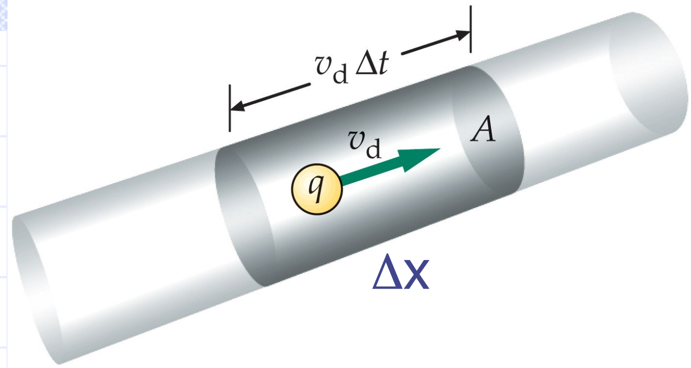
Chapter 17: Current

- Current $$I = \frac{dQ}{dt} \qquad Q = \int_0^t I(t)dt$$

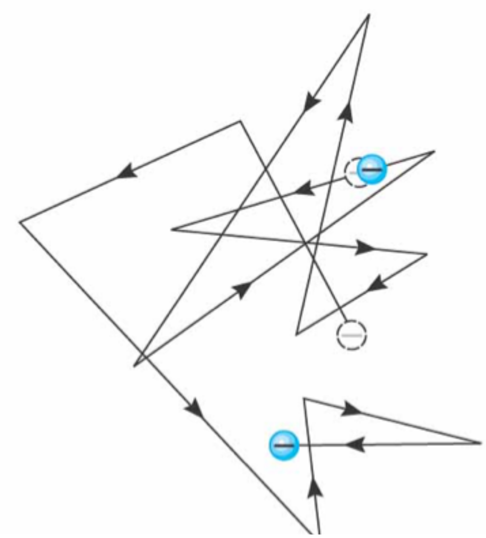
- In terms of the current density $$I = \int \vec{J} \cdot d\vec{A}$$

- For a uniform current density perpendicular to the area element $$J = I / A$$

Microscopic Description of Current



- Consider a conductor with cross sectional area A and a segment length Δx
- If there is no potential difference across it, the electric field in the wire is zero and therefore the current is zero
- However, there are electrons moving within the conductor
- These conduction electrons move in random directions, but at high speeds ~10^6 m/s



- No net displacement of the electrons → no current → no electric field
- However, if a ΔV is applied then there is an electric field in the conductor and a current
- Considering the current at a microscopic level, there is

  → a volume element of AΔx

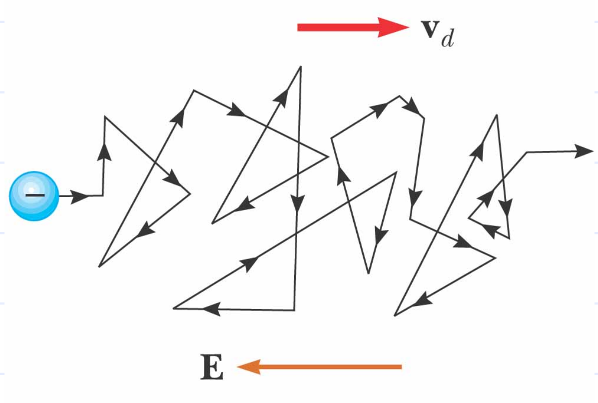
  → with n total number of charge carriers per unit volume

  → each with positive charge q
- The total charge in the volume element is

$$\Delta Q = nA\Delta xq$$

- They move with a constant speed, the drift speed

- In a vacuum with a uniform electric field, electrons move in a straight line in the opposite direction of the field lines
- However, in a conductor, the electrons travel for short distances (~40 nm), in random directions until they encounter an atom, where the electron is scattered in a random direction
- Nevertheless, the electrons move slowly in the direction opposite the electric field at the drift speed (~10^{-4} m/s)



©2004 Thomson - Brooks/Cole

- The drift speed of electrical conduction can be understood through the Drude model which applies classical mechanics