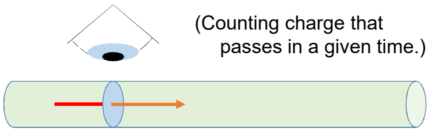
Electric Current
(rate of charge flow)

Average Current:

$$I_{\text{ave}} = \frac{\Delta Q}{\Delta t}$$

(Counting charge that passes in a given time.)

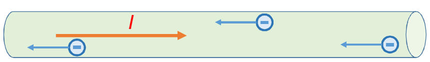


Electric Current
(rate of charge flow)

Average Current:

$$I_{\text{ave}} = \frac{\Delta Q}{\Delta t}$$

Positive current refers to flow of positive charges. If moving charges are negative (electrons), the current is in the opposite "direction".



Electric Current
(rate of charge flow)

Average Current:

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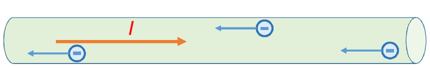
It is odd to speak of direction associated with current. Current is a scalar, but it does have a sign.



Electric Current
(rate of charge flow)

Average Current:

$$I_{\text{ave}} = \frac{\Delta Q}{\Delta t}$$

Instantaneous Current:

$$I = \frac{dQ}{\mathrm{d}t}$$

Unit of current is ampere (A) or amp. $1\text{A} = \frac{1\text{C}}{1\text{s}}$

Electric Current
(rate of charge flow)

Typical Currents:

• 100W light bulb	1A
• Automobile starter motor	200A
• Electronics	nA - mA

Current and Current Density

The current in a wire is the sum of all the charge per time passing through a cross-section of the wire.

$$\text{Current} = \frac{\text{charge}}{(\text{area})(\text{time})}(\text{area})$$

$$I = \int \vec{J} \cdot d\vec{A}$$

$\vec{J}$ is current density.

Current and Current Density

$$I = \int \vec{J} \cdot d\vec{A}$$

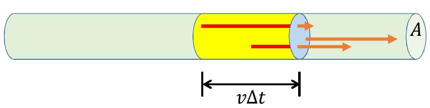
In many applications,
$\vec{J}$ is uniform and parallel to $d\vec{A}$.

$$I = \int \vec{J} \cdot d\vec{A} = J \int dA = JA$$

or

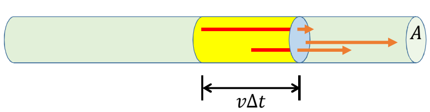
$$J = \frac{I}{A}$$

Current
A microscopic view



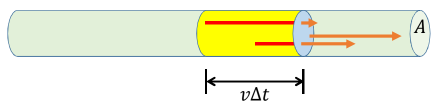
- Charges passing a given point in time, Δt, are those initially in a volume, $(v\Delta t)A$.

Current
A microscopic view



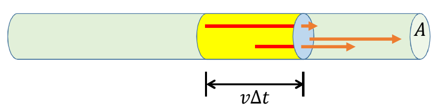
- Charges passing a given point in time, Δt, are those initially in a volume, $(v\Delta t)A$.
- The number of passing charges depends on the charge density, *n*. $N = n(v\Delta tA)$

Current
A microscopic view



- Charges passing a given point in time, Δt, are those initially in a volume, $(v\Delta t)A$.
- The number of passing charges depends on the charge density, *n*. $N = n(v\Delta tA)$
- The amount of passing charge depends on the charge per carrier, *q*. $\Delta Q = q(nv\Delta tA)$

Current
A microscopic view



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

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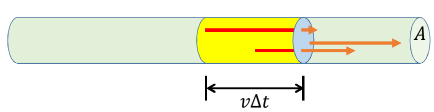
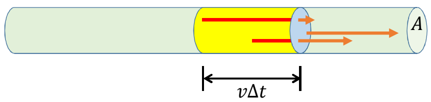
Current
A microscopic view



$$I = \frac{\Delta Q}{\Delta t} = nqvA \qquad J = \frac{I}{A} = nqv$$

(not quite correct)

Current Density Corrected



$I = \frac{\Delta Q}{\Delta t} = nqvA$ $\vec{J} = nq\vec{v}_d$

$\vec{v}_d$ is the average velocity, called drift velocity.

Current Density Corrected

$\vec{J} = nq\vec{v}_d$

Some free electron densities:

- Silver $n = 5.86 \times 10^{28}\ /\mathrm{m}^3$
- Gold $n = 5.90 \times 10^{28}\ /\mathrm{m}^3$
- Copper $n = 8.47 \times 10^{28}\ /\mathrm{m}^3$
- Aluminum $n = 18.1 \times 10^{28}\ /\mathrm{m}^3$

Example: Determine the drift speed of electrons in a 14-guage wire carrying a current of $0.5\mathrm{A}$. [Free electron density in copper is $8.47 \times 10^{28}/\mathrm{m}^3$ and 14-guage wire has a diameter of $1.63\mathrm{mm}$.]