Announcements

- Homework
    - Nothing due tonight!
    - WebWorK will be due on Wednesday as per usual
- Lab this week on magnetic forces
- I'm getting going through my completion/grading of all your tests. Hopefully I'll have some feedback for you by the end of the week
- I'm aiming to get updated grade reports (with at least what I have) posted soon
- Polling: `rembold-class.ddns.net`

Review Question

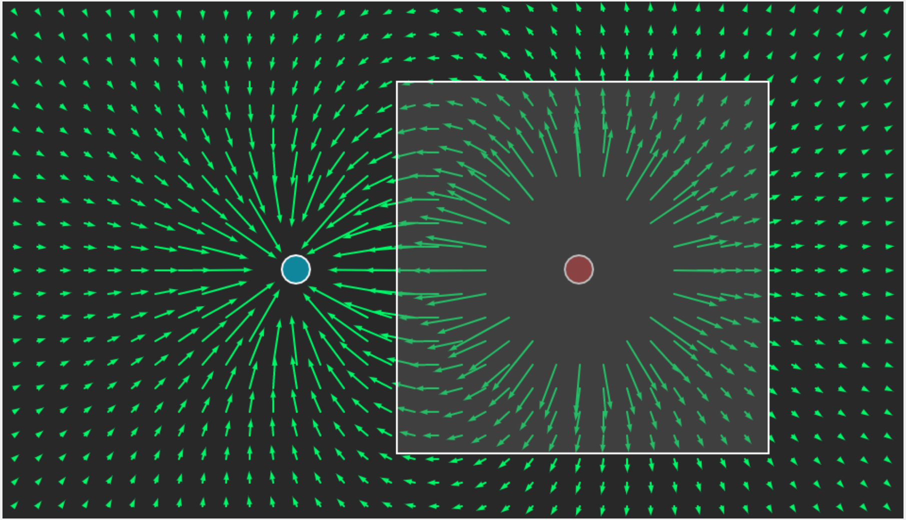
Suppose I wanted to power a 25 W lightbulb which had a resistance of 100 Ω. How fast would I need to move a 50 cm bar to drive a motional current through the bulb and light it up to peak brightness? You are moving the bar through a typical low magnetic field situation, where $B = 1\,\mathrm{mT}$.

A) 500 m/s
B) 50 km/s
C) 100 km/s
D) 2500 km/s

Solution: 100 km/s

Back to the Origins

- Thus far this semester, we've focused on how sources *create* electric or magnetic fields
    - Charges particle create electric fields
    - Moving charges create magnetic fields
- We've had lots of practice going from sources to the surrounding fields
- Now we want to go backwards
    - What can fields tell us about their source charges?
    - Given a configuration of fields, can we determine what source created those fields?

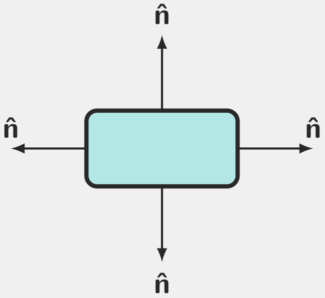


Rules of Thumb

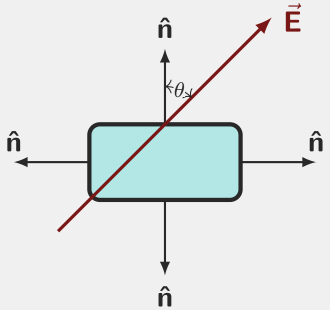
- Playing around with our mysterious box, a few things become evident:
  - If a positive charge is enclosed, we have mostly arrows pointing out of the box
  - If a negative charge is enclosed, we have mostly arrows pointing into the box
  - If no charge is enclosed, we have a mixture
- Electric Field can't just disappear: it comes out of positive charges and goes into negative charges
  - Boxes with positive charges must have more field lines pointing out
  - Boxes with negative charges must have more field lines pointing in
  - When no charge is enclosed, the amount of arrows pointing in must equal the amount coming out!
- Basically just accounting but with electric fields
- **Need** closed surfaces. Otherwise your accounting has huge holes in it!

In a state of Flux

- We need to quantify this behavior
- Need a way to measure how much is going in (or out)
- Should account for:
  - Size of box
  - Strength of electric field
  - Orientation of field (in or out?)
- What direction is “out”?
  - In the direction *normal* to the surface



The Electric Flux



- We only want the part of the electric field coming out or going in
  - Can throw away the part parallel to the surface
  - Means we want to keep an $E\cos\theta$

Electric Flux

We define the electric flux to be

$$\Phi_{el} = \sum_{surface} \vec{\mathbf{E}} \cdot \Delta A \hat{\mathbf{n}} = \sum_{surface} E \Delta A \cos\theta$$

where $\vec{\mathbf{E}}$ is the electric field and ΔA is a small bit of area. Units are V m.

Fluxy Example

Was the is electric flux through the top of a $1\,\mathrm{m} \times 1\,\mathrm{m} \times 1\,\mathrm{m}$ level cube if the electric field is $\langle 3, 5, 7 \rangle$?

Solution: $5\,\mathrm{V\,m}$

Fluxier Example

Two rectangles, each with dimensions of $10\,\mathrm{cm} \times 5\,\mathrm{cm}$ are leaned against one another to create an equilateral triangle in a region with a constant electric field of $\langle 5, 3, 0 \rangle\ \mathrm{V/m}$. What is the net flux through both rectangles?

Solution: $15\,\mathrm{mV\,m}$

The Law of Gauss

- Recall that our objective was to quantify how the electric field passing through a surface relates to the charge inside that surface

Gauss's Law

The electric flux through a surface is related to the amount of charge interior to the surface by

$$\oint \vec{\mathbf{E}} \cdot \hat{\mathbf{n}} dA = \Phi_{el,closed} = \frac{q_{enc}}{\epsilon_0}$$

where q_{enc} is the total enclosed net charge.

- For you math folk, this is directly related to the divergence theorem
- While neat, Gauss's law only really helps us in particular cases
- Notice the circle on the integral sign: it *must* be a *closed* surface!