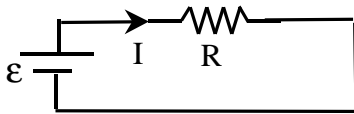


Measuring Instruments

Ammeters

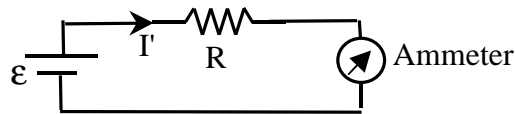
A current measuring instrument is called an 'ammeter'. A 'galvanometer' is an earlier form of a current measuring instrument. However any gadget that 'reacts' or responds to a current is not necessarily a good ammeter. All measuring instruments in general have to meet one criterion - they cannot disturb or alter the physical quantity being measured. This for an ammeter means that it cannot change the current in the circuit.

Consider for example the circuit below:



$$\text{Here } I = \frac{e}{R}$$

Modify the circuit to include an ammeter (Note ammeters are always used in series - they have to pass all the current that you are trying to measure)



$$\text{Then } I' = \frac{e}{(R + r)}; \text{ Thus } I' = I \text{ only if } r \ll R$$

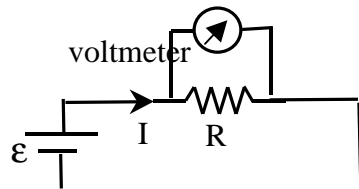
The fractional error in measuring the current is therefore:

$$\frac{I' - I}{I} = \frac{\Delta I}{I} = \frac{r}{R}.$$

Thus an ideal ammeter has zero internal resistance.

Voltmeters

Voltmeters are always used in PARALLEL as shown in the figure below.



Requirement on a voltmeter is that it should not disturb the current through R .

$$I = \frac{e}{R} \text{ and } I' = \frac{e}{R_{eq}} \text{ where } R_{eq} = \frac{R_v R}{(R_v + R)}$$

The fractional error in measured voltage is:

$$\frac{\Delta V}{e} = \left[1 - \left(\frac{R_v + R}{R_v} \right) \right] = -\frac{R}{R_v}$$

Thus for $R_v \gg R$ the fractional error is small. Typical voltmeters have $R_v \sim 10 - 100 \text{ M}\Omega$.