Announcements

- Welcome back all! Hope break was good and you are staying healthy!
- Homework reminders
  - Nothing due tonight
  - Webwork 16 due on Wednesday
- We'll discuss Test 2 plans in a moment
  - Doing something a bit different here
  - Rubric and some examples will be posted by Tuesday
- Friday is last day to choose to take the class C/NC
- Almost caught up with the VHW grading!
- Polling: `rembold-class.ddns.net`

Test 2: I made up my mind!

- Due: email to me by midnight Friday evening
- You are going to write 4 test questions for me!
  - Should be based off section's learning objectives. I'll gather these together for you.
  - Two separate pdfs to submit:
    - The test itself. All 4 questions, no solutions. Any necessary visuals or diagrams. Just like I would give you on test day.
    - The solution key, with your *worked out* solutions for each problem. Also, a quick explanation of what specific learning objective(s) the question is covering.
  - Questions should be your own. You can be inspired or do something similar to previous video hw, hw, or questions from the book, but the ultimate product here needs to be of your own devising.
  - At least one question should have a visual, diagram, or graphical component to the question.
- Scoring will be based on how well my solutions agree with yours, as well as how well your question met the desired objective.
- EC for tying all the questions together with a theme!

Warm Up!

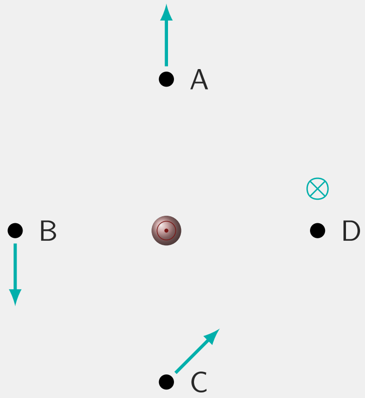
A proton is traveling out of the page, toward you. 4 other protons are individually positioned an equal distance away and are traveling at the same speed in different directions. How does the magnitude of the magnetic force each experiences from the center proton compare?

A) $A = B = D > C$

B) $A = D > C > B$

C) $A = B > C > D$

D) $A > C > B > D$



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- In current carrying wires, we replace qv with $\mathrm{I}\Delta\vec{\ell}$

$$\Rightarrow \Delta\vec{\mathbf{F}}_{mag} = \mathrm{I}\Delta\vec{\ell} \times \vec{\mathbf{B}}$$

  - So wires also both create magnetic fields and feel forces due to magnetic fields!
  - Does mean two wires though can have mutual forces between them

Suppose you have two wires in a power line, each carrying 100 A and separated by a distance of 1 m. If the current of both wires is flowing in the same direction along a 10 m span, what force do the wires feel? Is it attractive or repulsive?

With our powers combined. . .

- Can now talk about forces on objects traveling through both electric and magnetic fields
- Both yield vectors, so we can just add their effects!

The Lorentz Force

The Lorentz force is just the combination of the forces due to electric and magnetic fields:

$$\vec{\mathbf{F}} = q\vec{\mathbf{E}} + q\vec{\mathbf{v}} \times \vec{\mathbf{B}}$$

Picky Velocities

Suppose we have a $2\,\mathrm{T}$ magnetic field pointing out of the board at us ($\hat{\mathbf{z}}$) and a $500\,\mathrm{V/m}$ electric field pointing upwards ($\hat{\mathbf{y}}$). We are shooting protons horizontally from the left to the right. At what velocity must they be fired to ensure that they experience no deflection along their path?

Understanding Check

Suppose you have a magnetic field that looks like $\langle 5, -5, 0 \rangle$ T and an electric field of $\langle 10, 20, 30 \rangle$ V/m. At some time, a 1 C particle is traveling with velocity $\langle 2, 2, 0 \rangle$ m/s. What force does the particle feel due to the combined electric and magnetic fields?

A. $\langle 10, 20, 50 \rangle$ N
B. $\langle 10, 50, 20 \rangle$ N
C. $\langle 20, 10, 30 \rangle$ N
D. $\langle 10, 20, 10 \rangle$ N

Entering the Hall

- Lets return to our image of a simple circuit
  - Battery creates a charge gradient
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  - Current flows along electric fields
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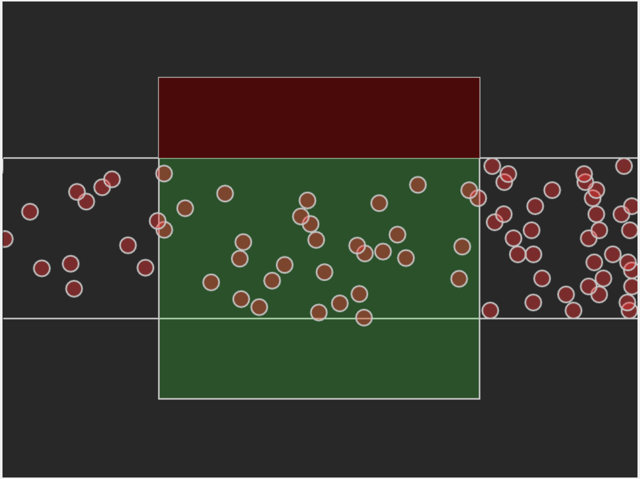
  - Will result in an *extra* build-up of charge on the top and bottom of the wire

Behold Thine Hallway



The Math behind the Hall

- Top and bottom charged opposite implies an electric field *perpendicular* to the one driving the current
- In steady state, the force of that electric field must counter the force of the magnetic field:

$$q\bar{v}B = qE_\perp \qquad \Rightarrow \qquad E_\perp = \bar{v}B$$

- Electric fields mean we could measure a change in voltage!

$$\Delta V_{Hall} = E_\perp h = \bar{v}Bh = \left(\frac{\mathrm{I}}{|q|nA}\right)Bh$$

where h is the cross-sectional distance.

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  - Based on the sign of the voltage, we can determine the principle charge carriers!
    - Electrons would still feel a magnetic force in the same direction
    - Would charge the top of the wire *negative*
    - Flips the sign of our voltage measurement!

An Effective Example

Say we have a square wire which measured 1 mm per side and had a current of 3 A flowing horizontally through it. When we place it in a 1 T magnetic field, we measure a potential difference of 0.3 μV across the top of the wire to the bottom of the wire. What is the charge density of the wire?