Superconductivity

THIS IS LIKE SUPERMAN FOR CONDUCTORS.

Pi Day!!!

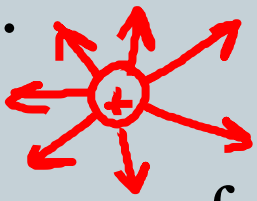
- On Wednesday of next week.
- It's the day after the test.
- Review test and celebrate summer birthdays.
- Einstein Masks
  - If caught wearing (not putting on) an Einstein mask other teachers might give you a slip saying you participated in this day. If you turn it in it is worth 1 point each. Can be turned in either 3rd or 4th quarter.

Quiz #3: Electrostatics

1. What is one characteristic of a conductor? Example of a conductor? Cubic Crystalline Structure, Free electrons, current flows. Example: Any Metal
2. What is one characteristic of an insulator? Example of an insulator? Complex Structure, no current flow. Example: Glass, Plastic, pure water
3. Charged objects attract neutral objects by the process of Polarization.
4. How do we explain being able to hold an iron nail between the two ends of the Wimshurst generator and not have to worry about being shocked because the ark doesn't travel through us? The Path of Least Resistance

Quiz #3: Electrostatics

5. Where is the charge of a charged object located?
   The outside surface
6. Draw the electric field of a proton.



7. What is the force between two charges of 1C and 5μC that are separated by 3 meters?

$$F_e = (9\times10^9)\frac{(1\,C)(5\times10^{-6}\,C)}{(3\,m)^2} = 5000N$$

8. Who improved and popularized the electrophorus?
   Alessandro Volta
9. Extra Credit: Who is $F_e=Kq_1q_2/d^2$ named after?
   Charles-Augustin de Coulomb

Make-up or Improve Quiz Score

- Write a paragraph (roughly 5 sentences) about Coulomb and his contributions to electricity and magnetism. You can also include some of his other contributions. Max 10 sentences. Maximum points is 10. Due Monday March 12th.

Superconductors

- Conductors and Insulators (very specific materials) cooled to a temperature such that these materials exhibit ZERO resistance to current running through it.
- Combining this idea with Lenz's Law we get a very neat effect known as the Meissner Effect.
  - The superconductor opposes magnetic flux so much that it is equal and opposite magnetic field.
  - Magnets levitate over it.

History of Superconductors

- 1911, ONNES (Holland), Hg at 4.2K (liquid He)--Nobel Prize 1913
- 1933, MEISSNER EFFECT explained: diamagnetism
- 1957, BCS Theory: Cooper pairs of electrons--Nobel Prize 1972
- 1986, IBM (Switzerland), LaBaCuOx at 35K--Nobel Prize 1987
- 1987, CHU (Univ of Houston), YBa2Cu3Ox at 92K (use liquid N2)
- Today, research has achieved 150K (-190F) superconductivity

Demo: Meissner Effect

- Liquid Nitrogen cool a superconductor that exhibits no magnetic properties before being cooled.
- Once cooled it allows the magnet to levitate.

Superconductor videos

- https://www.youtube.com/watch?v=Ws6AAhTw7RA
  - Straight to the demonstration we can't afford.
- https://www.youtube.com/watch?v=Z4XEQVnIFmQ
  - Better explanation of the physics but longer video.

Physics of Today's Demo

- Electrons pair up (Cooper pairs) if below critical current and critical temperature
- PLACE nd MAGNET NEAR SUPERCONDUCTOR
- INDUCES CURRENT FLOW IN SUPERCONDUCTOR (Faraday)
- CREATES MAGNETIC FIELD (Oersted)
- OPPOSES THE APPLIED (nd) MAGNETIC FIELD (diamagnetism)

Switching Gears

- Coulomb's Law Problem (Review for test)

1 μC 5 μC

30 cm

$$F_e = \left(9 \times 10^9 \frac{N m^2}{C^2}\right) \frac{(1 \times 10^{-6} C)(5 \times 10^{-6} C)}{(0.3 m)^2}$$

$$= 0.5 N$$