Announcements

- Homework
  - Video Homework 2 due tonight
  - Online Homework due on Wednesday
- Lab this week has computational and experimental parts
- Should wrap up Ch 14 on Wednesday
- Polling: `rembold-class.ddns.net`

Review Question

You peel a piece of tape off the table, positively charging it in the process. You then bring it near an object of unknown charge, and note that your tape is attracted to the unknown object. What is the charge of the unknown object?

A. Only Neutral

B. Positive or Neutral

C. Negative or Neutral

D. Only Negative

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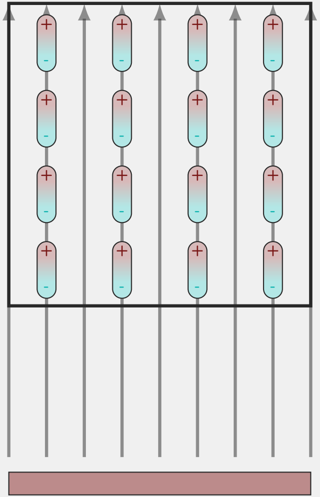

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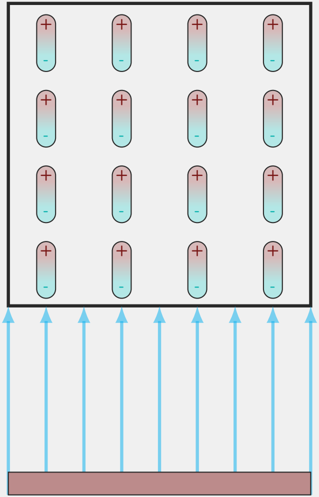

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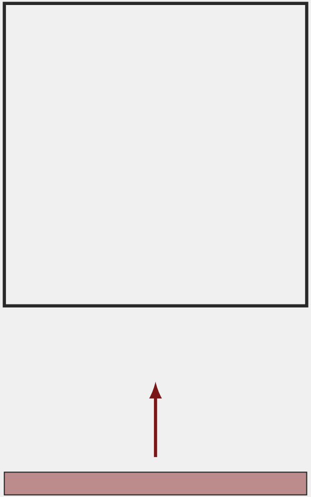
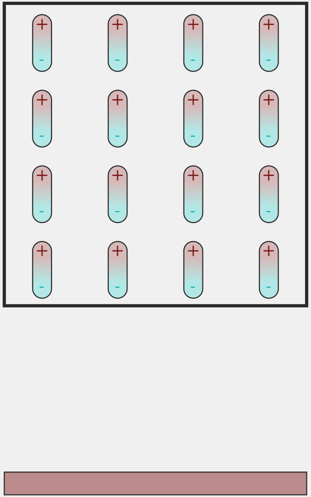
2. The electric field induced dipoles in the neutral material
3. The dipoles generate their own electric field, following our discussed conventions
4. This electric field interacts with the charged particle, causing attraction in all cases



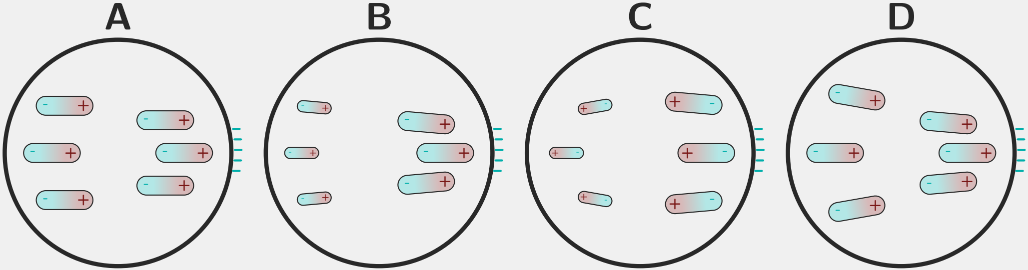
Polarizing Insulators



- Recall that insulators hold charges in place
- Charges don't have far to move, so it will happen quickly
- Excess charge will stay where it is on the insulator (and polarize accordingly)
- Technically, nearby induced dipoles should affect the strength of other nearby induced dipoles
  - We'll ignore that effect
  - Low-Density Approximation

Understanding Check

A solid plastic ball has negative charge spread over a small patch of surface. Which diagram best shows the polarization of the molecules inside the ball?



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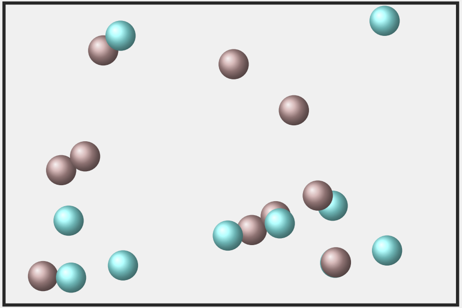

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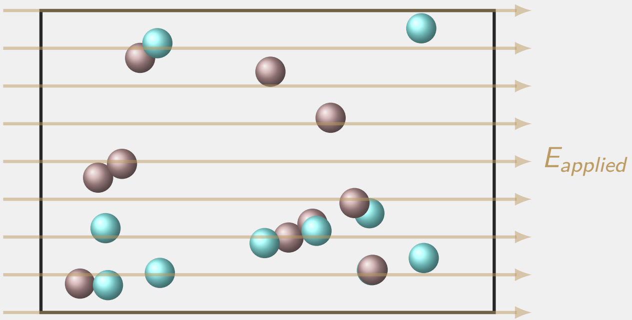

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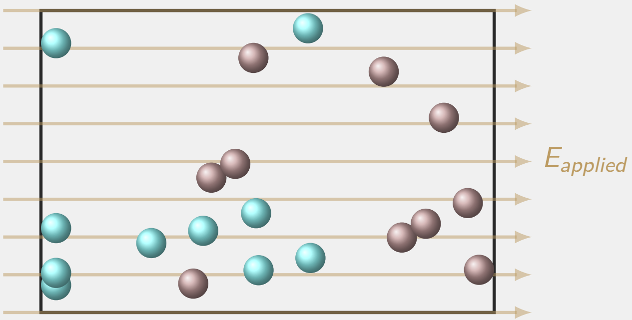

Polarizing Conductors

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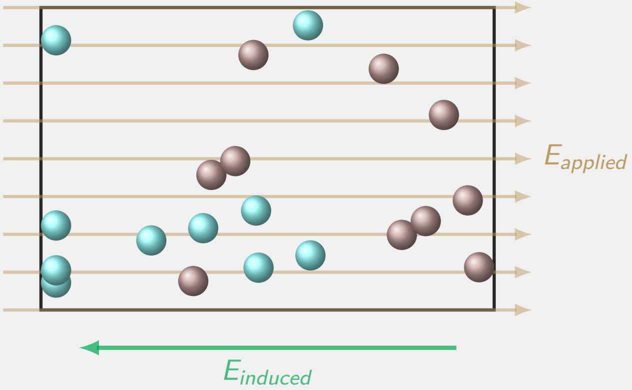
- Electric field pushes positive charges one direction, negatives the other
- Buildup of charge creates its own induced electric field pointing the opposite direction



True Neutral: Gaining Equilibrium

- Applied electric field moves charges out of balance
- Displaced charges create counter electric field
- At some point fields should cancel
- At equilibrium:

$$\vec{\mathbf{E}}_{net} = 0$$
$$\Rightarrow \vec{\mathbf{F}}_{net} = 0$$
$$\Rightarrow \bar{v} \stackrel{?}{=} 0$$

- Flow of charges stops once equilibrium is reached
  - Why not continue on at constant speed? (Newtons 1st)

Electron Bumper Cars

- A constant electric field does *not* yield a constant acceleration of the charge
- A molecular/atomic "drag" present
  - Mainly due to the amount of other molecules/charges in the way
  - Imagine a crowd entering and exiting a subway simultaneously
- Charges end up moving at the drift speed:

$$\bar{v} = uE_{net}$$

  where $\bar{v}$ is the average drift speed and u is the *mobility* of the charge
- Mobility is generally a measured property of the material or solution
  - But can we theoretically predict it?

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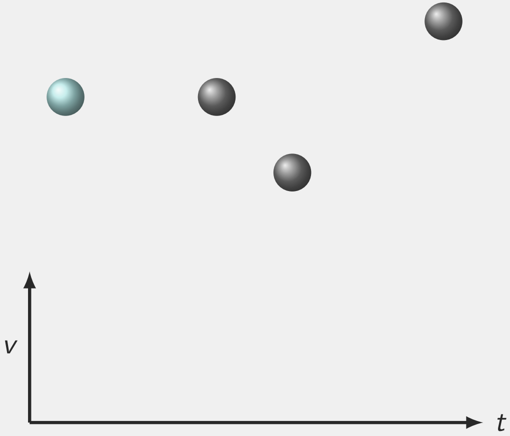

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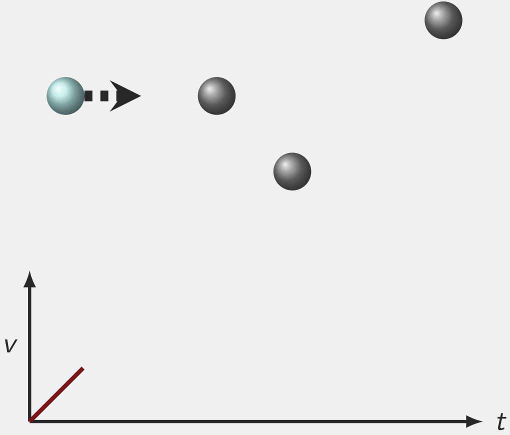

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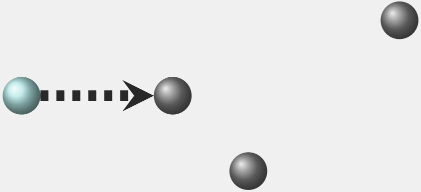

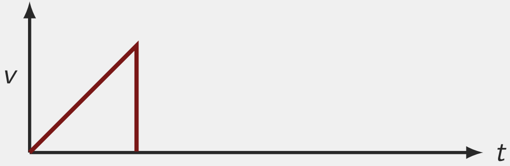

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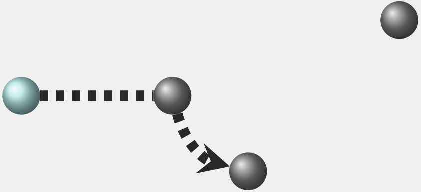

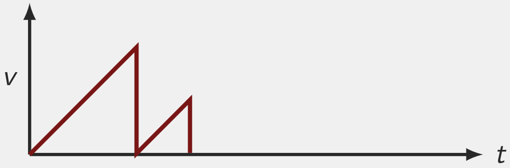

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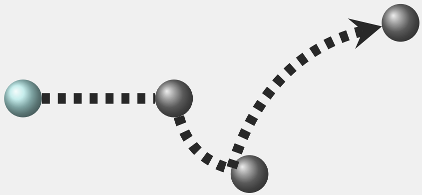

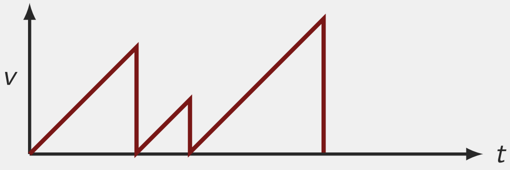

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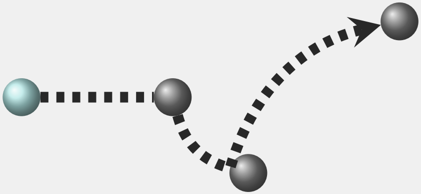

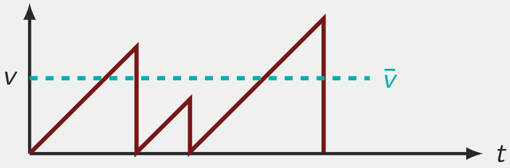

Mobility and Conductor Properties

- Use momentum principle to find a single velocity before collision:

$$\Delta\vec{\mathbf{p}} = \vec{\mathbf{F}}_{net}\Delta t$$

$$\vec{\mathbf{p}}_f - 0 = eE_{net}\Delta t$$

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- Comparing this to our earlier equation:

$$u = \frac{e\overline{\Delta t}}{m_e}$$

where $\overline{\Delta t}$ is the average time between collisions and depends on the material and temperature

A Golden Example

Gold has a mobility of around $4.5 \times 10^{-3}\,\mathrm{C\,s/kg}$. A gold wire has a $100\,\mathrm{N/C}$ electric field applied across it. What is the average time between collisions and how quickly are the electrons moving on average?