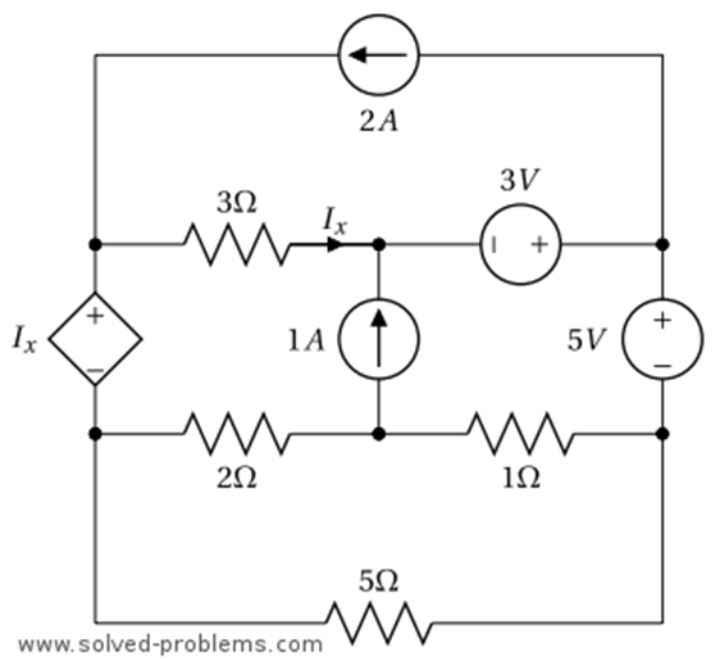
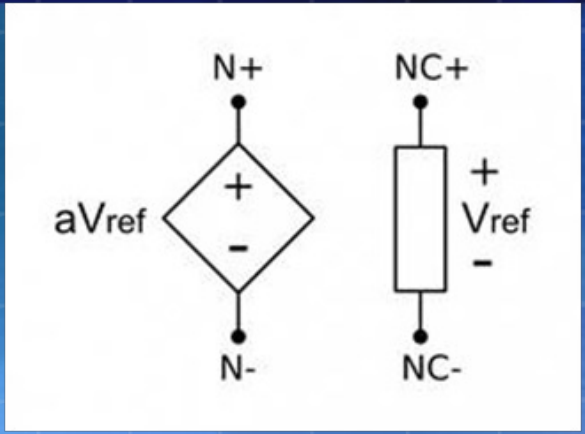




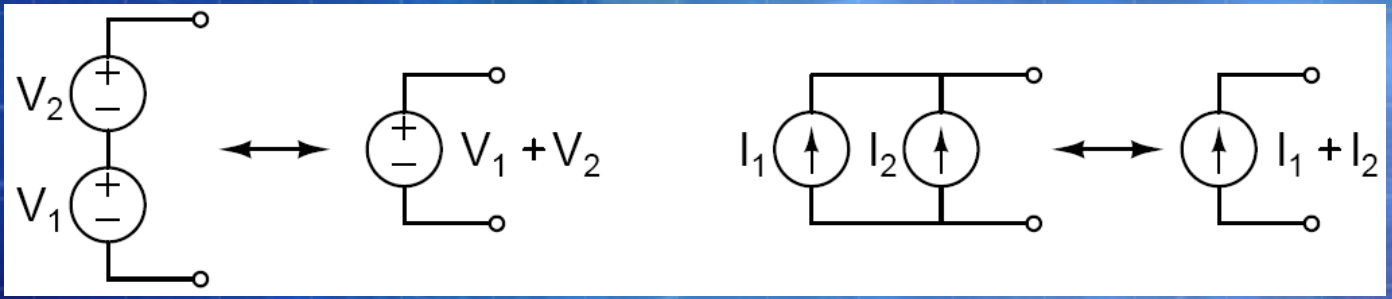
Circuit Lab

Practice #11—Specialty Devices, Dependent Sources, Superposition, and Troubleshooting

Mr. Burleson
geaux15@hotmail.com

Multiple Sources

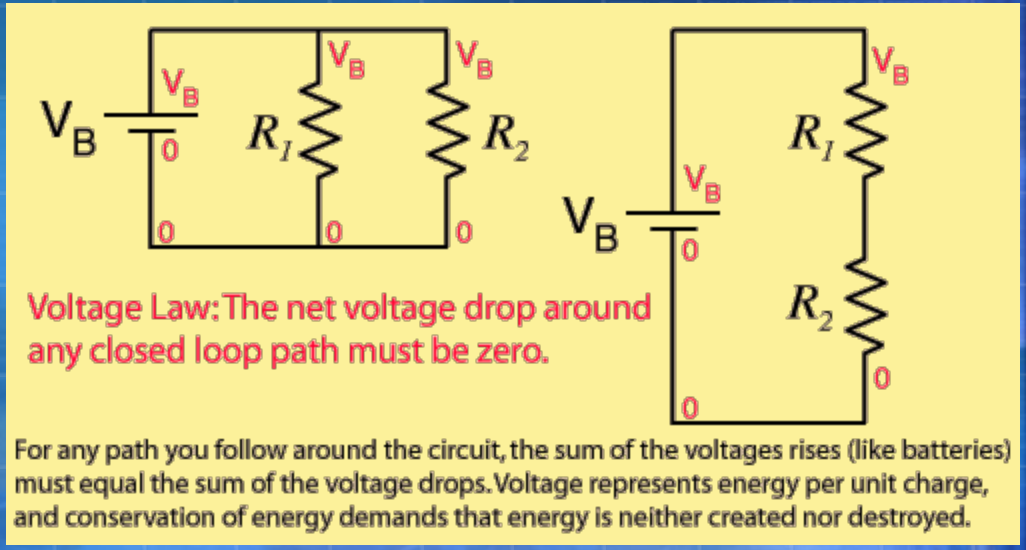
- Sometimes a circuit has more than one source
- Voltage Sources should be added in series
- Current Sources should be added in parallel
- You shouldn't put voltage sources in parallel or current sources in series, as it can create a situation that violates circuit rules.



Kirchhoff's Voltage Law (KVL)

(Division C Only)

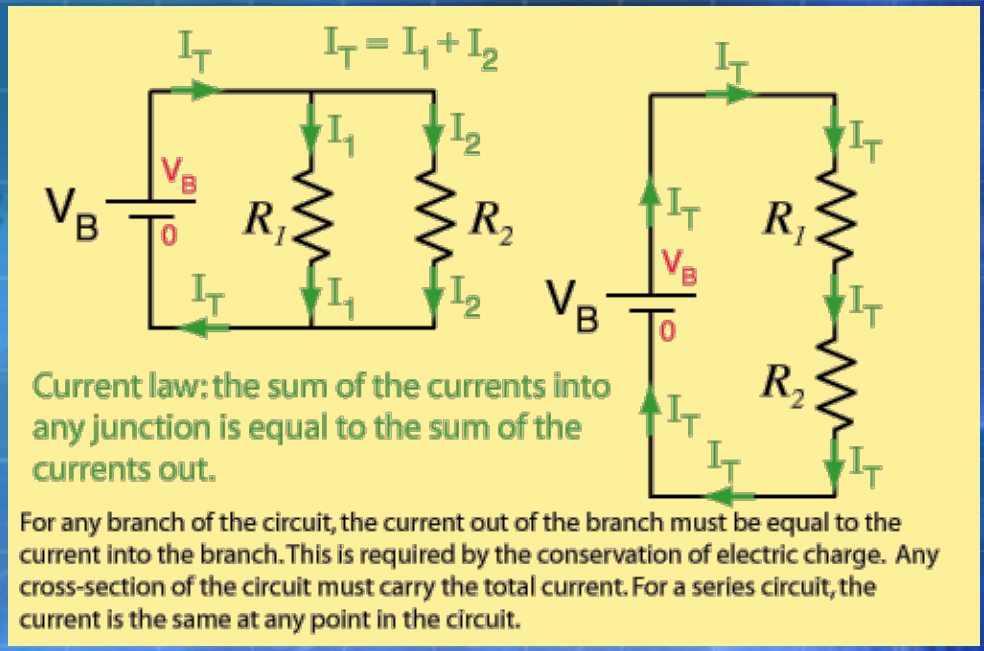
- The directed sum of the electrical potential differences (voltage) around any closed network is zero
- or: the sum of the voltage in any closed loop is equivalent to the sum of the potential drops in that loop



Kirchhoff's Current Law (KCL)

(Division C Only)

- At any node (junction) in an electrical circuit, the sum of currents flowing into that node is equal to the sum of currents flowing out of that node
- or: The algebraic sum of currents in a network of conductors meeting at a point is zero.
- or: All current into a node equals all current out!

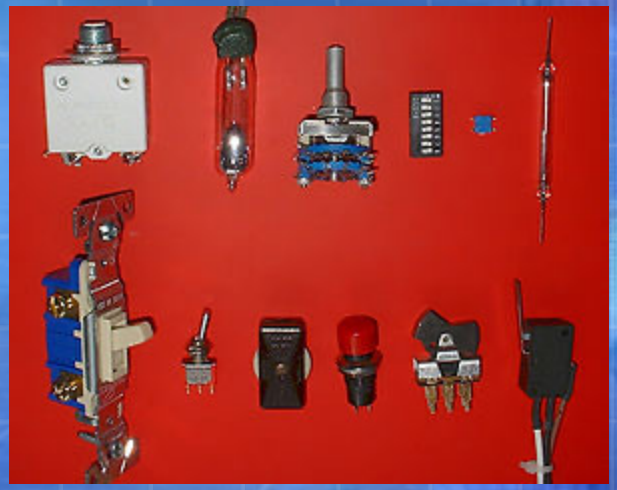


For any branch of the circuit, the current out of the branch must be equal to the current into the branch. This is required by the conservation of electric charge. Any cross-section of the circuit must carry the total current. For a series circuit, the current is the same at any point in the circuit.

Switches

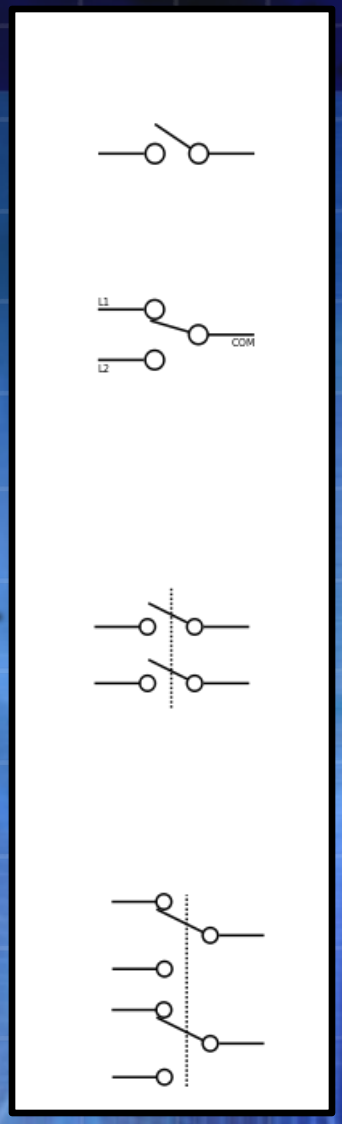
- A switch is an electrical component that can break an electrical circuit or divert it from one conductor to another.
- Usually has two states “Open” or “Closed”
  - Open is the circuit is Open or OFF
  - Closed is the circuit is connected/short or ON
- Can be a Toggle or Momentary

When doing switch problems, redraw the circuit for every configuration you want to test.



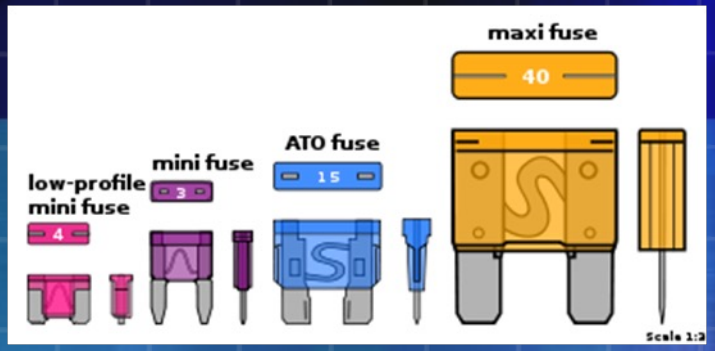
Types of switches

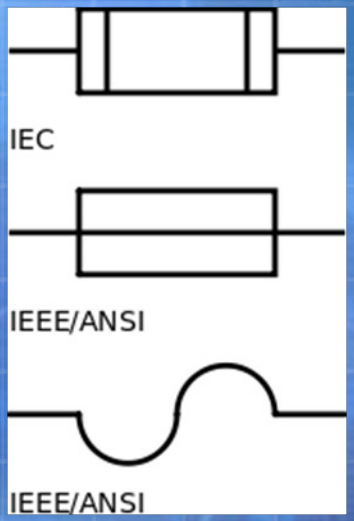
- Single Pole Single Throw (SPST)—a simple on/off switch. Light switch.
- Single Pole, Double Throw (SPDT)—a simple change over switch. Turns on one thing or another, not both.
- Double pole, Single Throw (DPST)—equal to two SPST switches controlled by a single mechanism. Like flipping two light switches at once.
- Double Pole, Double Throw (DPDT)—equivalent to two SPDT switches controlled by a single mechanism.



Fuses

- A safety device which "burns out" at a given current
  - Prevents a short or high current from damaging other systems, melting wires, etc. from a short or other problem
  - Fuses must be replaced after burn out, but not before the problem is resolved.
  - Usually faster than circuit breakers.



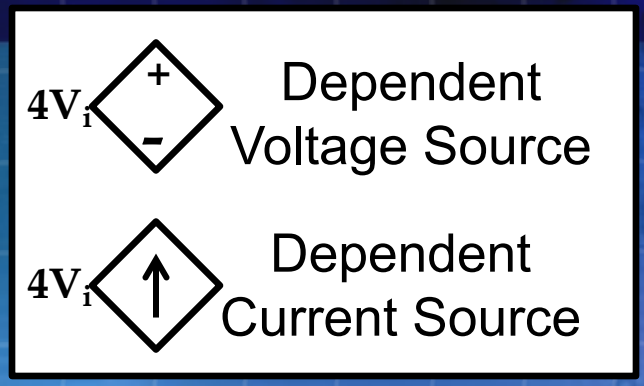


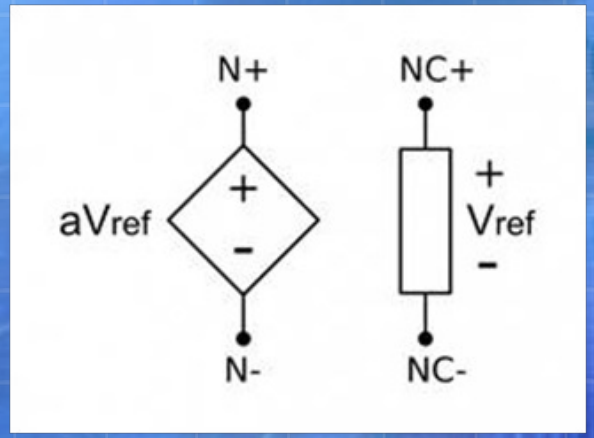
Circuit Breaker

- A safety device which "trips" at a given current
  - Prevents a short or high current from damaging other systems, melting wires, etc. from a short or other problem
  - Circuit Breakers may be reset after tripping, but <u>should not be reset unless the problem has been resolved.</u>
  - Usually a little slower than fuses.

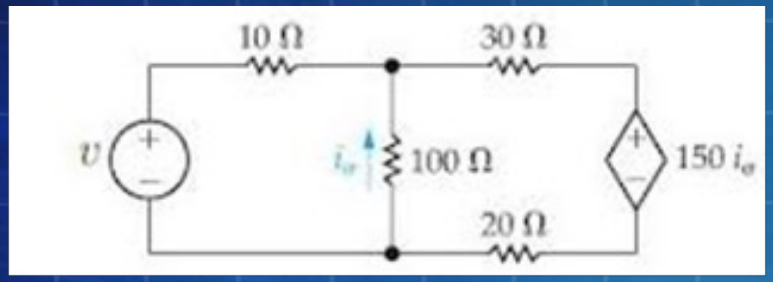
Dependent Sources

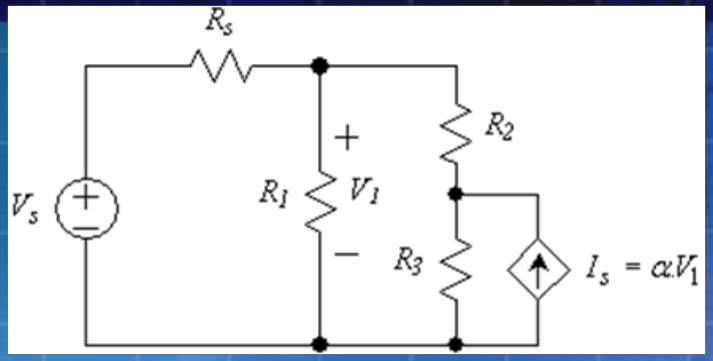
- Shown by diamond shape
- Sources that are dependent upon another element or measurement in a circuit.
  - Could reference other devices like an amplifier
- Use KVL and KCL to develop an equation and then solve

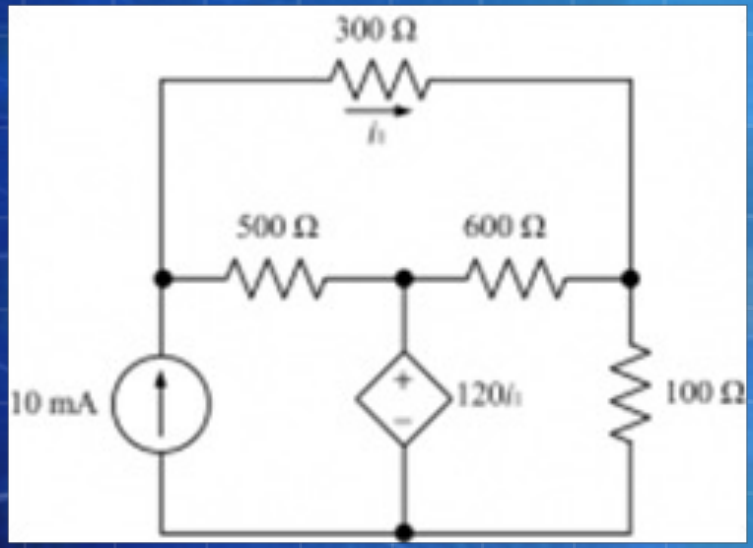


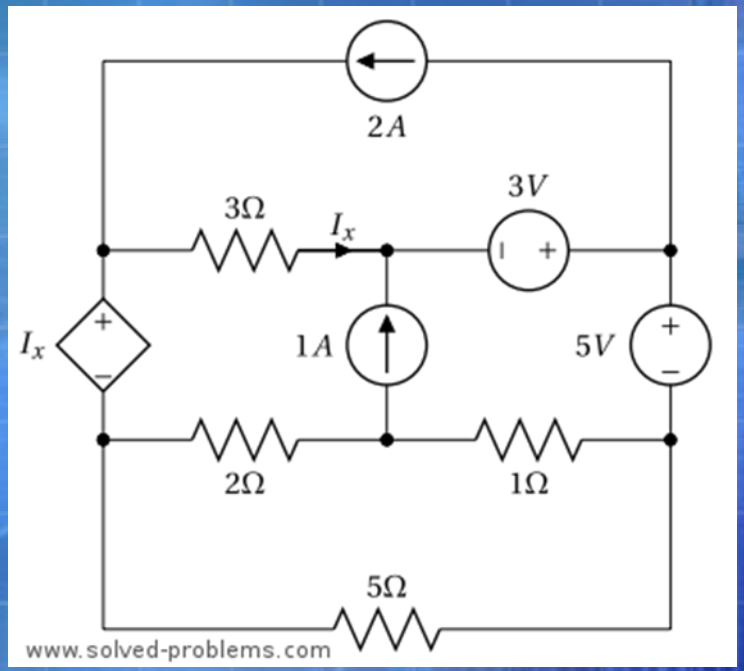


Dependent Source Examples



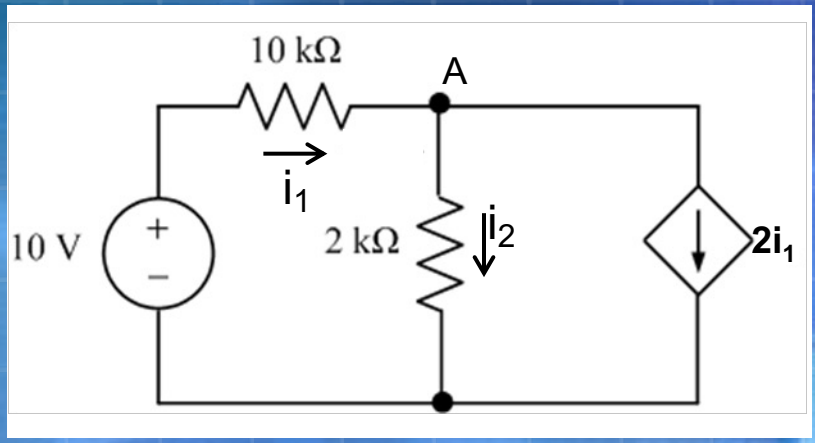






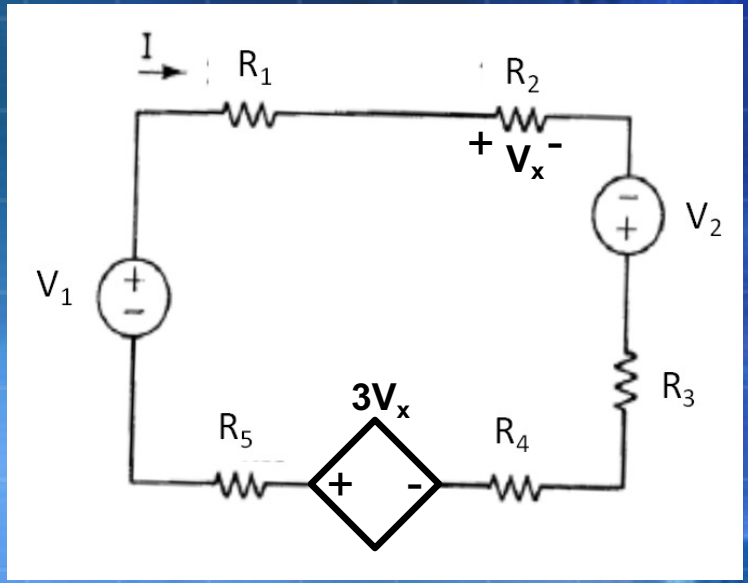
Solving Dependent Source

- With dependent current source
- KVL around left loop
  - $10V = i_1\ 10k\Omega + i_2\ 2k\Omega$
- KCL at node A
  - $i_1 = i_2 + 2\ i_1$
  - Subtract $2\ i_1$ from both sides
  - $-\ i_1 = i_2$
- Combine equations
  - $10\ V = i_1\ 10k\Omega + (-\ i_1)2k\Omega$
  - $10\ V = i_1\ (10k\Omega\ -\ 2k\Omega) = i_1(8k\Omega)$
  - $i_1 = 10\ V/8k\Omega = 1.25mA$
  - $i_2 = -i_1 = -1.25mA$
  - $2\ i_1 = 2.5mA$



Solving Dependent Source

- With dependent voltage source
  - $R_1 = R_2 = R_3 = R_4 = R_5 = 100\Omega$
  - $V_1 = 20$ V, $V_2 = 30$V
  - Solve for I
- KVL around loop
  - $V_1 + V_2 + 3V_X = IR_1 + IR_2 + IR_3 + IR_4 + IR_5$
  - $V_X = IR_2$
- Combine equations
  - $V_1 + V_2 + 3\,IR_2 = IR_1 + IR_2 + IR_3 + IR_4 + IR_5$
  - $V_1 + V_2 = IR_1 + IR_2 - 3\,IR_2 + IR_3 + IR_4 + IR_5 = I\,(R_1 - 2R_2 + R_3 + R_4 + R_5) = I\,(200\Omega)$
  - $I = (V_1 + V_2)/200\Omega = 50V/\,200\Omega = 0.25$ A



Superposition

- The superposition theorem for electrical circuits states that for a linear system the response (Voltage or Current) in any branch of a circuit having more than one independent source equals the algebraic sum of the responses caused by each independent source acting alone, while all other independent sources are replaced by their internal impedances.
- To ascertain the contribution of each individual source, all of the other sources first must be "turned off" (set to zero) by:
  - Replacing all other independent voltage sources with a short circuit (thereby eliminating difference of potential. i.e. V=0, internal impedance of ideal voltage source is ZERO (short circuit)).
  - Replacing all other independent current sources with an open circuit (thereby eliminating current. i.e. I=0, internal impedance of ideal current source is infinite (open circuit).
- Does NOT work with DEPENDENT SOURCES or POWER
- Will cover this in more detail later.

Troubleshooting

- Figure out if it worked previously
  - If it never worked it might be a design error
  - If it worked before, something had to change
- If it never worked, check the design for any flaws including Open and Short Circuits
- If it worked before, check for changes:
  - Is power connected? Is it "plugged in"--#1 PROBLEM OF ALL TIME
  - Are the batteries "dead"? use the voltmeter
  - Are the switches set up right/is it turned on
  - Fuse burnt out/circuit breaker tripped
  - Light bulb/resistor/motor burned out
  - Wire loose, light bulb loose
  - Figure out the design and draw it out
  - Test the design

Troubleshooting (cont.)

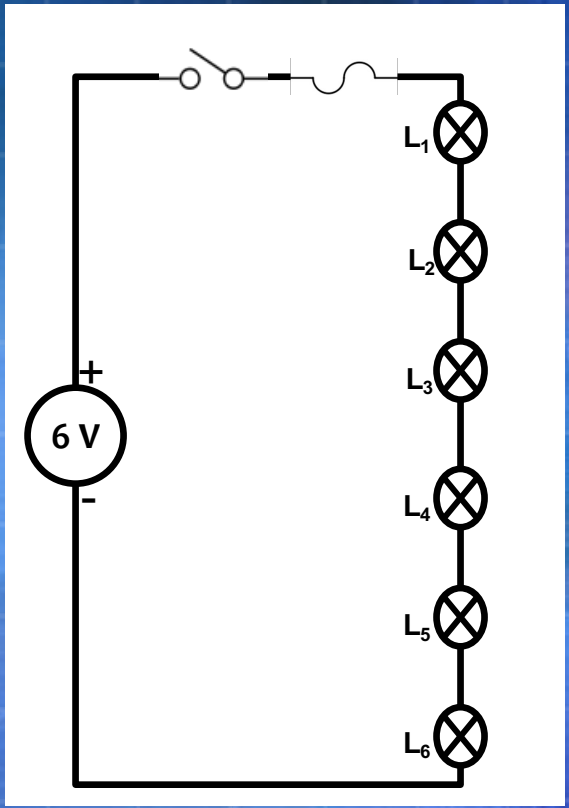
- If it used to work and it passed the tests on the previous slide, you need to look at the design
  - First DRAW and label it!
  - What should the voltage and/or resistance be between nodes? Write it down on your drawing
  - Measure voltage in parallel to the elements, with the power source on, just like it is running. Compare to your calculations.
  - Measure resistance in parallel to the elements, with the power source removed or switched off
    - Be careful that if you measure resistance you account for both paths between leads. Both between the element you have or any other path back.

Troubleshooting Tips

- Always check obvious stuff first (plugged in, battery not dead, switch on, wires connected, nothing loose).
- Series—they all go out
- Parallel—only the burned out one goes out
- Remember you only get voltage if you have both Current (I) and Resistance (R)
  - A Short Circuit will have both Voltage and Resistance = zero
  - An Open Circuit will have Resistance = Overload "1", only if there is not another path (i.e. back through the rest of the circuit)
- The Voltage across a bunch of resistors in series, with no current, will remain the same.
- The best way to measure resistance is to remove the element being tested and to test it alone.

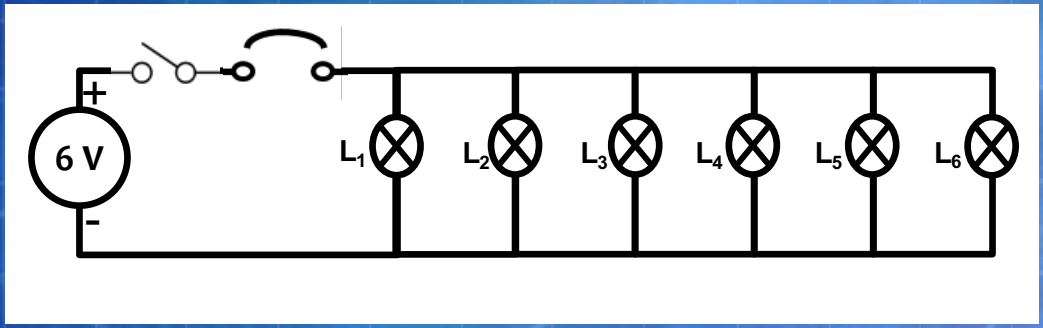
Troubleshooting a Series Circuit

- In the circuit, all the lights (12 Ω each) were working but stopped suddenly.
- What are the obvious things to check?
- What should we measure and how?
- What should be the resistance and voltage for each element?
- If everything else checks out and the voltage at L_5 = 10V, what's wrong?



Troubleshooting a Parallel Circuit

- In the circuit, all the lights (12 Ω each) were working but stopped suddenly.
- What are the obvious things to check?
- You fix the obvious problem, but still L_5 is out
- What should we measure and how?
  - What should the resistance and voltage be for each element?



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

Homework

- Update your binder to get it competition ready
- Complete the circuit problems from the Homework Generator
  - Level 11 Wheatstone
  - Level 12 Dependent Source
  - Level 13 Superposition
  - Level 14 Norton-Thevenin
- Correct the problems you missed on the practice competition on separate paper.