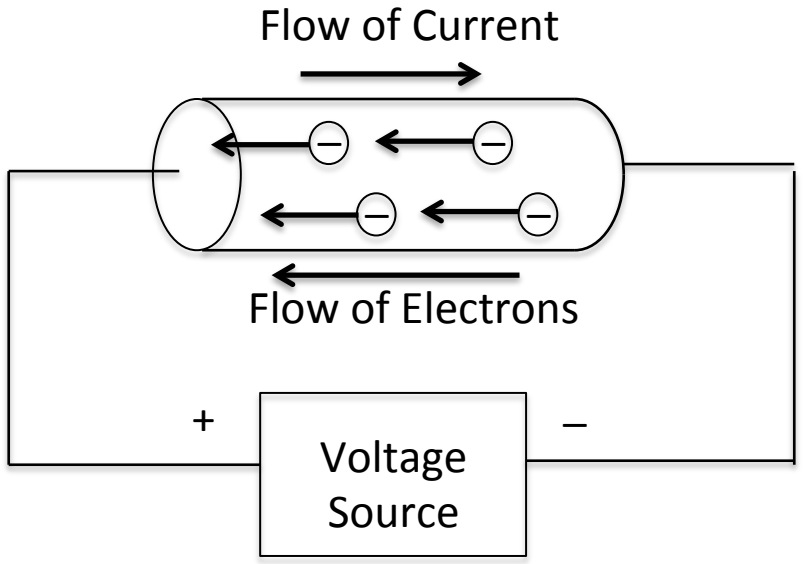
BME 301

2-Electric Circuits

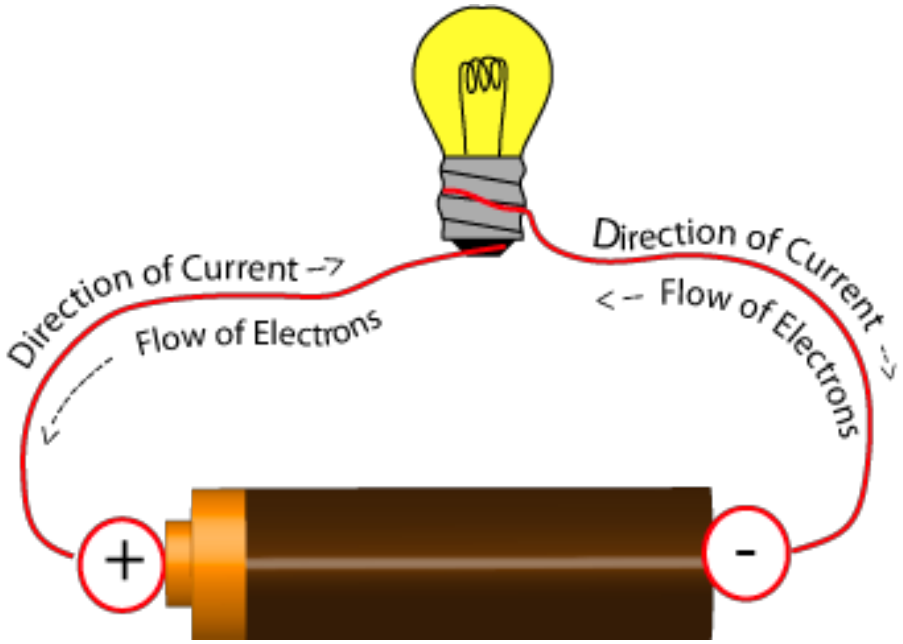
Some refreshing

Electrical Basic Parameters
Voltage and Current

- Current
  - Electricity is the flow of charge carriers; typically electrons.
  - The flow of charge carriers is called a current and has the units flow of charge (coulombs per second) or Amperes.
- Voltage
  - The “force” needed to create this flow of charges is called the Voltage.
  - Voltage has the units energy per charge (joules per coulomb) or Volts



Electrical Basic Parameters



Electrical Basics
Circuit Elements

- In order to have a circuit you need Circuit Elements
  - There are two types of circuit elements: active and passive.
  - Active elements provide energy
    - Battery
    - Wall socket
  - Passive elements use the energy provided by the active element either storing the energy or dissipating the energy.

Electrical Basics

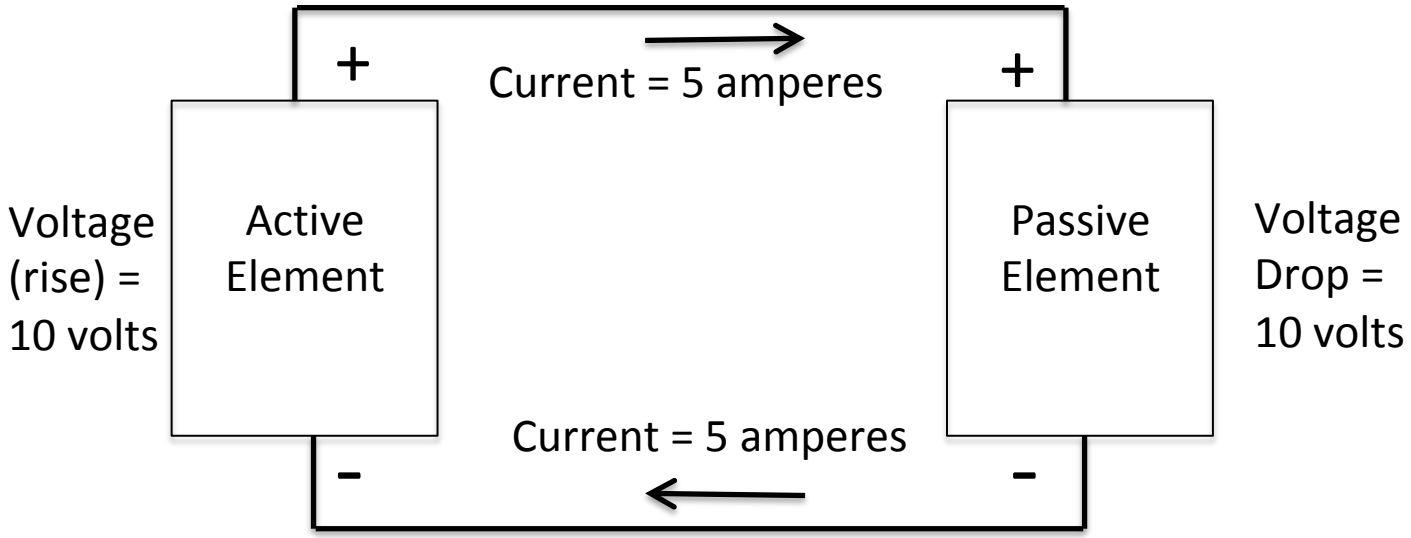
- Electric Circuits
  - Electric Circuits consist of circuit element with at least one active element and one passive element.
  - The circuit elements in a circuit must be connected together as a ***closed circuit*** such that current can flow from the active element(s) through the passive element(s) and return back to the active element.
  - If the circuit is not closed (there is no return path), current can not flow and the energy from the active element can not be used.

Electrical Basics

- Closed Circuits
  - When a circuit is closed, there is a current flowing through each element and a voltage appears across each element.
  - The voltage across the active element(s) is associated with the energy supplied by the active element and is the voltage provided by the source.
  - The voltage across the passive elements is associated with the energy used by the element and is called the voltage drop. (Therefore, sometimes the voltage across the active element is called a voltage rise.)

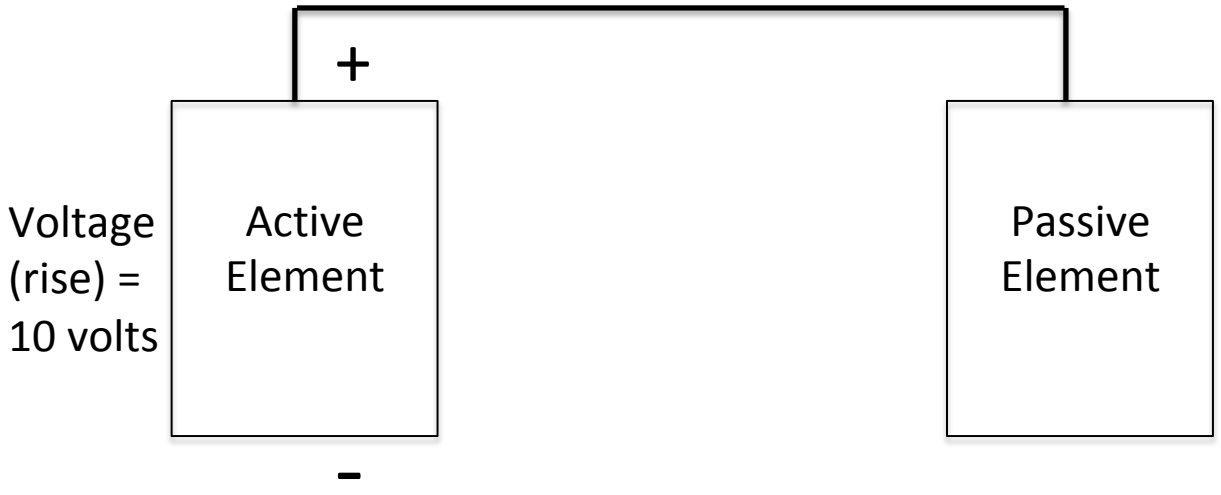
A Simple Closed Circuit

- Note the circuit is closed since there is a return path.
- Therefore there is the current flowing from the active element to the passive element is the same as current flowing from the passive element to the active element.
- Also note that the voltage provided by the active element equals the voltage used by the passive element. This is a consequence of conservation of energy.
- The electric power either delivered by a active element or used by an passive element is the product of the its voltage times the current flowing through it. In this example, the power is 10*5= 50 watts.
- Finally, note that the current flows out of the positive terminal of the active element and flows into the positive terminal of the passive element. So the polarity of the active elements voltage is in the opposite direction of the polarity of the passive element.



Not a Closed circuit

- Note that the circuit is not closed since there is no return path. (We usually say that there is an open circuit between the active and passive elements.)
- Therefore, no current can flow and no energy is transferred to the passive element.
- The voltage across the active element still exists but it only represents a potential energy.

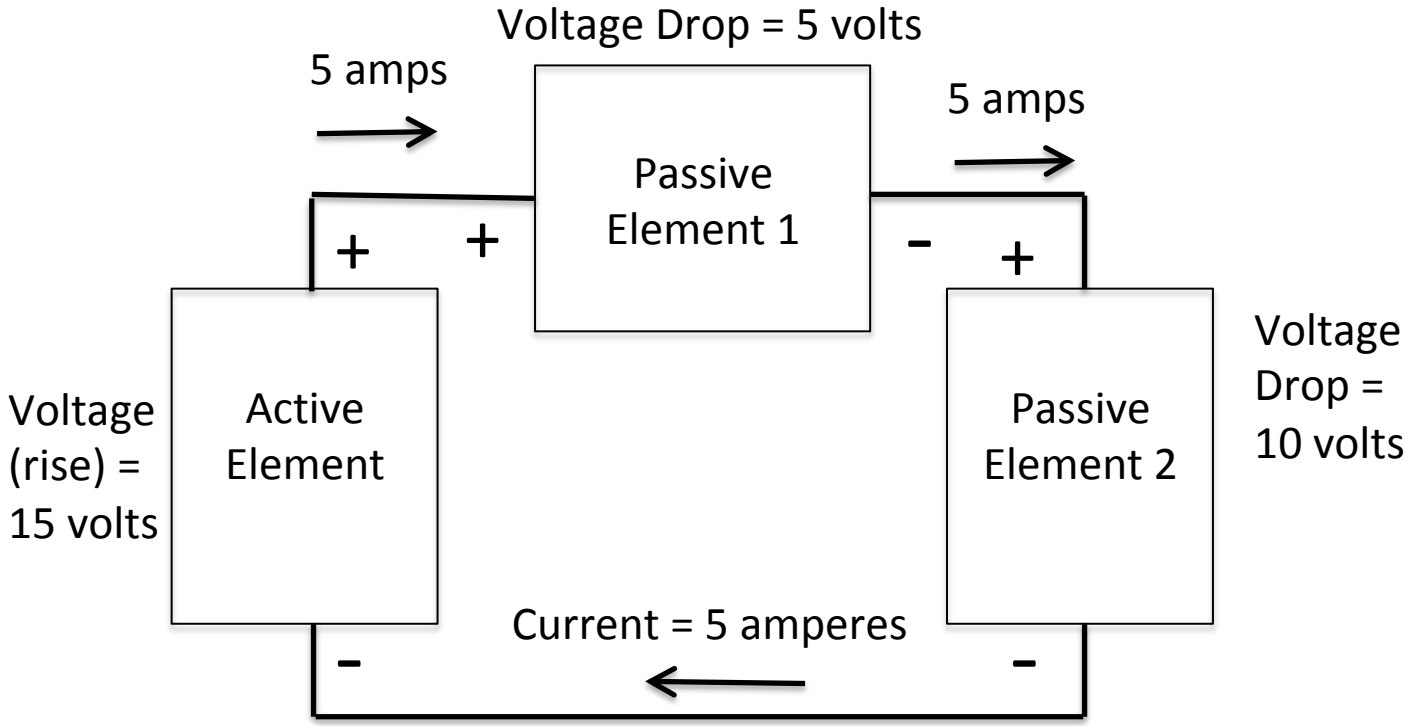


Circuit Connection

- Circuit elements form a circuit when they are connected together.
- Circuit Elements can be connected in series or in parallel or any combination of serial or parallel.

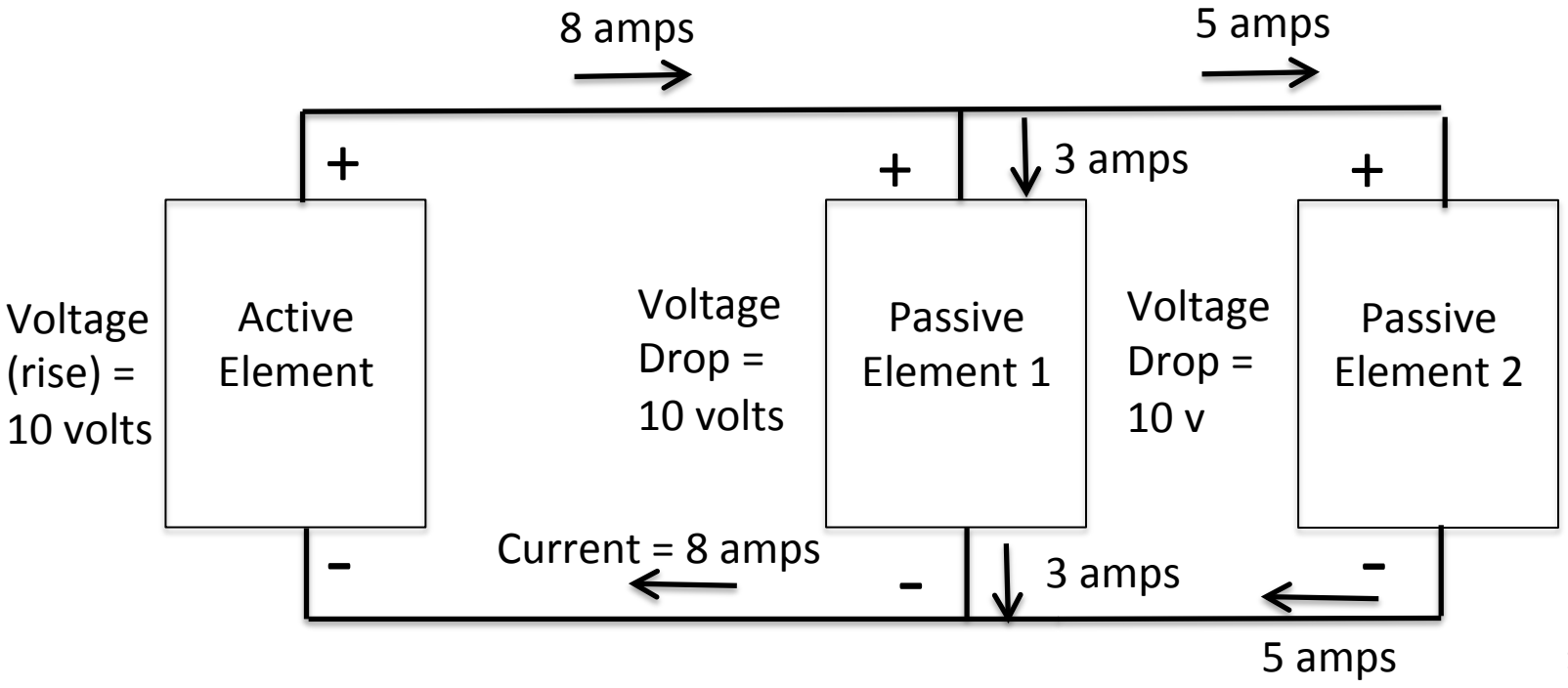
Series Circuit Connection

- A series connection is one where the same (identical) current flows through the elements.
- You can connect 2 or more elements in series.
- Note that passive element 1 and passive element 2 have the same identical current flowing through them and are therefore in series. In fact all three elements are in series.
- Note in this circuit although both passive elements have the same current flowing through them, they do not have the same voltage across each and therefore the voltage of the active element has to be equal to the sum of these two passive elements.



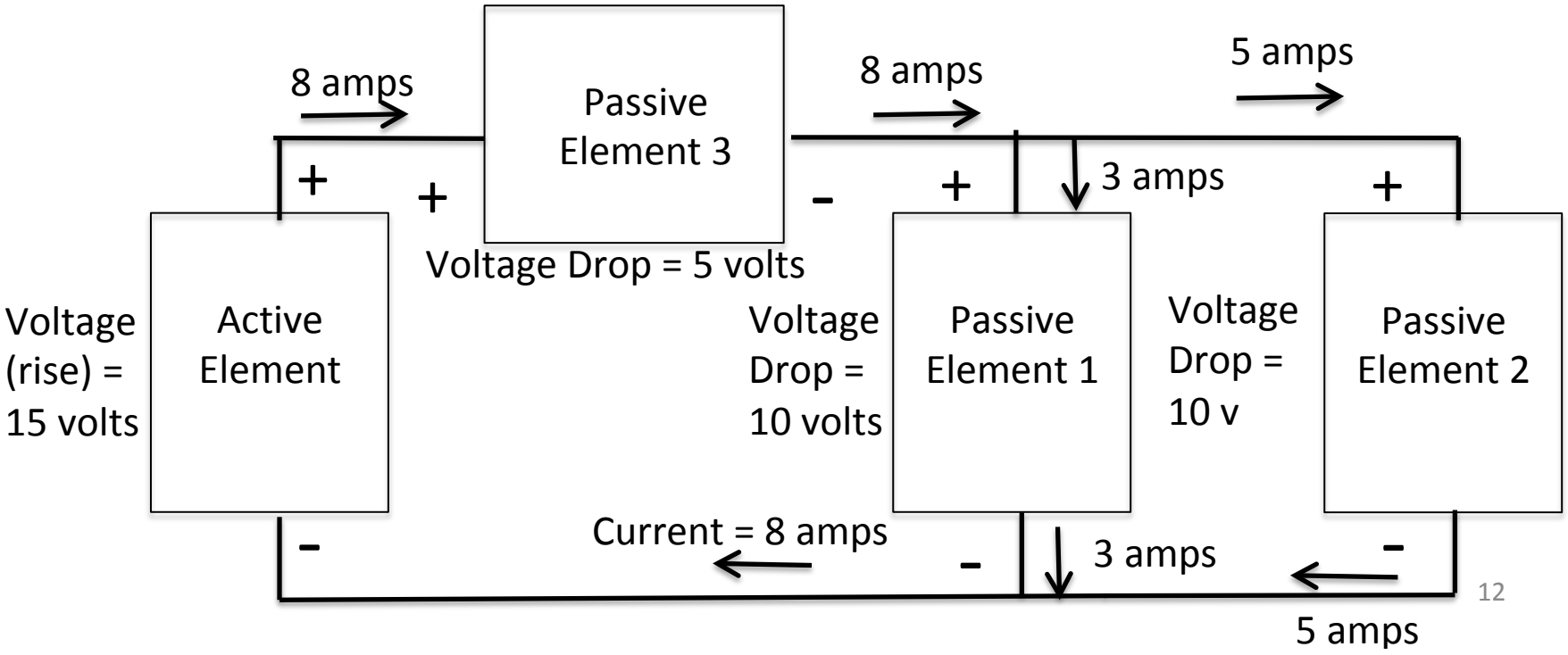
Parallel Circuit Connection

- A parallel connection is one where the same (identical) voltage appears across the elements.
- You can connect 2 or more elements in parallel.
- Note that passive element 1 and passive element 2 have the same identical voltage across them and are therefore in parallel. In fact all three elements are in parallel.
- Note in this circuit although both passive elements have the same voltage across them, they do not have the same current flowing through them and therefore the current flowing to and from the active element has to be equal to the sum of these two passive elements.



Mixture of serial and parallel

- In this figure passive element 1 and passive element 2 form a parallel combination. This parallel combination is in series with passive element 3.
- This is because the parallel combination of 1 and 2 can be replaced by a single passive element which will have 10 volts across it and 8 amps flowing through it. Call it passive element 4.
- So if you replace the parallel combination with the single passive 4, it will look like the figure for the series combination (2 slides back). That would be make 4 in series with 3. There the calculation of the voltage for the active element is the same.

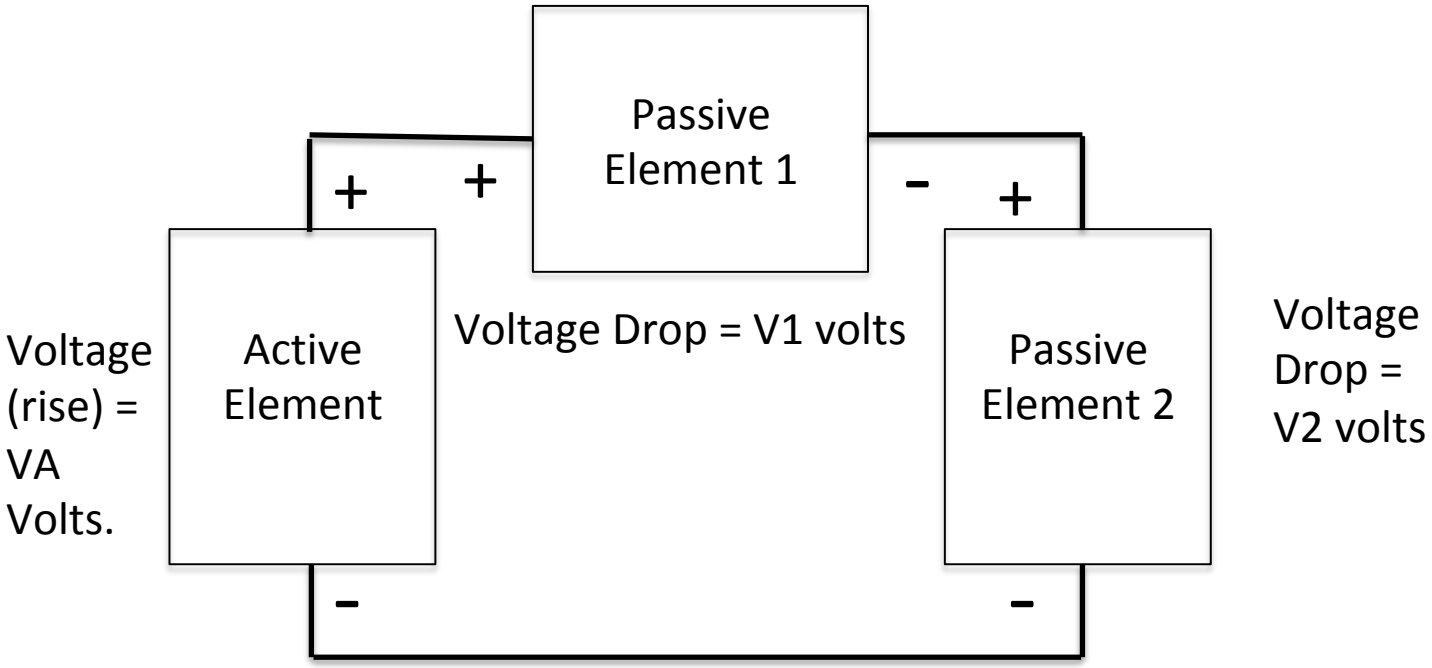


Kirchhoff Law's

- There are two Kirchhoff Law's
- Kirchhoff Voltage Law (KVL): The sum of the voltages around a loop must equal zero.
- Kirchhoff Current Law (KCL): The sum of the currents leaving (entering) a node must equal zero.

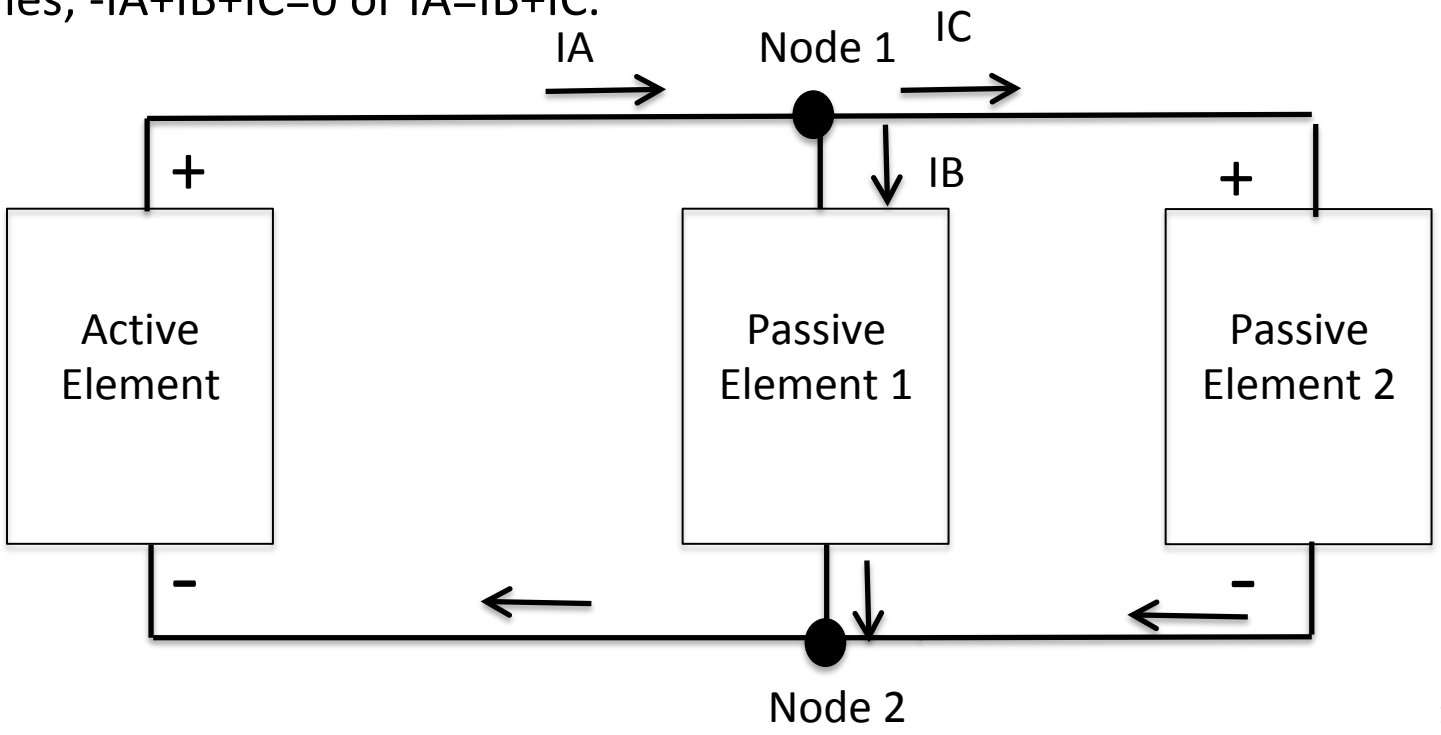
Kirchhoff Voltage Law

- This circuit is a simple loop.
- If one starts on the bottom left and moves clockwise around the loop, there is a voltage rise of VA volts. Then there are 2 voltage drops of V1 and V2. Note that the polarity of the voltage rise is opposite in sign of the voltage drops.
- Making the voltage rise positive and the voltage drops negative, Kirchhoff Voltage Law becomes: VA-V1-V2=0 or VA=V1+V2.



Kirchhoff's Current Law

- Nodes are points on the circuit diagram where several connections are made In this circuit there are 2 nodes:
- Taking Node 1, one current, IA, enters node 1 and two currents, IB and IC leave node 1.
- Taking currents leaving the node as positive, Kirchhoff's current law becomes; -IA+IB+IC=0 or IA=IB+IC.



Homework

1. Why does a circuit need a closed path?
2. What are the two types of circuit elements?
3. What are their functions?
4. Provide two examples of a circuit using both serial and parallel connections? What are there functions
5. HONORS STUDENTS ADD THE FOLLOWING

What physical law do each of Kirchhoff laws obey? Why?