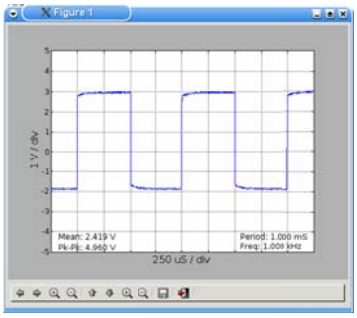
用電子訊號作工具來學科學

- 示波器：顯示電壓隨時間的變化(需要電流嗎? 輸入阻抗=?)，
  電子世界的眼睛



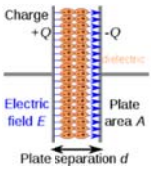
Trigger: Trigger Level, Trigger Slope and Trigger Mode (讓波形不跳動)

可測量：示波器內建參考方波、電池之電壓、
交流電之波形(用衰減探棒)、雜訊、小馬達發電 …

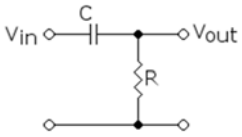
示波器問世之前，See 張文亮著 電學之父－法拉第的故事「第十五章電磁感應交響曲」
Google search : "第十五章電磁感應交響曲"

- Remember the Ohm's law. It is useful all the time.

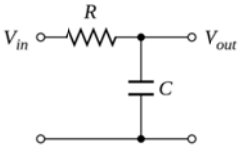
- 電容：Q = CV



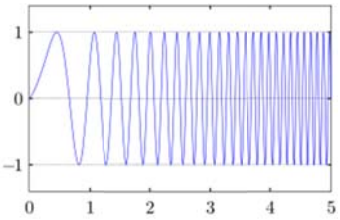
High pass filter: Image how it works.
想像一下它是如何運作的



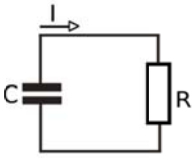
Low pass filter:



With a chirped sinusoidal wave, we can see the frequency response.



RC circuit:

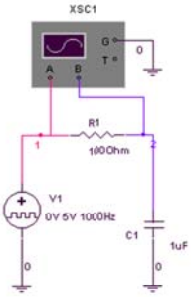


$i = -dQ/dt = -C dV/dt$

$V = iR = -RC dV/dt$ $\quad dV/dt \propto V$

This is a first-order kinetic equation, which happens very often in research and in nature (almost everywhere).

See "指數函數及其斜率.docx"



空電容 Vs. 充滿的電容 AC Vs. DC

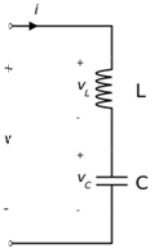
http://wps.prenhall.com/chet_floyd_principles_7/5/1290/330458.cw/index.html

⌖ 電感：$V = L\, di/dt$

To achieve a much higher voltage than the input voltage.

e.g., 點火線圈, …

用電流來思考 (電流須連續?)

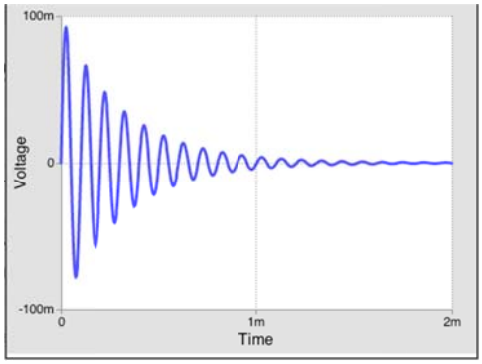


⌖ LC circuit:

$V = V_C + V_L$

Measure the peak-to-peak values of V, V_C and V_L at resonance and at off-resonance?

⌖ Complex Impedance is useful in analyzing L and C. See
http://hyperphysics.phy-astr.gsu.edu/hbase/electric/impcom.html



⌖ Euler's formula in complex analysis is very helpful.

$e^{ix} = \cos(x) + i \sin(x)$ $\quad i = \sqrt{-1}$

for example: $e^{ix} e^{iy} = e^{i(x+y)}$ such that

$[\cos(x) + i \sin(x)][\cos(y) + i \sin(y)] = \cos(x+y) + i \sin(x+y)$

See: https://en.wikipedia.org/wiki/Euler%27s_formula

⌖ 電波訊號傳遞與反射

When I was young, after sitting for 2 days in front of an oscilloscope, I understood how to imagine …

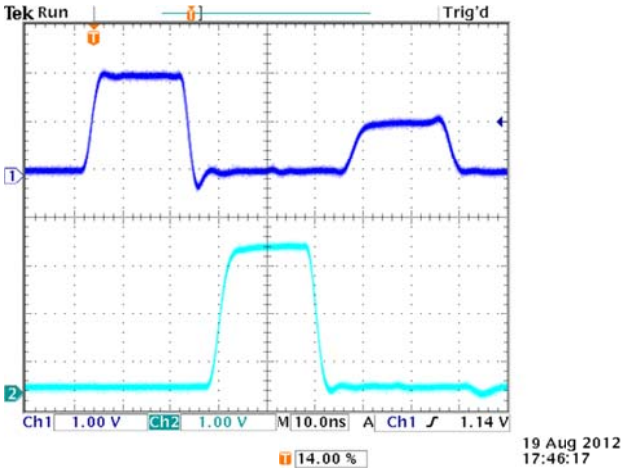
Useful tips:

(1) 電波之傳遞需要時間(接近光速?)

(2) 電波在電纜中傳遞，當還沒到達末端時，
電波本身會覺得電纜是無限長的

(3) 電荷不會憑空消失(Where the charges go?)

(4) 電阻的運作遵守歐姆定律，ΔV=IR，
ΔV 為電阻兩端之電壓差



⌖ 物理模型與實驗相互修正…

答案是可以在示波器上看見的，學習如何看見

實驗觀察可暗示模型；好的模型可解釋實驗並能做預測

Picture source: Wiki