PHY-112
Principles of Physics-II
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Electric Current: A Controlled Motion of Charges

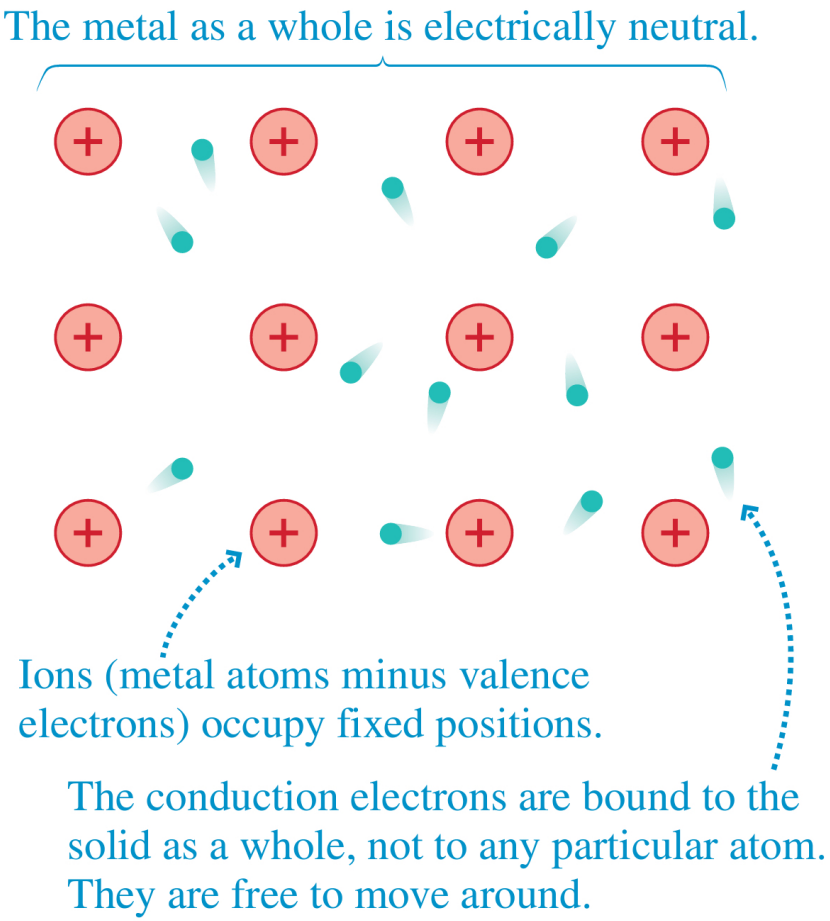
Electric Current: A Controlled Motion of Charges

Define **current** as flow of charge carriers within a conductor.

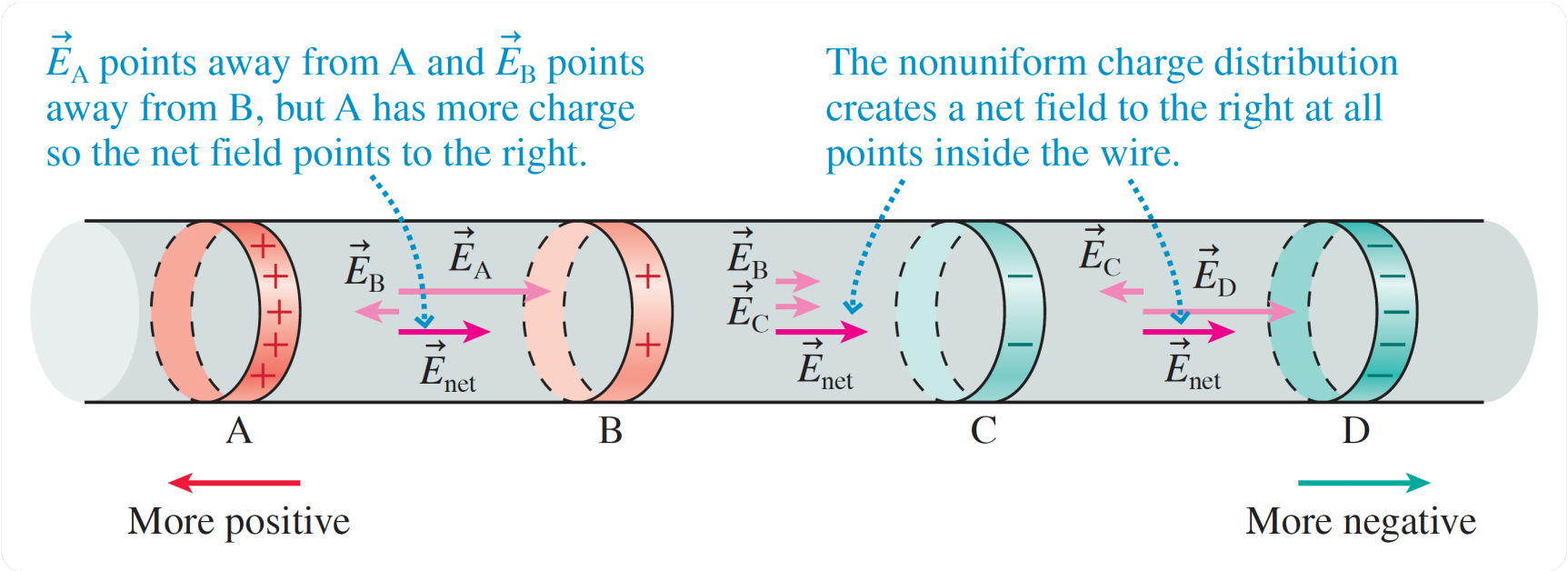
$$I = \frac{\Delta Q}{\Delta t}$$

- measured in [A] ampere
- is a scalar
- does not change its motion path *yet*
- heats up the conductor

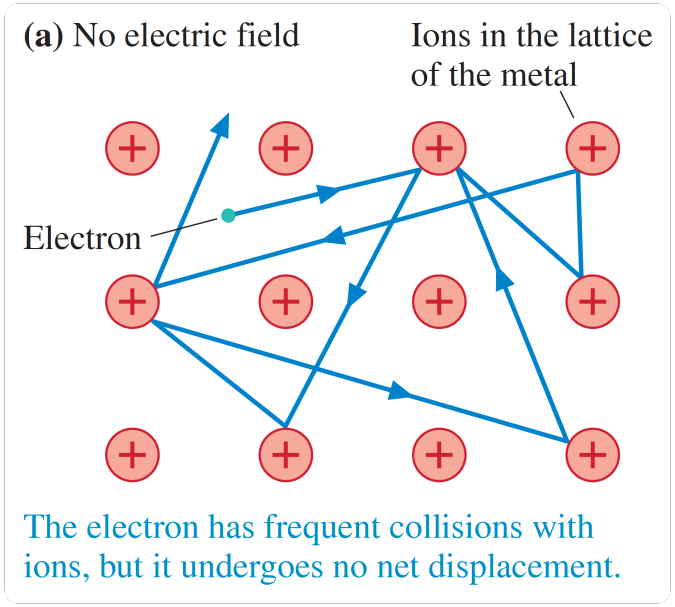
Free Electron Model

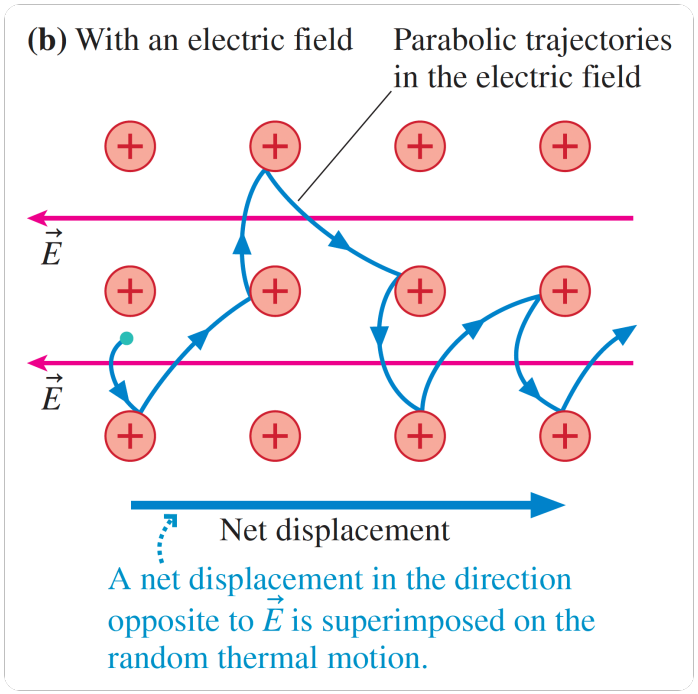


Establishing an Electric Field in a Wire



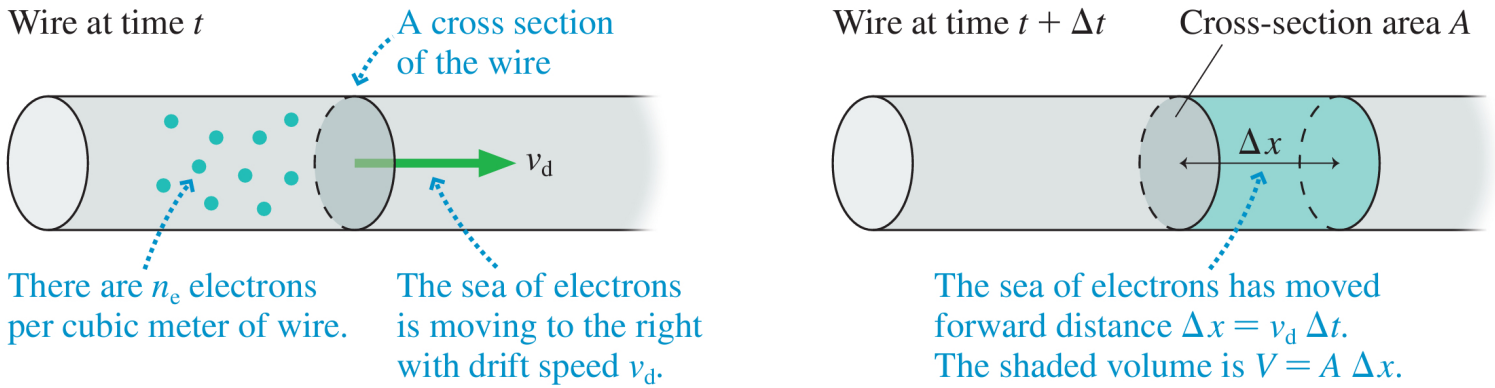
Theory of Metallic (Microscopic) Conduction





The steady electric force causes the electrons to move along *parabolic trajectories* between collisions.

Drift Velocity



The number N_e of electrons that pass through the cross section during the time interval Δt is

$$\Delta Q = i_e \Delta t$$
$$n_e V = n_e A \Delta x = i_e \Delta t$$
$$n_e A v_d \Delta t = i_e \Delta t$$
$$i_e = n_e A v_d$$

Long Story Short

Electrons don't just magically move through a wire as a *current*. They move because an electric field inside the wire—a field created by a nonuniform surface charge density on the wire—pushes on the sea of electrons to create the *electron current*. It is measured in $\mathrm{A\,C^{-1}}$ unit or simply electrons $\mathrm{s^{-1}}$ unit.

Testing Concepts (1)

Q: What is the electron current in a 2.0 mm-diameter copper wire if the electron drift speed is 10^{-4} mm s^{-1}? The electron density for copper as 8.5×10^{28} m^{-3}.

Testing Concepts (2)

Q: These four wires are made of the same metal. Rank in order, from largest to smallest, the electron currents i_A to i_D.