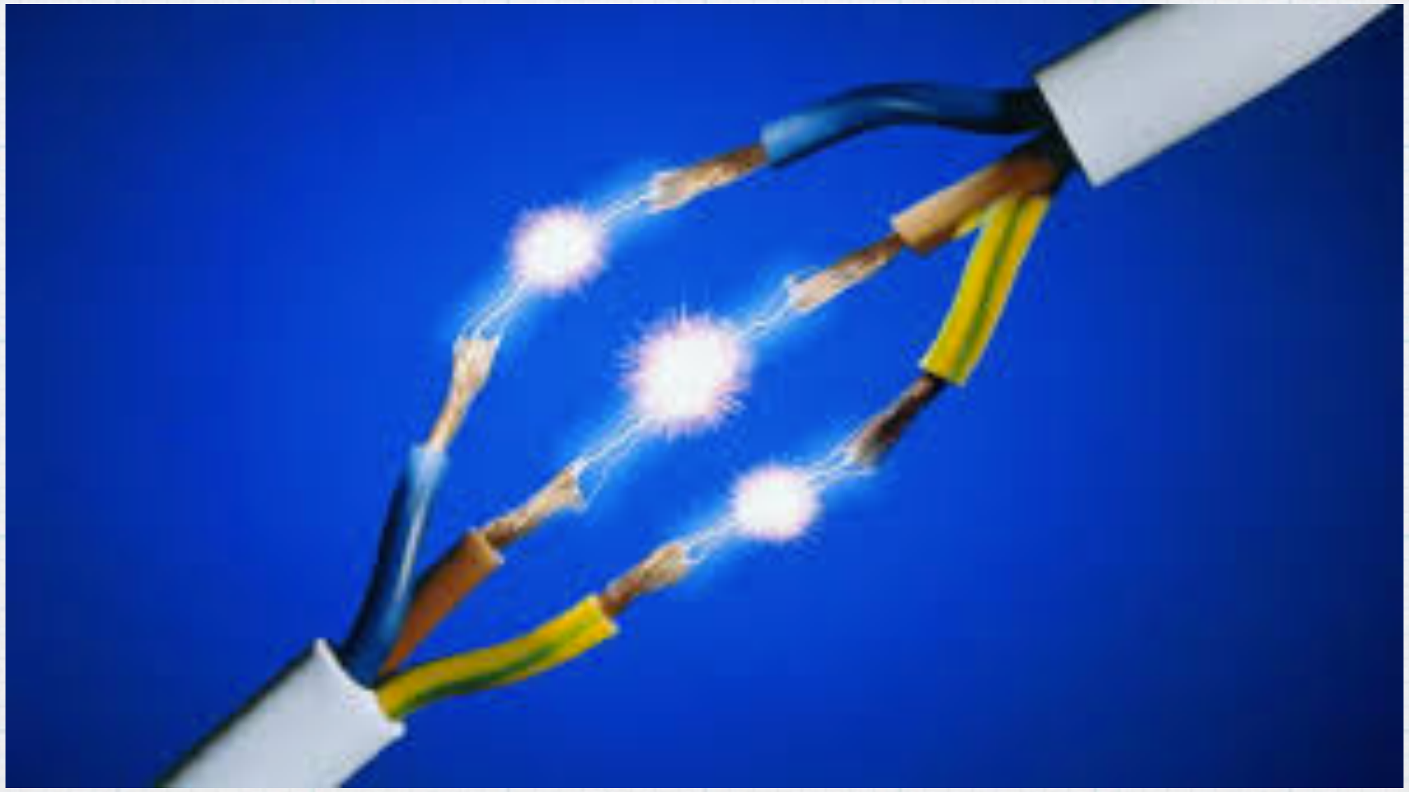
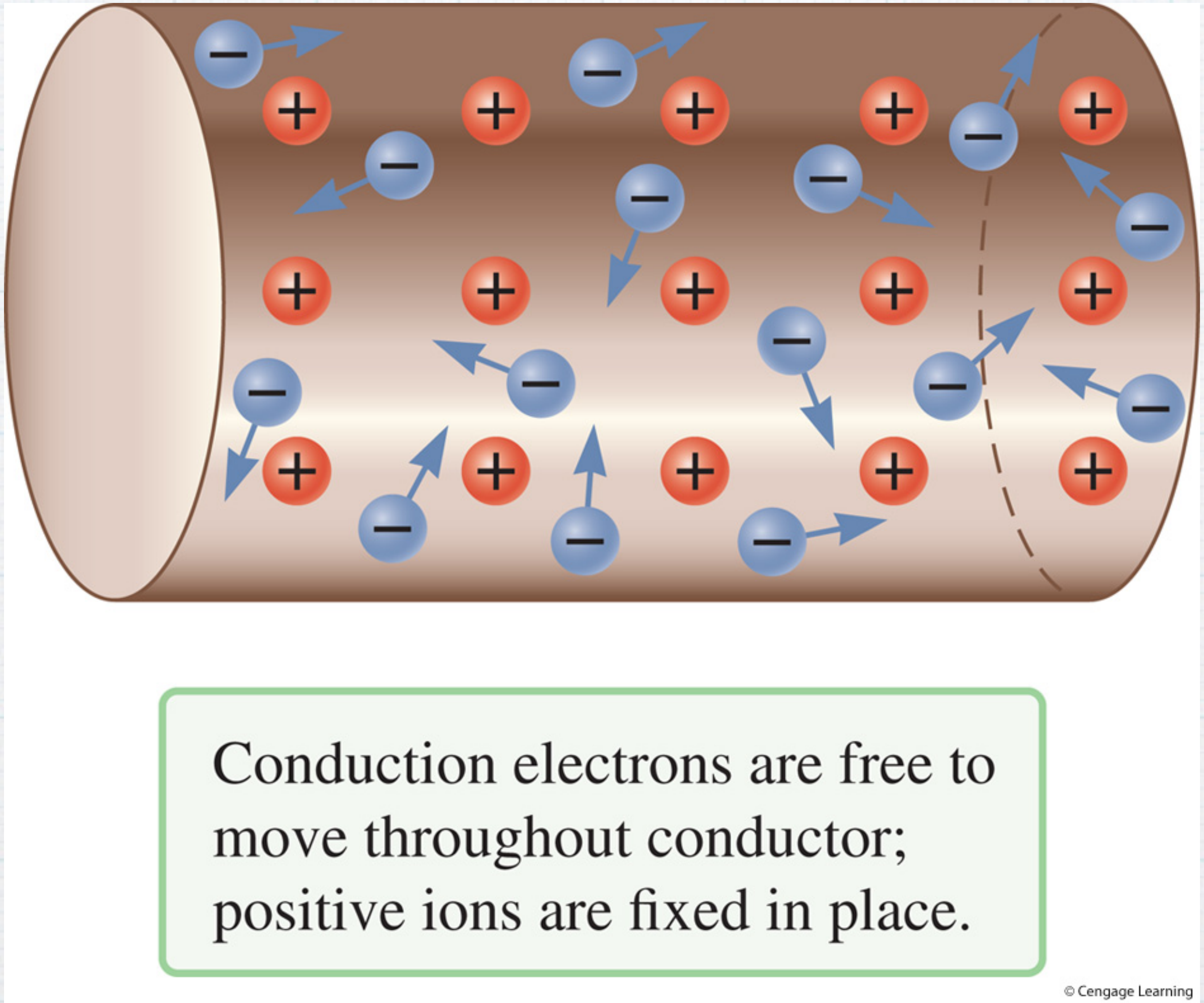
Current and Resistance




Conduction electrons are free to move throughout conductor; positive ions are fixed in place.
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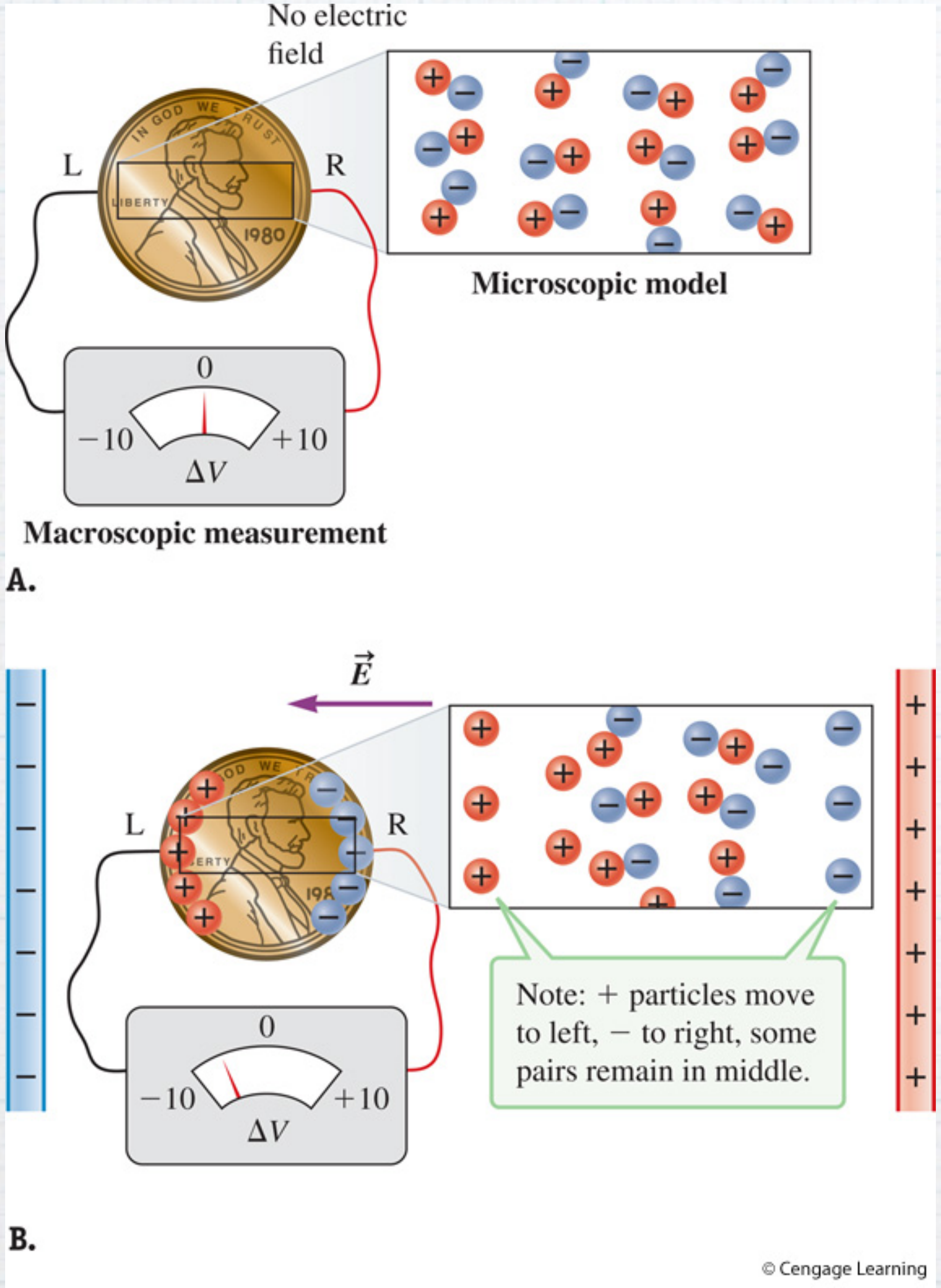
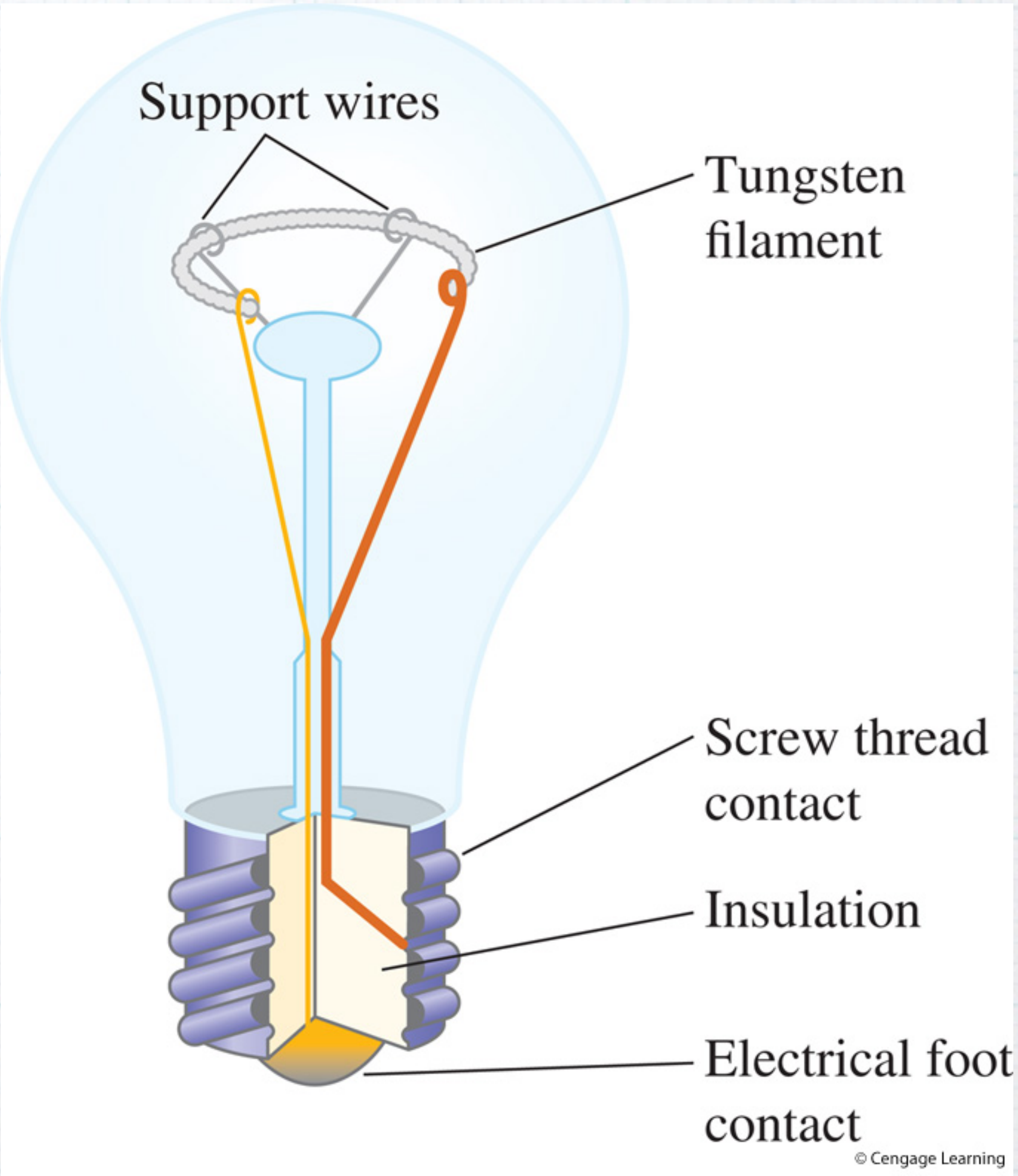
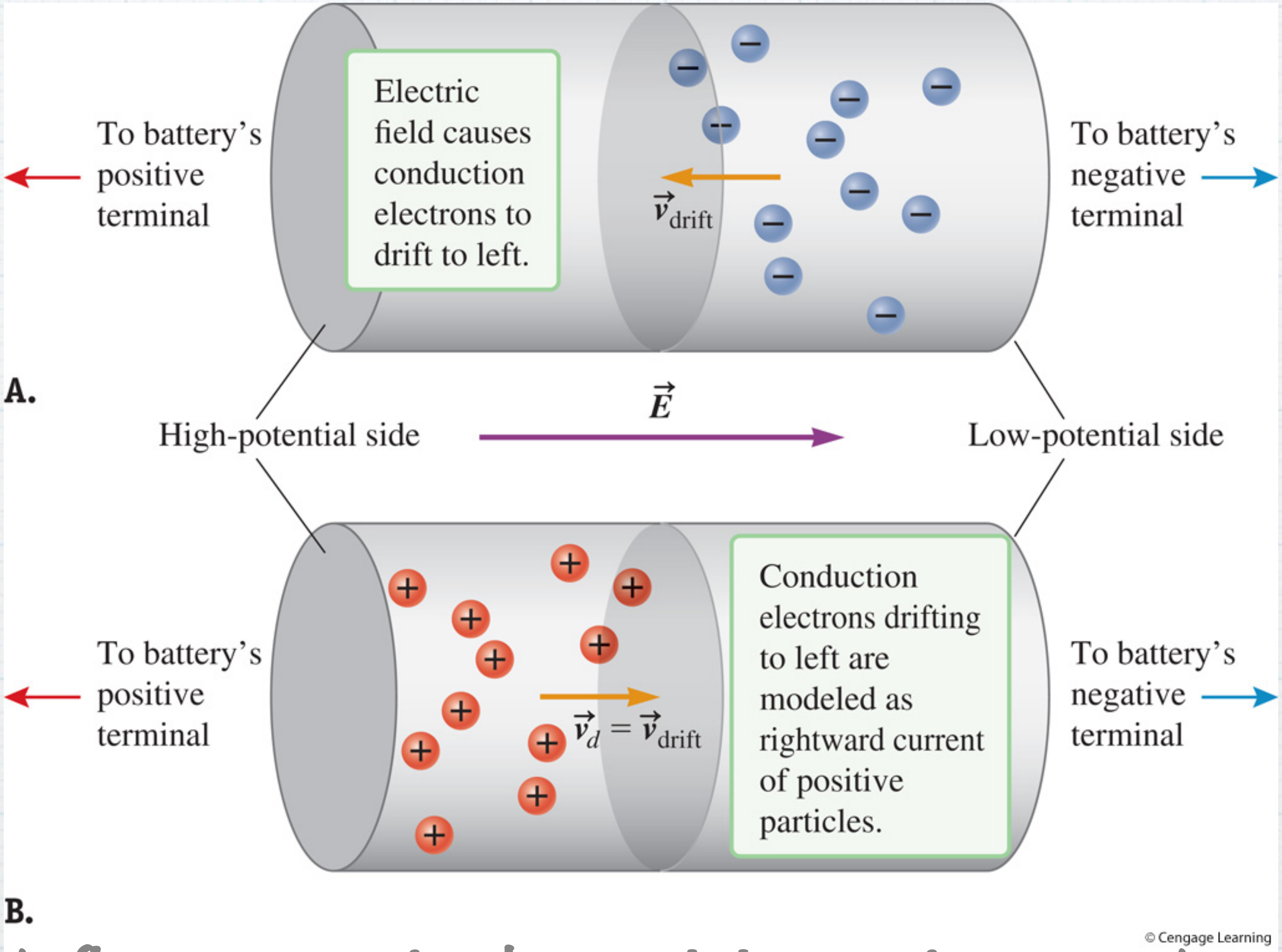




$$\vec{F}_e = q\vec{E} \quad \vec{E} = -E_x\hat{i}$$

Let's do it for the protons and the electrons

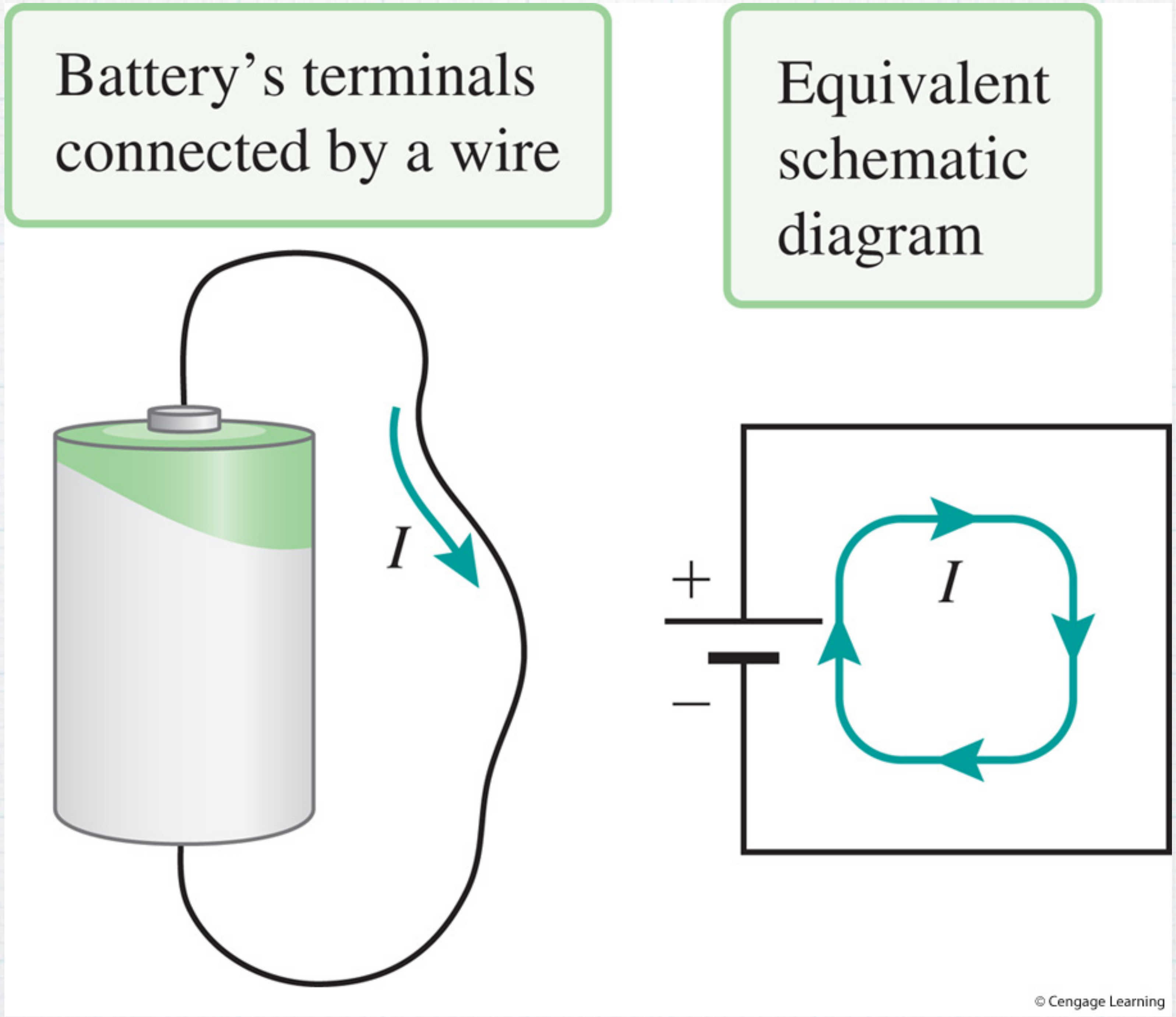


Electron's flow towards the positive end, proton's to the negative end

Current

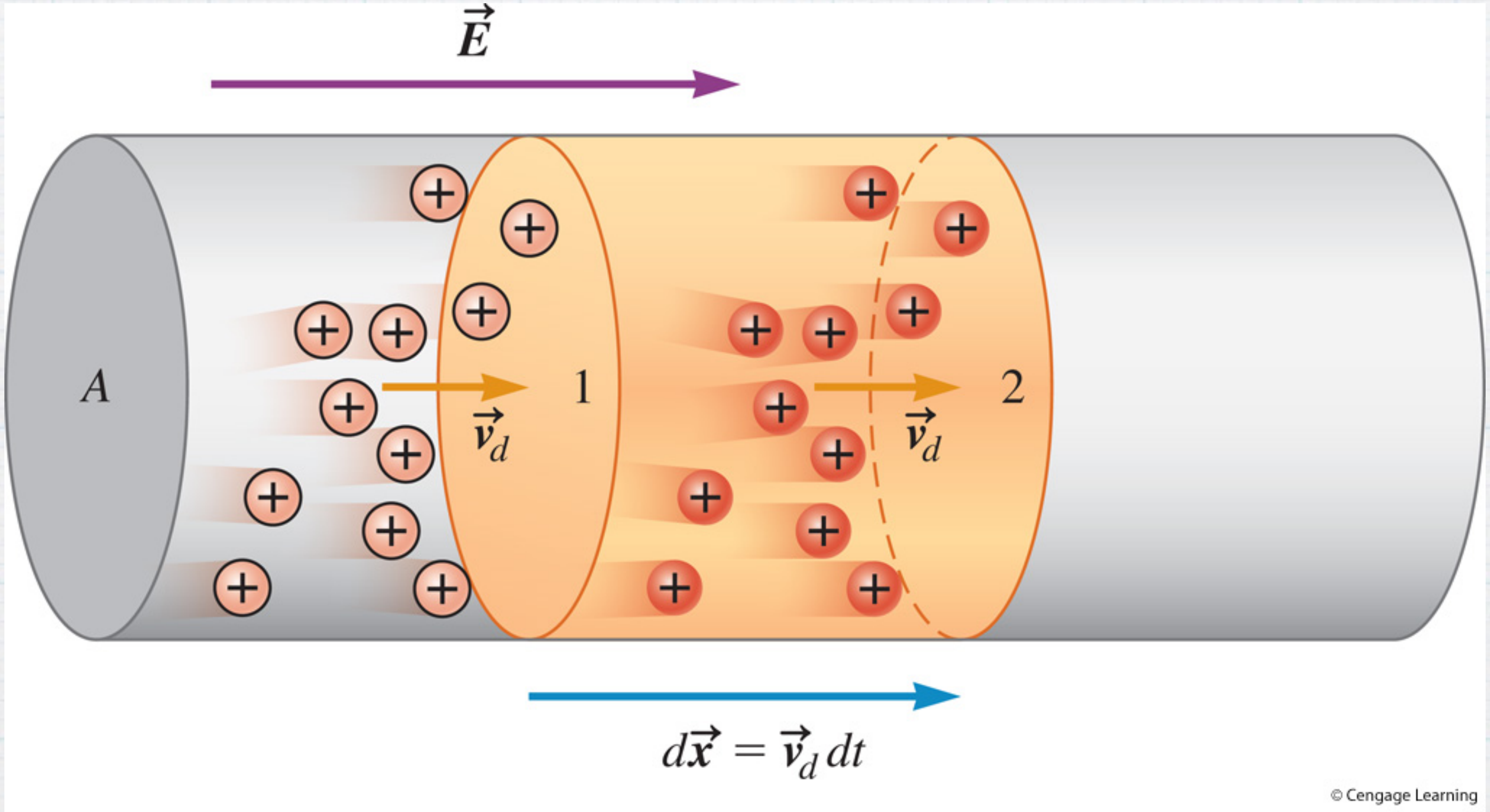
* Ok, somewhat silly
* The electrons do the moving, but we pretend the current is in the direction of the protons
* I is the symbol for current, its units are amperes (A) or Coulombs/second

$$I = \frac{dq}{dt} \rightarrow q = \int dq = \int_0^t I\,dt$$



flash light = .5A
Vacuum Cleaner = 10A

Current density and drift speed



$$J = \frac{I}{A} \rightarrow \vec{J} \propto \vec{E}$$

$$v_d = \frac{I}{neA}$$

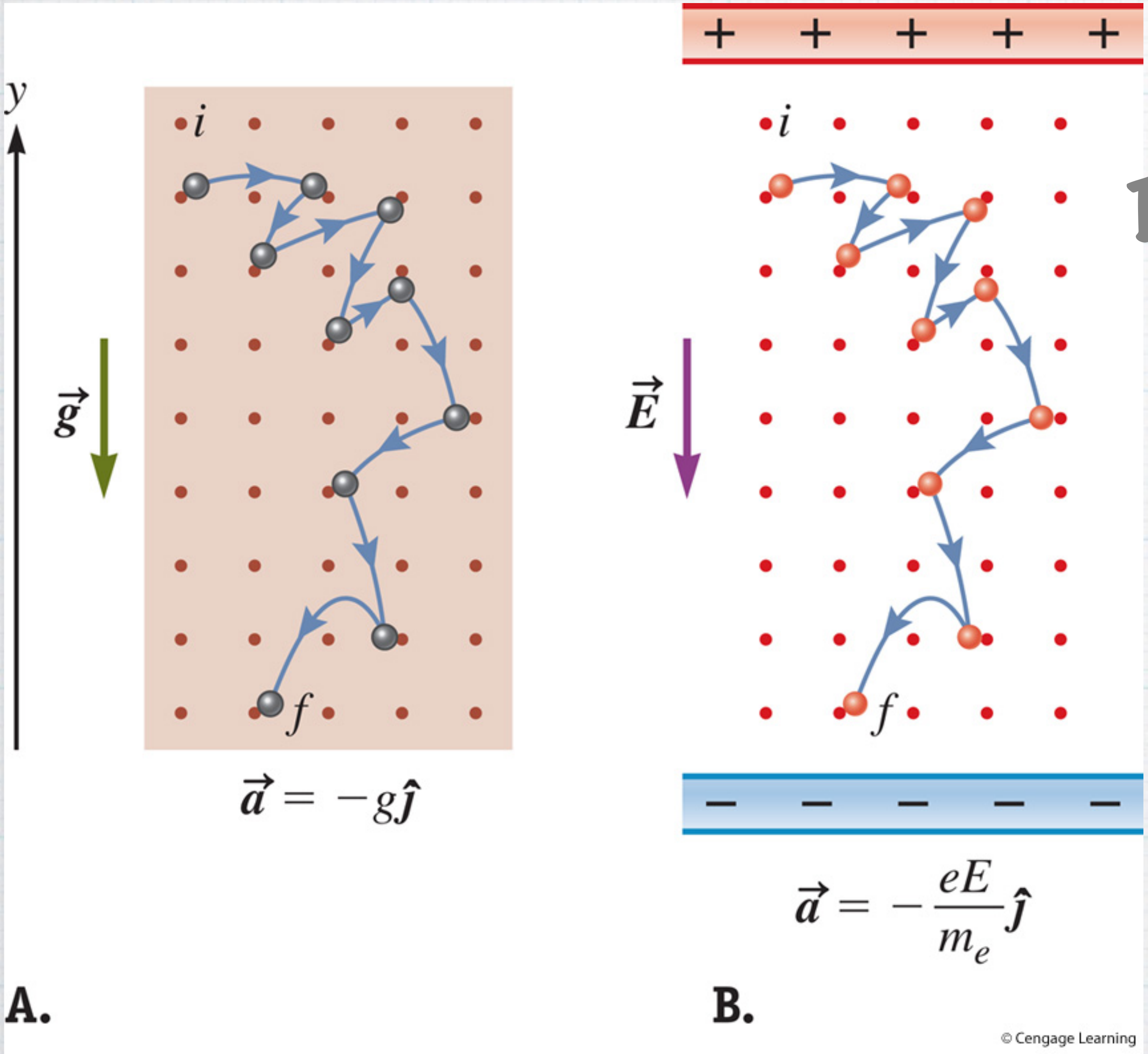
Example

Reading Question 28.2

Current is defined by the rate of imaginary positive particles passing through a section of wire. The SI unit for current is the ampere, what is an ampere equivalent to?

a. C / eV
b. J / C s
c. J / eV
d. C / s

Resistivity and Conductivity



collisions

first, gravity

Then electrical field

$$\vec{E} = -E\hat{j}$$

$$\vec{F} = q\vec{E} = m\vec{a}$$

$$\vec{a} = -\frac{eE}{m}\hat{j}$$

$$\vec{v}_d = -(\frac{qE}{m})t\hat{j}$$

but $J = nqv_d$

$$\vec{J} = \frac{ne^2}{m_e}t\vec{E}$$

$$\vec{J} = \frac{ne^2}{m_e} t\vec{E}$$

$$\sigma = \frac{ne^2}{m_e} t \rightarrow \vec{J} = \sigma\vec{E}$$

$$\sigma = \frac{A/v}{m}$$ conductivity

Resistivity

$$\frac{1}{\sigma} = \rho$$

$$\vec{E} = \rho\vec{J}$$

Higher conductivity, lower resistivity

Resistance - 1 V/A = 1 ohm = 1Ω

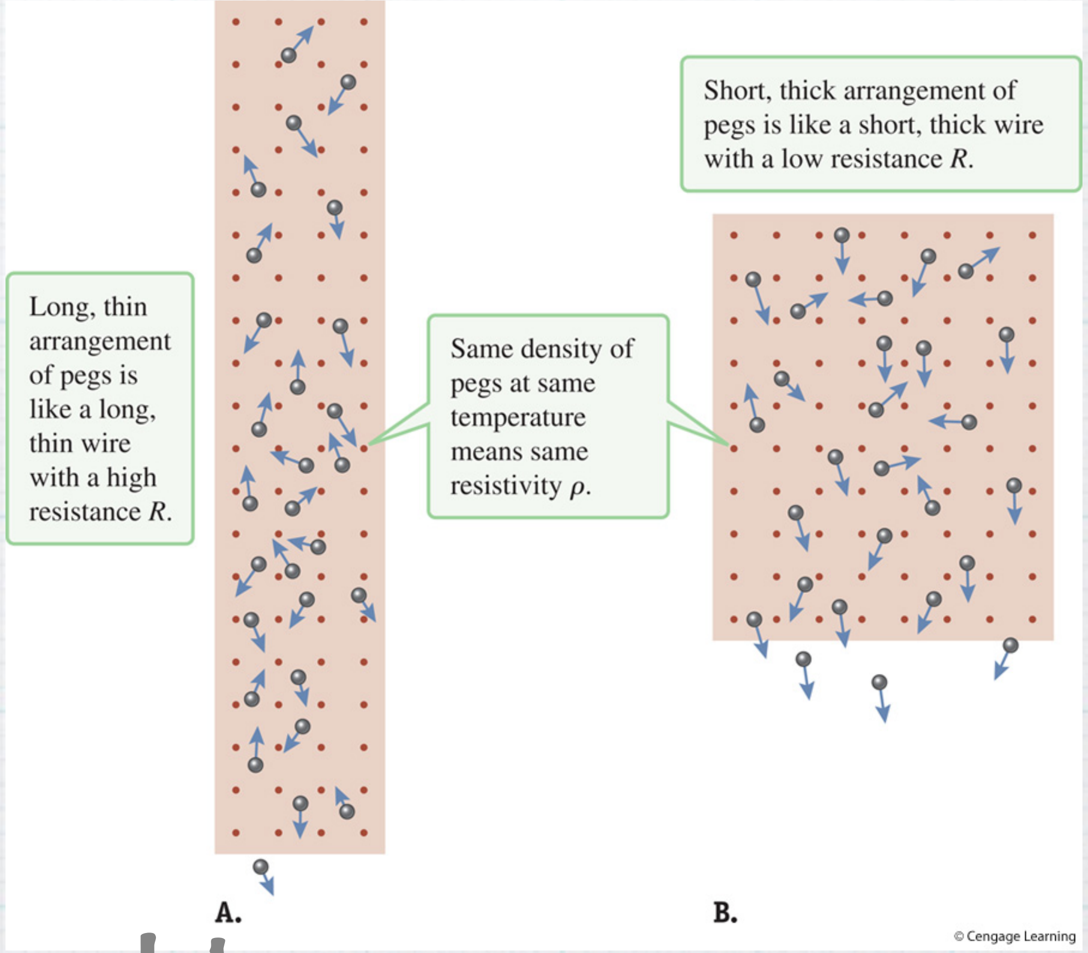
Resistance

For a constant electrical field (see derivation in book)

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

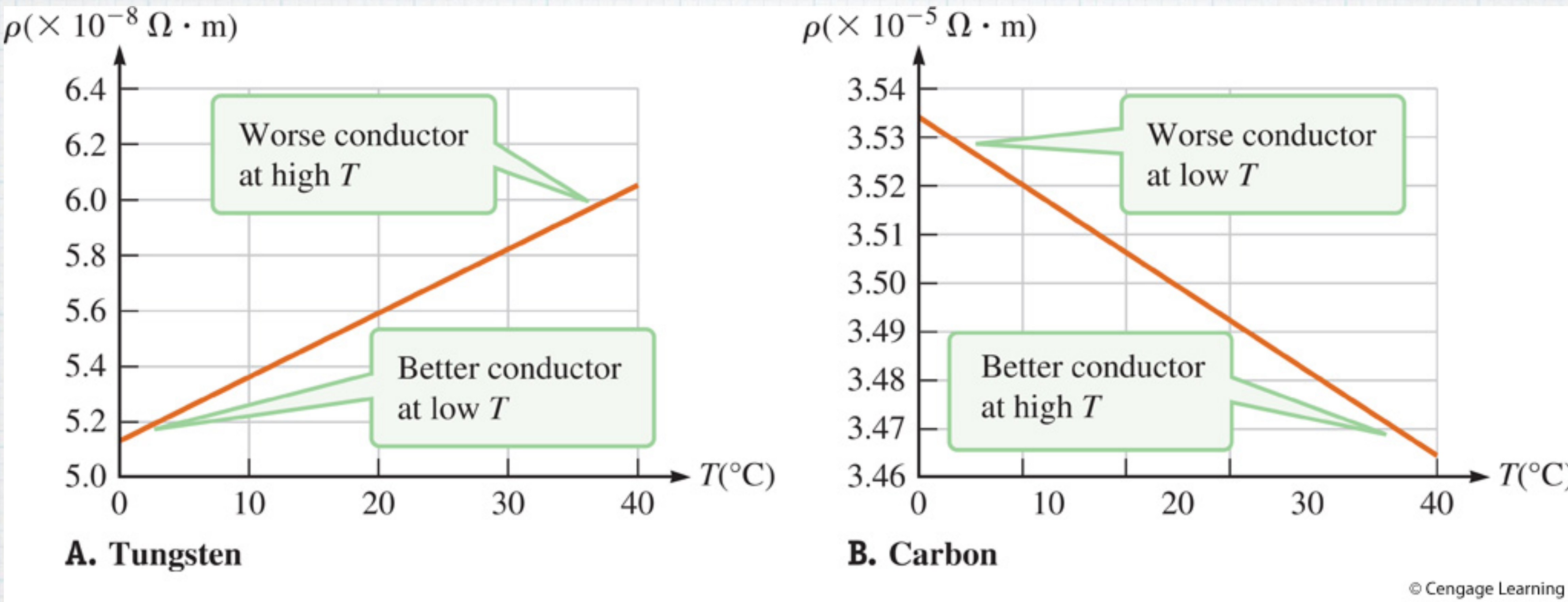
$$\rho(T) = \rho_0[1 + \alpha(T - T_0)]$$

$$R(T) = R_0[1 + \alpha(T - T_0)]$$



Reference temperature is 20 degrees celsius

Examples, change configuration, change temperature



ρ(× 10−8 Ω · m)
6.4
6.2
6.0
5.8
5.6
5.4
5.2
5.0
Worse conductor at high T
Better conductor at low T
0
10
20
30
40
T(°C)
A. Tungsten
ρ(× 10−5 Ω · m)
3.54
3.53
3.52
3.51
3.50
3.49
3.48
3.47
3.46
Worse conductor at low T
Better conductor at high T
0
10
20
30
40
T(°C)
B. Carbon
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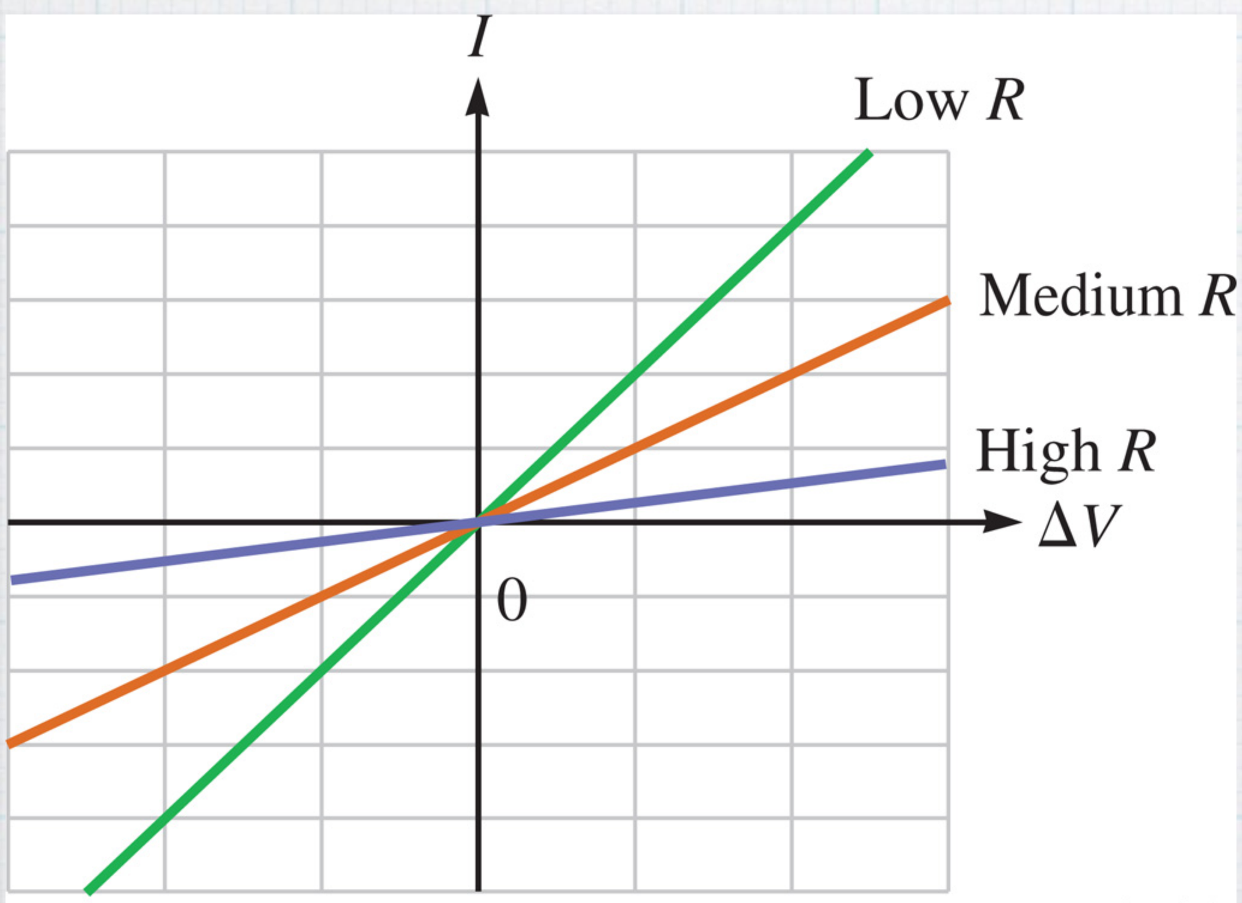
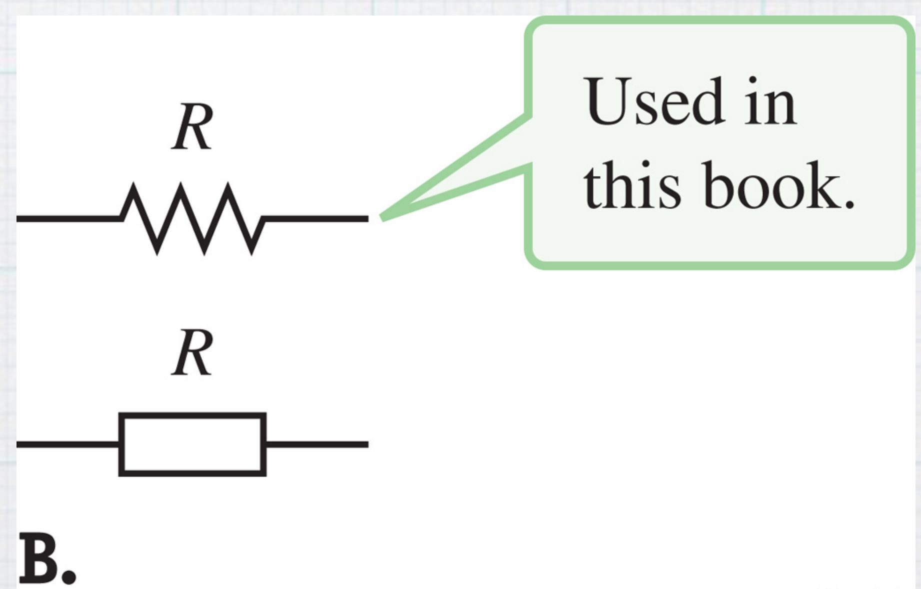
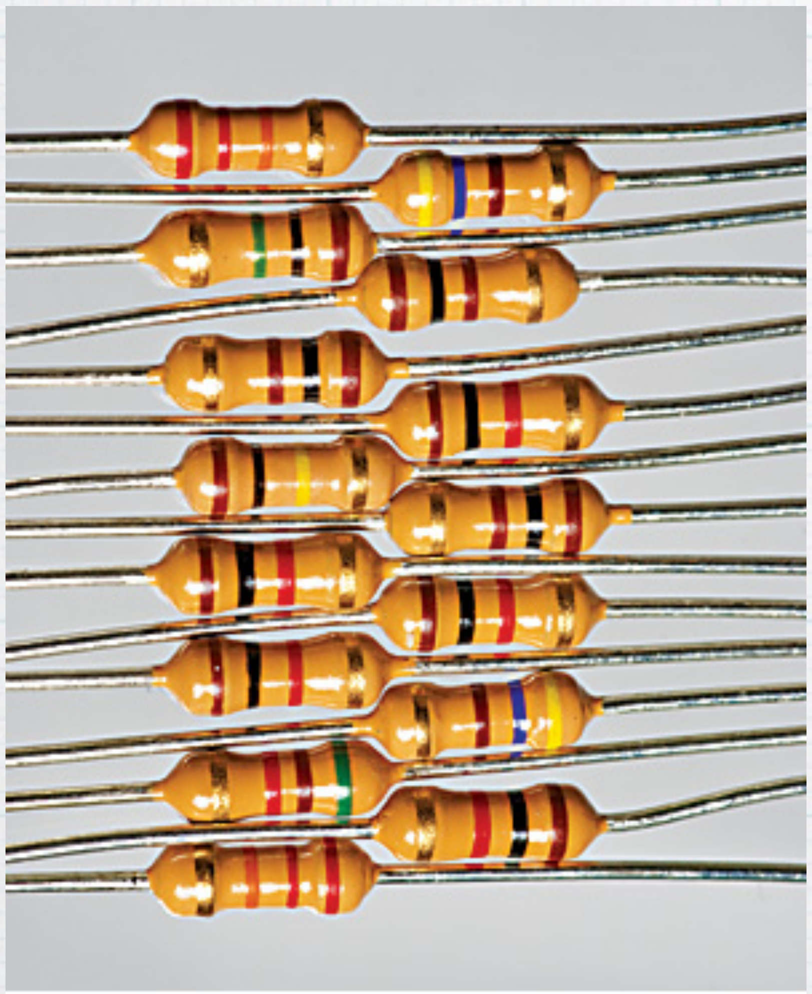
Ohm's Law

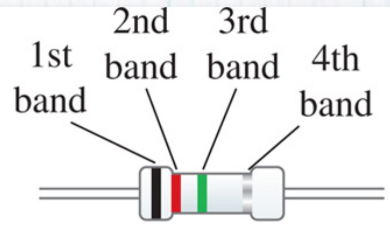
- The potential dropped as a current crosses a resistor is $\Delta V = IR$
- Circuit diagram, water analogy





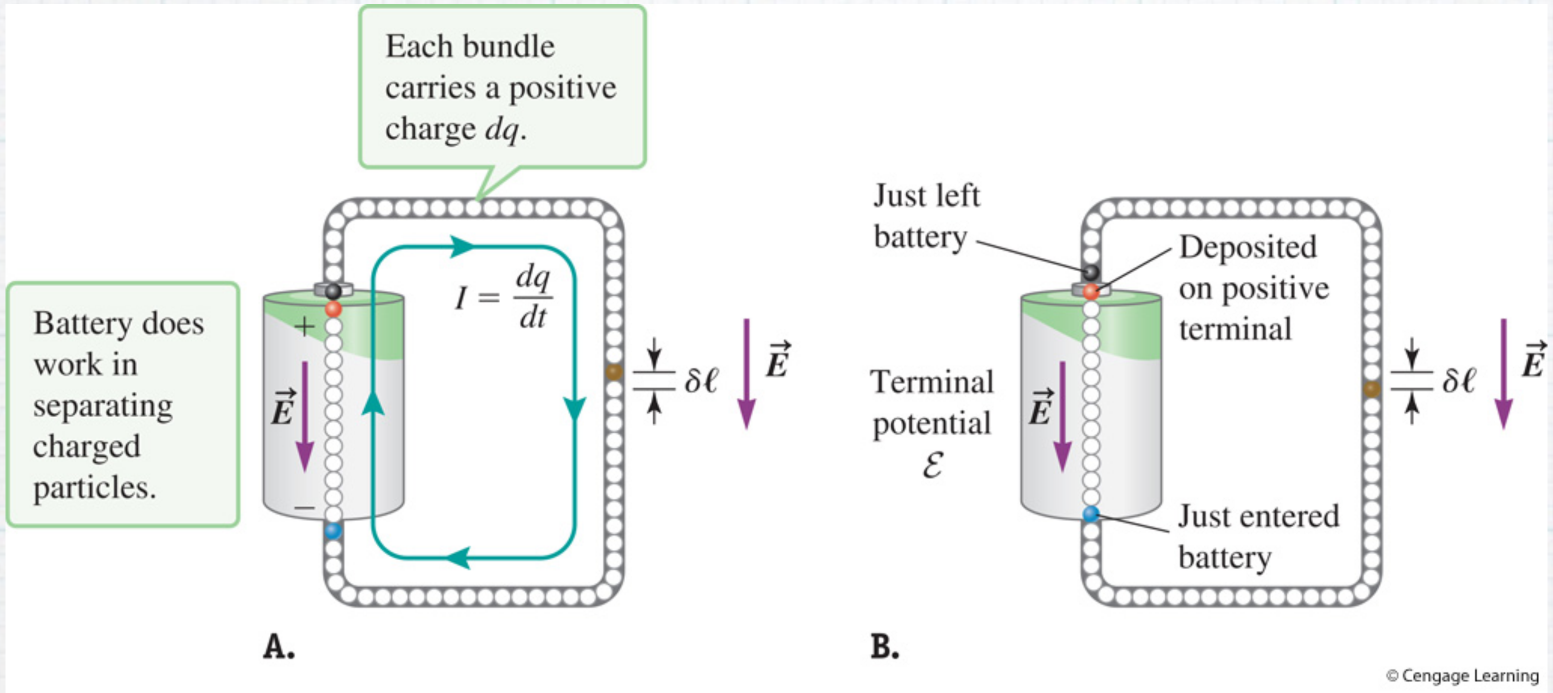


Charles Knowles/Shutterstock



Color	1st band (1st figure)	2nd band (2nd figure)	3rd band (multiplier)	4th band (tolerance)
Black	0	0	10^0	
Brown	1	1	10^1	
Red	2	2	10^2	±2%
Orange	3	3	10^3	
Yellow	4	4	10^4	
Green	5	5	10^5	
Blue	6	6	10^6	
Violet	7	7	10^7	
Gray	8	8	10^8	
White	9	9	10^9	
Gold			10^{-1}	±5%
Silver			10^{-2}	±10%

Power in a circuit



$$dU = \xi dq \rightarrow q\Delta V$$

$$dq = I dt$$

$$\frac{dU}{dt} = I\xi$$

$$P = I\xi = I\Delta V$$

Using Ohm's Law

$$P = I\xi = I\Delta V = I^2 R = \frac{\Delta V^2}{R}$$

Example with kilowatt hours