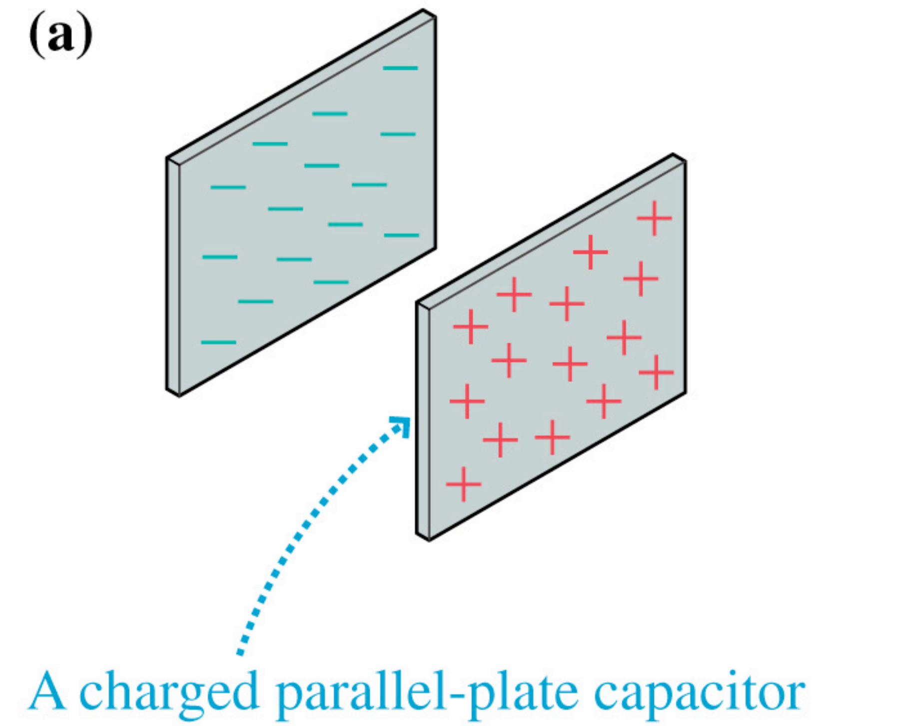
Lecture 24

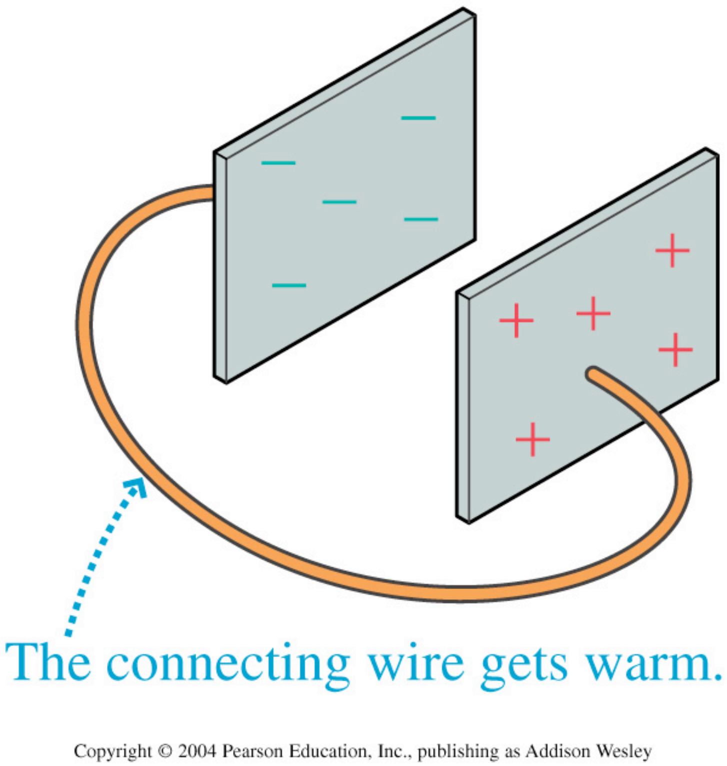
- start chapter 31 (Current and Resistance)
- creating current: model of conduction

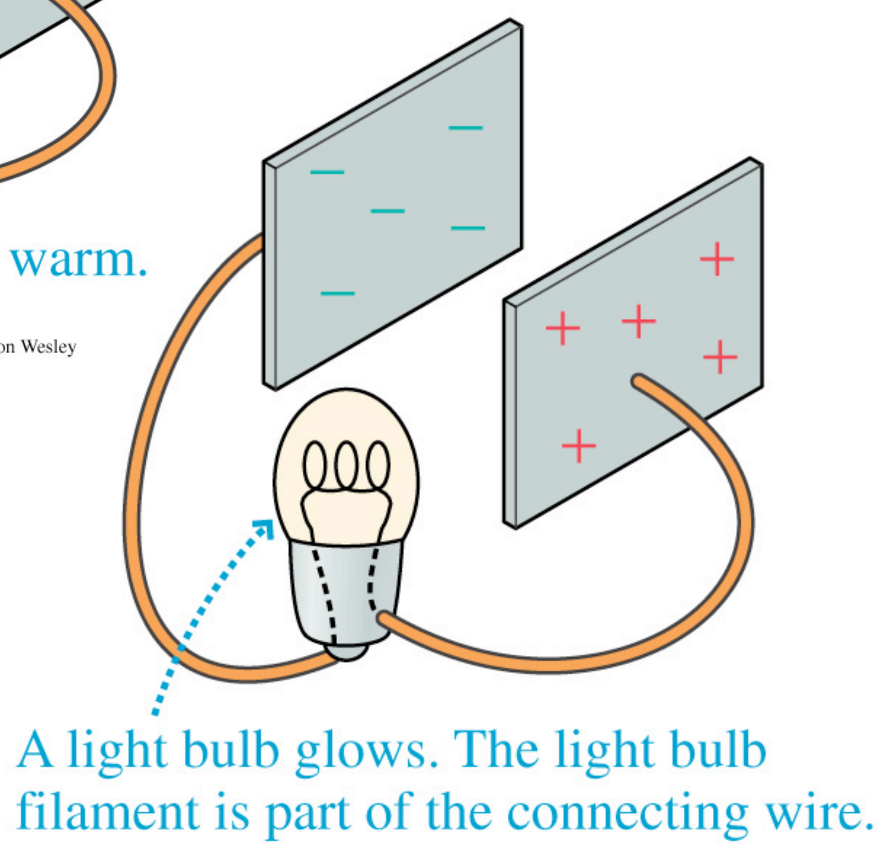
Outline of Chapter 31 (Current and Resistance)

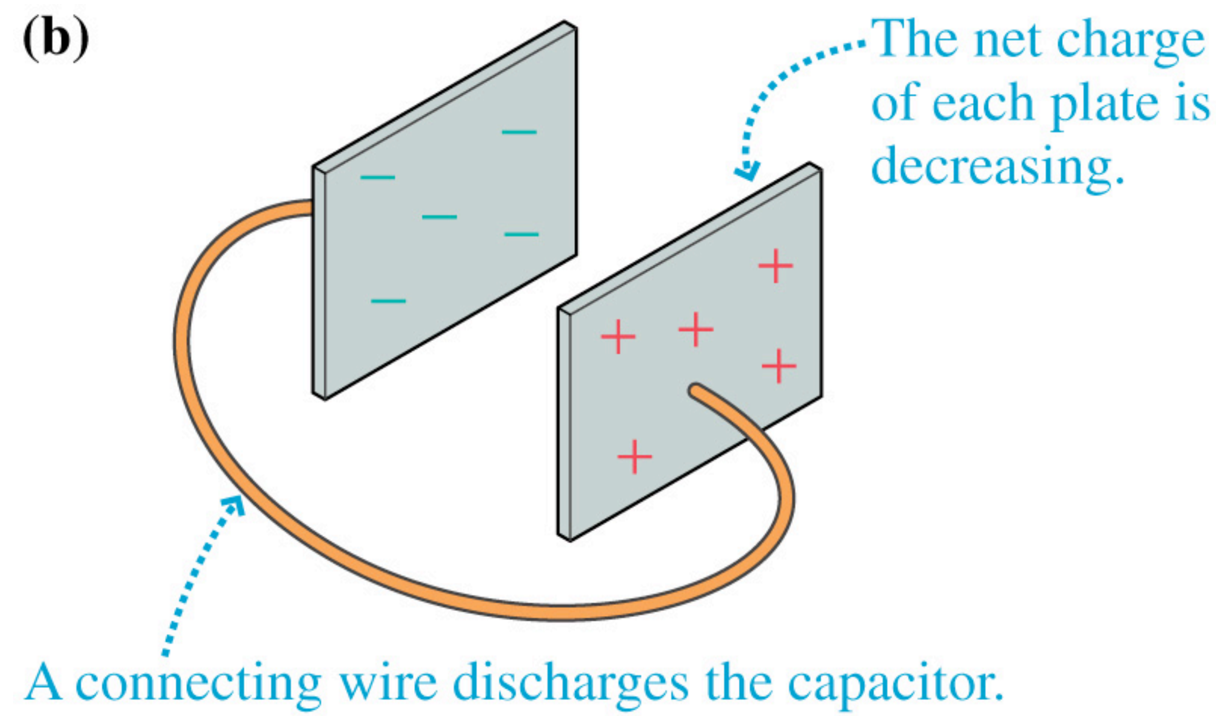
- motion of charges thru' wire (current): due to electric field inside wire (relation to charging/electrostatics)
- law of conservation of current
- relate current to conductivity



excess charge moves (current)



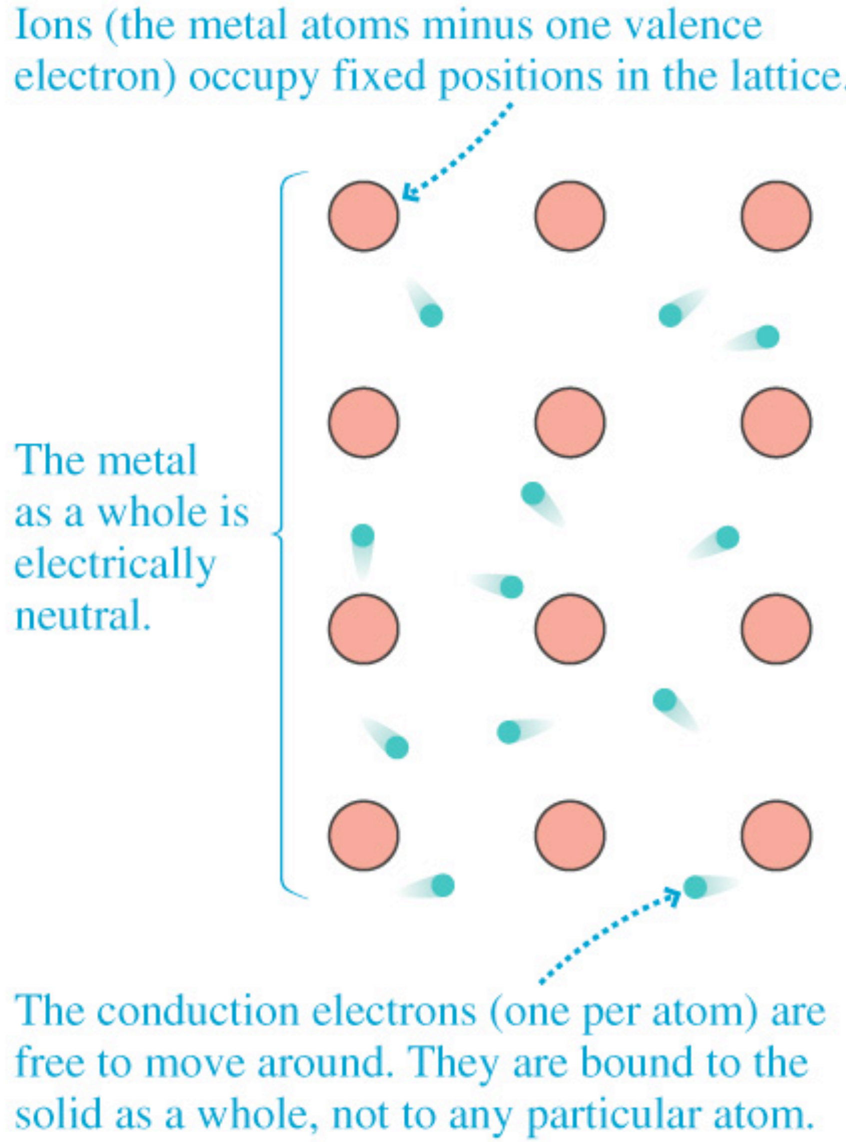


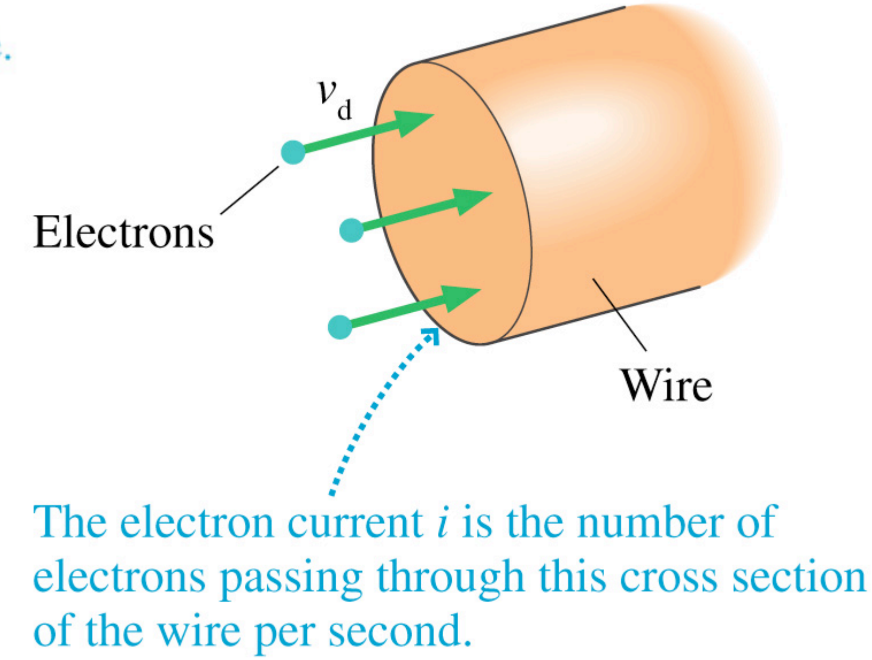


indicators of current

Electron Current

- charge carriers (that move): electrons in metals
- no current : electrons moving rapidly, no net motion
- push on sea of electrons using $\bar{E}$: drift speed v_d superposed on random thermal

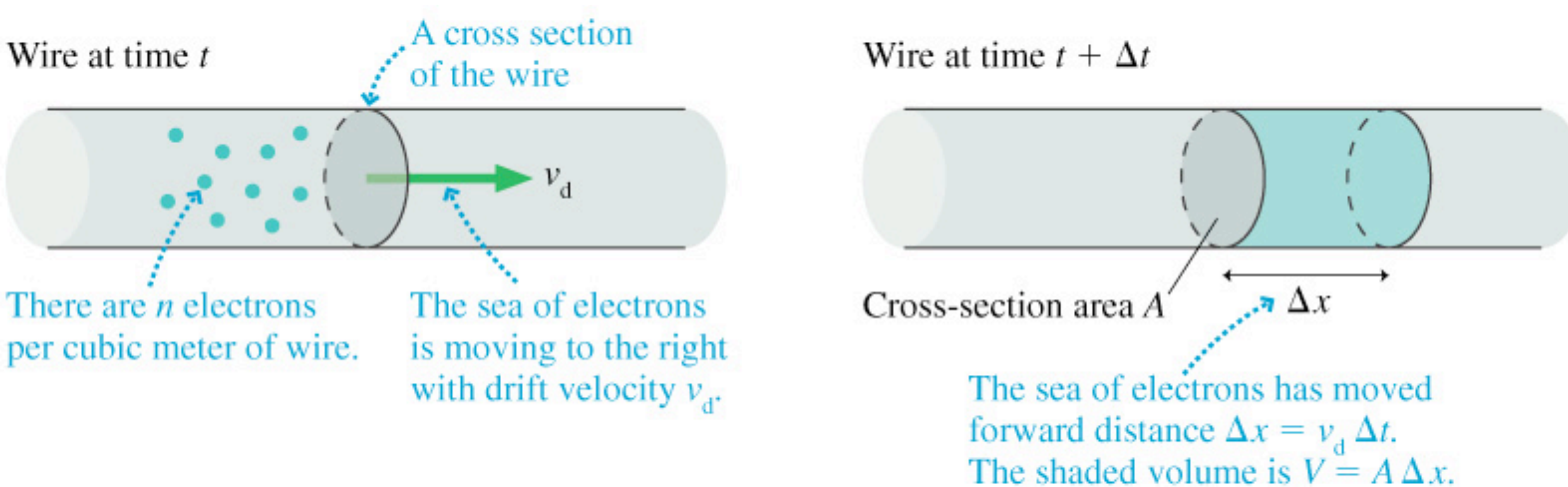




$$N_e = i\Delta t$$

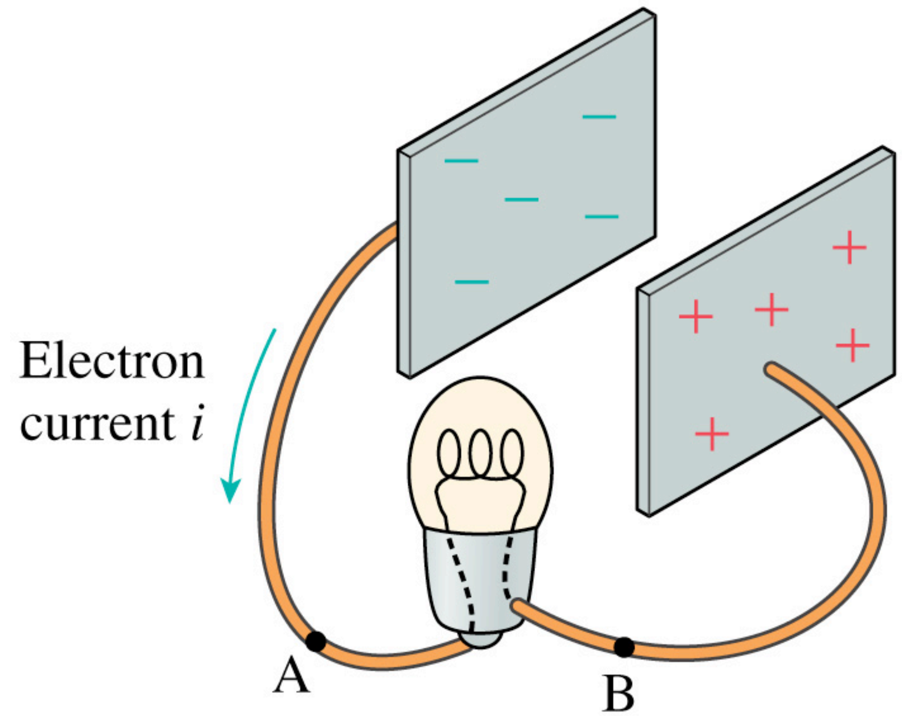
$$N_e = nV = nA\Delta x = nAv_d\Delta t$$

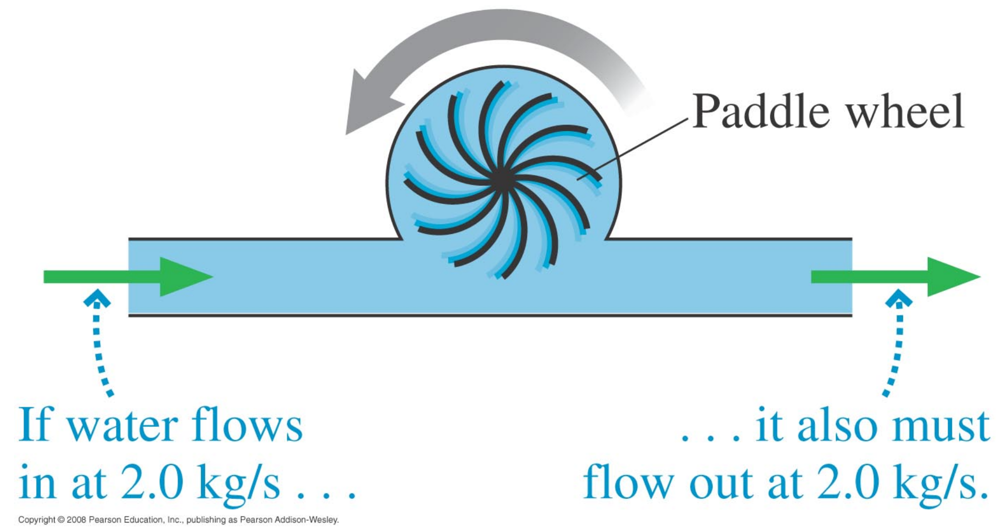
$$i = nAv_d$$



Conservation of current

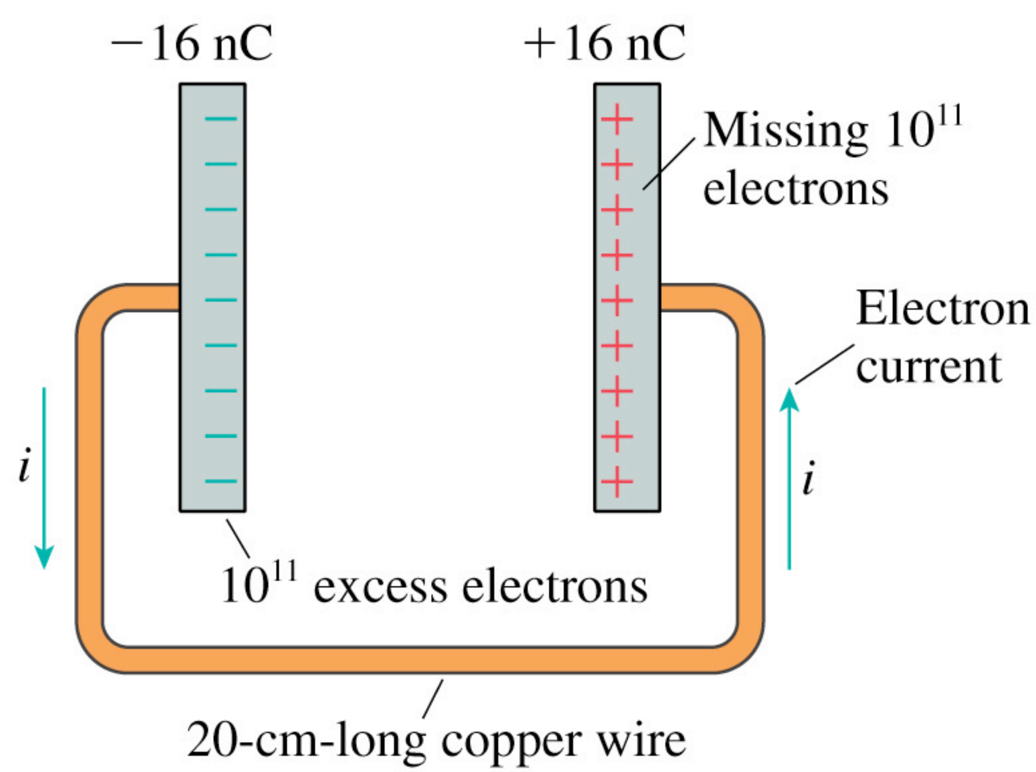
- electron current same at A and B: can't be created/ destroyed/ stored: lightbulb uses energy (work done to push electrons)

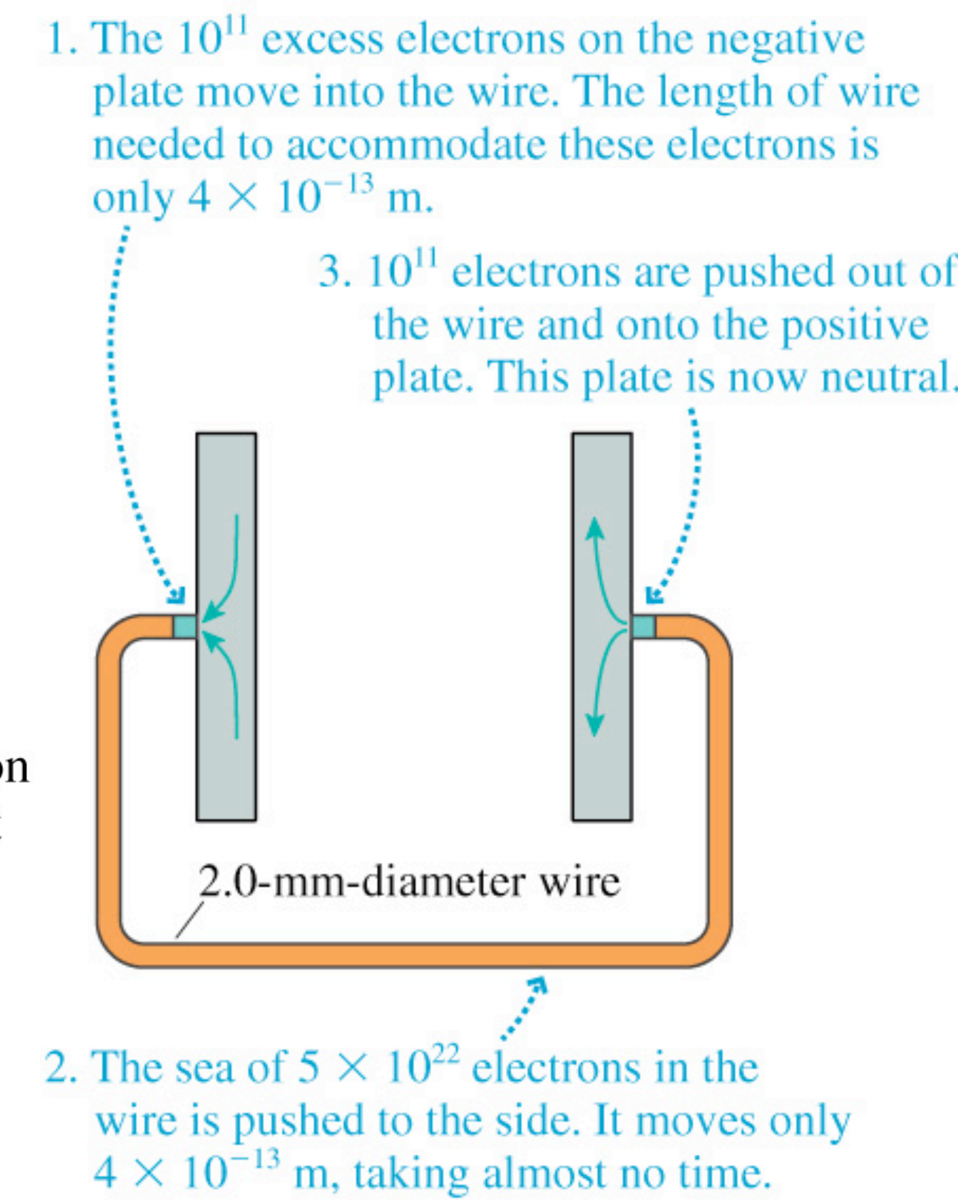




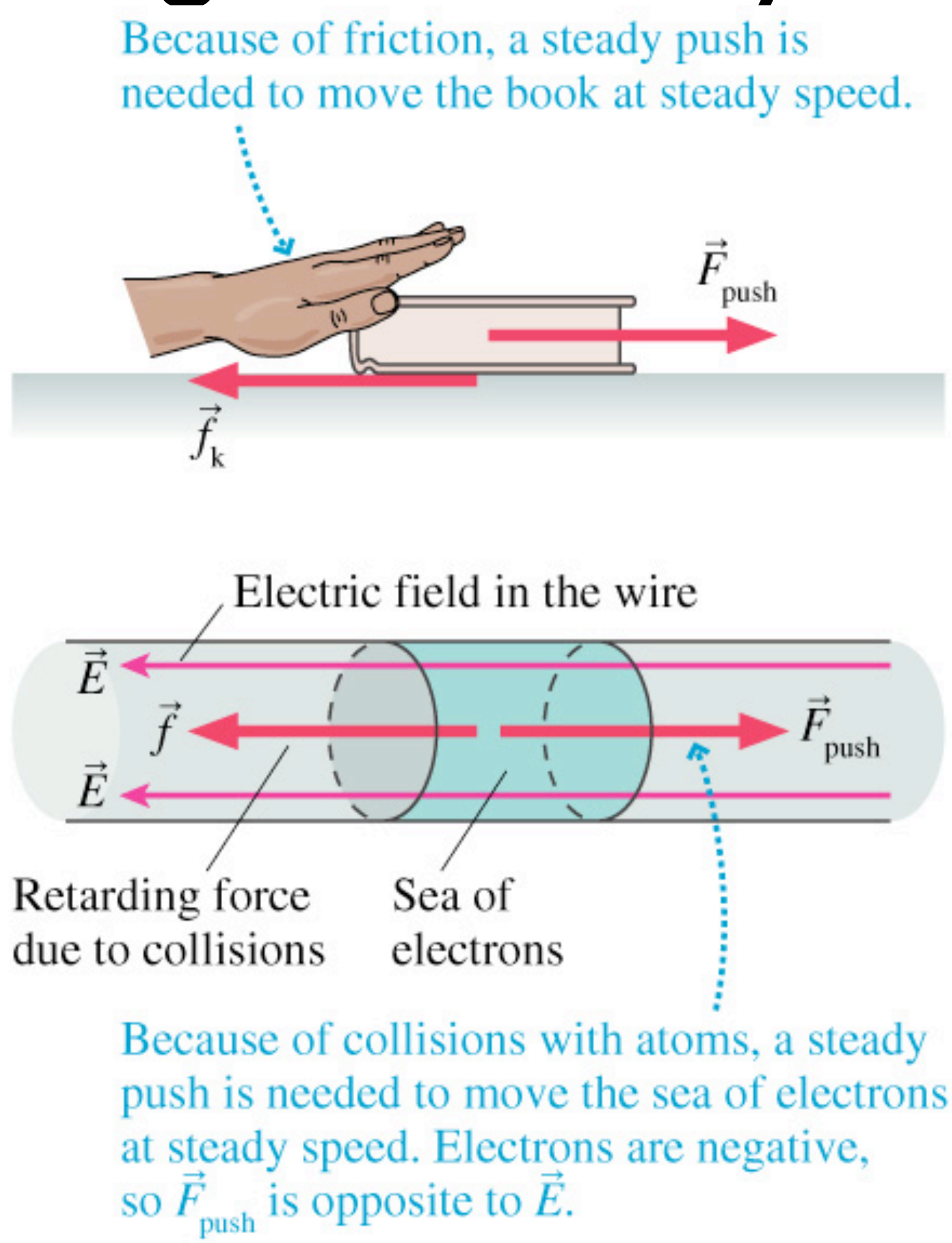
Discharge of capacitor is instantaneous

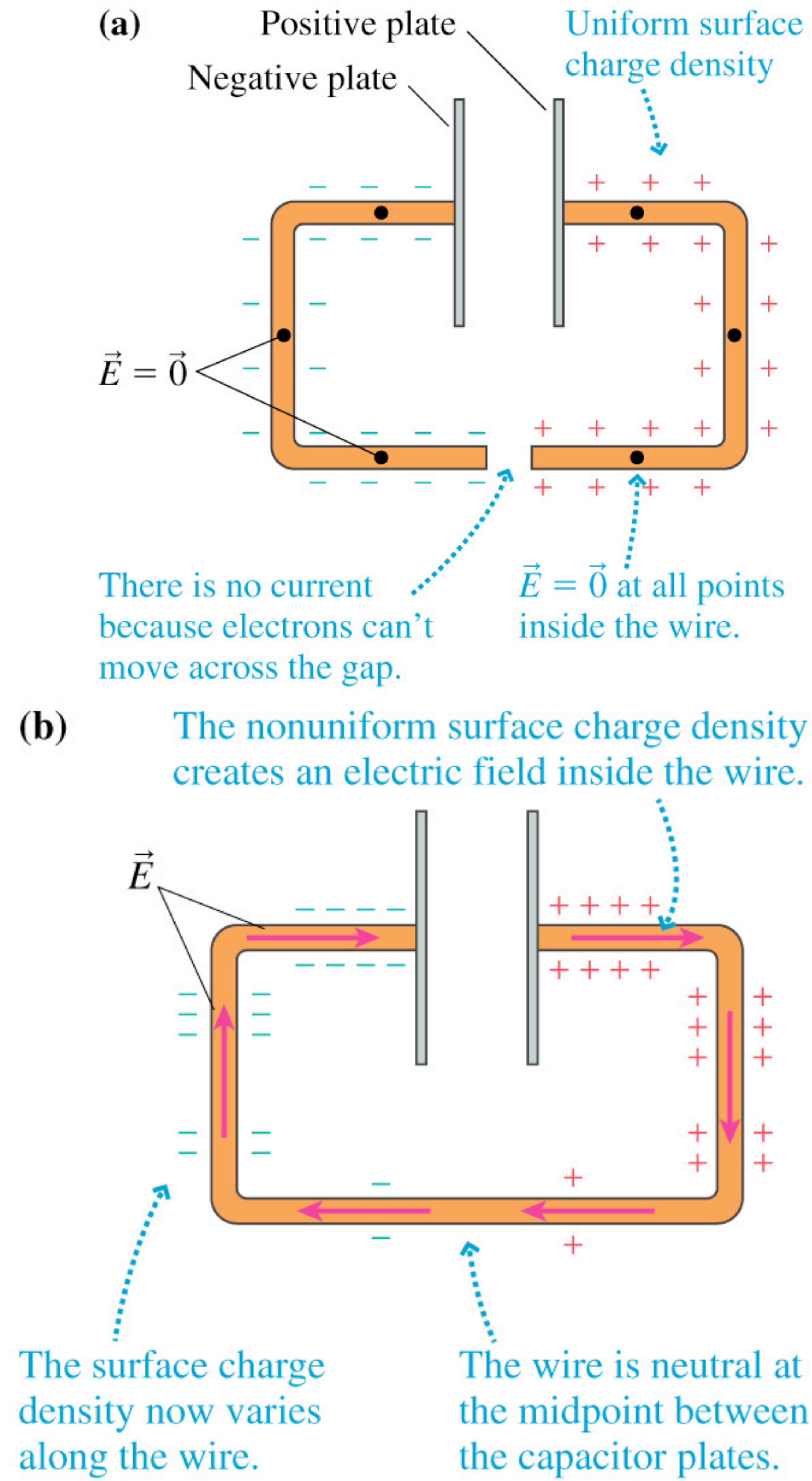
- wire full of electrons, don't have to move from plate to plate (just shift/ rearrange





Creating Current by $\bar{E}$





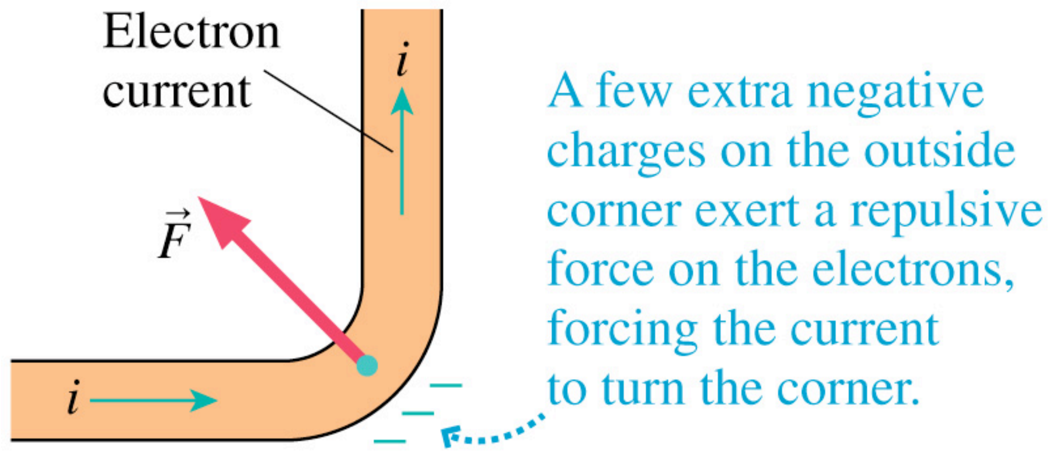
- electron current is non-equilibrium motion of charges sustained by internal $\bar{E}$
- establishing $\bar{E}$ in wire

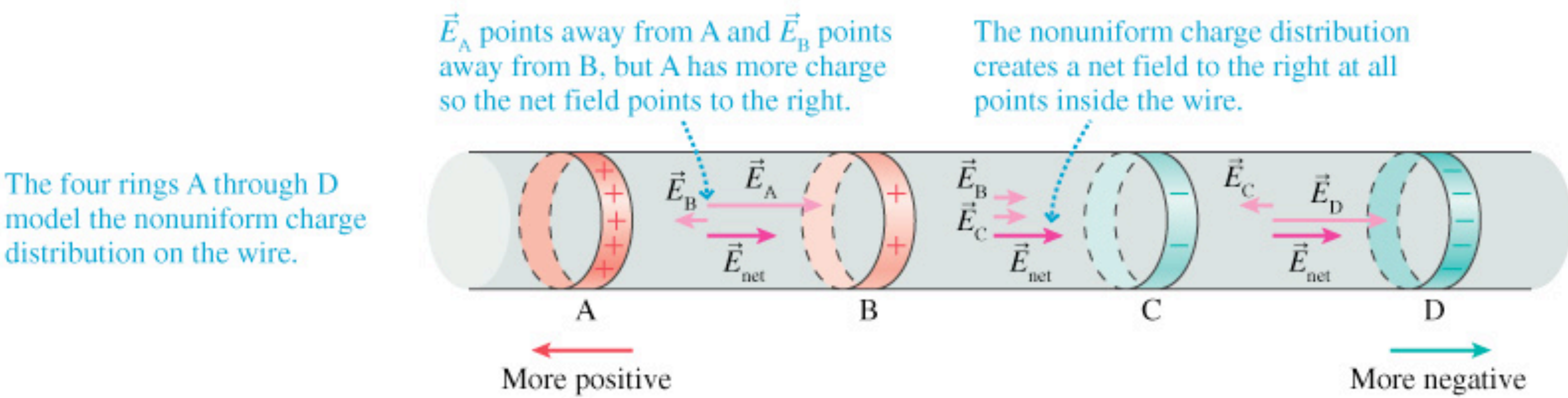
Creating Current by $\bar{E}$

- model wire with rings of varying charge: use $\bar{E}$ (i) points away from positive ring; (ii) $\propto$ charge and (iii) decrease with distance

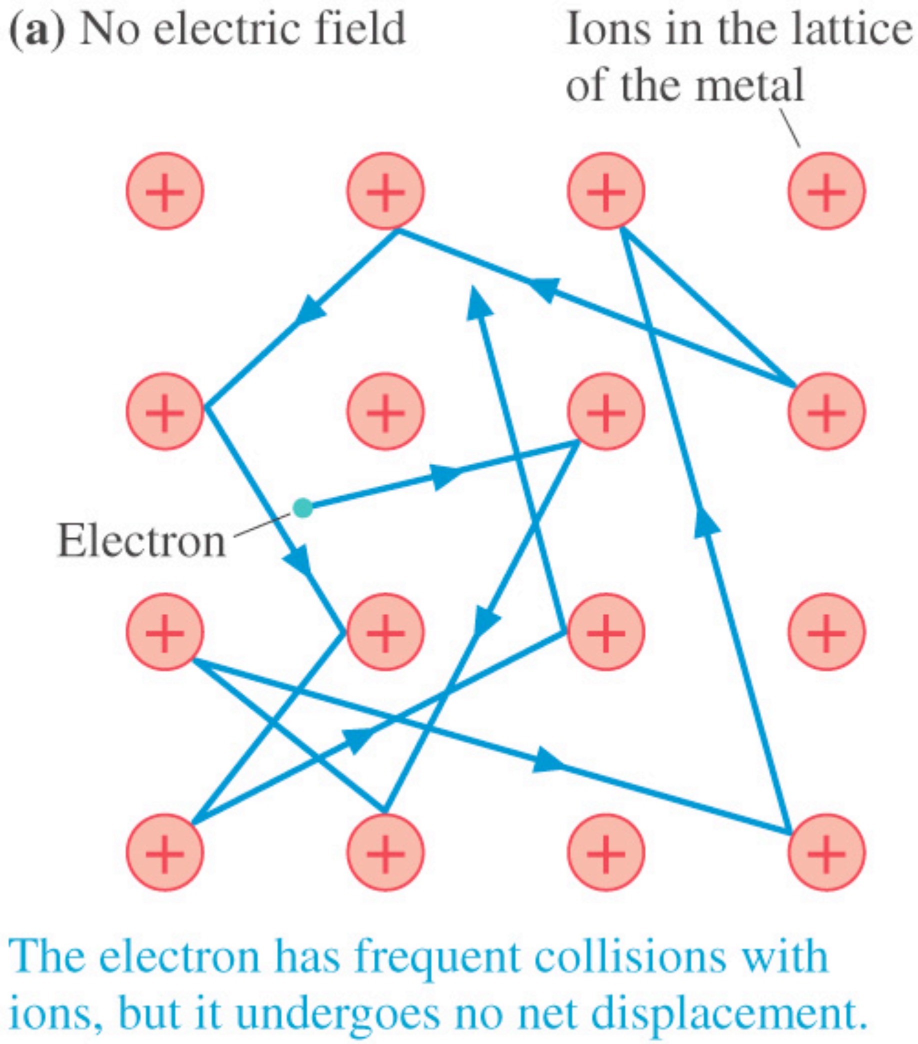
- net $\bar{E}$ inside wire (from non-uniform charge distribution) pushes electron current

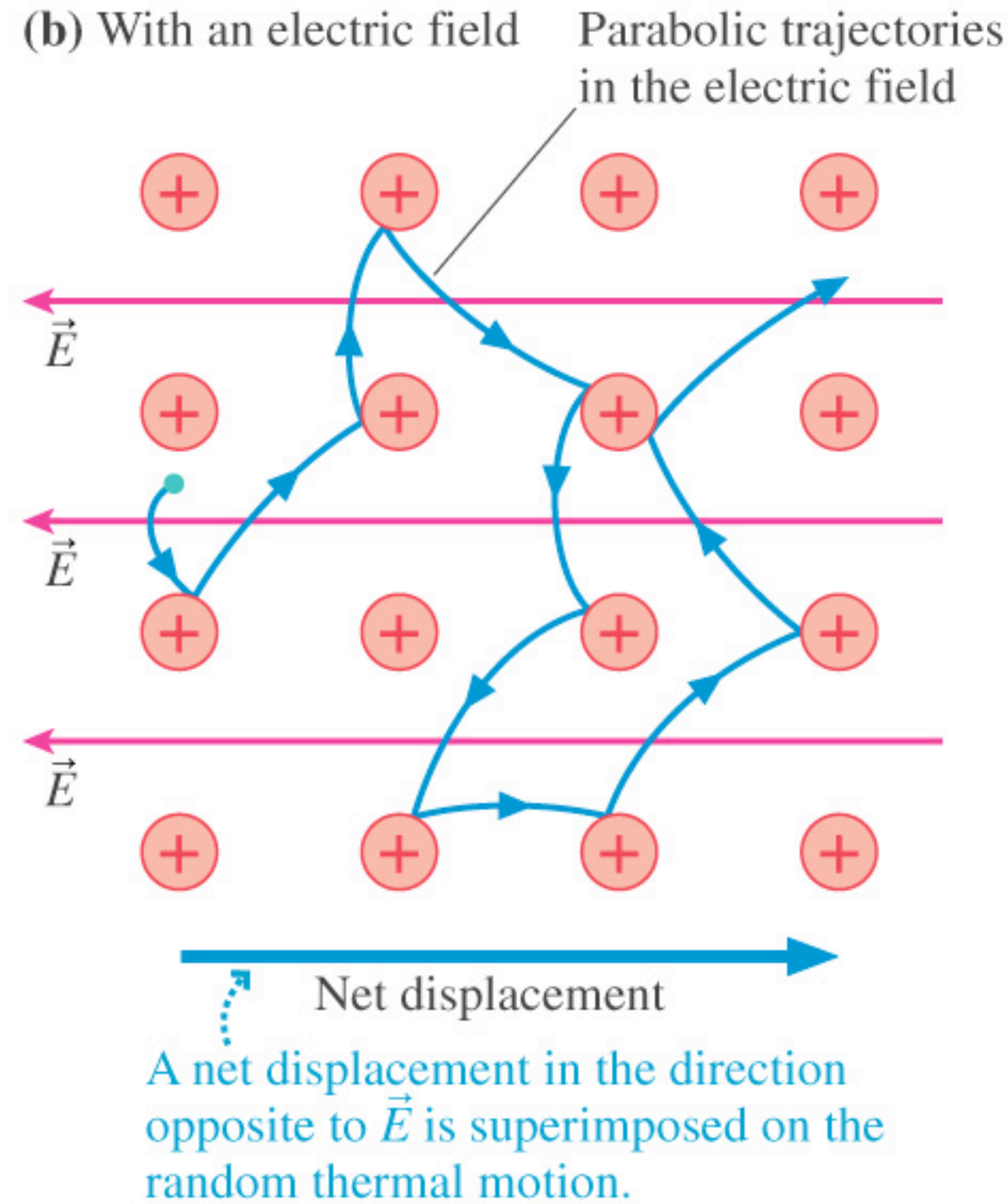
- how electron current turns a corner





Model of conduction





- micro/marco link (like relating T, p f gas to energy of molecules): conduction electrons are "free" (average kinetic energy $\frac{3}{2}kT$)
- $\bar{E} = 0$: zero average velocity; straight lines between collisions
- $\bar{E} \neq 0$: drift in direction opposite to $\bar{E}$; net (small) motion (between collisions) superimposed on (larger) thermal motion

Model of conduction (current $\propto \bar{E}$)

- After collision: $a_x = \frac{F}{m} = \frac{eE}{m}$; $v_x = v_{ix} + a_x \Delta t = v_{ix} + \frac{eE}{m}\Delta t$
- till next collision (transfers energy to ion; raises temperature of wire); rebounds with new velocity ("reset")
- repeated speeding up (between collisions) non-zero average velocity for single electron (drift speed, v_d)
- average over all electrons: $v_d = \bar{v_x} = \bar{v_{ix}} + \frac{eE}{m}\bar{\Delta t}$

$\tau \equiv \bar{\Delta t}$ (some shorter, other larger): $v_d = \frac{e\tau}{m}E \Rightarrow$ Using $i = nAv_d \longrightarrow i = \frac{ne\tau A}{m}E$