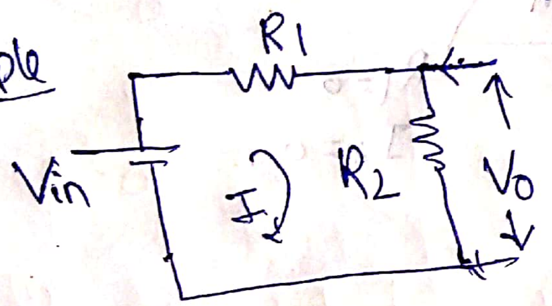
Loading Effect

x———x———x

- loading effect take place in voltmeter and Ammeter.

We know that for voltmeter-

Example



$$I = \frac{V_{in}}{R_1+R_2}$$

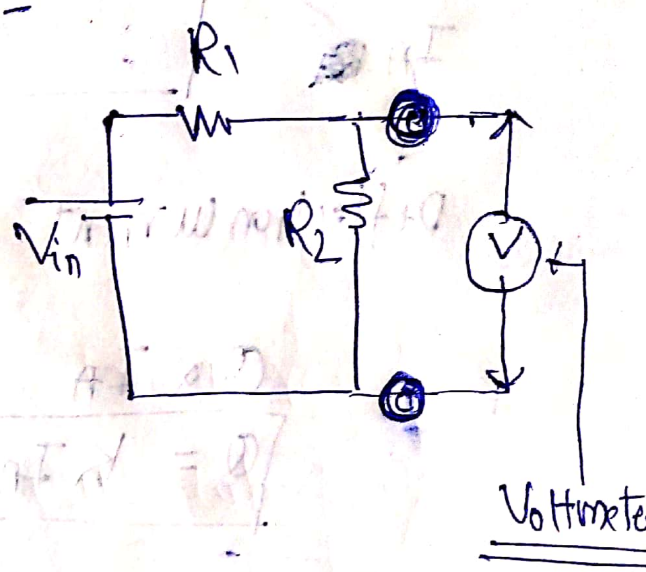
$$V_o = I \times R_2$$

$$\boxed{V_o = \frac{V_{in} R_2}{R_1+R_2}}$$

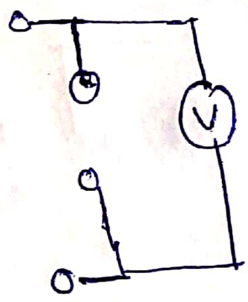
A

True value

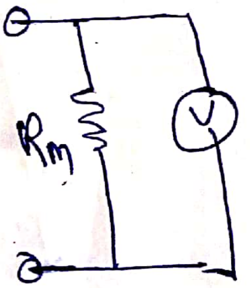
This circuit has without voltmeter



Voltmeter (concept):-



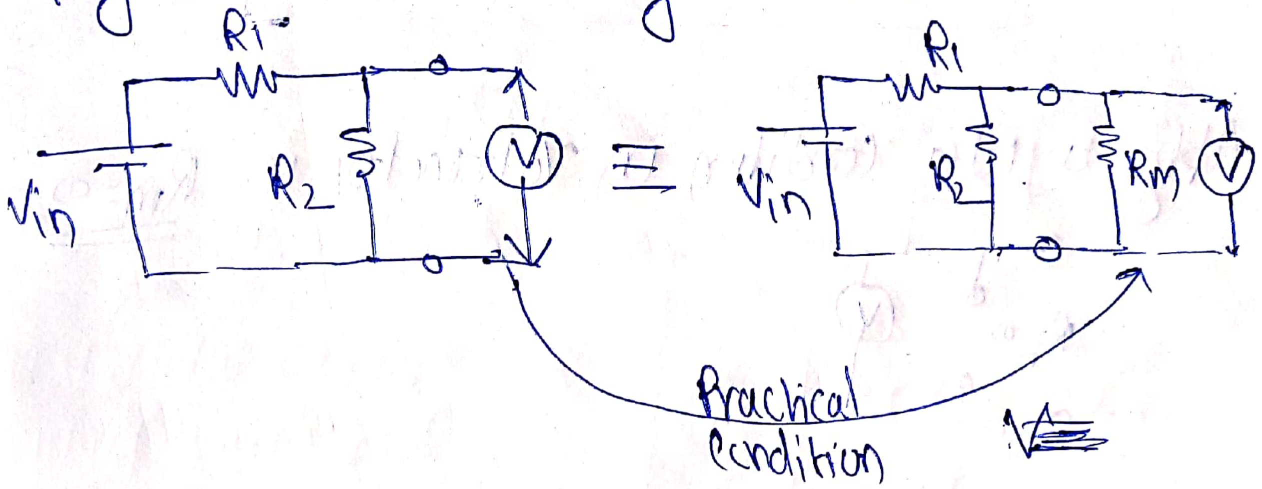
Ideal



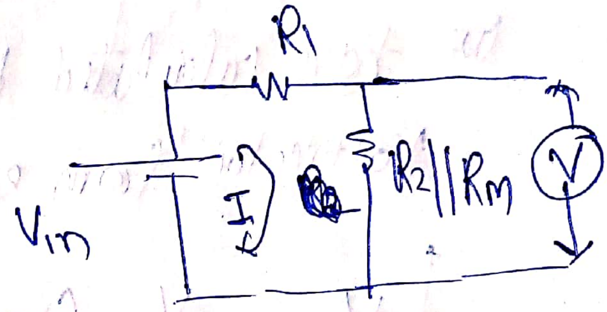
Practical

Again draw the circuit.
Since, the voltmeter consist of internal resistance Rm in practical and Rm = ∞ (open) in ideal

Apply practical condition of voltmeter



$$I = \frac{V_{in}}{R_1 + (R_2 \| R_m)} \quad \text{— (I)}$$



and $V = I \times (R_2 \| R_m)$ — (II)

Put the value of I in equation II

$$\boxed{V = \frac{V_{in}(R_2 \| R_m)}{R_1 + (R_2 \| R_m)}} \quad \text{— (III)}$$

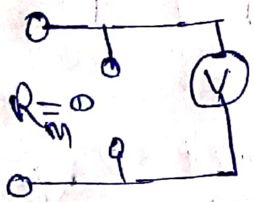
Measured value

Therefore, you can see, there is true value and measured value, which is not equal.

i.e. $\boxed{V_0 = \frac{V_{in} R_2}{R_1 + R_2}} \neq \boxed{V = \frac{V_{in}(R_2 \| R_m)}{R_1 + (R_2 \| R_m)}}$

i.e. $\boxed{V_{(measured)} \neq V_0\,(true)}$

Apply a ideal condition in voltmeter i.e. $R_m = \infty$



we have calculated the practical value read by voltmeter from equation (iii) which is

$$\boxed{V = \frac{V_{in}\,(R_2 \| R_m)}{R_1 + (R_2 \| R_m)}}$$

or

$$V = \frac{V_{in}\left(\dfrac{R_2 \times R_m}{R_2 + R_m}\right)}{R_1 + \dfrac{R_2 \times R_m}{R_2 + R_m}} = \frac{(R_2+R_m) \div V_{in}(R_2 R_m)}{R_1(R_2+R_m) + R_2 R_m}$$

$$\boxed{V = \frac{\left(\cancel{\dfrac{R_2}{R_m}}^{\,0} + 1\right) \div (V_{in} R_2)}{\cancel{\dfrac{R_1 R_2}{R_m}}^{\,0} + \dfrac{R_1 \cancel{R_m}}{\cancel{R_m}} + R_2}}$$

Put $R_m = \infty$ for ideal voltmeter in above expression

$$\boxed{V = \frac{V_{in} R_2}{R_1 + R_2}}$$

i.e. At ideal condition :-

True value = measure value

$$\boxed{V_0 = \frac{V_{in} R_2}{R_1 + R_2}} \equiv \boxed{V = \frac{V_{in} R_2}{R_1 + R_2}}$$

$$\boxed{\begin{aligned} \text{Error} &= \text{True value} - \text{measured value} \\ &= 0 \end{aligned}}$$

Summary : loading effect is a phenomenon ~~phenomenia~~, it happened due to presence of internal resistance of voltmeter.

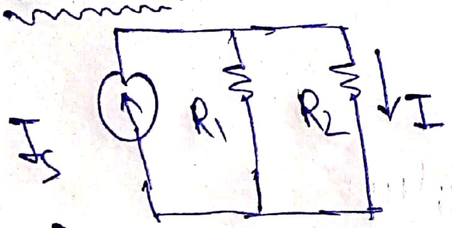
It can overcome by increasing the value of internal resistance.

i.e $\boxed{R_m \uparrow \quad \text{loading effect} \downarrow}$

Note i.e the voltmeter resistance should be high as ~~much~~ much as possible

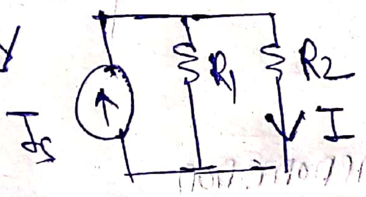
Loading Effect in Ammeter

Example:



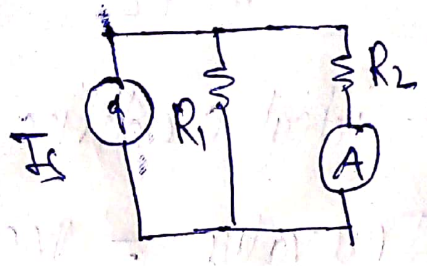
$$\boxed{I = \frac{I_s \times R_1}{R_1+R_2}} \quad \text{— (1)}$$

True value



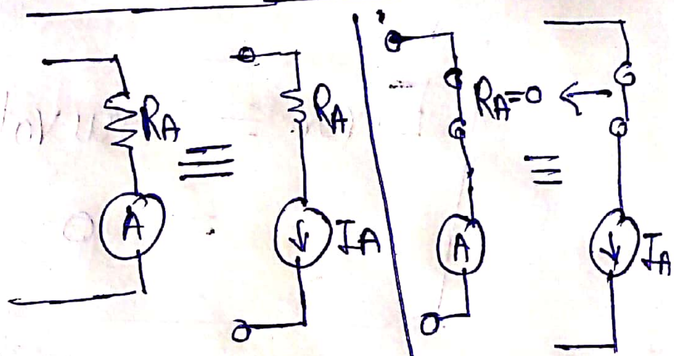
Note: This circuit has without Ammeter
i.e no internal resistance

Measured value



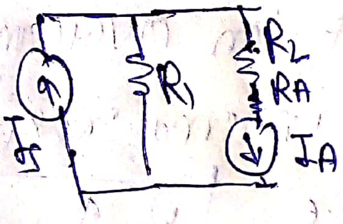
(A) ≡ Ammeter which is used to measure the current

We know that:

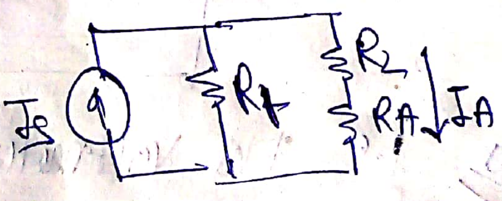


(Practical Ammeter) (Ideal Ammeter)

Apply Practical Ammeter first



Or



$$\boxed{I_A = \frac{I_s R_1}{R_1+R_2+R_A}} \quad \text{— (1')}$$

we can see that true value is not equal to measured value. Therefore, load effect taking place which is happen due to presence of internal resistance.

ie. $\boxed{I = \frac{I_S \times R_1}{R_1+R_L}} \neq \boxed{I_A = \frac{I_S \times R_1}{R_1+R_2+R_A}}$

True value — Measured Value

⇒ How to overcome the load effect.
It is possible only when neglect the internal resistance of Ammeter ie $\boxed{R_A=0}$

we have, $I_A = \frac{I_S \times R_1}{R_1+R_2+R_A} = \frac{I_S \times R_1}{R_1+R_2}$

$R_A \to 0$

$$\boxed{I_A = \frac{I_S \times R_1}{R_1+R_L}}$$ — IIV

Under this condition — True value = measured value

ie $\boxed{I = \frac{I_S \times R_1}{R_1+R_L}} = \boxed{I_A = \frac{I_S \times R_1}{R_1+R_L}}$