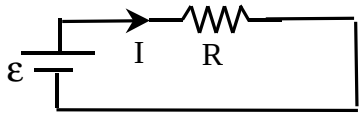
# Measuring Instruments

## Ammeters

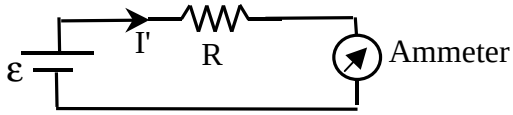
A current measuring instrument is called an 'ammeter'. A 'galvanometer' is an earlier form of a current measuring instrument. However any gadget that 'reacts' or responds to a current is not necessarily a good ammeter. All measuring instruments in general have to meet one criterion - they cannot disturb 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:




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)




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

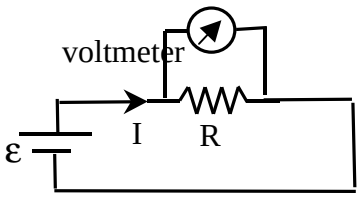
The fractional error in measuring the current is therefore:

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

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.

$I = \frac{e}{R}$ and $I' = \frac{e}{R_{eq}}$ 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 $R_V$ >> R the fractional error is small. Typical voltmeters have $R_V$ ~ 10 -100 MΩ.