# Announcements

- Homework
  - Webwork 15b due tonight!
  - No Webwork or Video HW over break!
- We'll determine Test 2's date in a moment
- Today we start a bit on Chapter 20
  - Will NOT be on Test 2
- Polling: `rembold-class.ddns.net`

# Feedback Poll!

On what day would you prefer to have Test 2?

A) Wednesday, April 1

B) Friday, April 3

**Solution:** Friday won!

# Ideal Battery

Suppose you have a $9\,\mathrm{V}$ battery which, when hooked up to a $100\,\Omega$ resistor only creates a current of only $75\,\mathrm{mA}$. What is the internal resistance of the battery?

**Solution:** $20\,\Omega$

# Review Question

Two identical batteries with an emf of 6 V are hooked up in series to a 10 Ω and 50 Ω resistor. Measuring the current gives a value of 194 mA. What is the internal resistance of each battery?

A. 300 mΩ

B. 928 mΩ

C. 1.85 Ω

D. 30 Ω

**Solution:** 928 mΩ

# Measuring Circuits

- Want our measurements to disrupt the circuit as little as possible
- Measuring Current
  - Need an ammeter
  - Requires resistance to be small to not disrupt circuit
    - Else less current will flow, defeating the purpose
  - Must hook into series with circuit
- Measuring Voltage
  - Need a voltmeter
  - Requires resistance to be large to not disrupt circuit
    - Else a large portion of current will flow through the voltmeter instead of the circuit
  - Must hook into parallel with circuit

Upcoming:

# Chapter 20: Magnetic Force

# Understanding Magnetic Force

- We've talked about magnetic fields, and how they interact with currents

$$\vec{\mathbf{B}} = \frac{\mu_0}{4\pi} \frac{q\vec{\mathbf{v}} \times \hat{\mathbf{r}}}{r^2}$$

or

$$\Delta\vec{\mathbf{B}} = \frac{\mu_0}{4\pi} \frac{\mathrm{I}\Delta\vec{\ell} \times \hat{\mathbf{r}}}{r^2}$$

- Haven't yet related them to our favorite thing:

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Force!

# Demo

- Questions to ponder:
  - What direction are the charges moving?
  - What direction is the magnetic field?
  - What direction is the force?
  - Are stationary charges feeling a force?

# The Magnetic Force

## The Magnetic Force

We define the magnetic force as

$$\vec{\mathbf{F}}_{mag} = q\vec{\mathbf{v}} \times \vec{\mathbf{B}}$$

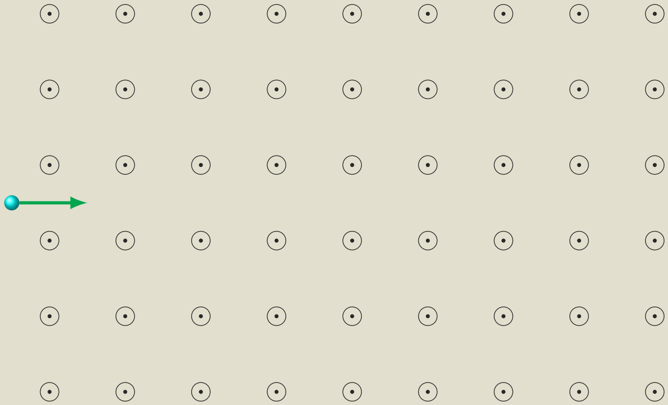
where $q$ is the charge (including sign!), $\vec{\mathbf{v}}$ the velocity and $\vec{\mathbf{B}}$ the magnetic field

- No charge or no motion? No force for you!
- Force is always perpendicular to the velocity: No work done!
- Only changes the direction of motion

$$\left|\frac{\mathrm{d}\vec{\mathbf{p}}}{\mathrm{d}t}\right| = |qvB| \sin\theta$$

# Qualitative Deflection

Suppose we are firing electrons from the left to the right through a magnetic field that points out of the board. Will the path of the electron deflect up or down?



**Solution:** Up!

# Traveling in Circles

- If the region of the magnetic field is large enough, can turn a complete circle!
- Actually the easiest form of motion of evaluate
- Recall from last semester that, for circular motion:

$$\left|\frac{\mathrm{d}\vec{\mathbf{p}}}{\mathrm{d}t}_\perp\right| = p\left(\frac{v}{R}\right)$$

  where $p$ is the momentum, $v$ the velocity and $R$ the radius.
- Convenient to write in terms of the angular velocity, $\omega = \frac{v}{R}$
- For slow moving objects then:

$$\begin{aligned} |q|vB\sin(90^\circ) &= \frac{mv^2}{R} \\ |q|B &= m\omega \\ \Rightarrow \omega &= \frac{|q|B}{m} \end{aligned}$$

# Rotation Time

Suppose we took the same example as previously but set the strength of our magnetic field to be $1\,\mu\mathrm{T}$ and the electron was moving at $50\,\mathrm{m/s}$. How long will it take the electron to complete one rotation?

**Solution:** About $36\,\mu\mathrm{s}$