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→ Active Elements - Sources

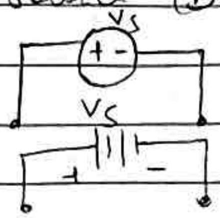
• Voltage source :

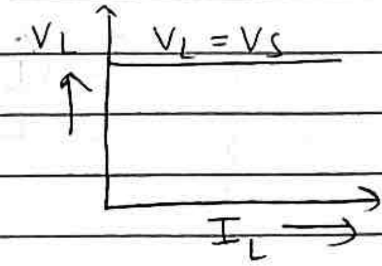
1. Ideal (constant)

• Maintains constant voltage irrespective of connected load

• Internal resistance $R_S = 0$

Ideal voltage source (DC)

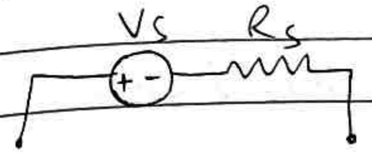




2. Practical : Real

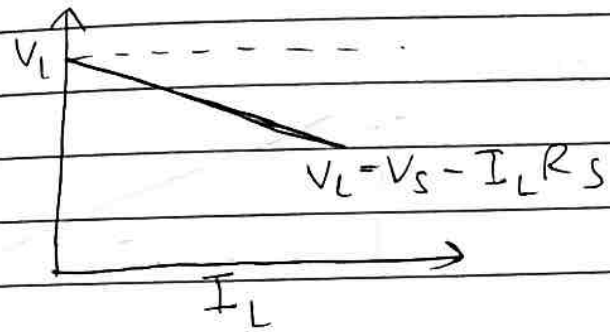
• Terminal voltage changes based on the connected load

• Internal resistance $R_S \neq 0$



~~(smaller the R_S, the closer to ideal voltage source)~~

Practical voltage source



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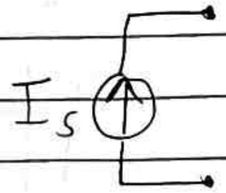
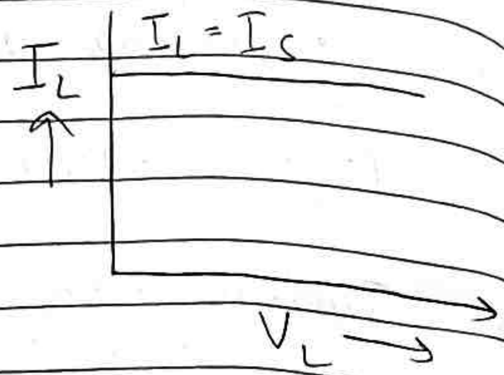
- Current source

1. Ideal: constant
- Maintains constant current irrespective of the load connected
- Internal resistance $R_S = \infty$

Ideal current source (DC)

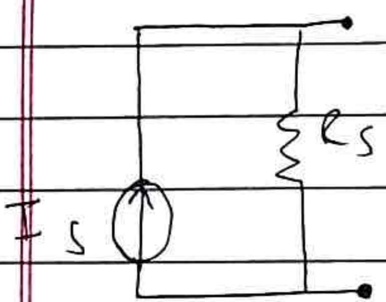


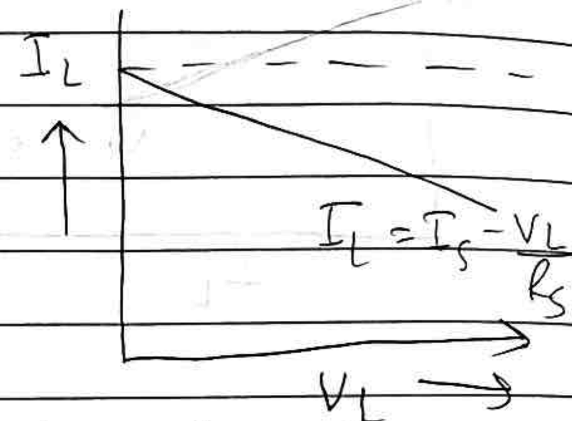


2. Practical: real

- Output current changes based on the connected load.
- Internal resistance $(R_S/R_i/R_{int}) < \infty$

Practical Current Source





(The larger the value of R_S, the closer to ideal current source) energy consuming element 23/10/21

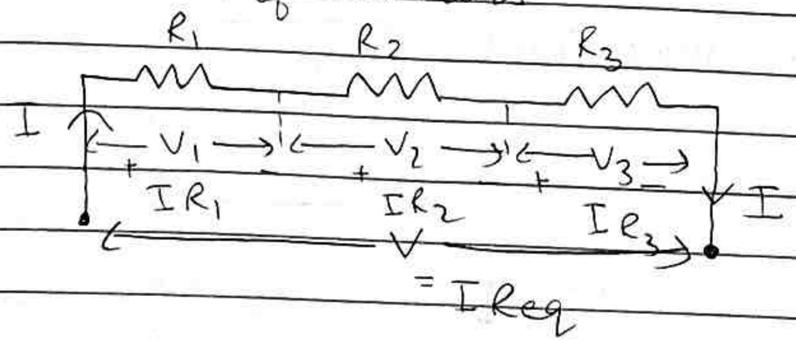
→ Resistor :

• Passive electric device that dissipates energy

• Resistance : property which opposes flow of current
  • Symbol : R
  • Unit : Ohms (Ω)
  • Power consumed $= I^2R$

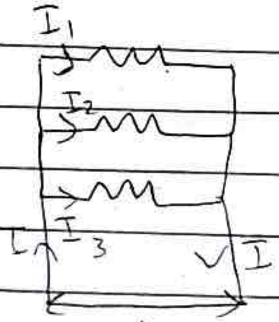
• Conductance :
  • reciprocal of resistance
  • symbol : G
  • unit - Siemens (S)

→ Series connection of resistors



• Current (I) in all the resistors remains same
• $V = V_1 + V_2 + V_3$
• $R_{eq} = R_1 + R_2 + R_3$

→ Parallel ~~comb~~ connection of resistors



• Voltage (V) is same
• $I = I_1 + I_2 + I_3$
• $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

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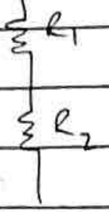
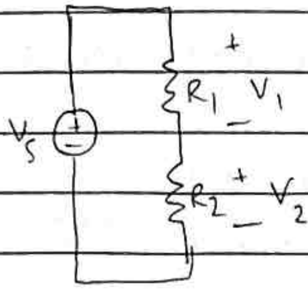
- Series resistors :



$R_{eq} = R_1 + R_2$

$(V_S = V_1 + V_2)$

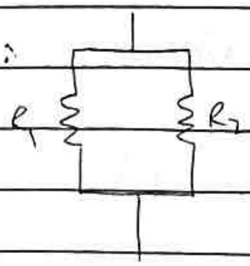
- Voltage divider :



$V_1 = \frac{R_1}{R_1 + R_2} V_S$

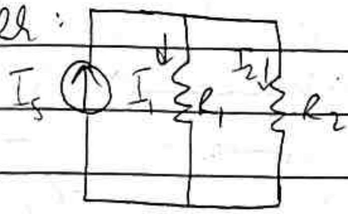
$V_2 = \frac{R_2}{R_1 + R_2} V_S$

- Parallel resistors :



$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$

- Current divider :



$I_1 = \frac{R_2}{R_1 + R_2} I_S$ $\qquad$ $I_2 = \frac{R_1}{R_1 + R_2} I_S$

→ Delivering and absorbing power by a source:

- A battery is discharging (delivering power/ energy), if current is <u>coming out</u> from +ve terminal.

- A battery is charging (absorbing power/energy) if current is <u>flowing into</u> +ve terminal.

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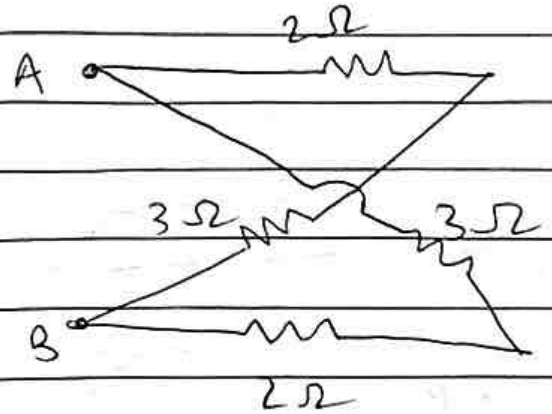
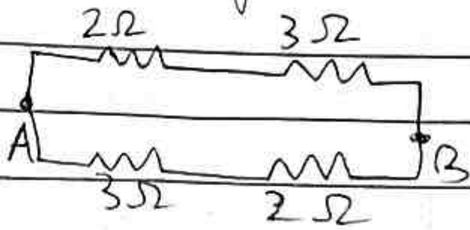
- When current flows through a resistor, power is dissipated.

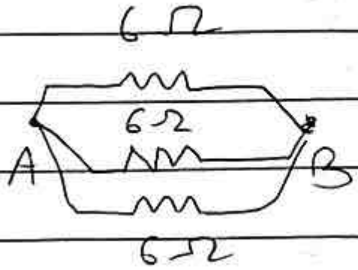
Q. Find equivalent resistance of networks given below.





$$R_{eff} = \frac{5 \times 5}{5+5}$$

$$= \frac{25}{10} = 2.5\,\Omega$$



$$\frac{1}{R_{eff}} = \frac{1}{6} + \frac{1}{6} + \frac{1}{6}$$

$$= \frac{3}{6} = \frac{1}{2}$$

$$R_{eff} = 2\,\Omega$$

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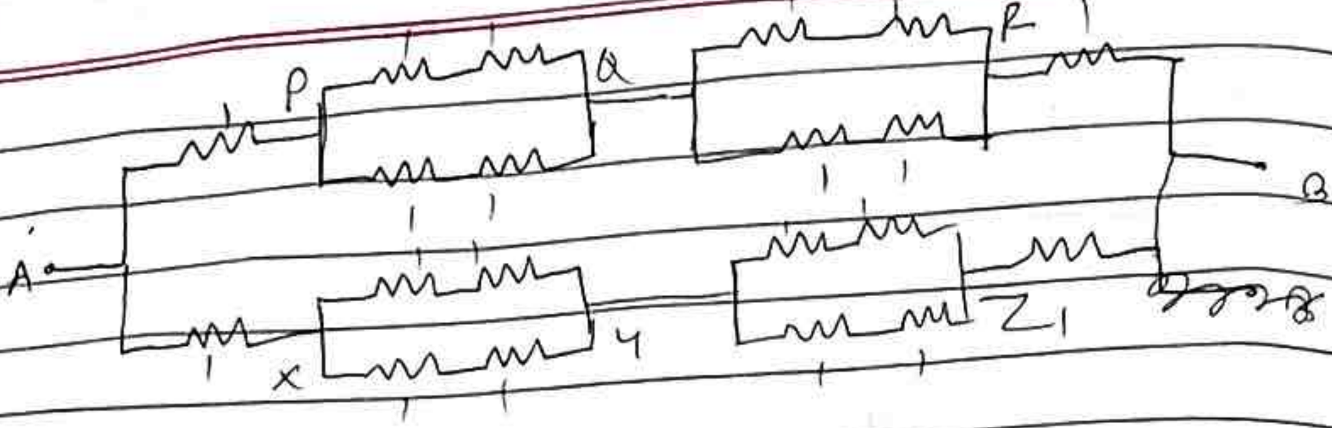
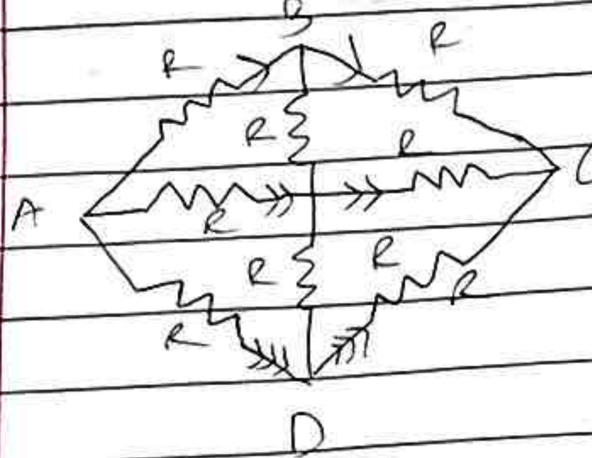
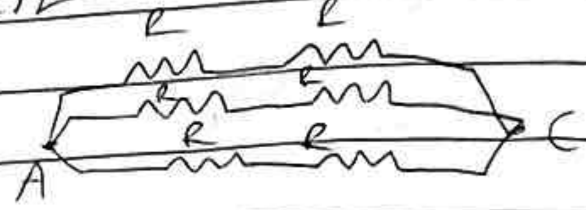


$R_{eff} = \cancel{1+2+2+1}\ 2\Omega$

Q.

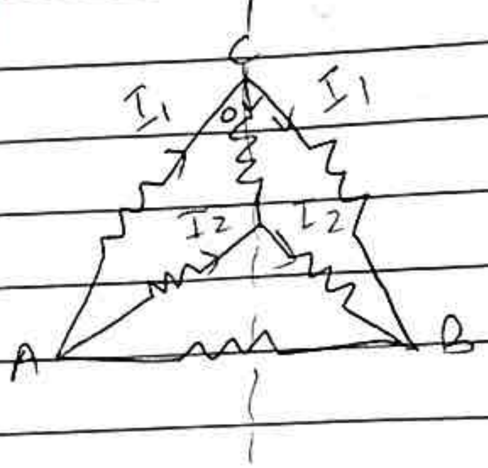


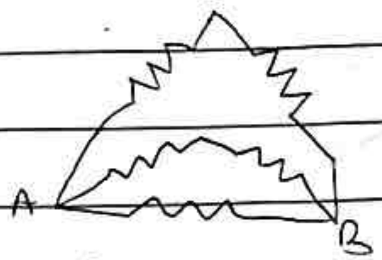


$$\frac{1}{R_P} = \frac{1}{2R} + \frac{1}{2R} + \frac{1}{2R}$$

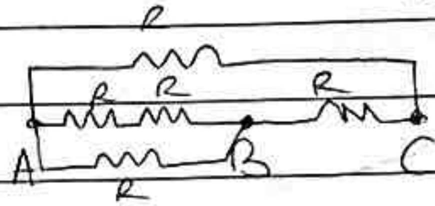
$$R_P = \frac{2R}{3}\ \Omega$$

Q.





2R



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→ Inductor:

- Passive electric device that stores energy in its magnetic field when current flows through it.
- A coil of wire wound on a core
  e.g: air core or iron core inductor
- Inductance: property which opposes rate of change of current
  Symbol: L
  Unit: Henry (H)

- The voltage across inductor is proportional to the rate of change of current through it.

$$V_L = L\frac{di}{dt}$$

→ Inductive Circuit:

For a coil uniformly wound on an air-core of uniform cross section, self inductance is given by

$$L = \frac{\mu_0 A N^2}{l}$$

l = length of magnetic circuit in meter
A = cross sectional area in square meters
μ_0 = permeability of air $= 4\pi \times 10^{-7}$
N = No of turns in the coil

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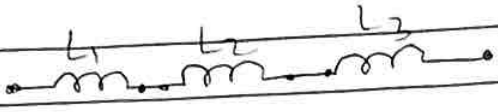
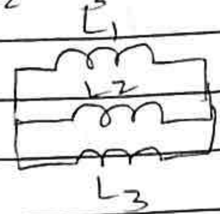
- Equivalent inductance

Series



$$L_{eq} = L_1 + L_2 + L_3$$

Parallel



$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}$$

Energy stored in an Inductor

- Instantaneous power,

$$p = v_L \cdot i = L i \frac{di}{dt}$$

- Energy absorbed in 'dt' time is

$$dw = L i \, di$$

- Energy absorbed by the magnetic field when current increases from 0 to I amperes is

$$W = \int_0^I L i \, di = \frac{1}{2} L I^2$$

classmate
Date
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→ Capacitors :

- Passive electric device that stores energy in the electric field between a pair of closely spaced conductors

- Capacitance: property which opposes the rate of change of voltage

  Symbol : C
  Unit : Farad (F)

- The capacitive current is proportional to the rate of change of voltage across it

$$i_c = C\frac{dv_c}{dt}$$

- Charge stored in a capacitor whose plates are maintained at constant voltage

$$Q = CV$$

Terminologies :

- Electric field strength

$$E = \frac{V}{d} \text{ volts/m}$$

- Electric flux density

$$D = \frac{Q}{A} \text{ C/m}^2$$

- Permittivity of free space

$$\varepsilon_0 = 8.854 \times 10^{-12} \text{ F/m}$$

- Relative permittivity: ε_r

- Capacitance of parallel plate capacitor

$$C = \frac{\varepsilon_0 \varepsilon_r A}{d}$$

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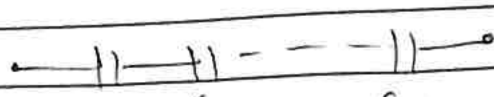
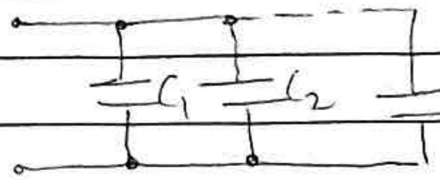
Equivalent capacitance

Series



$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_n}$$

Parallel



$$C_{eq} = C_1 + C_2 + \cdots + C_n$$

→ Energy stored in a capacitor

- Instantaneous power

$$p = v_C \times i = C v_C \frac{dv_C}{dt}$$

- Energy supplied during 'dt' time is :

$$dW = C v_C \, dv_C$$

- Energy stored in the electric field when potential rises from 0 to V volts is

$$W = \int_0^V C v_C \, dv_C = \frac{1}{2} C V^2 \text{ J}$$