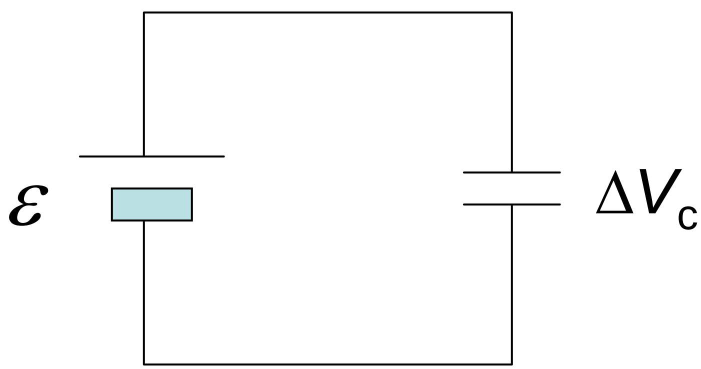
Lecture 12: Chapter 31 Beginning, October 13 2005

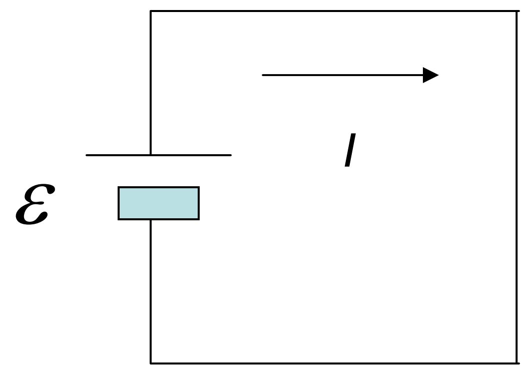
Outline
- Resistors and Ohm's Law
- Real Batteries
- Power
- Circuitry and Kirchhoff's Laws

For a capacitor we assumed $\Delta V_c = \varepsilon$ for $t \to \infty$. Why is that?



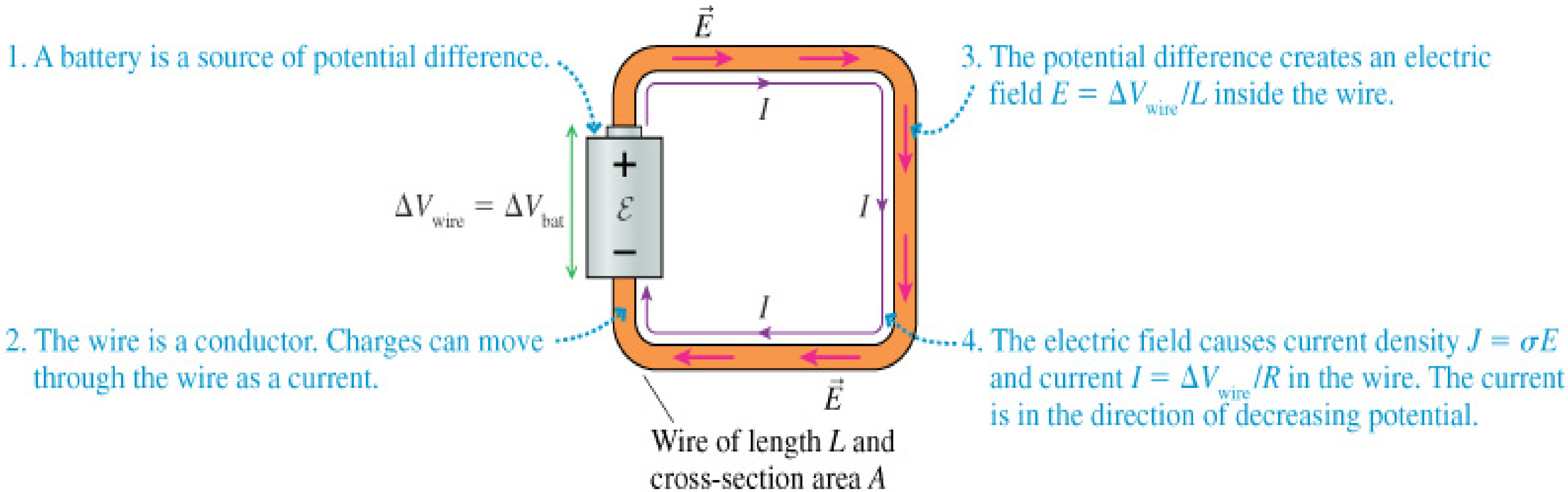
What is I? What is the potential drop on the wires?

Let us consider a short.



What is I? What is the potential drop on the wires?

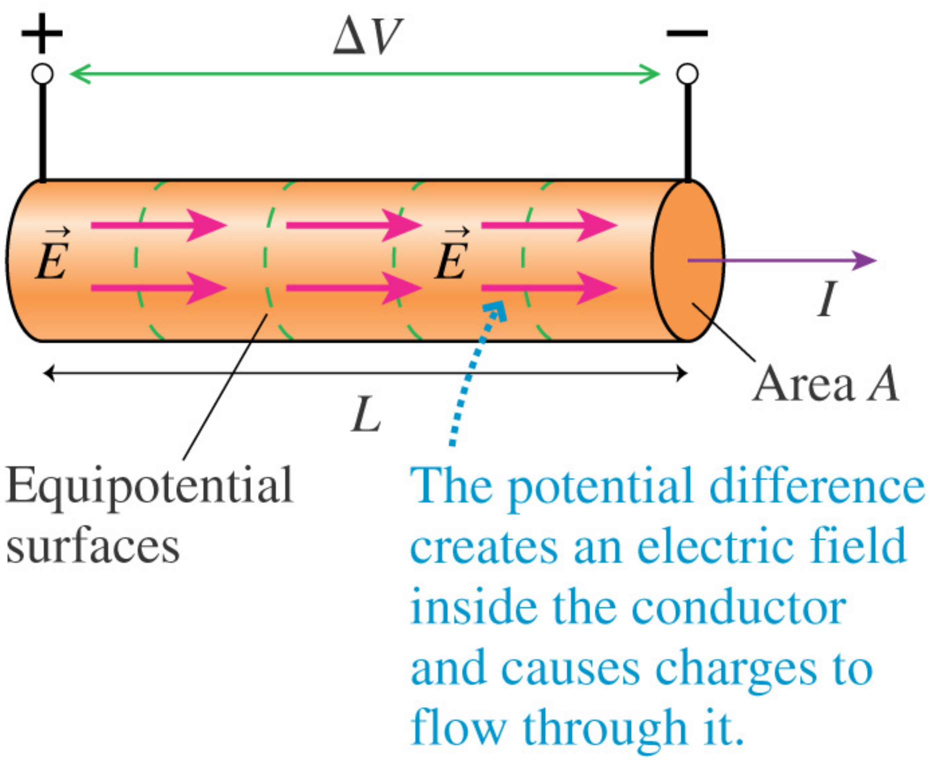
More detailed look…



- Don't try it at home. What will happen to the circuit and to the battery?
- Is current zero or nonzero?
- Is there potential change along the wires?

Resistors and Ohm's Law

Consider a part of this circuit:



$J = \sigma E = E/\rho$

$I = JA = EA/\rho = (\Delta V/L)A/\rho$

The quantity $R = \rho L/A$ – resistance of the conductor. The unit is the *ohm*, where 1ohm = 1V/A

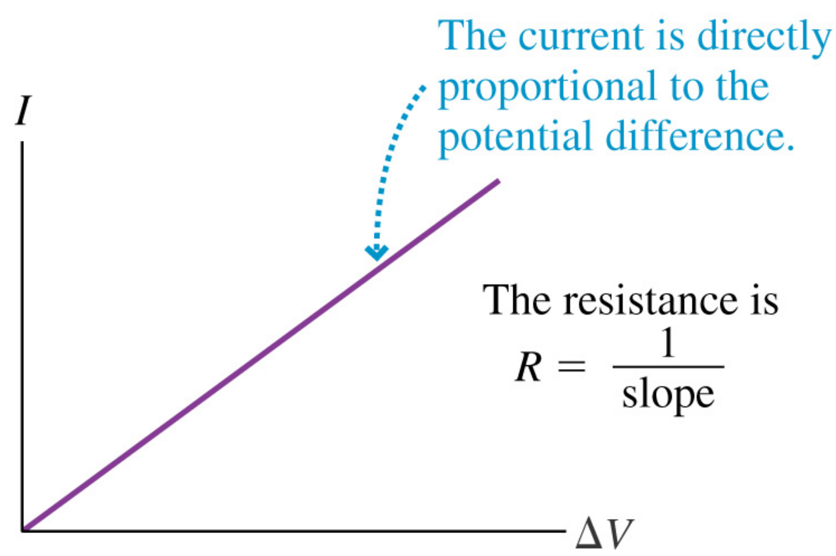
$I = \Delta V/R$ – this relationship between I and ΔV is known as Ohm's Law

Often used as $V = IR$

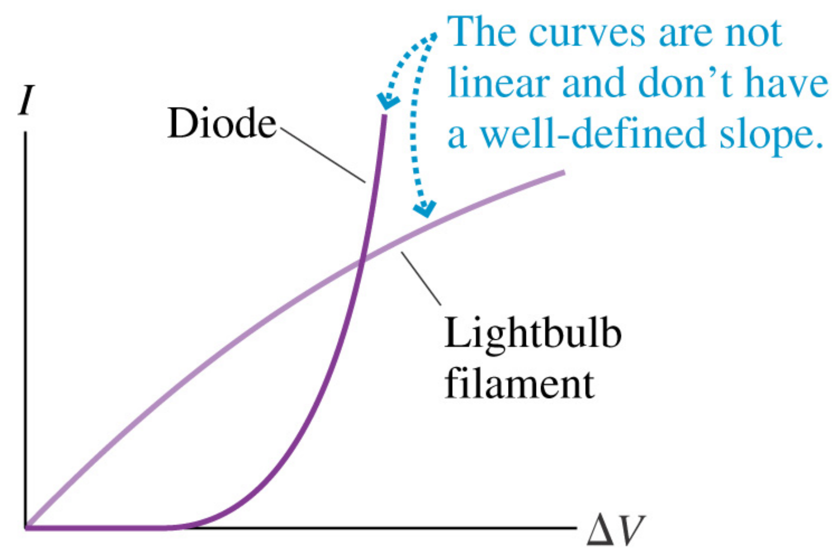
Ohmic and Nonohmic Materials

Despite its name Ohm's law is *not* a law of nature. It is limited to those materials whose resistance R remains constant during use.

(a) Ohmic material



(b) Nonohmic materials

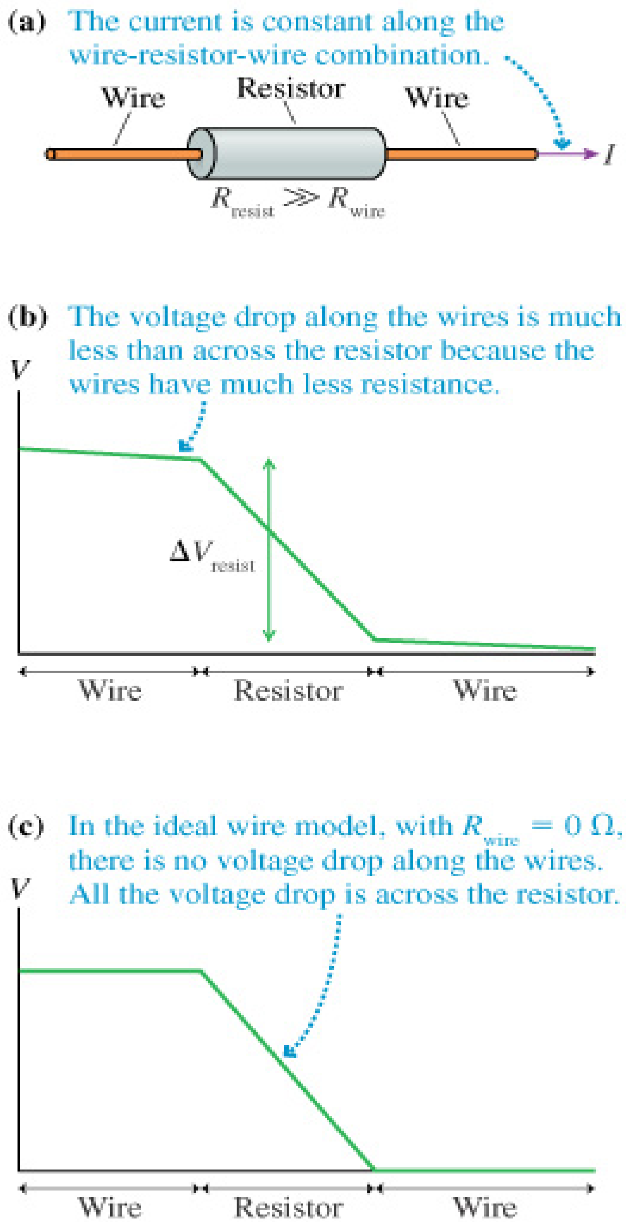


Ohm's Law typically applies to the resistors *only*.

Nonohmic devices:

- Batteries where ε = Const
- Semiconductors
- Capacitors where the I_{DC} = 0, but $I_{AC} \neq 0$.

Examples of Ohmic circuit materials

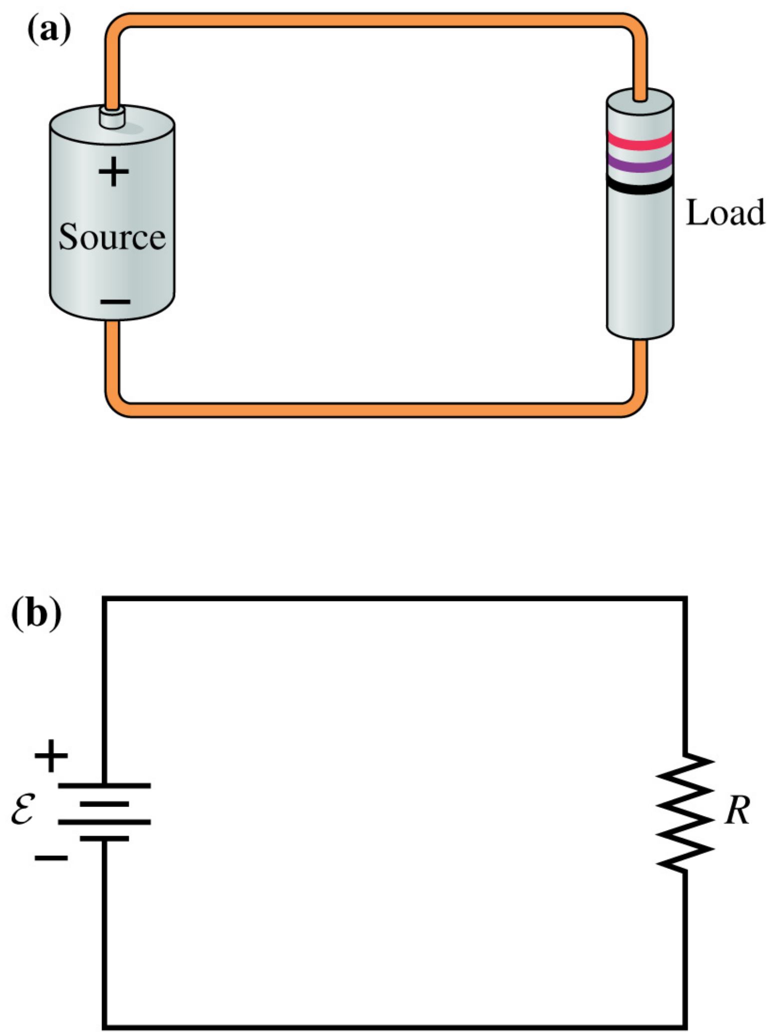


• ***Wires*** are metals with very small resistivities ρ and very small resistances R<<1Ω
An **ideal wire** has R = 0 Ω

• ***Resistors*** are poor conductors with resistances 10Ω < R < 10^6 Ω. They can be made from thin metal wire with high ρ.

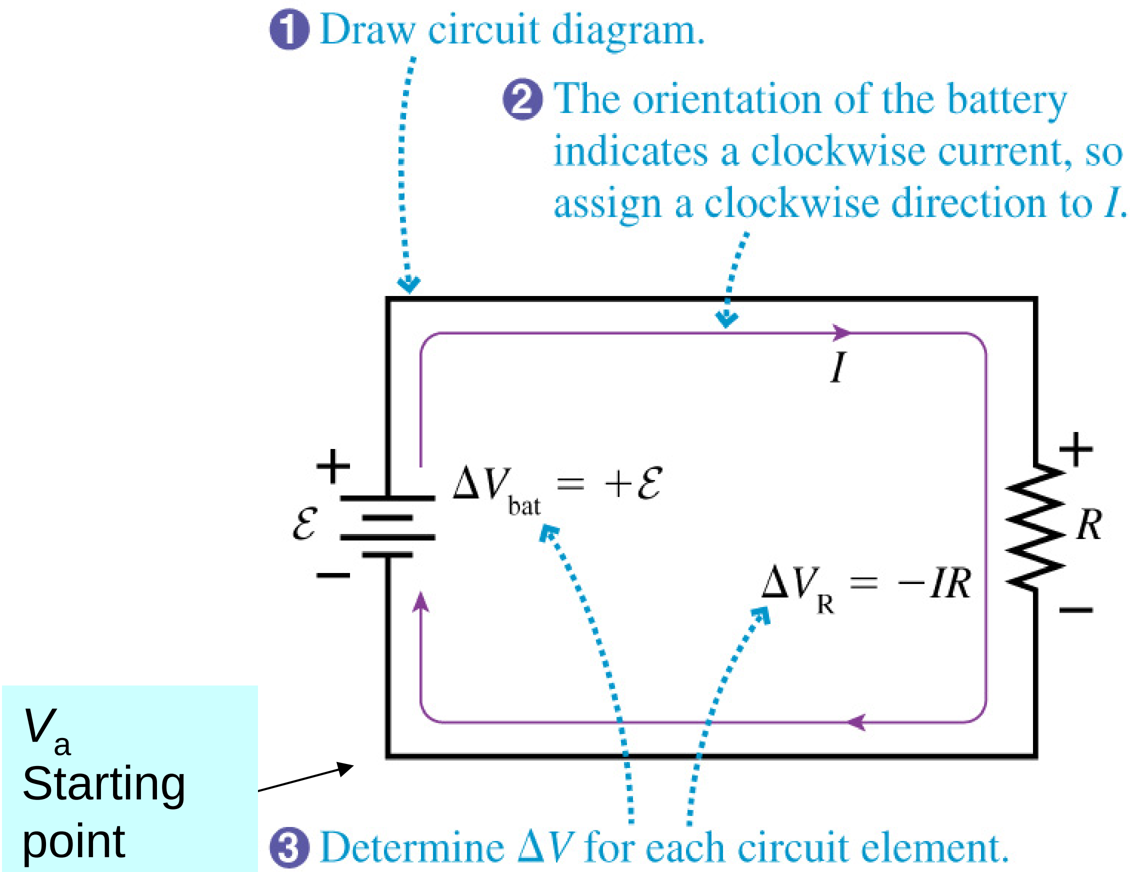
• ***Insulators*** are materials such as glass, plastic, or glass.
An **ideal insulator** has $R \to \infty$.

Control Question



Assuming Ohm's law ($\Delta V = IR$) where would you expect the potential to drop in a circuit: across the wires or across resistors?

How to find the current



Loop Rule:

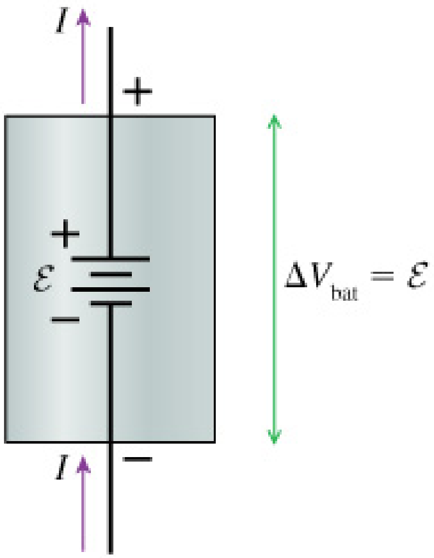
$$V_a + \mathcal{E} - IR = V_a$$

$$\mathcal{E} - IR = 0 \Rightarrow I = \mathcal{E}/R$$

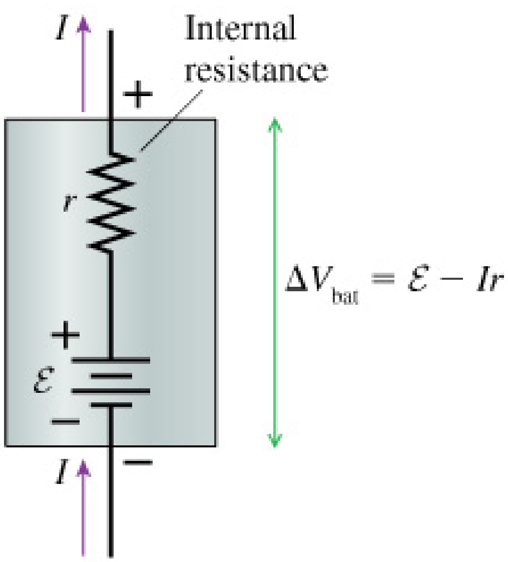
Resistance Rule: For a move through *R* in the direction of current, the change in potential is –*IR*, otherwise it is +*IR*

EMF Rule: For a move through an ideal battery in the direction of the EMF, the change in potential is +*E*, otherwise it is -*E*

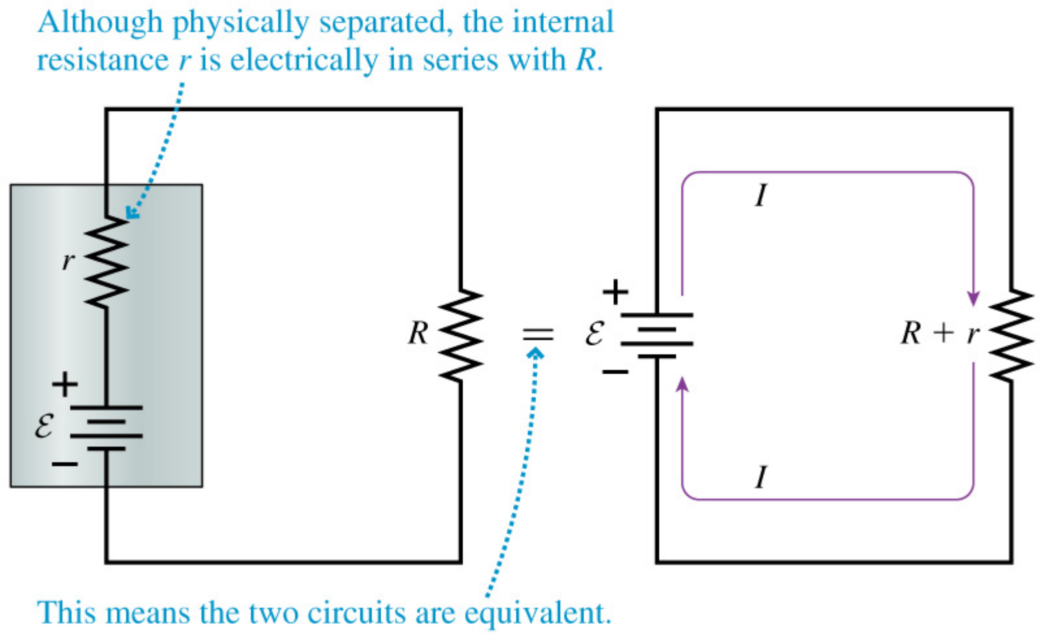
Real Batteries



Ideal battery



Real battery



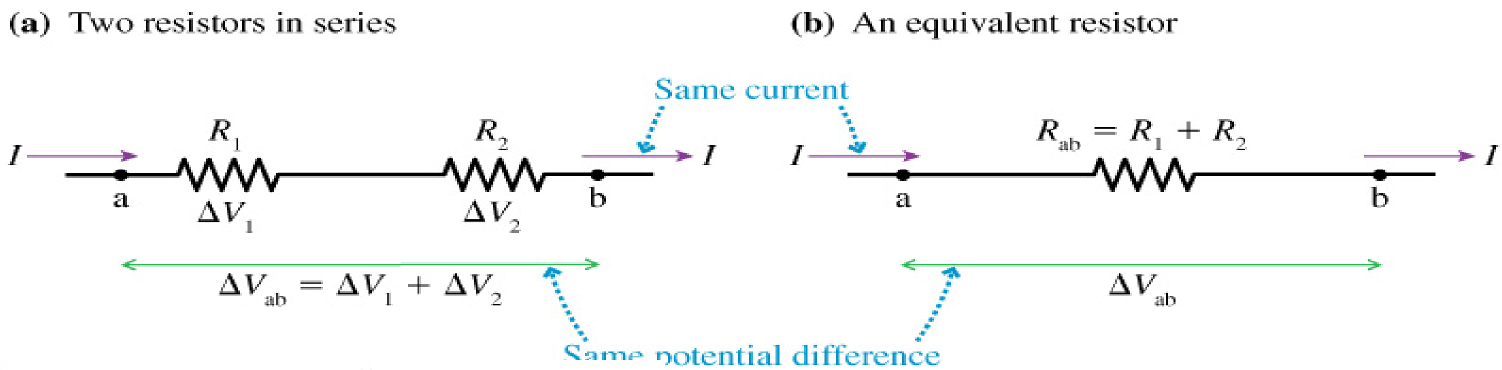
Show that:

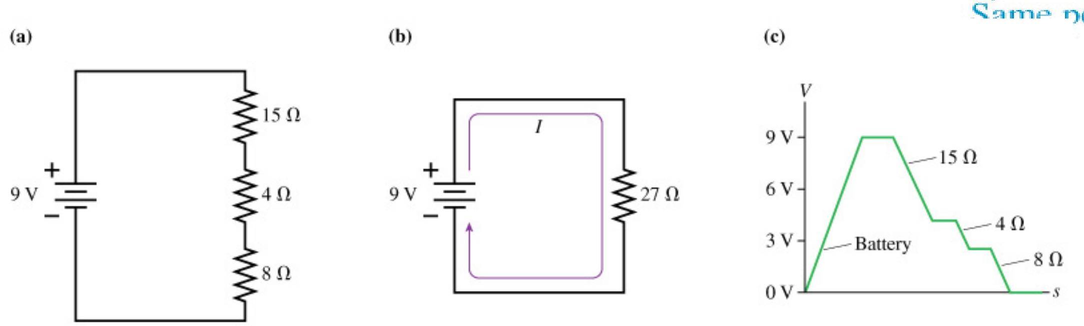
$I = \mathcal{E}/(R + r)$

Energy and Power – Reading Chapter 31

$P_R = I\Delta V_R = I^2R = (\Delta V_R)^2/R$ – Important expressions

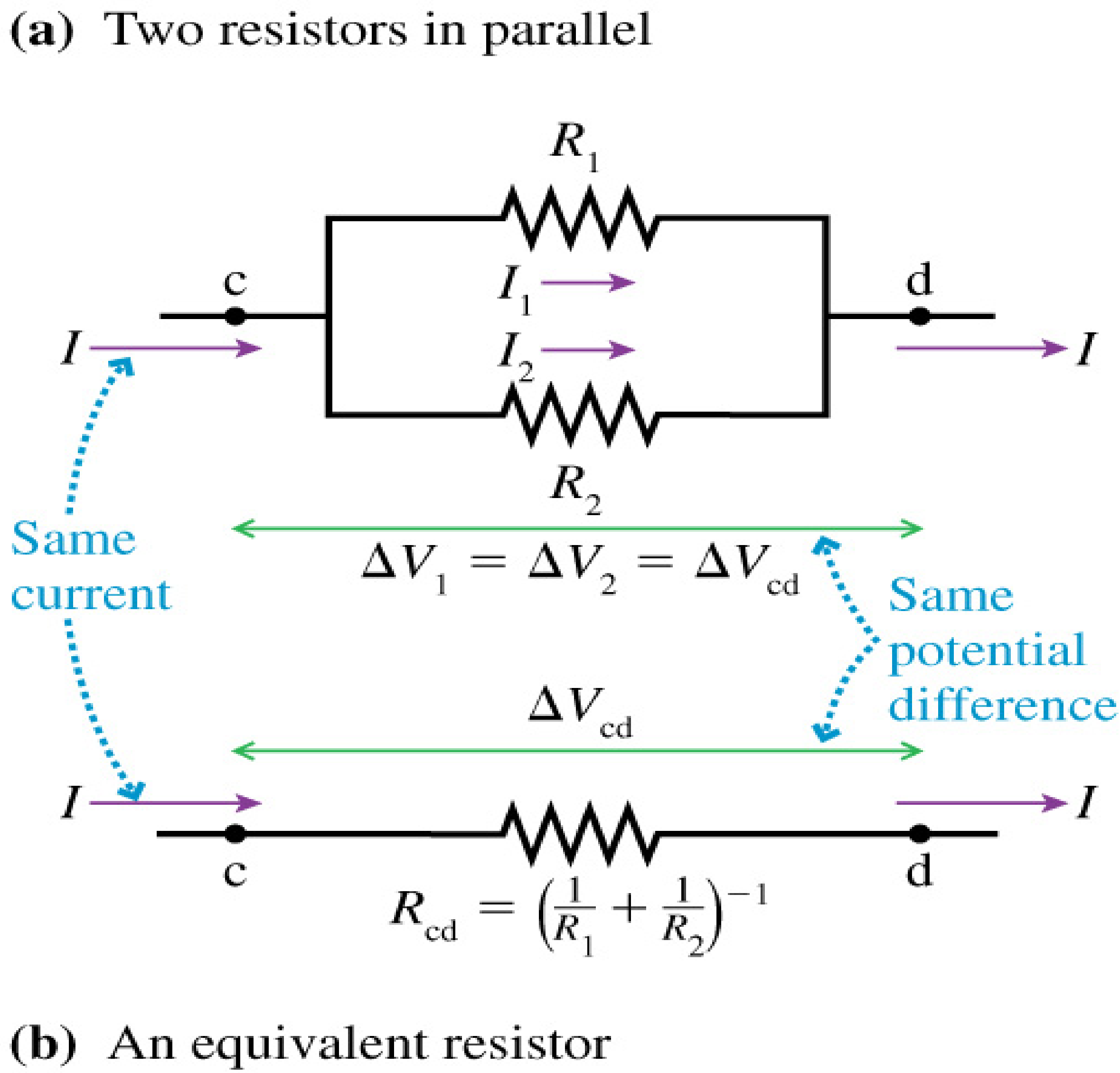
Series Resistors





$R_{eq} = R_1 + R_2 + \ldots + R_N$

Parallel Resistors – Reading Chapter 31



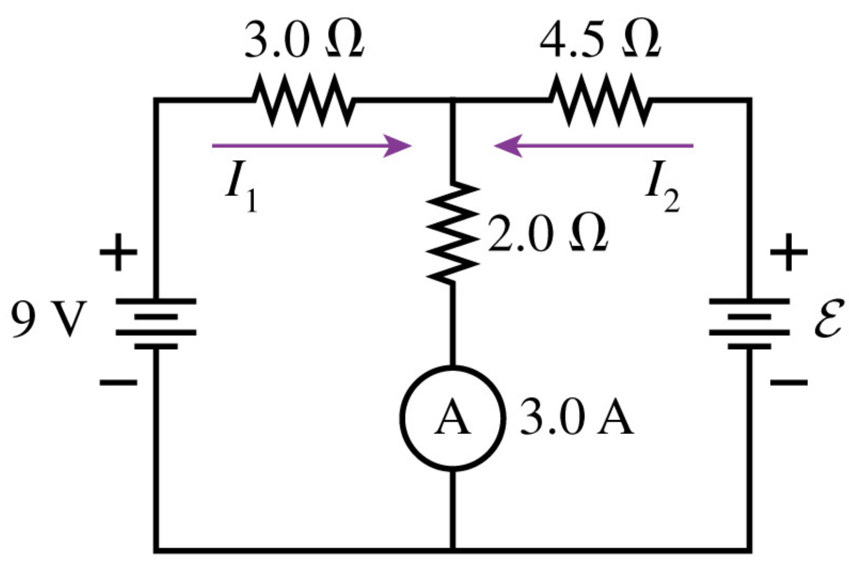
The rules of connecting resistors in series and in parallel are opposite to that for capacitors

Fundamentals of Circuits

Goals

• To be able to find currents and potential differences in most complicated circuits such as multiloop circuit exemplified below

• To be able to consider real (complited) circuits where battery is included in the circuit such as this one:



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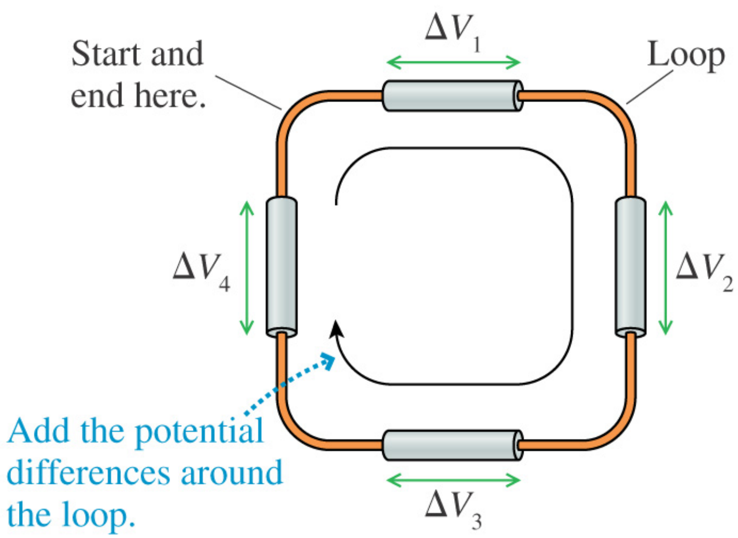
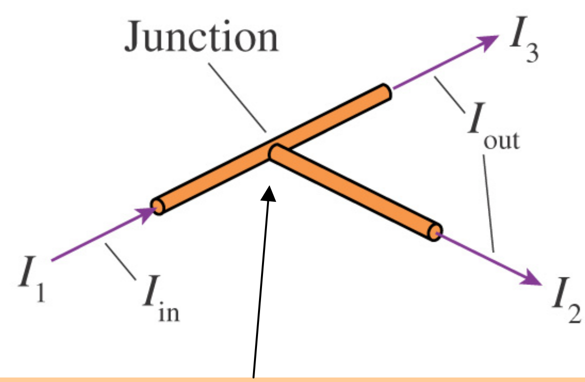
Rules of circuit's algebra

- Assume arbitrary directions for currents
- Assume arbitrary directions of making the loop
- Use the Kirchhoff's junction rule
- Use the Kirchhoff's loop rule:





Junction law: $I_1 = I_2 + I_3$

Loop law: $\Delta V_1 + \Delta V_2 + \Delta V_3 + \Delta V_4 = 0$

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End of Lecture 12
Reading: Chapter 31
Review for Quiz 6
HW 6 and HW7