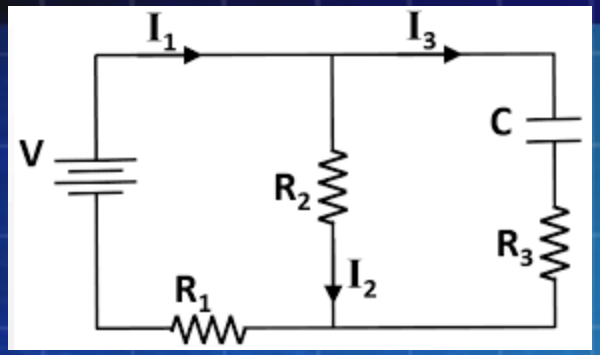
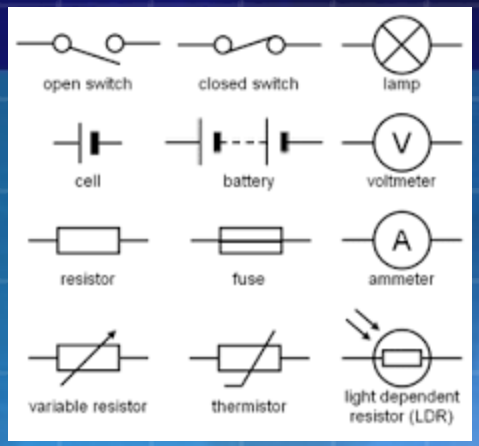
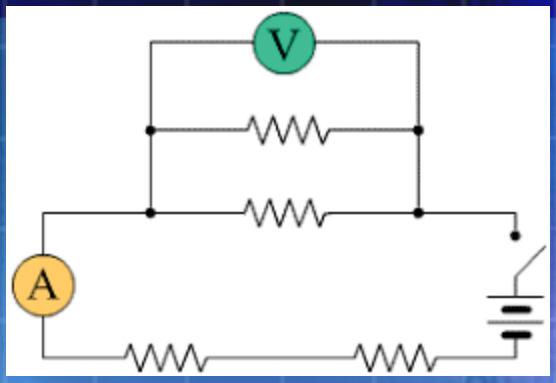






Circuit Lab

Practice #1—Introduction, Circuits, Basic Terms, Ohm's Law

Mr. Burleson
geaux15@hotmail.com

Ground Rules

- The narration will not read all bullets, but the slides are available in the dropbox.
- This is provided to augment and not replace your team's coaching, so always go with your own coaches advice or training first
- National Science Olympiad rules, clarifications, and FAQs take precedence, so always go with what is on the official website www.soinc.org
- Each student is responsible for their own learning of this topic, so be prepared to learn more using other resources including the internet
- Follow all safety rules and use low voltage (12VDC or less) for hands on activities, we are developing a full guide of safety rules to be put in the drop box
- Put any questions in the comments section and be respectful and helpful to others.
- Always come prepared to practices with completed homework and all your questions
- Listen, participate, and always follow your coaches

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

Agenda

- Introduction and Rules
- Basics of Electricity
- Circuit Lab (B) Practical
- Homework

Who am I?

- Mr. Russ Burleson, Electrical Engineer and member of the National Science Olympiad Physics Committee. I have been an event supervisor (Invitational, Regional, State, and National) and a coach (Division B).
- Engineer at Northrop Grumman with experience in several different types of engineering from making radars to making soap.
- Masters in Electrical Engineering from the Air Force Institute of Technology at Wright Patterson AFB
- Bachelors in Electrical Engineering from LSU in Baton Rouge, Louisiana (favorite team)
- I have three kids. Bobby was in Science Olympiad for Magsig Middle (OH) school.
- Get input from several people, but always work with your coach first

Circuit Lab (B) Rules and Scoring

- Allowed to use notes and/or calculators
- Scoring is 50-75% for Theoretical Portion (Test) and 25-50% for Practical (Lab) Portion
- Historical perspective of the discoveries of electricity and the key people involved
- Properties of electrical charge, sources/hazards of static electricity, Coulomb's Law and capacitance
- Direct current(DC) characteristics, sources, uses, simple circuit diagrams, DC hazards
- Alternating current(AC) characteristics, sources, uses, AC hazards
- Concepts and units of current, voltage, resistance, power and energy and using Ohm's law
- Magnetic poles/fields, electromagnets, transformers, motors/generators, right-hand rule for torque
- Electrical controls devices including 3 way light switch circuit
- Simple measurements, constructions, and configurations of a circuit and individual components
- Basic characteristics and operation of a light emitting diode (LED)
- Simple circuit analysis using Kirchhoff's Voltage & Current Laws
- Basic digital logic and digital logic operations
- Time constant of a RC circuit
- Electrical characteristics of a silicon PN junction
- Basics and application of Operational Amplifiers (OpAmps)

*Underlined bullets are Division C only

Circuit Lab (B) Practice Recommendations

- Recommend practicing at least once a week with studying between practices. Most practices would be approximately 1 to 1.5 hours.
  - 15 minutes—Grading homework.
  - 30 minutes—Learning Lesson of the Day
  - 15 minutes—In Practice quick test on Lesson of the Day
  - 25 minutes—Practical testing
  - 5 minutes—Sending out homework
- If YOU miss a Practice, YOU are responsible to get the notes and homework to be ready for the next Practice.

Resources

- Every file in this drop box.
- Text books especially those focused on electricity and magnetism
- Wikipedia pages are great places to start your investigation, but you will need more
- Khan academy, Hyper Science, Bozeman Science, and electronics tutorials have some great resources and videos
- Just find the resource that works best for you, sometimes a different way of explaining a topic just makes sense
- Remember that www.soinc.org is the official website and the rules/clarifications there are the official rules
- www.scioly.org is an alumni run website that has lots of great resources and old tests, but it is NOT official. Everything there is just opinion.
  - Do not get caught up into arguments online

https://www.youtube.com/watch?v=F_vLWkkOETI
https://www.youtube.com/watch?v=0YOGrTNgGhE
https://www.youtube.com/watch?v=NXMgvrS8Gr8
https://www.youtube.com/watch?v=ZRLXDiiUv8Q
https://www.youtube.com/watch?v=8Y4JSp5U82I
https://ibphysicsnotes.wordpress.com/topic5/
https://www.youtube.com/watch?v=mc979OhitAg
https://en.wikipedia.org/wiki/Electricity
https://en.wikipedia.org/wiki/Magnetism
http://www.bozemanscience.com/
https://www.electronics-tutorials.ws/
http://hyperphysics.phy-astr.gsu.edu/hbase/emcon.html#emcon

Things to consider

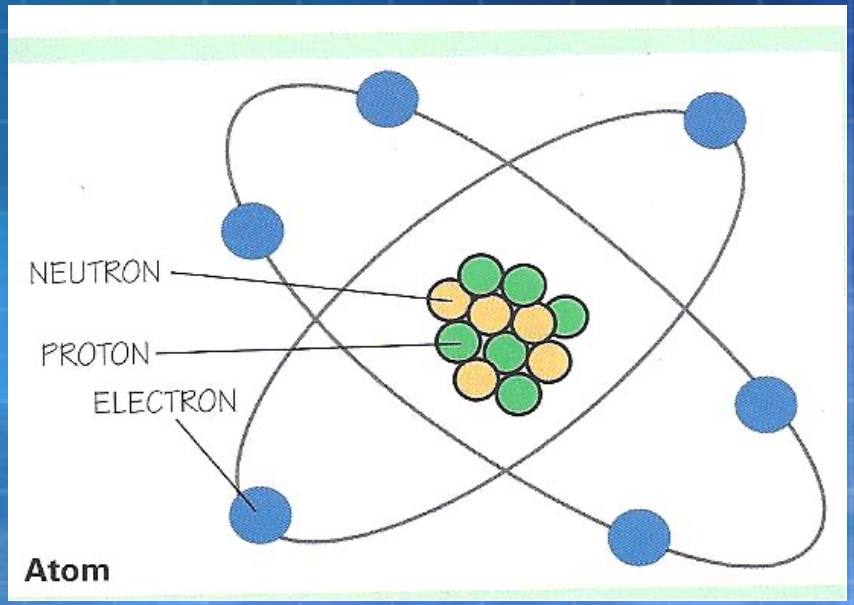
- Winners prepare
  - No one knows this material naturally, those that prepare the best will do better.
  - Study and do homework before practice, use practice for asking questions
  - Plan on doing work on this a few times a week in addition to practice
- Winners work together
  - Be a good partner
  - Work off each other strengths
  - Practice together
- Event Supervisors are volunteers
  - They have given up their time to prepare for the competition, run the event, score, etc.
  - Some are more experienced than others
  - Some know the rules more than others
  - Be respectful and work with them
  - Always listen to instructions and read the test before you ask your questions
  - Different Event Supervisors ask the same question differently

Arguing an Illegal Question

- Always make sure you read the question again to ensure it really is illegal.
  - Event supervisor might have old rules, but double check your rules first.
- Ask for how to implement the question within the rules.
  - Remove the illegal items like capacitors/inductors/LEDs/etc.
  - Operate it as DC instead of AC.
- Reference the specific rule, normally in section 3.d
- Semiconductors include diodes, LEDs, transistors, OpAmps, and integrated circuits. LEDs, Diodes and OpAmps are now allowed in certain circumstances.
- AC circuit theory includes frequency analysis, two or three phase power, capacitor/inductor reactance. But they can sometimes be made legal by switching to a DC system.
- AC devices include transformers, rectifiers, others. Most will not work with DC.
- Several items are only available for Division C and not for B

Basics of Electricity

- Atoms
- Protons
- Neutrons
- Electrons
- Electrical current



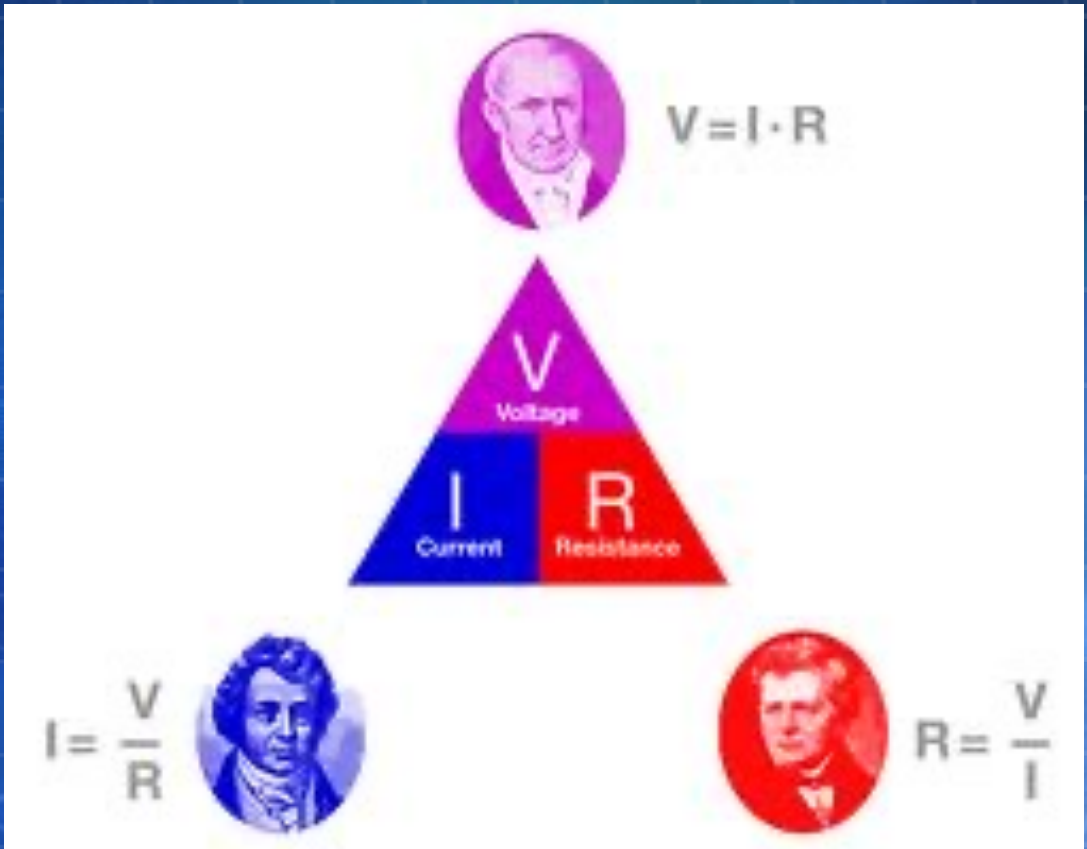
Famous Electric Scientist

Thales of Miletus

Nikola Tesla

Emperor Palpatine

The Big Three—Volta, Ampere, and Ohm



Important Terms

- Volt (V)—unit of electric potential or how much strength the charge is "pushed"
  - Batteries are 1.5-24 V
  - Home electricity 110-220 V
  - Lightning can be millions of volts
  - Also called Potential Difference
  - Is the force behind the electrons
- Ampere (A)—unit of electric current or how many electrons go past a given point in a second.
  - Also called an "Amp"
  - Amperage can heat up a wire and too much can melt a wire or start a fire. That is why we have breakers and fuses.

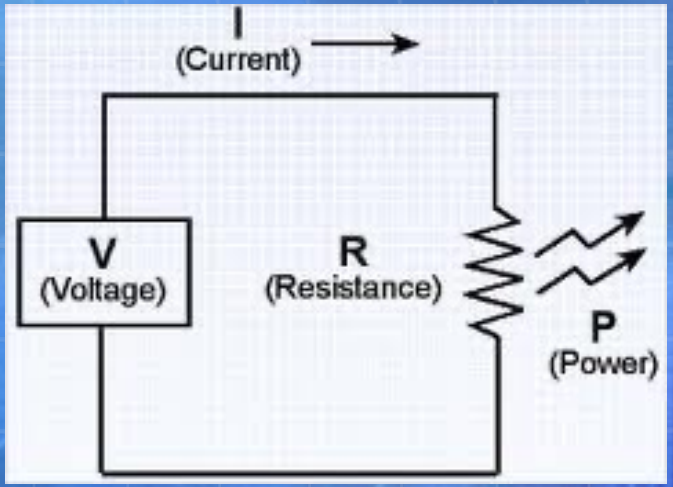
Important Terms

- Direct Current (DC) is an electric current of constant direction.
  - All batteries are DC
  - Most electronics need DC, so you have special transformers and rectifiers to convert house AC voltage to DC.
  - Most of the problems in Circuit Lab are DC.
- Alternating Current (AC) is electric current that regularly reverses direction.
  - House electricity and power lines are AC
  - AC is even more dangerous than DC
  - AC has less power loss to heat during transmission so it is used for generation and transmission
  - AC is transmitted at very high voltages and stepped down using a transformer for home usage (normally around 220V AC in the US)

Important Terms

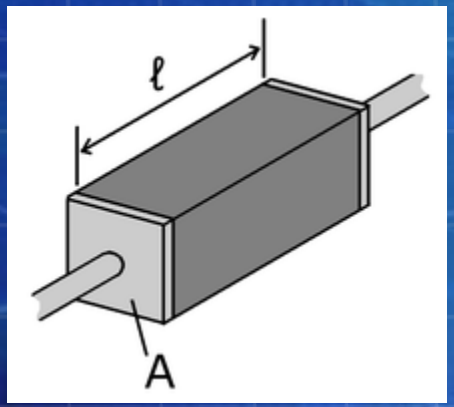
- Resistance is the opposition against the free transfer of electrons in a conductor.
  - Copper, Silver, and other conductors have low resistance
  - Glass, wood, rubber, plastic, and other insulators have high resistance.
  - Transfer (or current) is usually due to some force like the EMF from the Voltage of a battery

- Ohms (Ω)—unit of electric resistance which is equal to the ratio of voltage to amperage.



Resistance (Ω)

- Many resistors and conductors have a uniform cross section with a uniform flow of electric current, and are made of one material. In this case, the electrical resistivity ρ (Greek: rho) is defined as:



$$\rho = R\frac{A}{\ell}$$

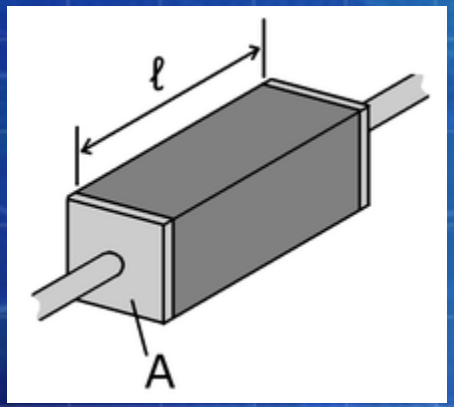
$$R = \rho\frac{\ell}{A}$$

- Resistance increases
  - Longer lengths
  - Less area/smaller cross section
  - Higher temperature
  - Less conductive material
- Resistance decreases
  - Shorter lengths
  - Larger area/cross section
  - Lower temperature
  - More conductive material

https://en.wikipedia.org/wiki/Electrical_resistivity_and_conductivity

Resistance of Common Materials

- Always have tables of resistivity, ρ units are Ω•m
- Superconductors = 0 Ω•m
- Metals/Conductors ~10^{-8} Ω•m
- Semiconductors (variable upon doping)
- Insulators ~10^{16} Ω•m
- Superinsulators ~∞ Ω•m



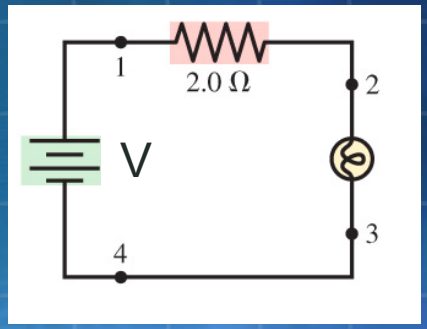
$$\rho = R\frac{A}{\ell}$$

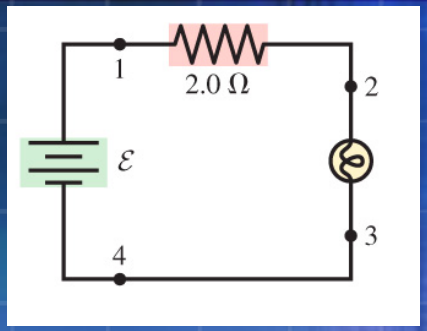
$$R = \rho\frac{\ell}{A}$$

- Top Common Conductors
  - Silver ρ = 1.59x10^{-8} Ω•m
  - Copper ρ = 1.68x10^{-8} Ω•m
  - Gold ρ = 2.44x10^{-8} Ω•m
  - Aluminum ρ = 2.65x10^{-8} Ω•m
- Top Common Semiconductors
  - GaAs ρ = 1x10^{-3} to 1x10^{8}Ω•m
  - Germanium ρ = 4.6x10^{-1}Ω•m
  - Silicon ρ = 6.4x10^{2} Ω•m
- Top Common Insulators
  - Deionized water, Glass, Diamond, Hard Rubber, Air, and Dry Wood
  - Fused Quartz ρ = 7.5x10^{17}Ω•m
  - PET ρ = 1x10^{21}Ω•m
  - Teflon ρ = 1x10^{23} to 1x10^{25}Ω•m

Physics Teachers versus Engineers

- Physicists and Engineers look at circuit problems differently and sometimes put focus on different areas
- Both are right, but you should be prepared because you don't know who writes your test
- Always look at lots of different sample tests to get a flavor for all the ways a question may be asked
- The diagrams to the right are equivalent, one uses a Voltage Source and one an Electromotor Force source (EMF)—same thing

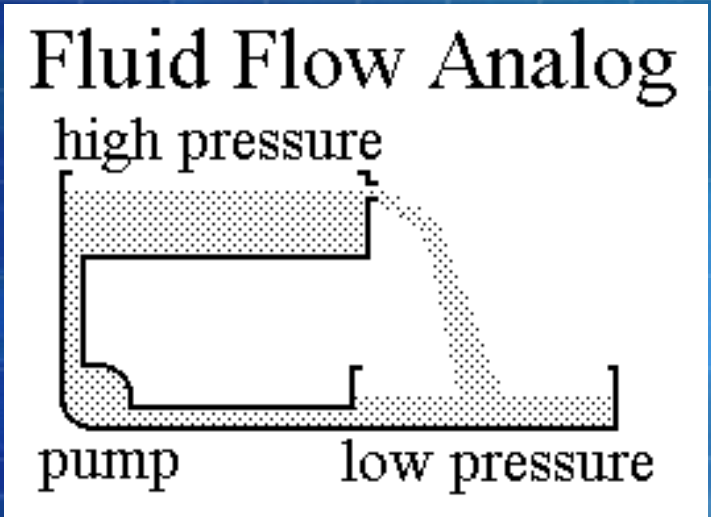




- Conventional current (which is what is mainly used) flows from the positive terminal of a battery or EMF source and would be clockwise in the diagrams above
  - This is the direction of positive charges, but not electrons which flow the opposite way
- Physicsts often prefer to use "Real Current" which flows the opposite direction to match electron flow (counter clockwise or out of negative to positive)

https://en.wikipedia.org/wiki/Circuit_diagram

How it compares to water flowing



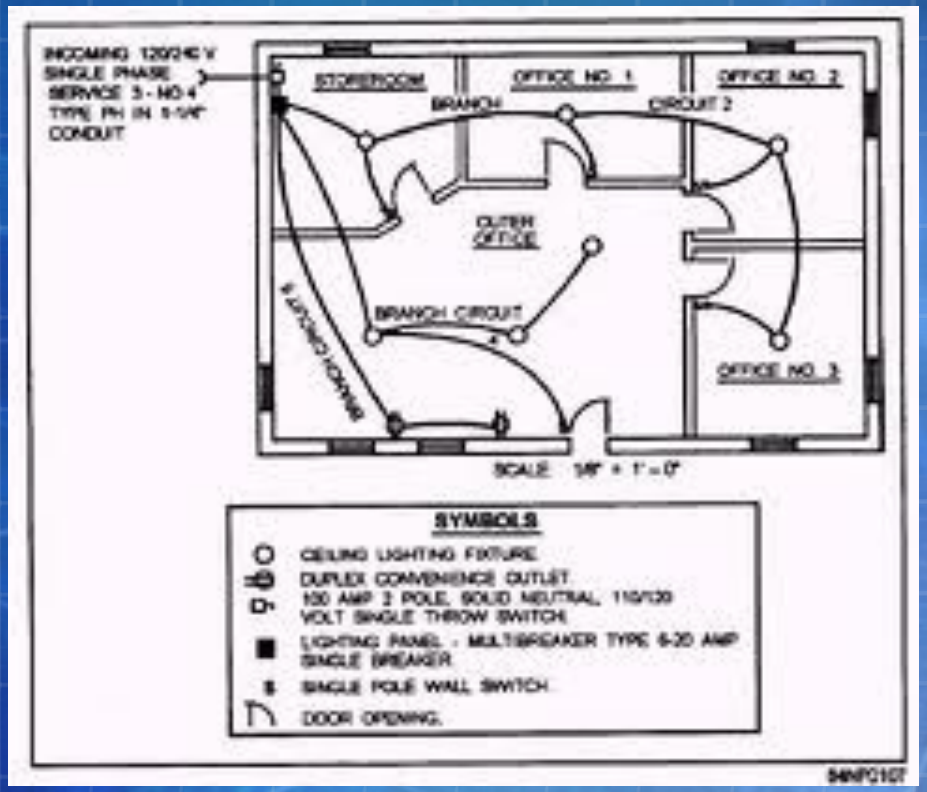
- Pressure is like voltage
- Flow is like amperage
- Resistance is how difficult it is for the water to flow
- The pump is the voltage source, like a battery

Practical

- Requires several batteries of differing types and voltages
  - Identify the parts of a battery and set up a circuit with a switch
    - Remember each circuit is powered by a battery where the current can flow from the + (positive) side to the – (negative) side.
    - Any break in the circuit is an Open Circuit and no current flows
    - Any circuit without resistance is a Short Circuit and it is dangerous

Homework #1 Make a wiring diagram of one room in the house

- Draw a floor plan of a room and show the circuits
- Draw a circuit for a flashlight.



Homework #2
Homework Generator

- The Homework generator is a simple Excel spreadsheet which creates random problem sheets to allow you to practice.
- Each tab represents a different level of difficulty or different topic
  - Level 1 VIR is for simple Voltage (V), Current (I), and Resistance (R) problems with a series circuit
- The answers are either provided at the bottom of the sheet or on the back of the sheet
- New random values are created each time you hit the F9 key, reload a sheet, or print a sheet.
- Recommend that you do a new sheet if you miss any problems on a sheet to ensure you understand the materials
- After you get 100% on a sheet, time yourself to improve how quickly you can answer an entire sheet, but redo it you miss any thing (accuracy is more important than speed)
- New Versions of the sheet will be distributed with new problems (i.e. OpAmps and Diodes are next)