Electricity and Magnetism
Lab 3
Ohm's Law

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Overview

- Current in a circuit
- Resistance and resistivity
- Reading resistor markings
- Ammeters and voltmeters
- Ohm's Law

Current and Potential Difference

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The units of current are Amps, A.

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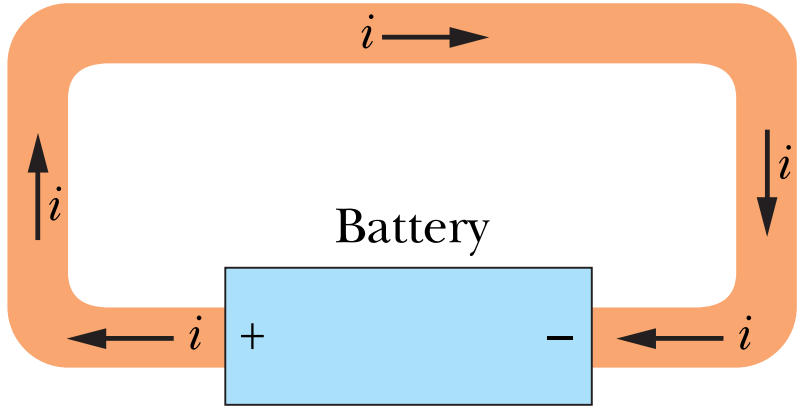
Potential difference is the potential energy of each charged object, divided by the object's charge.

For now, think of it as the "pump" that drives the flow of charge.

Its symbol is V, and the units are Volts, V.

Current and Potential Difference

(a)



(b)

Resistance

A **resistor** resists the flow of current in a circuit.

All materials, even conductors, have some resistance. The only exception is superconductors.

We measure resistance using this equation

$$R = \frac{V}{I}$$

Resistance is a property of a particular component in a circuit.

The unit of resistance are Ohms, written Ω.

Resistivity

Resistivity is a property of a material. Its symbol is ρ.

Resistivity

Resistivities of Some Materials at Room Temperature (20°C)

Material	Resistivity, ρ ($\Omega \cdot m$)	Temperature Coefficient of Resistivity, α (K^{-1})
	Typical Metals	
Silver	1.62×10^{-8}	4.1×10^{-3}
Copper	1.69×10^{-8}	4.3×10^{-3}
Gold	2.35×10^{-8}	4.0×10^{-3}
Aluminum	2.75×10^{-8}	4.4×10^{-3}
Manganin[a]	4.82×10^{-8}	0.002×10^{-3}
Tungsten	5.25×10^{-8}	4.5×10^{-3}
Iron	9.68×10^{-8}	6.5×10^{-3}
Platinum	10.6×10^{-8}	3.9×10^{-3}
	Typical Semiconductors	
Silicon, pure	2.5×10^{3}	-70×10^{-3}
Silicon, *n*-type[b]	8.7×10^{-4}	
Silicon, *p*-type[c]	2.8×10^{-3}	
	Typical Insulators	
Glass	$10^{10} - 10^{14}$	
Fused quartz	$\sim 10^{16}$	

Resistivity

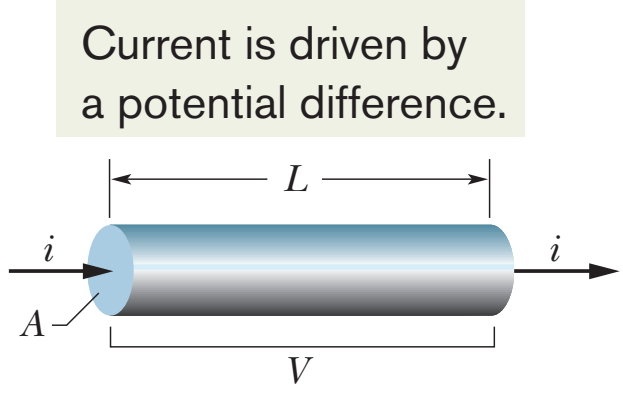
Resistivity is a property of a material. Its symbol is ρ.

Together with the geometry of the component made of that material, we can predict the resistance of the component.

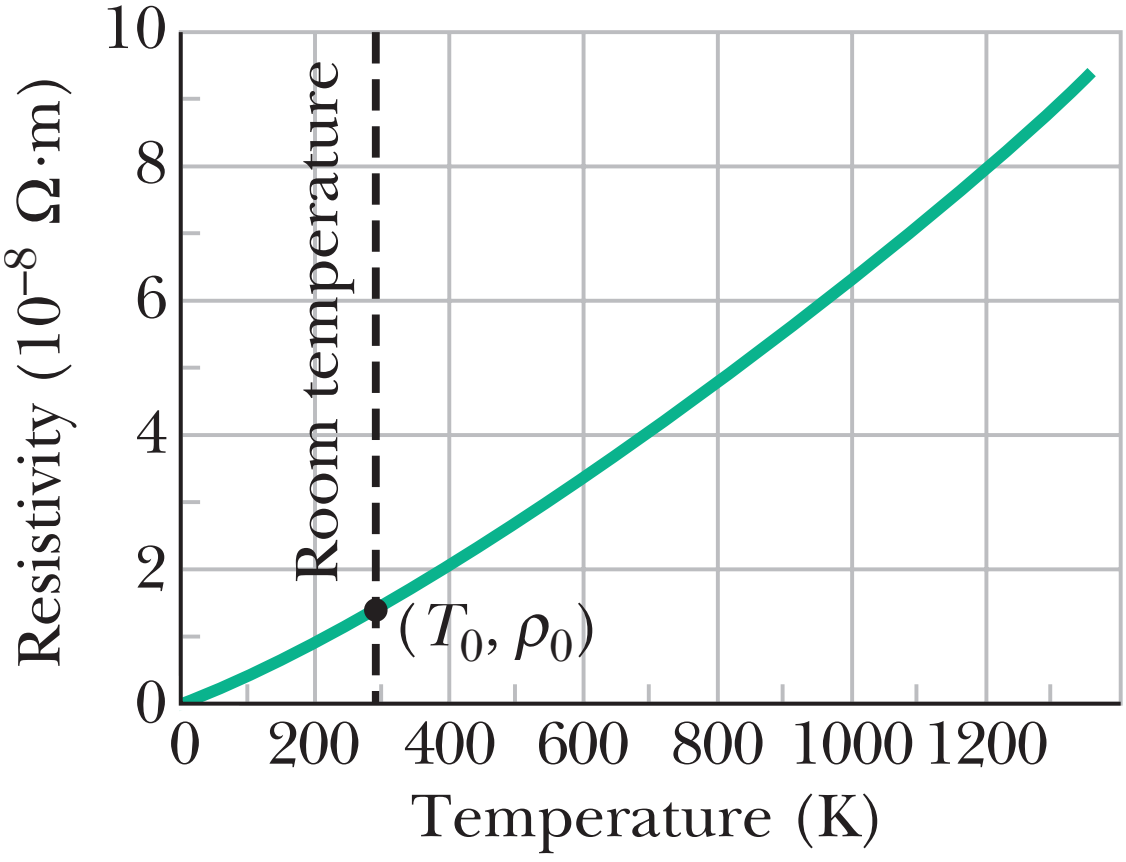
For a wire or cylinder made of material with resistivity ρ:

$$R = \frac{\rho L}{A}$$

where A is the cross-sectional area of the wire, and L is the length of the wire.



Resistivity can depend on Temperature

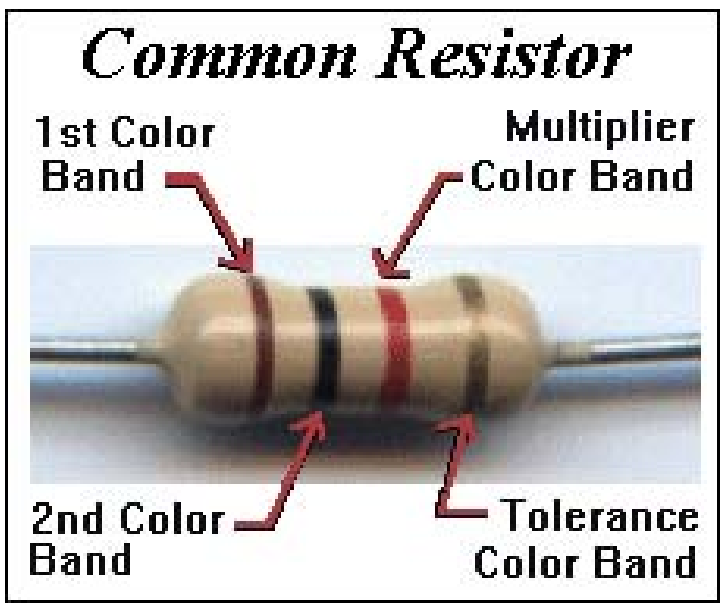


Reading the Value of Resistors

Color guide:

Resistor Color Code

	Black	Brown	Red	Orange	Yellow	Green	Blue	Violet	Gray	White
	0	1	2	3	4	5	6	7	8	9
Multiplier	1	10	100	1,000	10,000	100,000	1,000,000	10,000,000	100,000,000	--



[1] Images from orcadxcc.org.

Ohm's Law

Ohm's law is the principle we will use to measure resistance when we plot ΔV vs I.

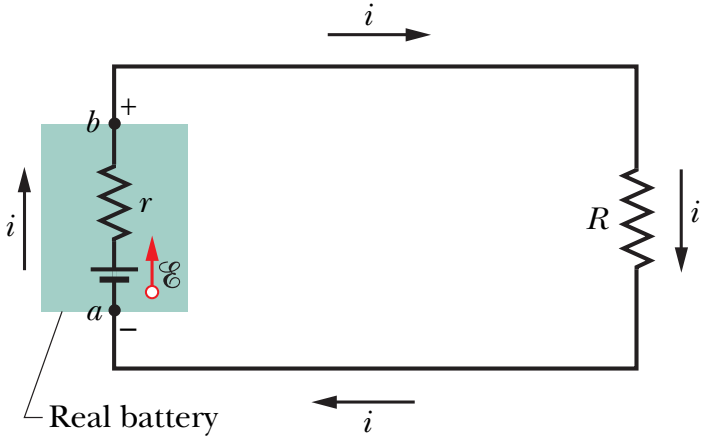
In this lab, we want to understand Ohm's law, and thereby understand how the resistance meters we use work.

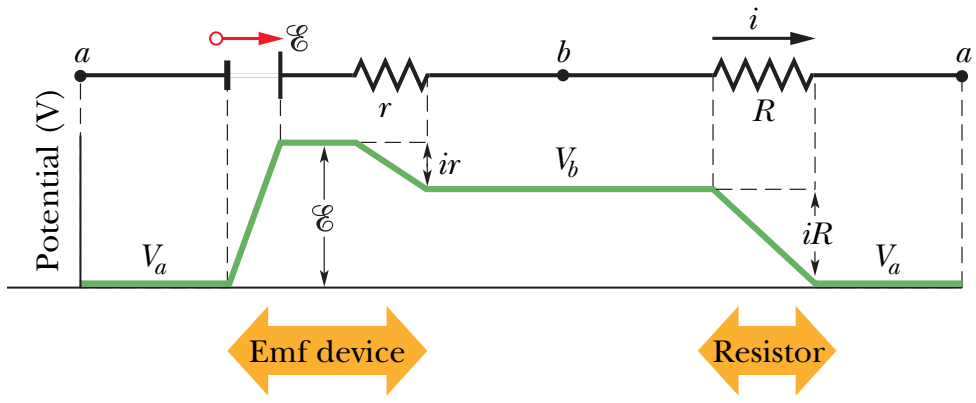
If Ohm's Law holds for a resistor:

$$\Delta V \propto I$$

This means that $\Delta V = IR$, with R the constant of proportionality. R is independent of ΔV.

Current and Potential Difference in a Circuit

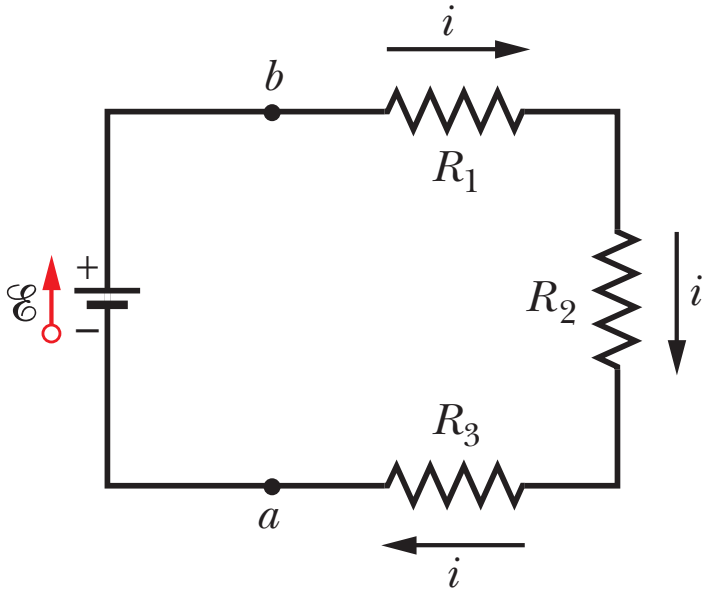




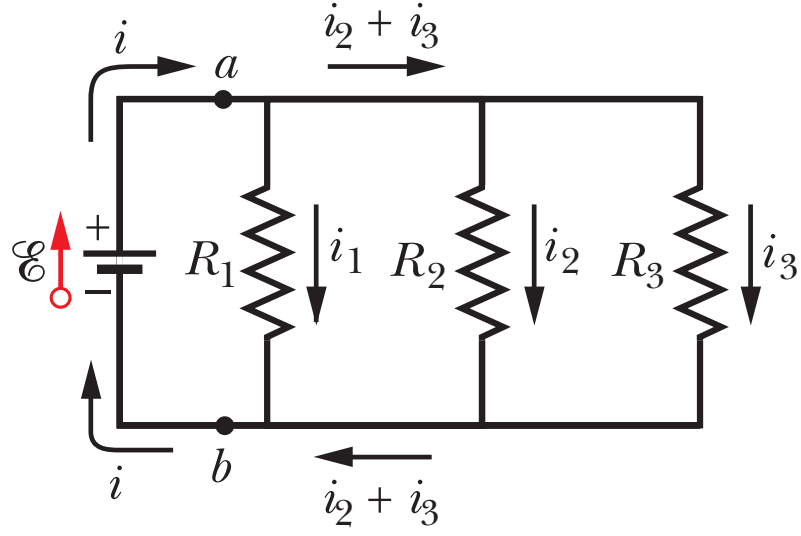
Series and Parallel

Example

Resistors in series:



Resistors in parallel:



Meters

Ammeter

A device for measuring **current** in a circuit.

The ammeter must be connected in series in the part of the circuit where you want to test the current.

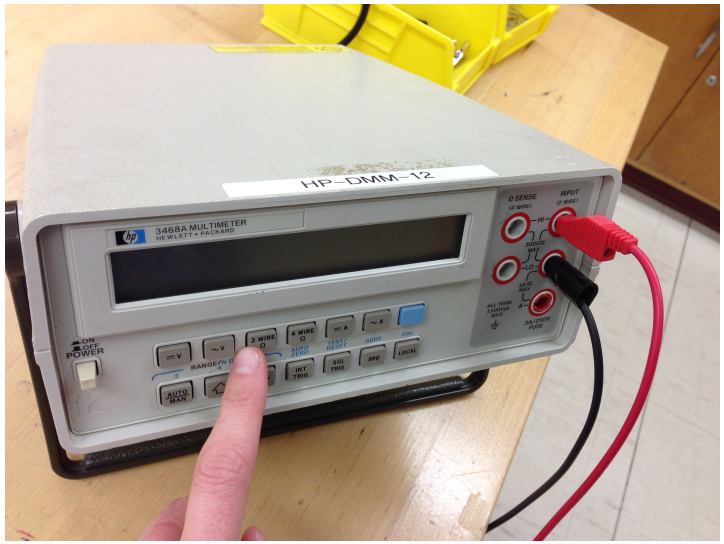
Voltmeter

A device for measuring **potential difference** across a component of a circuit.

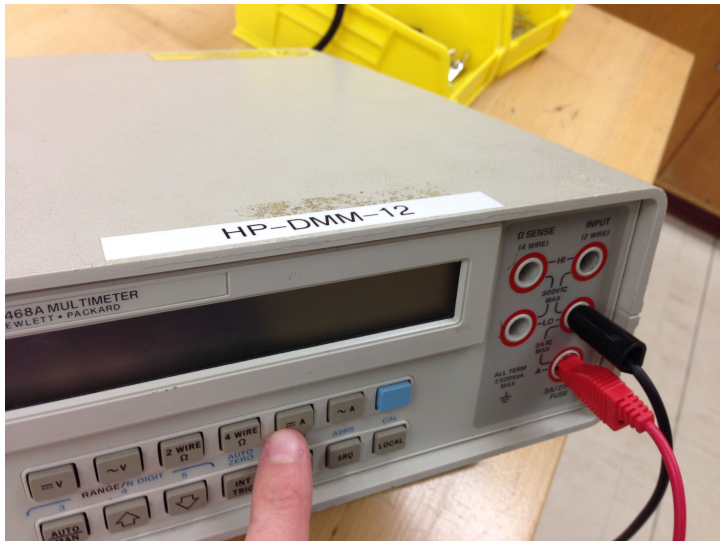
The voltmeter must be connected in parallel across the component where you wish to measure the potential drop.

HP DMM wiring

To measure resistance:

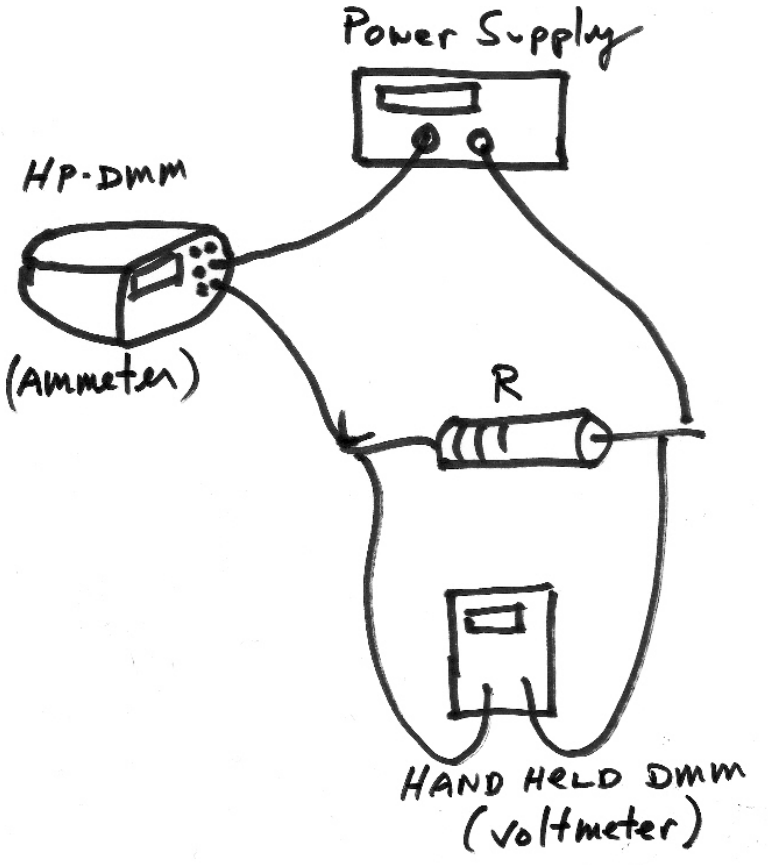


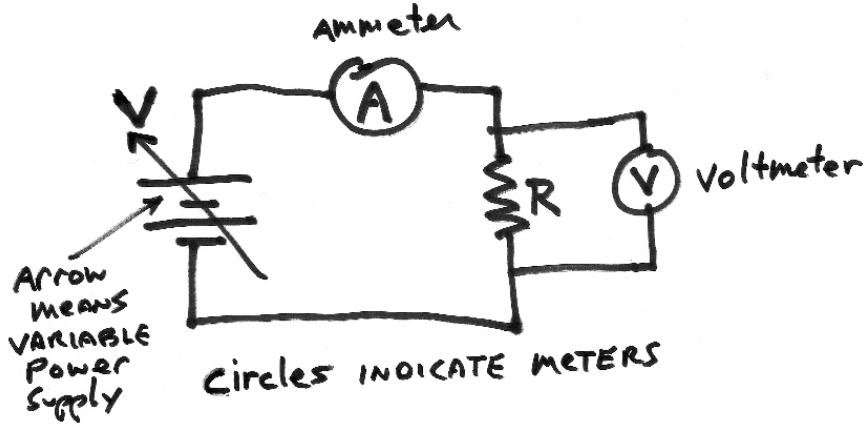
To measure current (ammeter):



Procedure

We will construct this circuit:





Notice the ammeter (HP DMM) is in series in the circuit and the voltmeter (Hand Held DMM) is in parallel across the resistor only.

Procedure

On your table that will look like: