Maxwell's Equations in a Plastic Cup

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Motivation:

Physics in Entertainment and The Arts Lab

- Design Constraints
  - Core course for non-science majors
  - 500 non-science students per year
  - Explore the physics of everyday objects
    - a few basic ideas
    - minimal technical equipment
  - Focuses on:
    - sound and light waves
    - how waves shape music and the visual arts
  - Reports easy for students to use and for TAs to grade
- Examples of lab activities
  - Frequencies and standing waves
  - Frequency content of musical instruments and its influence on sound perception
  - **Maxwell's equations and making a speaker out of a plastic cup and wire**
  - Frequency content of light sources and its influence on color perception

An Electric Current Gives Magnetic Force

- Put a magnet into the center of the coil and observe the magnet's response

Sample Observations:

Current Pattern	Voltage	Frequency	Describe push or pull on magnet	Describe any sound heard
DC (constant)	0 Volts	0 Hz		
DC (constant)	½ maximum	0 Hz		
DC (constant)	Maximum	0 Hz		
AC (sine)	Maximum	1 Hz		
AC (sine)	Maximum	10 Hz		
AC (sine)	Maximum	200 Hz		

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Playing with Magnets:

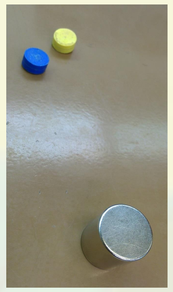
the magnetic field

- Use small magnets to observe basic properties of magnetic fields

Sample observation (choose one):

How close can you approach the magnets before you can feel a force between them?

- ❑ Of course we didn't feel anything until the magnets actually touched.
- ❑ We started feeling something when they were about a finger's width away from each other.
- ❑ We started feeling something when they were about a hands' length away.
- ❑ We started feeling something when the magnets were about an arm's length away.



Magnets to play with (colored, top) and 1 magnet not to play with (silvery, bottom. Be careful!: will pinch fingers and erase credit cards).

Making and Testing a Loudspeaker

- Hot glue the coil to the cup: use lots of hot glue!
- Apply 200 Hz sine wave
- Hold the magnet up to the coil (at right).

Speaker attached to the computer sound output.

Sample Observation: What do you hear?

- Connect to a sound source, YouTube or an mp3 player, and play a song you know.

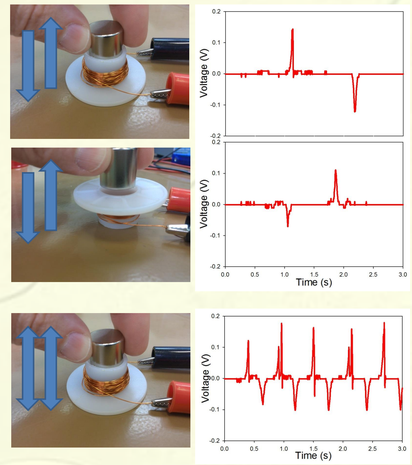
Sample Observation: Were you able to recognize the piece of music? How would you characterize this speaker…for the price?

- Try at least two things to try to make the speaker sound better. Some possibilities:
  - Cut down the cup to make it shorter.
  - Place the cup magnet-down on the table.
  - Place the cup top-down on the table
  - Add more hot glue if the coil is loose

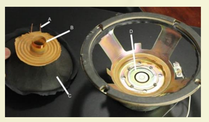
A Primitive Microphone:

changing magnetic field makes electric signal

- Make a coil of wire, connect to voltage sensor & move magnet...
  - In and out of the coil
  - In and out of inverted coil
  - In and out of coil repeatedly



Comparing Your Speaker to a Commercial One



Sample Observation: What letter on the diagram corresponds to the coil?

Click here to enter text.

Sample Observation: What letter on the diagram corresponds to the magnet?

Click here to enter text.

Results/Observations

Physics can be interesting and approachable

- Students, TAs, faculty were all struck by:
  - seeing the jumping magnets/coils
  - hearing and feeling the speaker work
- Need to assess but students seem to get basic concepts
- Our favorite student quote:
  "Heavy metal out of a plastic cup is (amazing)!"