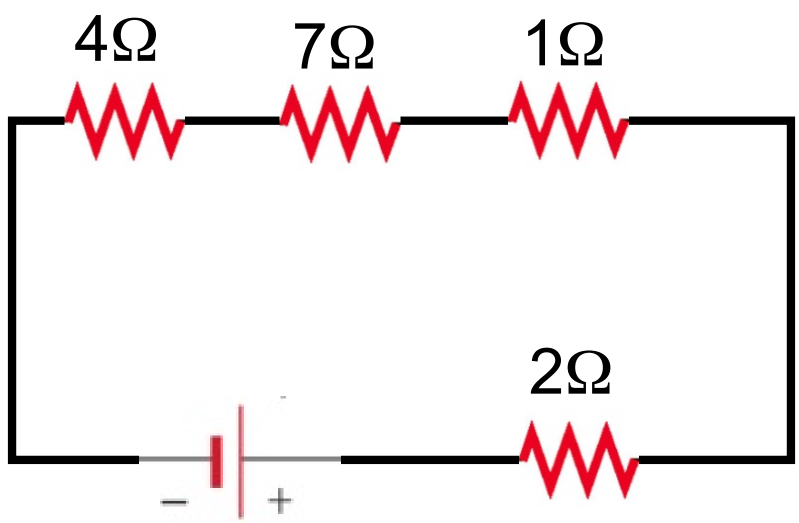
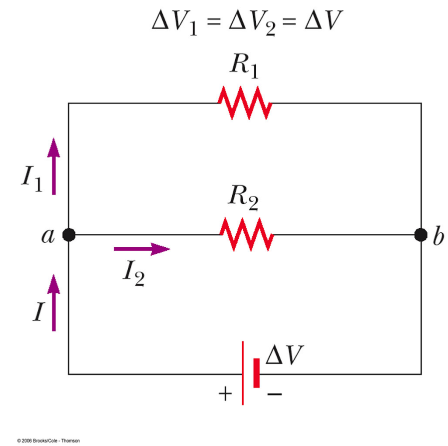
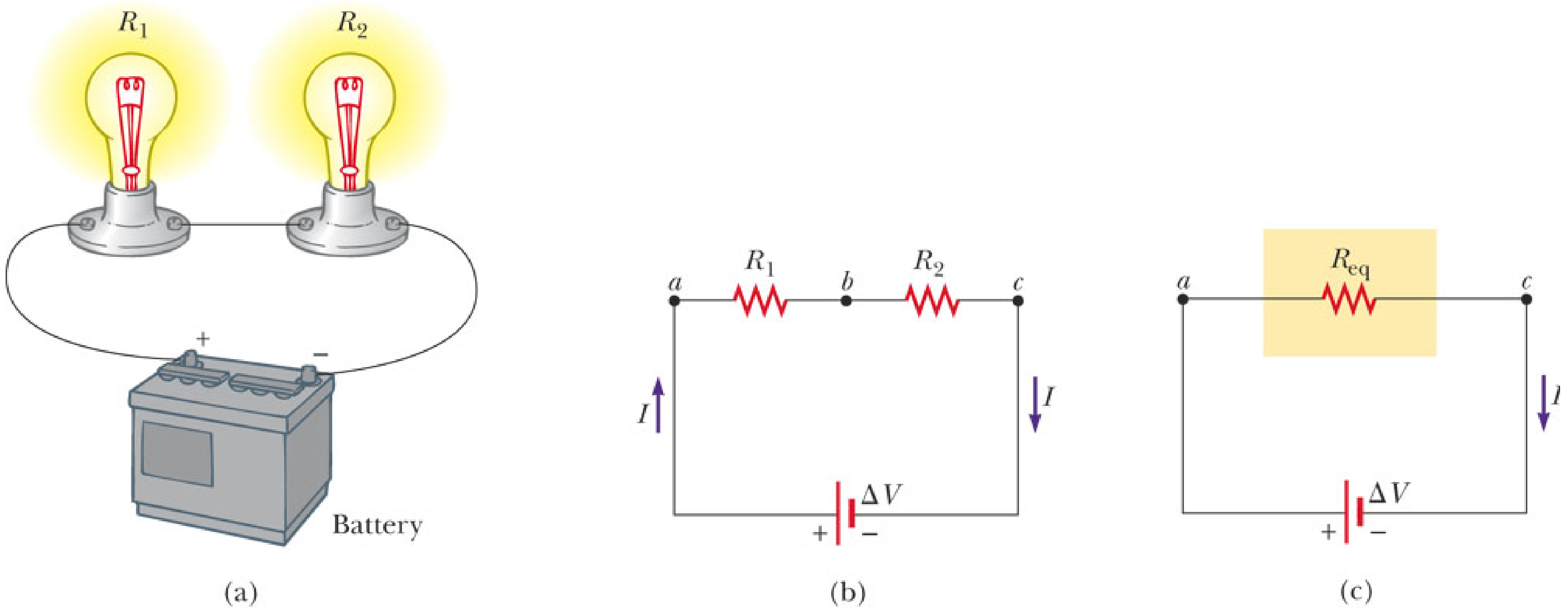
21.7: Combinations of resistors: in series or in parallel





Resistors connected in series



What's R_{eq} in terms of R_1 and R_2?

$$\Delta V = IR_{eq}$$

Resistors connected in series

Note: Current is the same in R_1 and R_2.

$\Delta V_1 = IR_1$

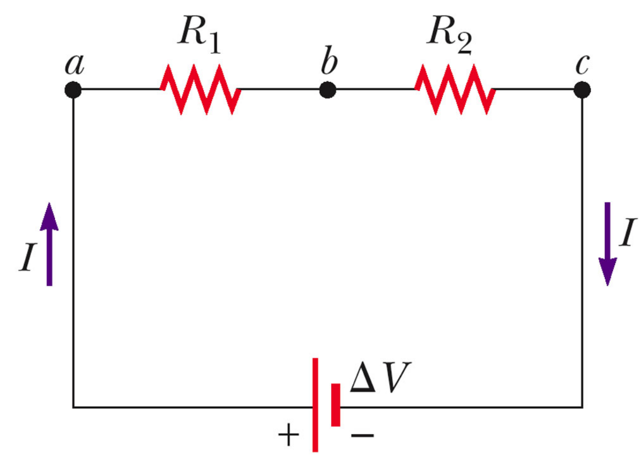
$\Delta V_2 = IR_2$

$\Delta V = \Delta V_1 + \Delta V_2$

$\Delta V = IR_1 + IR_2 = I(R_1+R_2)$

$\Delta V = IR_{eq}$

$R_{eq} = R_1 + R_2$

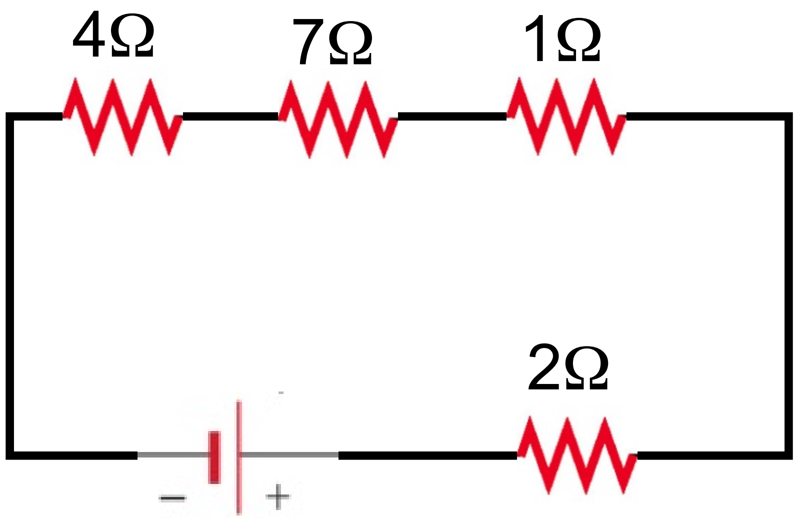


For N resistors in series:

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

Note that R_{eq} is larger than any one individual R value

Resistors connected in series



Find R_{eq}:

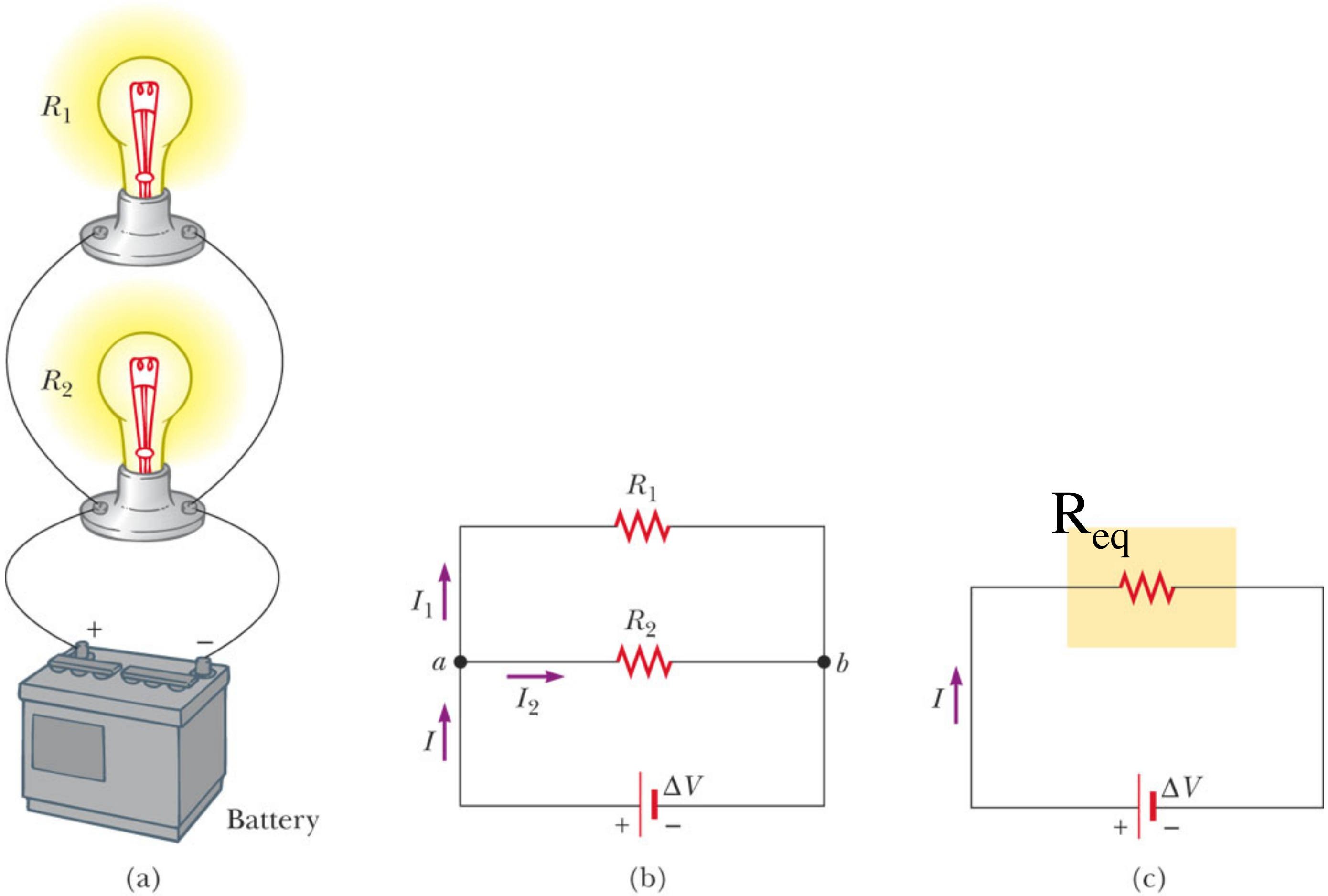
$R_{eq} = 4\Omega + 7\Omega + 1\Omega + 2\Omega = 14\Omega$

Understanding the Series Law

$$R = \rho \frac{L}{A}$$ means R is prop.to L

Total R is prop. to $(L_1 + L_2)$

Resistors in Parallel



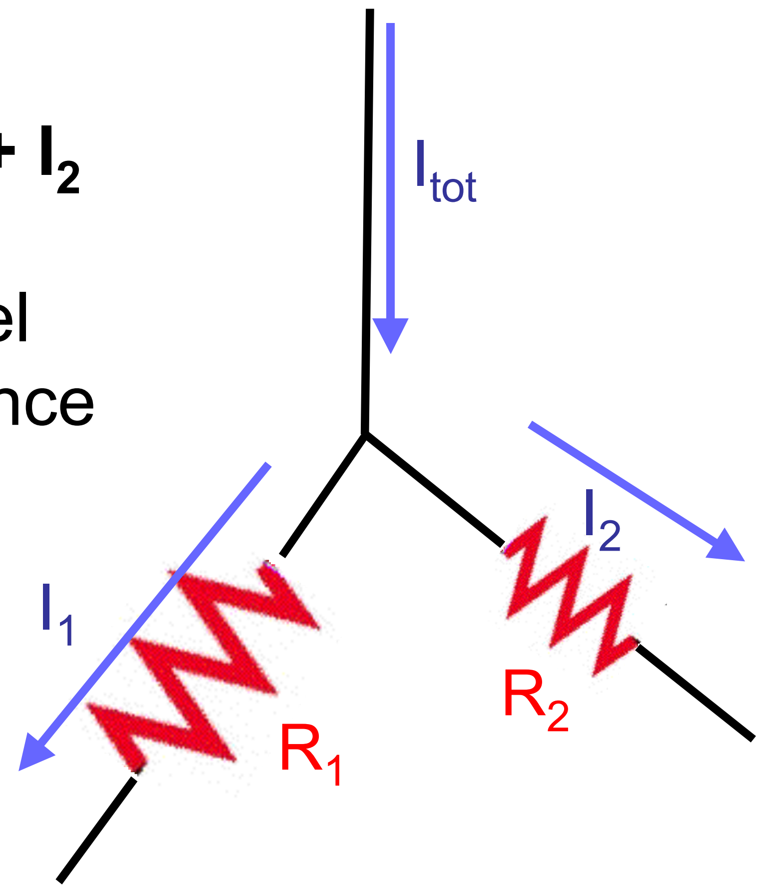
What happens at a junction?

Initial current I_{tot} splits up:
I_1 through R_1 and I_2 through R_2

Charge is conserved: $I_{tot} = I_1 + I_2$

More charge will be able to travel through the path of least resistance

If $R_1 > R_2$, then $I_2 > I_1$



Resistors in Parallel

Note: ΔV across each resistor is the same

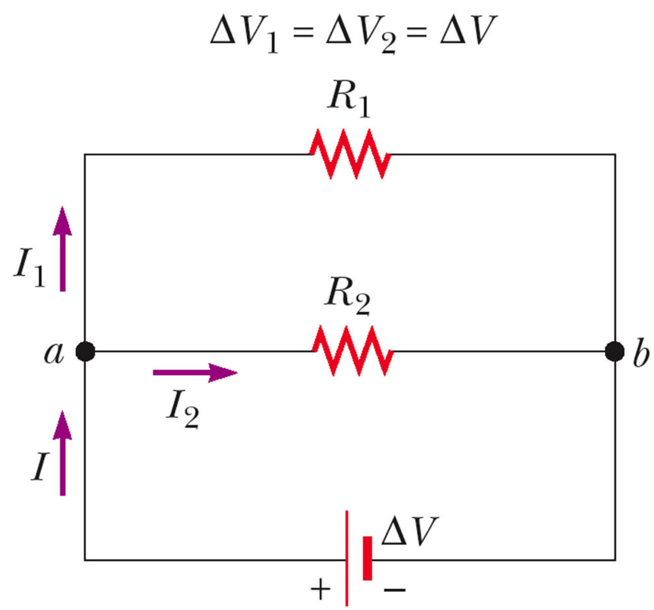
$I = I_1 + I_2 = \Delta V / R_1 + \Delta V / R_2 = \Delta V(1/R_1 + 1/R_2)$

$\Delta V = I / (1/R_1 + 1/R_2)$

$\Delta V = I R_{eq}$

$R_{eq} = 1 / (1/R_1 + 1/R_2)$

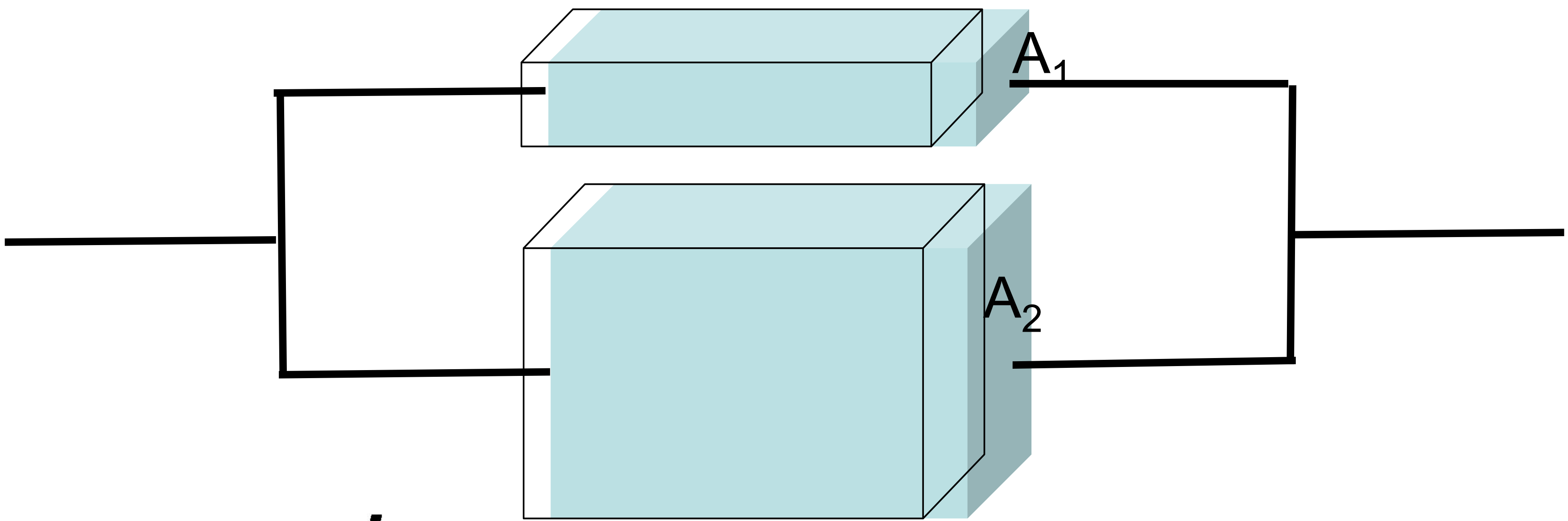
$1/R_{eq} = (1/R_1 + 1/R_2)$



For N resistors in parallel:

$1/R_{eq} = 1/R_1 + 1/R_2 + \ldots + 1/R_N$

Understanding the parallel law



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

R is prop.to 1/A

$A_{tot} = A_1 + A_2$

A_{tot} prop.to $1/R_1 + 1/R_2$

R_{tot} prop.to $1/A_{tot}$

$1/R_{tot}$ prop.to $1/R_1 + 1/R_2$

Example:

Find the current in each resistor.

$I_1 = \Delta V/R_1$ = 18V/3Ω = 6A

$I_2 = \Delta V/R_2$ = 18V/6Ω = 3A

$I_3 = \Delta V/R_3$ = 18V/9Ω = 2A

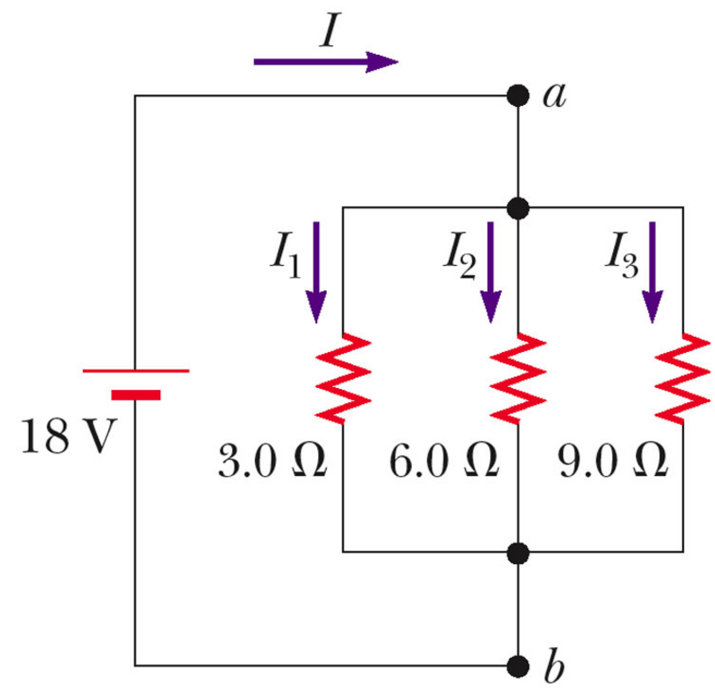
(Total I = 11A)

Find the power dissipated in each resistor:

$P_1 = I_1\Delta V$ = 6A ×18V = 108 W

$P_2 = I_2\Delta V$ = 3A ×18V = 54 W

Py = $I_3\Delta V$ = 2A ×18V = 36 W



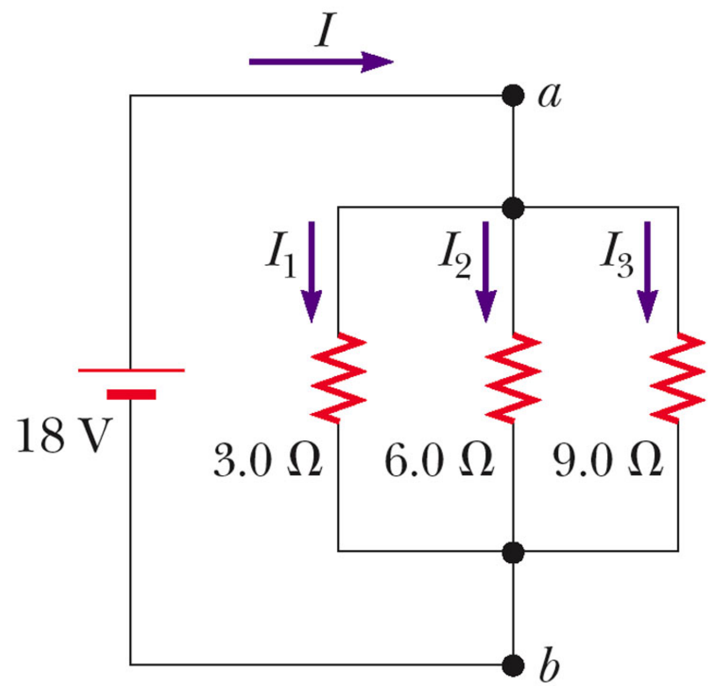
Total P = 198 W

Example:

Find R_{eq}:

$1/R_{eq} = 1/R_1 + 1/R_2 + 1/R_3 =$
$1/(3\Omega) + 1/(6\Omega) + 1/(9\Omega) =$
$11/(18\Omega)$

$R_{eq} = (18/11)\Omega = 1.64\ \Omega$



Find the power dissipated in the equivalent resistor:

$P = (\Delta V)^2/R_{eq} = (18V)^2/1.64\Omega =$
198 W

Also, $P = I\Delta V = 11A \times 18V =$
198W

Comparing resistors and capacitors

Resistors in series are like capacitors in parallel. Resistors in parallel are like capacitors in series.

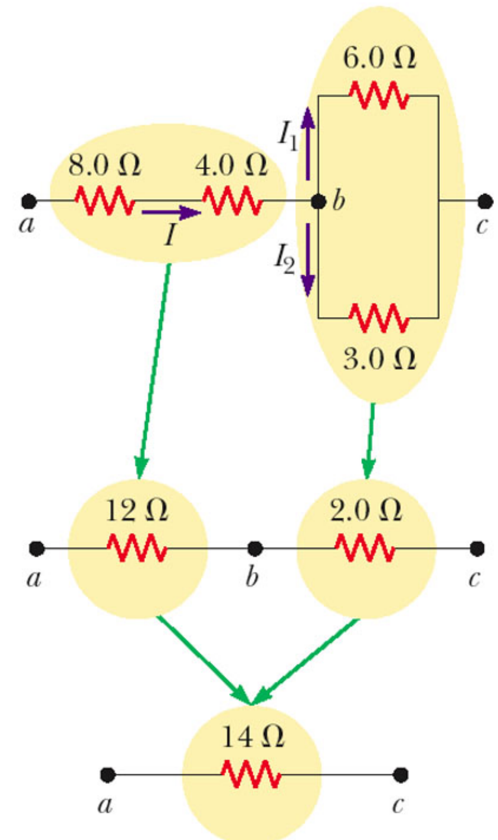
$R \propto L$ and $C \propto 1/L$

$R \propto 1/A$ and $C \propto A$

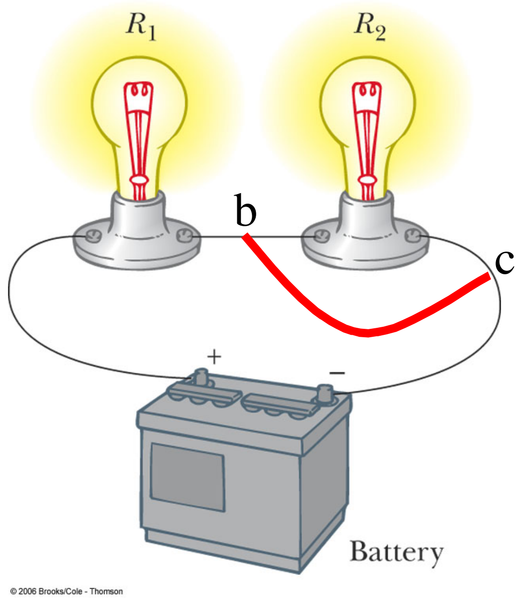
What happens when you have resistors in series AND in parallel?

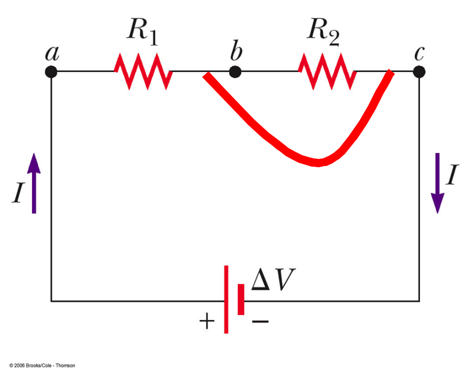
Find R_{eq} through multiple steps:

1. Connect in series
2. Then connect in parallel
3. Repeat #1-2 as needed



The next 3 slides cover quick quizzes 21.5-21.7; I did not have time to review them in lecture Tuesday





Quick Quiz 21.5

Use a piece of conducting wire to connect points b & c, bypassing R_2.

What happens to the brightness of Bulb 2?

It goes out.

What happens to the brightness of Bulb 1?

$\Delta V = I_{orig}(R_1+R_2)$

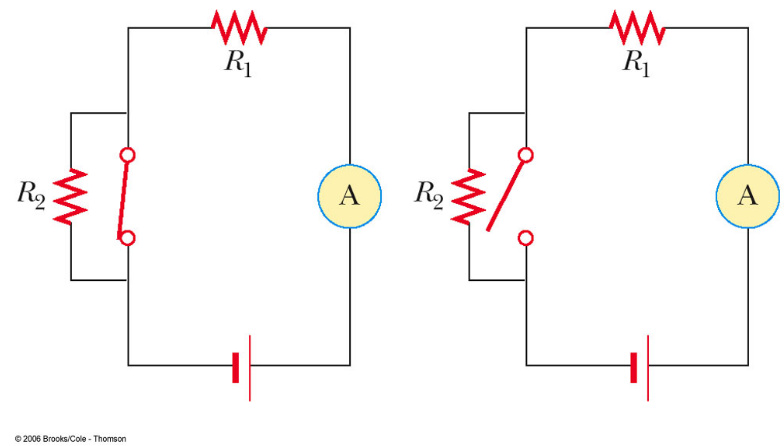
$\Delta V = I_{new}(R_1)$

$I_{new} > I_{orig}$

Brightness of Bulb 1 increases due to increased power due to increased current.

Quick Quiz 21.6:

Current I_{orig} is measured in the ammeter with the switch closed. When the switch is opened, what happens to the reading on the ammeter?



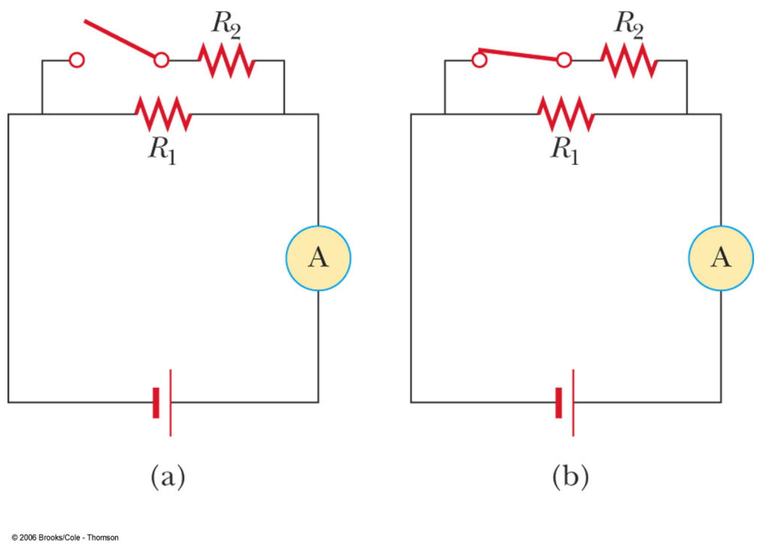
Initially, all current flows through switch, bypassing R_2.
$\Delta V = I_{orig} R_1$

When switch is opened, all current is forced through R_2; we have a circuit with two resistors in series.

$\Delta V = I_{new}(R_1+R_2) = I_{new}(R_{eq})$

$R_{eq} > R_1$ and ΔV remains fixed, so $I_{new} < I_{orig}$. (current decreases)

Quick Quiz 21.7



Initially: switch closed, no current through R2. Current in R1, measured with ammeter. When the switch is opened, current begins to flow through R2. What happens to the reading on the ammeter?

Initially, $\Delta V = I_{init}R_1$

Then, $\Delta V = I_{final}R_{eq}$

For R's in parallel, R_{eq} is < individual R's.

So $I_{final} > I_{init}$