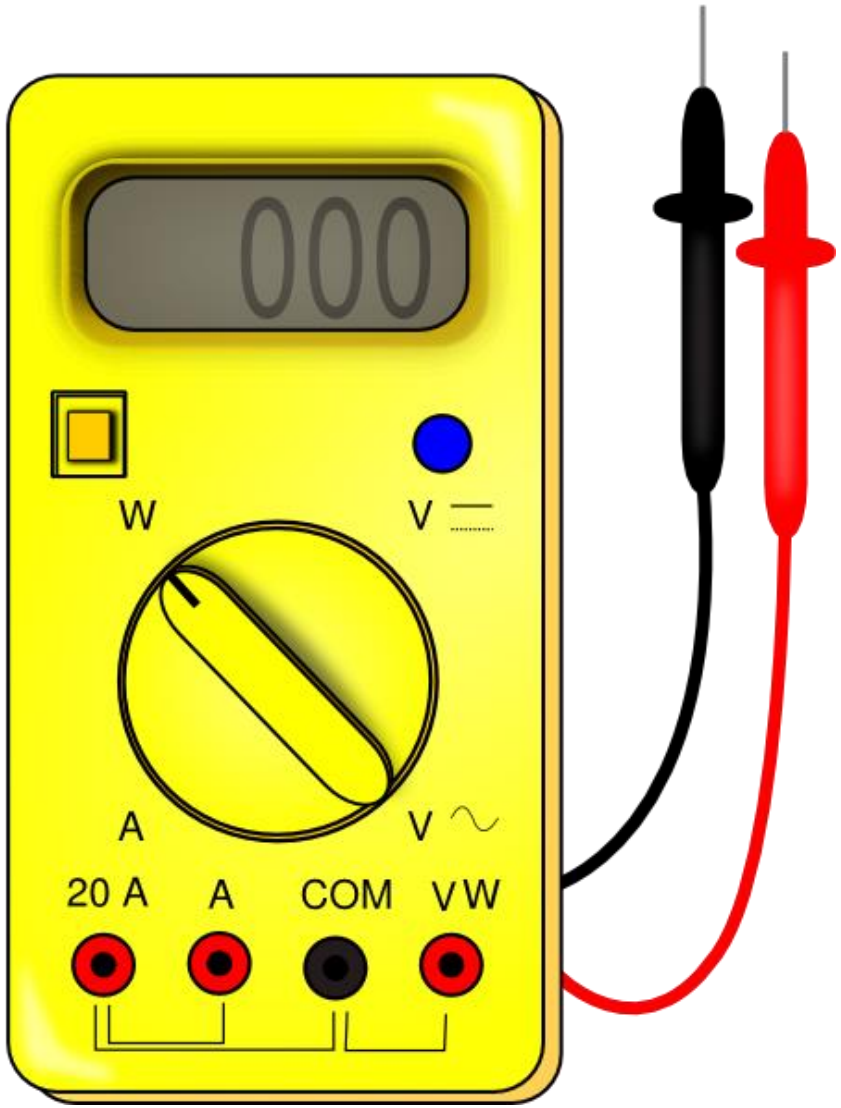
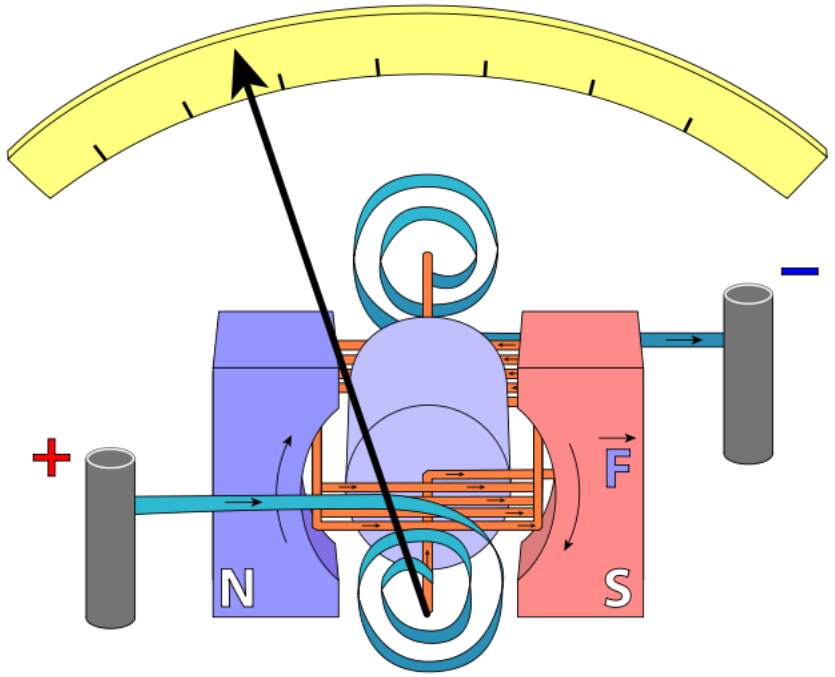
Design Multimeters

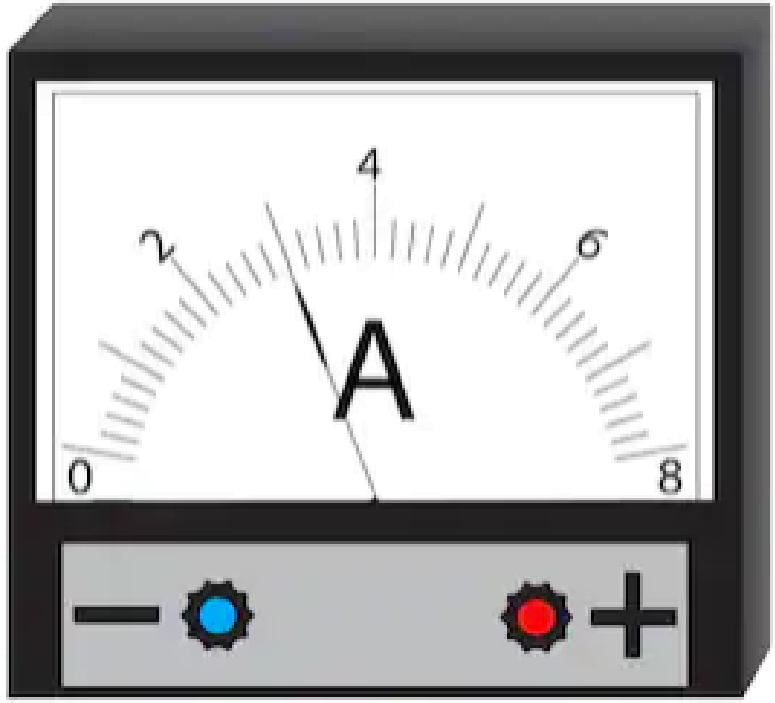
Mingquan He| College of physics

Multimeter



Ammeter

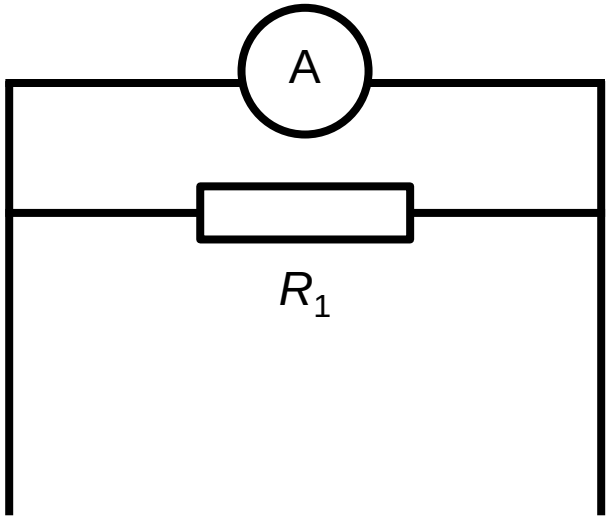




Galvanometer

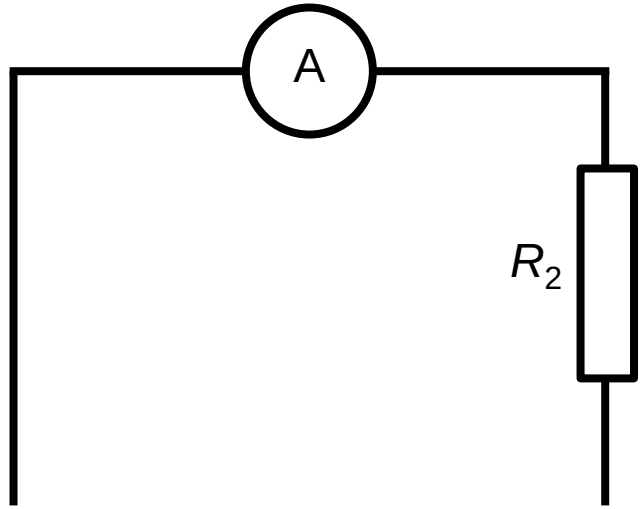
It is named after the Italian scientist Luigi Galvani, who invented the frog galvanoscope.

Design Multimeters based on an Ammeter



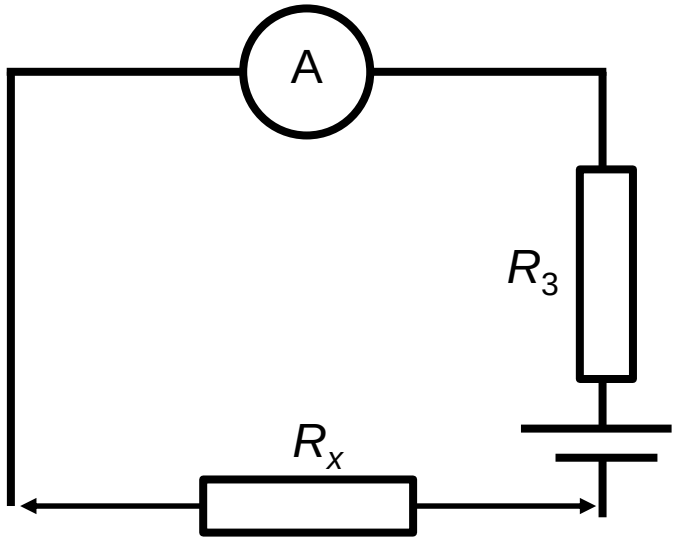
In-parallel

Ammeter



In-series

Voltmeter

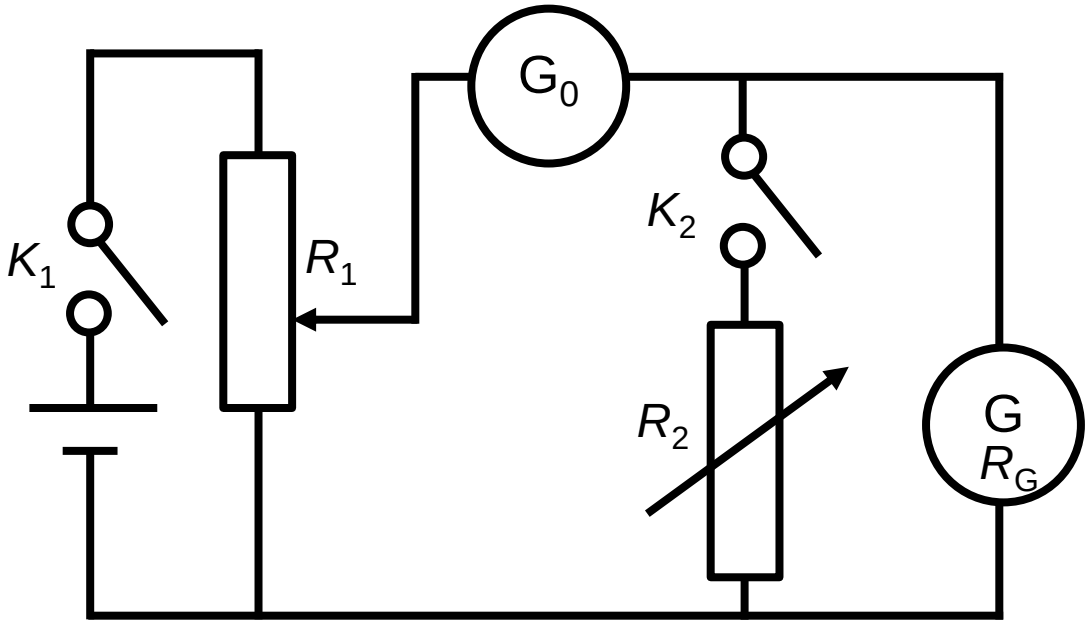


In-series with a voltmeter

Ohmmeter

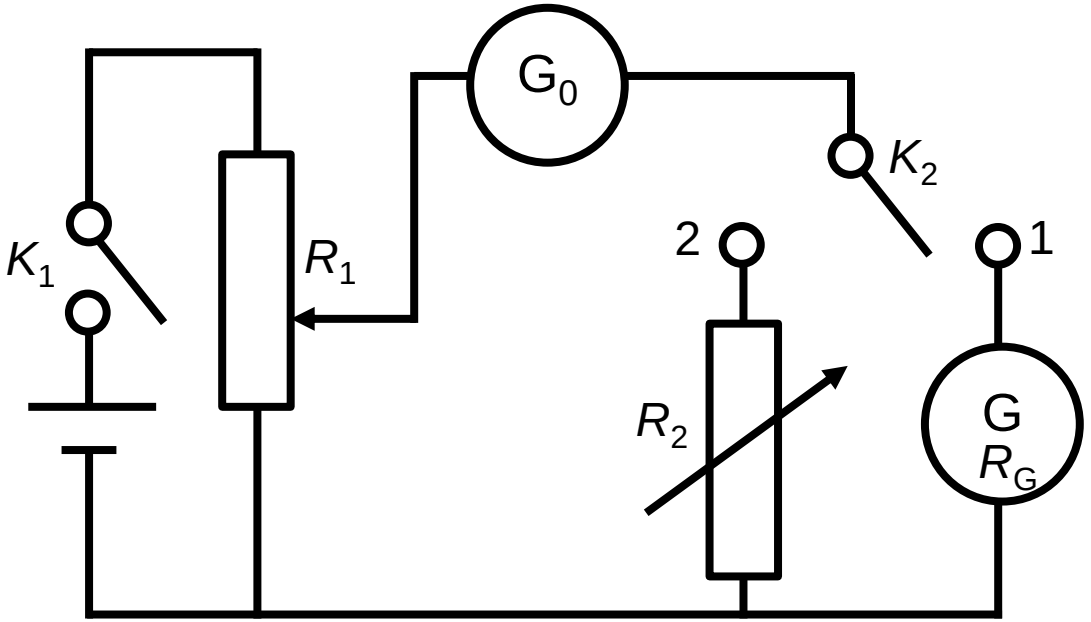
Task: determine R_1, R_2, R_3

Internal Resistance of the Ammeter



Plan A

Half Value Method



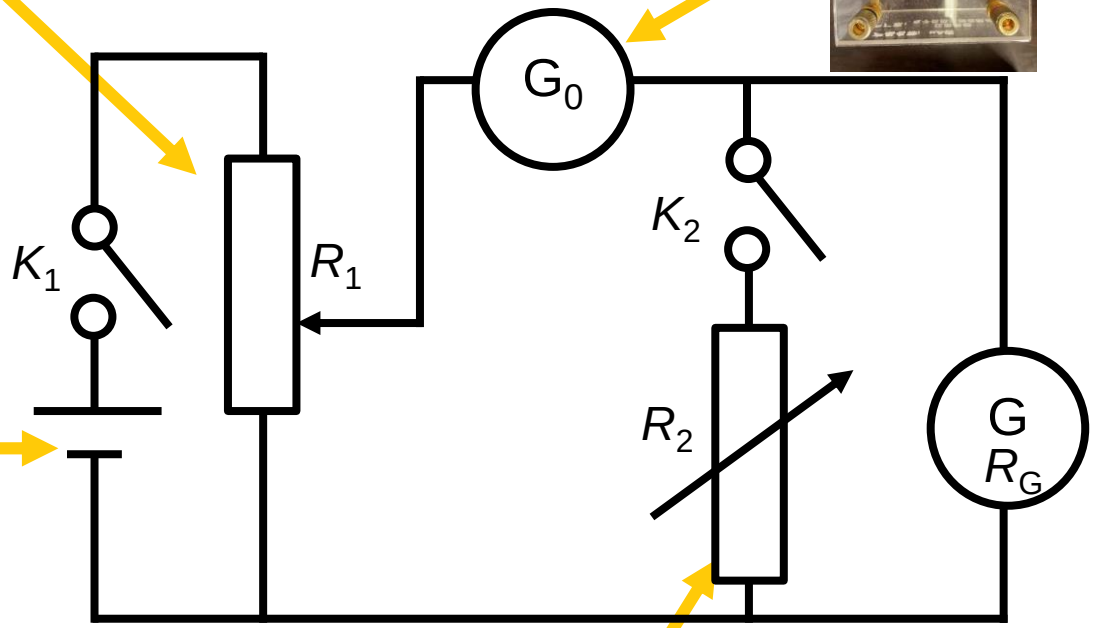
Plan B

Replacement Method

The first step: determine the internal resistance of a given Ammeter.

Internal Resistance of the Ammeter

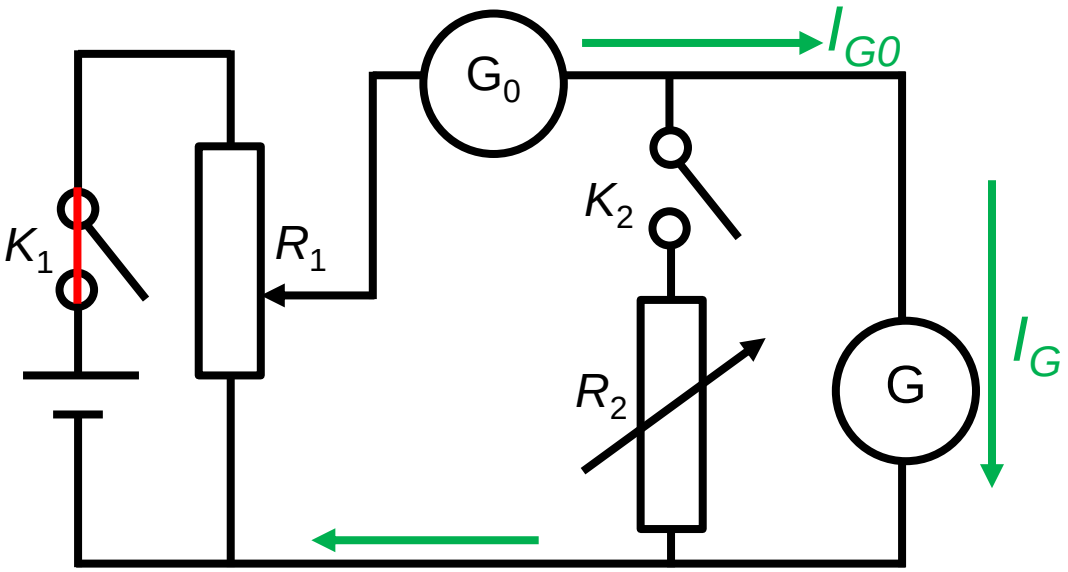
0.5 V

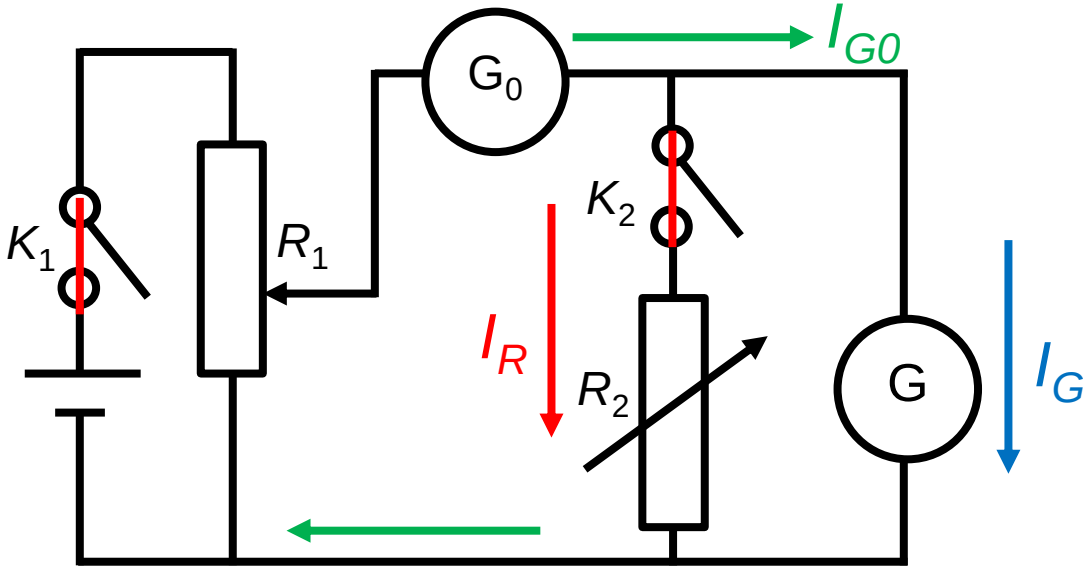


Plan A

Half Value Method

Internal Resistance of the Ammeter





Plan A Half Value Method

R_1: sliding rheostat G_0: reference ammeter

R_2: resistance box G: ammeter under test

Step 1:

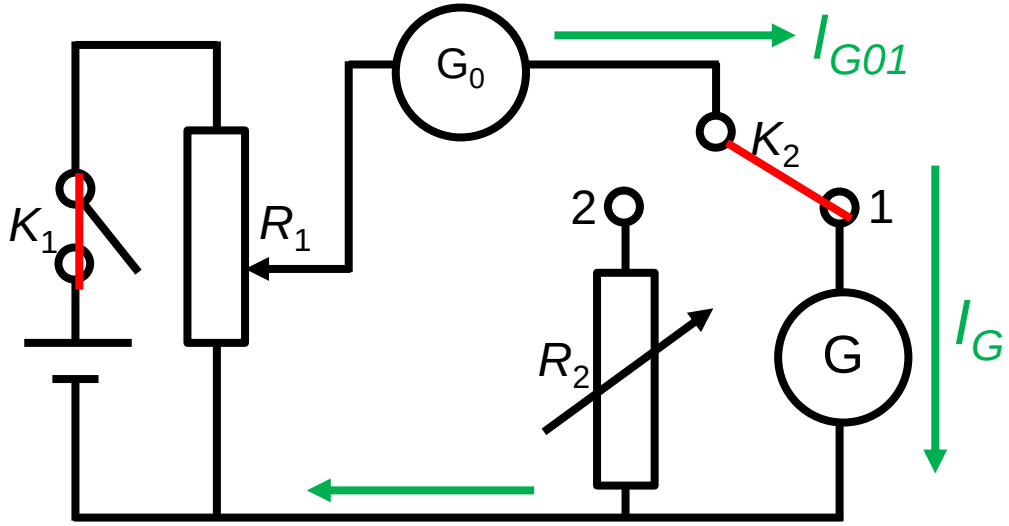
- K_1 ON K_2 OFF G_0 and G are in series
- Tune R_1 and keep G at its full range $I_{G0} = I_G$

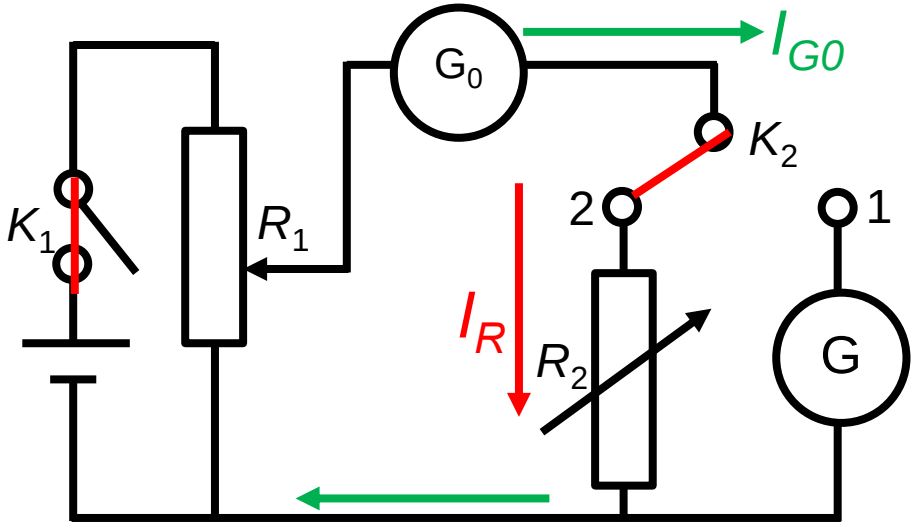
Step 2:

- K_1 ON K_2 ON, R_2 and G are in parallel
- Tune R_1 and R_2 until $I_G = I_{G0}/2$
- Then one finds $R_G = R_2$

R_G: the internal resistance of G

Internal Resistance of the Ammeter





Plan B Replacement Method

R_1: sliding rheostat G_0: reference ammeter

R_2: resistance box G: ammeter under test

Step 1:

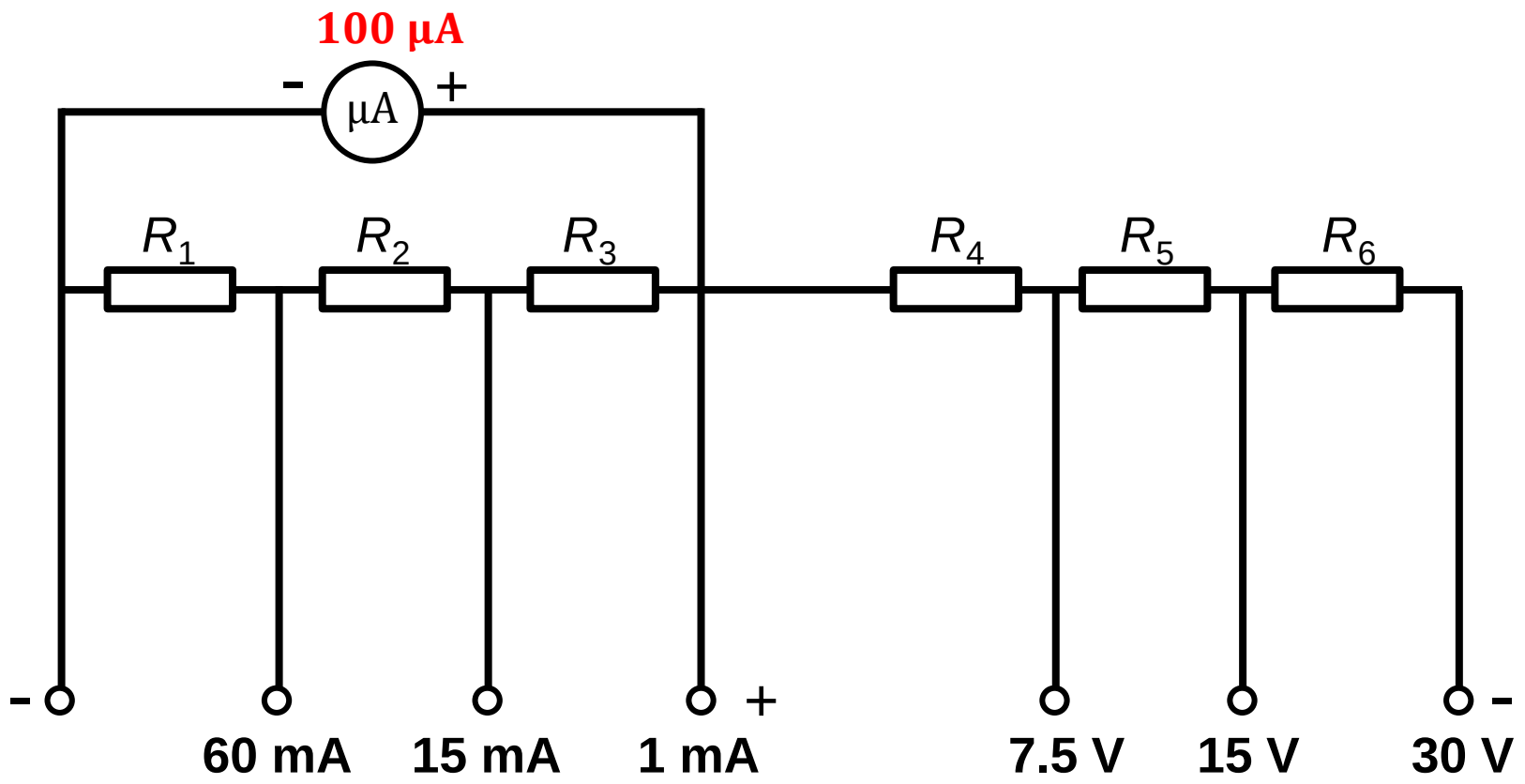
- K_1 ON, Connect K_2 to point 1 G_0 and G are in series
- Tune R_1 and keep G at its full range $I_{G01} = I_G$

Step 2:

- K_1 ON, Connect K_2 to point 2 R_2 and G_0 are in series
- Keep R_1 fixed and tune R_2 until $I_{G02} = I_{G01}$
- Then one finds $R_G = R_2$

R_G: the internal resistance of G

Design Ammeters and Voltmeters

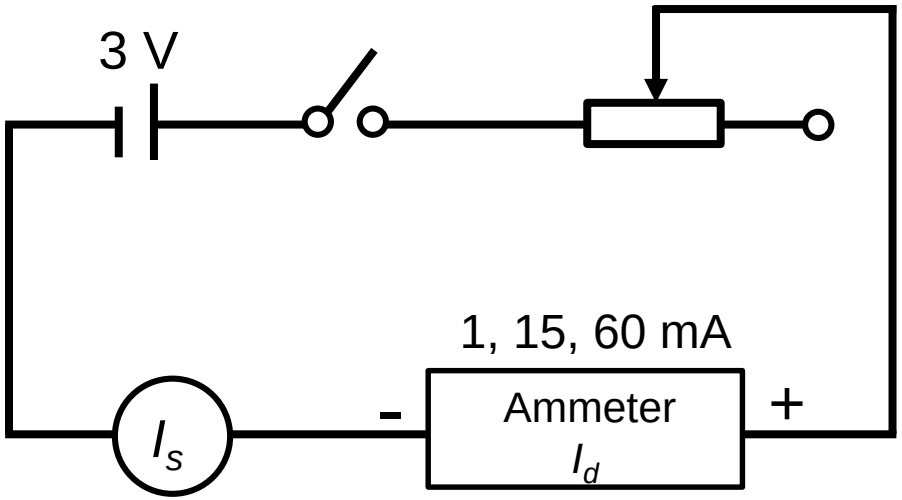


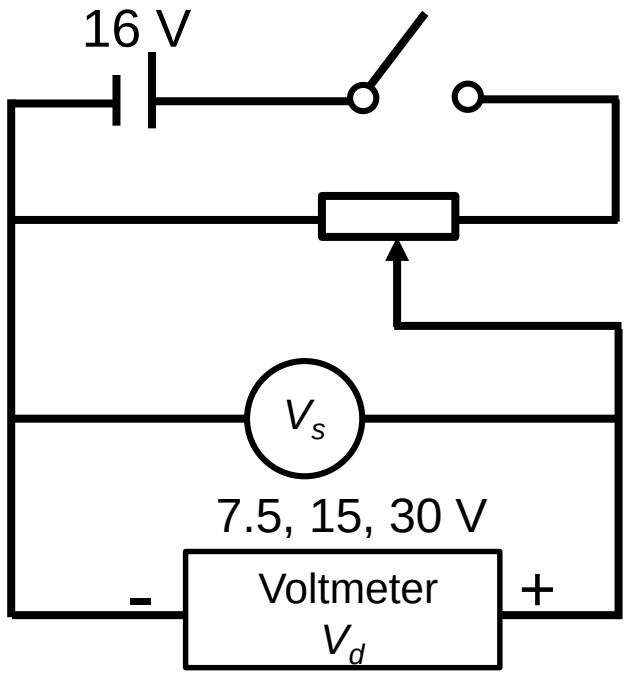
Ammeter

Voltmeter

$R_1 = 4.26\ \Omega$
$R_2 = 12.8\ \Omega$
$R_3 = 238\ \Omega$
$R_4 = 7.27\ \text{k}\Omega$
$R_5 = 7.5\ \text{k}\Omega$
$R_6 = 15\ \text{k}\Omega$

Calibration of Ammeters and Voltmeters

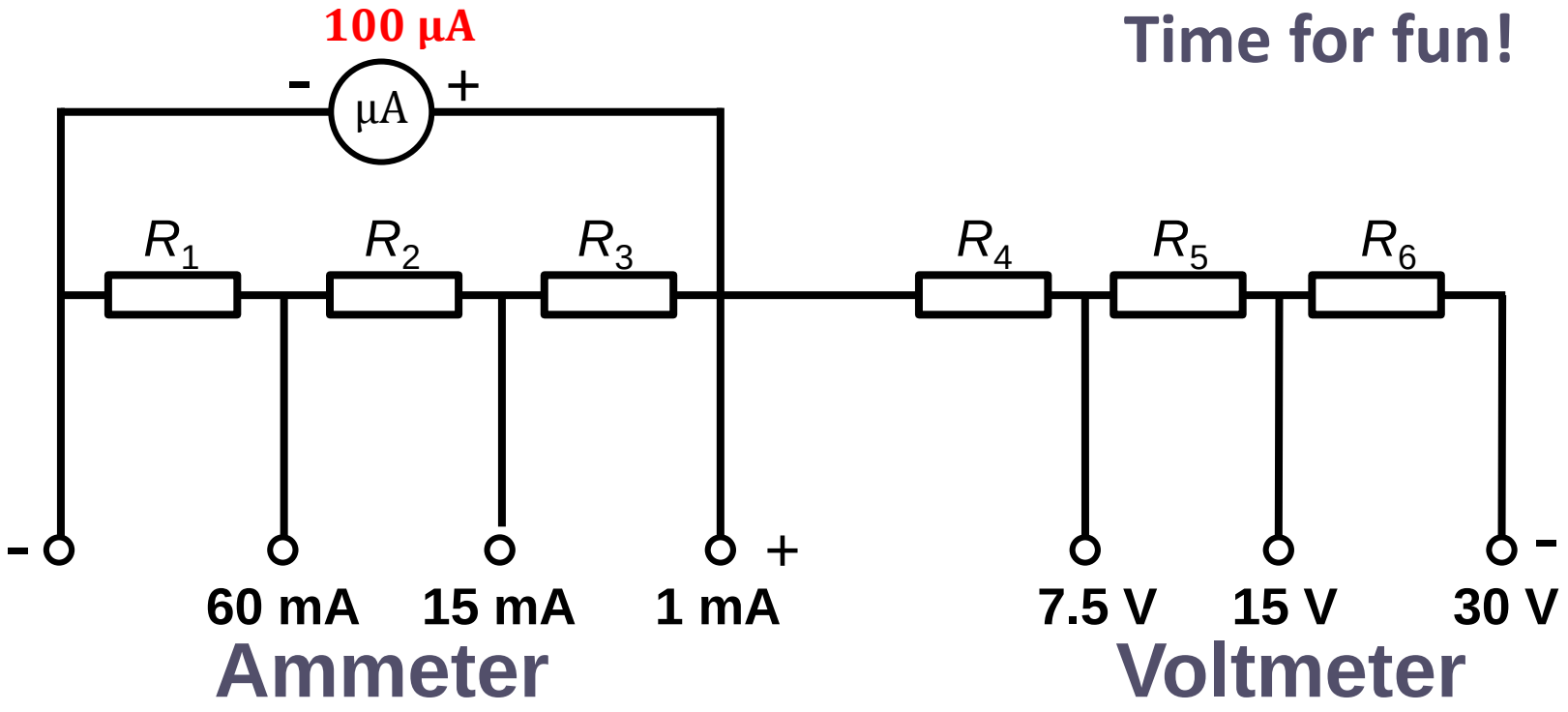




$I_d(\mathrm{mA})$	$I_s(\mathrm{mA})$	$\Delta I(\mathrm{mA})$
1		
15		
60		

$V_d(\mathrm{V})$	$V_s(\mathrm{V})$	$\Delta V(\mathrm{V})$
7.5		
15		
30		

Design Multimeters



Time for fun!

$R_1 = 4.26\ \Omega$
$R_2 = 12.8\ \Omega$
$R_3 = 238\ \Omega$
$R_4 = 7.27\ \text{k}\Omega$
$R_5 = 7.5\ \text{k}\Omega$
$R_6 = 15\ \text{k}\Omega$

Appendix Table I: Experimental Raw Data for Multimeters

Internal Resistance of the Ammeter (Ω)		I_d(mA)	I_s(mA)	ΔI(mA)	V_d(V)	V_s(V)	ΔV(V)
Half value method		1			7.5		
Replacement method		15			15		
Measured by multimeter		60			30		

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THANK YOU!