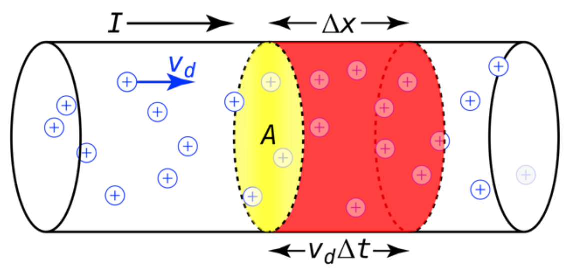
Flipping Physics Lecture Notes:
Current and Drift Velocity
http://www.flippingphysics.com/current-drift-velocity.html

Electric current, I, is defined as the derivative of charge with respect to time: $I \equiv \frac{dq}{dt}$

- $I \equiv \frac{dq}{dt} \Rightarrow \frac{\text{coulombs}, C}{\text{seconds}, s} = \text{amperes}, A$
    - Amperes are a base S.I. unit.
    - This is instantaneous current.
- $I_{\text{average}} = \frac{\Delta Q}{\Delta t}$
- Current is the electric charge of the charges which pass by a point in a current carrying wire divided by the time it takes for those charges to pass by that point.
- Current occurs when there is an electric potential difference across a wire. If there is no electric potential difference, current does not flow.
    - $\Delta V = 0 \Rightarrow I = 0$

Unless otherwise stated, electric current in this class is all considered to be *conventional current*:

- The direction of conventional current is the direction positive charges *would* flow.
- Reality is that, in most circuits, negative charge carries (electrons, e^-) move opposite the direction of conventional current.



Let's look at charges flowing in a wire:
Start with the average current over a small section of the wire Δx:

- $I_{\text{average}} = \frac{\Delta Q}{\Delta t}$
- $\Delta Q = (\text{\# of charge carriers})(\text{charge per carrier}, q)$
- Charge carrier density, n:
- $n = \frac{\text{\# of charge carriers}}{\text{volume}, V} \Rightarrow \text{\# of charge carriers} = nV$
  $\Rightarrow \Delta Q = nVq \;\; \& \;\; V = A\Delta x \Rightarrow \Delta Q = nA\Delta xq$
- $v_{\text{drift}} = v_d = \frac{\Delta x}{\Delta t} \Rightarrow \Delta x = v_d \Delta t$
    - Drift velocity, v_d: The average velocity of the charge carriers in a current carrying wire.
        - If the current is zero, the charge carriers are still moving, however, the average velocity of the charge carriers is zero.
        - v_d typically is quite low. On the order of 0.1 mm/s. The reason lightbulbs in a circuit (for example) turn on immediately when you flip the switch is because all the electrons are already in the wire. When you flip the switch, they all start flowing.
- $\Rightarrow \Delta Q = nAv_d\Delta tq \Rightarrow I = \frac{\Delta Q}{\Delta t} = \frac{nAv_d\Delta tq}{\Delta t} \Rightarrow I = nAv_dq$