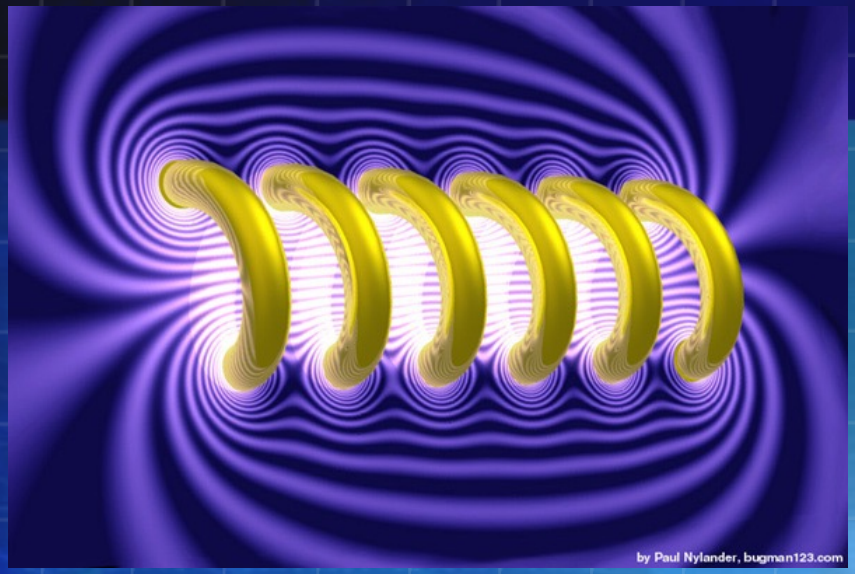

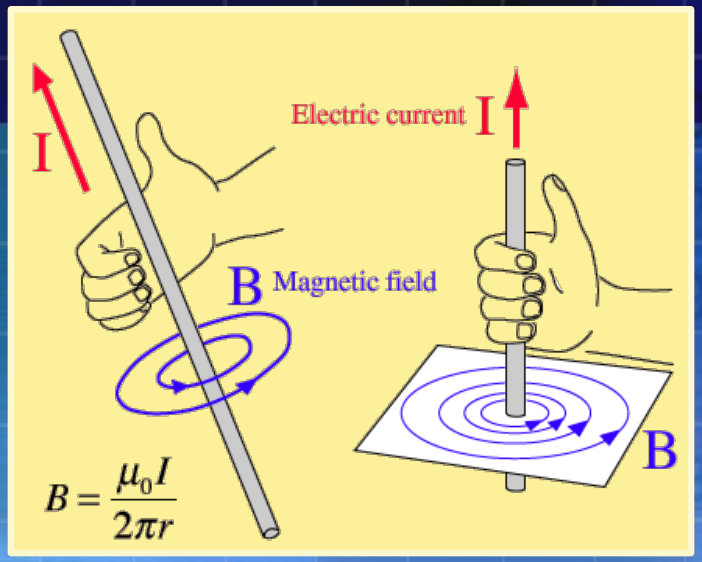

Circuit Lab

Practice #8—Motors and Sample Competition

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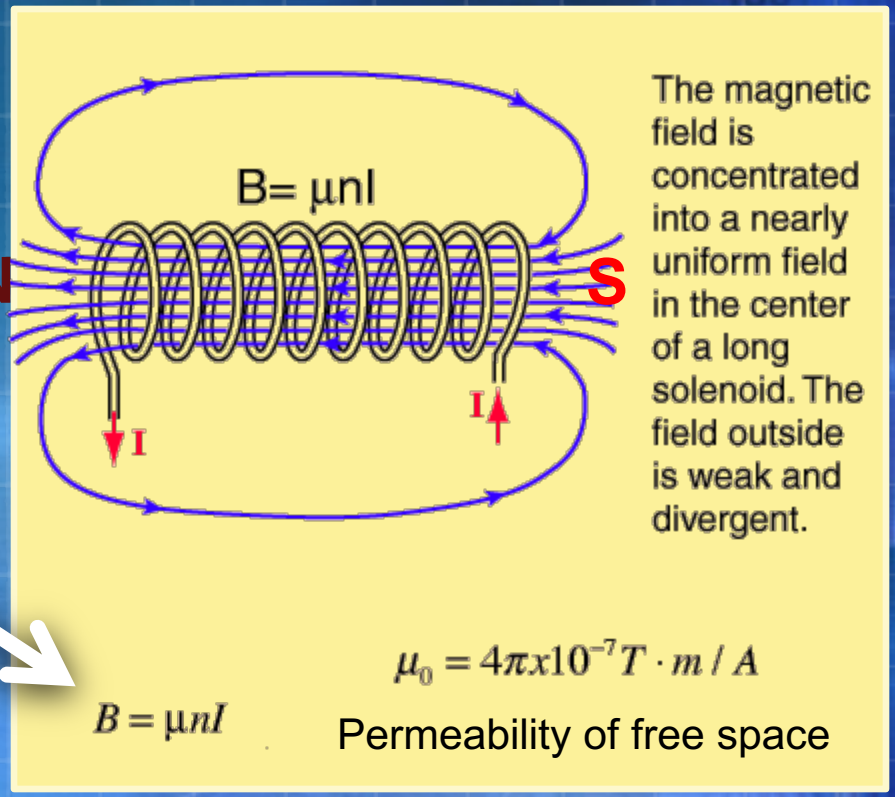
Agenda

- 15 minutes—Grading homework.
- 20 minutes—Learning Lesson of the Day
- 40 minutes—In Practice Sample Competition
- 10 minutes—Notebook Review
- 5 minutes—Sending out homework

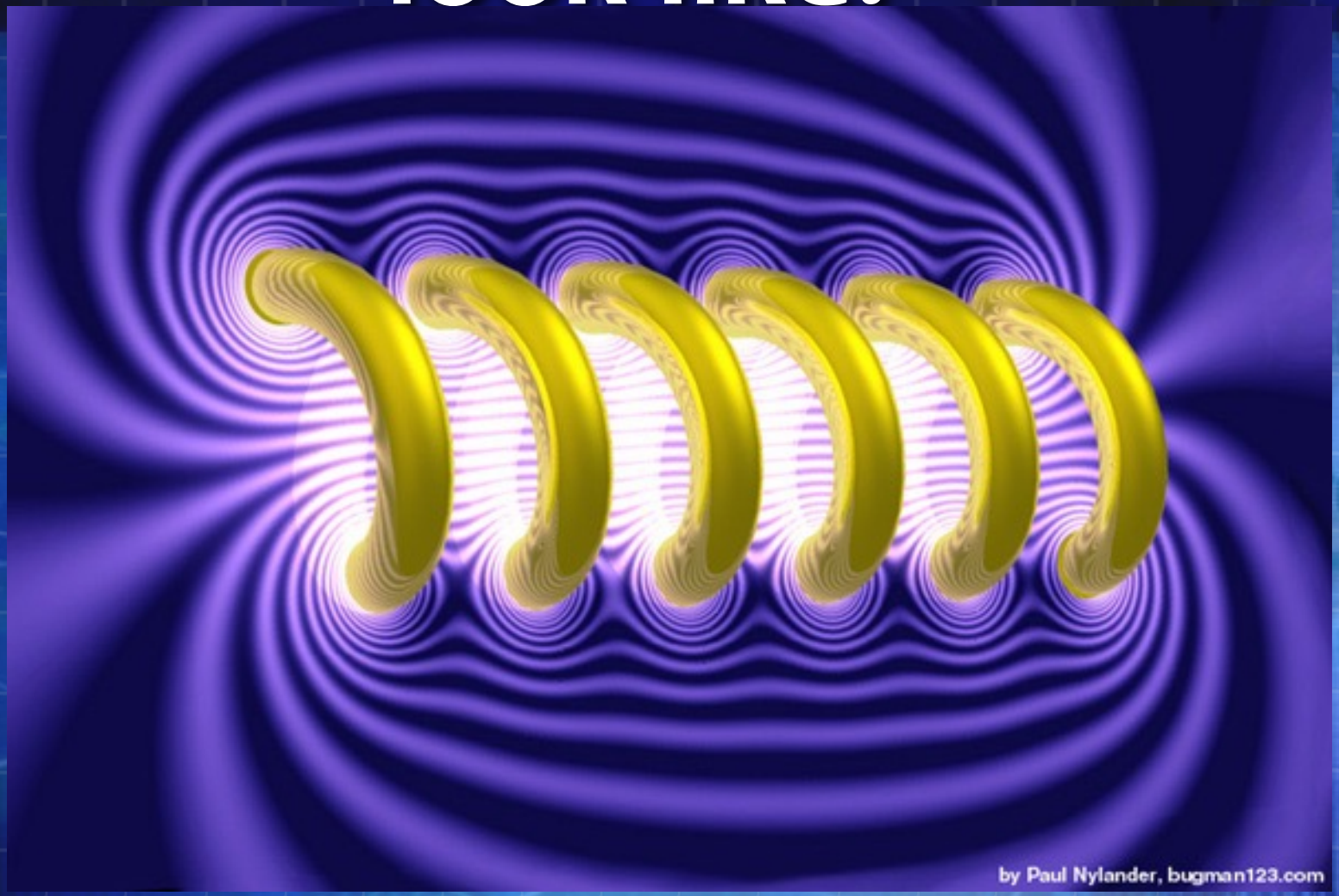
Magnetic Field of Electromagnet

- An electromagnet is just a solenoid
  - The core material's permeability can dramatically increase the strength of the electromagnet or solenoid.
  - The number of turns over the length or turn density can dramatically affect the strength of the electromagnet or solenoid.
  - See the formula for B for center of the electromagnet
    - μ is the permeability
    - n is the turn density (turns/m)
      - For example if you have 100 turns per 0.01m, n = 100/0.01 = 10,000 turns/m
    - I is the current



Iron cores have a much higher (~200x) permeability than free space or air, and make better solenoids.

What does the field look like?



Lorentz Force Law

- Force is applied on all charged particles by both magnetic and electric fields
- The Force of the Electric field is equal to $F_{elect} = qE$ and is in the direction of the Electric field
- The Force of the Magnetic Field is equal to $F_{mag} = qv\ x\ B$ and is in the direction diagonal to the magnetic field and the moving charge
  - if the charge isn't moving there is no magnetic force
  - If the charge is moving in the line of the magnetic field there is no magnetic force

Electric field in N/C or volts/m.

$$\vec{E} = \frac{\vec{F}}{q}$$

$\vec{F}$: electric force in Newtons

q: charge in Coulombs

Since the measured electric field can depend upon your reference frame, a more general definition of the electric field comes from the Lorentz force law. The electric field can be defined as the electromagnetic force per unit charge in the rest frame of the charge.

$$\vec{F} = q\vec{E} + q\vec{v}\ x\ \vec{B}$$

Electric force *Magnetic force*

A charge that is moving relative to the source will experience part of the force as a magnetic force.

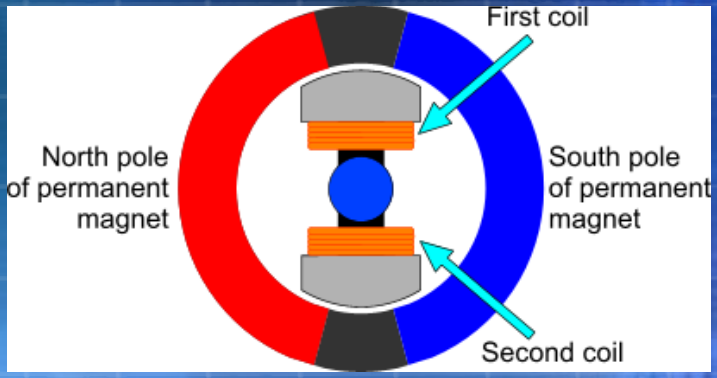
Lorentz force law

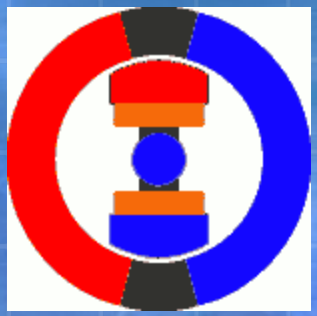
What are electric motors?

- Motors that turn flowing electric current into mechanical motion/work
- They are the opposite of generators, which turn mechanical motion/work into flowing electrical power.
- To make one you need a magnetic field and flowing current. Like with an electromagnet, the more turns the more powerful the magnetic field.
- The moving part is the Rotor
- The stationary part is the Stator
- If you reverse the polarity (voltage/current), the motor will run in revers

How does a motor work?

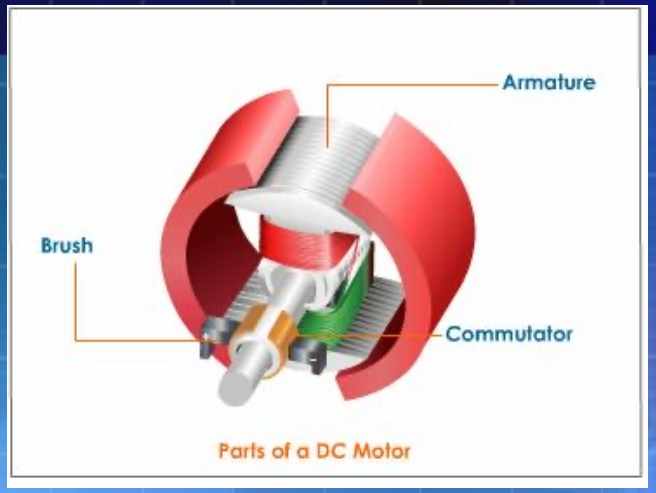
- DC motor has two windings and two permanent magnets
- Coils are powered from the Commutator and the Brushes
- The current that runs through each windings changes direction at the halfway point (caused by the connection of the commutator)
- Magnets are wound such that when one is North, the other is South
  - Please note this is colored differently than we normally used

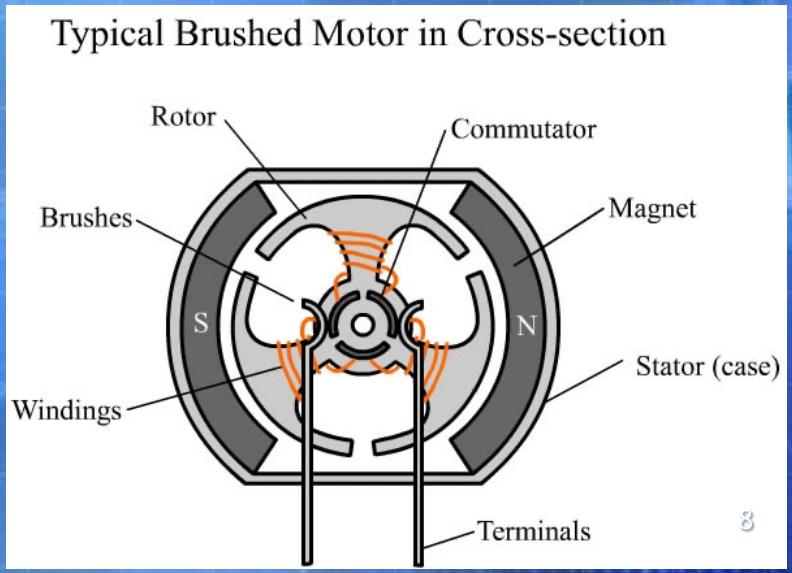




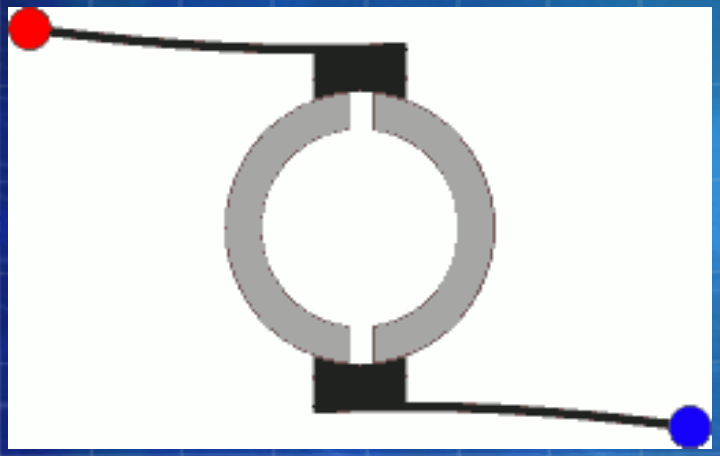
Parts of Motor

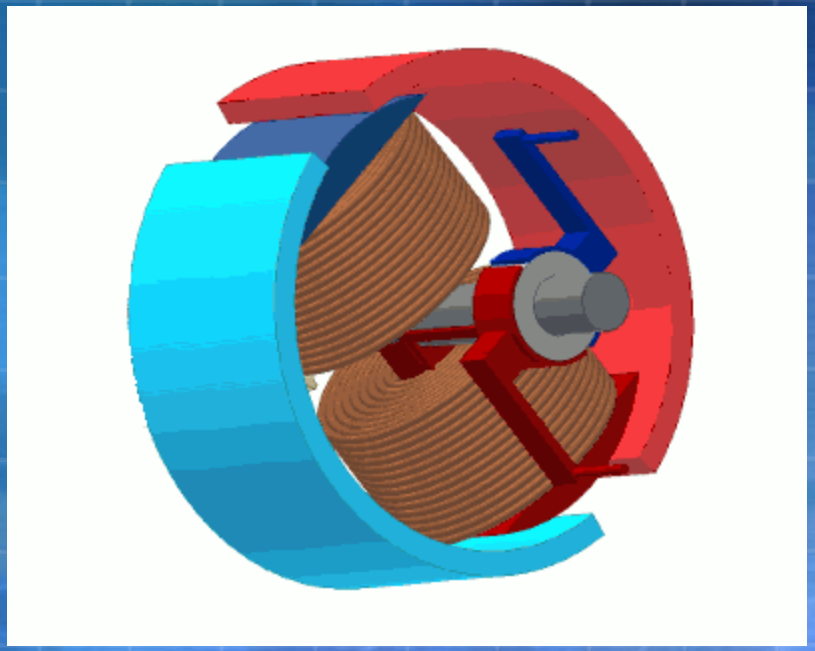
- The part that rotates in the middle is called the Rotor
  - In a Brushed DC motor, this has the windings
  - Armature is the part that contains the main current-carrying winding. The armature usually consists of a coil of copper wire wound around an iron or steel core.
- The part that doesn't move on the outside is called the Stator
  - In a Brushed DC motor, this is where the permanent magnets are located





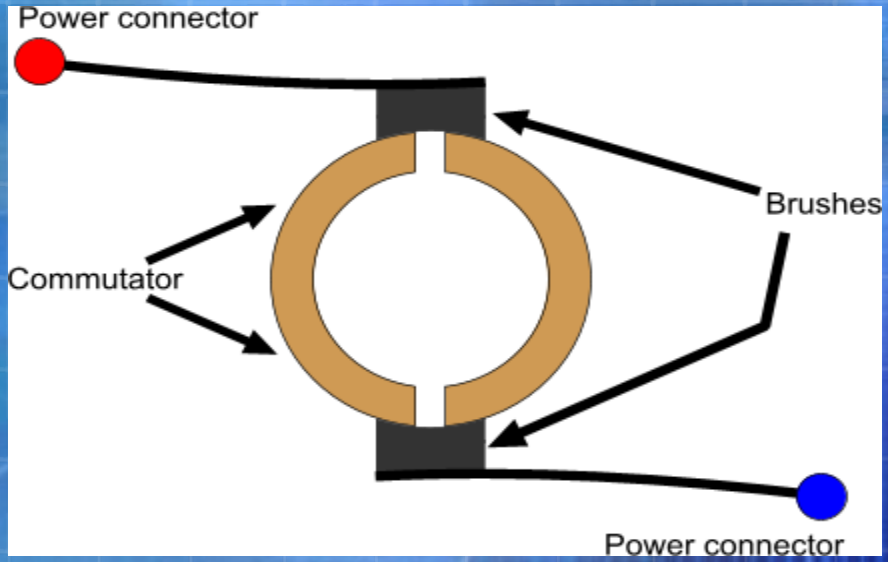
DC Motors in Motion





DC Motor Continued

- This is a "Brushed DC Motor"
- Brushes (normally made out of carbon) allow the current to continue even as the Rotor rotates
- There is a small gap when the brushes switch from one set of windings to the next (causing the switch of polarities) on the Commutator
- Commutator is a metal ring that is fixed on the shaft of the motor, so it rotates too

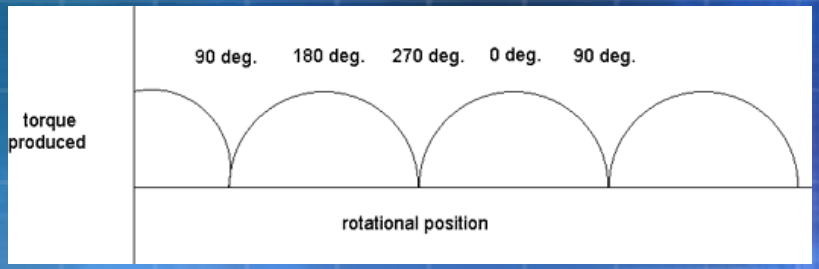


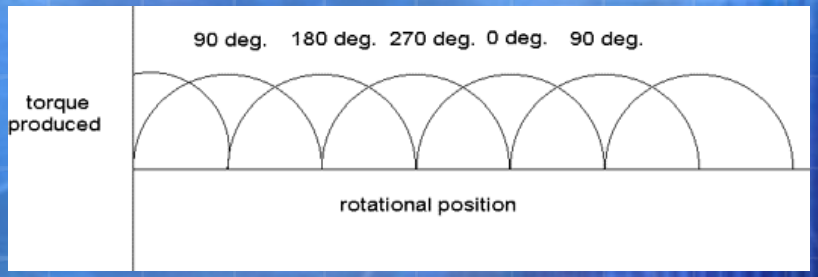
Brushed versus Non-Brushed DC Motors

- Brushed motors are the most common, but the brushes eventually wear out—especially if the motor was used with too much power, too fast, or is not cleaned.
- Non-Brushed Motors use the magnets on the Rotor and then pulse the current on the windings on the Stator. The motor will move as fast as the pulses.

Torque Problems with a DC Motor

- Brushes wear out
- The angular force or Torque changes as the rotor spins around.
- For a single coil system the Torque goes to zero at 180
- For two coil systems you can greatly increase the average Torque and smooth out the force.





Your Binder is Your Lifeline

- A good binder is like having an open book test
- Use your binder in all studying, practices, and at tournaments
- Always build your own binder in case something happens to your partner's
- First page should be the rules, so you can find them quickly
- Always have easy to read tables for constants, materials, and equations
- Organize into sections that work for you and your teammate with tabs for easy finding
- Focus on the things you have to look up or don't understand
- Include other tests with keys and work shown
- When you have two or more pictures of the same thing, include ALL of them (often Event Supervisors will get diagrams and samples from the internet)
- When you solve a difficult problem, show all your work and put that in the binder to help remind you how you solved that difficult problem
- Keep the binder small enough to be useful, but big enough to be comprehensive
- Test you skills at finding things in the binder each practice so that it takes no more than 10 seconds to find anything
- Make sure you can read it (good fonts)
- Use sheet protectors when possible

In Practice Sample Competition

- 100 points
- Timed—40 minutes
- Do the following written quiz individually
- You may use any and all notes in your binder
- You may use your calculator
- Make sure you fill out your name and team at the top of each page
- Tackle the easy problems first, then the tough ones you know how to tackle, then finally the ones you have to guess on.
- If you have time, check your answers

Homework

- Update your binder to get it competition ready
- Complete the circuit problems from the Homework Generator
  - Level 1 Magnetism
  - Level 4 Combination
  - Level 5 Combination
  - Level 6 Combination