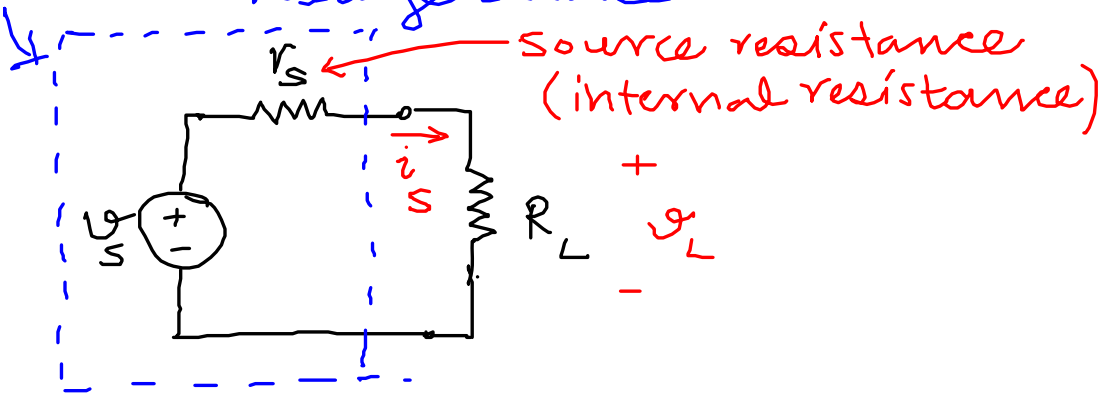
Practical Voltage & Current Sources

Non-ideal Voltage Source

Practical Voltage Source



Ideal voltage source $r_s = 0$

$$v_L = \frac{R_L}{r_s + R_L} v_s$$

$v_L \sim v_s$ if $r_s \ll R_L$

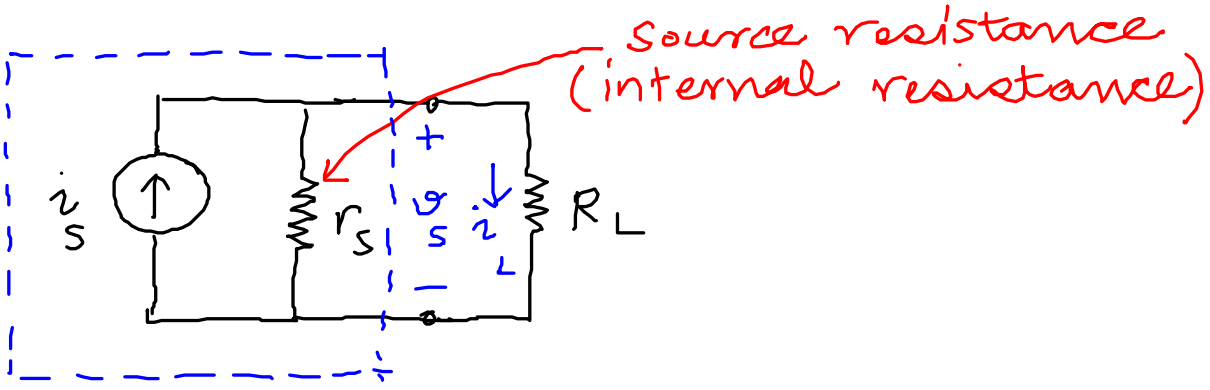
$v_L \sim 0$ if $r_s \gg R_L$

maximum voltage source current

$$i_s = \frac{v_s}{r_s + R_L}$$

$$i_{s,max} = \frac{v_s}{r_s} \qquad R_L = 0 \text{ (short circuit)}$$

Non-Ideal current source
Practical current source



ideal current source $r_s \to \infty$

$$i_L = \frac{\frac{1}{R_L}}{\frac{1}{r_s}+\frac{1}{R_L}} i_s = \frac{r_s}{r_s+R_L} i_s$$

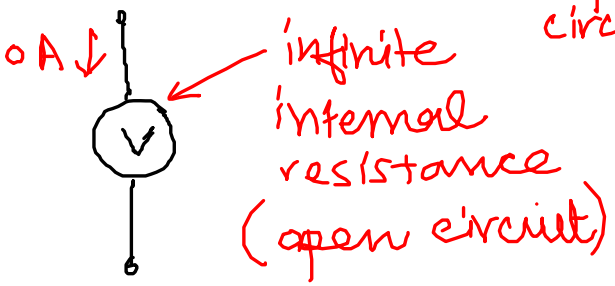
$i_L \sim i_s$ if $r_s \gg R_L$

$i_L \sim 0$ if $r_s \ll R_L$

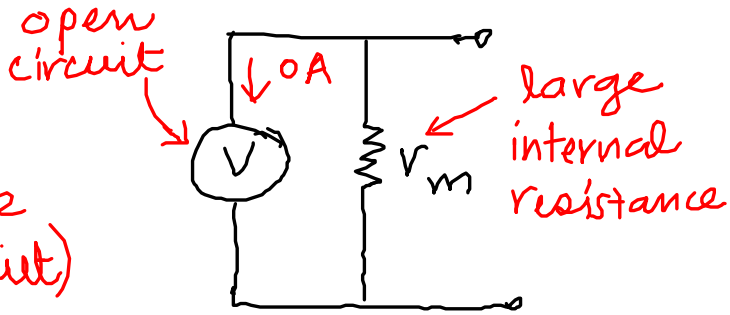
$$v_s = i_L R_L = \frac{r_s R_L}{r_s+R_L} i_s = \frac{i_s}{\frac{1}{r_s}+\frac{1}{R_L}}$$

$$v_{s,max} = \frac{i_s}{\frac{1}{r_s}} = r_s i_s \quad \text{if } R_L \to \infty \text{ (open)}$$

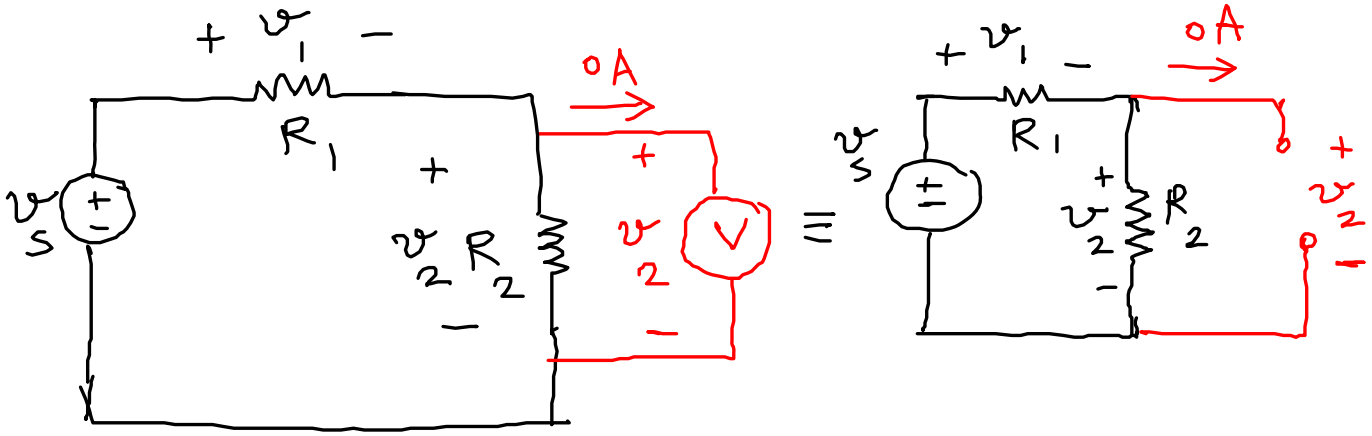
Voltmeter

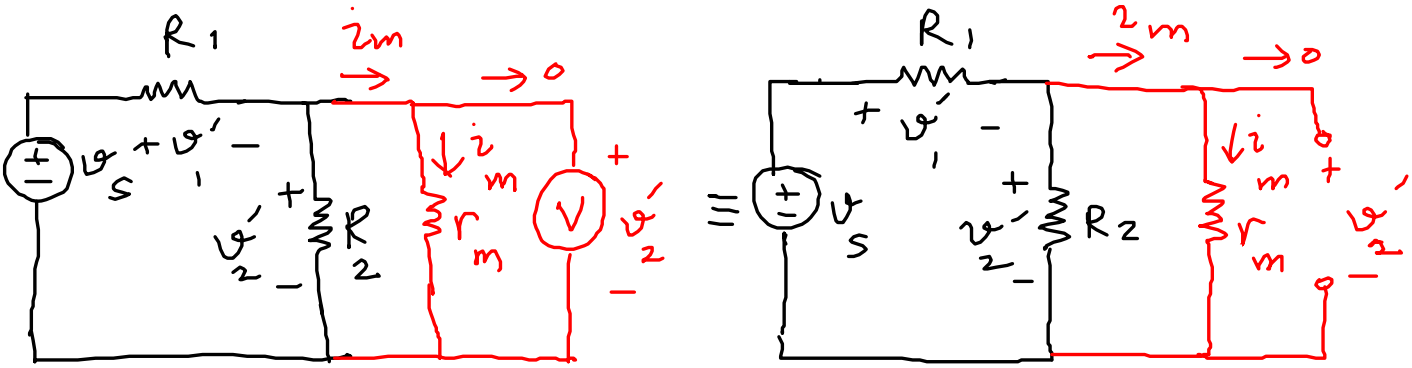


ideal Voltmeter



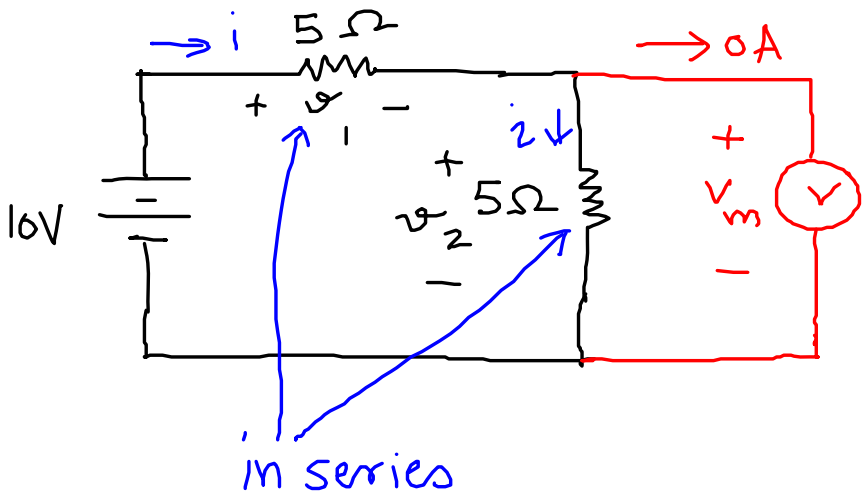
non-ideal (practical) Voltmeter





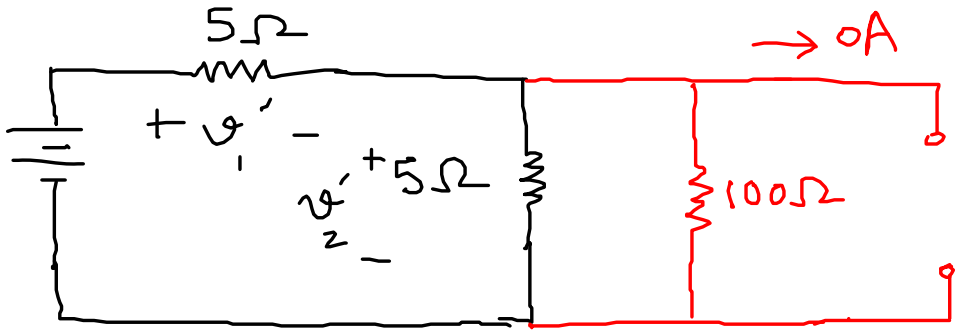
$v_1' \neq v_1$ $v_2' \neq v_2$

non-ideal voltmeter affects the voltages being measured

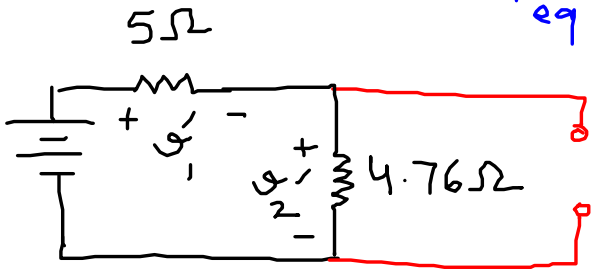


$$v_1 = \frac{5}{5+5}10 = 5V \qquad v_2 = \frac{5}{5+5}10 = 5V$$

$$V_m = v_2 = 5V$$



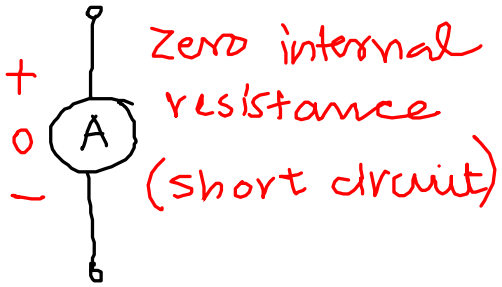
$$\frac{1}{R_{eq}} = \frac{1}{5} + \frac{1}{100} \qquad R_{eq} = 4.76\Omega$$



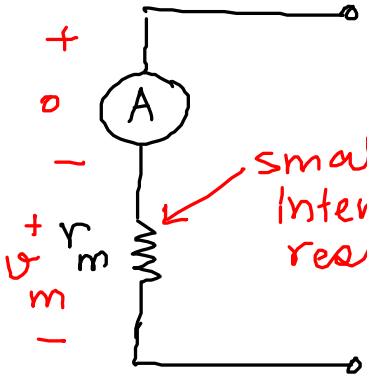
$$v_1' = \frac{5}{5+4.76}10 = 5.12V$$

$$v_2' = \frac{4.76}{5+4.76}10 = 4.88V$$

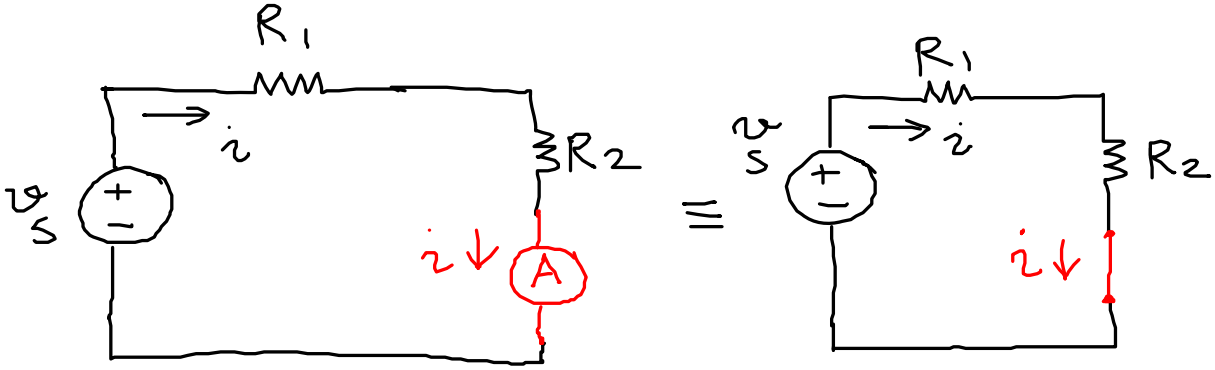
Ammeter

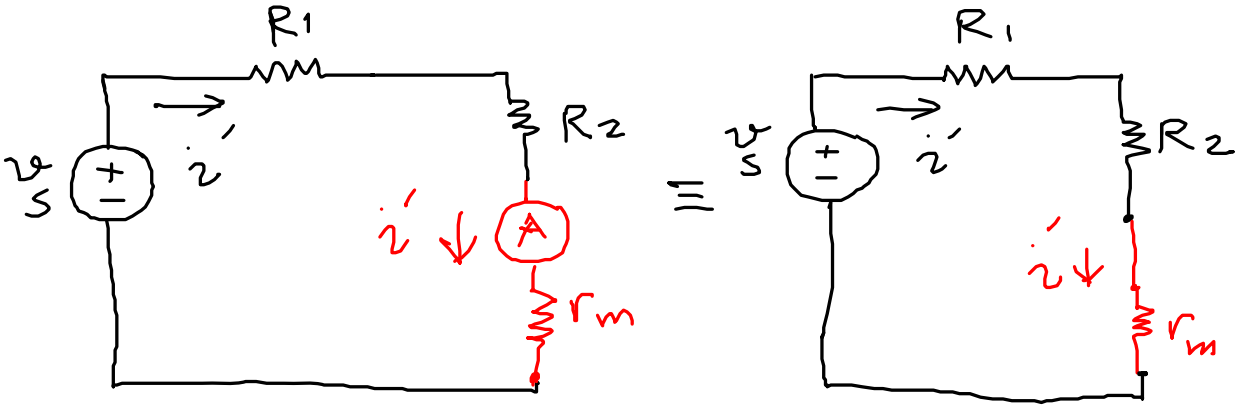


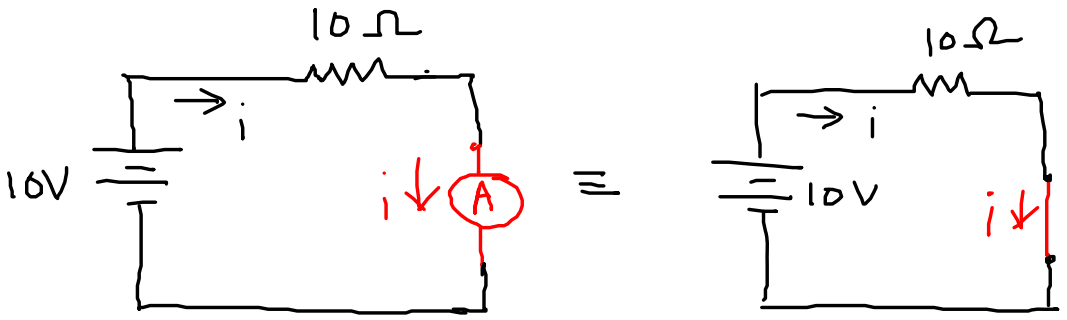
Ideal Ammeter



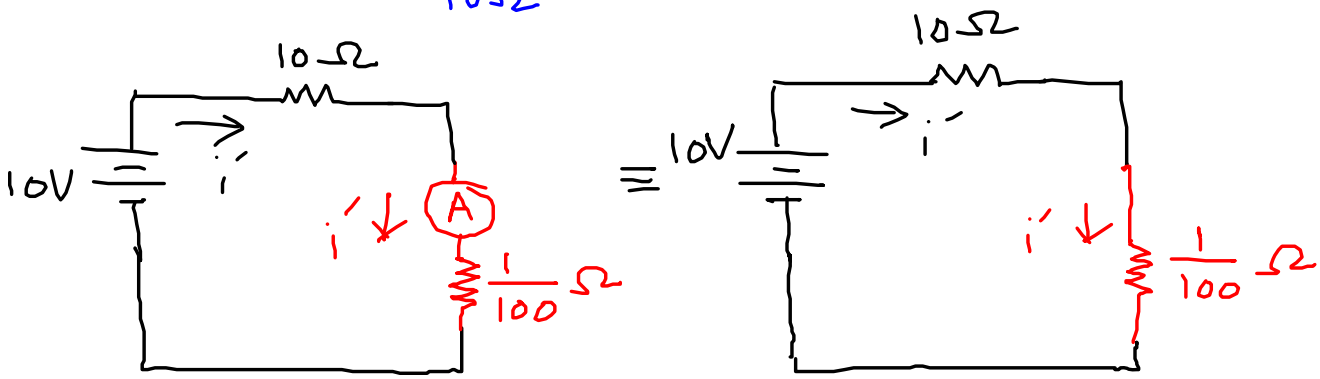
Non-Ideal (Practical) Ammeter





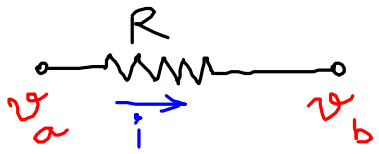


$$i = \frac{10V}{10\Omega} = 1A$$

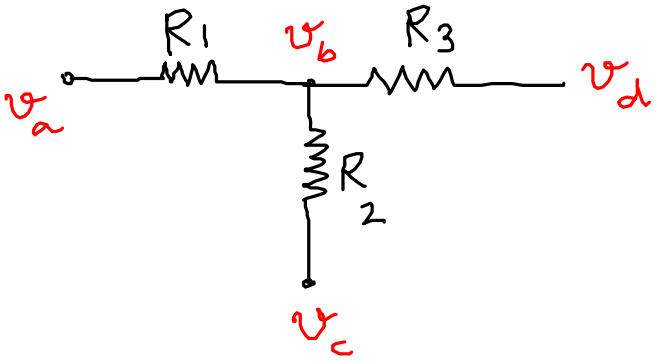


$$i' = \frac{10V}{10\Omega + 0.01\Omega} = 0.99\,A$$

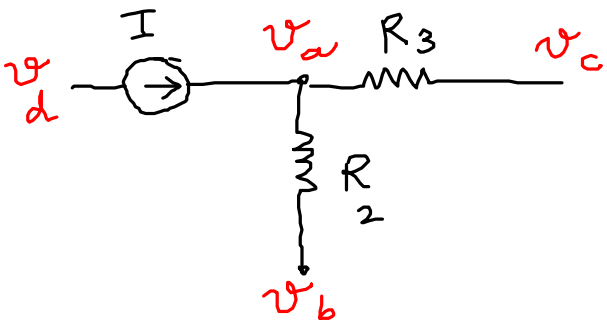
Node Analysis



$$i = \frac{v_a - v_b}{R}$$

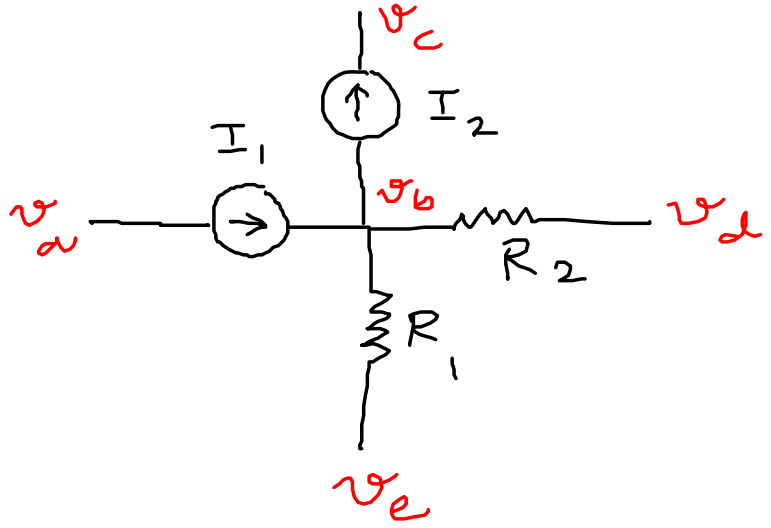


KCL : $\frac{v_a - v_b}{R_1} + \frac{v_c - v_b}{R_2} + \frac{v_d - v_b}{R_3} = 0$

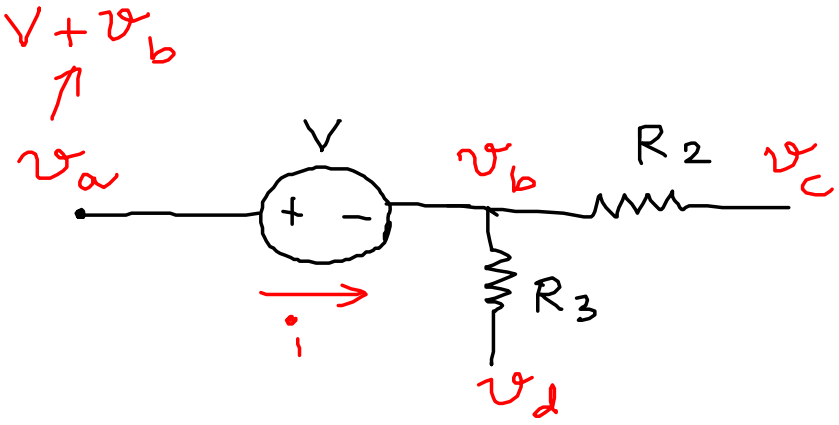


v_d does not appear in this equation

KCL : $I + \frac{v_b - v_a}{R_2} + \frac{v_c - v_a}{R_3} = 0$



KCL: $$I_1 - I_2 + \frac{v_e - v_b}{R_1} + \frac{v_d - v_b}{R_2} = 0$$



KCL: $$i + \frac{v_d - v_b}{R_3} + \frac{v_c - v_b}{R_2} = 0$$