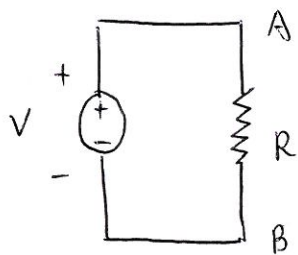Review: In last lecture, we came to one conclusion:

Anything we do on the earth, we do it by changing the form of energy.

In the ECE field, we do sth by building a circuit, where we put a battery to create an electrical potential difference (voltage).

Since charges will experience a force in an electrical field, the voltage "V" will push positive charges to go through the resistor R from A ⟹ B.
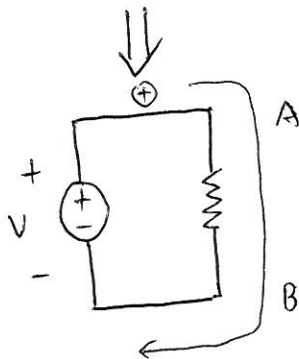
During this process, charges move from a high electrical potential to a low potential (A ⟹ B), and thus lose their electrical energy.
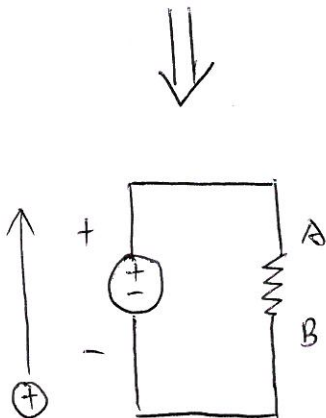
When the positive charges come back to the negative terminal of the battery, the chemical mechanism inside the battery will pull the positive charges up to the positive terminal.

During this process, charges obtain electrical energy and battery loses chemical energy. Then, charges carry electrical energy to the resistor again.

The whole process is about "chemical energy" ⟹ "electrical energy".

L3 : Basic Electronics : Energy & Power.

1. Energy :

* Energy is an attribute of objects & system.

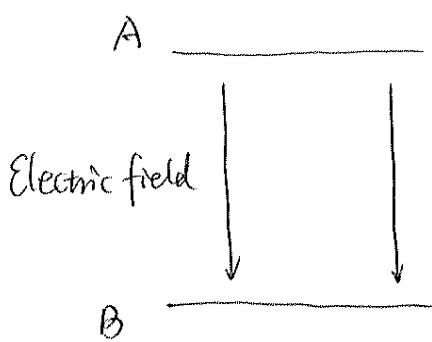 Symbol : E

  Unit : Joule or J

  Forms of Energy · Mechanical (Kinetic & Potential), Thermal, Electrical, Chemical.

* Energy Conservation :

  Exercise :   Mass = 2 Tons, Velocity = 100 km/h

  $$E_k = \frac{1}{2} m v^2$$

* Energy in ECE ·

A _____

Electric field

B _____

Pushing an object to a higher position gives potential Energy to the object $\Rightarrow$

Pushing a change from a lower electric potential B to a higher electric potential A gives electric energy to the change

Infact, the energy $E = q \times V_{AB}$ where $V_{AB} = V_A - V_B$

The formal definition of voltage is $V_{AB} = \frac{E}{q}$: The potential difference between A & B $=$ Energy (work) needed to move a unit change against the static electric field between A & B.

2. Power

If energy is the ability to do work, power is the rate of doing work.

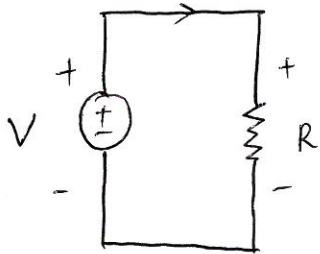Power is defined as the rate at which energy is produced / consumed / dissipated.

* Symbol : P

  unit : Watt / w / $\frac{J}{s}$

$$P = \frac{E}{t}$$

* Electrical Power :

Assuming Q charges go through the resistor in t seconds, what is the power (consumed) of the "R".

$$P = \frac{E}{t} = \frac{V \cdot Q}{t} = V \cdot \frac{Q}{t} = V \cdot I \longrightarrow \text{Rate of moving charges}$$

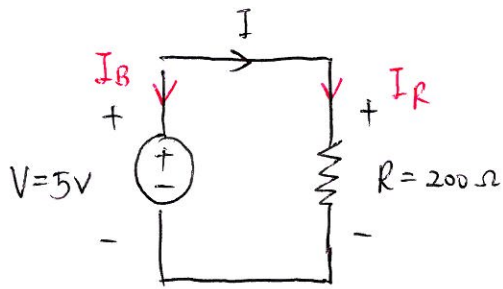Energy to move one Coulomb of charge

$$P = VI = I^2 R = \frac{V^2}{R}$$

* Power rating of a speaker = maximum power that can be delivered without damage.

Example : The power rating of a speaker = 100 w. Internal resistance = 16 Ω.

What is maximum safe current ?

$$P = I^2 R \Rightarrow I^2 = \frac{P}{R} \Rightarrow I = \sqrt{\frac{P}{R}} = \sqrt{\frac{100}{16}} = \frac{10}{4} = 2.5 A.$$

Example:

What is the power consumed by R and the battery?
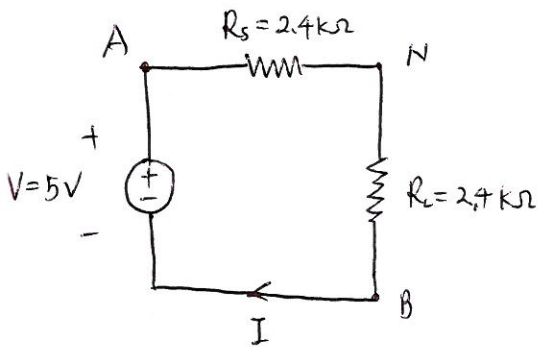
$$I = \frac{V}{R} = \frac{5}{200} A$$

$$P_R = VI = \frac{V^2}{R} = \frac{25}{200} = \frac{1}{8} w.$$

How about P_B, power consumed by the battery? $P_B = VI$? then $P_B = P_R > 0$ ✗

※ Reference direction: Current enters the component from the positive terminal.

$$I_R = I \quad but \quad I_B = -I . \quad Thus, \quad P_R = V_R I_R = VI$$

$$P_B = V_B I_B = -VI$$

$$\left. \begin{array}{c} \end{array} \right\} P_R = -P_B$$

Consumed = Produced.

Resistor Network

What is the power for the load R_L?

Method 1: $\quad I = \frac{V_{AB}}{R_{AB}} = \frac{5}{R_S + R_L} = \frac{5}{4.8 k\Omega} = 1.04 mA$

$$P_L = I^2 R_L = (1.04 mA)^2 \times 2.4 k\Omega = 2.6 mW.$$

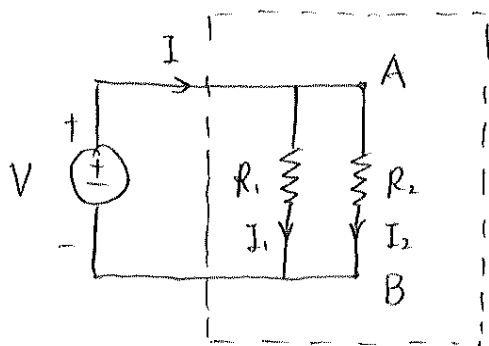Method 2: $\quad P = \frac{V^2}{R} = \frac{5^2}{R_S + R_L} = 5.2 mW \quad (total \ power)$

$$P_L = \frac{P}{2} = 2.6 mW.$$

3. Resistors in series : Voltage divider.

For the above network, $\quad V_{NB} = R_L \cdot I = R_L \cdot \frac{V_{AB}}{R_S + R_L} = \frac{R_L}{R_S + R_L} V_{AB}$

↓

Voltage is divided according to the ratio of the resistance.
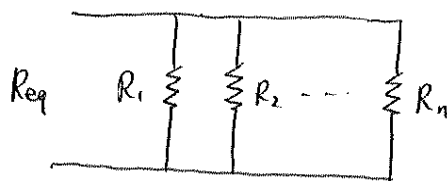
4. Resistors in Parallel

What is the equivalent resistance for the boxed resistive network?

$$I_1 = \frac{V}{R_1}$$

$$I_2 = \frac{V}{R_2}$$

$$\Rightarrow$$

$$I = I_1 + I_2 = \frac{V}{R_1} + \frac{V}{R_2}$$

$$R_{eq} = \frac{V}{I}$$

$$\Rightarrow \quad R_{eq} = \frac{V}{\frac{V}{R_1} + \frac{V}{R_2}} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} = \frac{R_1 R_2}{R_1 + R_2}$$

Similarly, we can prove that R_{eq} for n resistors in parallel is given by

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots \frac{1}{R_n}$$

Obviously, for such a case, it is easier to work with $\frac{1}{R}$.

* $\frac{1}{R}$ is called conductance having the unit Siemens (s) or Ω^{-1}, mho, $\mho$, etc.

* Energy Sources : DC + AC.

Exercise: On the battery of iPhone 6, you can see some parameters

$$3.8 V, \quad 2915 \, mAh.$$

Question: If we change this iPhone everyday (fully), how much do we need to pay assuming the electricity price at $1 \, HKD/kWh$.

Sol:

$$E = V \cdot Q = 3.8V \times 2915 \times 10^{-3} \times \frac{C}{S} \times 3600 \, S$$

$$= 3.8 \times 2915 \times 10^{-3} \times 3600 \, J \quad \longrightarrow \text{ one changing.}$$

One day $\rightarrow \$ = \dfrac{E}{kWh} = \dfrac{3.8 \times 2915 \times 10^{-3} \times 3600}{10^3 \times 3600} = 0.011077 \, HKD$

1 year $\rightarrow \$ = \$ \times 365 \simeq 4 \, HKD.$