

PHY-112

PRINCIPLES OF PHYSICS-II

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SPRING-24 | CLASS-14

ELECTRIC CURRENT: A
CONTROLLED MOTION OF
CHARGES

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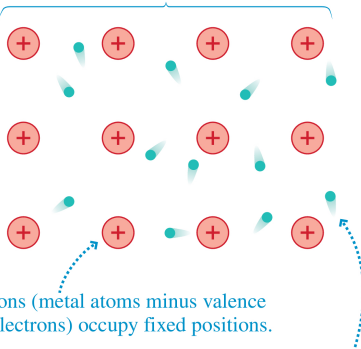
Define **current** as flow of charge carriers within a conductor.

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

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

FREE ELECTRON MODEL

The metal as a whole is electrically neutral.



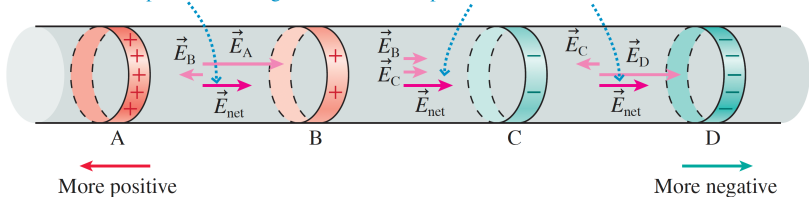
Ions (metal atoms minus valence electrons) occupy fixed positions.

The conduction electrons are bound to the solid as a whole, not to any particular atom. They are free to move around.

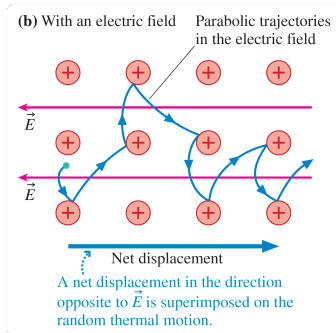
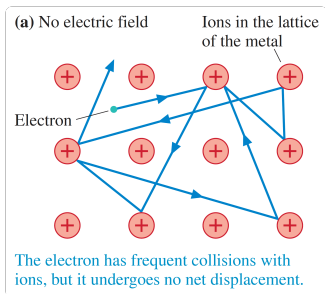
ESTABLISHING AN ELECTRIC FIELD IN A WIRE

\vec{E}_A points away from A and \vec{E}_B points away from B, but A has more charge so the net field points to the right.

The nonuniform charge distribution creates a net field to the right at all points inside the wire.

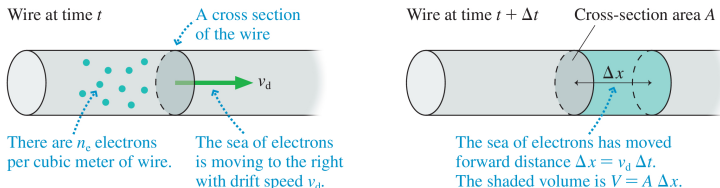


THEORY OF METALLIC (MICROSCOPIC) CONDUCTION



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

$$\begin{aligned}\Delta Q &= i_e \Delta t \\ n_e V &= n_e A \Delta x = i_e \Delta t \\ n_e A v_d \Delta t &= i_e \Delta t \\ i_e &= n_e A v_d\end{aligned}$$

LONG STORY SHORT

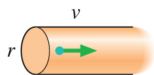
Electrons don't just magically move through a wire as a *current*. They move because an electric field inside the wire—a field created by a nonuniform surface charge density on the wire—pushes on the sea of electrons to create the *electron current*. It is measured in A C^{-1} unit or simply electrons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

TESTING CONCEPTS (1)

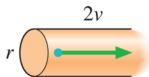
Q: What is the electron current in a 2.0 mm-diameter copper wire if the electron drift speed is $10^{-4} \text{ mm s}^{-1}$? The electron density for copper as $8.5 \times 10^{28} \text{ m}^{-3}$.

TESTING CONCEPTS (2)

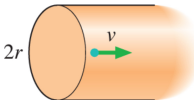
Q: These four wires are made of the same metal. Rank in order, from largest to smallest, the electron currents i_A to i_D .



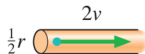
A



B



C



D