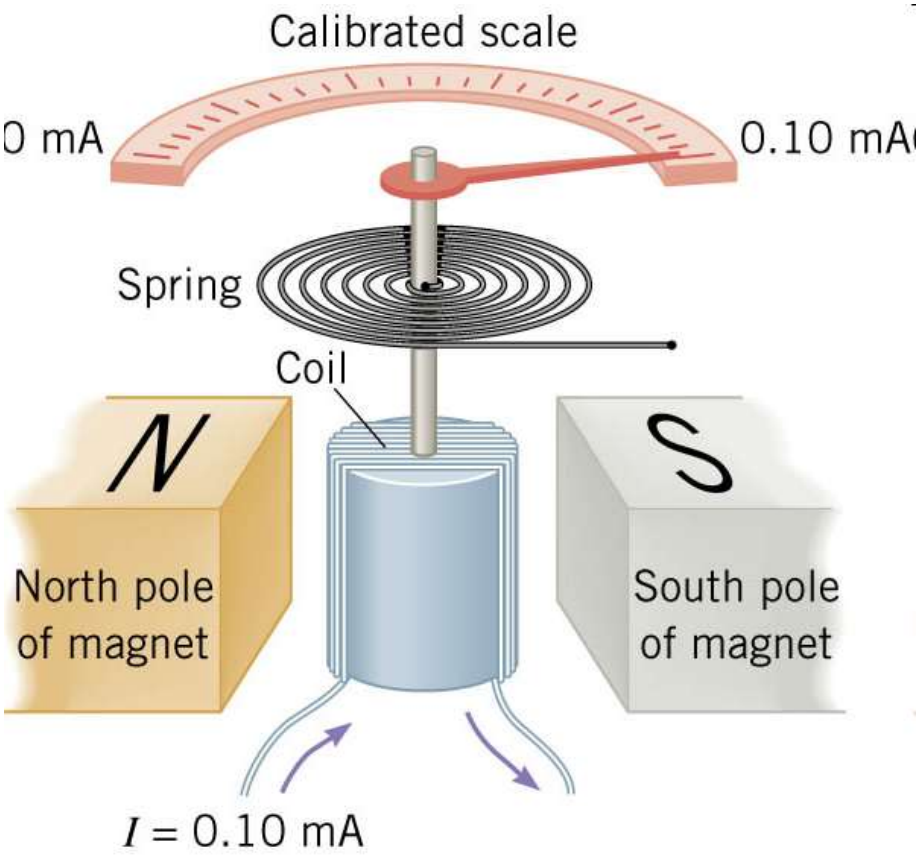
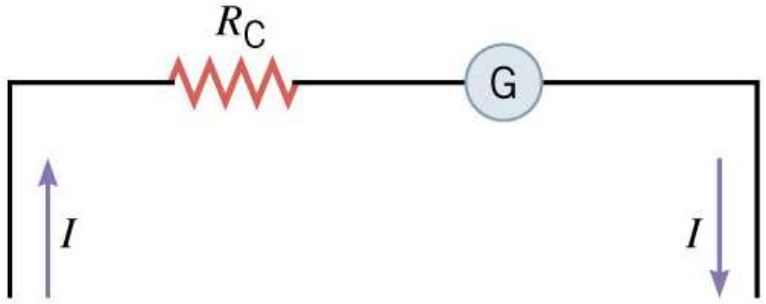
Ammeters & Voltmeters



(a)



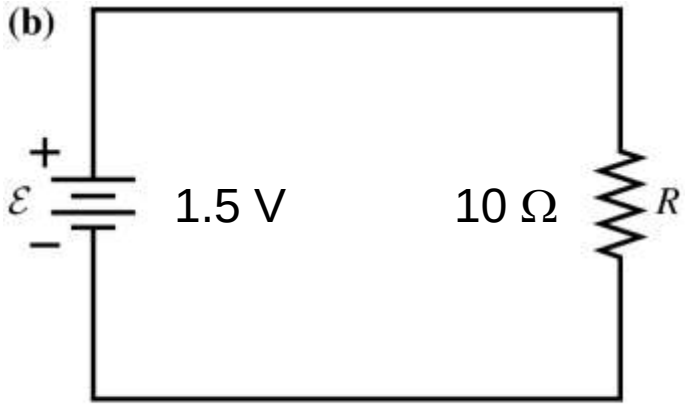
A coil of wire in a magnetic field twists proportionally to the current.

Galvanometer.

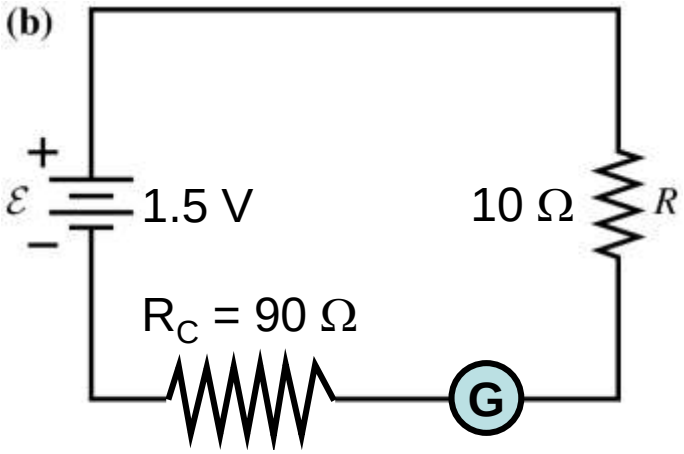
Problem – resistance R_C wrong size to use alone to measure I or V.

The Problem – Galvanometer not a good Ammeter

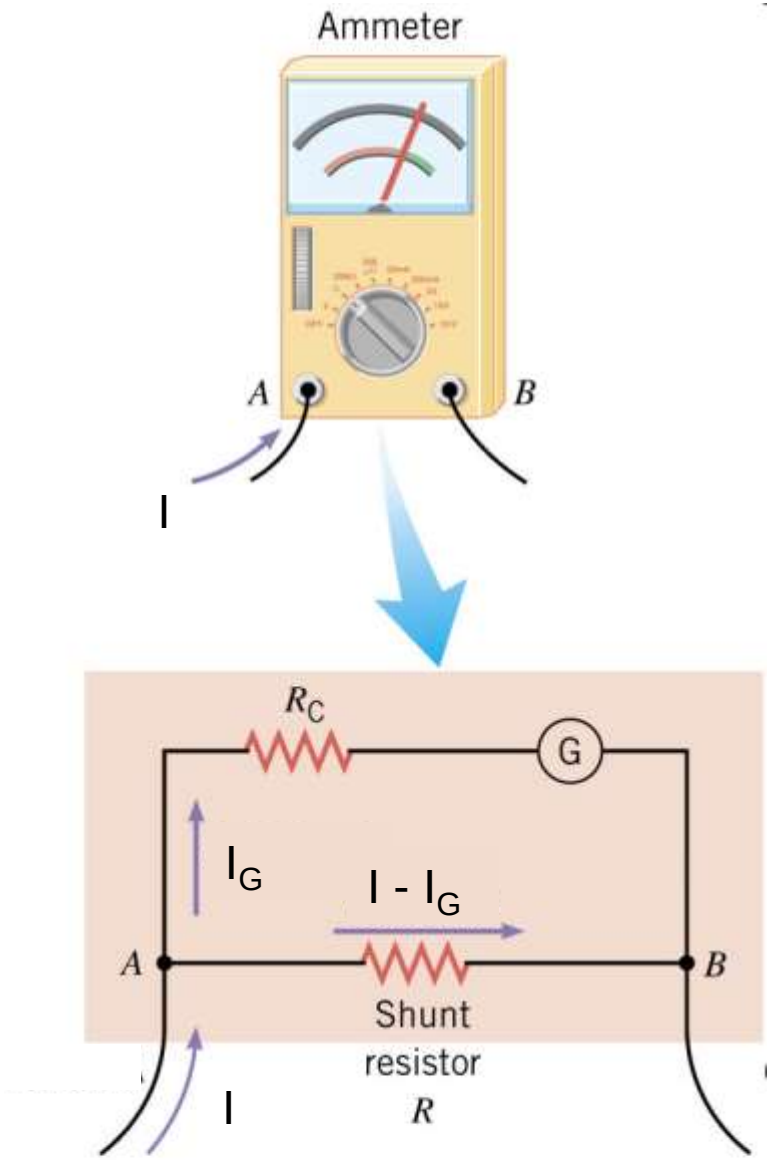
- We want to measure I for a circuit where either V or R is unknown.
- But if R_C is big compared to R, I is wrong



I = V/R = 1.5 / 10 = 0.15 A



$I = V/R_{EQ} = 1.5 / 100 = 0.015$ A



Ammeter

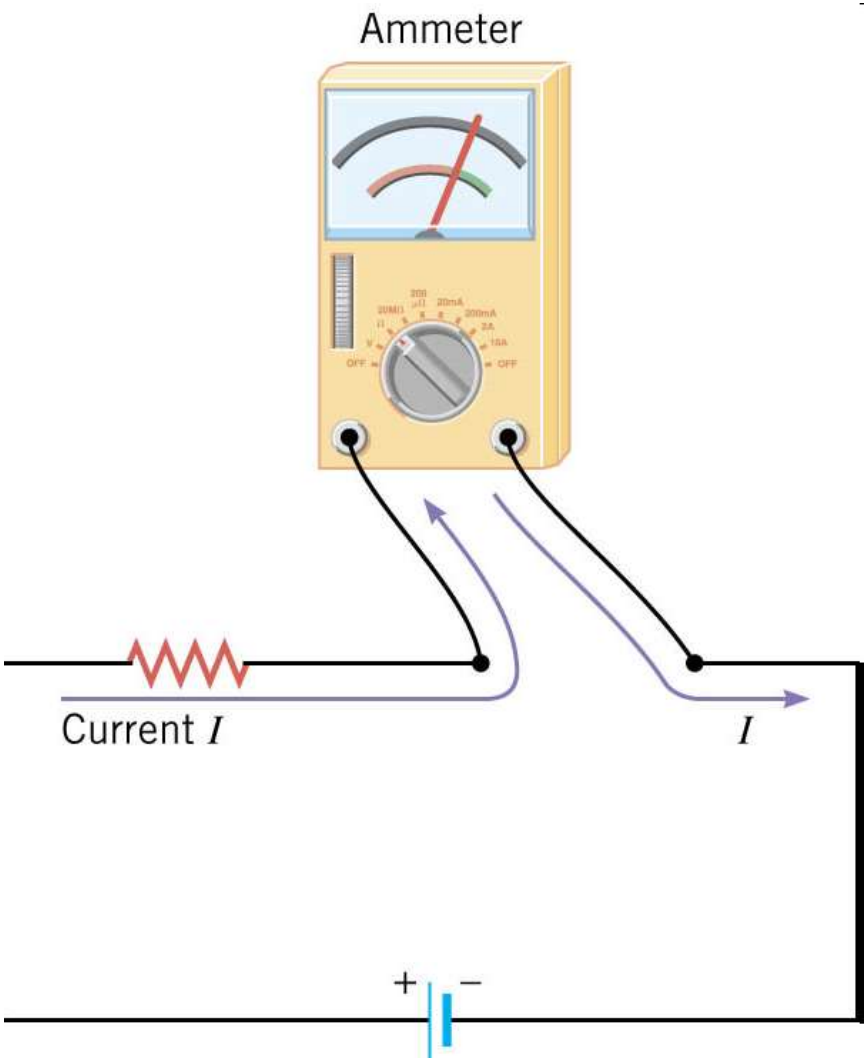
We construct an ammeter by connecting a small shunt resistor in parallel.

Shunt carries most of the current.

$$I_G R_c = (I - I_G) R_{shunt}$$

$$\frac{1}{R_A} = \frac{1}{R_c} + \frac{1}{R_{shunt}}$$

Ammeter



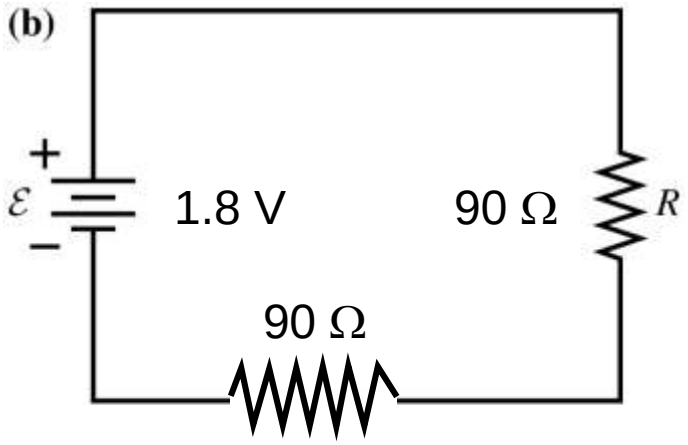
Ammeters must be connected inline (series) to get correct measurement.

R_A must be much smaller than R in branch for I to be correct.

Typically if, $R_A = R/100$, $I = 99\%$ of I_{TRUE}

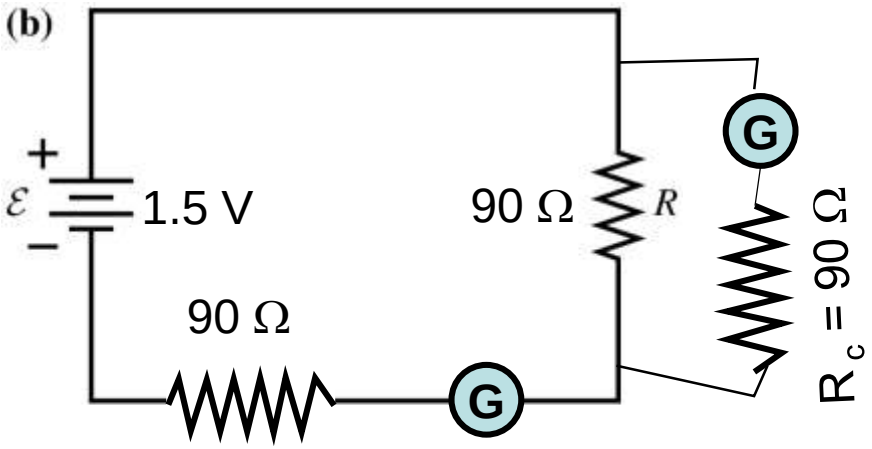
The Problem – Galvanometer not a good Voltmeter

- But if R_C is not big compared to R, V is wrong



$I = V_B / (R+90) = 0.01$ A

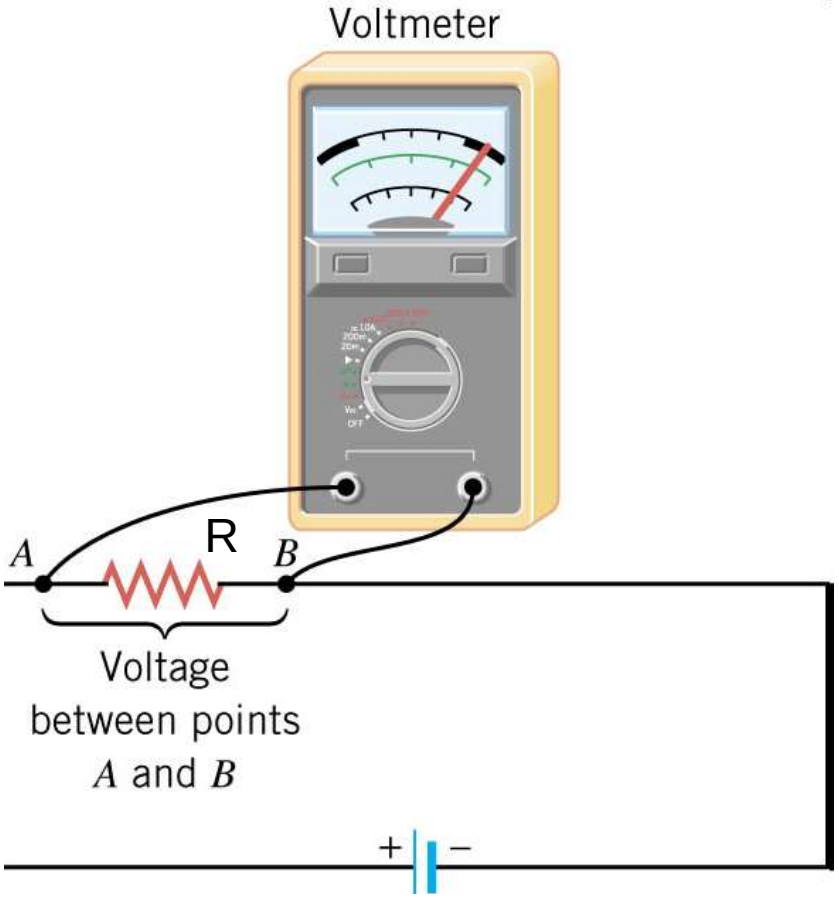
$V_R = 90 \times 0.01 = 0.9$ V

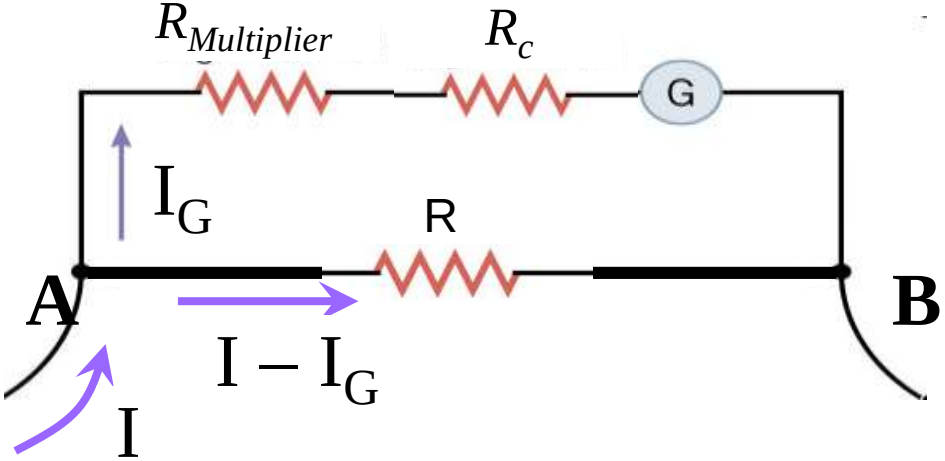


$R_{EQ} = 90 + (1/90 + 1/90)^{-1} = 135\ \Omega$

$I = 1.8 / 135 = 0.013333$ A

$V_G = I_G R_C = (0.013333/2)90 = 0.6$ V





Voltmeter

We construct a voltmeter by connecting a large multiplier resistor in series.

Need $R_M + R_c >> R$ by about 100 times

$$V = (R_{multiplier} + R_c) I_G$$

$$R_V = R_{multiplier} + R_c$$

Remember

- Ammeters have a small resistance, make sure $R_A << R$
- Connect in series
- Voltmeters have a large resistance, make sure $R_V >> R$
- Connect in parallel