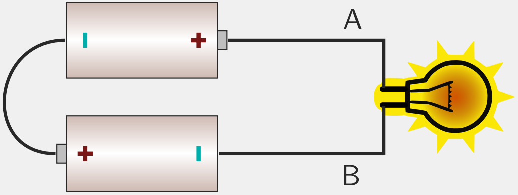
Announcements

- Homework
  - Video Homework 6 due tonight
  - Webwork will be due on Wednesday
- Exam 2 is a week from Friday
- Lab this week on Magnetic Dipoles
- Polling: `rembold-class.ddns.net`

Consider the below circuit. You've connected all the wires so that *the light is shining* brightly. How do you think the current will compare section B vs in section A?

A. $I_B > I_A$
B. $I_B = I_A$
C. $I_B < I_A$
D. $I_B = 0$



Water Works

What if you instead considered a stream of water flowing past and turning a water wheel. This is another form of current. Discuss with your neighbors if this is the same situation as the electric current. Would you say that the water current above and below the water wheel differs?

What about traffic? Say you have traffic moving past a crash site such that it narrows to a single lane. How does the traffic "current" compare normally to the "current" in and around that single lane?

Compressibility

- Traffic flow is compressible (up to a point)
  - Cars can fill in gaps between other cars
  - Means that when the road narrows, traffic slows down
- Electron current (and water) is incompressible
  - The flow must go on!
  - Narrowing the pipe just forces the electrons (or water) through faster
    - Think putting your finger over a portion of your hose
  - Electronically, this is why the drift speed depends on the cross-sectional area
  - Also explains why we don't get a build up of charge (or water) at various locations

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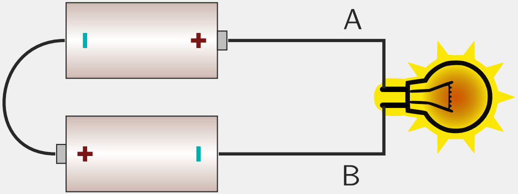


Circuit Conservation

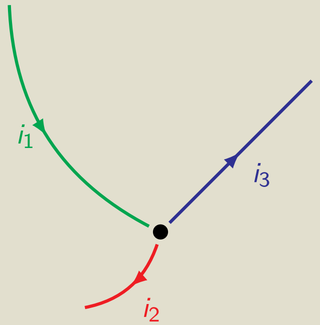
- In considering the circuit as the system, energy may be converted to thermal or some other energy type by resistive (frictional) forces
- Charge can neither be created or destroyed though
- So current must be conserved throughout the circuit.

Current Node Rule

In the steady state, the current entering a node (junction) in a circuit is equal to the current leaving that node.

Loopy Example

Suppose we have a portion of a circuit as shown below, where $i_1 = 500$ electrons/s and $i_2 = 200$ electrons/s. What is the electron current i_3 and is it moving toward or away from the junction?



Solution: 300 electrons/s away

Understanding Check!

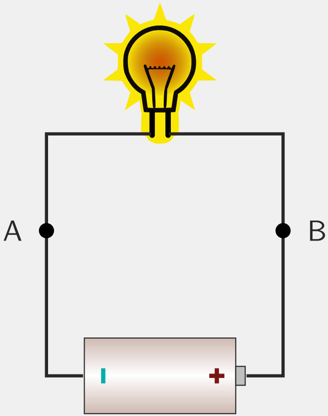
The circuit to the right is completed so that it is in a steady-state. What can be said about the magnitude of the *electric field* in the circuit wire?

A. It is 0.

B. It is the same everywhere.

C. It is greater at point A than point B

D. It is greater at point B than point A



Solution: It is the same everywhere.

A Summary thus far

- Current must be conserved throughout the circuit
  - “What goes in must come out.”
  - Drift velocity increases in narrow wires
- Energy might be transformed from one form to another by elements of the circuit
- The electric field points in the direction of the current and is uniform across the wire

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- Need an electric field to drive current
- Electric fields originate from charges
- Where are the excess charges here?
  - Can't be inside the conductor. Equal numbers of electrons and holes.

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- Where are the excess charges here?
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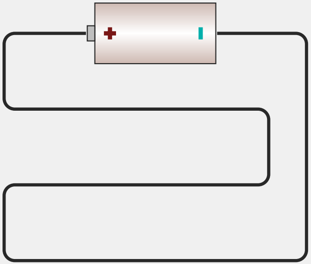
  - The light?
  - The battery?
  - Where else is there even?

Is it the Battery?

- Battery acting like a dipole with positive and negative sides



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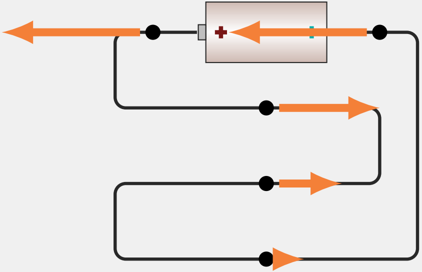

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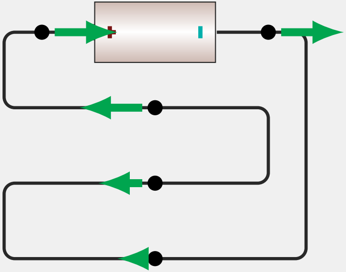
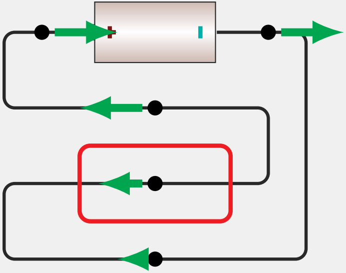
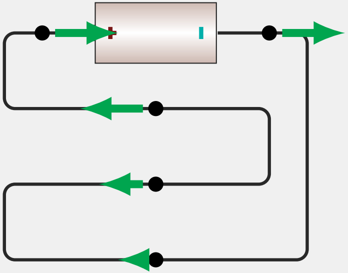


Is it the Battery?

- Battery acting like a dipole with positive and negative sides
- Would give a corresponding electric field: 
- Electric field would drive electron drifts: 
- Doesn't always point in the correct direction!
- Can't be just the battery!



Some Insight



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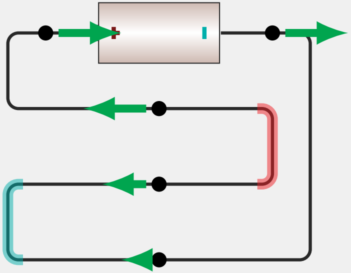

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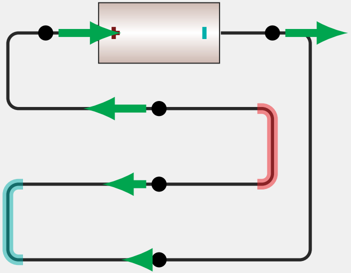

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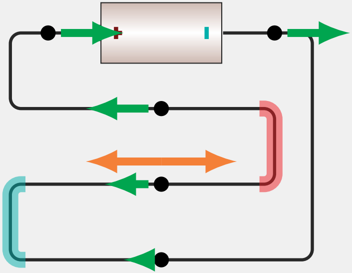

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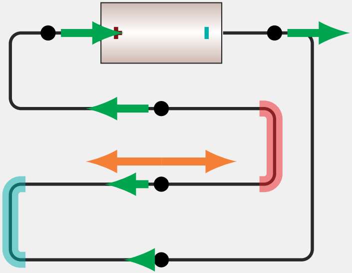

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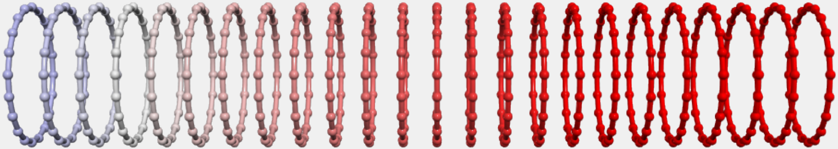
- Buildup will continue until $E_{bend} > E_{battery}$, at which point electrons would stop getting trapped
- Happens throughout the circuit, until all regions provide the needed net electric field

Charge Distributions

- So charge is dispersed along the surface of the wire
- What distribution would get us uniform electric fields on the inside?

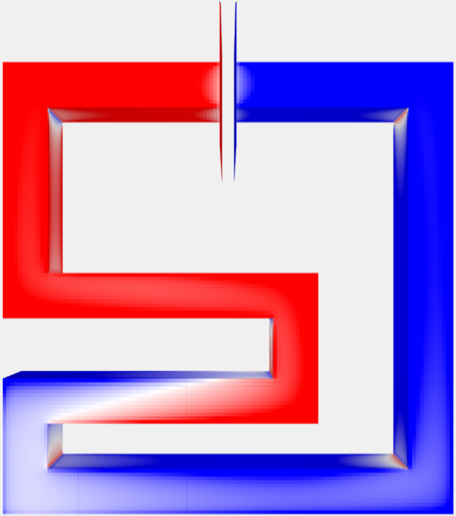


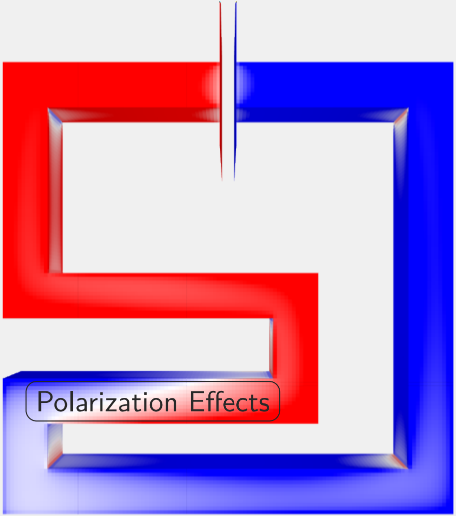
- Amount of charge on wires for normal currents is very very small!

Not Always Negligible

Link: here

Wrapping Up Charge Distributions




Polarization Effects

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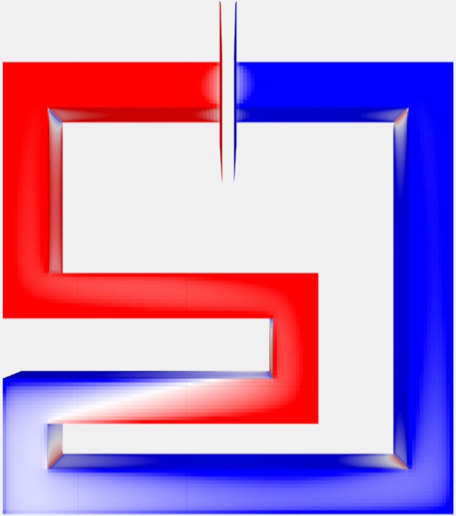

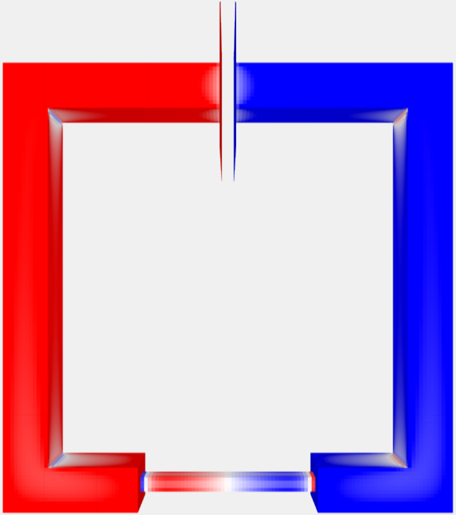

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