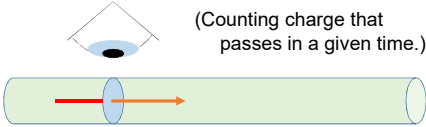


Electric Current
(rate of charge flow)

Average Current:

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

(Counting charge that passes in a given time.)




The diagram shows a green cylindrical wire. A blue circle represents a cross-section. An eye is positioned above the wire, looking through the cross-section. A red arrow points from left to right through the cross-section, representing the direction of current flow.

Electric Current
(rate of charge flow)

Average Current:

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

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




The diagram shows a green cylindrical wire. A red arrow labeled 'I' points from left to right, representing the direction of current. Three blue circles with minus signs and arrows pointing from right to left represent the movement of electrons.

Electric Current
(rate of charge flow)

Average Current:

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

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



The diagram shows a green cylindrical wire. A red arrow labeled 'I' points from left to right, representing the direction of current. Three blue circles with minus signs and arrows pointing from right to left represent the movement of electrons.

Electric Current
(rate of charge flow)

Average Current:

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

Instantaneous Current:

$$I = \frac{dQ}{dt}$$

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,

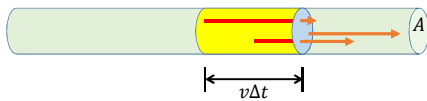
\vec{j} is uniform and parallel to $d\vec{A}$.

$$I = \int \vec{j} \cdot d\vec{A} = j \int dA = jA$$

or

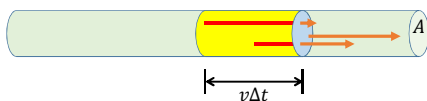
$$j = \frac{I}{A}$$

Current A microscopic view



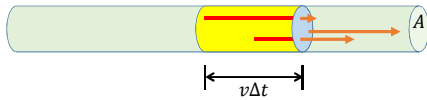
- Charges passing a given point in time, Δt , are those initially in a volume, $(v\Delta t)A$.

Current A microscopic view



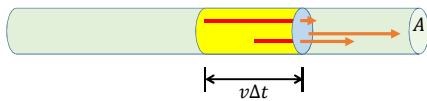
- Charges passing a given point in time, Δt , are those initially in a volume, $(v\Delta t)A$.
- The number of passing charges depends on the charge density, n . $N = n(v\Delta t)A$

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 . $N = n(v\Delta t)A$
- The amount of passing charge depends on the charge per carrier, q . $\Delta Q = q(nv\Delta t)A$

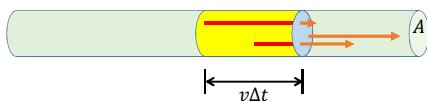
Current
A microscopic view



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

- The amount of passing charge depends on the charge per carrier, q . $\Delta Q = q(nv\Delta t)A$

Current
A microscopic view

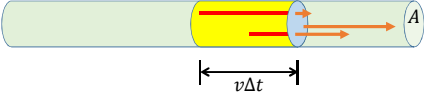


$$I = \frac{\Delta Q}{\Delta t} = nqvA$$

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

(not quite correct)


Current Density Corrected



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

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

Current Density Corrected



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

Some free electron densities:

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

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