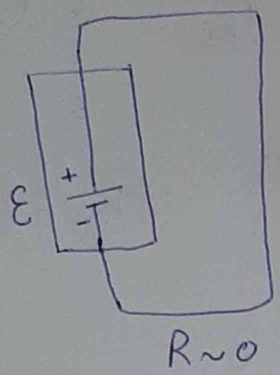
Exp 2

Source Internal Resistance, Loading problems & Circuit Impedance Matching

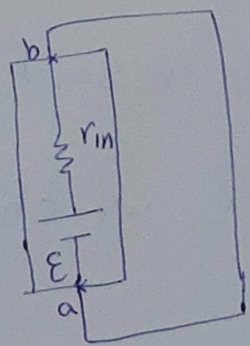
* Source Internal Resistance:



Ohm's Law: $I = \frac{\varepsilon}{R} \rightarrow \infty$ [Ideal battery] ✗

* In Real battery: neither maintain its (emf) as a voltage difference across its terminals nor can it provide the circuit with unlimited current.

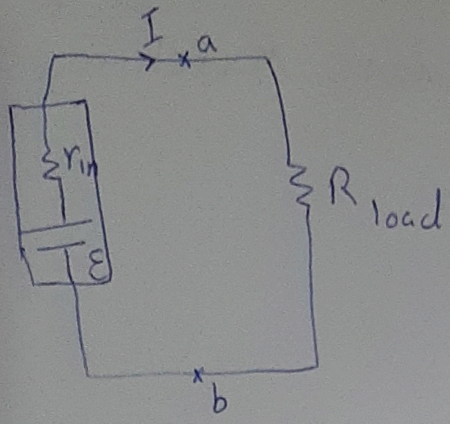
$\Rightarrow$ so



small internal resistance

$\Rightarrow V_{ab} \sim \varepsilon$

* Loading problem:



$$I = \frac{\varepsilon}{R_L + r_{in}}$$

$$V_{ab} = V_{R_L} = I\,R_L$$

$$\boxed{V_{R_L} = \frac{\varepsilon}{(R_L + r_{in})} R_L}$$

* if $R_L \gg r_{in} \Rightarrow V_{R_L} \simeq \varepsilon$

* if $R_L \sim r_{in} \Rightarrow V_{R_L} = \frac{\varepsilon}{2\cancel{R_L}} \cancel{R_L} = \frac{\varepsilon}{2}$

in this case a considerable amount of power is consumed inside the source & converted to heat energy.

[the source is said to be loaded] *

To avoid this we choose $R_L \geq 10\, r_{in}$

* Impedanc Matching:-

The power consumed in the load resistor is:

$$P = I^2 R_L$$

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

$P(R_L)$ has max. value when $\frac{dP}{dR_L} = 0$

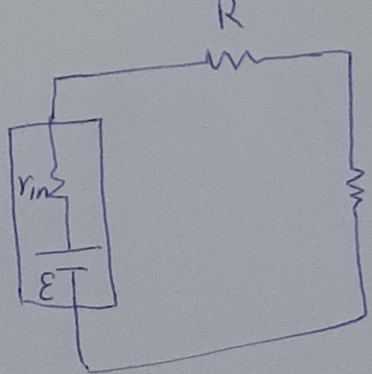
$$\Rightarrow \boxed{R_L = r_{in}}$$

This condition for transferring max. power to the load resistance.

This choice of load restanc is called Impedanc matching.

* To achieve this condition with avoiding loading problem:

since r_{in} is small, additional resistanc is added.

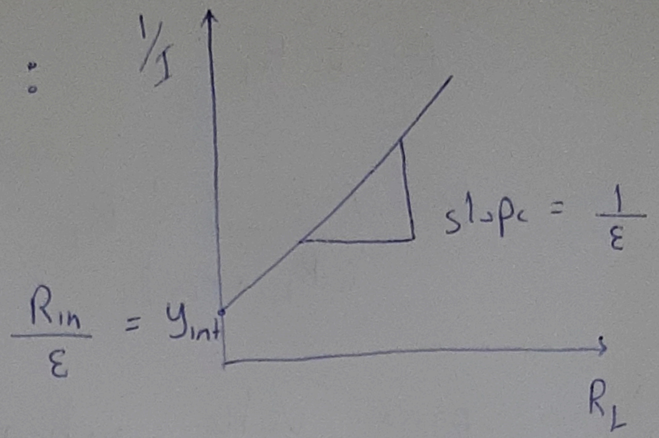


$$I = \frac{\mathcal{E}}{r_{in} + R + R_L}$$

$$\frac{1}{I} = \left(\frac{1}{\mathcal{E}}\right) R_L + \frac{r_{in} + R}{\mathcal{E}} \quad , \quad \text{let } \boxed{r_{in} + R = R_{in}}$$

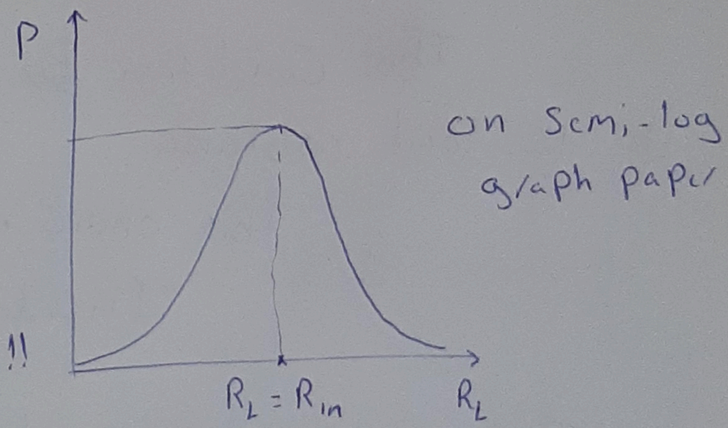
$$\frac{1}{I} = \frac{R_L}{\varepsilon} + \frac{R_{in}}{\varepsilon}$$

plotting $\frac{1}{I}$ Vs. R_L :



Find ε, R_{in}, knowing $R = 1\,k\Omega$, find r_{in} !!

plotting P Vs. R_L



Find R_L that satisfies the condition of max. power !!