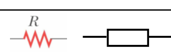
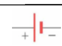
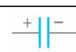
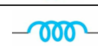
Physics 202, Lecture 9

This week's Topics

- Basic DC circuits: Chapter 28
  - Basic circuit components(Ɛ, R, C, …)
  - Single loop circuits
  - Resistors in series and in parallel
- Kirchhoff's Rules: multi-loop circuits
- RC Circuits
- Homework #4: problems from Ch. 26, 27, 28
  due Monday, Oct 8 at 10 PM
- Reading quiz: for Thursday (optional, for extra credit)

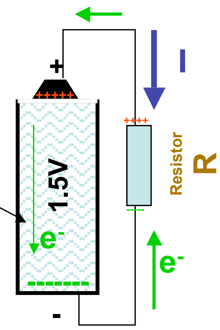
Basic Circuit Components

Component	Symbol	Behavior in circuit
Ideal battery, emf		$\Delta V = V_+ - V_- = \mathcal{E}$
Resistor		$\Delta V = -IR$
Realistic Battery		→ 
(Ideal) wire	—	$\Delta V=0$ (→$R=0, C=0$)
Capacitor		$\Delta V = V_- - V_+ = -q/C$, $dq/dt = I$
Inductor		Later this semester
(Ideal) Switch		$C=0$, $R=0$ (on), $R=\infty$ (off)
Transformer	Future Topics	
Diodes, Transistors,…		

emf: Electromotive “Force”

- Battery as a source of Electromotive “force” (emf)

Chemical inside the battery maintains a charge distribution which provides a persistent potential difference → emf



emf is a potential difference, it is not a force!

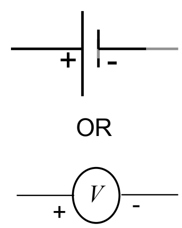
- emf can also be produced by changes of magnetic flux. (later in the course)

❖ Direct Current (DC) Circuit: Circuit driven by ε ~ constant

Devices: Summary

- Batteries:
  Voltage sources, sources of “emf” ε
  Purpose is to provide a constant <u>potential difference</u> between two points.

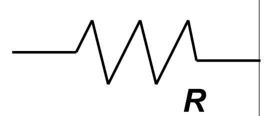
  Non-ideal batteries: "internal resistance" r



$$V = \varepsilon - Ir$$

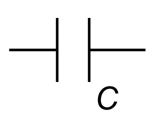
- Resistors: resist electric current

  Ohm’s Law: $V = IR$



- Capacitors: store charge (energy).

$$Q = CV$$



Example: Ch 28 #1

Simple Circuit 1: Resistors In Series

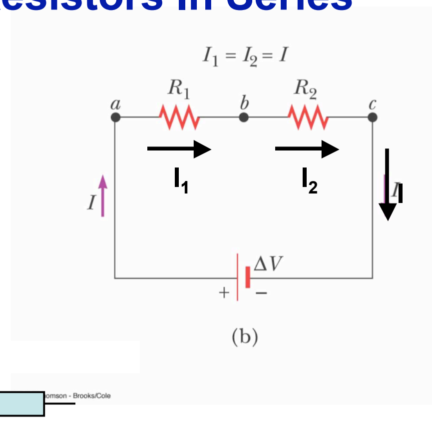
- Exercise: show

$$R_S = R_1 + R_2$$

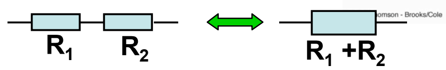
  - $I_1 = I_2 = I$

    $\rightarrow IR_1 + IR_2 = \Delta V \rightarrow$

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



i.e.



- In general: $R_S = R_1 + R_2 + R_3 + \ldots = \sum_i R_i$

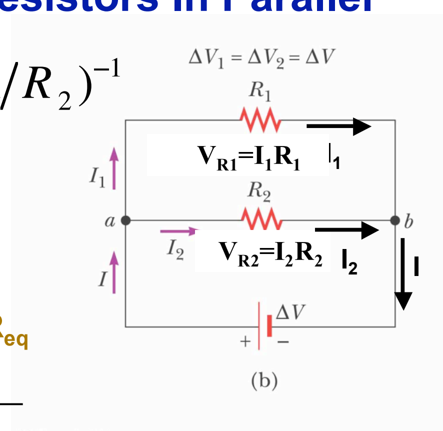
Simple Circuit 2: Resistors In Parallel

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

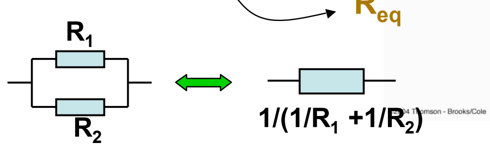
$I_1 + I_2 = I$

$\Delta V = I_1 R_1 = I_2 R_2$

$\rightarrow \Delta V = I \; 1/(1/R_1 + 1/R_2)$ → R_{eq}



i.e.



- In general: $R_P = (1/R_1 + 1/R_2 + 1/R_3 + \ldots)^{-1}$

Examples: Ch. 28 #9

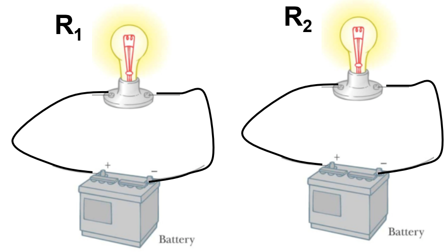
Wattage (Power) and Resistance

- $R_1 > R_2$, which is brighter?

R_1

R_2 ←

Same



Lower R → Higher wattage

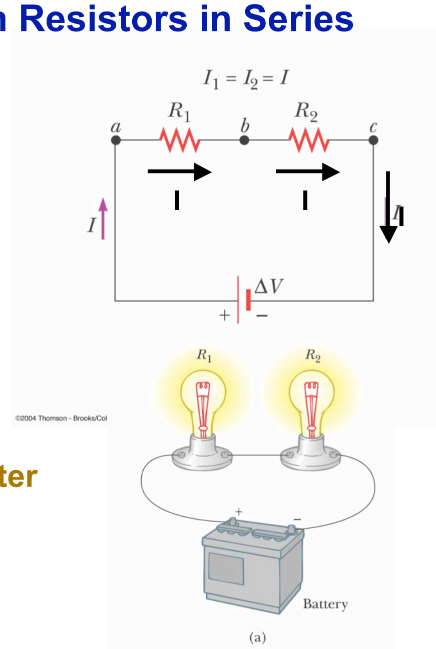
Power Distribution on Resistors in Series

- $R_1 > R_2$, which is brighter?

R_1 ←

R_2

Same



Bulb of lower wattage is brighter when connected in series

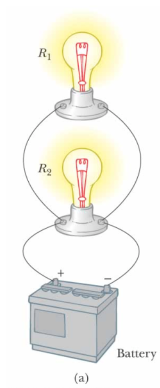
Power Distribution on Resistors in Parallel

- $R_1>R_2$, which is brighter?

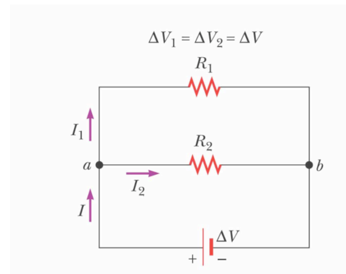
R_1

R_2 ←

Same



(a)



(b)

Exercise: Equivalent Resistance of a Combined Parallel and Serial Circuit

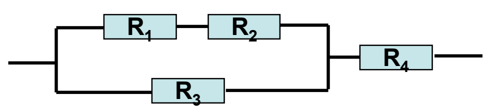
- What is R_{eq} for the combination shown?
  $R_1= R_2=1\Omega$, $R_3=2\Omega$, $R_4=4\Omega$.

8Ω

6Ω

→ 5Ω

None of above

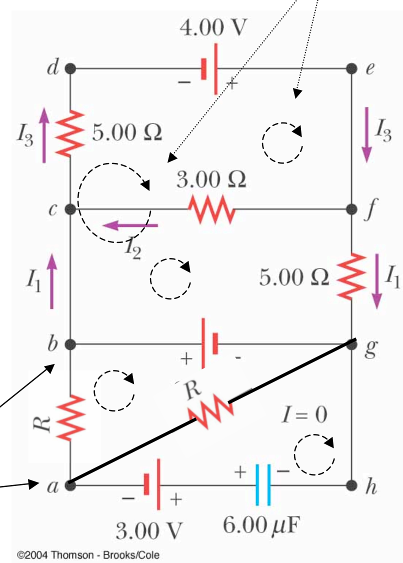


A Complicated Circuit

loops

A complicated circuit :

- May contain more than one emf
- May not be simplified as "in series" or "in parallel"
- May contain multi loops and junctions.



junctions

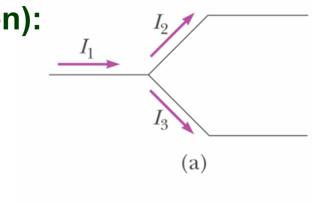
Kirchhoff's Rules: Junction Rule

$I_1=I_2+I_3$

- **Junction Rule (Charge conservation):**

Sum of currents entering any junction equals the sum of currents leaving that junction.

$\Sigma I_{in} = \Sigma I_{out}$



- In practice, the classifications of "in" and "out" determined by assigned direction for each current.

  The assignment of current directions can be arbitrary. (they may not be the same as actual directions)

  - "in" : current with assigned direction towards junction
  - "out" : current with assigned direction off junction

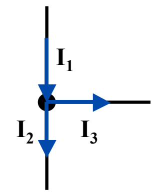
(Very) Quick Quiz: Junction Rule

- What is the junction rule for the current assignment shown?

$I_1+I_2=I_3$

$I_1=I_2+I_3$ ←

$I_1+I_3=I_2$



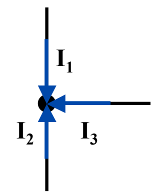
Quick Quiz: Junction Rule

- What is the junction rule for the current assignment shown?

$I_1+I_2=I_3$

$I_1+I_2+I_3=0$ ←

Neither

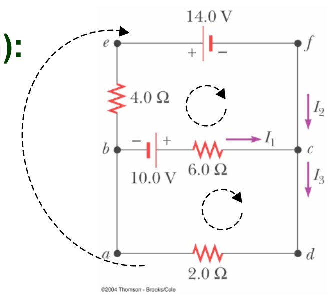


While the actual currents can not all goes into a junction, the assigned currents can.

Kirchhoff's Rules: Loop Rule

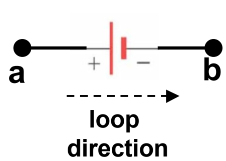
- ❑ **Loop Rule (Energy Conservation):** **The sum of potential drops across components along any closed circuit loop must be zero.**

  $\Sigma \Delta V = 0$

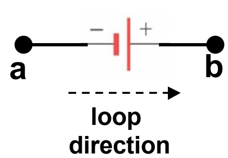


- ➢ **The exact form of the potential drop is determined by the type of component and the assigned current direction. (See next slides)**

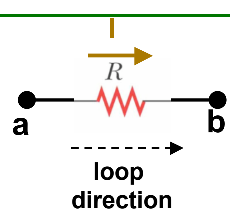
Determine Potential Difference(1)



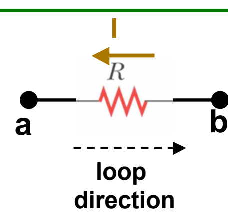
$\Delta V = V_b - V_a = -\varepsilon$



$\Delta V = V_b - V_a = +\varepsilon$



$\Delta V = V_b - V_a = -IR$



$\Delta V = V_b - V_a = +IR$