VII The electric current

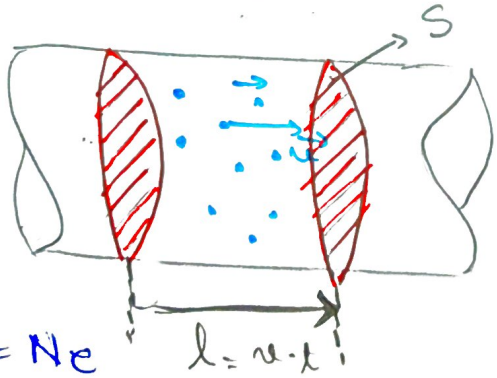
1. The electric current intensity

1.1. Definition

Def. The ordered motion of electric charge particle is called **electric current**.

- two types of electric current
  - **of conduction**
    - electrons in conductors;
    - electrons and poles in semiconductors;
    - ions, electrons in plasma/gases;
  - **of convection**

1.2.



$Q = Ne$

Note: $n = \frac{N}{V}$ (/* $n = \frac{dN}{dV}$ */)

$N = n \cdot V = n \cdot S \cdot l = n \cdot S \cdot v \cdot t$

$$\boxed{Q = n \cdot e \cdot v \cdot S \cdot t}$$

Def: $$I = \frac{dQ}{dt}$$

$$I = \frac{d}{dt}(n \cdot e \cdot v \cdot S \cdot t) = \frac{n \cdot e \cdot v \cdot S \cdot dt}{dt}$$

$$I = n \cdot e \cdot v \cdot S$$

Note: $$j^{dif} = \frac{dI}{dS}$$ the electric current density

$$j = \frac{d(n \cdot e \cdot v \cdot S)}{dS} \Rightarrow$$

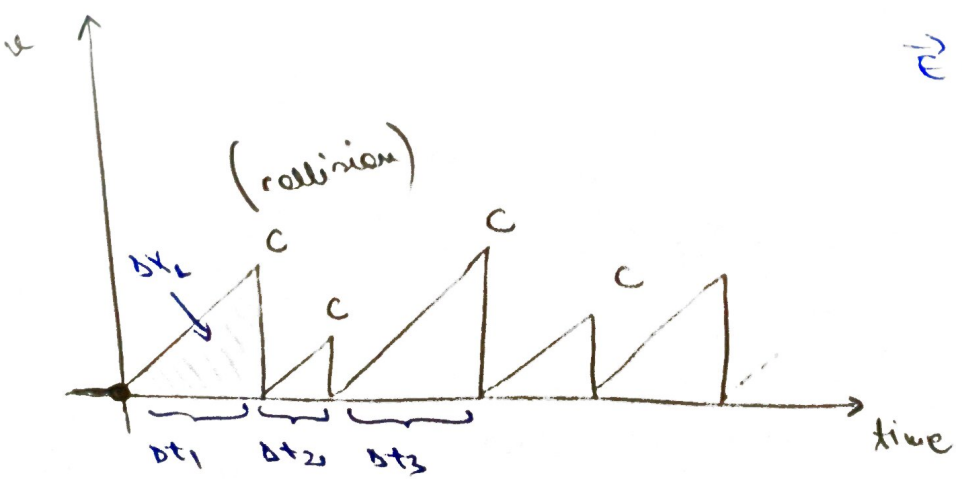
$$\vec{j} = n \cdot e \cdot \vec{v}$$

$$dI = \vec{j} \cdot d\vec{S} \;|\; \int \Rightarrow \int dI = \int_S \vec{j}\, d\vec{s} \Rightarrow$$

$$\Rightarrow I = \int_S \vec{j}\, d\vec{S}$$

2. The Ohm's law

(rollision)



(rollision)

$$\vec{E} = -\nabla V$$

$$\vec{F_e} = e\vec{E}$$

$$\vec{F}_e = m_e \cdot \vec{a}$$

$$\vec{a} = \frac{e\vec{E}}{m_e}$$

m_e: a universal constant

$$\Delta x_i = \frac{a \cdot \Delta t_i^2}{2} \Rightarrow \Delta x = \sum_{i=1}^{n} \Delta x_i = \frac{eE}{2m_e} \sum_{i=1}^{n} \Delta t_i^2$$

$$v = \frac{\Delta x}{\Delta t} = \frac{eE}{2m_e} \frac{\sum_{i=1}^{n} \Delta t_i^2}{\Delta t}$$

Note: $\tau = \frac{\sum_{i=1}^{n} \Delta t_i^2}{\Delta t}$ - the average time between two collisions

$$\left.\begin{aligned} \vec{v} &= \frac{e \cdot \tau}{2m_e} \cdot \vec{E} \\ \vec{j} &= n \cdot e \cdot \vec{v} \end{aligned}\right\} \Rightarrow$$

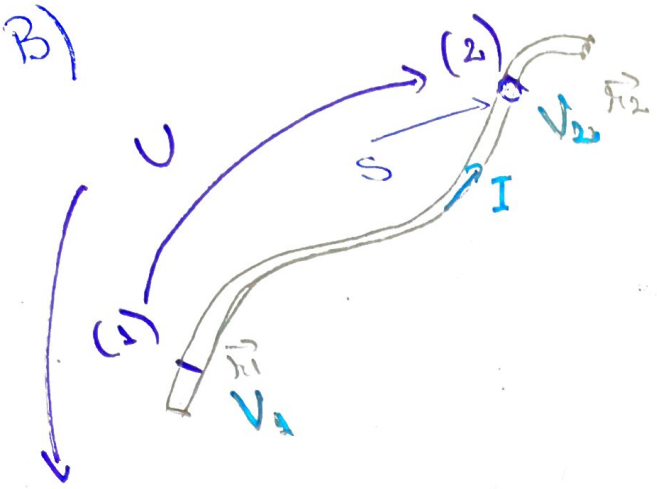
$$\Rightarrow \vec{j} = \frac{n \cdot e^2 \tau}{2m_e} \vec{E}$$

Note: $\gamma = \frac{n e^2 \tau}{2m_e}$ - the electric conductivity

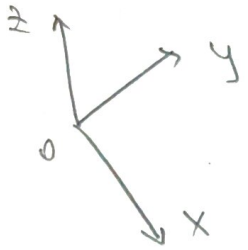
$$\boxed{\vec{j} = \gamma \cdot \vec{E}}$$

The local form of the OHM's law

B)



electric tension (a drop of potential)



$$j = \frac{I}{S}$$

Note $\boxed{\rho = \frac{1}{\gamma}}$ the electric resistivity

$$\Delta V = -\int_{\vec{r}_1}^{\vec{r}_2} \vec{E}\, d\vec{r}$$

$$U = V_1 - V_2 = -\Delta V \Rightarrow U = \int_{r_1}^{r_2} E\, dr = E\int_{r_1}^{r_2} dr$$

V_1: high potential, V_2: low potential

$$U = E \cdot l \Rightarrow \boxed{E = \frac{U}{l}}$$

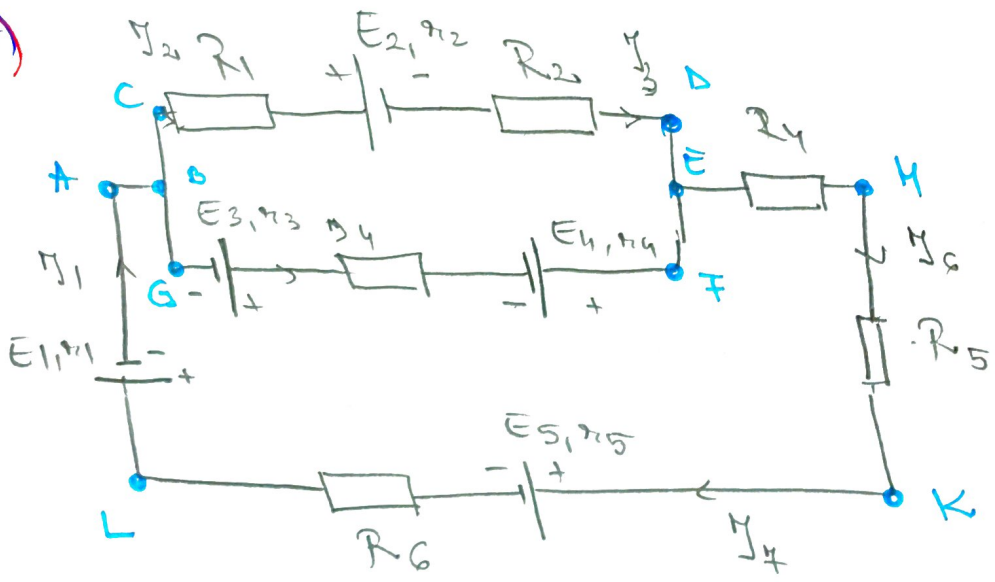
$$\frac{I}{S} = \frac{1}{\rho} \cdot \frac{U}{l} \Rightarrow U = \rho \cdot \frac{l}{S} I$$

Note: $\boxed{R = \rho \cdot \frac{l}{S}}$ – electric resistance

$\boxed{U = R \cdot I}$ Ohm's law.
for a part of an electric circuit

2. The elements of an electric circuit

a)



Kirchhoff's laws

L_1:

B, E : nodes

$$\boxed{\sum_i I_i = 0}$$

L_2 - refers to an eye of an electric circuit

a close loop

(C, D, E, F, G, B, C) - an eye

$$\sum_{i=1}^{n} \mathcal{E}_i = \sum_{j=1}^{N} R_j I_j$$

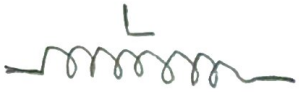
B)

- 

or 

resistance

- 

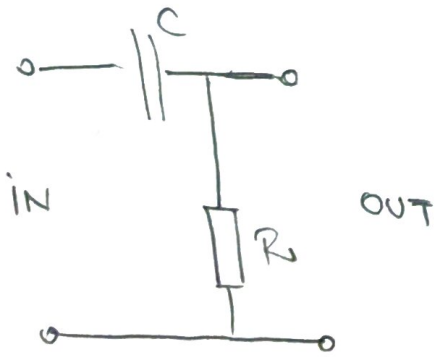
or 

inductance

- 

capacitor (capacitance)

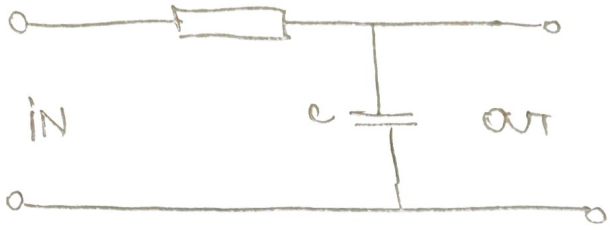
C)



high pass filter

$$V_C = \frac{1}{2\pi RC}$$

3) low pass filter

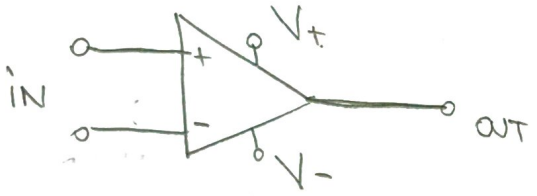


$$V_c = \frac{1}{2\pi RC}$$

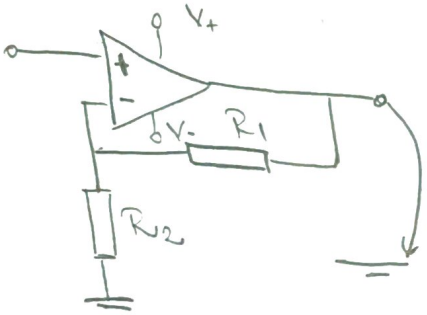
4) DAC (digital to analog converter)

ADC (analog to digital converter)

7) (Ops Amp
operational amplifiers)



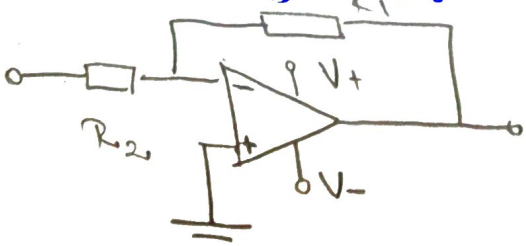
Project Ideas.

- 

$$A = 1 + \frac{R_1}{R_2}$$

Amplification (GAIN)

- inverting configuration



$$A = -\frac{R_1}{R_2}$$

(choose the right values for R_1, R_2)