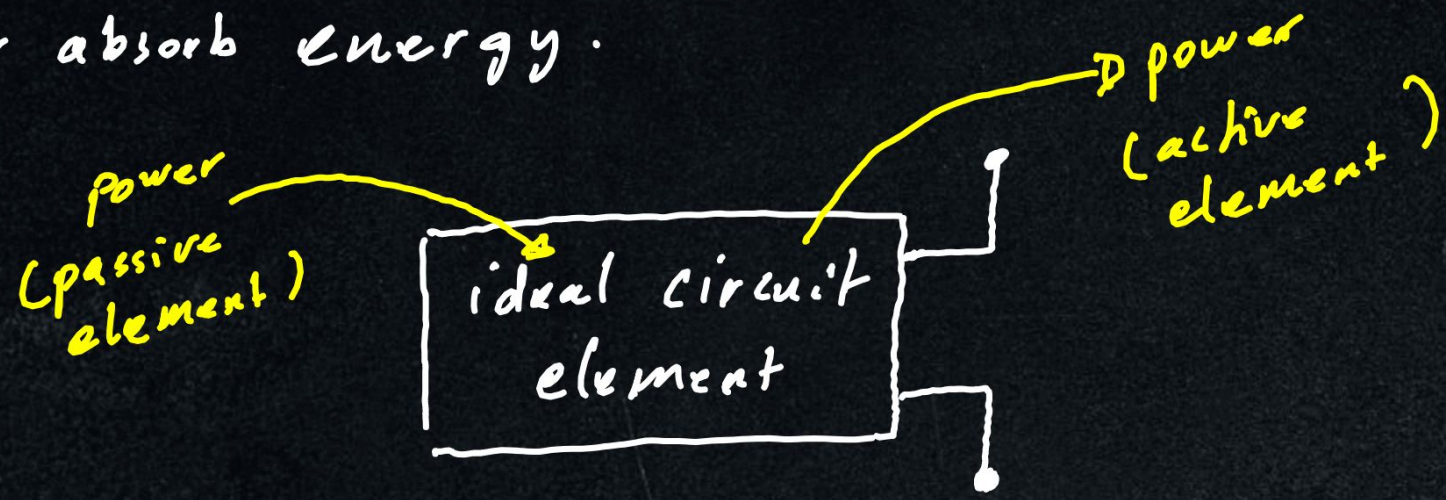
CH2: Circuit Elements

Ideal circuit element: It is a two-terminal device that can be classified as active or passive based simply on whether they supply energy to the circuit or absorb energy.



Active elements → Batteries and Generators

passive elements → Resistors, Capacitors, and Inductor.

① Active Elements (Sources)

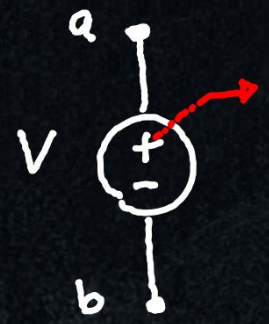
Non-electric energy ⟶ Electric energy

Active elements.

- 1.1) Independent sources
- 1.2) Dependent sources

1.1) Independent Sources

1.1.1) Voltage source : It maintains a specific voltage across its terminal independent of the current that flows through it.

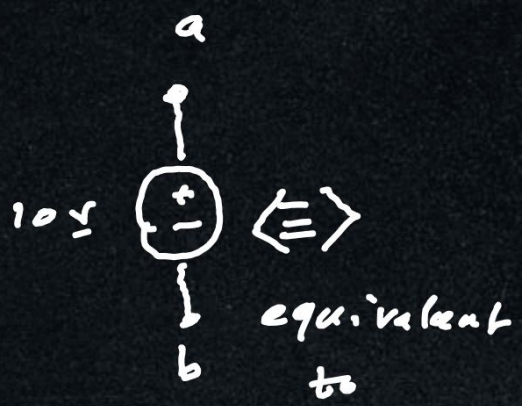


It represents the positive reference polarity

$V_{ab} = V$

$V_{ab} = 10\ V$

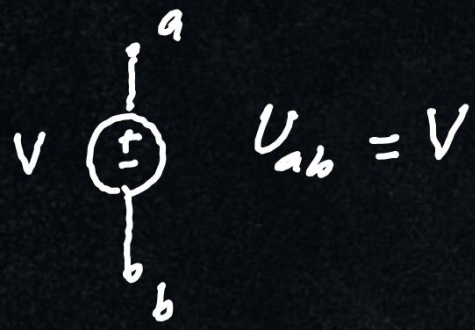
$V_{ba} = -10\ V$



DC: Direct current
AC: Alternating current

Voltage sources

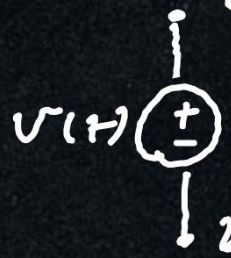
DC voltage source



$U_{ab} = V$

where V is constant

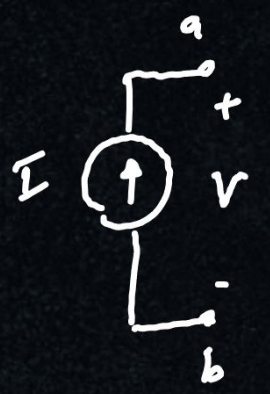
AC voltage source.

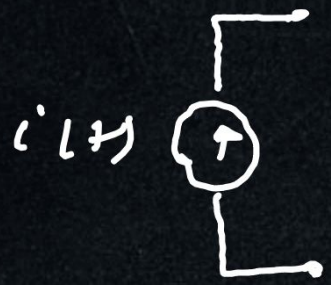


$U_{ab} = U(t)$

where U(t) is a function of time

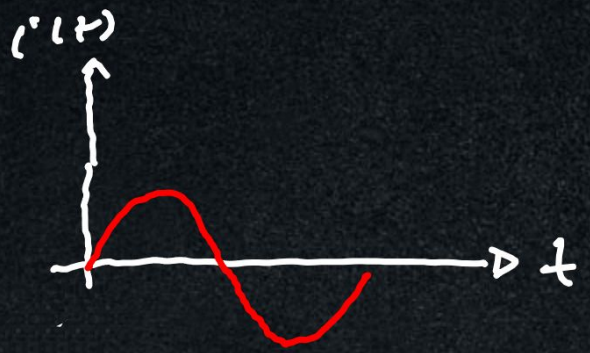
1.1.2) Current source :- It maintains a specific current through it independent of the voltage developed across its terminals.





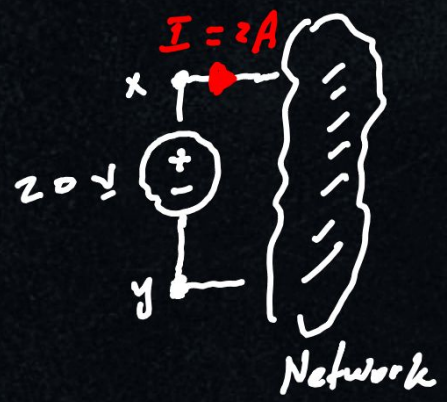
DC "Constant"

AC "Function of time"



Circuit Elements

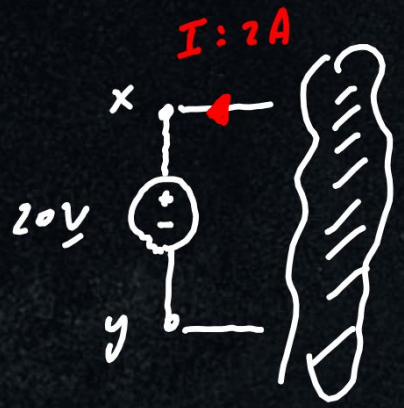
- ① Active (sources)
  - 1.1) Indep.
    - 1.1.1) Voltage source
      - AC
      - DC
    - 1.1.2) Current source
      - AC
      - DC
  - 1.2) Dep.
- ② Passive (R, L, C)



$V_{xy} = 20\ V$

$P = VI = 20(2) = 40\ W$ (delivered to the network)

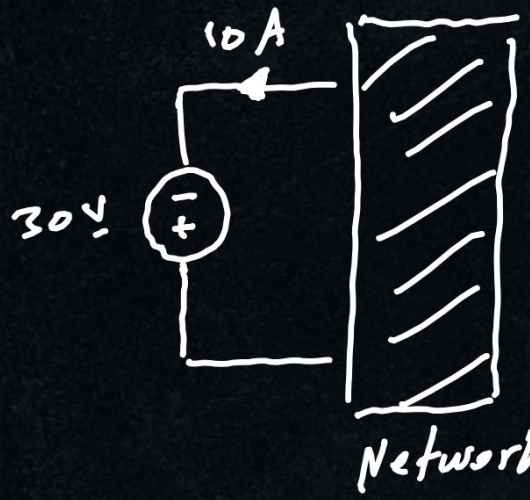
Machine (generator) or Battery (Discharge mode)



$P = VI = 20(2) = 40\ W$ (delivered to the source or absorbed by the source)

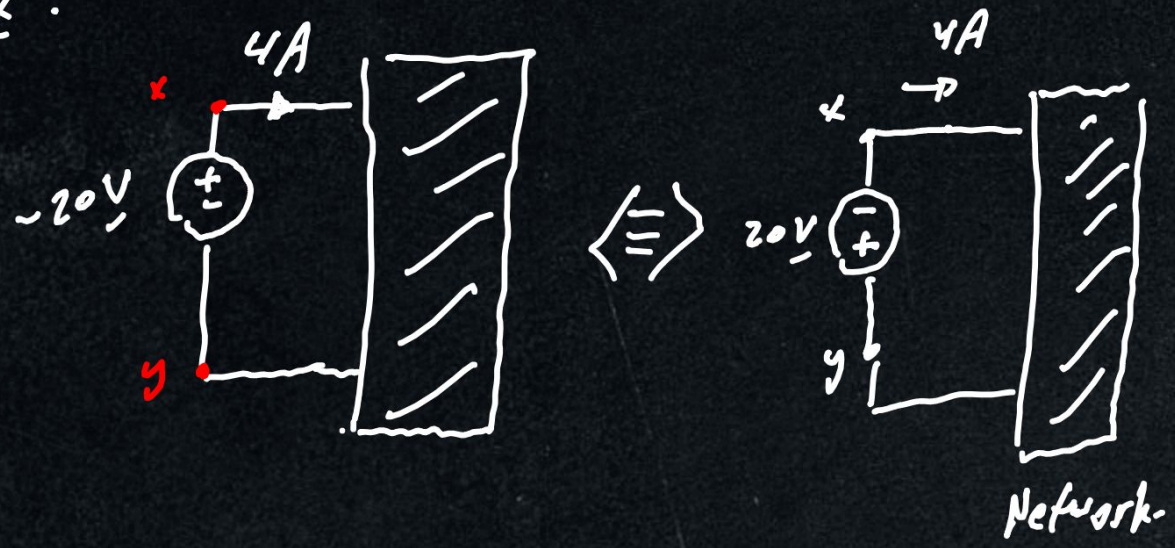
Machine (Motor) or Battery (charging mode)

Ex:



$P = 300\,W$ (delivered to the network)

Ex:

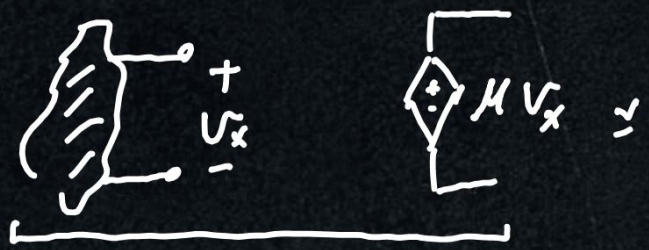


$P = 20(4) = 80\,W$ (delivered to the source)

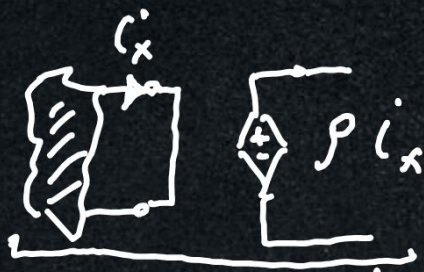
1.2) Dependent Sources (Controlled Sources)

- They generate a voltage or current that is determined by a voltage or current at a specified location in the circuit.
- Symbol 
- Examples (Transistors)

1.2.1) Voltage source

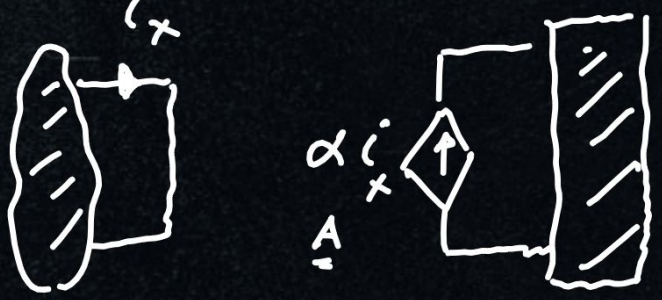


Voltage Controlled - voltage source

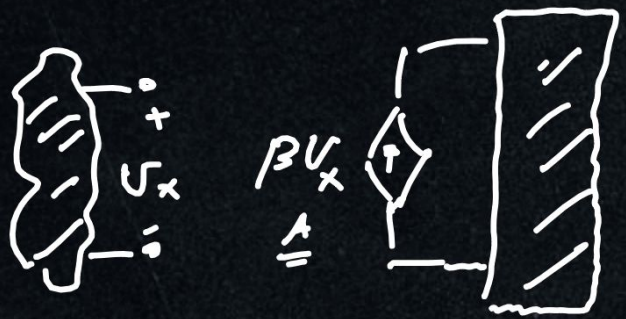


current controlled - voltage source

1.2.2) Current source

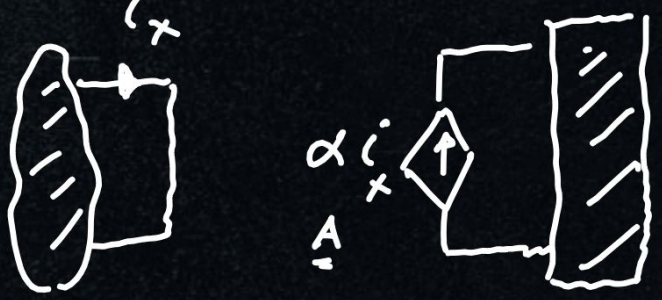


Current controlled Current source

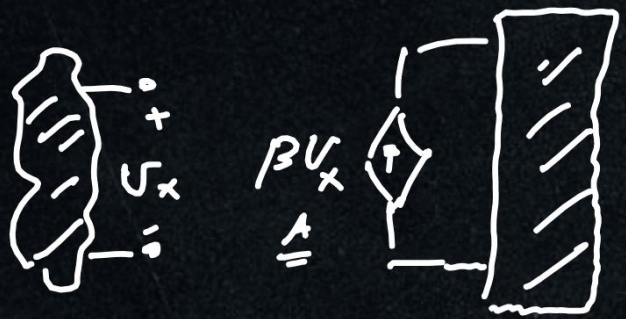


Voltage controlled current source

1.2.2) Current source



Current controlled Current source



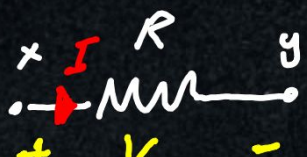
Voltage controlled current source

② Passive Elements

2.1) Resistor (R): It represents the part of the circuit in which energy entering the element by the flow of current through it, and then it is transformed to heat.

- The resistor is measured in ohms [Ω]
- Symbol

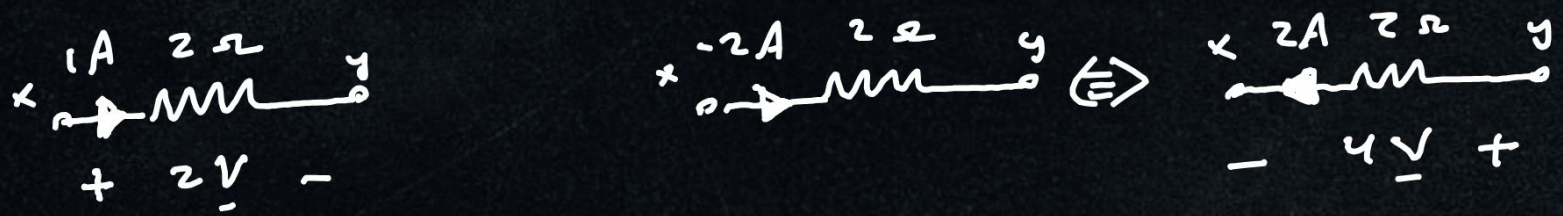
- The relationship between current and voltage across the resistor is linear (Ohm's Law)



$V = RI$

$V > 0$

$I > 0$

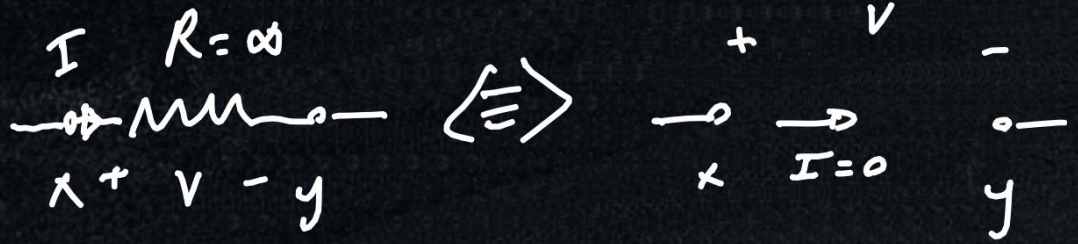


Conductance (G) :- It is the reciprocal of resistance and measured in [siemens or ℧]

$$G = \frac{1}{R}$$

When $R = 0 \Rightarrow V = RI = 0 \Rightarrow$ The element is called short circuit.

When $R = \infty \Rightarrow I = \frac{V}{R} = 0 \Rightarrow$ The element is called open circuit.



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power absorbed by the resistor $= P = VI = \frac{V^2}{R} = I^2 R$

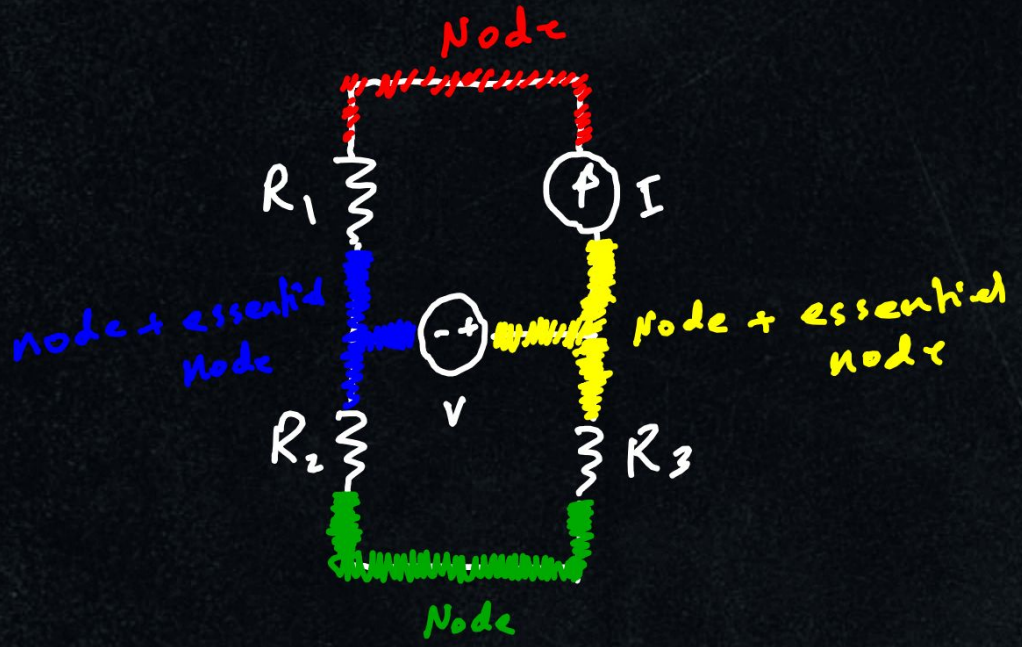
Kirchhoff laws

Kirchhoff's Voltage Law (KVL)

Kirchhoff's Current Law (KCL)

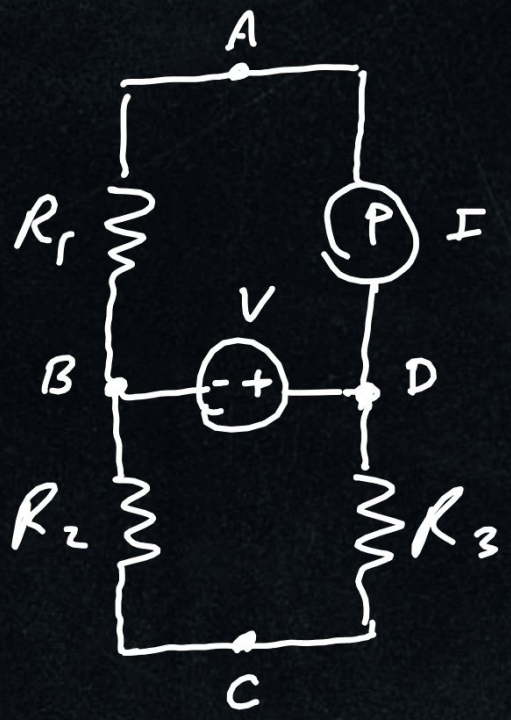
Node : It is a point of connection of two or more circuit elements.

Essential Node : It is a point of connection of three or more circuit elements



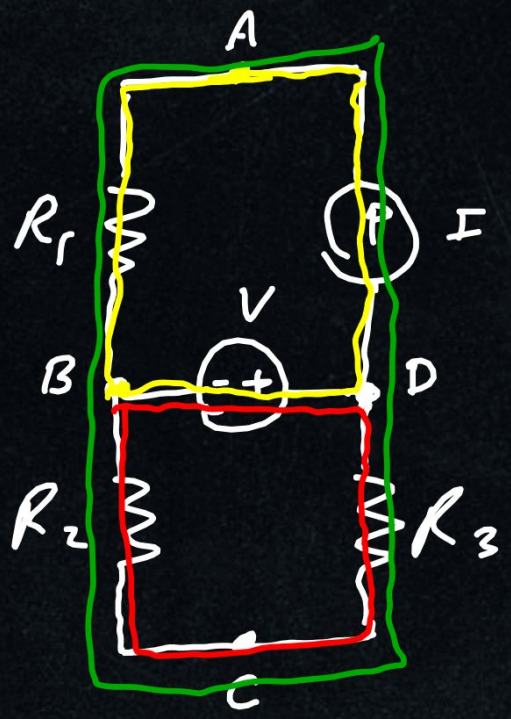
Loop: It is any closed path through the circuit such that no node is crossed more than once

Mesh: It is a loop with no loops inside it.



Loops: ABDA, BCDB, + ABCDA

Meshs: ABDA, BCDB

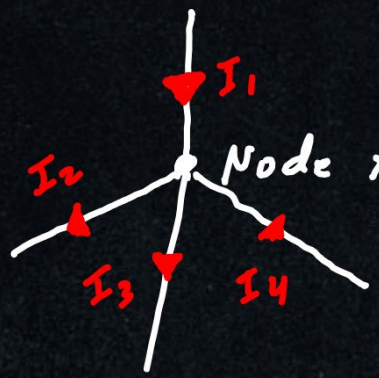


Loops: ABDA, BCDB, + ABCDA

Meshs: ABDA, BCDB

Kirchhoff Current Law (KCL)

The algebric sum of all currents at any node in the circuit equals to zero



$$I_1 = I_2 + I_3 + I_4$$

$$-I_1 + I_2 + I_3 + I_4 = 0$$

$$\sum_{i=1}^{N} I_i = 0$$

Node x

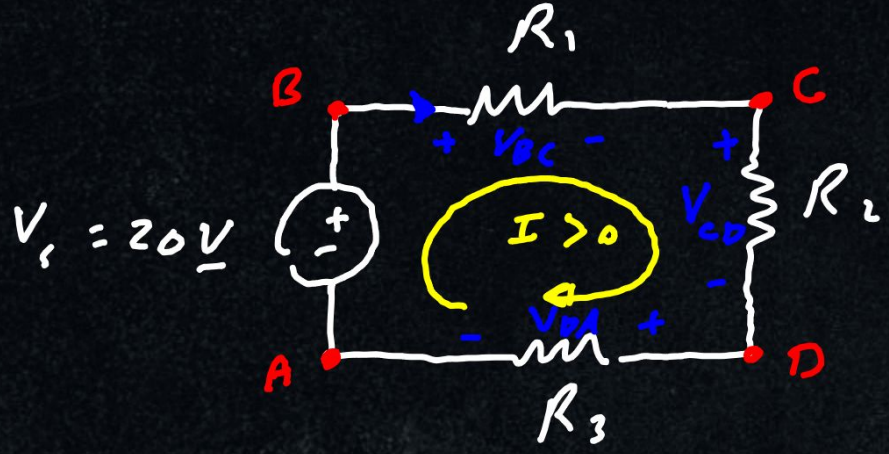
Note: The convention was taken here to be

Current flowing into the node is negative

Current flowing out of the node is positive

Kirchhoff's Voltage Law (KVL)

The algebric sum of all voltages around any closed path in the circuit is zero.



$V_{BA} = 20\ V$

$V_{AB} = -20\ V = -V_s$

starting at node A leads to the expression:

$$V_{AB} + V_{BC} + V_{CD} + V_{DA} = 0$$
$$-V_s + R_1 I + R_2 I + R_3 I = 0$$

] clockwise.

$$V_{AD} + V_{DC} + V_{CB} + V_{BA} = 0$$
$$-R_3 I - R_2 I - R_1 I + V_s = 0$$

] counter-clockwise.