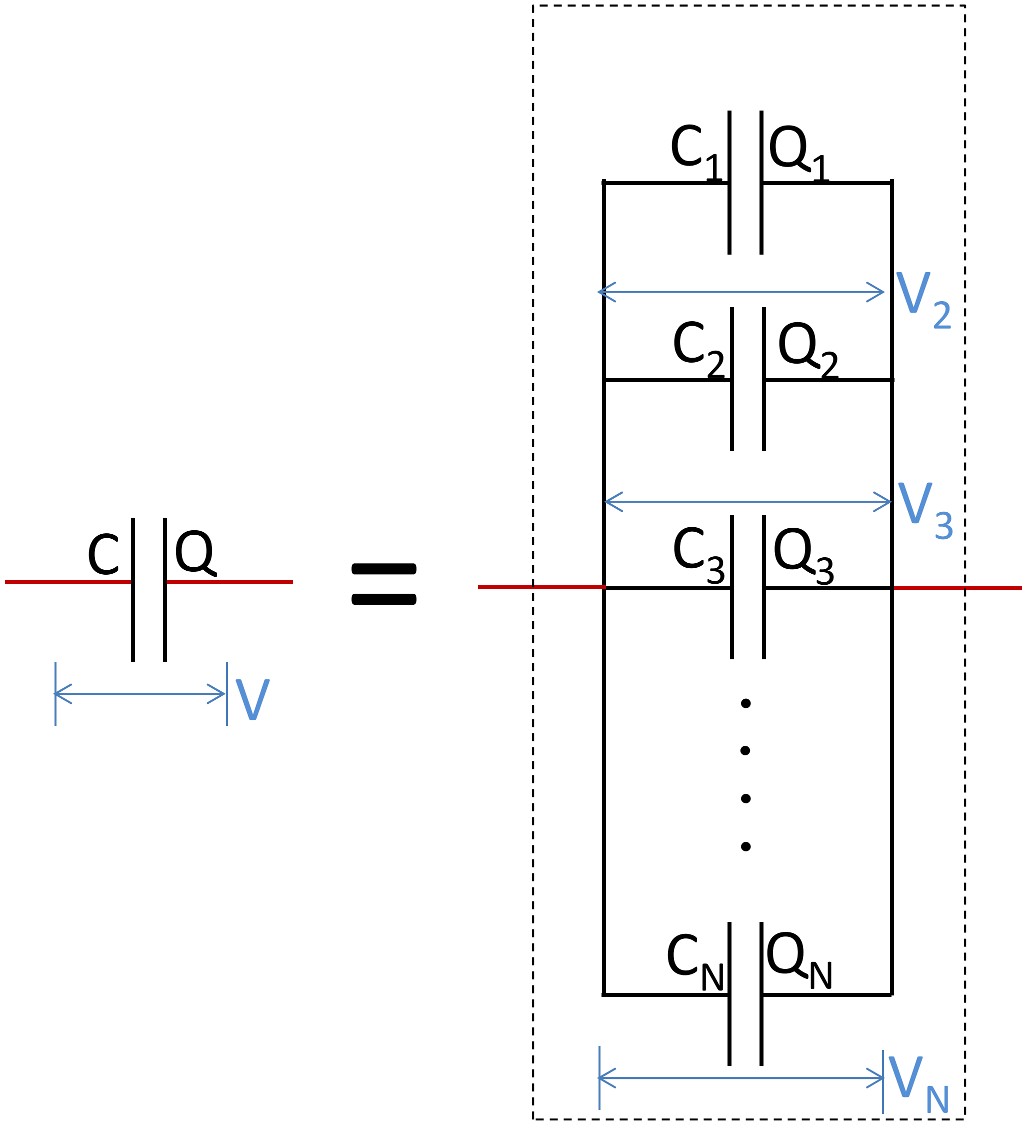
Capacitors in parallel and in series

Test 2 Next Wednesday (Oct 11)

1. Chapters 7, 8 (8.1-8.3).
2. You are not allowed to check your section number during the test. However, you will get 3 bonus points if you fill in your section number correctly.
3. 45 minutes sharp.
4. 4 multiple choices and 2 long problems.
5. Formula sheet provided.
6. Contact me before next Monday for prearrangement if you need special accommodation.

Connecting Capacitors in Parallel



$$C = C_1 + C_2 + C_3 + \cdots C_N$$

$$Q = Q_1 + Q_2 + Q_3 + \cdots Q_N$$

$$V = V_1 = V_2 = V_3 = \cdots V_N$$

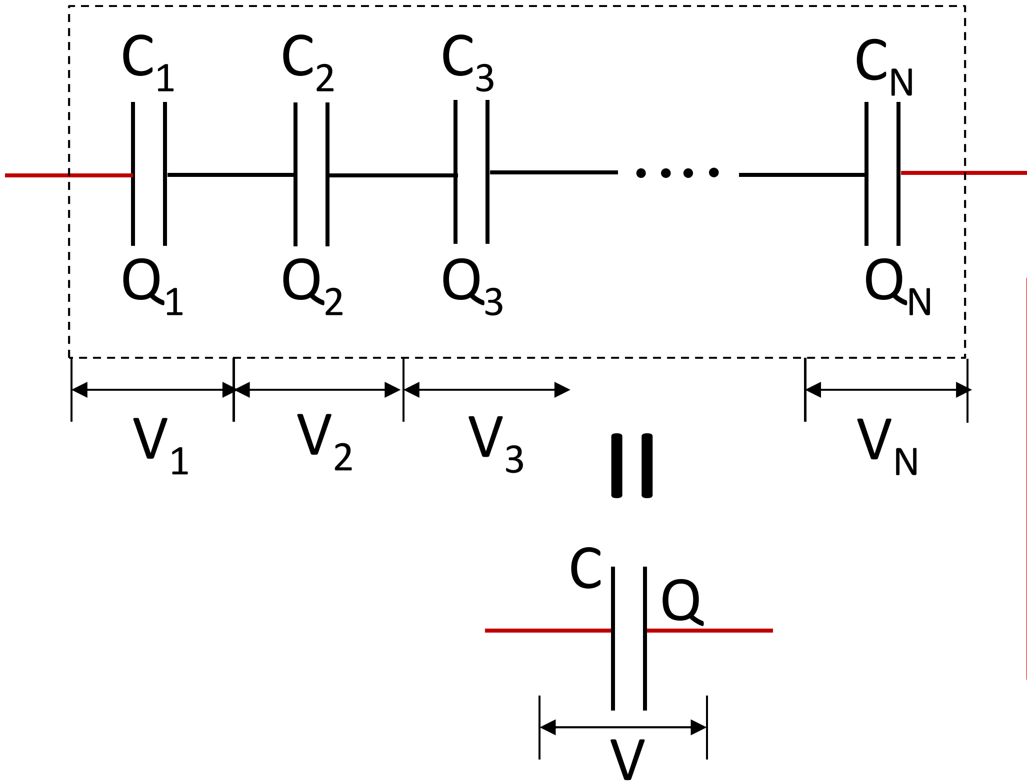
1. Potential difference across each individual capacitor is the same: (why?)

$$V = V_1 = V_2 = V_3 = \cdots V_N$$

$$\Rightarrow \frac{Q_1}{C_1} = \frac{Q_2}{C_2} = \frac{Q_3}{C_3} = \cdots \frac{Q_N}{C_N}$$

2. Charge stored in each individual capacitor should be different (unless they have the same capacitance).

Connecting Capacitors in Series



$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots \frac{1}{C_N}$$

$$Q = Q_1 = Q_2 = Q_3 = \cdots = Q_N$$

$$V = V_1 + V_2 + V_3 + \cdots + V_N$$

1. Charge stored in each individual capacitor is the same: (why?)

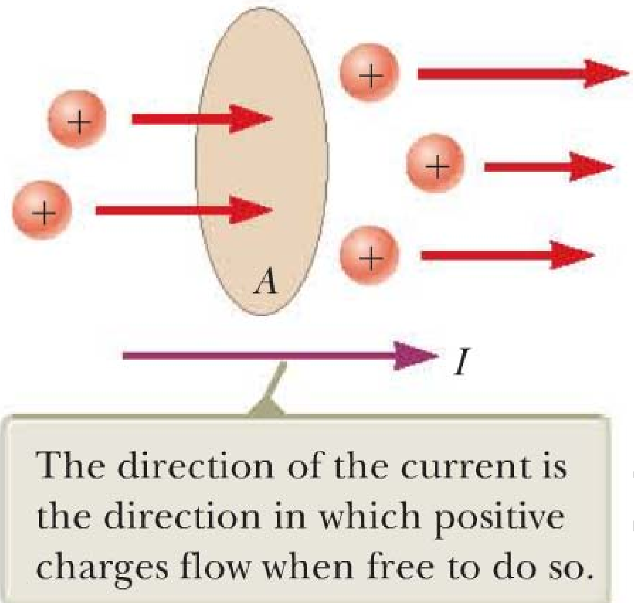
$$Q = Q_1 = Q_2 = Q_3 = \cdots = Q_N$$

$$\Rightarrow CV = C_1V_1 = C_2V_2 = C_3V_3 = \cdots = C_NV_N$$

2. Potential difference across each individual capacitor should be different (unless they have the same capacitance).

Class 19: Electric current and resistance, Ohm’s law

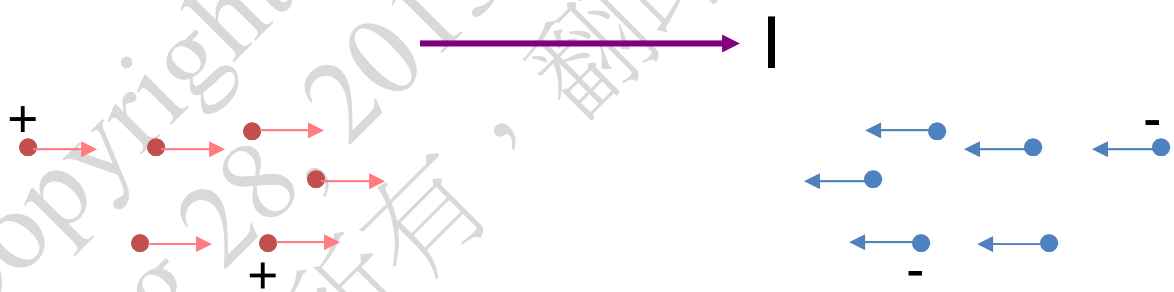
Current



If dQ is the amount of charge passes through A in a short time interval dt, current is defined as:

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

Units of current:
Ampere (A) ≡ C/s

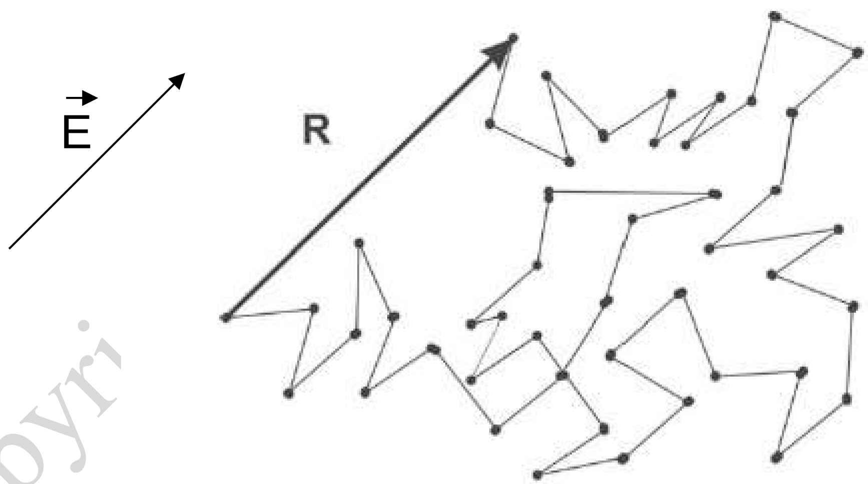


Electrically these two cases produce the same current, *but they can be distinguished with a magnetic field.*

Drifting velocity v_d

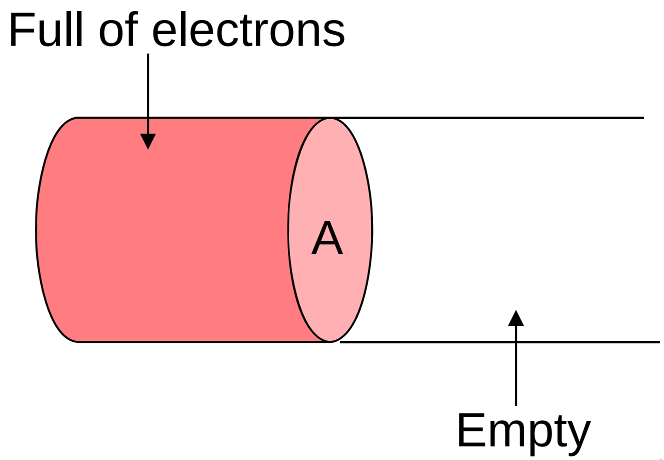
At any instant, electrons contributing to the current is moving very fast at about 10^6 m/s.

They also make collision with atoms and impurities very often, about 10^{14} times per second.

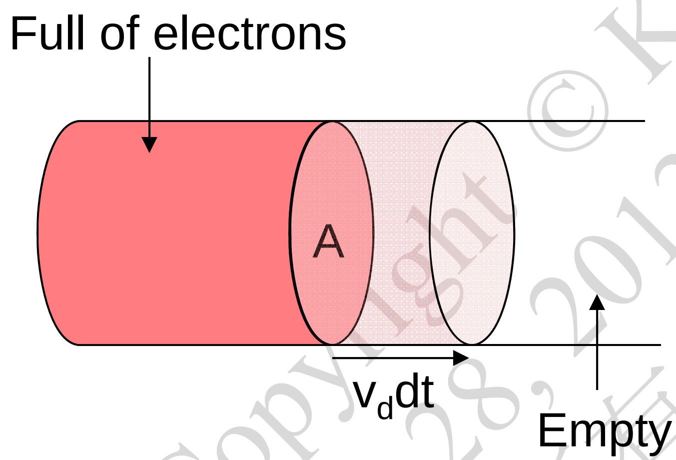


As a result, electrons drift very slowly along the electric field direction with a drifting velocity $v_d \sim 10^{-4}$ m/s.

Microscopic Model of Current



How many electron will pass the area A in a short time interval dt?



If n is the number of electrons per unit volume.

Number of electrons pass through area A
= n×volume = $n(v_d dt)A$

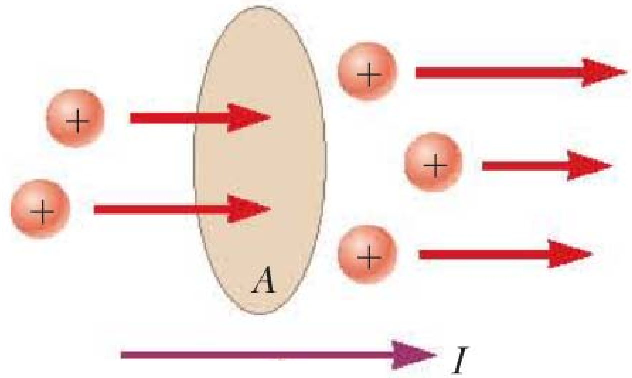
If the charge of electron is e.

Charge pass through area A is

$$dQ = ne(v_d dt)A$$

$$\therefore I = \frac{dQ}{dt} \Rightarrow \boxed{I = nev_d A}$$

Current Density and Ohm's Law (physics version)



Current density

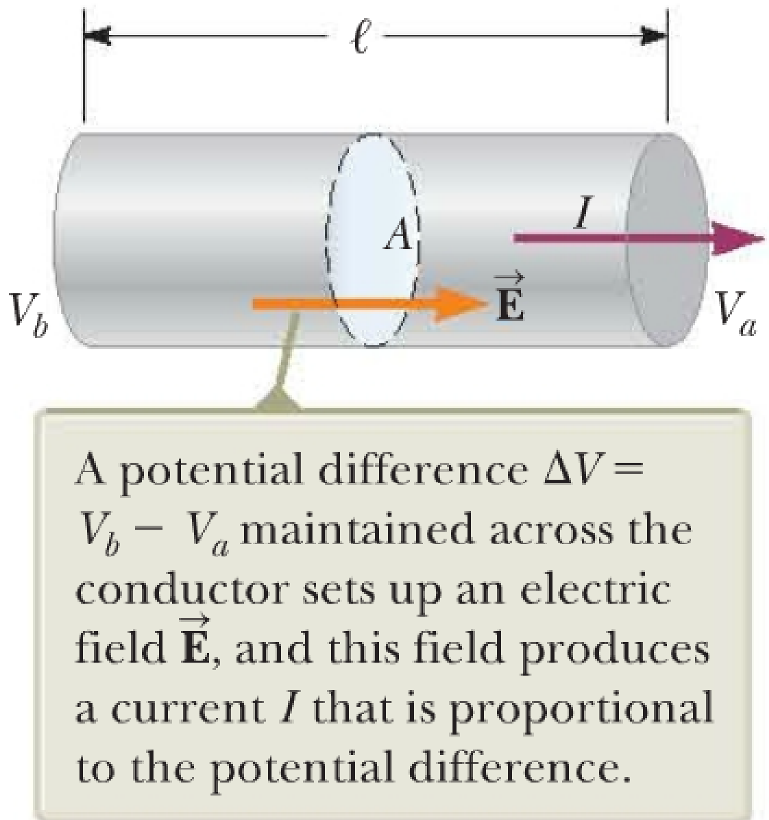
$$J = \frac{I}{A}$$

Ohm's Law (physics version)

$$\vec{J} \propto \vec{E} \;\Rightarrow\; \boxed{\vec{J} = \sigma \vec{E}} \qquad \text{or} \qquad \vec{J} = \frac{1}{\rho}\vec{E}$$

1. σ is called conductivity. *Do not confuse this with the surface charge density.*
2. ρ is called resistivity. *Do not confuse this with the volumetric charge density.*
3. σ and ρ represent the same information, $\boxed{\rho = \frac{1}{\sigma}}$.
4. σ and ρ are properties of materials.

Ohm's Law (electronics version)



$J \to I$ and $E \to V$

Ohm's Law:

$$J = \frac{1}{\rho} E \;\Rightarrow\; \frac{I}{A} = \frac{1}{\rho} \cdot \frac{\Delta V}{\ell}$$

$$\Rightarrow \Delta V = \left(\frac{\rho\,\ell}{A} \right) I$$

$$\Rightarrow \boxed{\Delta V = I\,R}$$

where

$$\boxed{R = \frac{\rho\,\ell}{A}}$$

1. R is called the resistance.
2. Units of resistance is Ohm (Ω). $\Omega \equiv V/A$