● **爲什麼要使用電路理論？**

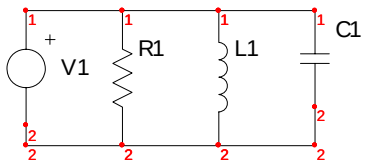
對任何電器行爲之正確分析應採用電磁學理論(但是太過於複雜，故採用電路理論來趨近)

● **電路理論(Circuit Theory)**

是確定一電器各部份間能量之移動與變換，並簡化只是“時間”的函數，不再與空間有關。Assumptions：假設電磁能之傳播速度爲無限大，而非光之速度！(ie.電路理論可以適用在尺寸不大之電路，電荷運動所產生之電磁場立即傳送至電路的任一部分）若尺寸太大，能量得以輻射能之觀點分析，以電磁學理論來分析能量之移轉與變換。

● **Electrical Circuit**：

Consist of various type of circuit elements connected by conductor in closed paths.



Electrical circuits are analogous to fluid-flow system

Battery → pump

Charges → fluid

Conductors → pipes

Electrical current → flow rate of fluid

● **Charged Bodies**： atoms (proton/neutron/electron……)

Proton(質子)　：　$+1.602 \times 10^{-19}$ (Coulombs)

Neutron(中子)　：　0 (Coulombs)

Electron(電子)　：　-1.602×10^{-19} (Coulombs)

International System of Units (SI system) based on MKS metric system

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MKS(meter-kilogram-second) / CGS(centimeter-gram-second) / British system (foot-pound-second) Coulomb for charge and Kelvin(Celsius) for temperature

Power of 10	Prefix name	Symbol
10^{12}	tera-	T
10^{9}	giga-	G
10^{6}	mega-	M
10^{3}	kilo-	k
10^{-2}	centi-	c
10^{-3}	milli-	m
10^{-6}	micro-	μ
10^{-9}	nano-	n
10^{-12}	pico-	p
10^{-15}	femto-	f

● Electrical Current：

Time rate of flow of electrical charge through a conductor or a circuit element.

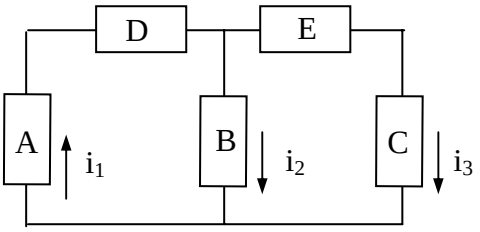
$$i = \frac{dq}{dt}(Ampere)(Coulomb/Sec)$$

● 構成：　a. 由一群流動的電子（金屬導體）

b. 由一群正、負離子之流動（電解導體）

● 方向：以正電荷流動之方向爲電流方向。

● 參考方向(假設)：

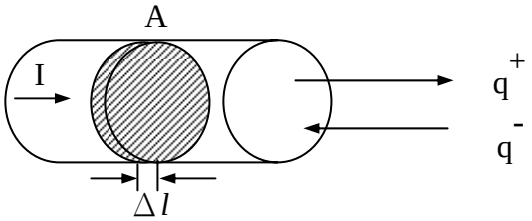


如果 $i_1 = -2A$ 表示流經元件 A 電流之實際方向爲由上往下

● Current Density（電流密度，J）

assume current equally distributed

$$J = \frac{I}{A} = \frac{Q}{A\Delta t}$$



N：單位體積內的帶電體

q：帶電體之帶電量(C) (p.s. 1 個電子之帶電量＝$1.602*10^{-19}$ C)

$$\Rightarrow Q = N(A\Delta l)*q$$

$$\Rightarrow J = \frac{N(A\Delta l)*q}{A*\Delta t} = N*\frac{\Delta l}{\Delta t}*q = N*q*v$$

其中　$v = \frac{\Delta l}{\Delta t}$　：　帶電體之移動速度

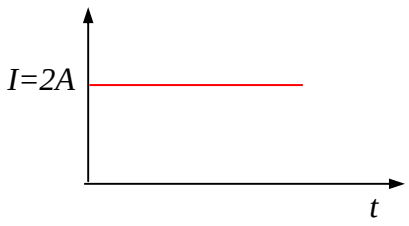
● AC／DC：

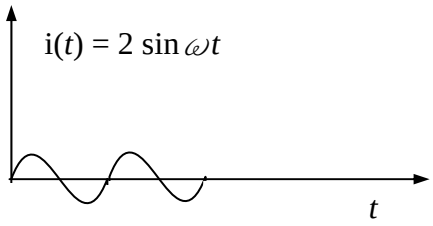
Direct Current：constant with time

Alternating Current：varying with time, reversing direction periodically

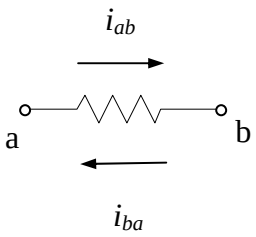
(ex.)　　I = 2A →DC

i(t) = 2 sin ωt →AC





● 表示方法： double-subscript notation for current

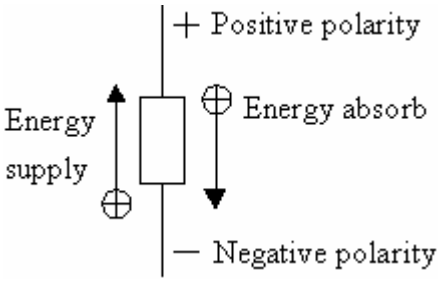


● Electrical Voltage(Electrical Potential)：

單位電荷在經過電路元件時所獲得或損失的能量。

$$V = \frac{dw}{dq}(Volts)(Joules/Coulomb)$$

Voltage are assigned polarity to indicate the direction of energy flow.

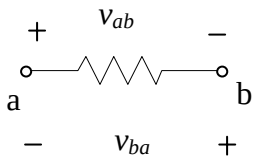


● Reference polarity (by assumptions)

● AC／DC Voltage

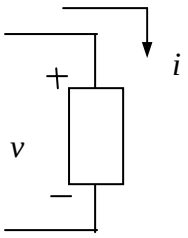
● 表示方法： double-subscript notation for voltage

$v_{ab} = - v_{ba}$

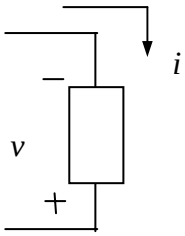


● Power(功率) : the rate of doing work

$$P = \frac{dw}{dt} = \frac{dw}{dq} * \frac{dq}{dt} = v * i \quad (Watts)\left(Joules/Sec\right)$$



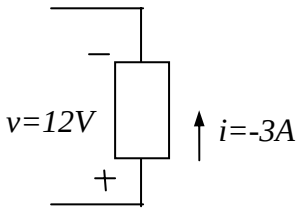
$P = vi$
元件吸收能量
(電池充電)



$P = -vi$
元件輸出能量
(電池放電)

When current flow in a load element from higher potential to lower potential point → energy spent by charge (or load absorbing power).
When current flow in a load element from lower potential to higher potential point → electric charges are gaining energy (or source delievering power to other elements)

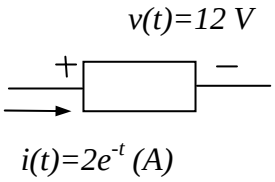
Example:



● Energy (能量)

$$W = \int_{t1}^{t2} P(t)dt \quad \text{(Joules or Watts-Sec or Newton-Meter)}$$

Ex. 1



Power =?
Energy =?

Ex. 2

1 度電 = 1 千瓦小時 (KWH) = 10^3 (watts)x 3600(sec) = $3.6x10^6$ (Joules)

Example:

If 3.3 NT dollars per kilowatt-hour in summer time, what is cost of leaving a 60-W lamp on for 7 days?