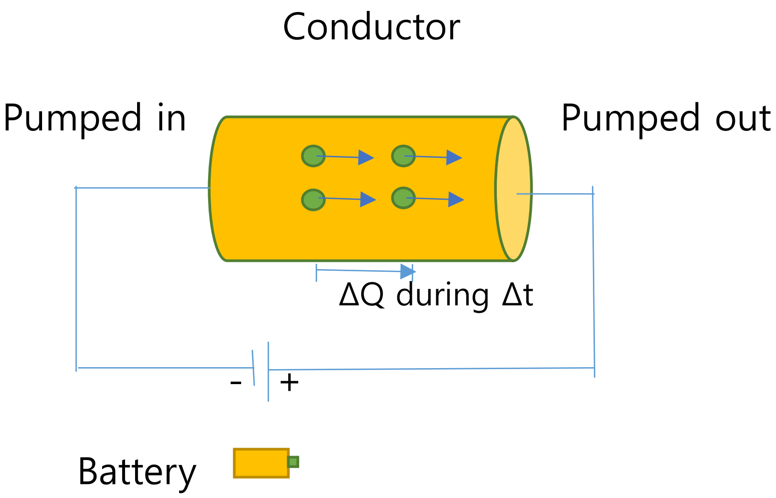
Lecture Note 1

Analogy bet.   Electrical and Mechanical system

Electrical ('Invisible') vs	Mechanical ('Visible')
Circuit	Pipeline network
Electrons	Water
Quantity/Charge [Coloumb,C]	Water amount [Kg]
Current [Ampere,A]	Flow rate [Kg/sec]
Voltage [Volt,V]	Pressure [Pascal]
Resistor [Ohm,Ω]	Nozzle/Orifice/Restrictor
Capacitor [Farad,F]	Accumulator/Reservoir/Tank

Current=amount of electric quantity flowing during unit time



(Current direction is the opposite to the electron movement)

Current, I ≡ ΔQ/Δt [Coloumb/sec] ≡ Ampere [A]

1A=1C/sec= 6.24E18 elcectrons charge / sec

(∵ One electron's charge=1.602E-19 C)

Current density, J=I/Area=Current per unit area [A/m^2]->Line Dia.

Ampere is a very big amount, thus

mA (=10^{-3}A), μA(=10^{-6}A), nA(=10^{-9}A), pA(=10^{-12}A) are commonly used.

Ex)

200mA for mobile phone; μA~pA for lower power micro-chips

100mA~1A for cardiac/respitory arrest

1A for 100W light bulb

2-3A for Labtop;1-3A for TV

8-13A for microwave

200A for Car starter; 1000A for thunder strike

*Current is measured by current meter, or multimeter by current knob, and the meter is connected SERIALLY to the circuit.

One electron's charge=1.602E-10 Coloumb

1 Coloumb=1A*sec

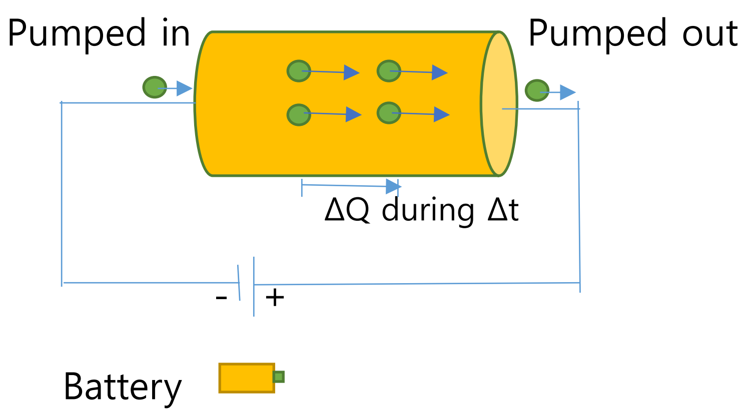
=Charge of 6.24E18 electrons

Ex) 4000mAh Battery of smartphone =4A*3600sec=14400 Asec

=14400 Coloumb ≒ 9E22 Electrons

Voltage [Volt,V]: pressure or potential for current to flow

Repulsive force to move away (free electron)



Vd=Drift velocity=0.002 mm/s=7.2mm/hour=172.8mm/day

Vs=Signal velocity≒Speed of light=300,000km/s=3.0E9 m/s

Vf=Thermal velocity=1.57E6 m/s ≒ 1/2000 (or 0.05%) of Vs

Voltage is the electromotive force (or emf) to push all free electrons (not electrons for binding) within the conductor, and

To make electrical current flow from one point to another

To propagate through the conductor at near the speed of light

1 Volt=Pressure or Potential to perform 1J of work, while moving 1C charge between the points ≡1J/1C, or V=W/Q=Power/Current=P/I

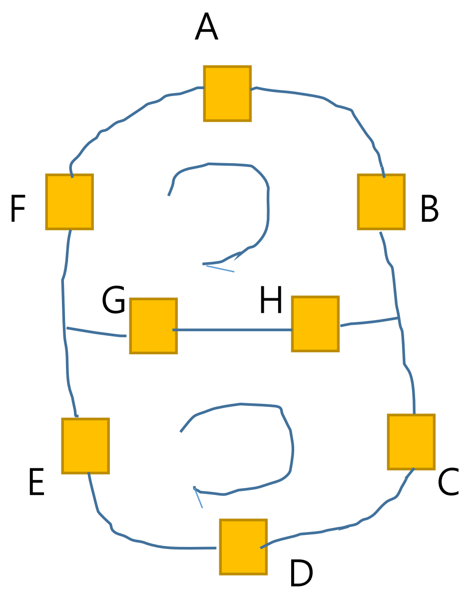
Ex)1.5V battery is capable of performing 1.5J work, while moving 1C charge through a circuit.

*Voltage is measured by voltmeter, or multimeter by voltage knobbing, and the meter is connected PARALLEL to the circuit.

Laws for DC circuit

1. Kirchhoff's Voltage Law

: For any closed loop, the sum of net voltage becomes zero, $\Sigma V=0$



For the 3 closed loops

1) $\Sigma V=V_A+V_B+V_C+V_D+V_E+V_F=0$ for the big closed loop
2) $\Sigma V=V_A+V_B+V_H+V_G+V_F=0$ for the upper closed loop
3) $\Sigma V=V_C+V_D+V_E+(-V_G)+(-V_H)=0$ for the lower closed loop

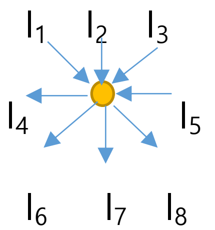
(Note the minus sign for V_G, V_H in the lower closed loop)

2. Kirchhoff's Current Law

:For any junctions (or meeting points),

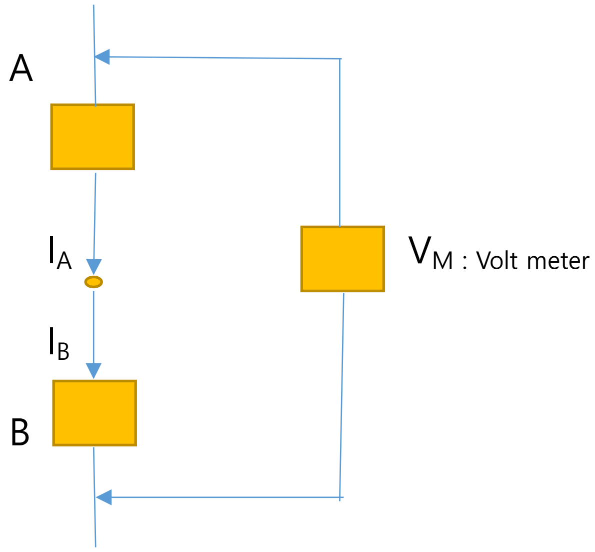
the sum of net current becomes zero, $\Sigma I=0$

$\Sigma\ I=(+I_1)+(+I_2)+(+I_3)+(+I_5)+(-I_8)+(-I_7)+(-I_6)+(-I_4)=0$



Note the minus sign for the coming-out current, $I_8\ I_7\ I_6\ I_4$

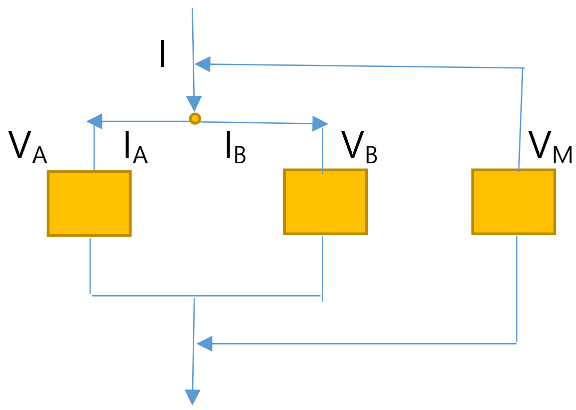
<Serial Circuit>



$V_A+V_B+(-V_M)=0\ \therefore\ V_M=V=V_A+V_B$ (Voltage is divided)

$I_A+(-I_B)=0\ \therefore\ I_A=I_B=I$ (Current is the same)

<Parallel Circuit>



$V_A+(-V_B)=0 \therefore V_A=V_B$

$V_B+(-V_M)=0 \therefore V_B=V_M=V_A$ (Voltage is the same)

$I+(-I_A)+(-I_B)=0 \therefore I=I_A+I_B$ (Current is divided)

The Kirchhoff's law applies to all circuit and junctions, and all the circuit design knowledge is based on the Kirchhoff's law.