

EC25202-CIRCUIT THEORY

Class Code: **rycufy5k**

UNIT I DC AND AC CIRCUIT ANALYSIS 9

Basic electrical components, Voltage, Current laws, Divider theorem, Short and Open Circuits, Resistors in Series and Parallel, Mesh and Nodal, Super Mesh and Super Node, Source transformation techniques, Star delta transformation techniques.

UNIT I NETWORK THEOREMS FOR DC AND AC CIRCUITS 9

Circuit analysis techniques - Linearity and Superposition, Thevenin and Norton equivalent circuits, Maximum power transfer, Analysis using dependent current sources and voltage sources.

UNIT III TRANSIENTS ANALYSIS OF DC AND AC CIRCUITS 9

Basic RL and RC circuits, The source - free RL circuit, The source-free RC Circuit, The Unit-Step function, Driven RL circuits, Driven RC circuits, Driven RLC circuits.

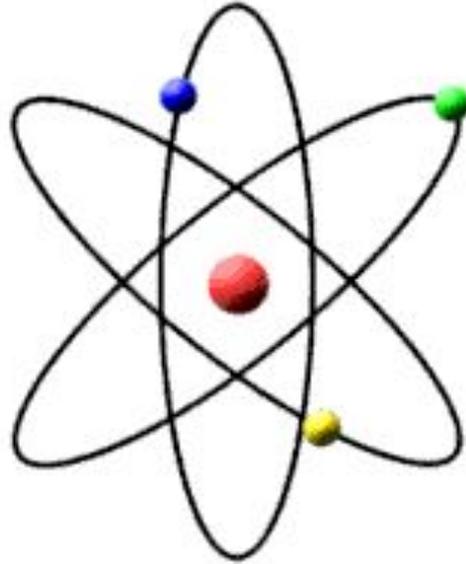
UNIT IV RESONANCE CIRCUITS 9

Series resonance - impedance and phase angle of a series resonant circuit - Voltages and currents in a series resonant circuit - Bandwidth of an RLC circuit - Quality factor and its effect on bandwidth-magnification in resonance - Parallel resonance - Resonant frequency for a tank circuit – Variation of impedance with frequency - Q-factor of parallel resonance – magnification.

UNIT V COUPLED CIRCUITS 9

Magnetically Coupled Circuits, Mutual Inductance, Linear Transformer, Ideal Transformer, An introduction to Network Topology, Trees and General Nodal analysis, Links and Loop analysis.

CHARGE



The fundamental unit of charge is the **coulomb (C)**.

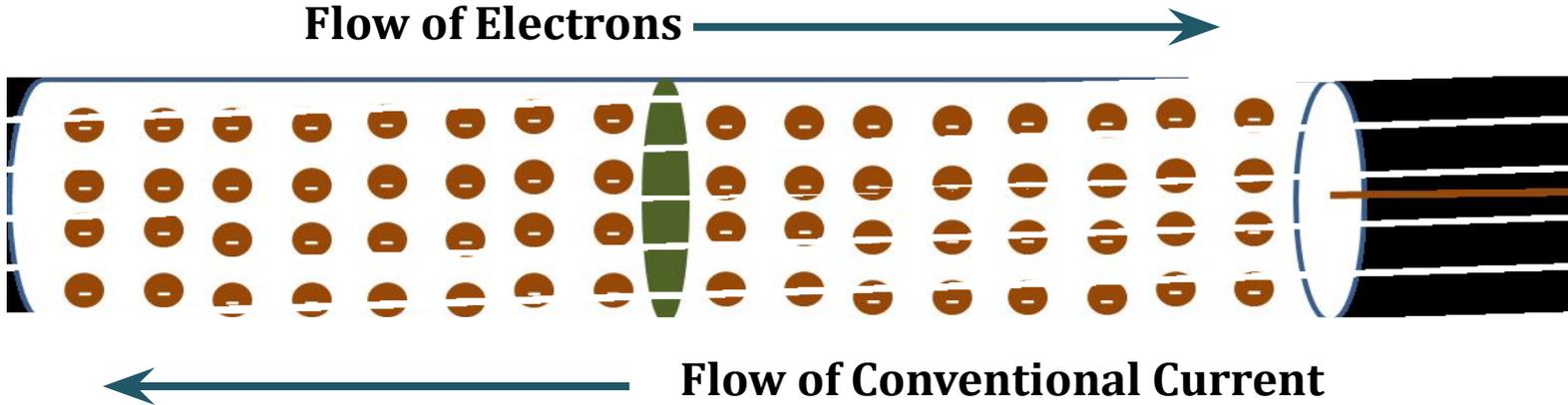
A single electron has a charge of $-1.602 \times 10^{-19} \text{ C}$

A single Proton has a charge of $+1.602 \times 10^{-19} \text{ C}$

CURRENT

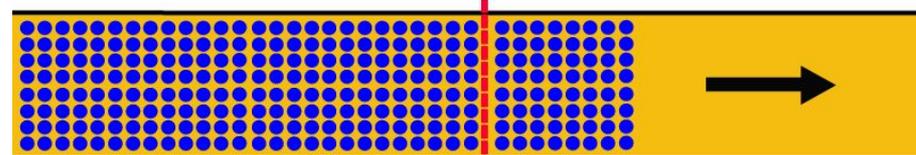
“transfer of charge” or “charge in motion”

$$i = \frac{dq}{dt} \quad \text{One ampere equals 1 coulomb per second}$$



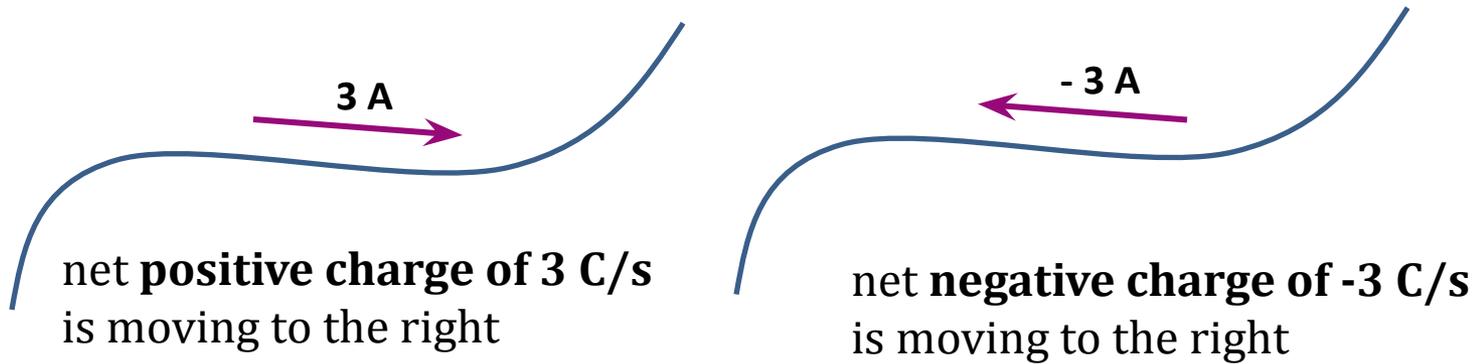
$$\begin{aligned} 1 \text{ electron is } & -1.602 \times 10^{-19} \text{ C or} \\ 1 \text{ C is } & \frac{1}{1.602} \times 10^{19} \text{ electrons} \end{aligned}$$

A wire carrying 1 ampere carries about ...

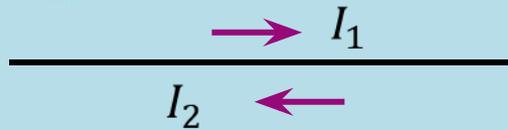


6,241,000,000,000,000,000,000,000
electrons across it per second!

SAME CURRENT

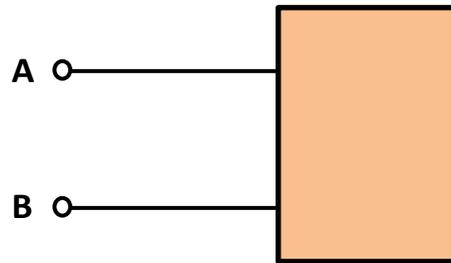
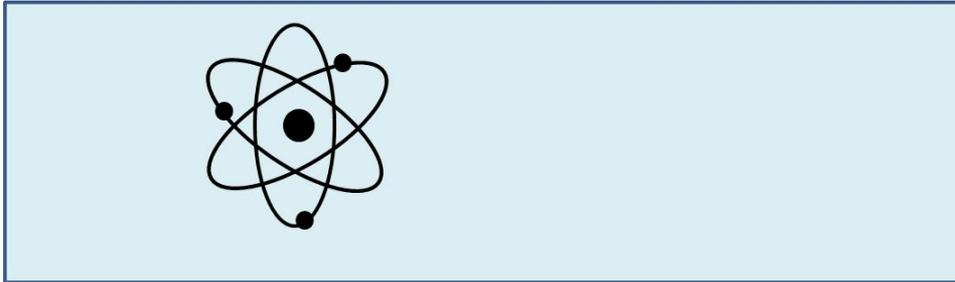


In the wire of, electrons are moving left to right to create a current of 1 mA . Determine I_1 and I_2 .



ANS: $I_1 = -1 \text{ mA}$ and $I_2 = 1 \text{ mA}$

VOLTAGE



A general two-terminal circuit element.

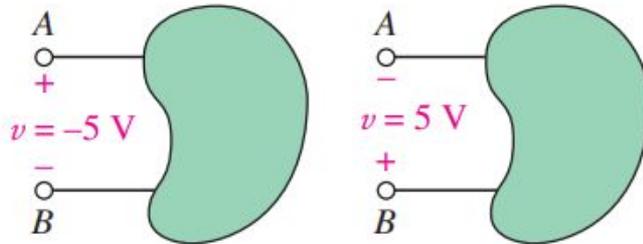
pushing charge through the element requires an expenditure of energy - say that an *electrical voltage (or a potential difference)* exists between the two terminals, or that there is a *voltage “across” the element.*

Voltage across a terminal pair is a measure of the work required to move charge through the element.

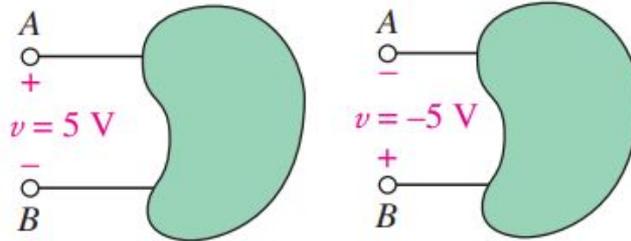
UNIT : J/C or volt

A voltage can exist between a pair of electrical terminals whether a current is flowing or not. Example: An automobile battery has a voltage of 12 V across its terminals even if nothing whatsoever is connected to the terminals

Convention to distinguish between energy supplied *to an element* and energy that is supplied *by the element* itself.



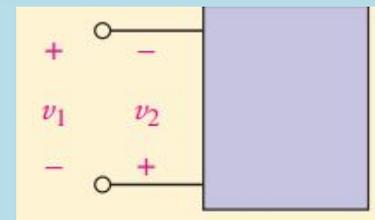
Terminal B is 5 V positive with respect to terminal A



Terminal A is 5 V positive with respect to terminal B

The definition of any voltage must include a plus-minus sign pair!

For the element, $v_1 = 17\text{ V}$. Determine v_2 .



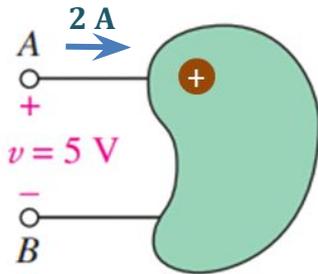
ANS: $v_2 = -17\text{ V}$

POWER

If one joule of energy is expended in transferring one coulomb of charge through the device in one second, then the rate of energy transfer is one watt.

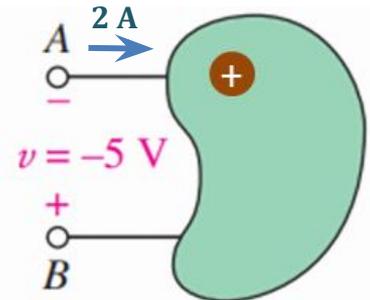
The absorbed power must be proportional both to the *number of coulombs transferred per second (current)* and to the *energy needed to transfer one coulomb through the element (voltage)*. Thus,

$$p = vi \text{ J/s, or W}$$

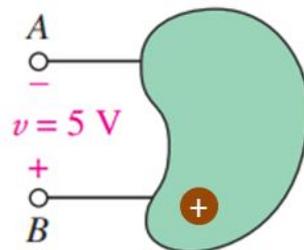
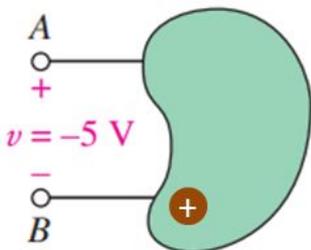


Terminal A is 5 V positive with respect to terminal B which means that 5 J of energy is required to move each coulomb of positive charge into terminal A, through the object, and out terminal B.

$$P = \left(5 \frac{\text{J}}{\text{C}}\right) \times \left(2 \frac{\text{C}}{\text{s}}\right) = 10 \text{ W}$$



object is absorbing 10 W of power



It takes -5 J/C to move charge from terminal A to terminal B, the object is absorbing

$$\left(-5 \frac{\text{J}}{\text{C}}\right) \times \left(2 \frac{\text{C}}{\text{s}}\right) = -10 \text{ W}$$

Negative absorbed power, is equivalent to positive supplied power

If the current arrow is directed into the “+” marked terminal of an element, then $p = vi$ yields the absorbed power. A negative value indicates that power is actually being generated by the element.

If the current arrow is directed out of the “+” terminal of an element, then $p = vi$ yields the supplied power. A negative value in this case indicates that power is being absorbed.

VOLTAGE AND CURRENT SOURCES

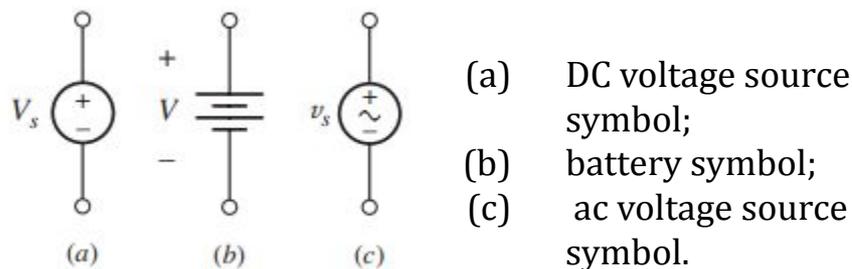
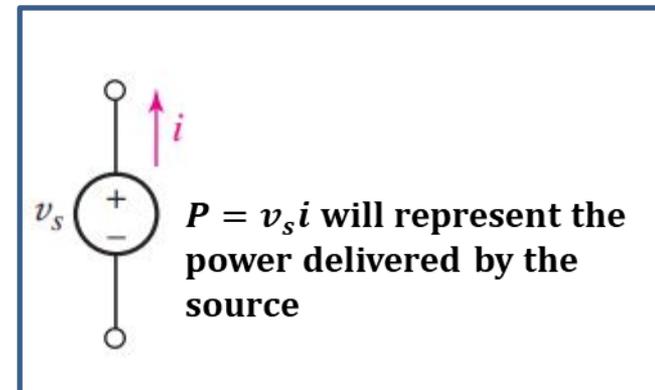
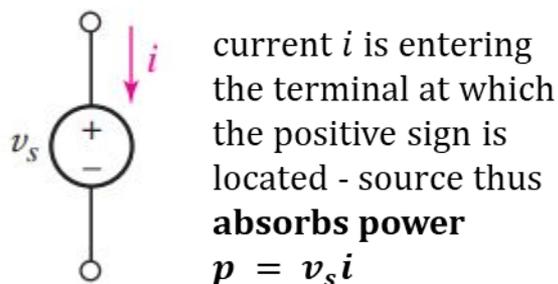
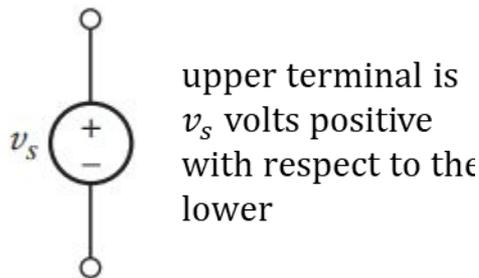
All the simple circuit elements that we will consider can be classified according to the relationship of the current through the element to the voltage across the element.

- **Resistor** - voltage across the element is *linearly proportional* to the current through it
- **Inductor** - voltages are proportional to the *derivative* of the current with respect to time
- **Capacitor** - voltages are proportional to the *integral* of the current with respect to time
- **Independent sources** - voltage is *completely independent* of the current, or the current is completely independent of the voltage
- **Dependent sources** - either the source voltage or current *depends* upon a current or voltage elsewhere in the circuit

Independent Voltage Sources

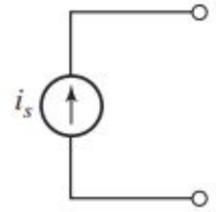
An independent voltage source is characterized by a terminal voltage which is completely independent of the current through it. This is an ideal source and does not represent exactly any real physical device. Ex:

- An automobile storage battery, has a 12 V terminal voltage that remains essentially constant as long as the current through it does not exceed a few amperes.
- If a small positive current is flowing **out of the positively marked terminal**, then the battery is **furnishing power to the headlights**.
- if the current is positive and flowing **into the positive terminal**, then the battery is charging by **absorbing energy from the alternator**

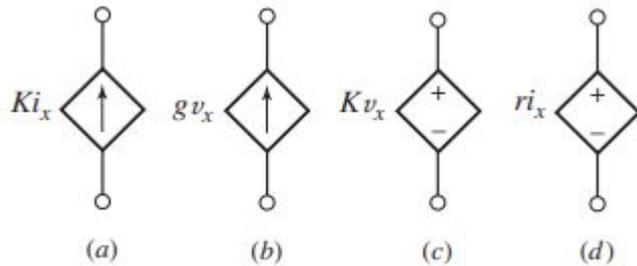


convention

Independent Current Sources: the current through the element is completely independent of the voltage across it.



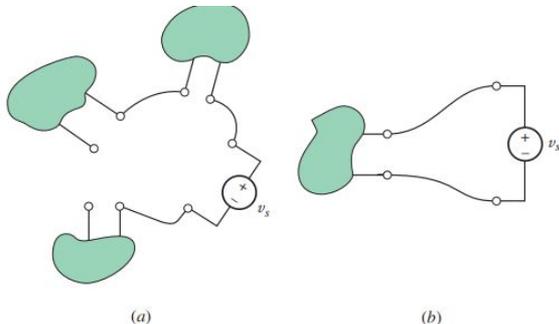
Dependent Sources - source quantity is determined by a voltage or current existing at some other location in the system being analyzed



- (a) current-controlled current source;
- (b) voltage-controlled current source;
- (c) voltage-controlled voltage source;
- (d) Current-controlled voltage source.

Networks and Circuits

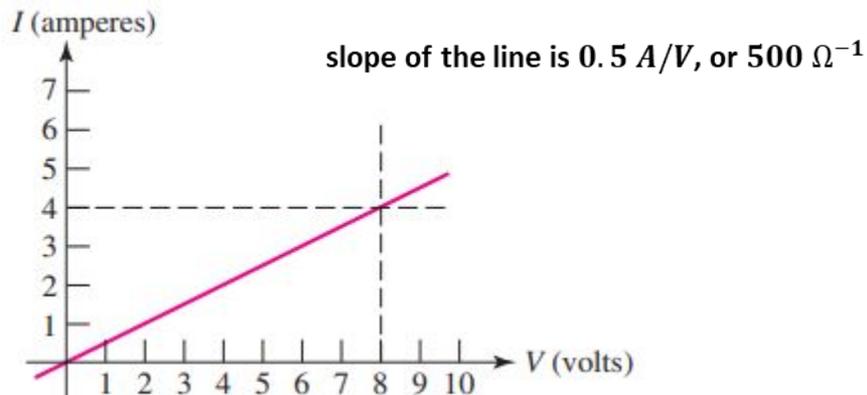
- The interconnection of two or more simple circuit elements forms an electrical network
- If the network contains at least one closed path, it is also an electric circuit.



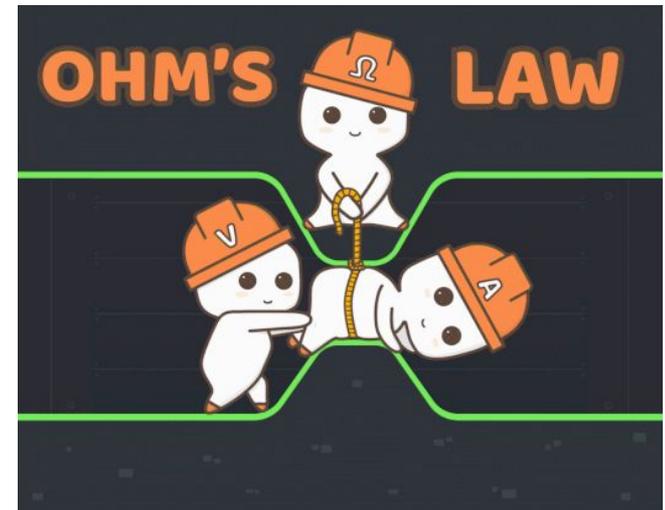
- (a) A network that is not a circuit.
- (b) A network that is a circuit.

OHM'S LAW

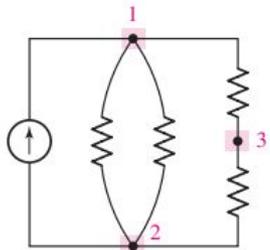
Ohm's law states that the **voltage across conducting materials is directly proportional to the current flowing through the material**, or $v = Ri$ where the constant of proportionality R is called the resistance. The unit of resistance is the ohm, which is 1 V/A or capital omega, Ω



Current-voltage relationship 2Ω linear resistor.



NODES, PATHS, LOOPS, AND BRANCHES



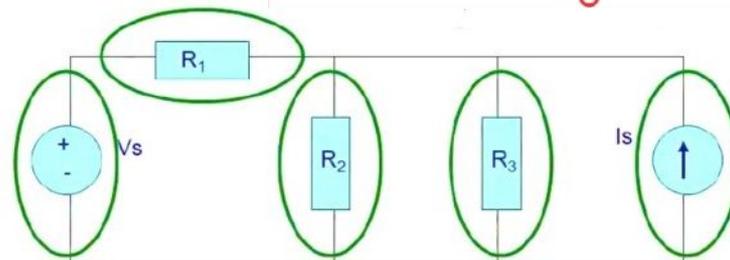
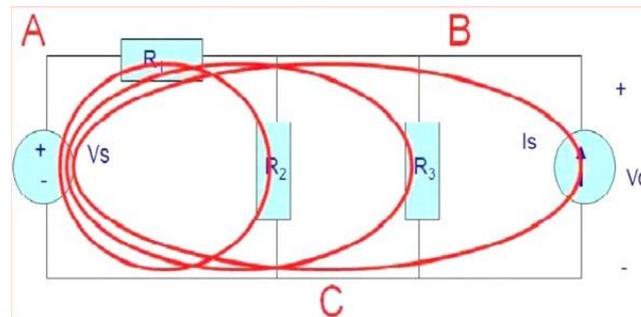
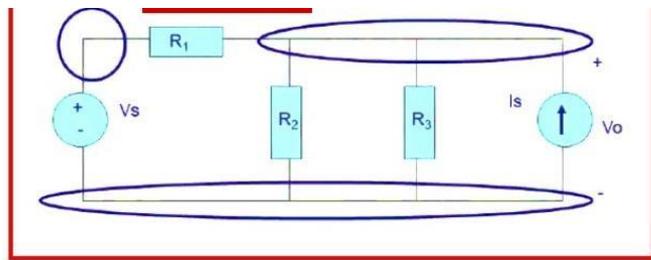
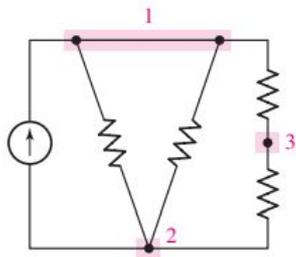
(a)

NODE - A point at which two or more elements have a common connection

PATH - The set of nodes and elements that we have pass through, If no node was encountered more than once

LOOP - If the node at which we started is the same as the node on which we ended, then the path is, a closed path or a loop.

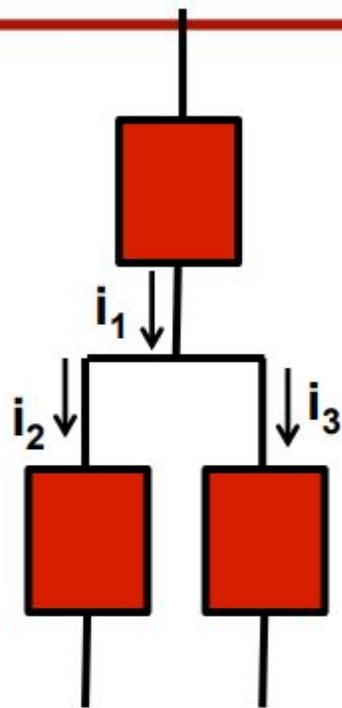
BRANCH - a single path in a network, composed of one simple element and the node at each end of that element.



Basic Components

Parameter	Resistor (R)	Inductor (L)	Capacitor (C)
Definition	Opposes the flow of electric current	Stores energy in magnetic field	Stores energy in electric field
Unit	Ohm (Ω)	Henry (H)	Farad (F)
Basic V–I relation	$v(t) = R i(t)$	$v(t) = L di(t)/dt$	$i(t) = C dv(t)/dt$
Integral form	$i(t) = v(t)/R$	$i(t) = (1/L) \int v(t) dt + i(0)$	$v(t) = (1/C) \int i(t) dt + v(0)$
Continuity property	$v(t)$ and $i(t)$ continuous	Current cannot change instantaneously	Voltage cannot change instantaneously
Energy relation	Energy dissipated as heat	$W = \frac{1}{2} L i^2$	$W = \frac{1}{2} C v^2$

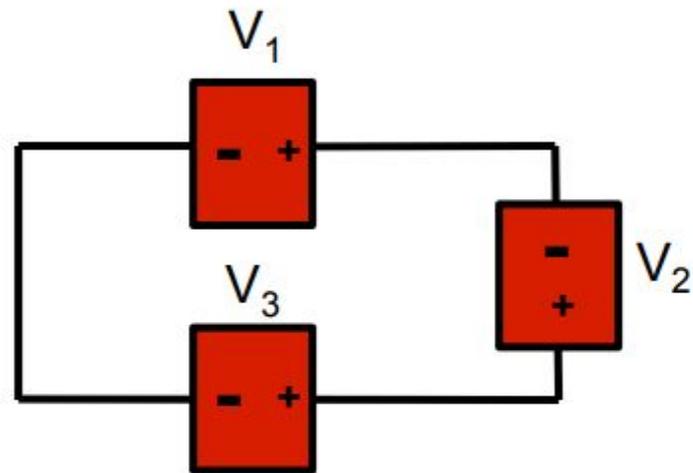
Kirchhoff's Current and Voltage Laws (KCL & KVL)



Kirchhoff's Current Law (KCL) states that the current flowing out of any node must equal the current flowing in. So, for example,

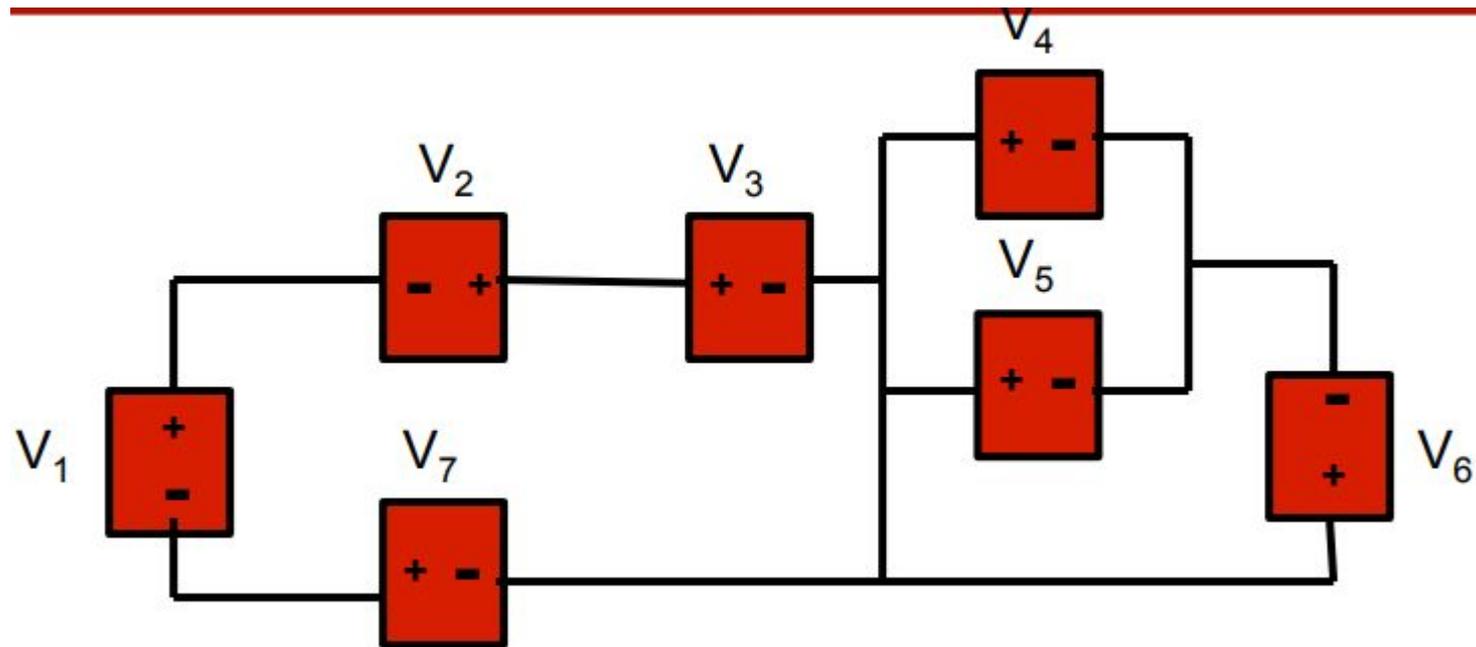
$$i_1 = i_2 + i_3$$

Rectangular Snip



Kirchhoff's Voltage Law (KVL) states that the algebraic sum of the voltages around any closed path must be zero. So, for example,

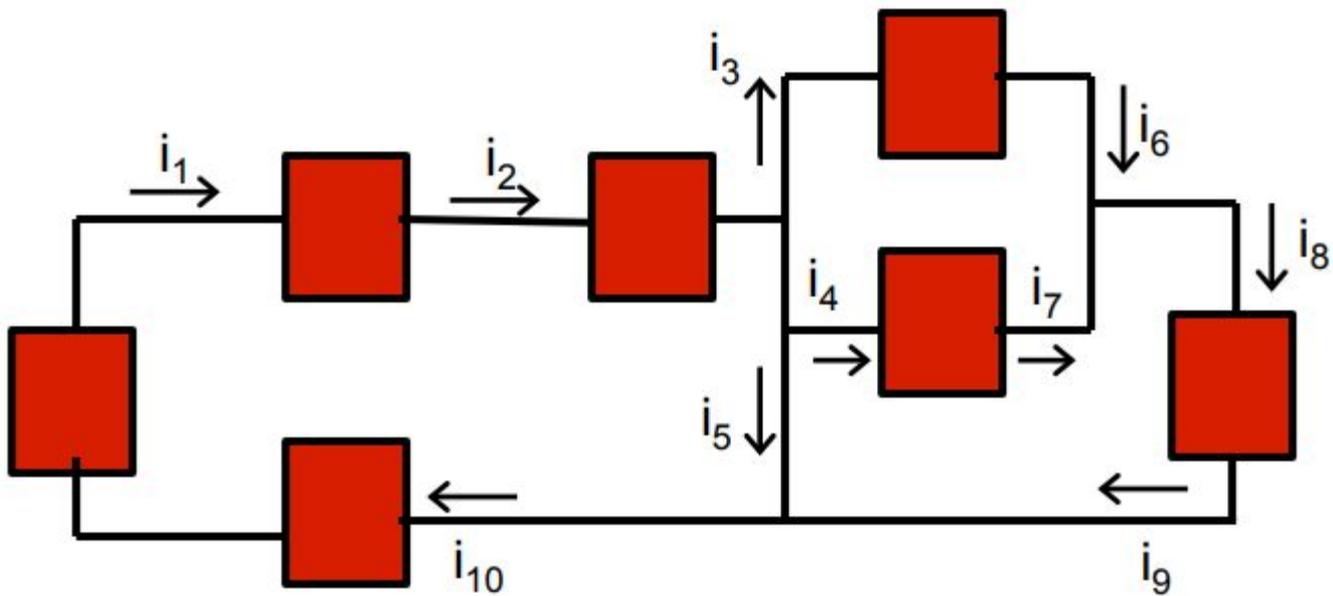
$$V_1 + V_2 - V_3 = 0$$



$$V_1 + V_2 - V_3 - V_4 + V_6 + V_7 = 0$$

$$V_1 + V_2 - V_3 + V_7 = 0$$

$$-V_4 + V_6 = 0$$



$$i_1 = i_2 = i_{10}$$

$$i_2 = i_3 + i_4 + i_5$$

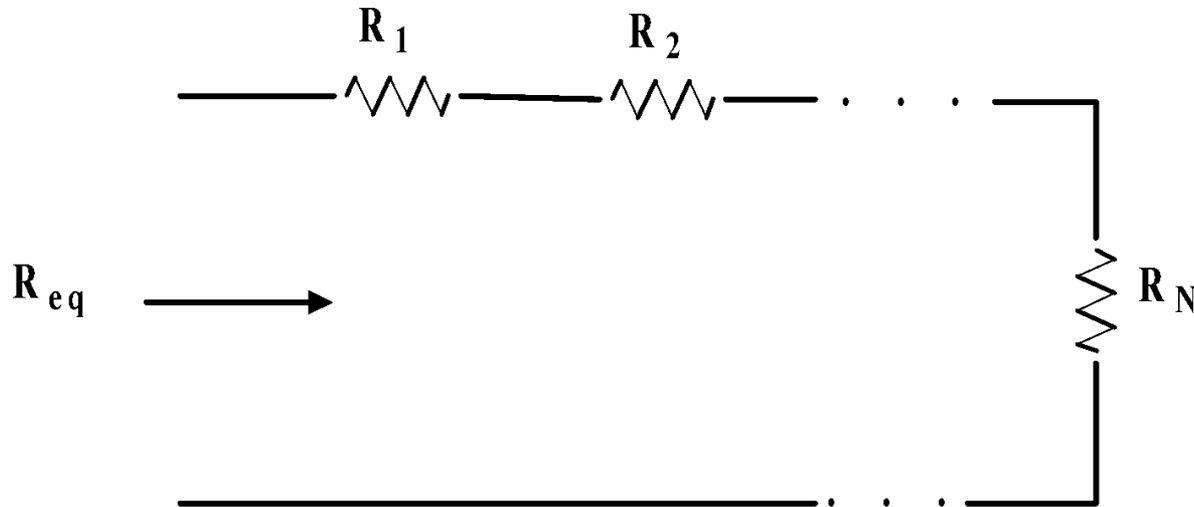
$$i_3 = i_6 \text{ and } i_4 = i_7$$

$$i_8 = i_9 = i_{10} - i_5$$

Resistors in Series

Equivalent Resistance:

We know the following for series resistors:

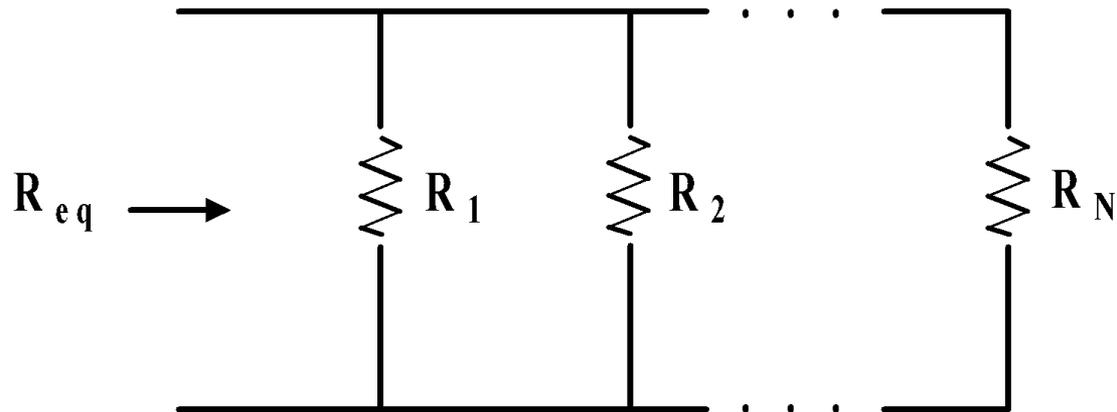


$$R_{eq} = R_1 + R_2 + \dots + R_N$$

Resistors in Parallel

Equivalent Resistance:

We know the following for parallel resistors:



$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_N}$$