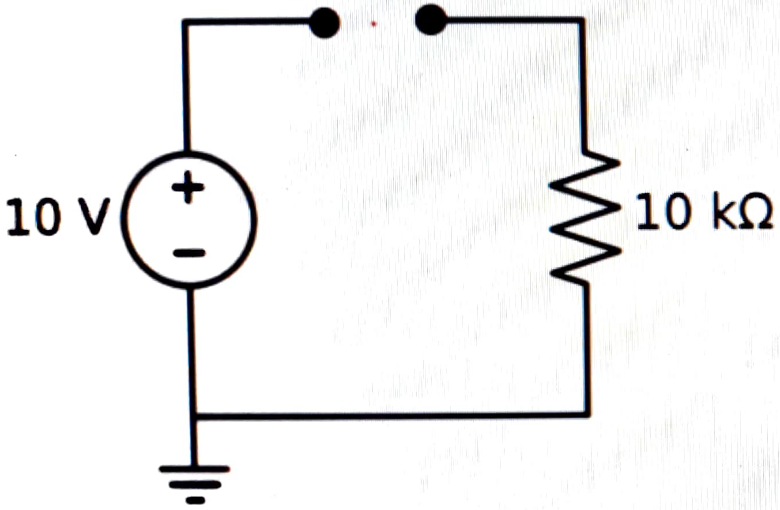
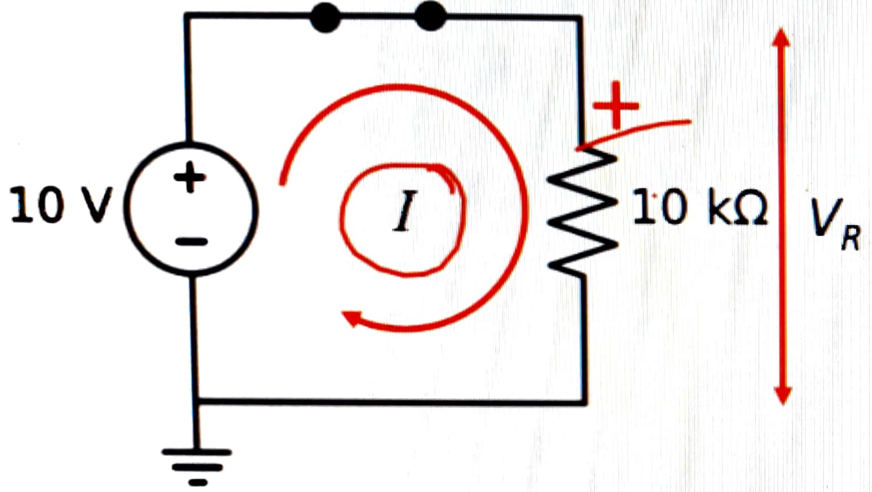
Resistor circuit



Open circuit, current = 0 A

Resistor circuit



$I = \frac{V}{R}$

Open circuit, current = 0 A

Closed circuit, current = I A

What is the magnitude of current

SAMYAK
1mA

JAYANTH
V/R

SHUBHAM
1mA

Circuit laws

- **Kirchhoff's current law (KCL)**
  - Algebraic sum of currents at a junction is zero
  - Algebraic sum of currents entering a junction is equal to the algebraic sum of currents leaving the junction
- **Kirchhoff's voltage law (KVL)**
  - Algebraic sum of voltages in a closed loop is equal to zero
  - Algebraic sum of potential rise is equal to algebraic sum of potential drops

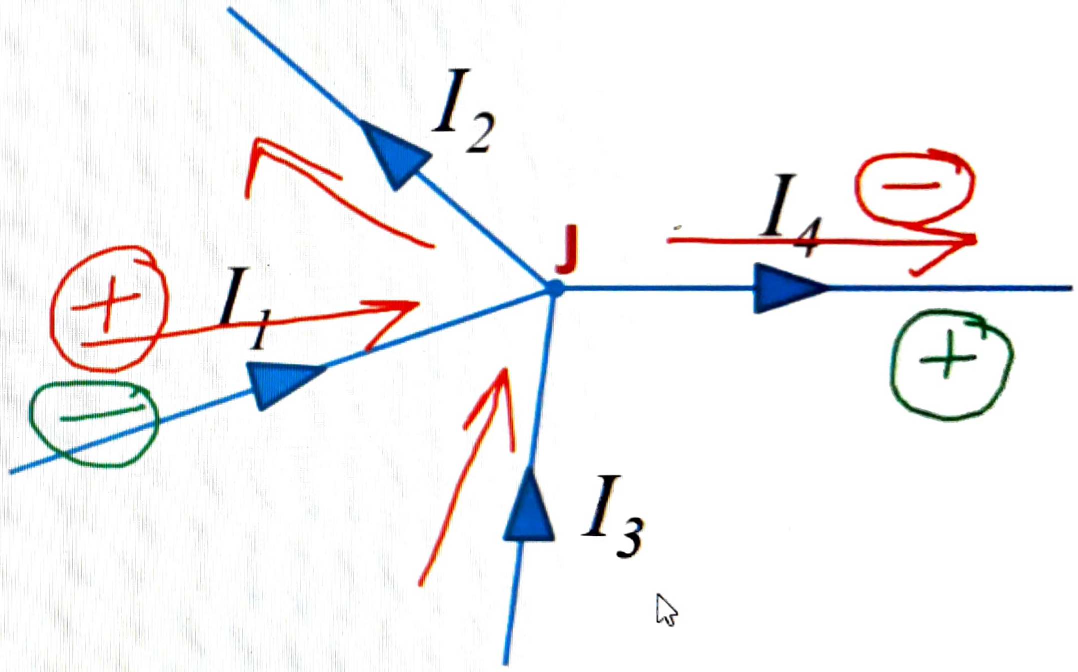
Kirchhoff's current law (KCL)

Algebraic sum of currents at a junction is zero

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

$$I_1 + I_3 = I_2 + I_4$$

Sum of currents entering a junction is equal to the sum of currents leaving the junction

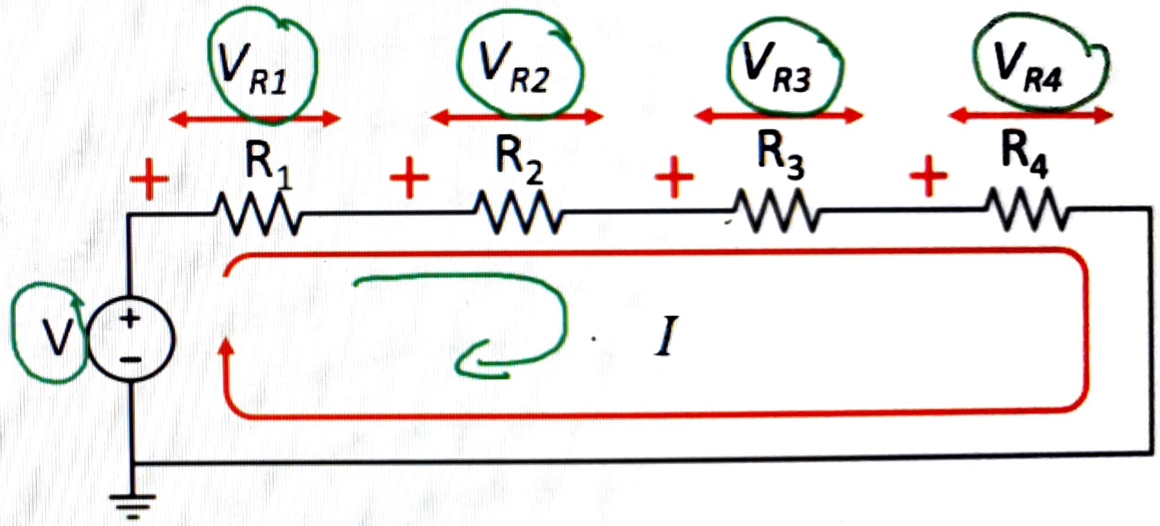


Kirchhoff's voltage law (KVL)

Algebraic sum of voltages in a closed loop is equal to zero

$$-V + V_{R_1} + V_{R_2} + V_{R_3} + V_{R_4} = 0$$

$$V = V_{R_1} + V_{R_2} + V_{R_3} + V_{R_4}$$



R circuit: what is the current flowing?

Scientific notation

KVL

$$-V_S + IR = 0$$

$$V_S = IR$$

$$10 = I(10\,\text{k})$$

$$I = \frac{10}{10\,\text{k}} = 1\,\text{mA}$$

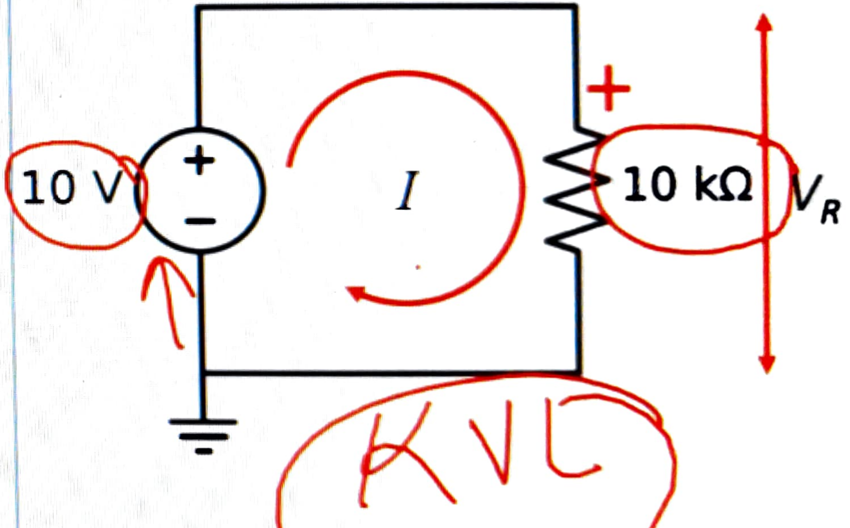
Voltage drop across 10 kΩ resistor

$$\frac{10}{10\times10^3} = 1\,\text{mA}$$

$$V_R = IR$$

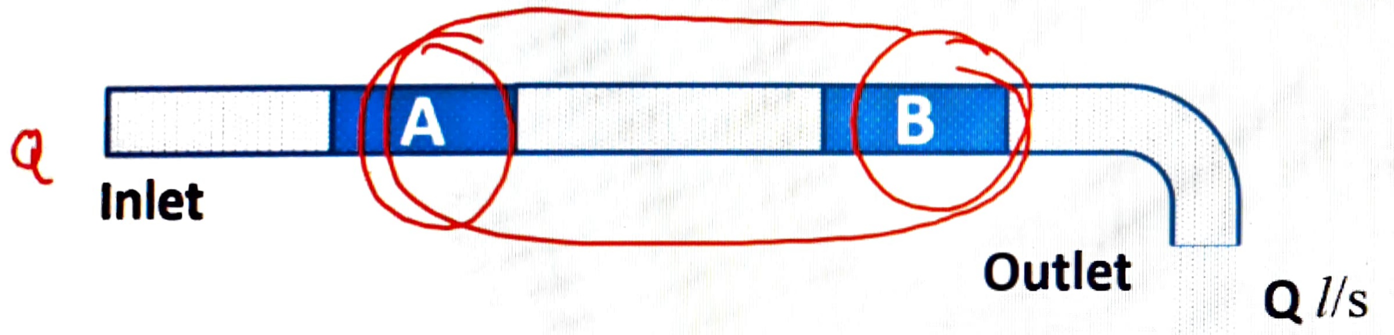
$$V_R = (1\,\text{m})(10\,\text{k}) = 10\,\text{V}$$

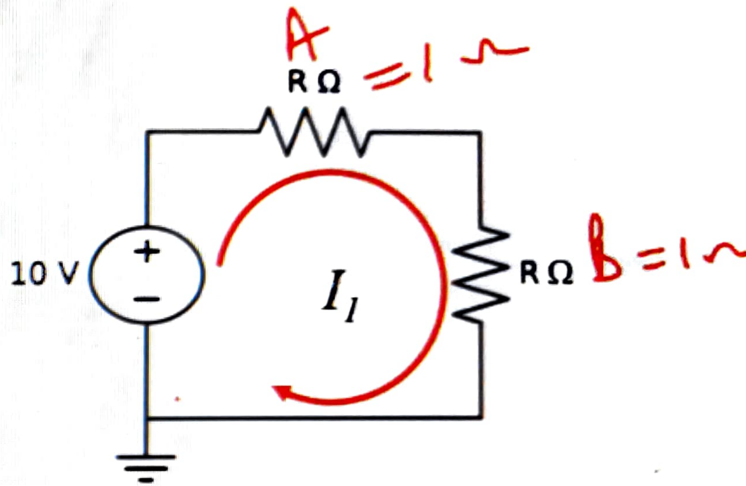
$$\boxed{V_S = V_R}$$



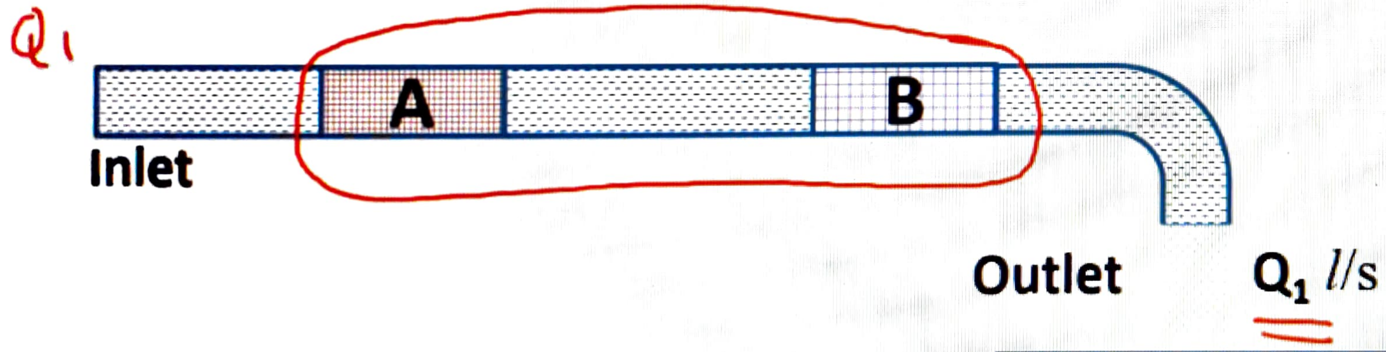
I and V_R are unknown variables

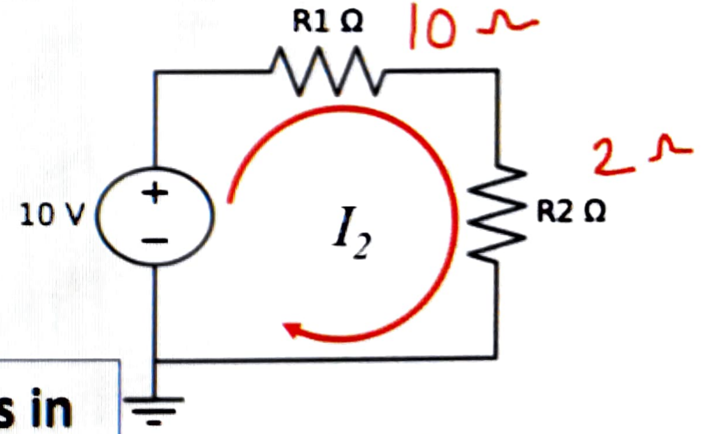
Series R circuit





Equal resistors





Unequal resistors

Fluid flow is equal at inlet and outlet

Same current flows in series circuit elements

Series R circuit: Equal resistors

KVL

$$-V_S + V_{R_1} + V_{R_2} = 0$$

$$-V_S + IR_1 + IR_2 = 0$$

$$V_S = IR_1 + IR_2$$

$$V_S = I\left(R_1 + R_2\right)$$

$$10 = I(10\,\text{k} + 10\,\text{k})$$

$$I = \frac{10}{10\,\text{k} + 10\,\text{k}} = 0.5\,\text{mA}$$

Current is flowing in CW direction

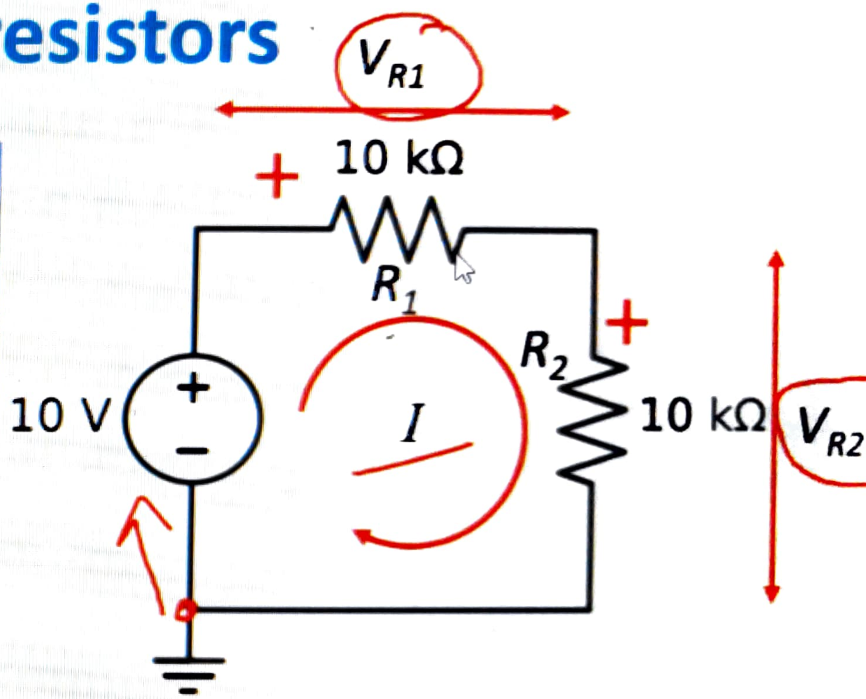
Voltage drop across resistors

$$V_{R_1} = IR_1$$

$$V_{R_1} = (0.5\,\text{m})(10\,\text{k}) = 5\,\text{V}$$

$$V_{R_2} = IR_2$$

$$V_{R_2} = (0.5\,\text{m})(10\,\text{k}) = 5\,\text{V}$$



unknown variables

I, V_{R1} and V_{R2}

Series R circuit: Different value resistors

$$I = 0.1\,\text{mA}$$

Let us calculate voltage drops

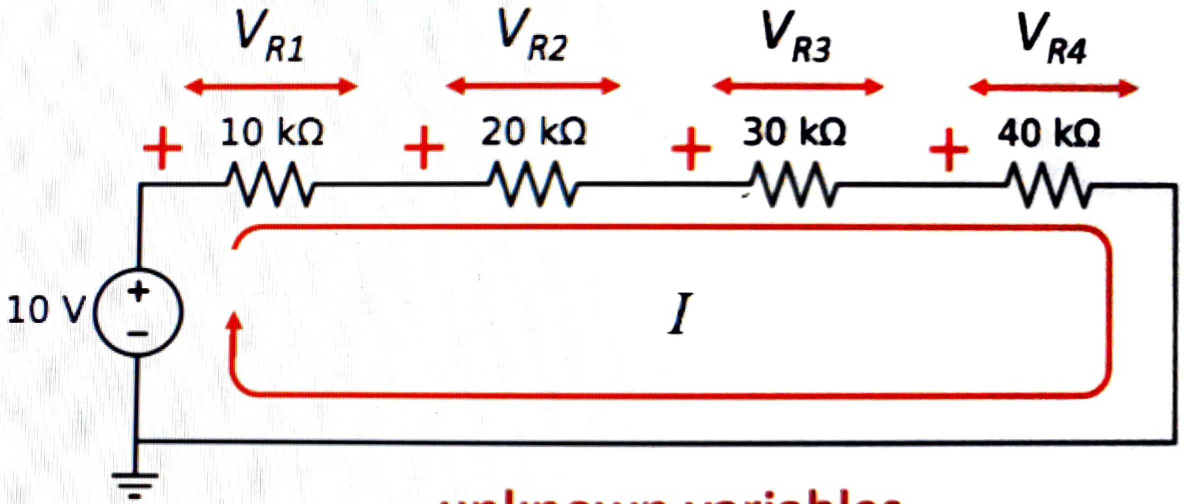
$$V_{R_1} = IR_1 = (0.1\,\text{m})(10\,\text{k}) = 1\,\text{V}$$

$$V_{R_2} = IR_2 = (0.1\,\text{m})(20\,\text{k}) = 2\,\text{V}$$

$$V_{R_3} = IR_3 = (0.1\,\text{m})(30\,\text{k}) = 3\,\text{V}$$

$$V_{R_1} = IR_1 = (0.1\,\text{m})(40\,\text{k}) = 4\,\text{V}$$

10 V



unknown variables

I, V_{R1} V_{R2} V_{R3} and V_{R4}

RAHUL

1V,2V,3V,4V

CHAND

Series R circuit: Different value resistors

KVL to the loop

$$V_s = V_{R_1} + V_{R_2} + V_{R_3} + V_{R_4} \quad \rightarrow (1)$$

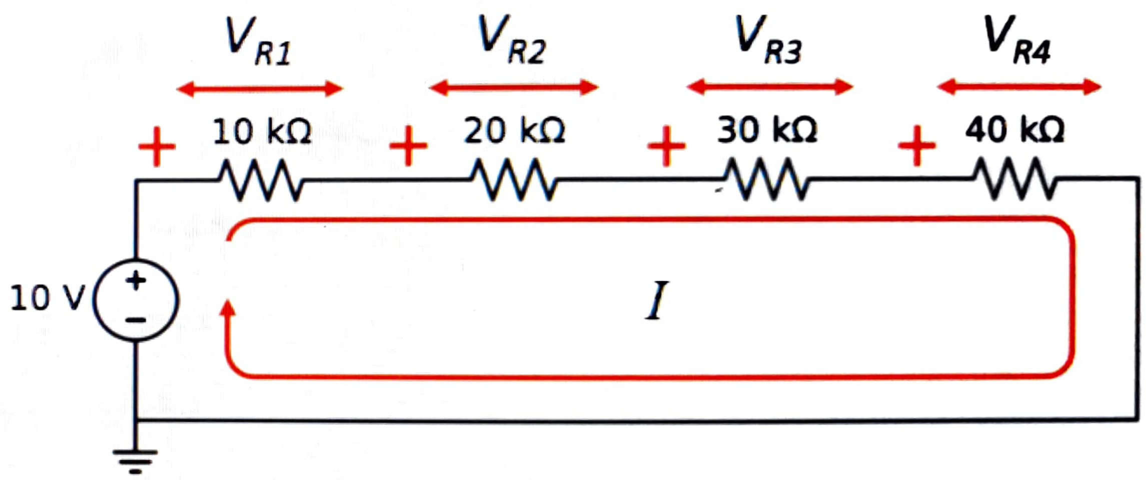
$$V_s = I(R_1 + R_2 + R_3 + R_4)$$

$$V_s = I(R_{eq})$$

$$I = \frac{V_s}{R_1 + R_2 + R_3 + R_4}$$

$$I = \frac{10}{10\,\text{k} + 20\,\text{k} + 30\,\text{k} + 40\,\text{k}}$$

$$I = 0.1\,\text{mA}$$



unknown variables

I, V_{R1}, V_{R2}, V_{R3} and V_{R4}

WARISH V

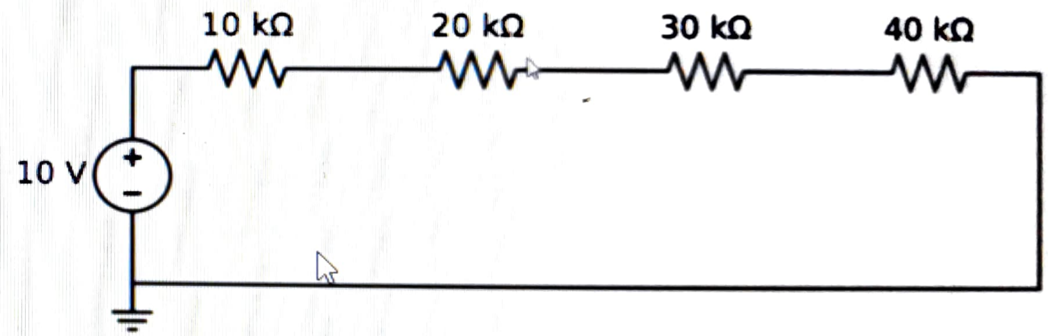
.01 mA , 1V,2V,3V,

Series R circuit: Points to remember

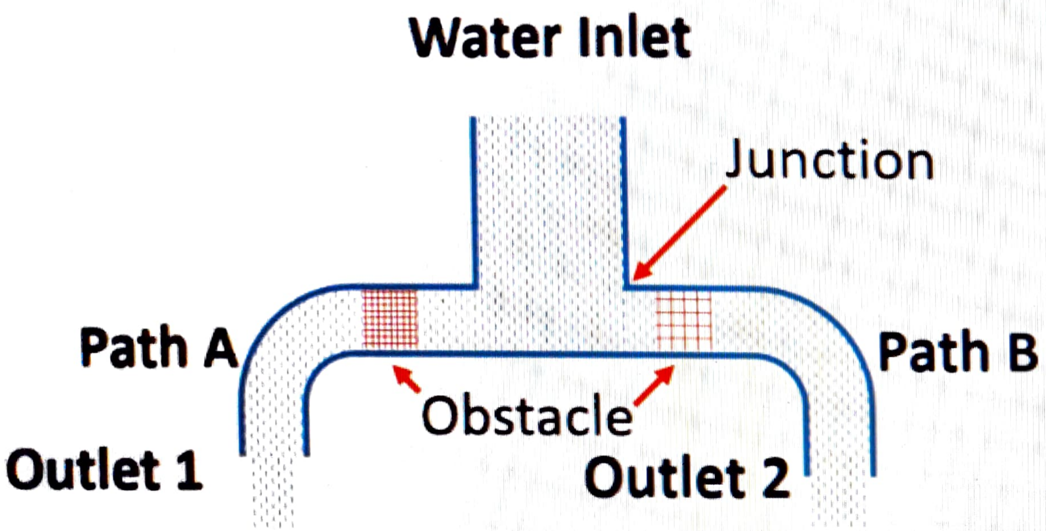
Current is same in all the elements

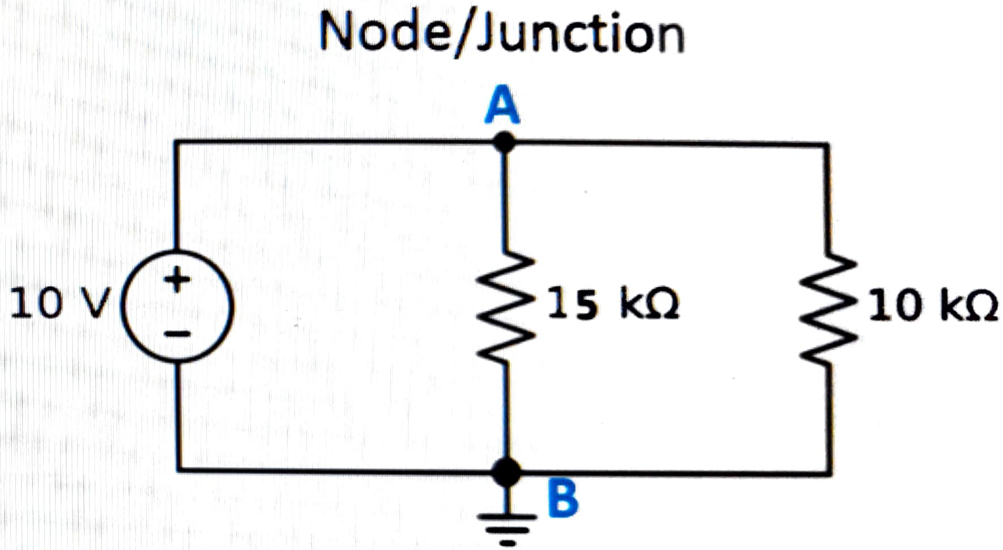
Voltage drop is in proportion to the magnitude of resistance

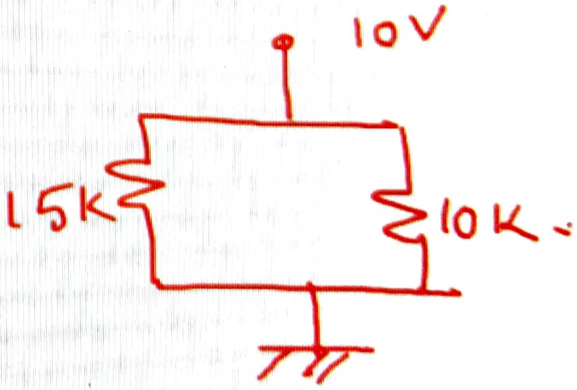
Voltage rise = Sum of Voltage drops in all the elements



Parallel R circuit



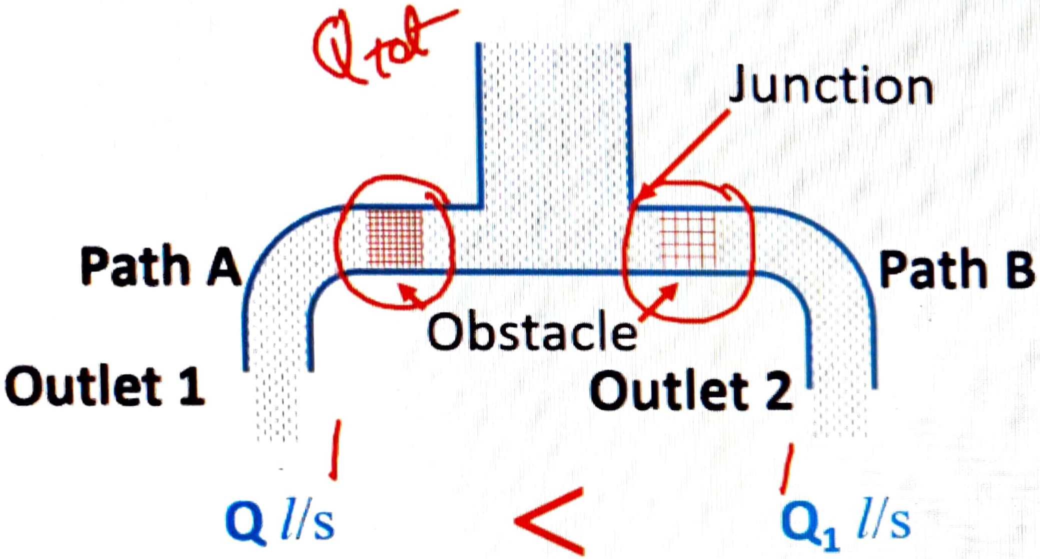




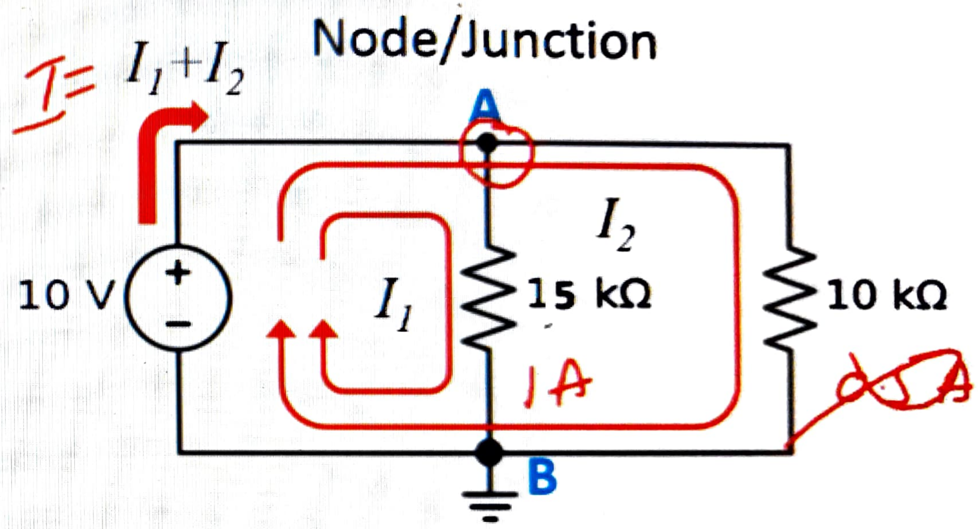
Parallel R circuit

$= Q + Q_1$

$I_1 < I_2$



$Q_1 > Q$



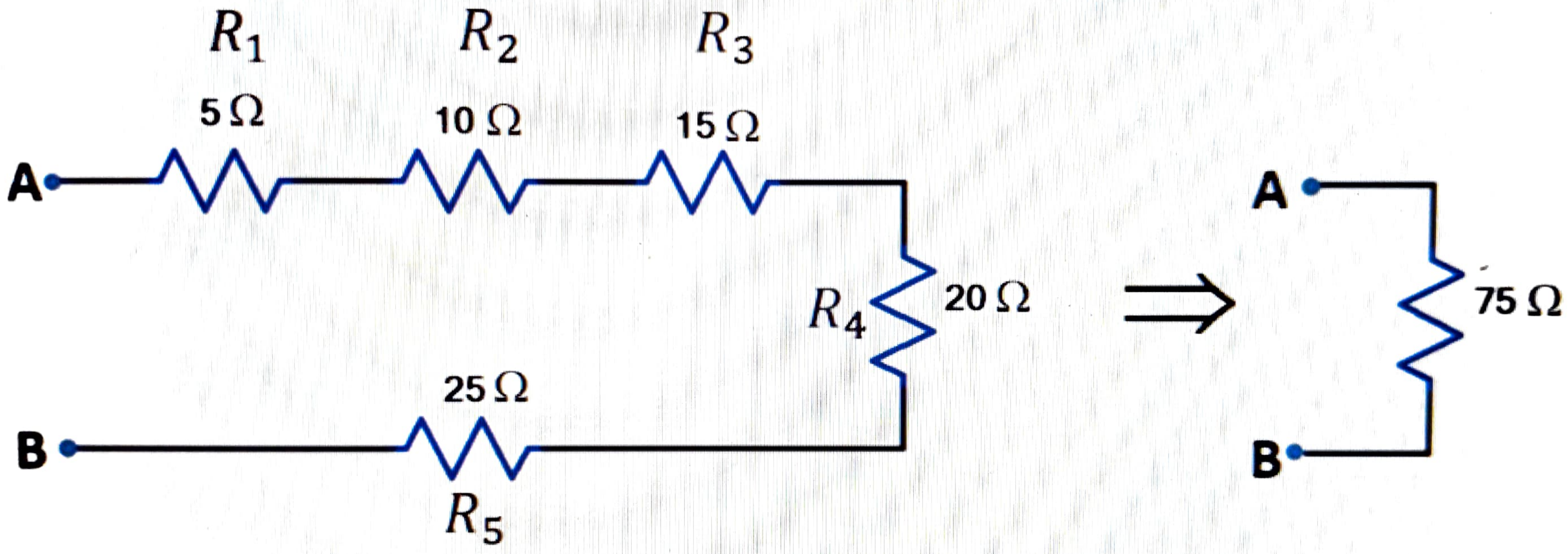
$I_1 < I_2$ 10V

current divides

- Water divides at a junction
- More water flows out of outlet, if the obstruction is less

- Current divides at a junction
- Magnitude of current is less if resistance is more

Series resistive circuit

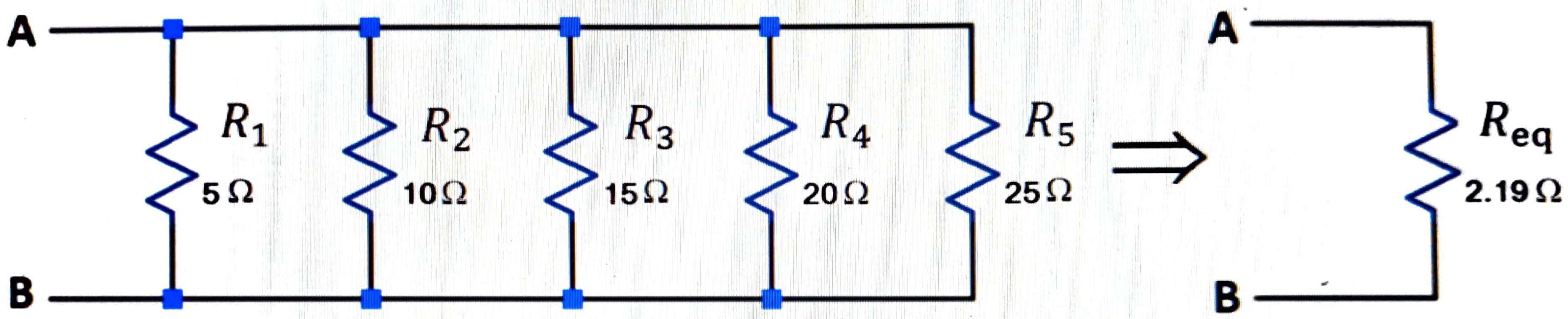


$$R_{eq} = R_1 + R_2 + R_3 + \ldots\ldots\ldots R_n$$

$$R_{eq} = 5 + 10 + 15 + 20 + 25 = 75\,\Omega$$

Equivalent resistance is greater than the largest resistance value.

Parallel resistive circuit



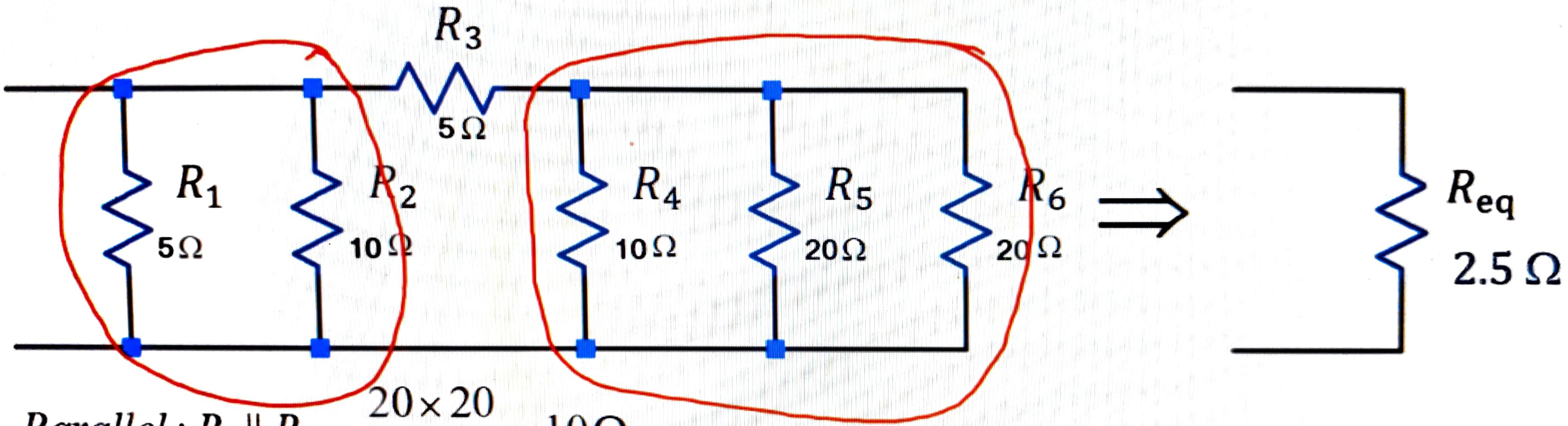
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}$$

$$\frac{1}{R_{eq}} = \frac{1}{5} + \frac{1}{10} + \frac{1}{15} + \frac{1}{20} + \frac{1}{25}$$

$$R_{eq} = 2.19\Omega$$

Equivalent resistance is lesser than the smallest resistance value.

Series-Parallel resistive circuit



$$Parallel: R_5 \parallel R_6 = \frac{20\times 20}{20+20} = 10\Omega$$

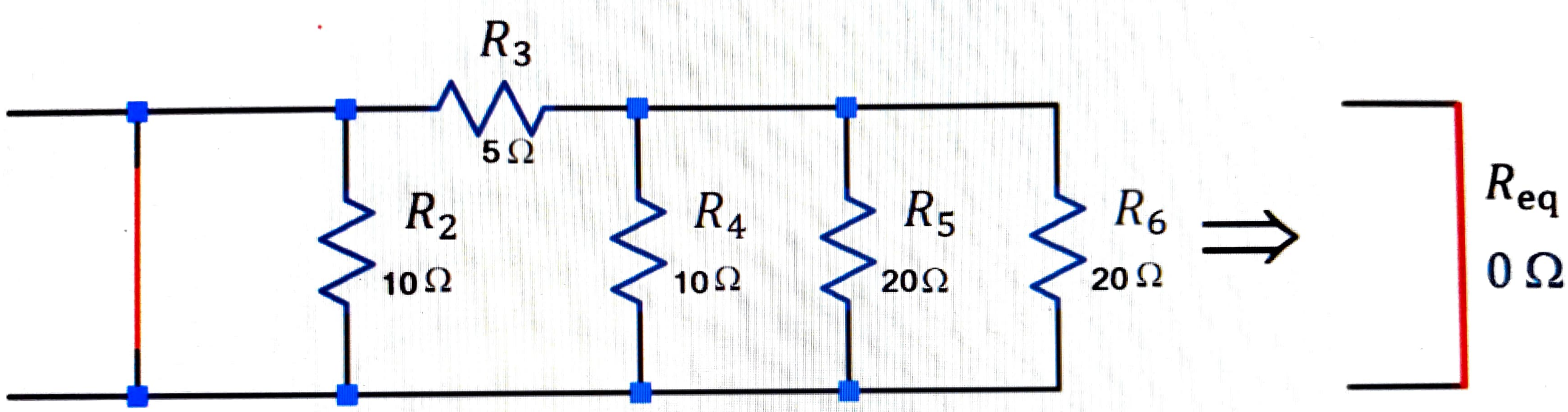
$$Parallel: 10\Omega \parallel R_4 = 5\Omega$$

$$Series: 5\Omega + R_3 = 10\Omega$$

$$Parallel: 10\Omega \parallel R_2 = 5\Omega$$

$$Parallel: 5\Omega \parallel R_1 = 2.5\Omega$$

Series-Parallel resistive circuit



$$Parallel: R_5 \parallel R_6 = \frac{20 \times 20}{20 + 20} = 10\Omega$$

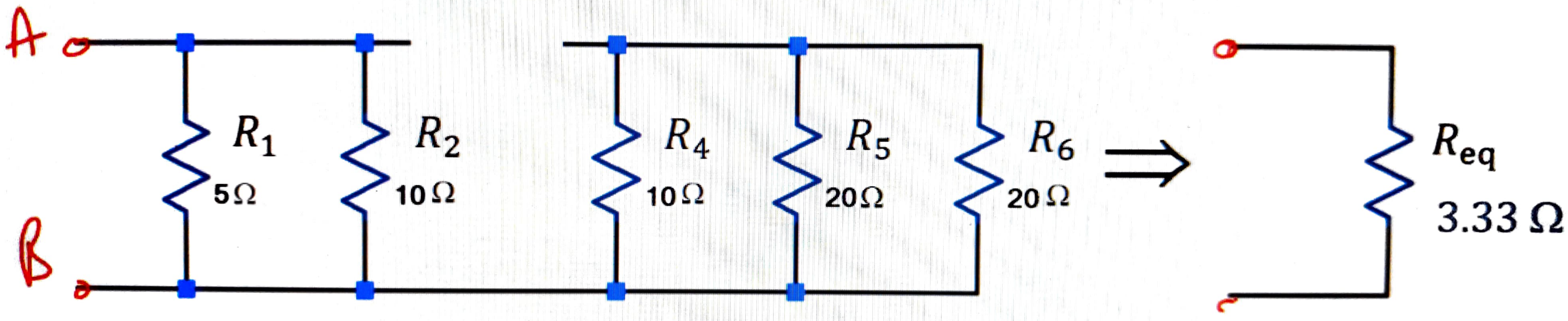
$$Parallel: 10\Omega \parallel R_4 = 5\Omega$$

$$Series: 5\Omega + R_3 = 10\Omega$$

$$Parallel: 10\Omega \parallel R_2 = 5\Omega$$

$$Parallel: 5\Omega \parallel 0\Omega = 0\Omega$$

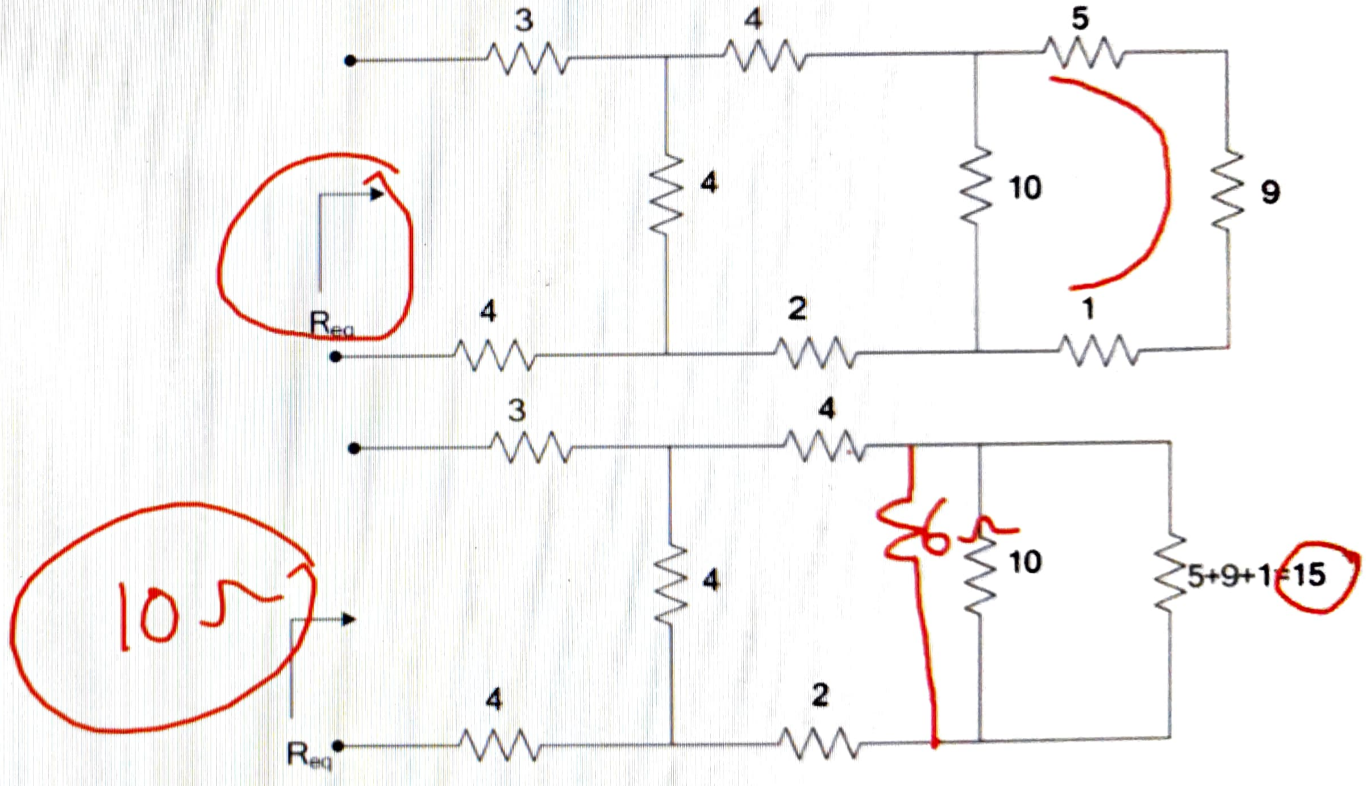
Series-Parallel resistive circuit



$$Parallel : R_1 \,||\, R_2 = \frac{10\times 5}{10+5} = 3.33\Omega$$

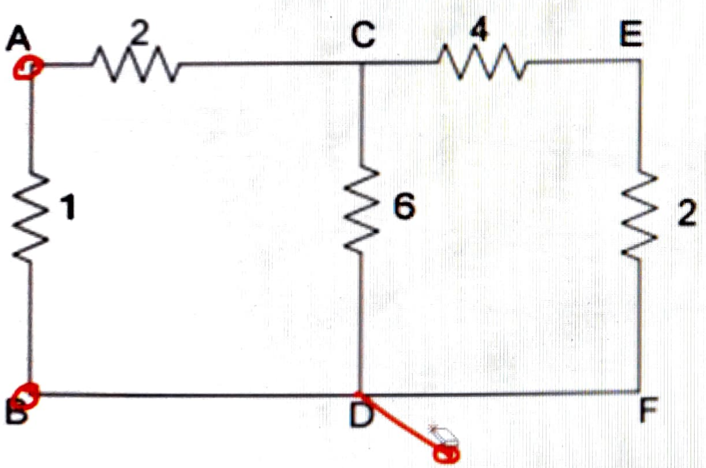
Problem: Equivalent resistance

$$\frac{10\times15}{25}$$

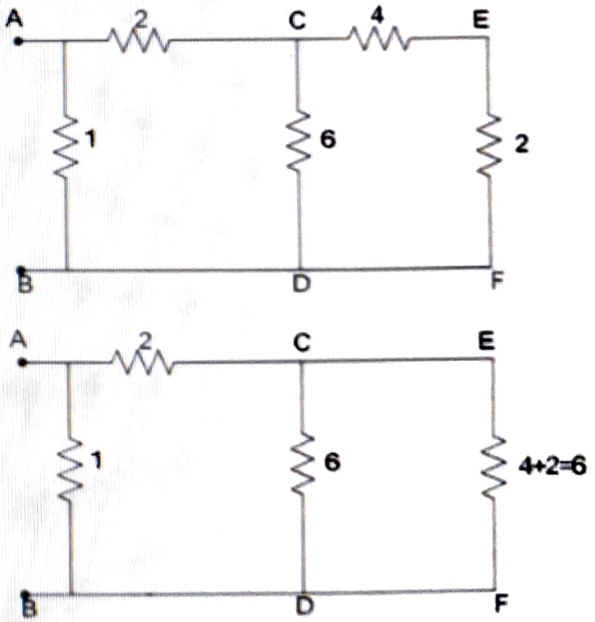


Problem: Equivalent resistance

- Between A & B and C & D terminals



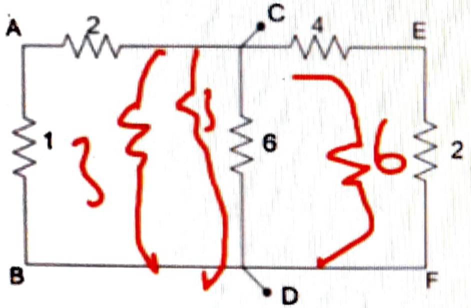
Between A & B

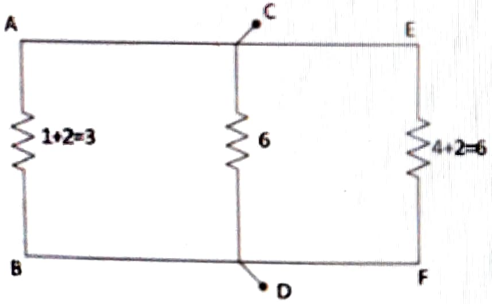


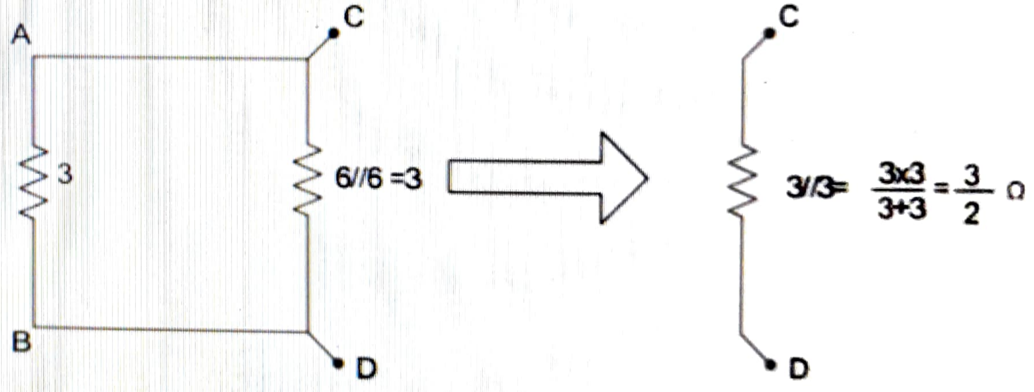
Problem: Equivalent resistance

- Between C & D

$$\frac{9}{6} = \frac{3}{2} = 1.5$$

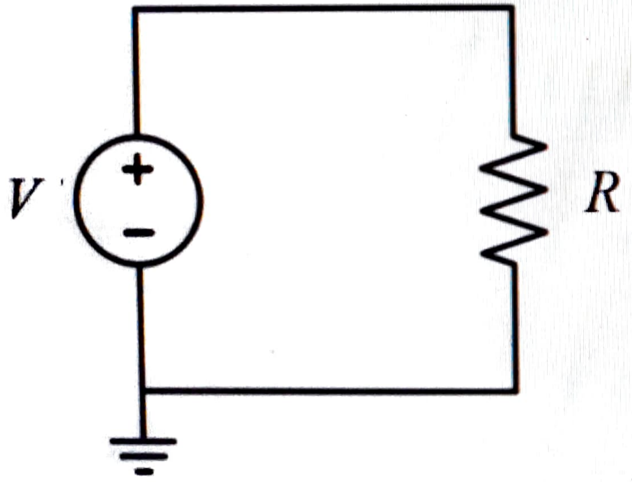






$R_{C-D} = \frac{3}{2}\,\Omega$

R circuit: what is the current flowing?



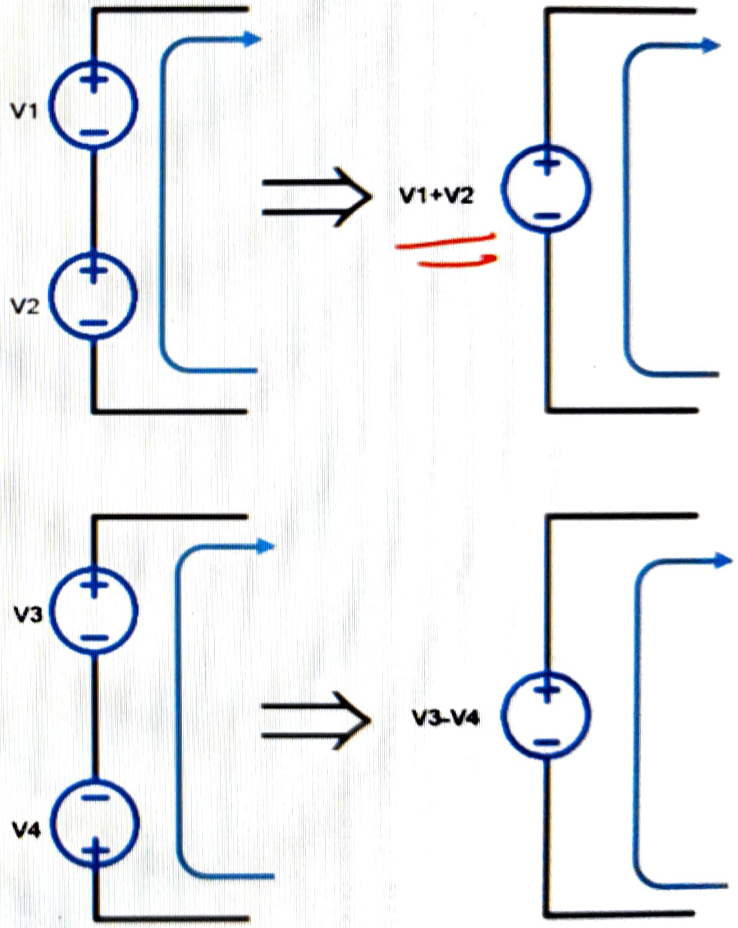
Examples

Immersion water heater

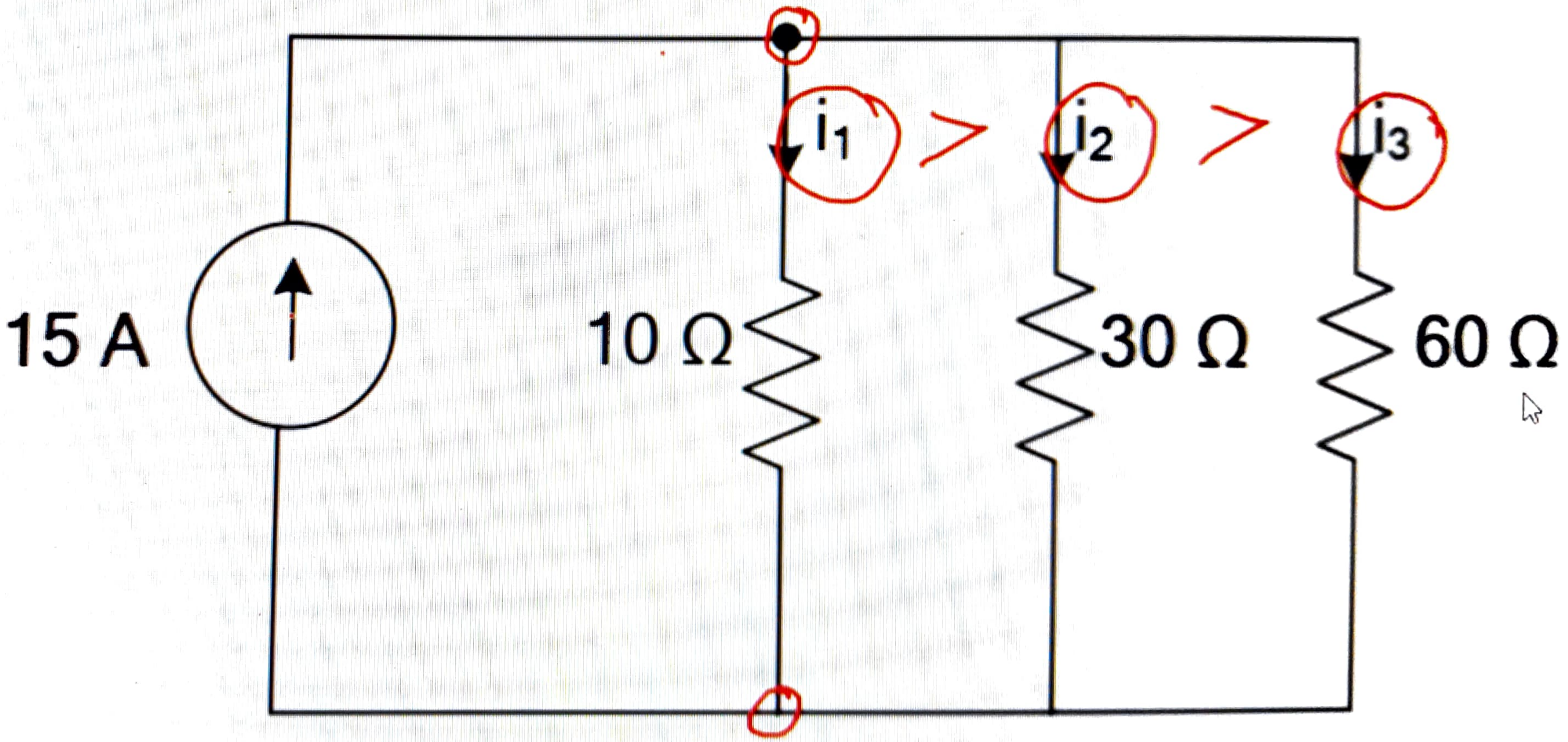
What is the resistance of the coil?

Typical specification of the coil are 1000 W at 230 V

Equivalent voltage sources

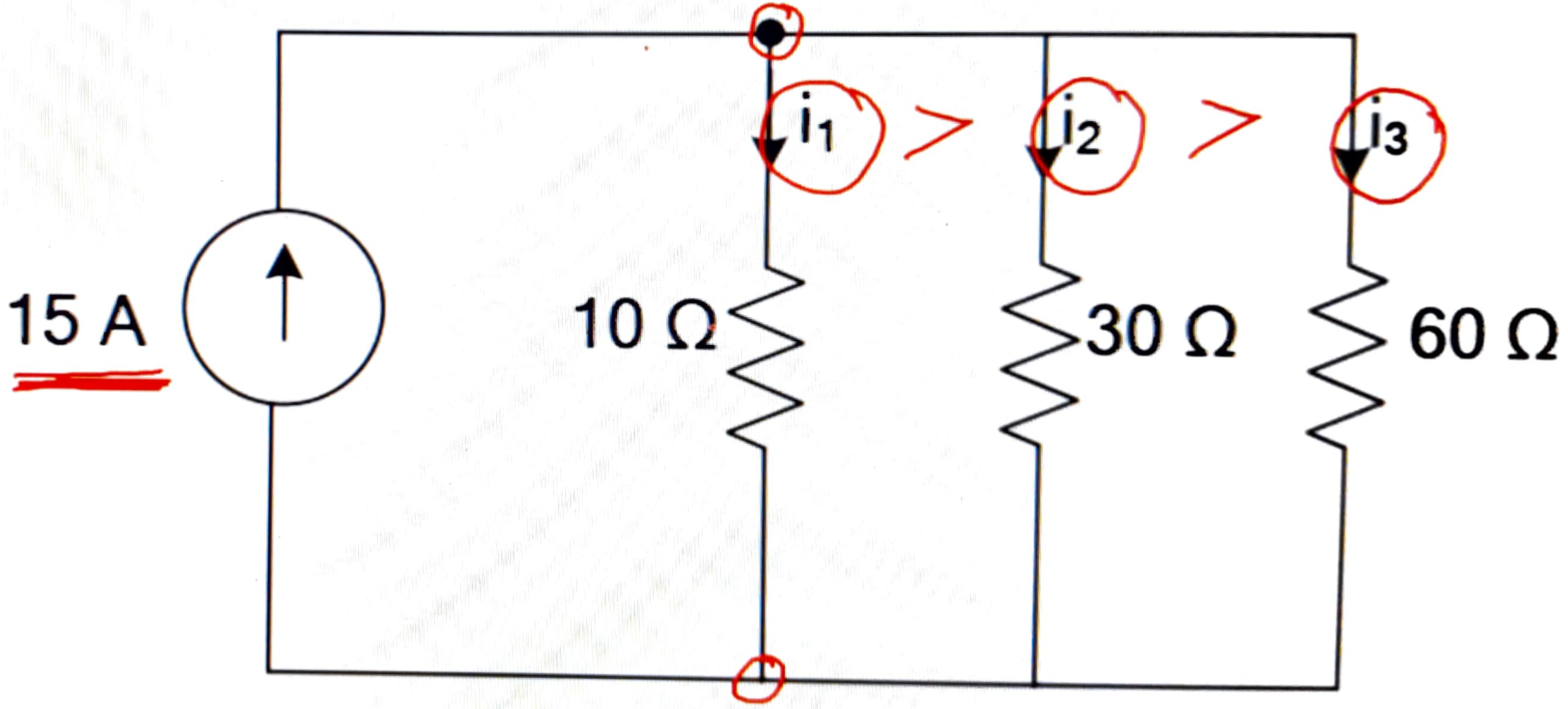


Find i_1, i_2 and i_3



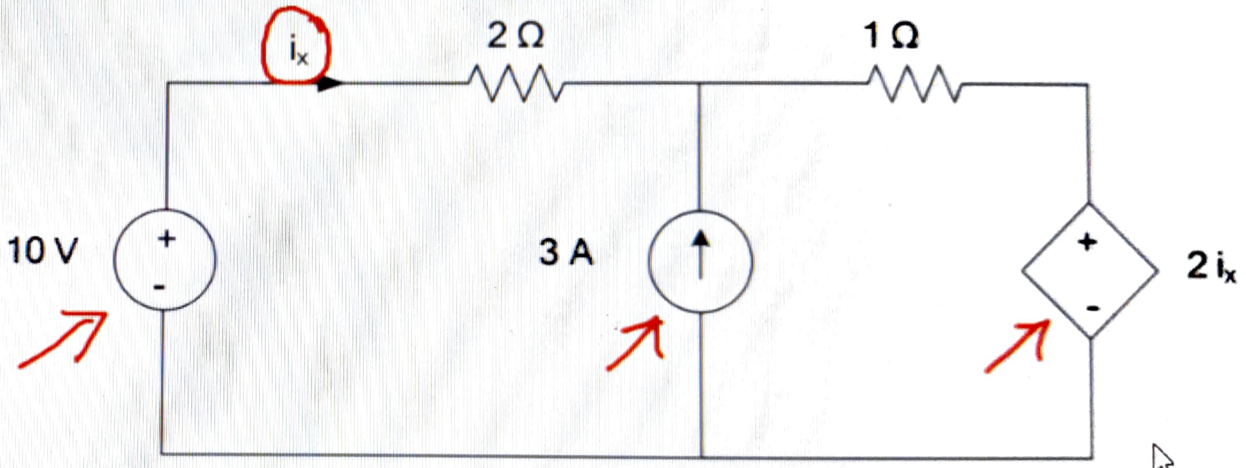
Find i_1, i_2 and i_3

$$i_1 = i_1 \frac{\left(\frac{30\times 60}{30+60}\right)}{10+}$$



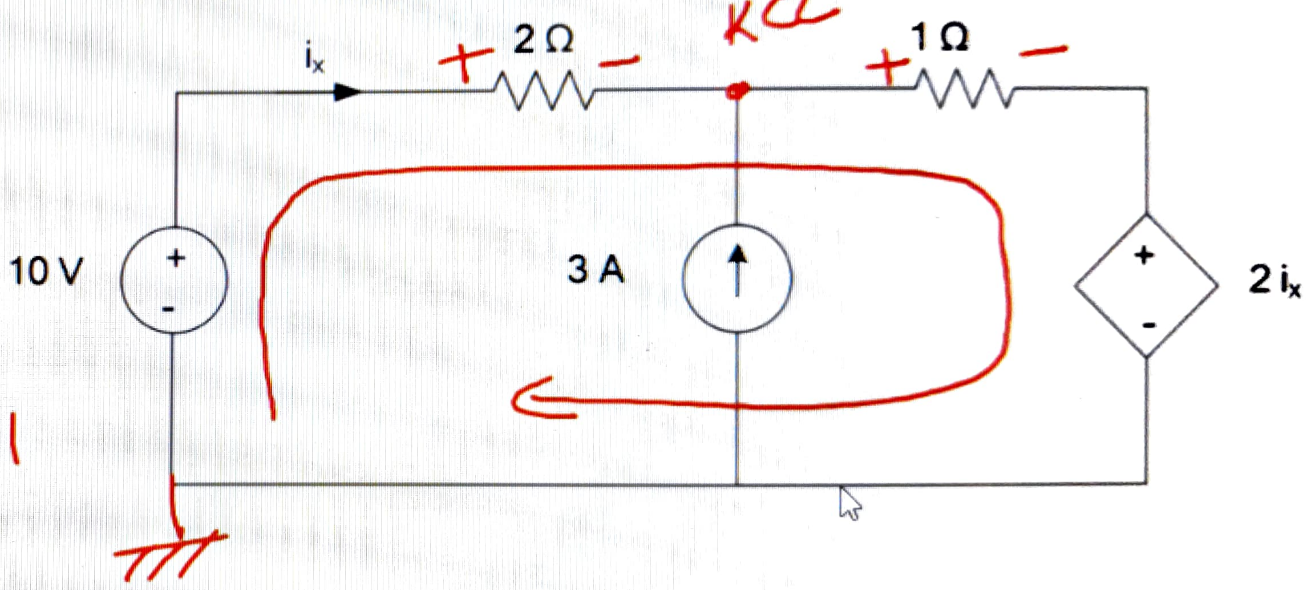
- Find i_x

$i_x = 1.4\ A$



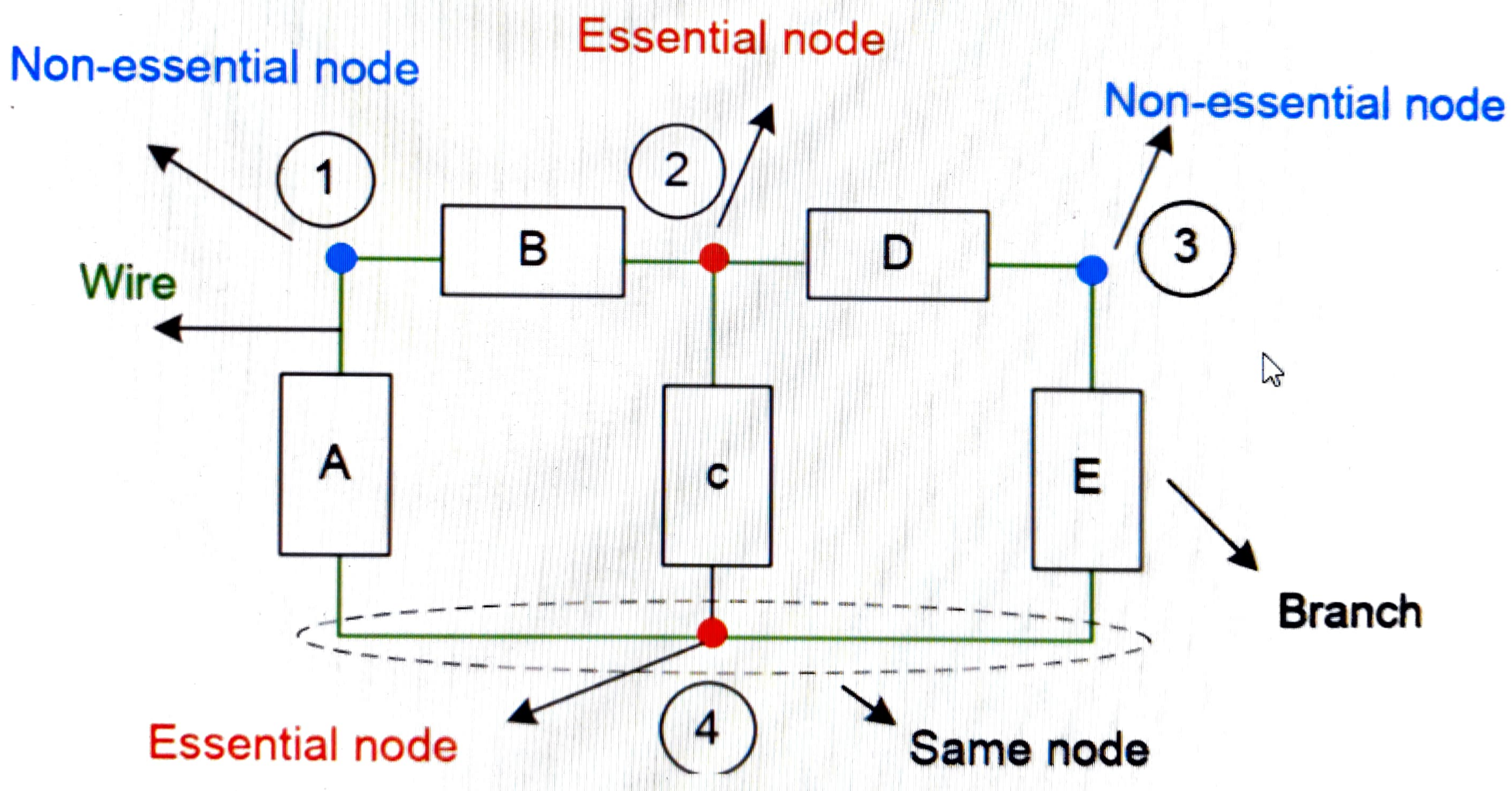
- Find i_x

$i_x = 1.4\ A$



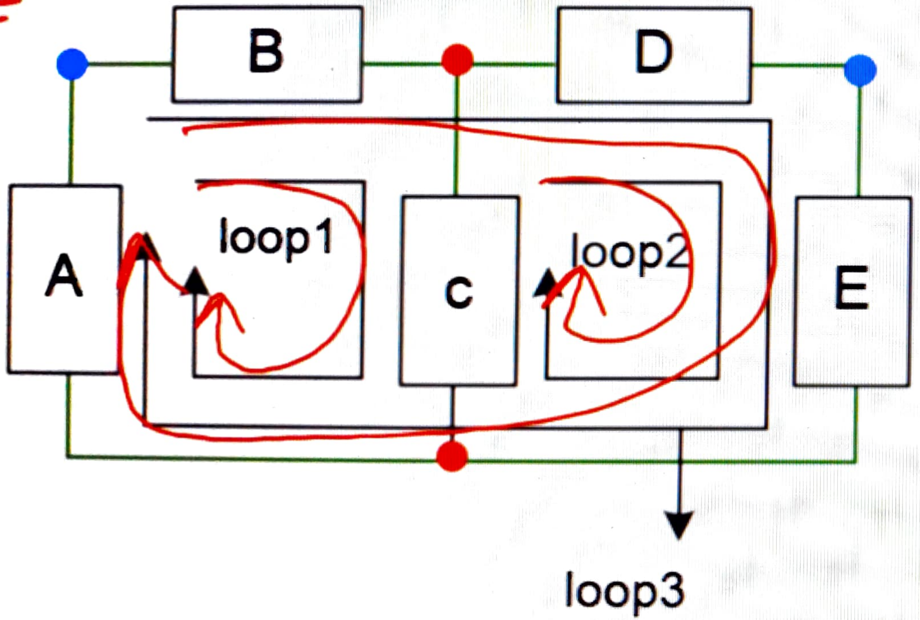
$$-10 + 2i_x + (3+i_x)1 + 2i_x = 0$$

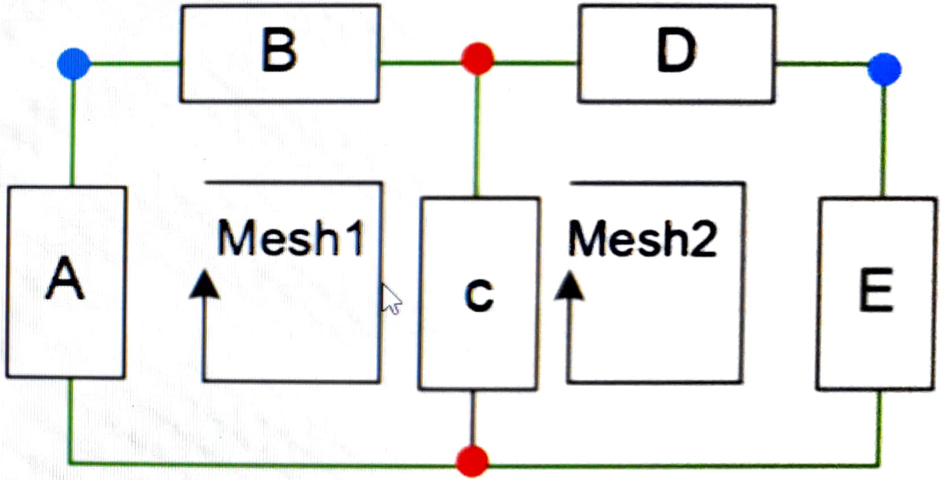
Node: Any junction point between two or more elements (1,2,3 and 4)
Essential node: A Junction between MORE than two elements (2 and 4)
Non-essential node: A Junction between only two elements (1 and 3)
Branch: The part of the circuit that lies between two nodes (A,B,C,D and E)



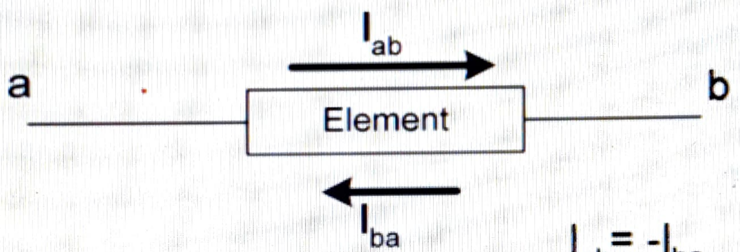
Loop: a closed path in a circuit (loop1, loop2 and loop3)

Mesh: a loop that does not contain any loops (Mesh1 and Mesh2)



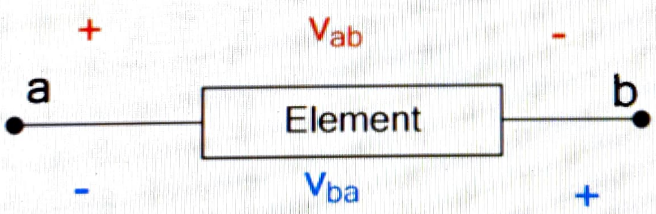


Double-subscript Notation for Currents:



$I_{ab} = -I_{ba}$

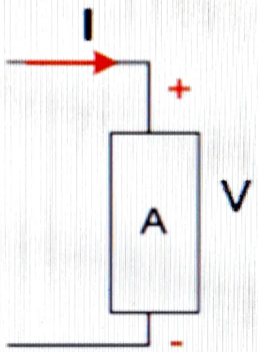
Double-subscript Notation for Voltages:



$V_{ab} - = V_{ba}$

Passive Reference Configuration:

In the following figure, notice that the current reference enters the positive polarity of the voltage. This arrangement is called passive reference configuration.

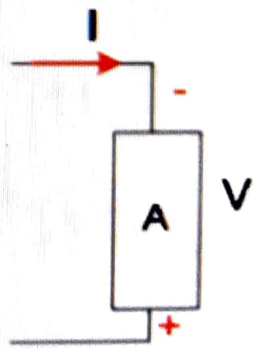


P= V.I

Note:

If the current reference enters the negative end of the reference polarity we compute the power as:

P=-V I



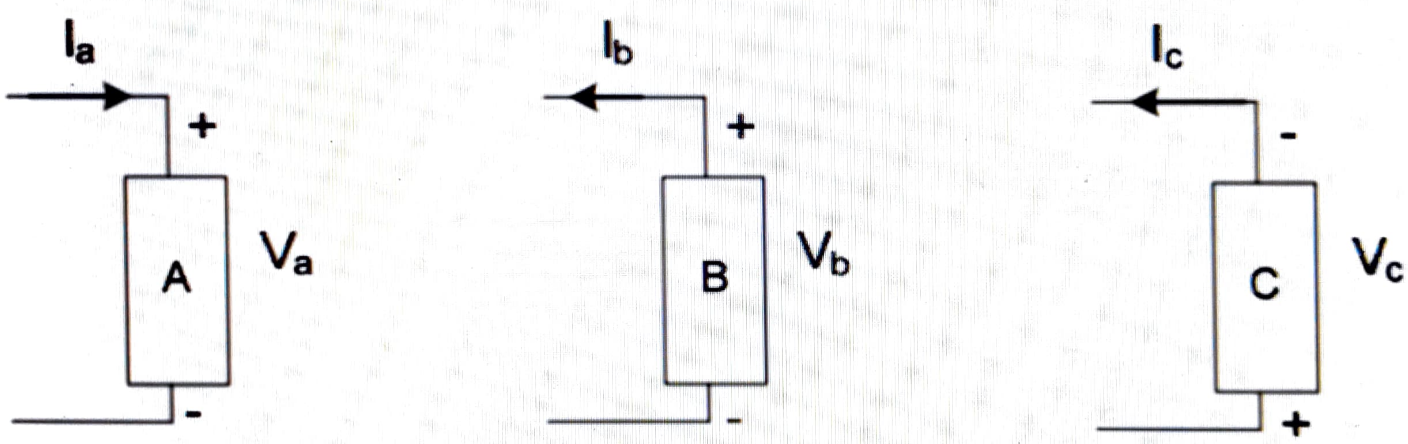
P= - V.I

A positive value for p indicates the energy is absorbed by the element and a negative value of p shows that the energy is supplied by the element

Power is conserved over all any circuit. This means that the magnitude of the supplied power MUST be equal to the magnitude of the absorbed power (see the last example of this note).

Example:

Calculate the power for each element.



V_a12 =V
I_a2 =A

V_b12 =V
I_b1 =A

V_c4 =V
Ic2 -=A

Solution

$P_a = v_a\, i_a = 12 \times 2 = 24$ w (Absorbed)

$P_b = -\, v_b\, i_b = -12 \times 1 = -12$ w (Supplied)

$P_c = v_c\, i_c = 4 \times (-2) = -8$ w (Supplied)

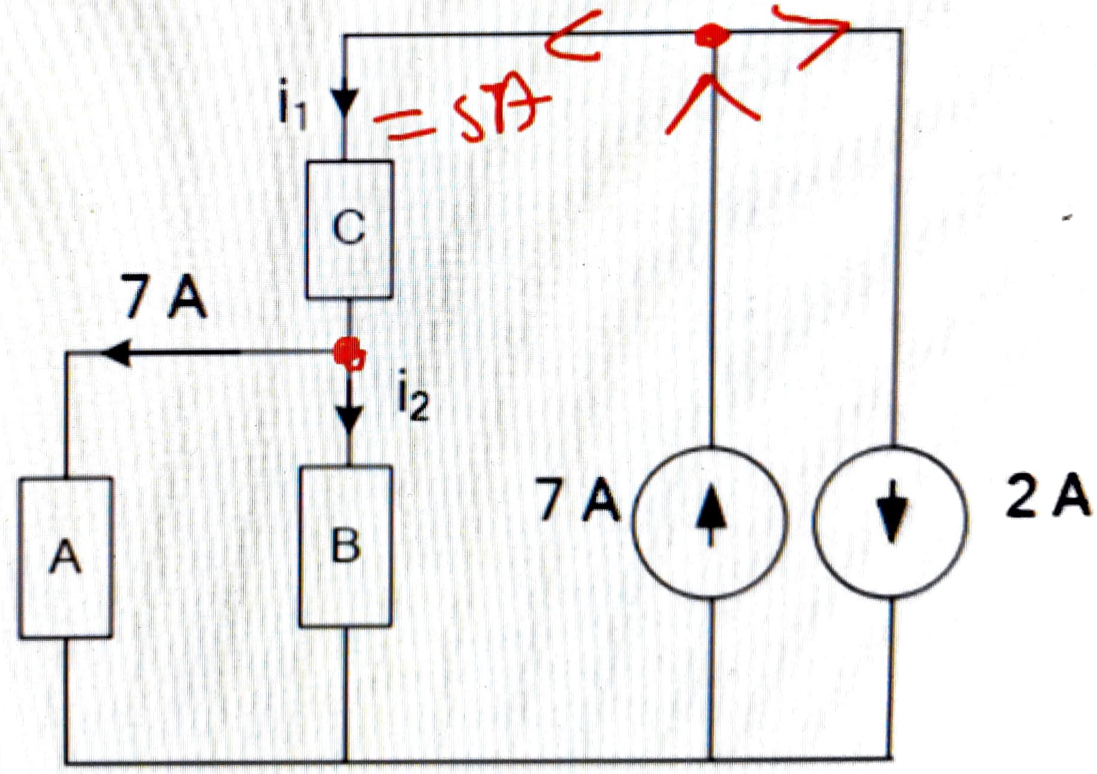
$i_1 + 2 = 7$

$\therefore i_1 = 5A$

Example:

Find the value of the i_1 and i_2:

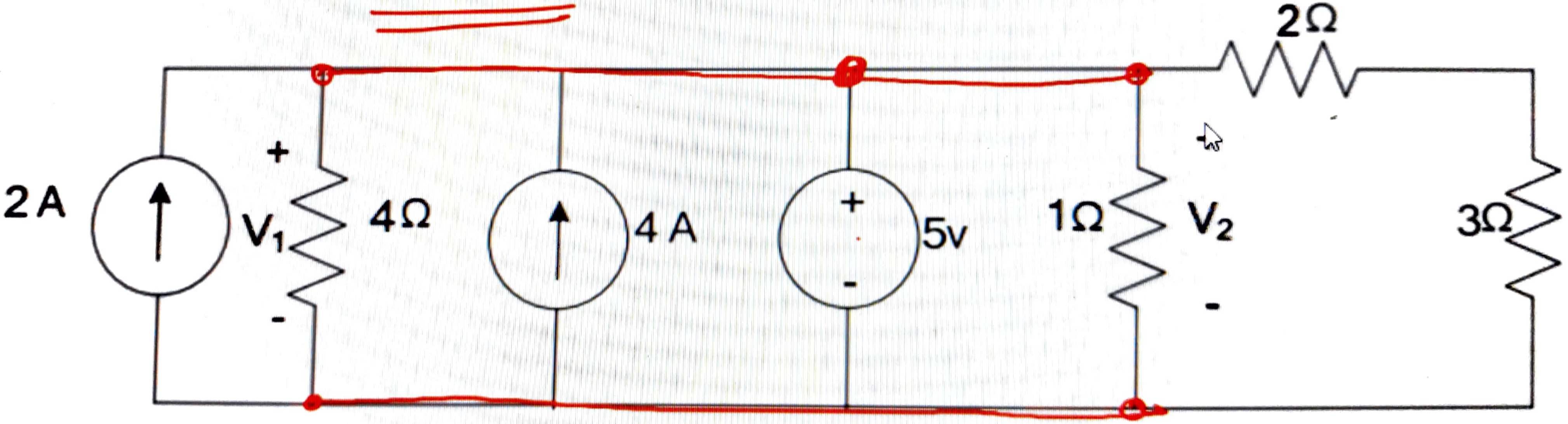
KCL



$V_1 = V_2$

Example:

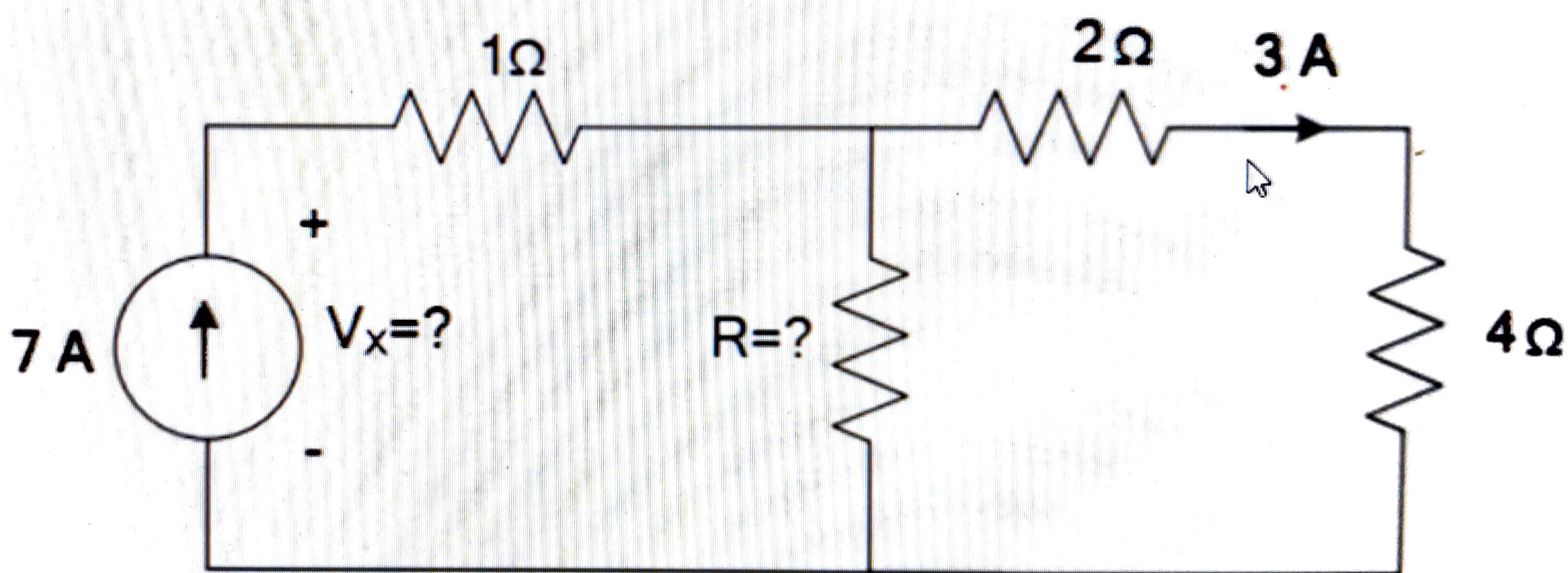
In the following circuit find V_1 and V_2.



For the following circuit

a. Find V_x and R.

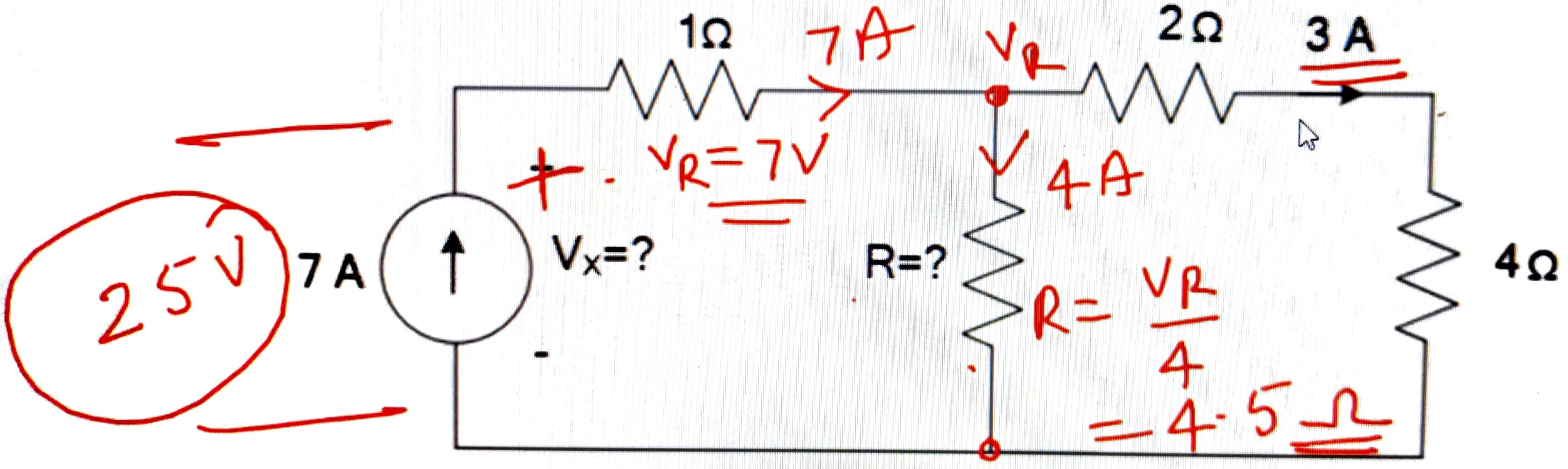
b. Prove that the supplied power is equal to the absorbed power.



For the following circuit

a. Find V_x and R.

b. Prove that the supplied power is equal to the absorbed power.

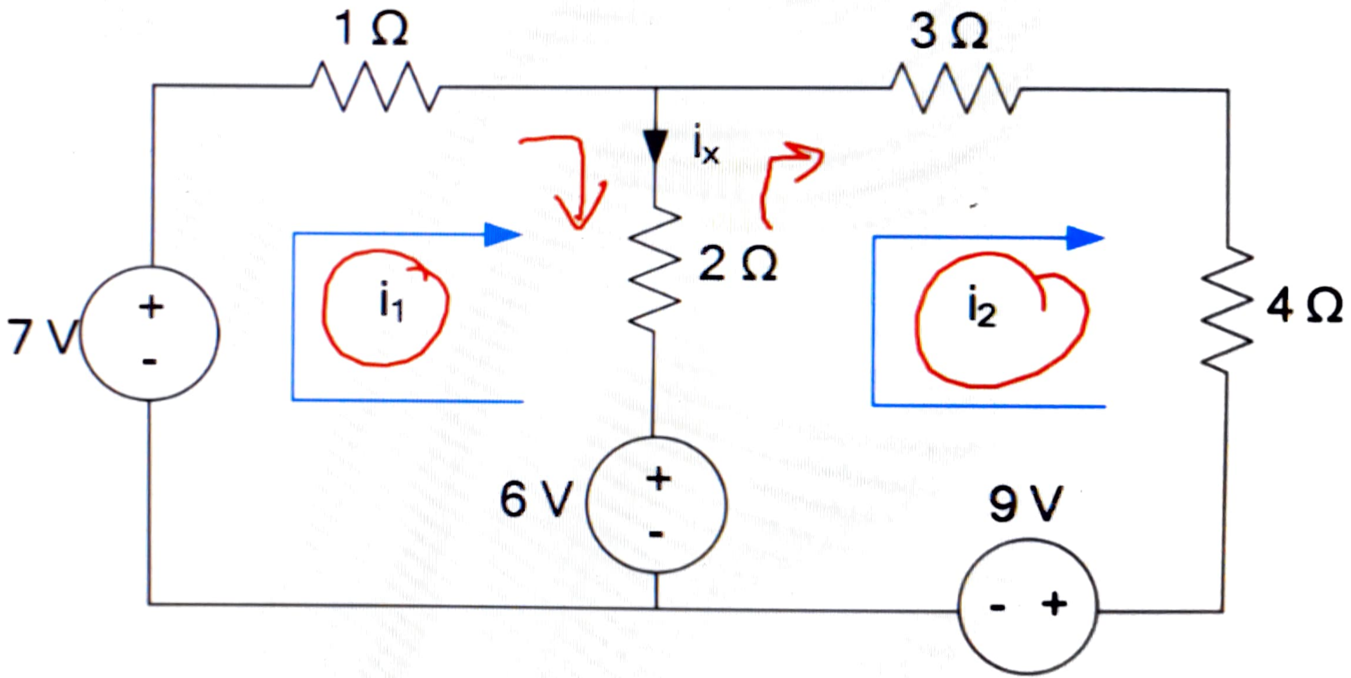


$R = 2 + 4 = 6\Omega$

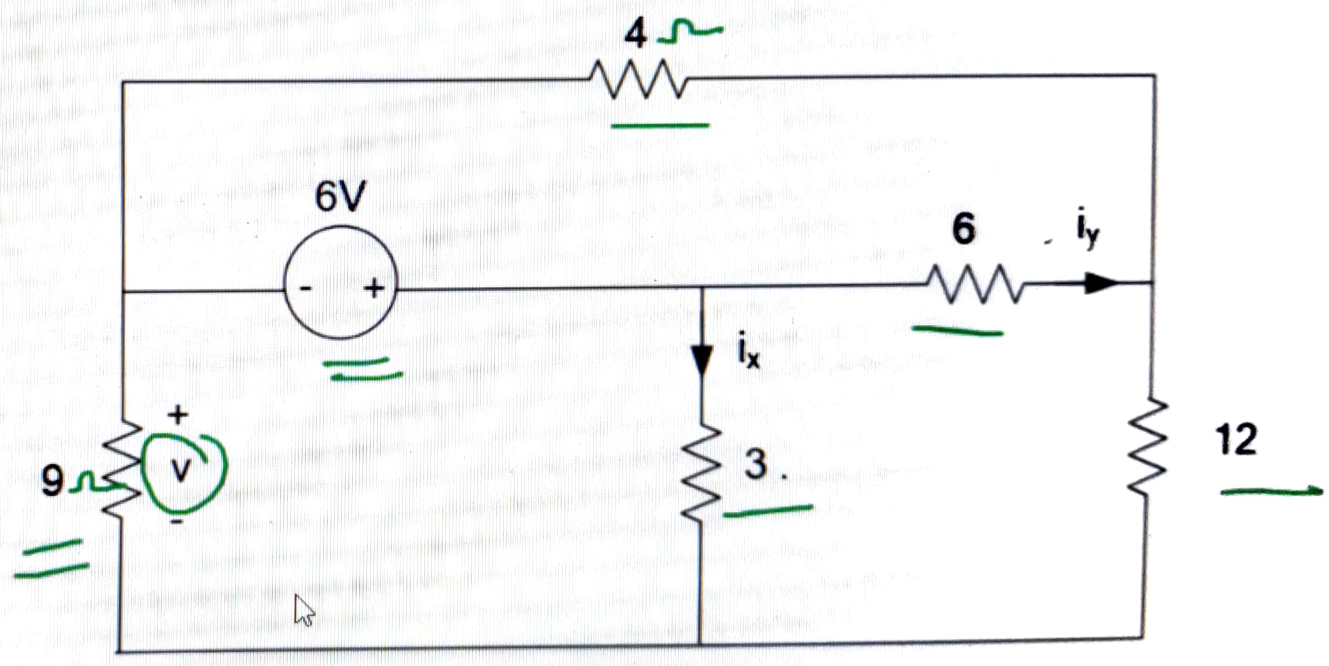
$V_R = 6 \times 3 = 18V$

$i_x = i_1 - i_2$

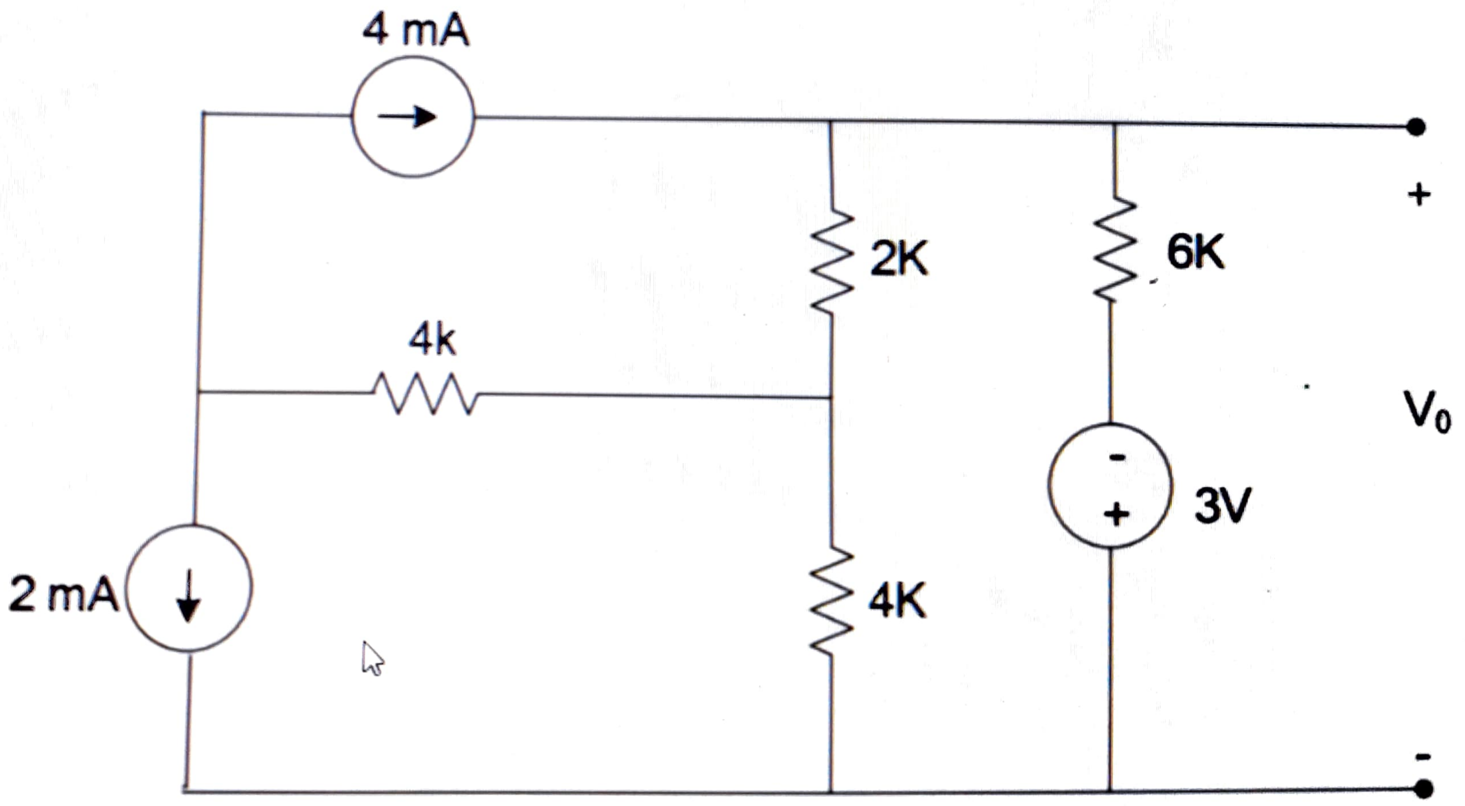
- Find i_1, i_2 and i_x.



find i_x, i_y and v



Find V_O



Find V_o