Electronics

MIEET 1º ano

Peter Stallinga, UAlg 2011

MIEET. The levels of knowledge

Physics

Electronics

Sensors and Actuators

Systems

Control

Digital Electronics

Integrated Circuits

Micro Assembler

Machine Language

Macro Assembler

High Level Programming Languages

Object-oriented Programming

Distributed Programming

Information Processing

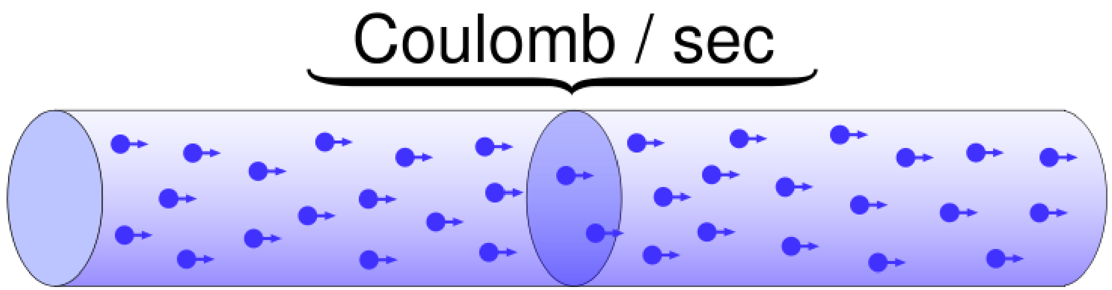
Optics / EM Waves

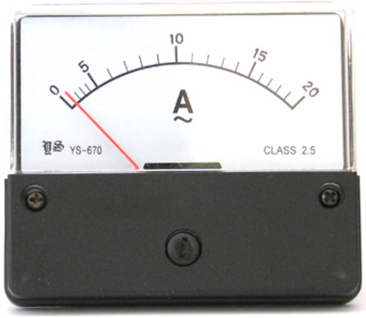
Telecommunications

Internet

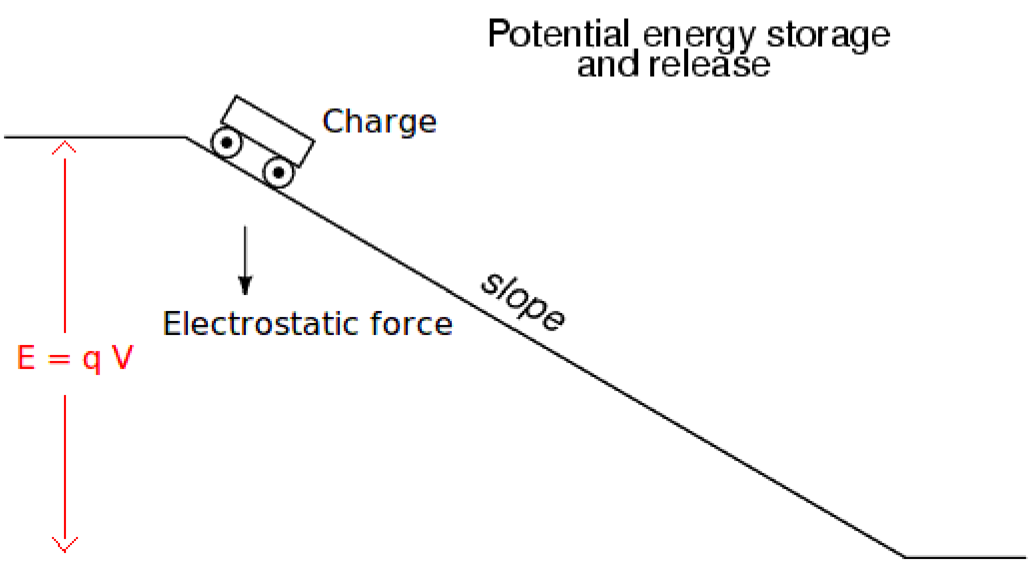
Today
IALP
MIEET

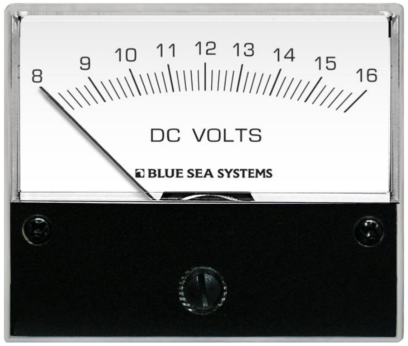
Current - Voltage



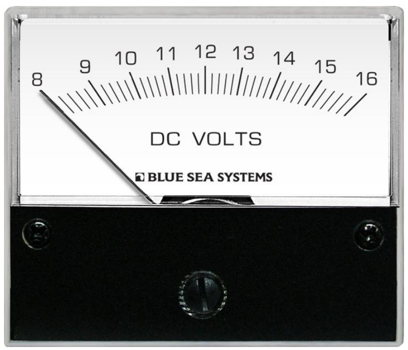


Current is the passage of charge
Voltage is the potential energy

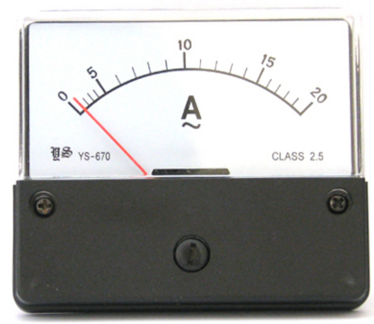




Power



X



=

$$V \times I = P$$

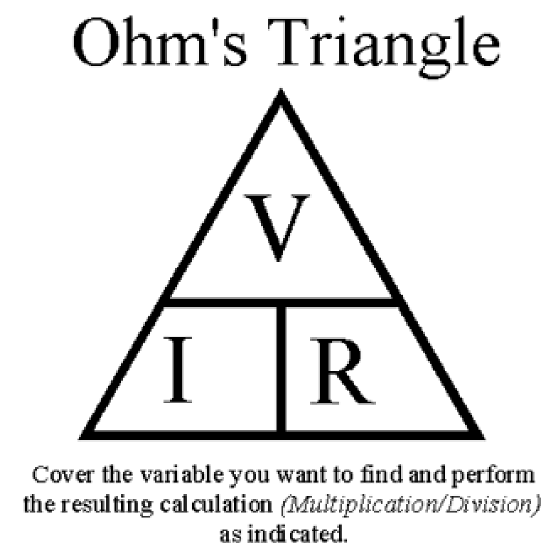
Ohm's Law

Linear relation between voltage (*V*) and current (*I*)

$$R = V / I$$

$$V = R \times I$$

$$I = V / R$$

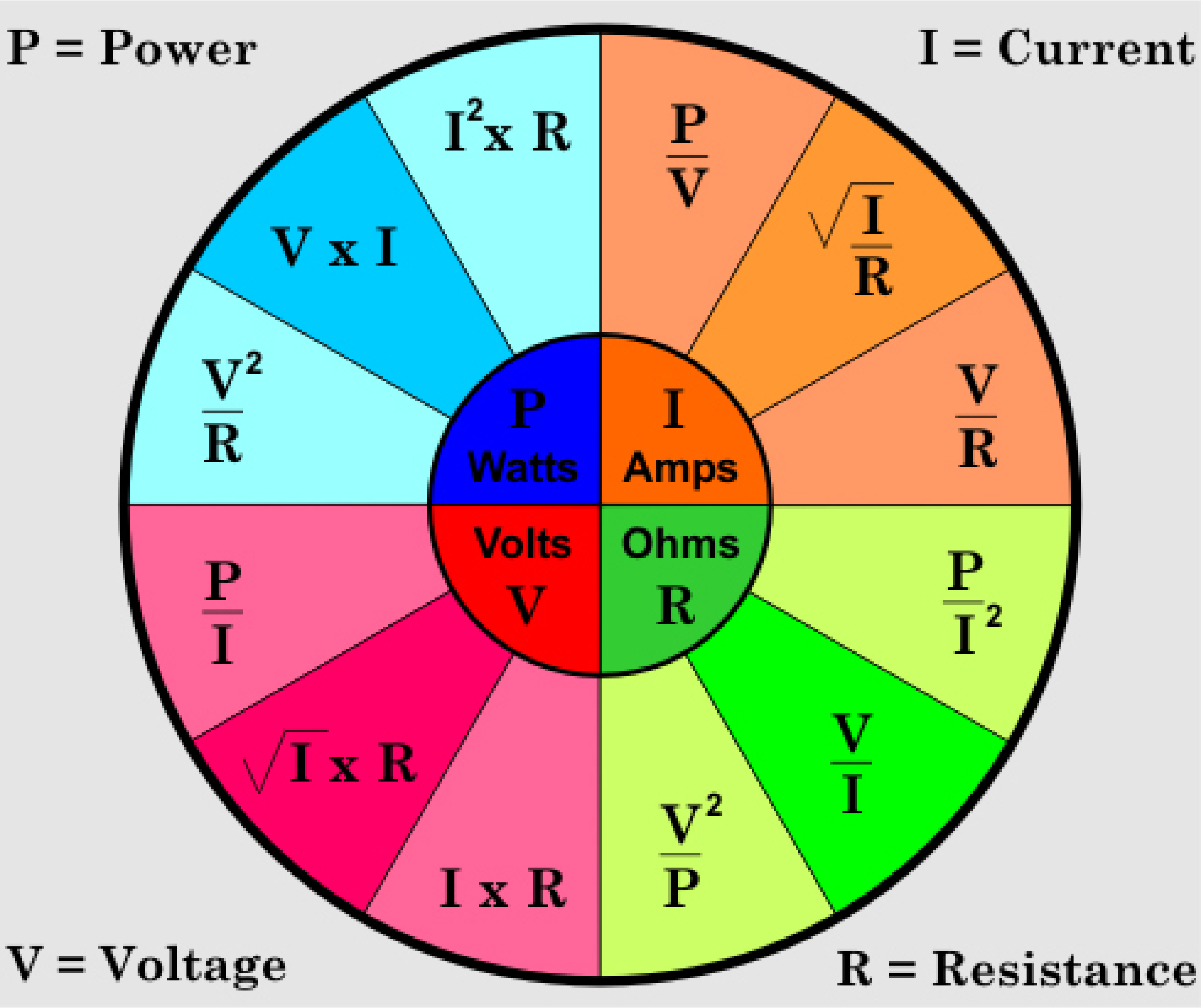


Resistance is the ability of an object to 'resist' the flow of current. Like 'friction'.
Slows down the charge and ($I = n \times v$) reduces the current

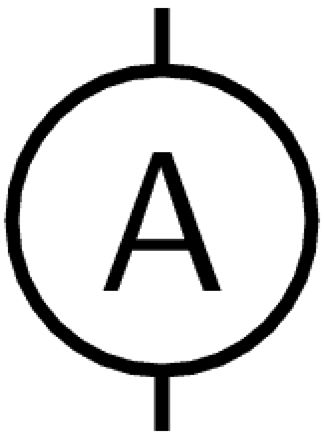
The current is proportional to applied power divided by resistance

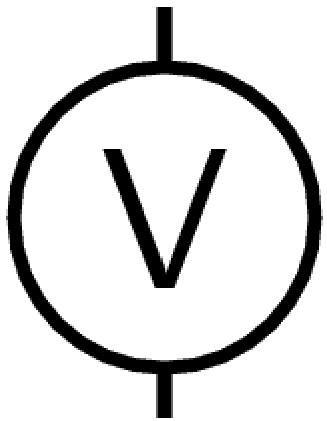
Power, current, voltage, resistance

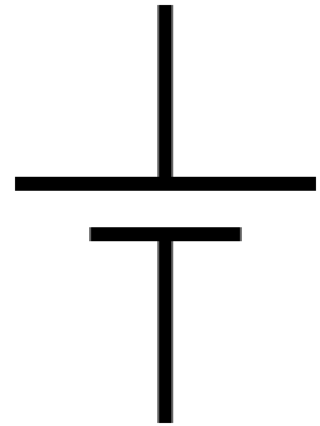
$$R = V / I \qquad P = V \times I$$



Symbols for electronic components





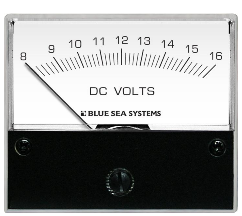



Amperimeter

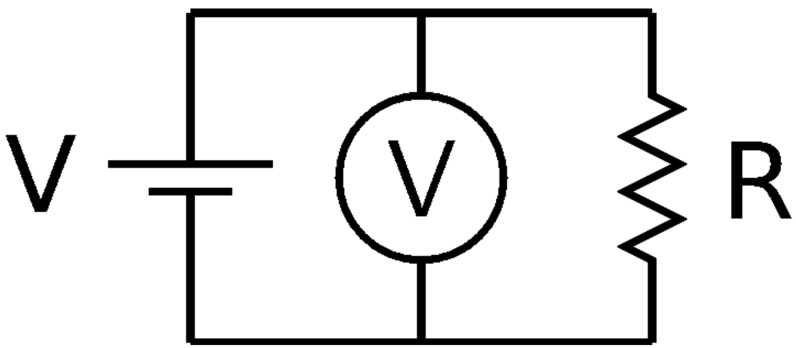
Voltmeter

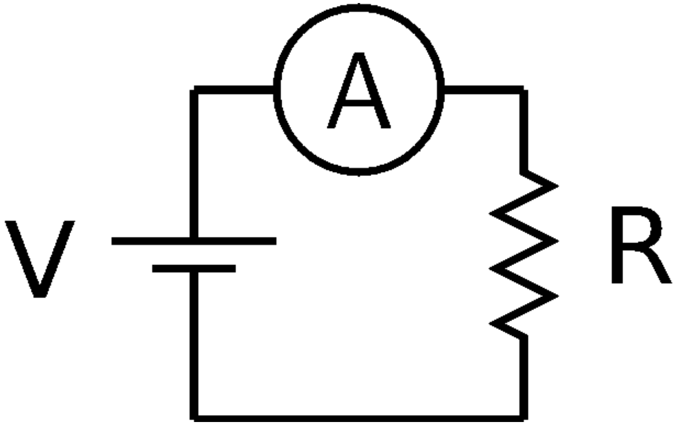
Voltage source

Resistance



Measuring



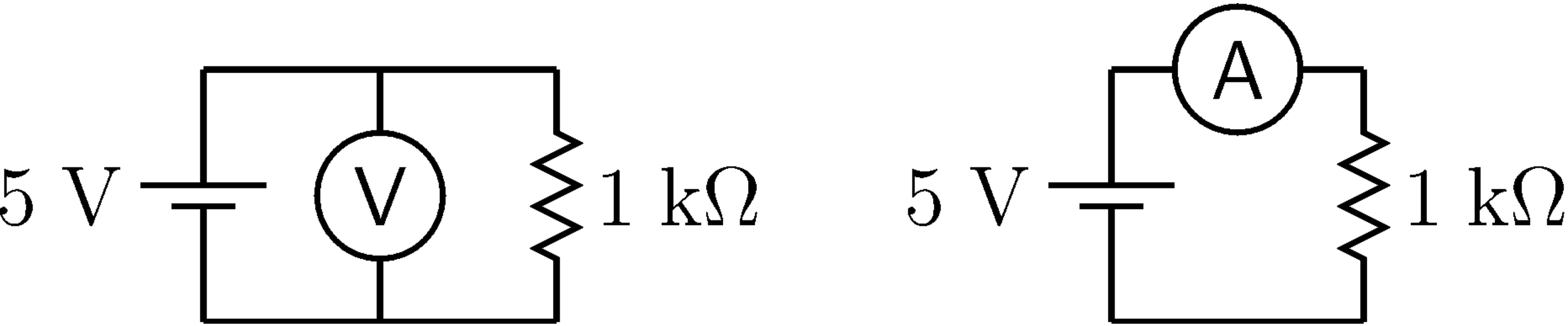


Applying a voltage to a resistance

Measuring voltage and current.
For the measuring of current we have to open the circuit and insert the amperimeter

Notes:
The voltmeter has infinite resistance (I = V/R = 0)
The current meter has zero resistance (V = IxR = 0)

Measuring example

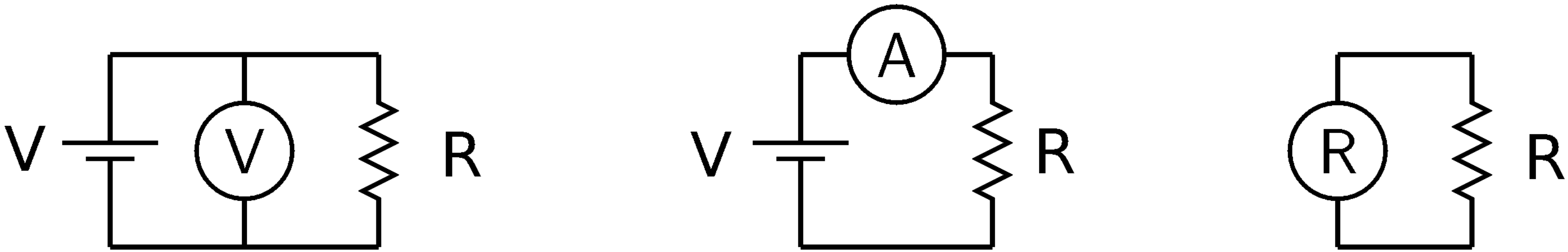


Example:

Voltmeter will indicate 5 V
Current meter will indicate 5 mA, because (5 V)/(1 kΩ) = 0.005

The resistance is R = (5 V)/(5 mA) = 1 kΩ

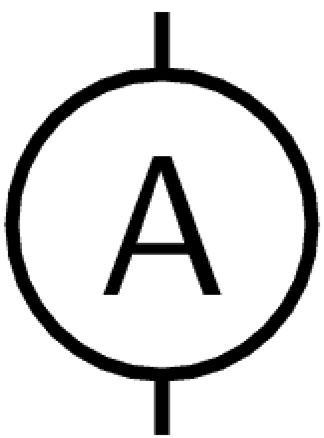
Measuring with a **multi**meter

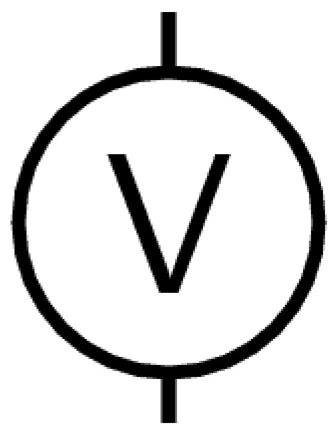


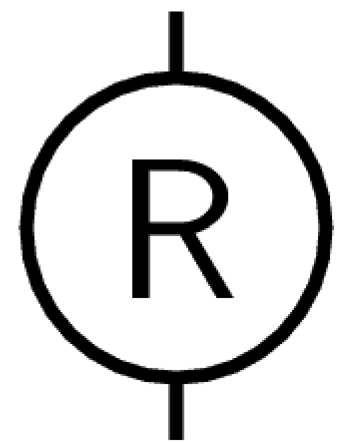
A multimeter can directly measure resistance
(apply voltage, measure current and do the calculation)

A multimeter can also (still) measure current and voltage

Multimeter



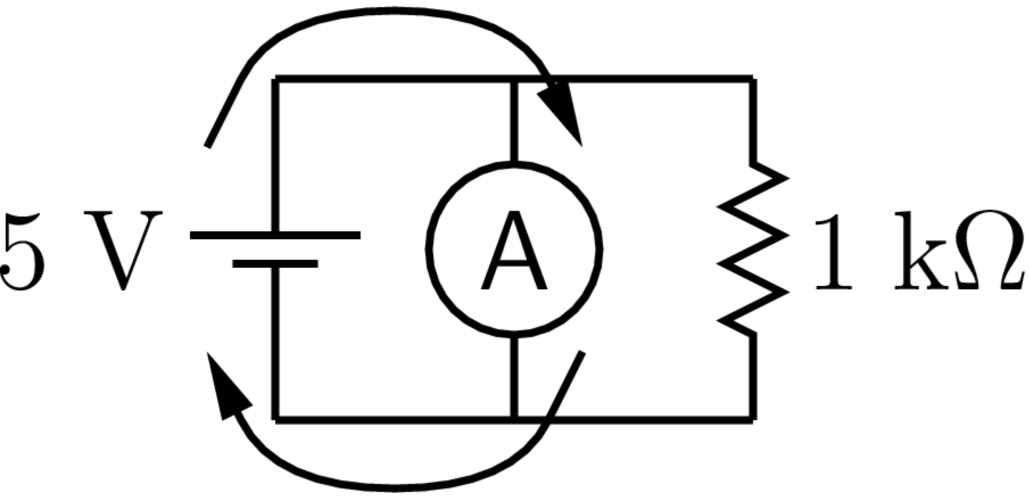




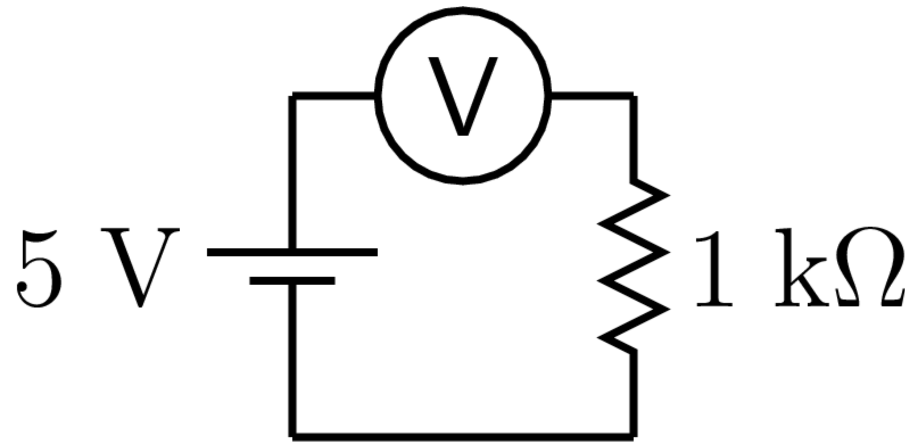
… and more (β, C, f, AC/DC)

Wrong connection

An amperimeter in the place of a voltmeter:



A voltmeter in the place of an amperimeter:



The current meter has zero resistance

$I = V / R = (5\text{ V})/(0) = \infty$

The voltmeter has infinite resistance

$I = V / R = (5\text{ V})/(\infty) = 0$

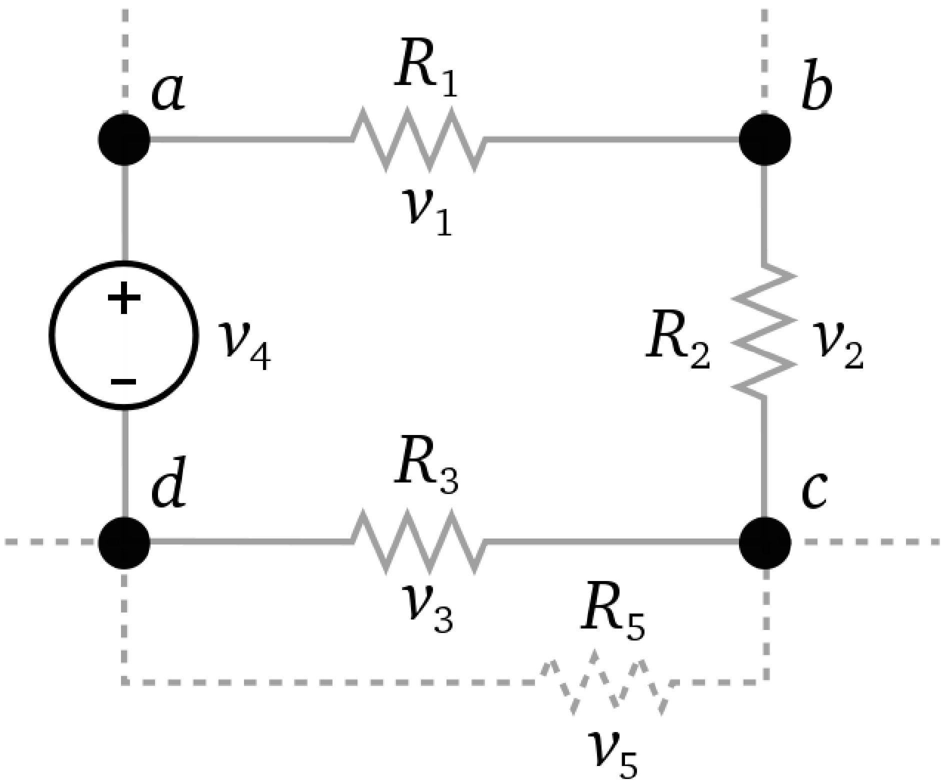
You just nuked the multimeter!

Kirchhoff's Circuit Laws (KCL)

1: Kirchhoff's Law of Loops

Going back to same place (closed loop) means same energy potential (V)

$$\sum \Delta V = 0$$

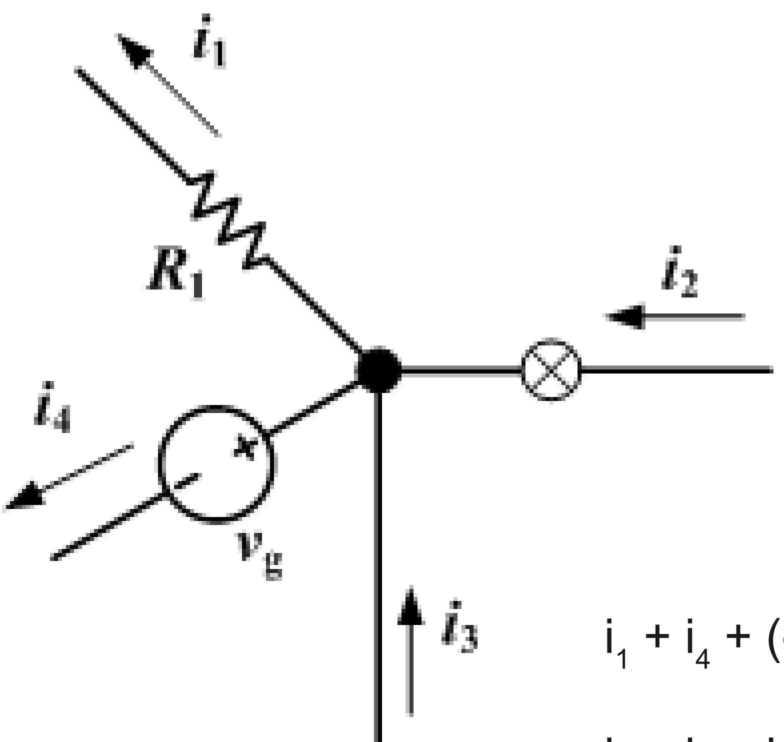


Walking from a → b → c → d → a
We must return to same potential.

Kirchhoff's Circuit Laws (KCL)

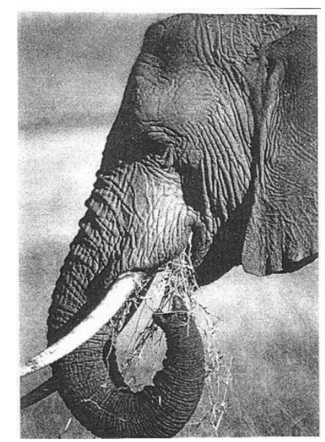
2: Kirchhoff's Law of Junctions

$$\sum \Delta I = 0$$



$i_1 + i_4 + (-i_2) + (-i_3) = 0$

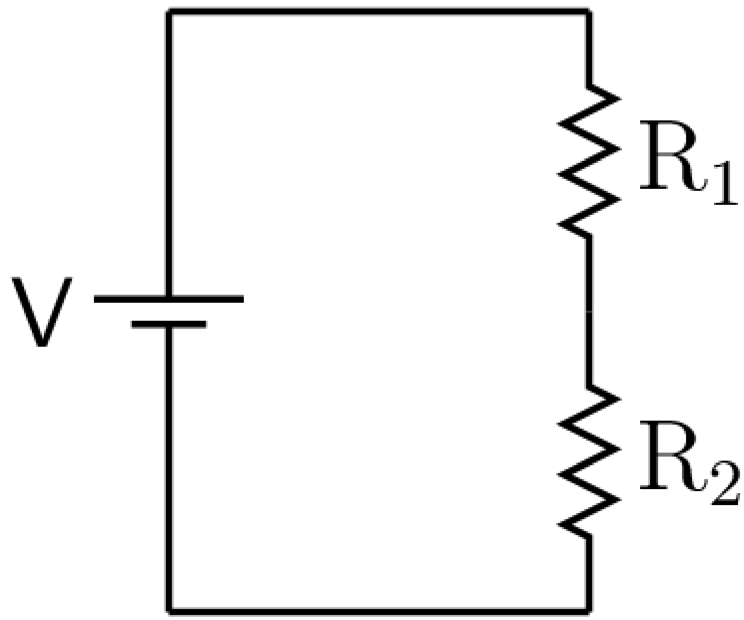
$i_1 + i_4 = i_2 + i_3$



“What goes in, must come out”

Cannot accumulate charge!

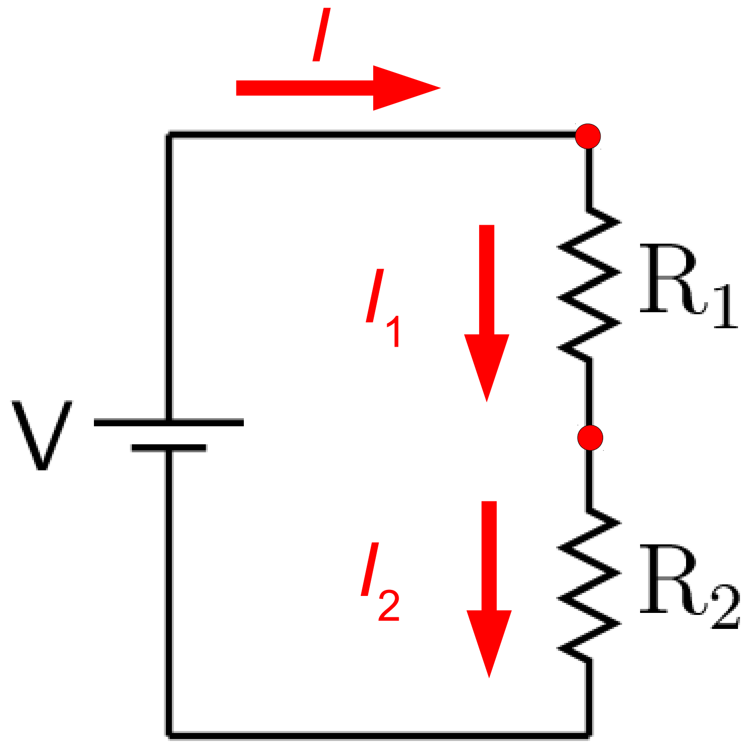
Series / parallel



What will be the effective resistance of two resistances 'in series'?

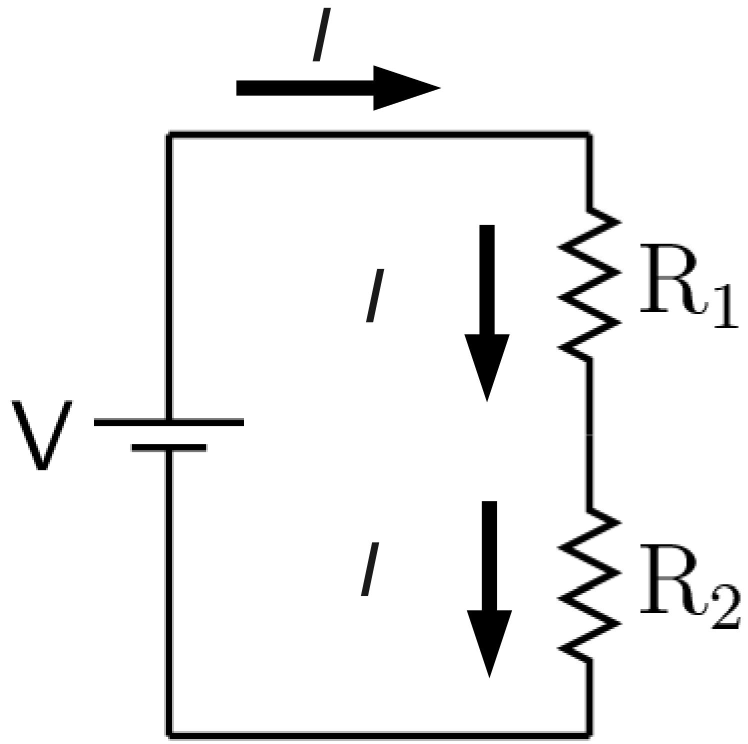
Calculate the current and use Ohm's Law $R = V / I$

Series / parallel



Kirchhoff: $I_1 = I_2 = I$

Series / parallel



Kirchhoff: $I_1 = I_2 = I$
Ohm: $V = I \times R$
Kirchhoff: sum of $\Delta V = 0$

$\Delta V_1 = I \times R_1$

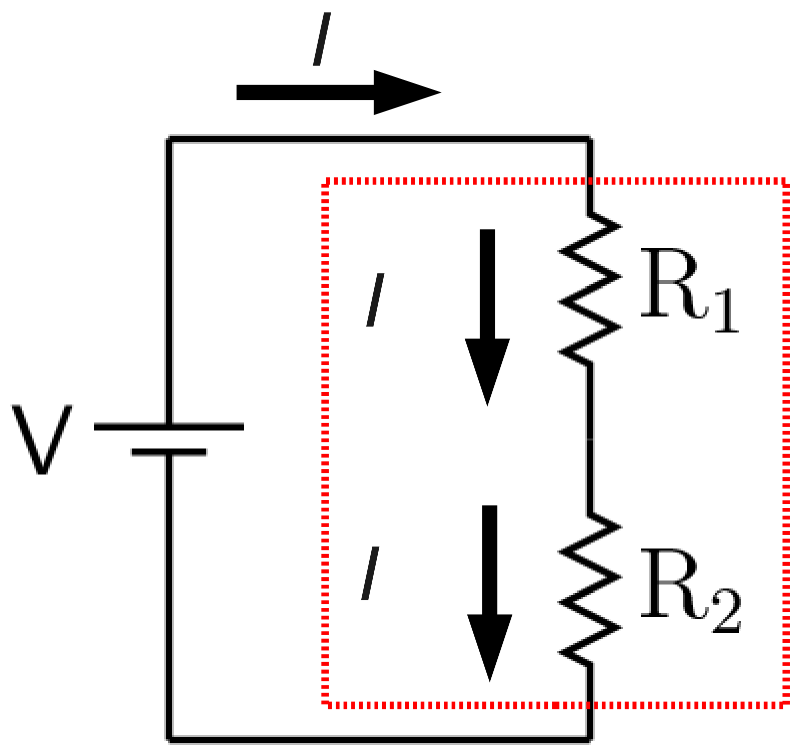
$\Delta V_2 = I \times R_2$

$- V$

+

$I \times R_1 + I \times R_2 - V = 0$

Series / parallel



Kirchhoff: $I_1 = I_2 = I$
Ohm: $V = I \times R$
Kirchhoff: sum of $\Delta V = 0$

$\Delta V_1 = I \times R_1$

$\Delta V_2 = I \times R_2$

$-V$

$+$

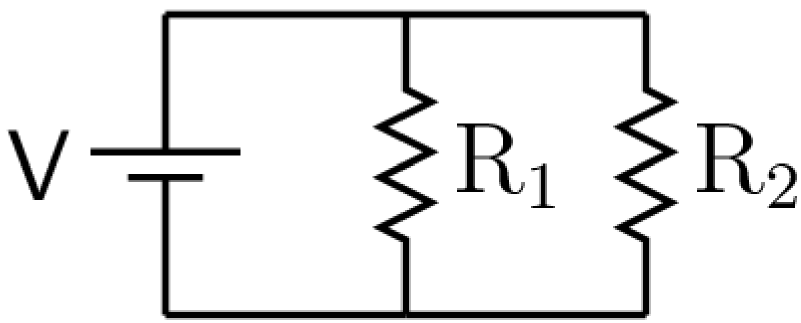
$I \times R_1 + I \times R_2 - V = 0$

Series:

$V = I \times (R_1 + R_2)$

$$R = V / I = R_1 + R_2$$

Series / parallel

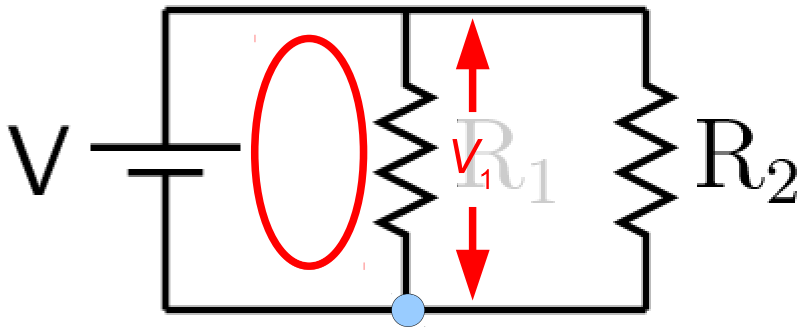


What will be the effective resistance of two resistances 'in parallel'?

Calculate the current and use Ohm's Law $R = V / I$

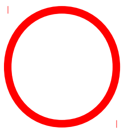
Series / parallel

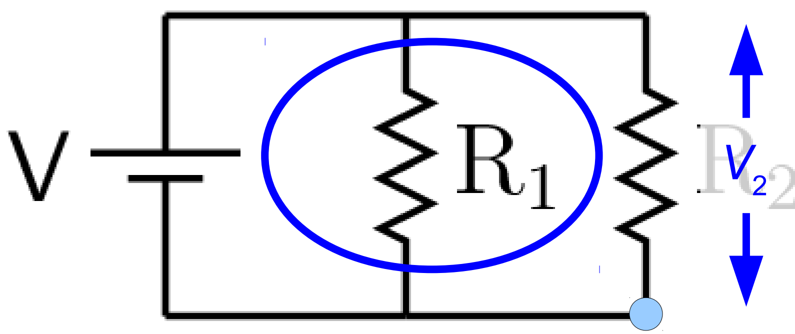
Kirchhoff's Law Loops:



$V_1 + (-V) = 0$:

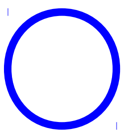
$V_1 = V$





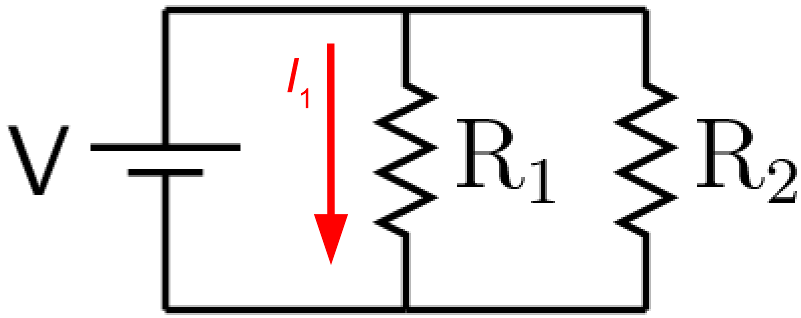
$V_2 + (-V) = 0$:

$V_2 = V$

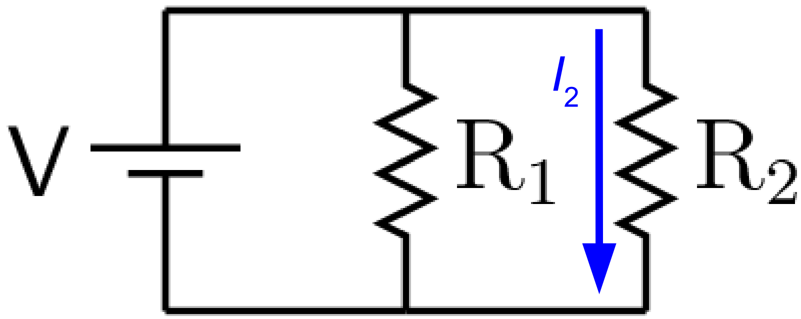


Series / parallel

Ohm's Law:

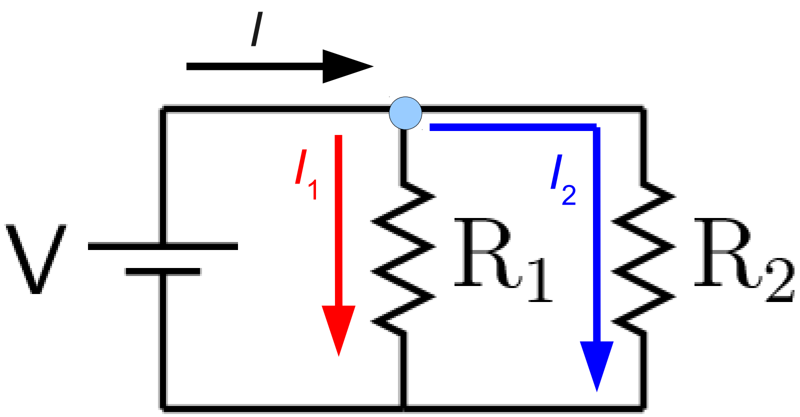


$I_1 = V / R_1$



$I_2 = V / R_2$

Series / parallel



Ohm's Law:

$I_1 = V / R_1$

$I_2 = V / R_2$

Kirchhoff's Junction Law:

$I = I_1 + I_2 = V / R_1 + V / R_2$

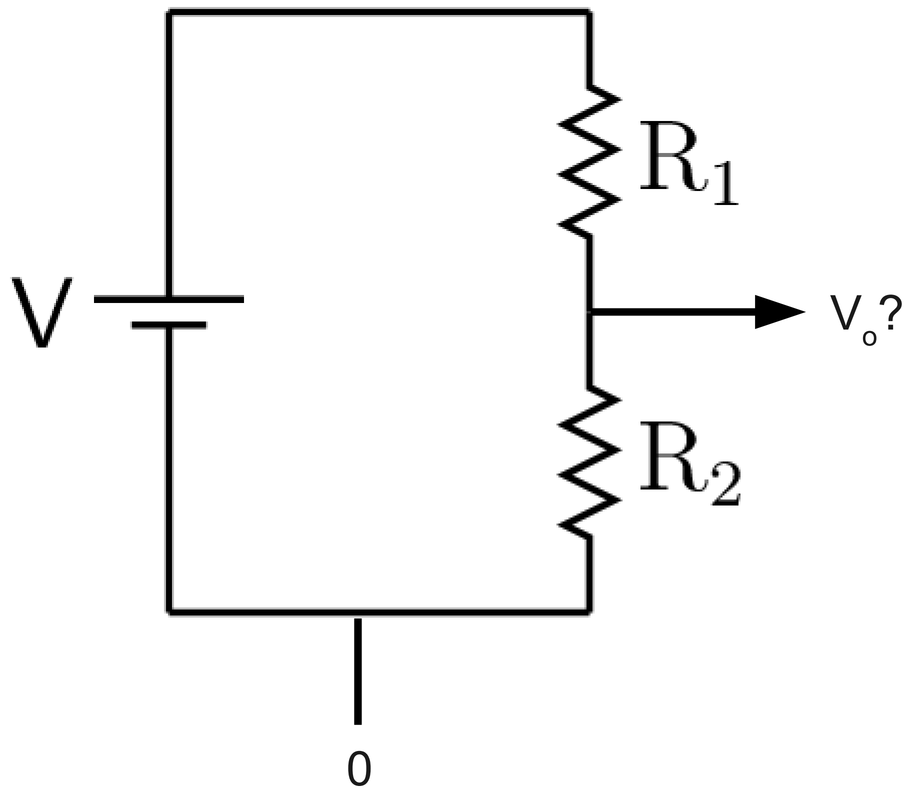
Ohm's Law: $R = V / I = \dfrac{V}{V / R_1 + V / R_2}$

Parallel:

$= (1/R_1 + 1/R_2)^{-1}$

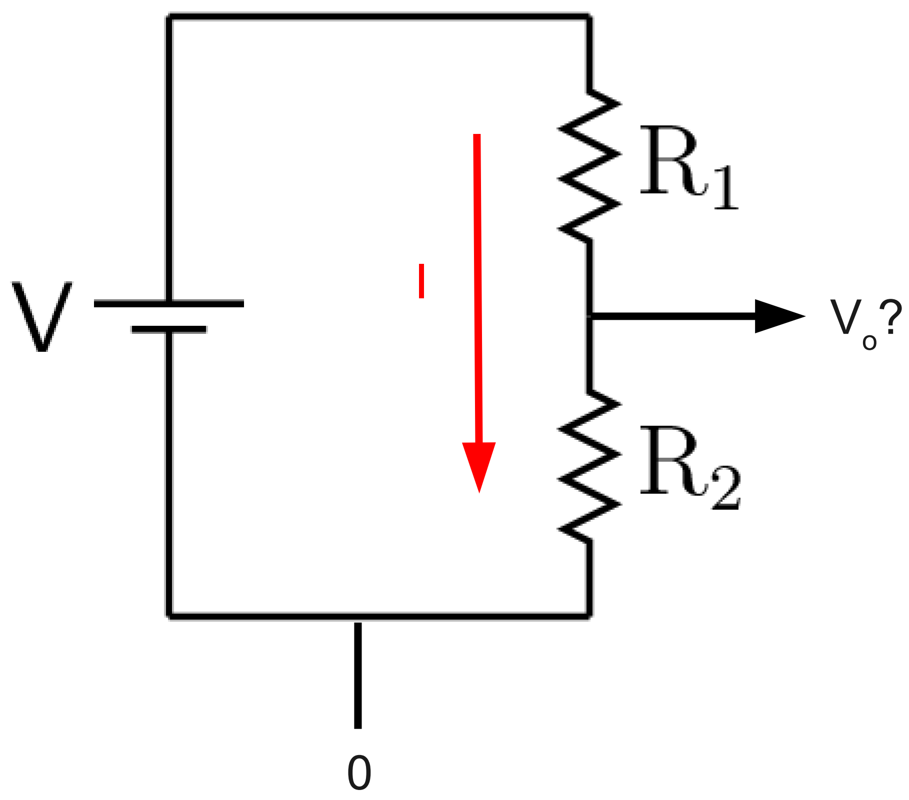
$= \dfrac{R_1 R_2}{R_1 + R_2}$ **(only for case with two resistors!)**

Voltage divider



What is the voltage halfway?

Voltage divider

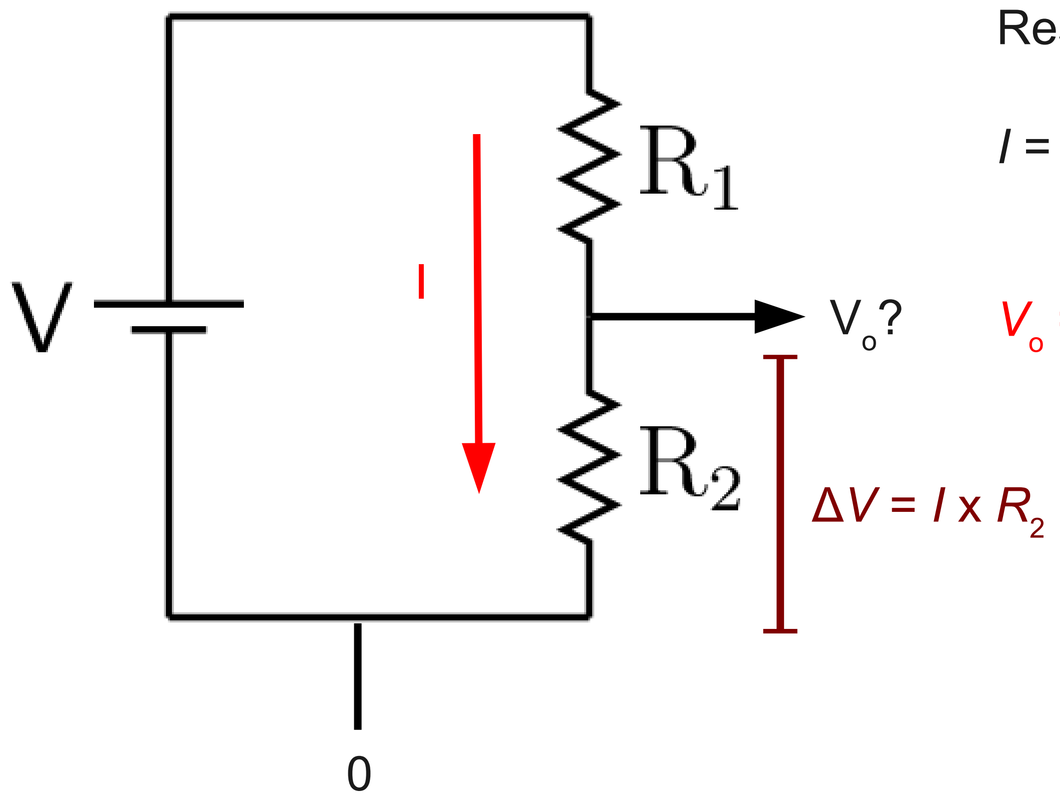


What is the voltage halfway?

Resistances in series: $R = R_1 + R_2$

$I = V / R = V / (R_1 + R_2)$

Voltage divider



What is the voltage halfway?

Resistances in series: $R = R_1 + R_2$

$I = V / R = V / (R_1 + R_2)$

$$V_o = 0 + I \times R_2 = V \frac{R_2}{R_1 + R_2}$$

Non-ohmic

Not everything behaves according to Ohm's Law

A capacitor is an element that has the capacity to **store** charge (instead of letting it pass).

The capacitance is by definition the amount of charge it can store per volt:

$$C = Q/V$$

$$V = Q/C$$

$$Q = C \times V$$

Current of a capacitor

If $Q = C \times V$, then: changes of voltage cause changes of stored charge:

$$\Delta Q = C \times \Delta V$$

How fast we do it matters

$$\Delta Q/\Delta t = C \times \Delta V/\Delta t$$

In the mathematical limit:

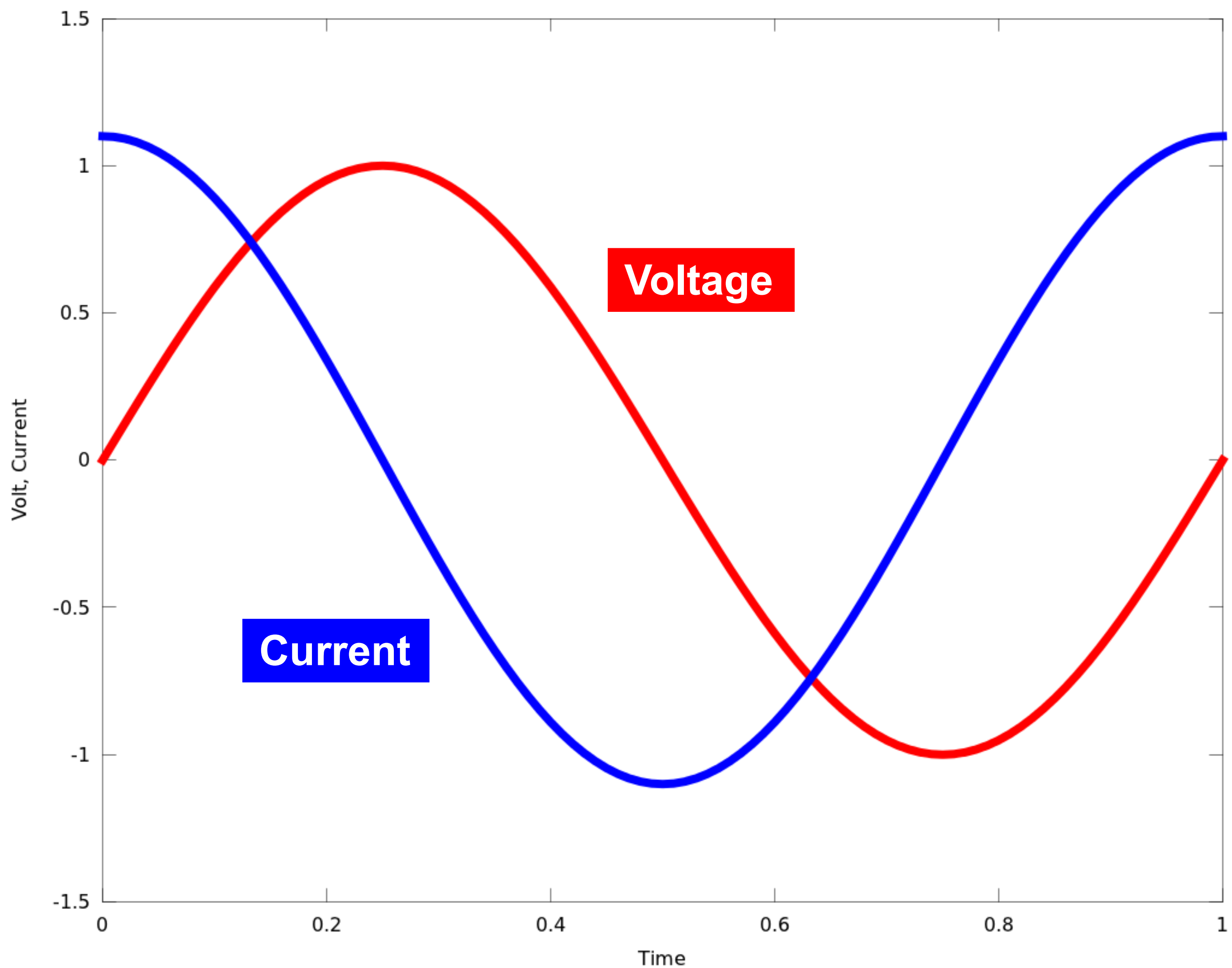
$$\mathrm{d}Q/\mathrm{d}t = C \times \mathrm{d}V/\mathrm{d}t$$

But, the left side is the **definition of current**

$$I = C \times \mathrm{d}V/\mathrm{d}t$$

Current in a capacitor is proportional to the speed of changes of the applied voltage

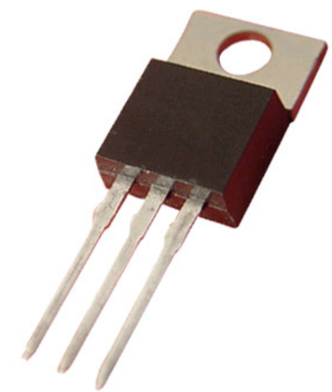
Capacitance example



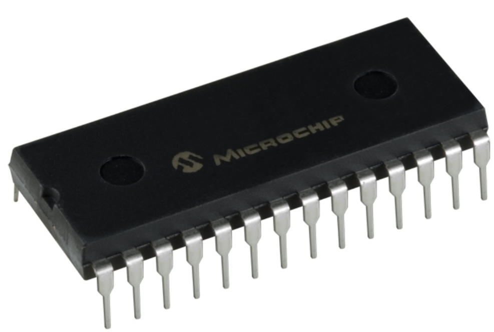
Other components

Coil (inductor)

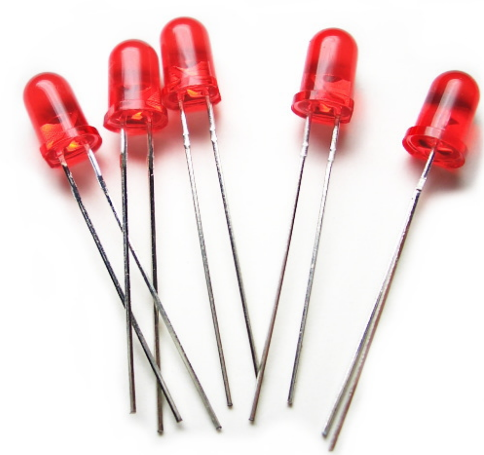
Diode



Transistor



Integrated circuit

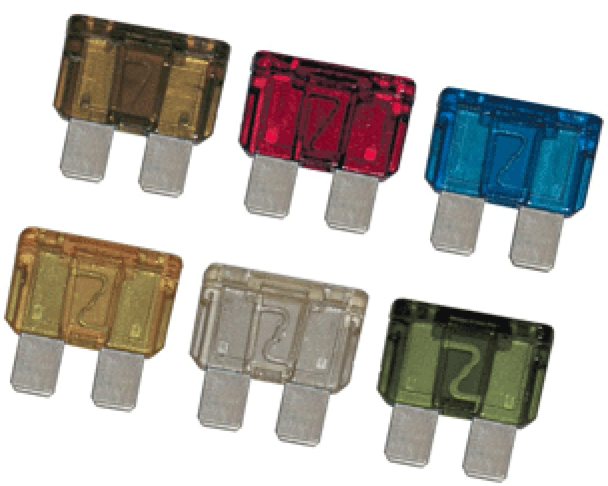


Light-emitting diode
(LED)

Other components

Fuses

Variable resistor / Potentiometer



Car fuses

Connector

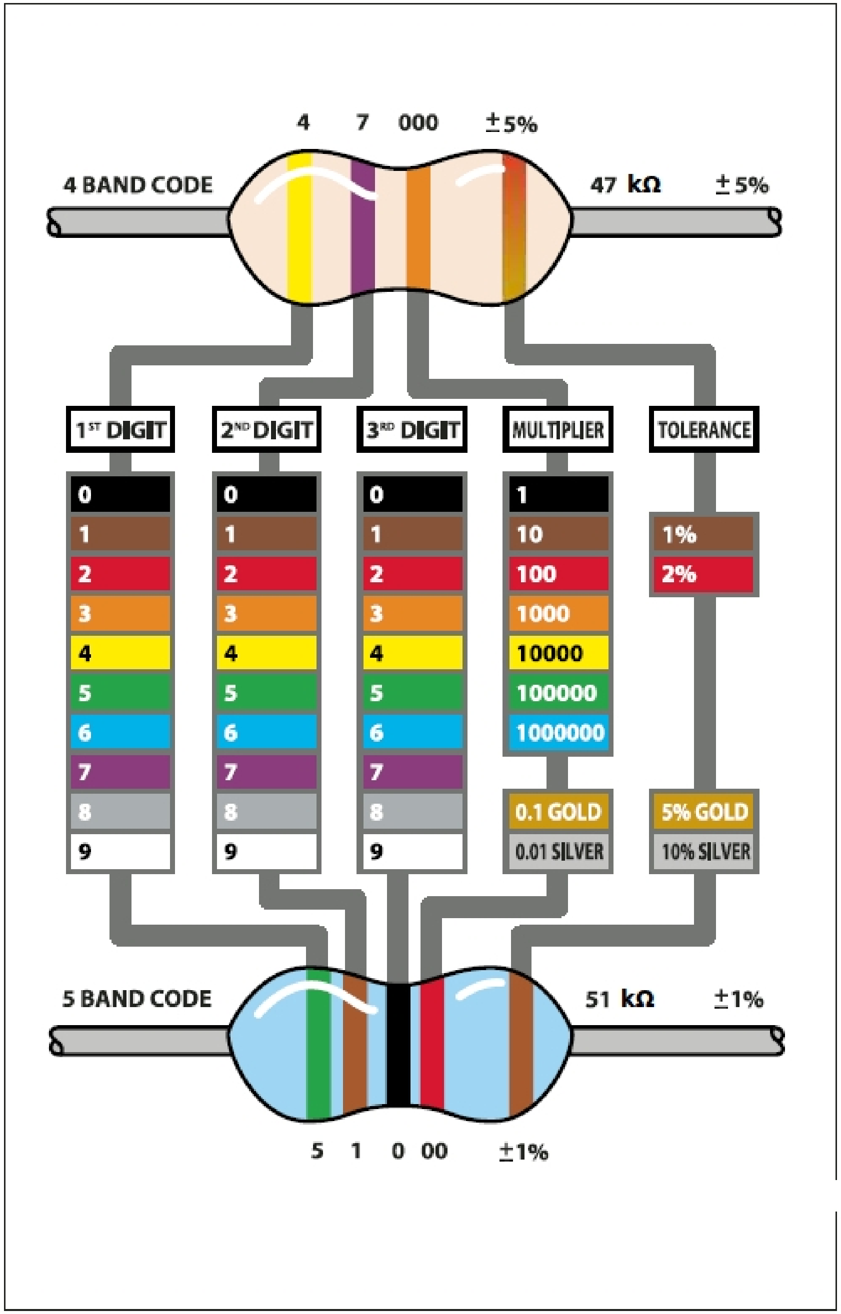
Other equipment

Variable voltage / current source

Signal source, $V(t)$

Oscilloscope: Visualize $V(t)$

Resistance color code



Never again forget this code!