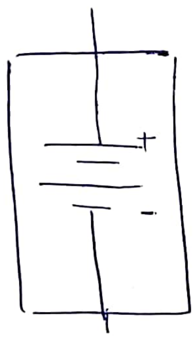
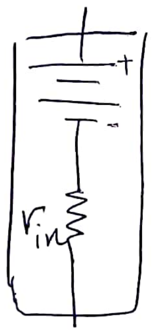
Exp2 : Source internal resistance, Loading problems and circuit impedance matching.

- Voltage Source is characterized by it's (emf)

emf: the open circuit voltage difference between it's terminals, and the max value of the current it can deliver to a short circuit.



Ideal Battery



Real Battery

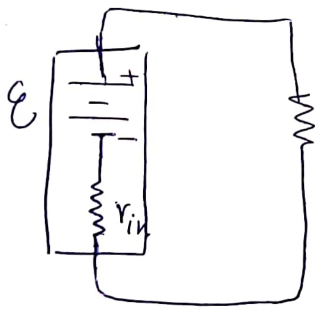
So : Voltage Source with small r_{in} ~~and~~ provide the circuit higer current, and maintain most of their emf as voltage differences between their terminals.

Voltage Source: provide useful electrical power to certain circuit component like; electric motors, light bulbs

- Load: any component which consumes electrical power to ~~certain~~ produce useful work

R_L : Load Resistance.

* Loading problem :-



$$I = \frac{V}{R} \qquad R = R_L + r_{in}$$

$$I = \frac{\varepsilon}{R_L + r_{in}}$$ * Current passing through this circuit.

$$\therefore V_{R_L} = \frac{\varepsilon}{R_L + r_{in}} R_L$$ * the voltage diffrence between the source terminals.

if $R_L \gg r_{in}$ $\therefore V_{R_L} \approx \mathcal{E}$

- if R_L comparable to r_{in} $\therefore V_{R_L}$ is smaller than $\mathcal{E}$ $\Rightarrow$ in this case the amout of power consumed inside the sourc and converted to unuseful heat energy, makes the source considered to be Load, to avoid this case

Choose $R_L \geq R_{in}$.

* Impedance Matching

- max power transfer: in real circuits, power consumed in the Load produces useful work, Therefore we seek to consume the max available power Here

$$P = I^2 R_L$$

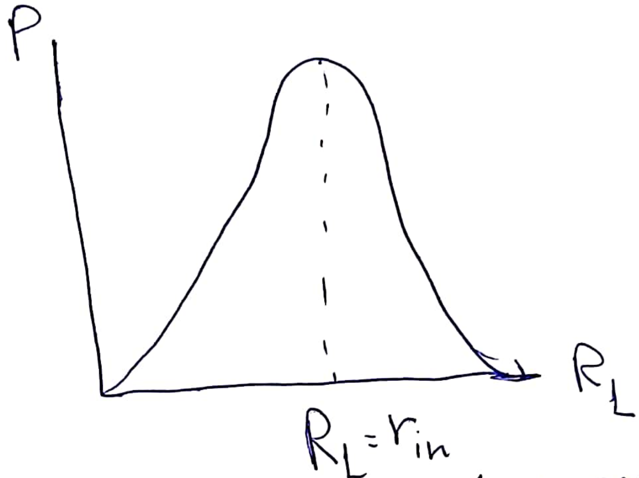
* power consumed in Load resistor

$$P = \frac{\mathcal{E}^2 R_L}{(R_L + r_{in})^2}$$

power as function of R_L

$\Rightarrow P(R_L)$ has max value and can be obtained by

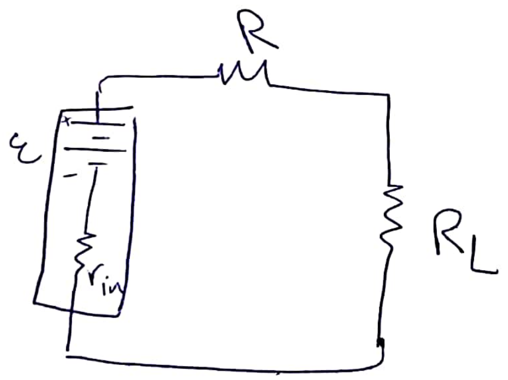
$$\frac{dP}{dR_L} = 0$$



max power $\therefore R_L = r_{in}$

This load resistance called impedance matching

- Impedance matching : is the process of making one impedance look like another (match a load R to the internal R)



So we add R to reach to the condition $R_L = R_{in}$ where $R_{in} = R + r_{in}$ (R_L see R as internal resistance)

$\Rightarrow$ then this R $\rightarrow$ avoiding the Loading problems and fulfilling the condition of Impedance matching.

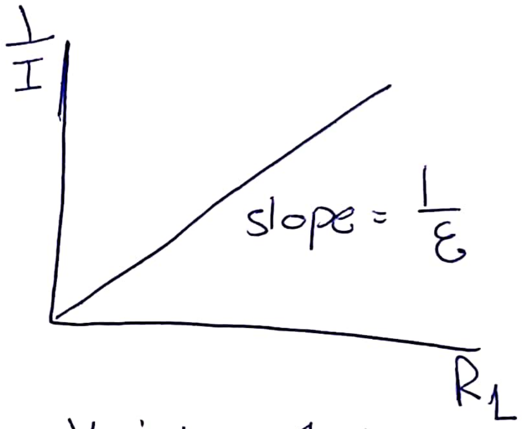
$\Rightarrow$ The only Disadvantage : this R consumes part of the power delivered to the circuit by the source.

by applying conservation of energy.

$$\mathcal{E} = I r_{in} + IR + IR_L$$

rearranging, we get

$$\frac{1}{I} = R_L \frac{1}{\mathcal{E}} + \frac{(r_{in}+R)}{\mathcal{E}}$$



Y-intercept $= \dfrac{r_{in}+R}{\mathcal{E}}$

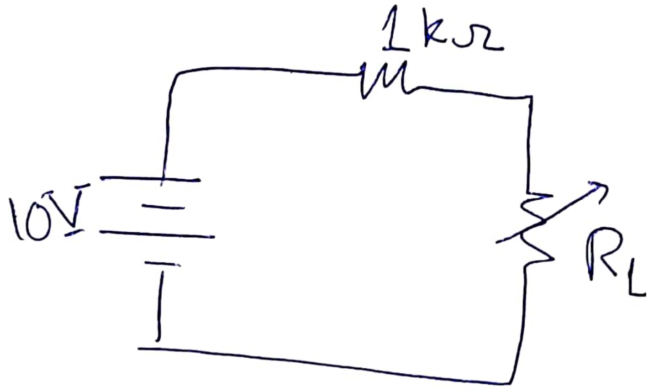
$$\boxed{\therefore R_L = R + r_{in}}$$

* **Efficiency**: The power dissipated in R_L divided by the power dissipated in the circuit

$$\eta\{R_L\} = \frac{I^2 R_L}{I^2 (R_L + r_{in})} = \frac{R_L}{R_L + r_{in}}$$

procedure:-

1. Connect the circuit as shown



2. Change R_L (0 - 1 MΩ) and record the I (current)

(take more data point around the value of R_L which satisfies the max power transfer condition)

3. plot $\frac{1}{I}$ with R_L : find ε, r_{in}

4. compute $P(R_L)$ and $\eta(R_L)$. from the graph find the value of R_L that satisfies the condition of max power transfer.