只用，無需設置輸入輸出模式。

紫外線指數(UV index)	電壓輸出(mV)
0	<50
1	50~227
2	227~318
3	318~408
4	408~503
5	503~606
6	606~696
7	696~795
8	795~881
9	881~976
10	976~1079
11+	1079~

Credit card-sized computers?

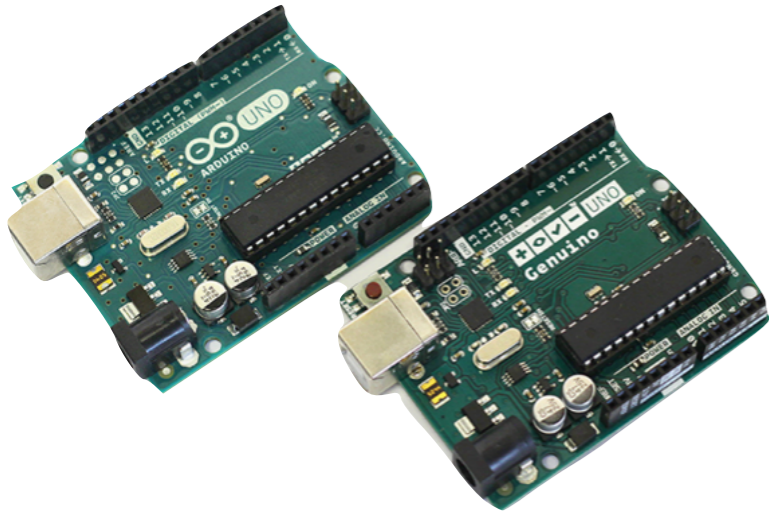
卡片式電腦？

Credit card-sized computers

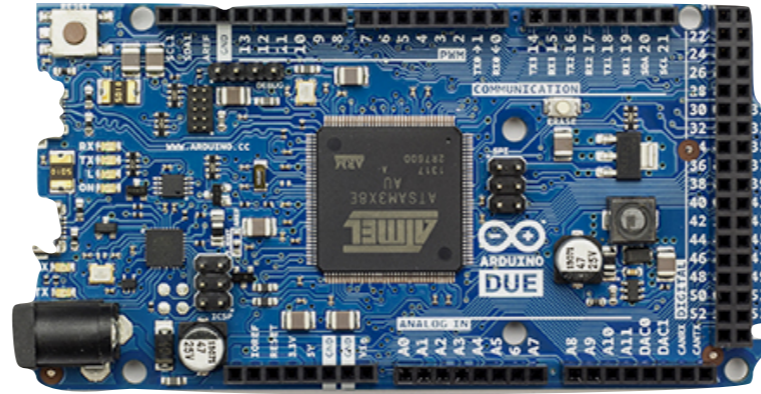
卡片式電腦

- Computer boards like Arduino or Raspberry Pi.
例如Arduino和樹莓派的小電腦板
- Often open source hardware.
很多時都是開源硬件。
- Software is written on a development computer and uploaded to the credit card-sized computer to run in an independent way.
在開發電腦上寫軟件，編譯後上載到卡片式電腦以獨立地運行。

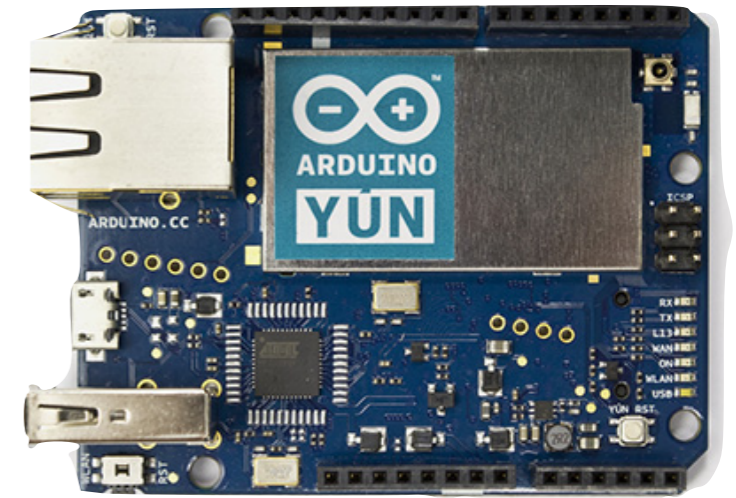
Some Arduino models 部分 Arduino 的類型



Arduino UNO / Genuino UNO



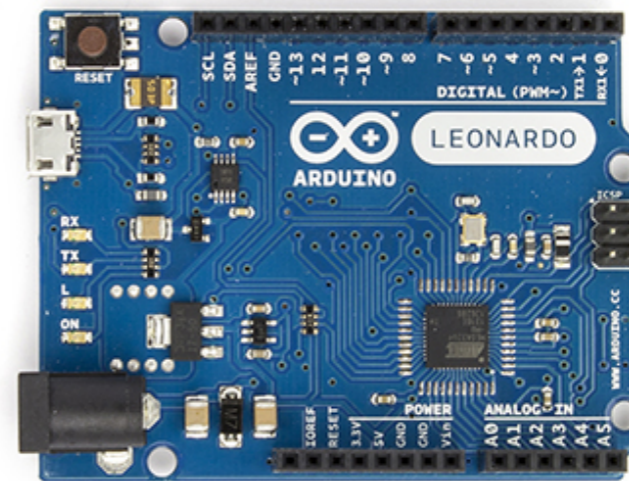
Arduino Due



Arduino Yun



Arduino Zero



Arduino Leonardo

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

Raspberry Pi

樹莓派

- Low cost, credit card-sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse.
便宜的卡片式電腦，可接駁顯示屏、鍵盤及滑鼠使用。
- Capable of doing everything you'd expect a desktop computer to do, from browsing the Internet and playing high-definition video, to making spreadsheets, word-processing, and playing games.
可作桌面式電腦使用，能用以瀏覽網頁、播放影片、製作試算表、文字報告或玩電腦遊戲等。
- 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。
- Can be used to learn how to program in languages like Scratch and Python.
可用以學習程式編寫如 Scratch 及 Python 等。
- Operating system: Raspbian; a Linux variant. 作業系統：Raspbian, Linux 的變種。

Some Raspberry Pi products

一些樹莓派產品



RASPBERRY PI 3 MODEL B

Our third-generation single-board computer



RASPBERRY PI 2 MODEL B

The Raspberry Pi 2 Model B is the second-generation Raspberry Pi



RASPBERRY PI 1 MODEL B+

The Model B+ is the final revision of the original Raspberry Pi



RASPBERRY PI 1 MODEL A+

The Model A+ is the low-cost variant of the Raspberry Pi



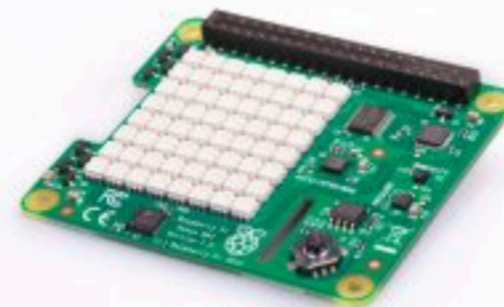
RASPBERRY PI ZERO W

Single-board computer with wireless and Bluetooth connectivity



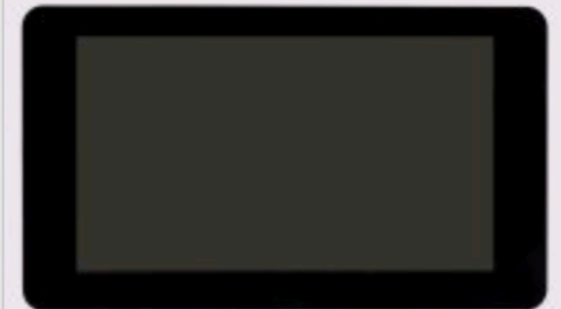
RASPBERRY PI ZERO

Our lowest-cost single-board computer



SENSE HAT

The Sense HAT is an add-on board for Raspberry Pi



RASPBERRY PI TOUCH DISPLAY

The 7" touchscreen monitor for Raspberry Pi

Some Raspberry Pi products

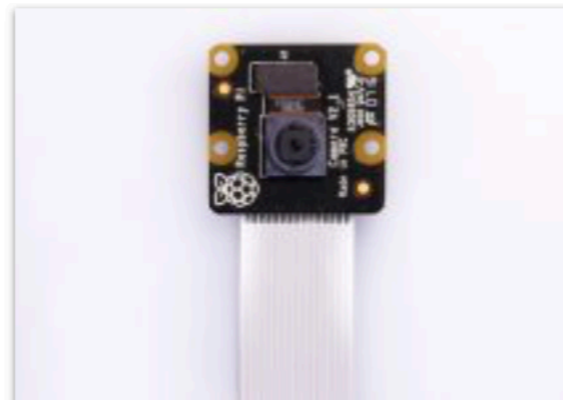
一些樹莓派產品

- <https://www.raspberrypi.org/products/>



CAMERA MODULE V2

The Raspberry Pi Camera Module v2



PI NOIR CAMERA V2

The infrared Camera Module v2 (Pi NoIR)

Connecting the UV sensor module to Arduino

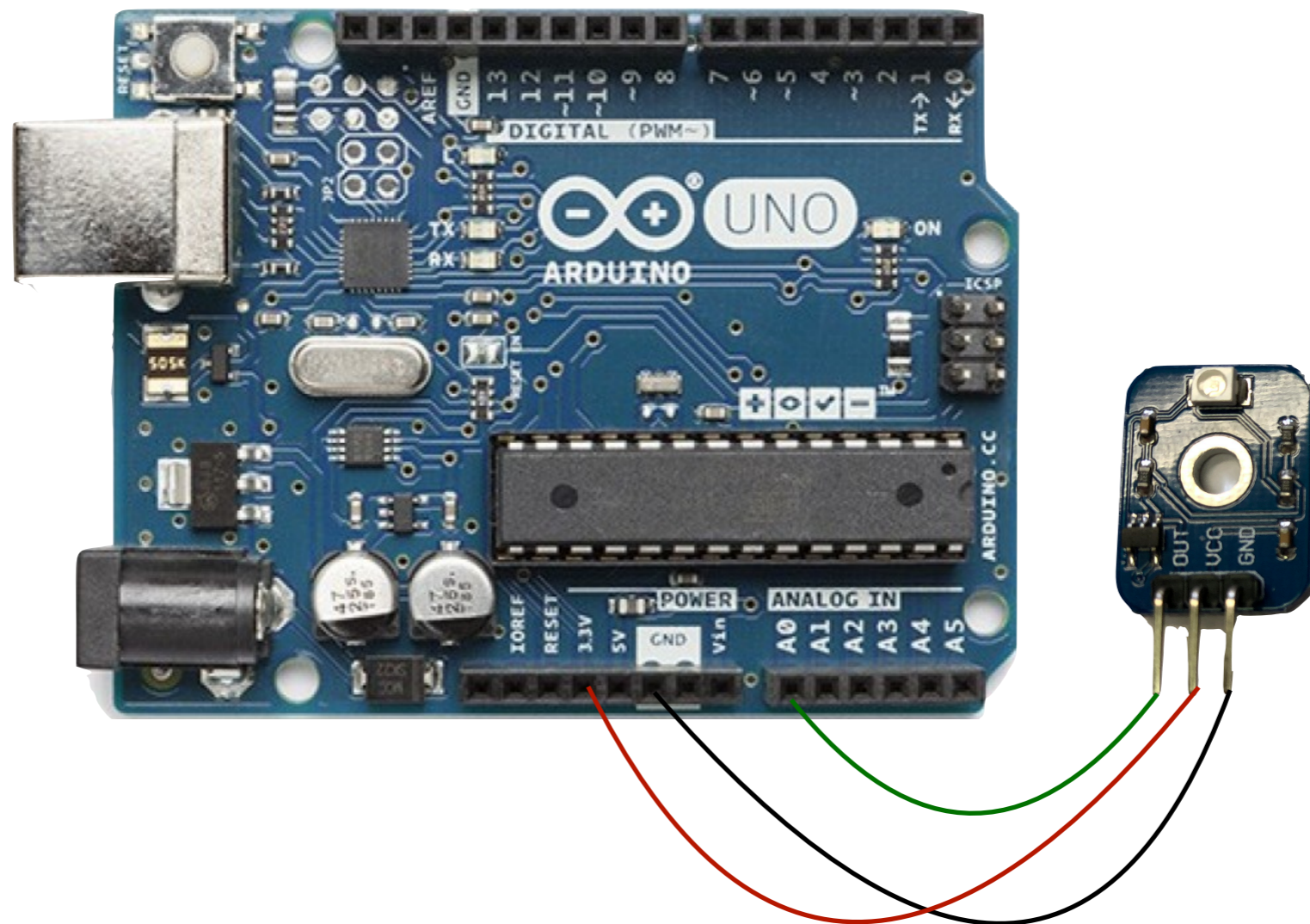
連接紫外線感測器模組至Arduino

接線方式：

VCC：為電源正極輸入口，接入 3.3V-5V 的電壓 ——

GND：為電源負極輸入口 ——

OUT：為模擬信號輸出口，鏈接 MCU 的 I/O 口 ——



Let's program!

一起編程吧！

Links 連結



- Competition website 比賽網頁
<http://www.cs.hku.hk/~uv/>
- Facebook page  
<https://www.facebook.com/UVCompetition/>
- Facebook group
<https://www.facebook.com/groups/UVCompetition/>
- Email 電郵 
uv@cs.hku.hk

Thank you 謝謝





<https://www.facebook.com/UVCompetition/>

