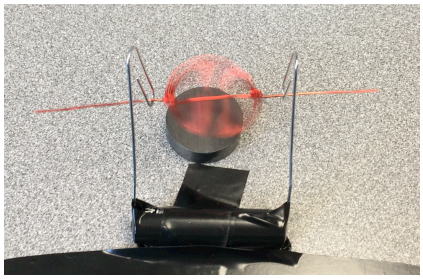
Simple DC Motors Manipulation



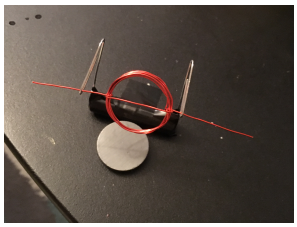
Presentation adapted from Prof. Anderson, Electrical and Computer Engineering, Ohio State, with thanks

1

Simple DC Motors

- Use electric current to produce a magnetic field
- Use the interaction of that magnetic field with a fixed magnet to spin a conductive wire
- How does that work?

How many people have taken EM?



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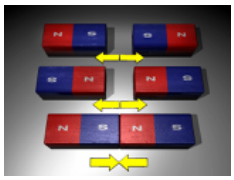
2

Magnets



- Magnets produce force
  - Like poles repel
  - Opposite poles attract
- That can move objects in the world
- (A thing that robots need to do…)

http://www.swe.org/iap/ip/magnets_03.html 3

3

Magnetic Fields

- Magnets emit a magnetic field
  - From the motion of electrically charged particles
- This field can act on objects
  - Repel or attract them
  - This is the source of the force we perceive
  - "Magnetism"
- But how does magnetism work?
  - One of the four fundamental forces (interactions)
    - Discrete quantum fields, mediated by elementary particles described by the Standard Model of particle physics
      - Gluons, quarks, bosons, w and z particles
      - I don't actually know quantum physics

en.wikipedia.org/wiki/Fundamental_interaction
hyperphysics.phy-astr.gsu.edu/.../elemag.html 4

4

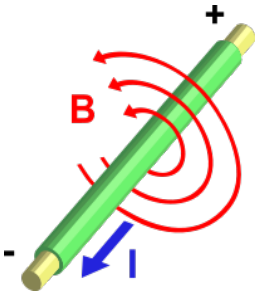
The Hall Effect

- In the presence of a magnetic field, electrons in a metal strip or wire are deflected toward one edge
  - Because they are charged particles!
- The Hall Effect: when a conductor or semiconductor with current flowing in one direction is perpendicular to a magnetic field, a voltage can be detected.
- Creates a voltage gradient across the short side of the strip (perpendicular)

en.wikipedia.org/wiki/Hall_effect_sensor
electricalfundablog.com/hall-effect-principle-history-theory-explanation-mathematical-expressions-applications 5

5

Generating EM Fields



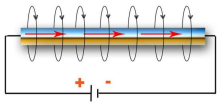
- When current (I) flows though a wire, it creates a magnetic field (B)
  - Properly, an *electromagnetic*, or EM, field
- Use right hand rule to find direction

http://en.wikipedia.org/wiki/Electromagnet 6

6

If the current changes

- Suppose the current reverses direction
- What will happen to the field?
  - It will reverse
- Can we use this to push a magnet around?
  - Yes, but it's pretty weak



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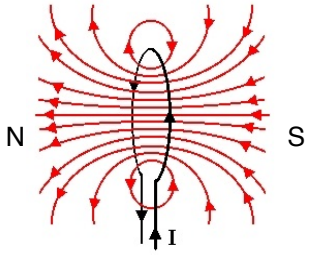
A Wire Loop

- All the field lines inside the loop go the same direction
- The field gets **concentrated**



physicsed.buffalostate.edu/.../ rhr/rhr.htm

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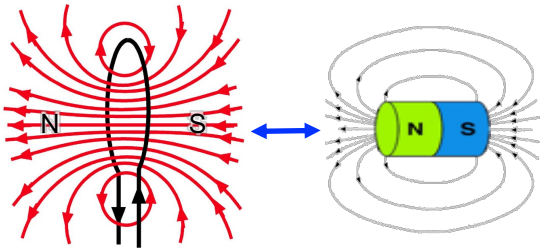
Loop Plus Magnet

- The two EM fields now interact
- Which direction is the force?



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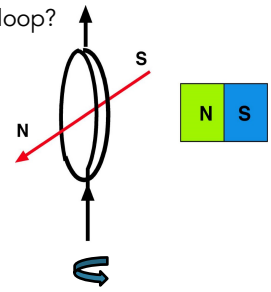
9

Suppose loop is upended

- What will happen to the loop?
  - N attracts S
  - N repels N
- Loop will rotate
- Once loop rotates halfway around, poles will be pointing the other way, and it will want to come back
- Will flap back and forth or stick in one position



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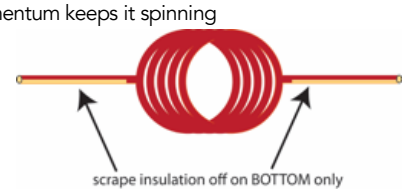
Trick: Insulate ONE side of wire

- When loop is turned one way:
  - Current flows
  - Magnet points in one direction
- When loop is turned the other way:
  - No current → no electromagnet
- Momentum keeps it spinning



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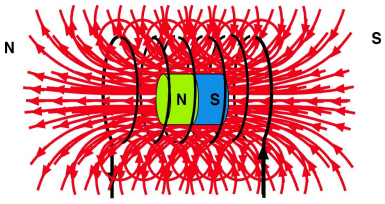
Ok! We can rotate the loop!

- Field is still weak
- Amplify by looping the wire repeatedly
- Many loops = many overlapping fields



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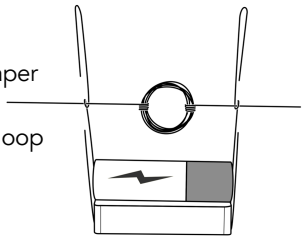
12

General Idea:

- Battery produces current
- You make a coil
- Suspend between conducting loops (paper clips, safety pins, …)
- Put a magnet under loop
  - Spin spin spin!
- Okay! Ready?

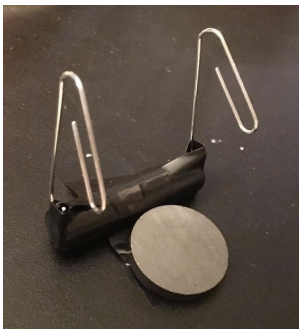


13

13

Build Frame from Parts

- Magnet
- 2 paper clips
- Battery
- ~2 feet of magnet wire
  - Plus a spare
- Sandpaper
- Come get tape or we'll pass it around
- We have spares of everything!

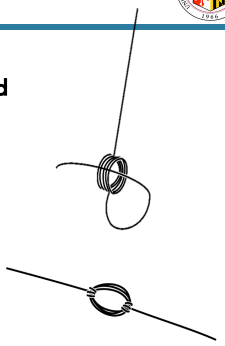


14

14

Building the Coil

- **Leave about 4 inches of wire unwrapped at the beginning and end of your coil**
  - These are your leads
- Make 5-10 loops (about the diameter of the magnet)
- Wrap each lead around the coil at least twice
- Keep wrapping the leads until they stick out at opposite sides of the coil



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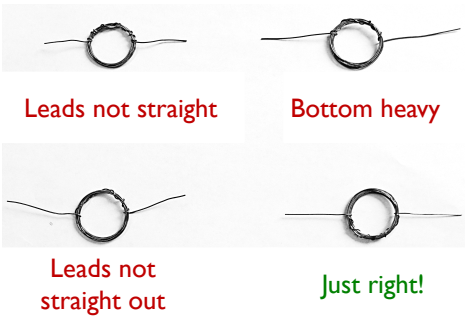
15

Common Coil Problems



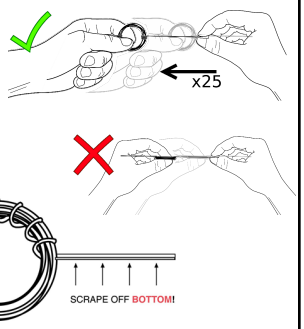
Slide from Prof. Anderson, Electrical and Computer Engineering, Ohio State, with thanks

16

16

Make the commutator

- Sand the insulation from bottom half of each lead
- Hint: Place the sand paper on your thumb or the table and drag the wire across it, making sure to get as much insulation off as possible (one side only)



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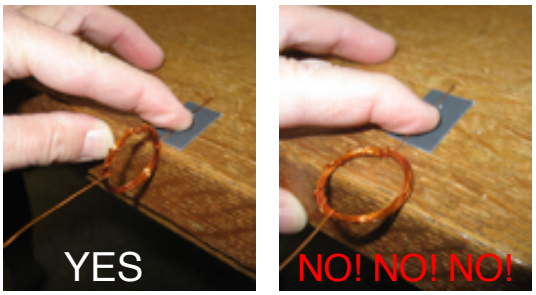
17

This is Important



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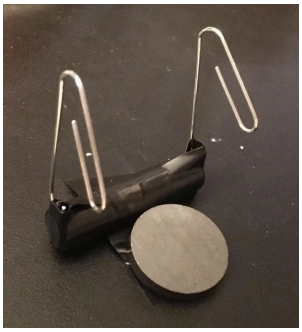
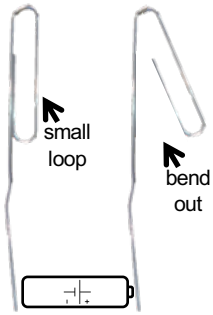
18

18

Build the Supports





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19

Add the coil

- Hang the coil in the loops made by the paper clips
- It will complete the circuit when the sanded side of the commutator is down
- Hint: Make sure all components are level and that the wires coming out of the coil are as straight as possible.

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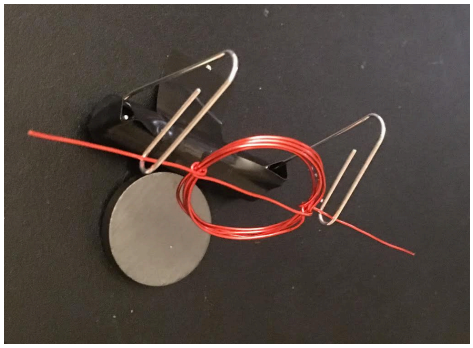
20

Assembled



21

21

Making Your Motor Run

- Just give coil a gentle spin and let go!

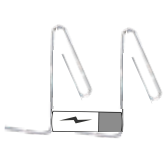
Troubleshooting:

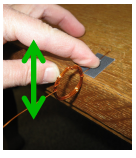
- Coil is bottom-heavy or leads aren't straight
  - Does it spin easily when you turn it in the supports?
  - We have plenty of wire; feel free to start over
- Not enough insulation sanded from coil leads
  - Try to get as close to the coil as possible when sanding
- No current through paper clips
  - Is it taped firmly and in place on the metal?
  - We have plenty of tape; come get more and try again

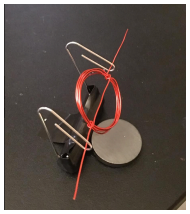
22

22

Let's Do It







23

23