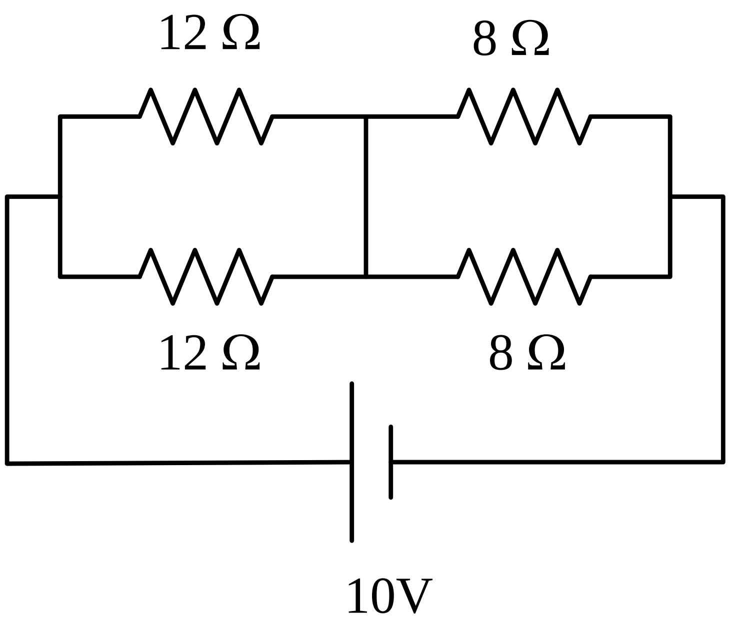
Tutorial 1

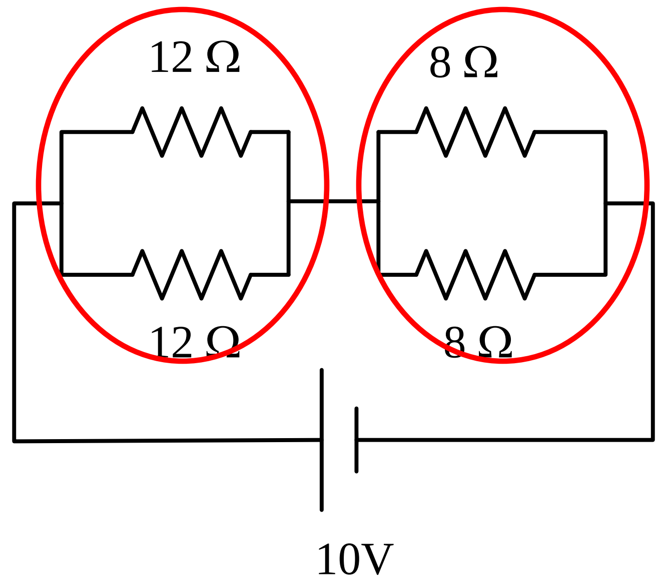
- ILOs
  - Solve numerical problems related to:
    - Series-parallel combination of resistances
    - Star-Delta transformation
    - Current & voltage division

Find current flowing out of the 10 V source.

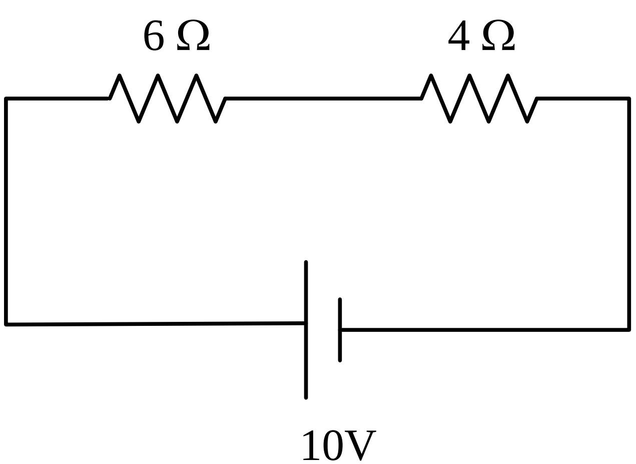


Solution:

- 1^{st} step: Redraw

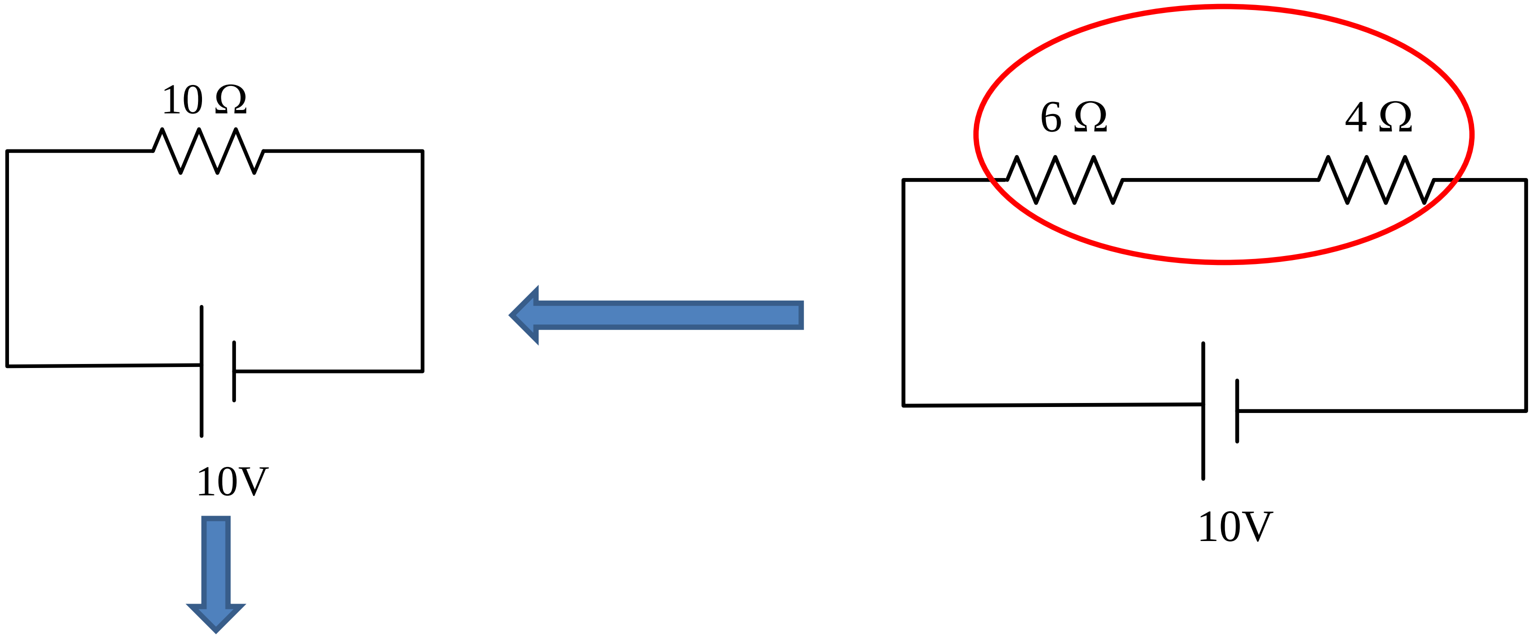


- 2^{nd} step:
  12//12 = 6 , 8 // 8 = 4



Find current flowing out of the 10 V source.

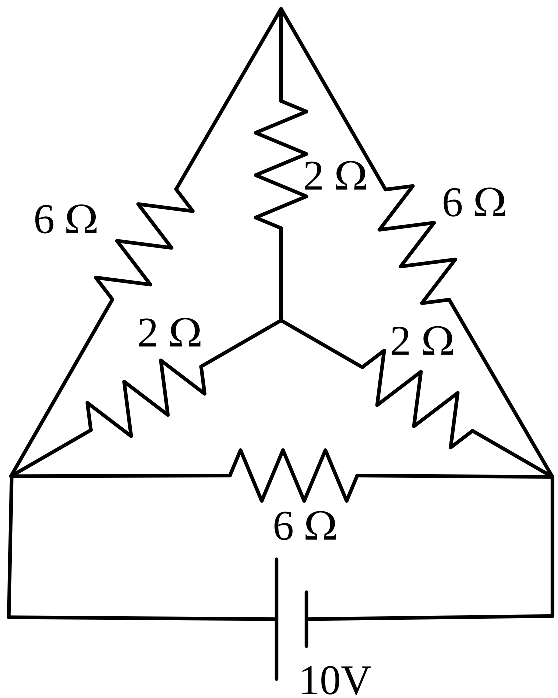
- 3rd step: 6 and 4 in series



- Finally:

$$I = \frac{10}{10} = 1\ A$$

Find current flowing out of the 10 V source.



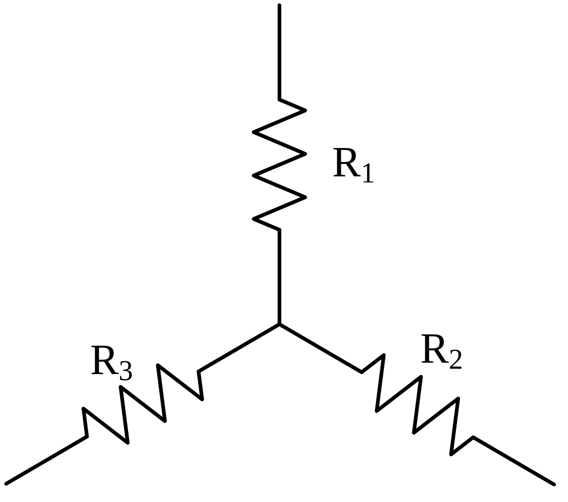
Solution:

- It is almost impossible to find out equivalent resistance of the circuit by simple series-parallel combination.

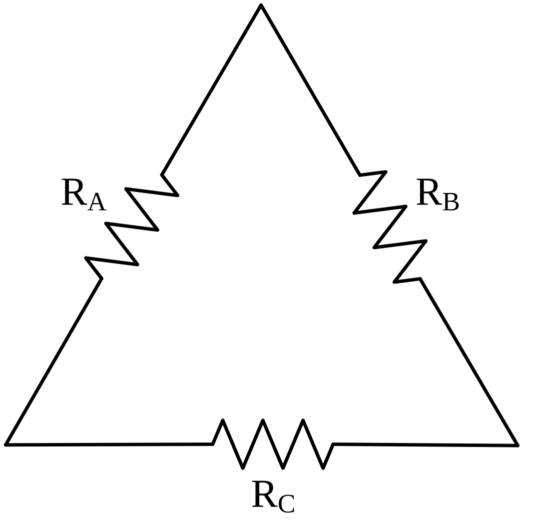
- In this case, it is necessary to introduce a new concept – called the **Star-Delta Transformation** technique.

Star-Delta Transformation

STAR network

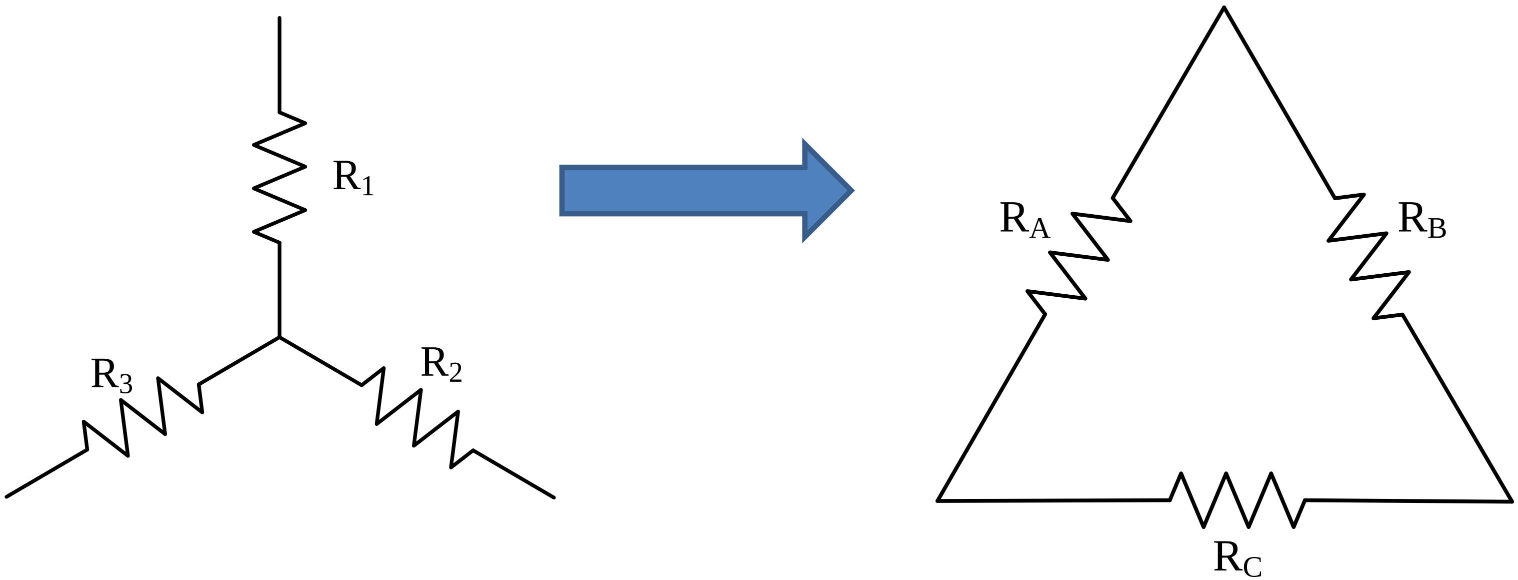


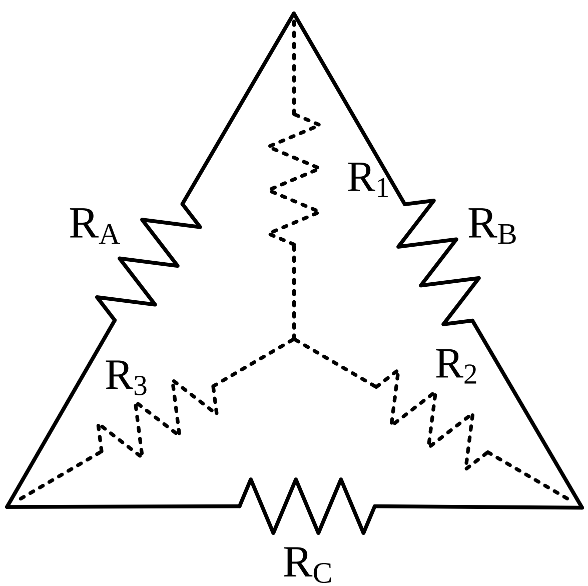
DELTA network



- It is possible to equivalently represent a star network by a delta network and vice versa without affecting the external signals.

Converting Star to Delta



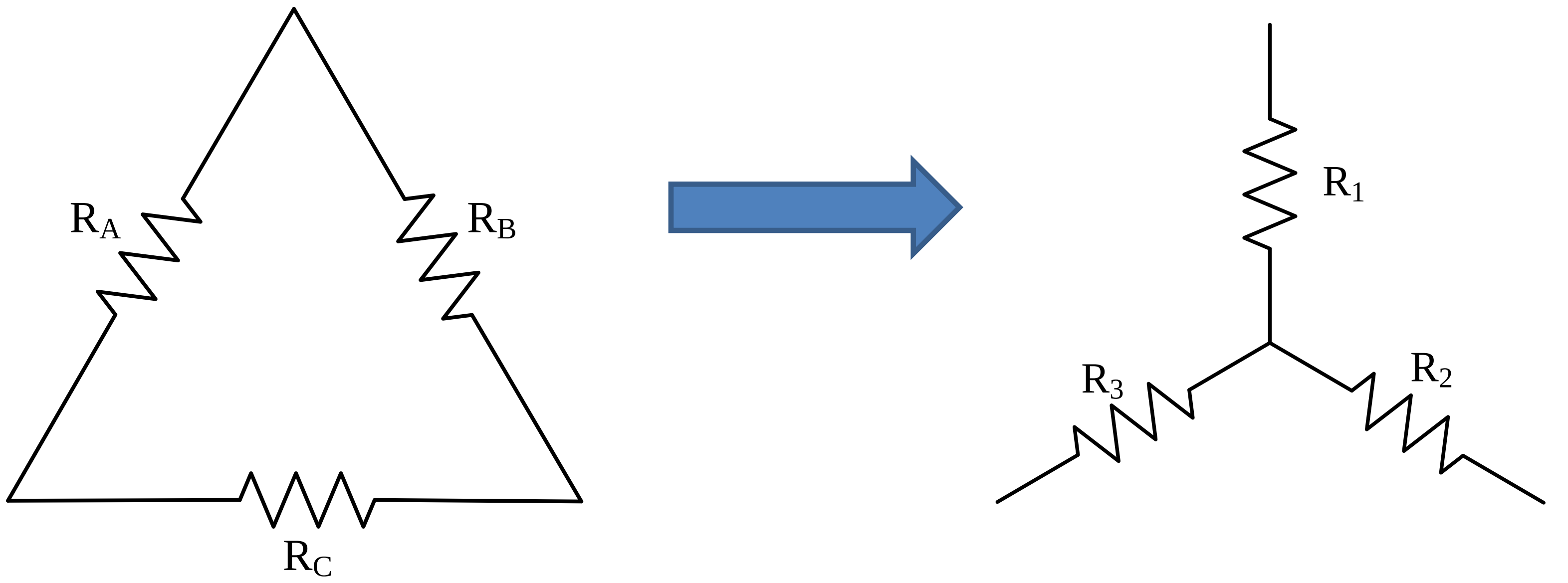


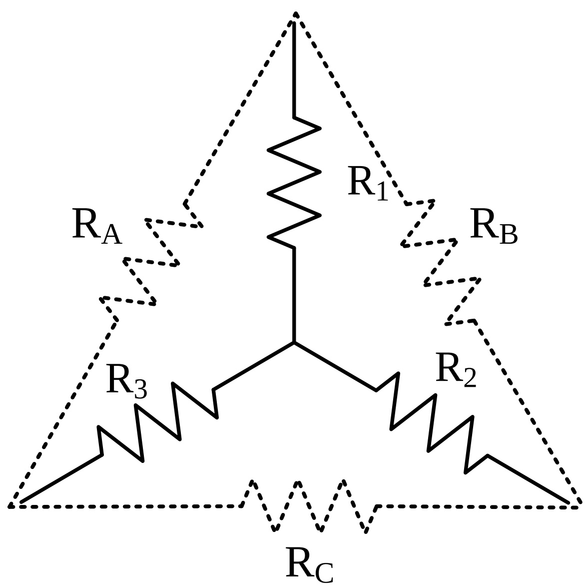
$$R_A = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2}$$

$$R_B = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3}$$

$$R_C = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1}$$

Converting Delta to Star



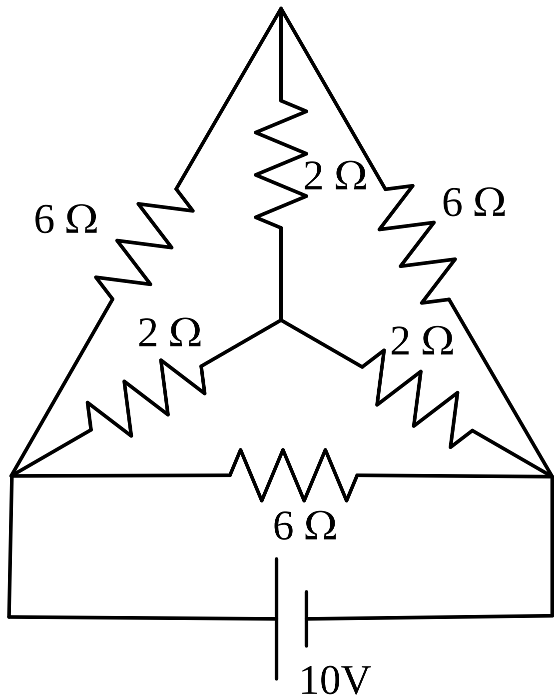


$$R_1 = \frac{R_A R_B}{R_A + R_B + R_C}$$

$$R_2 = \frac{R_B R_C}{R_A + R_B + R_C}$$

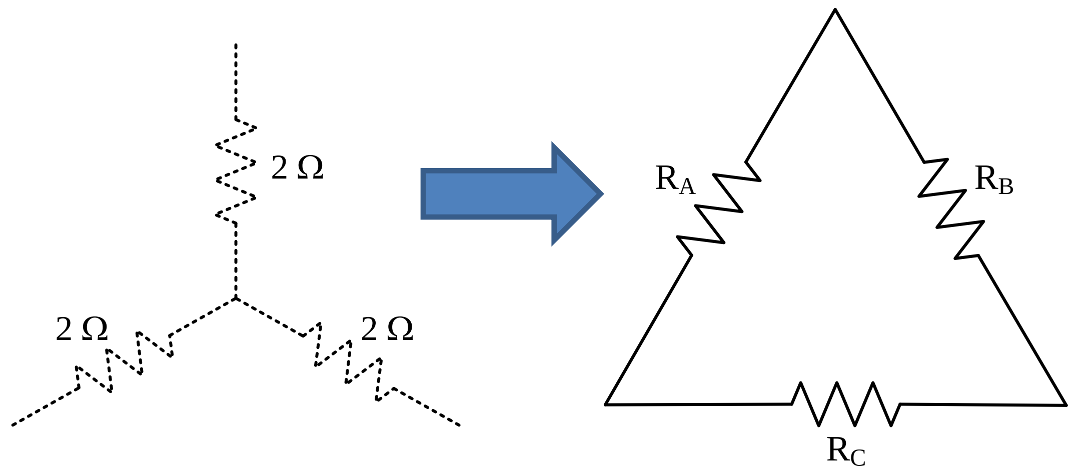
$$R_3 = \frac{R_C R_A}{R_A + R_B + R_C}$$

Find current flowing out of the 10 V source.



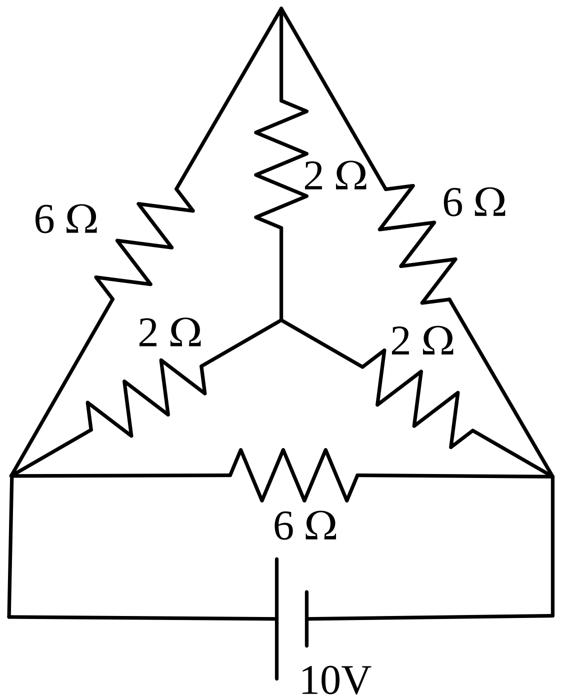
Solution:

Step 1: Convert the inner 2 Ω star network into its equivalent delta network.



$$R_A = R_B = R_C = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_2} = \frac{2\times 2 + 2\times 2 + 2\times 2}{2} = 6\Omega$$

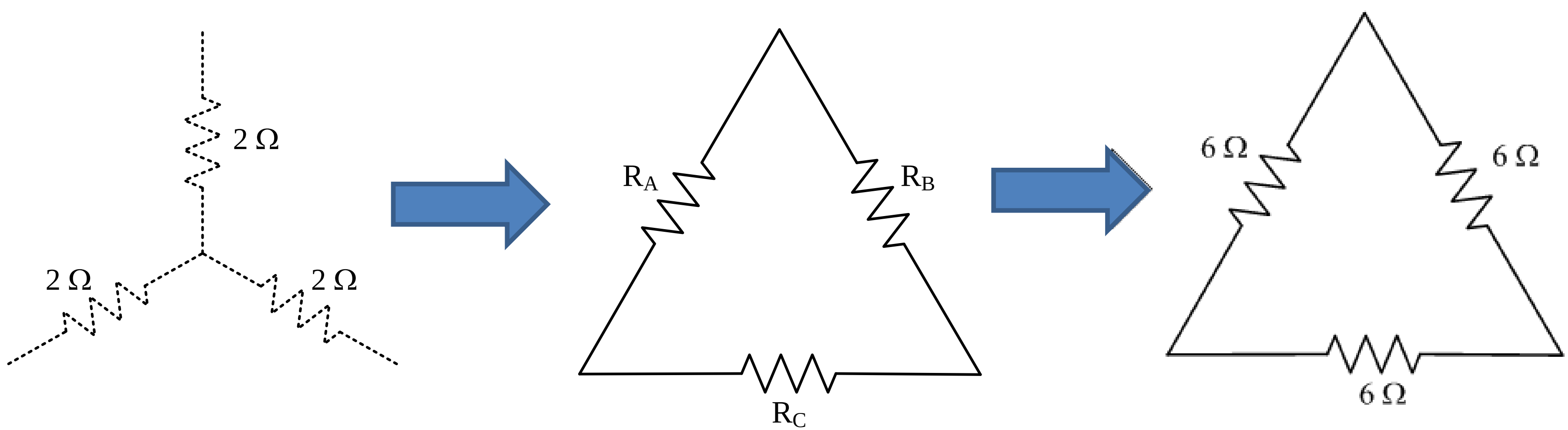
Find current flowing out of the 10 V source.



Solution:

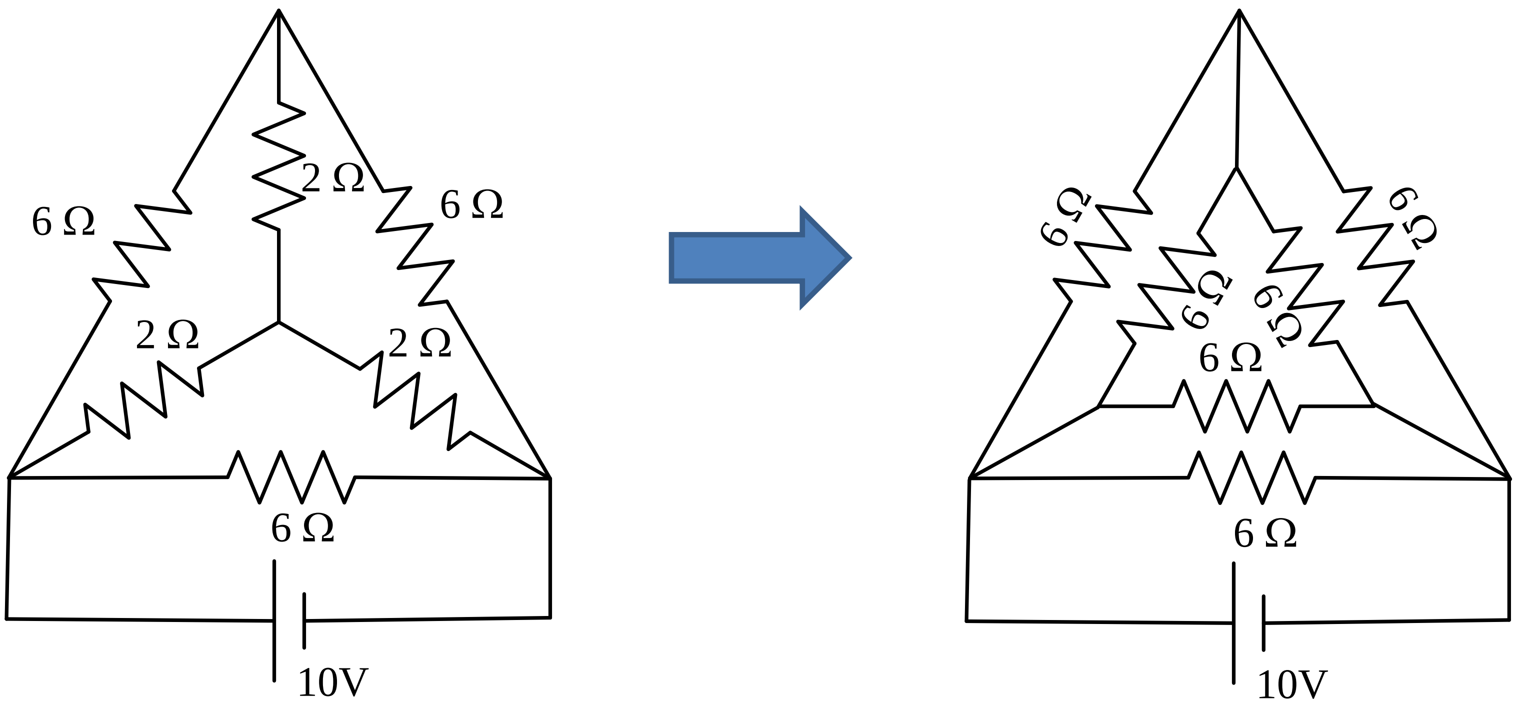
Step 1: Convert the inner 2 Ω star network into its equivalent delta network.

$$R_A = R_B = R_C = 6\Omega$$



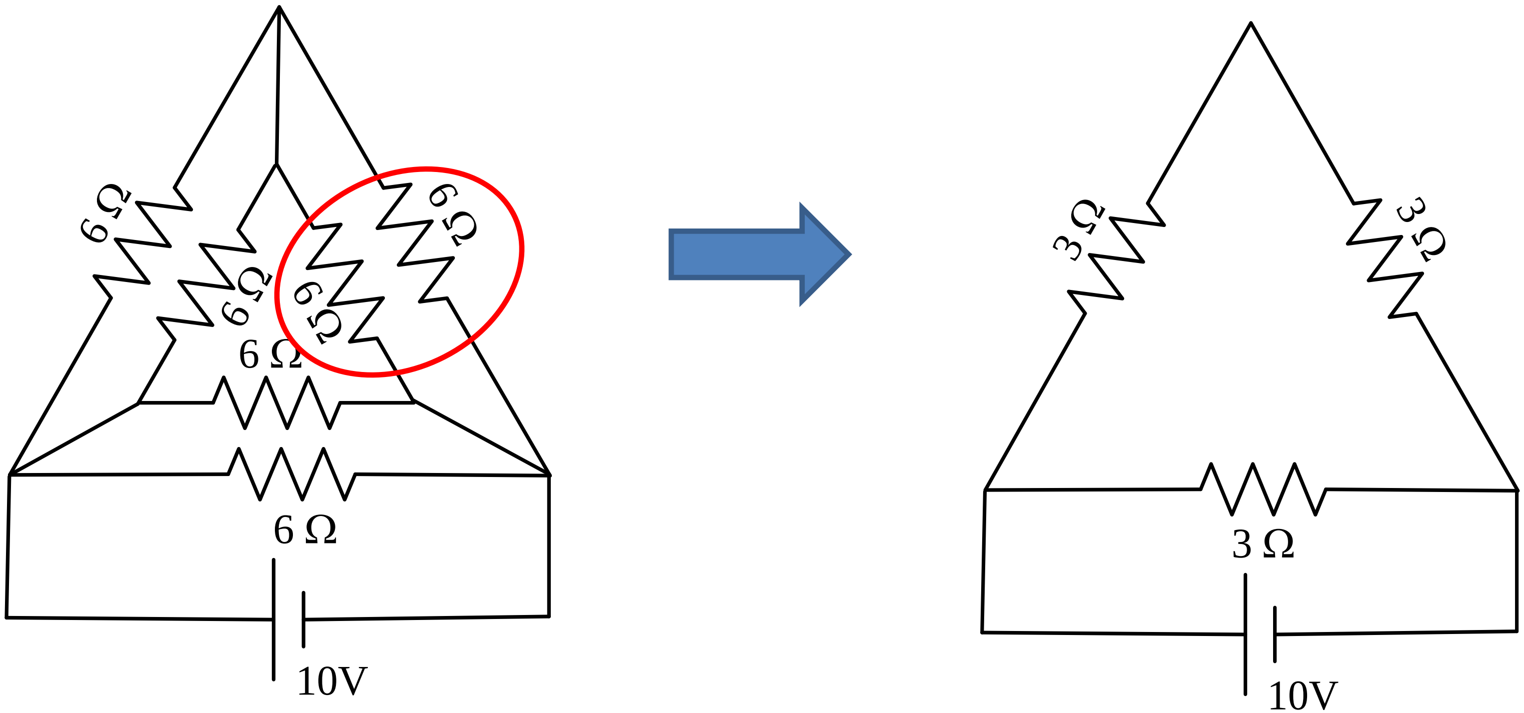
Step 2:

- The circuit already contains another delta network that is placed outside (6 ohm each).
- So the new delta (converted from 2 ohm star) and the original outer delta network now will be combined as shown below:

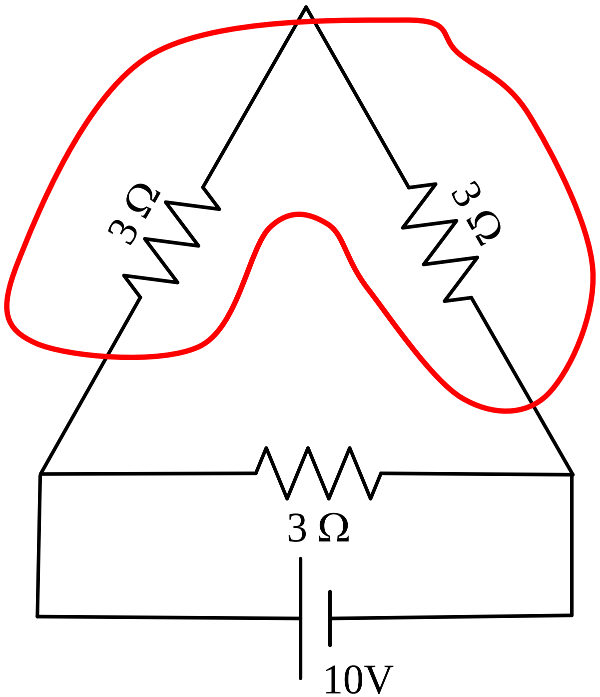


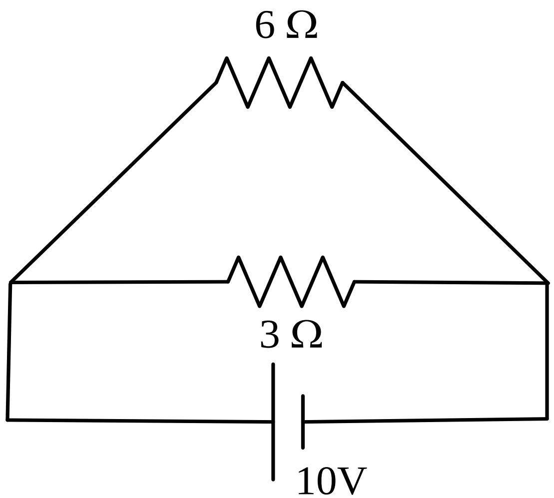
Step 3: Two 6Ω resistances in parallel in each of the three arms

Thus, 6//6 = 3



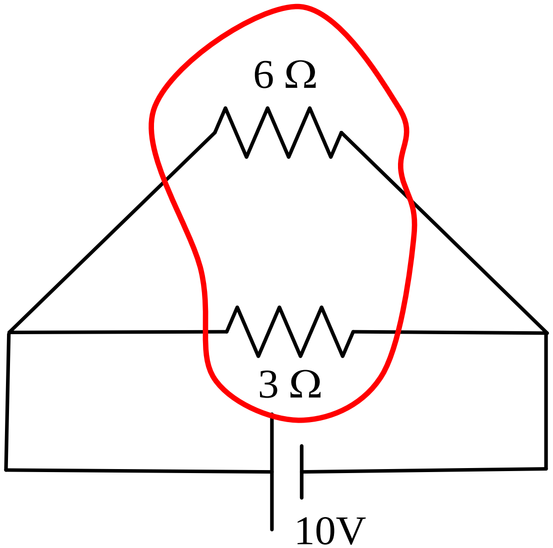
Step 4: The two upper 3 Ω resistances are in series:

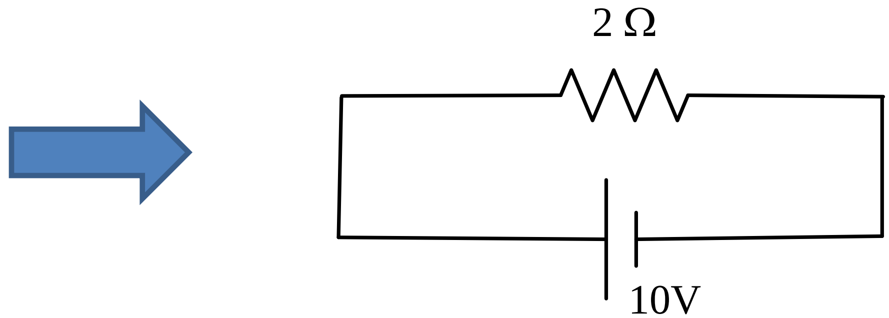




Step 5: The 6 Ω and 3Ω resistances now become in parallel:

$$6 // 3 = \frac{6 \times 3}{6+3} = 2$$





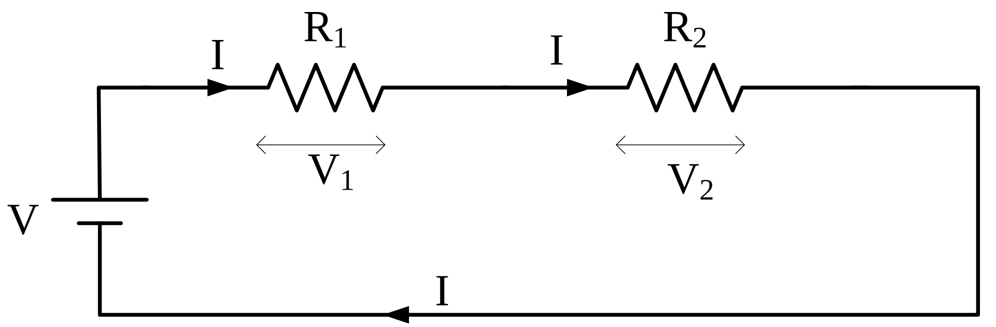
Step 6: Calculate current:

$$I = \frac{10}{2} = 5\ A$$

Voltage & current division

Voltage division in series circuit

- When two or more elements are connected in series, the total supply voltage gets divided among the individual elements.
- The share of voltage depends on the value of resistance.



$$V = V_1 + V_2$$

$$I = \frac{V}{R_1 + R_2}$$

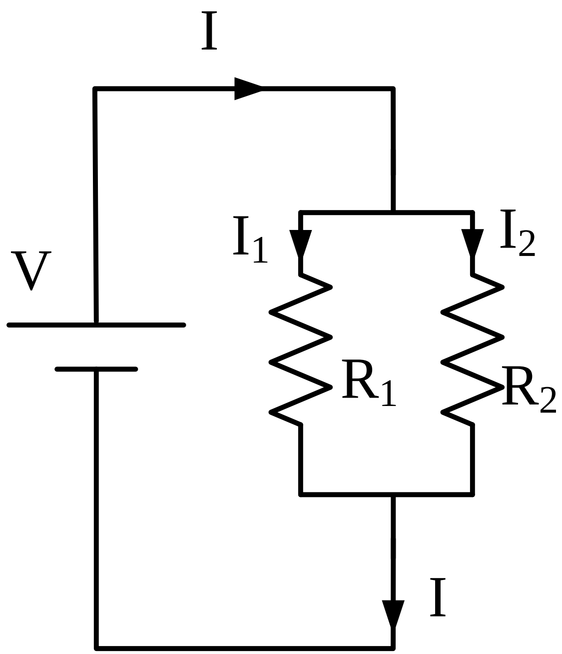
Thus, voltage across a resistance in a series circuit is the total voltage multiplied by value of the own resistance divided by summation of all the resistances connected in series.

$$V_1 = IR_1 = \frac{V}{R_1 + R_2} R_1 = \boxed{V \times \frac{R_1}{R_1 + R_2}}$$

$$V_2 = IR_2 = \frac{V}{R_1 + R_2} R_2 = \boxed{V \times \frac{R_2}{R_1 + R_2}}$$

Current division in parallel circuit

- When two or more elements are connected in parallel, the total supply current gets divided among the individual elements.
- The share of current carried by each resistance depends on the value of resistance.



Two resistances connected in parallel

$\therefore$ Equivalent resistance:

$$\therefore R = \frac{R_1 R_2}{R_1 + R_2}$$

$\therefore$ Total supply current:

$$I = \frac{V}{R} = \frac{V}{\dfrac{R_1 R_2}{R_1 + R_2}}$$

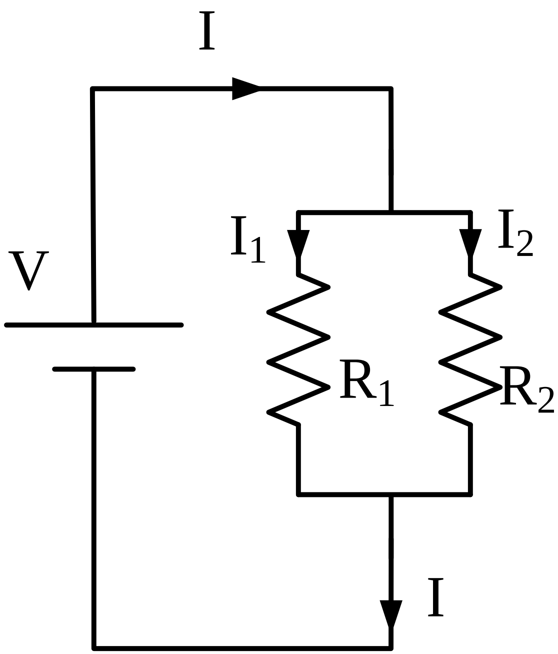
$$or,\ I = V \times \frac{(R_1 + R_2)}{R_1 R_2}$$

$$\boxed{\therefore V = I \times \frac{R_1 R_2}{R_1 + R_2}}$$

Current division in parallel circuit

$$V = I \times \frac{R_1 R_2}{R_1 + R_2}$$

Since the two resistances are connected in parallel, they get the same supply voltage V



$$V = I_1 R_1 = I_2 R_2$$

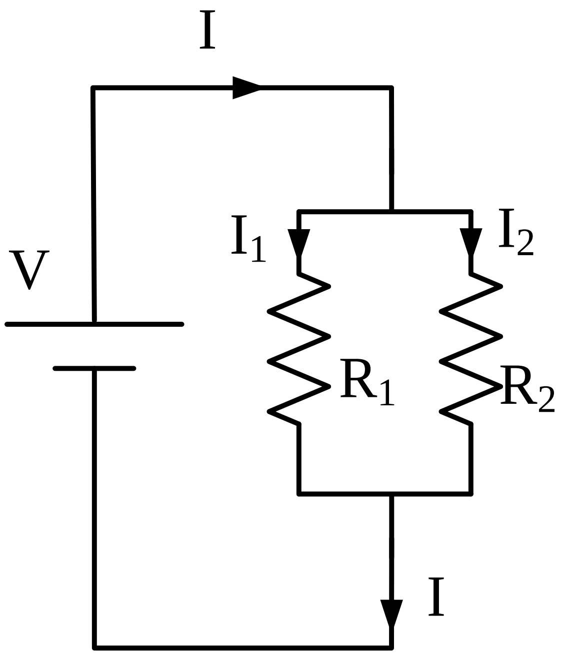
Total current is shared between the two

$$I = I_1 + I_2$$

$$I_1 = \frac{V}{R_1} = I \times \frac{R_1 R_2}{R_1 + R_2} \times \frac{1}{R_1} = \boxed{I \times \frac{R_2}{R_1 + R_2}}$$

$$I_2 = \frac{V}{R_2} = I \times \frac{R_1 R_2}{R_1 + R_2} \times \frac{1}{R_2} = \boxed{I \times \frac{R_1}{R_1 + R_2}}$$

Current division in parallel circuit

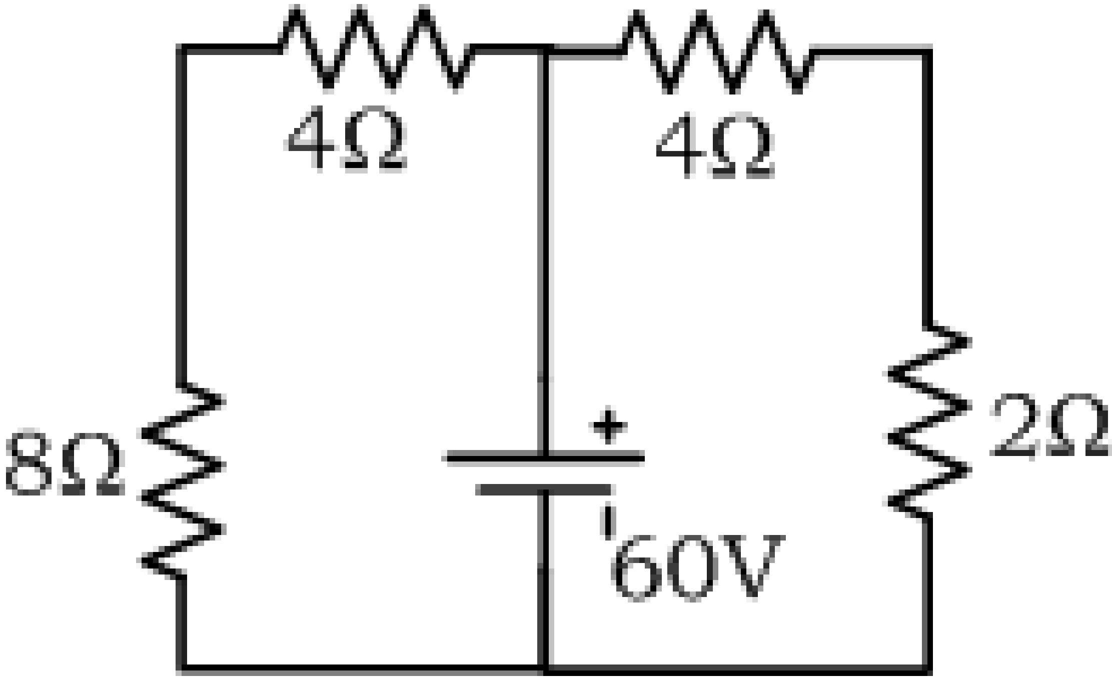


$$I_1 = I \times \frac{R_2}{R_1 + R_2}$$

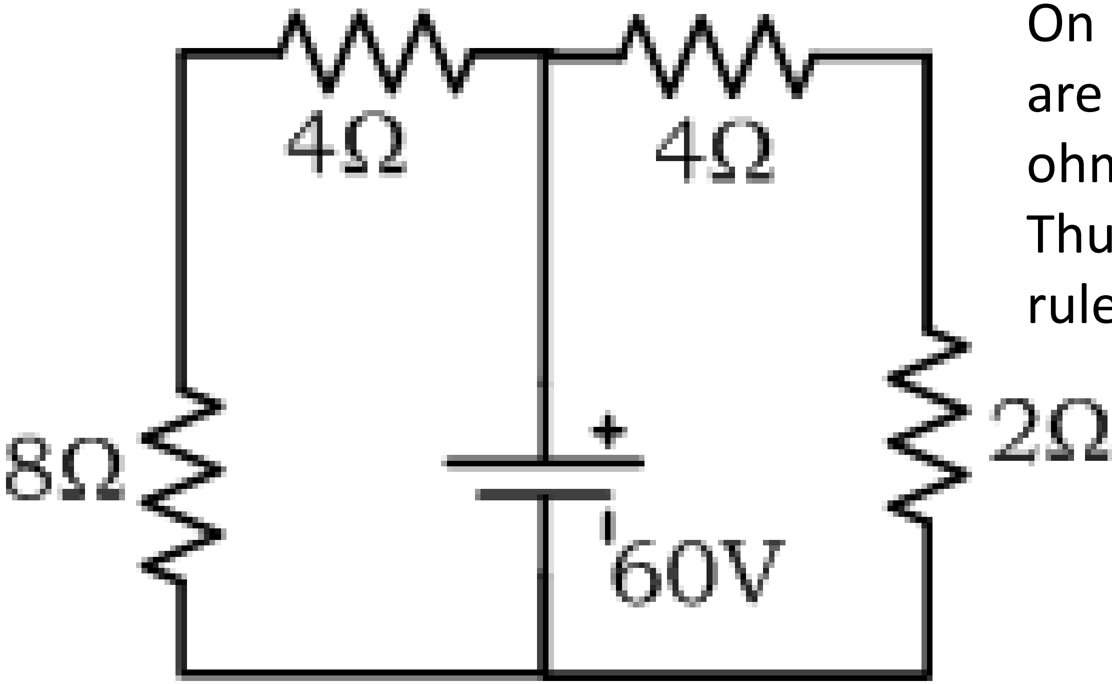
$$I_2 = I \times \frac{R_1}{R_1 + R_2}$$

Thus, current through a resistance in a parallel circuit is the total current multiplied by value of the ***opposite resistance*** *divided by summation of the two resistances.*

In the circuit shown in figure , find the voltage across each element



In the circuit shown in figure , find the voltage across each element



Solution:

On both sides of the circuit, there are series connections of 4 and 2 ohm resistances.
Thus, we can apply voltage division rule

$$V_1 = V \times \frac{R_1}{R_1 + R_2}$$

On right side branch:

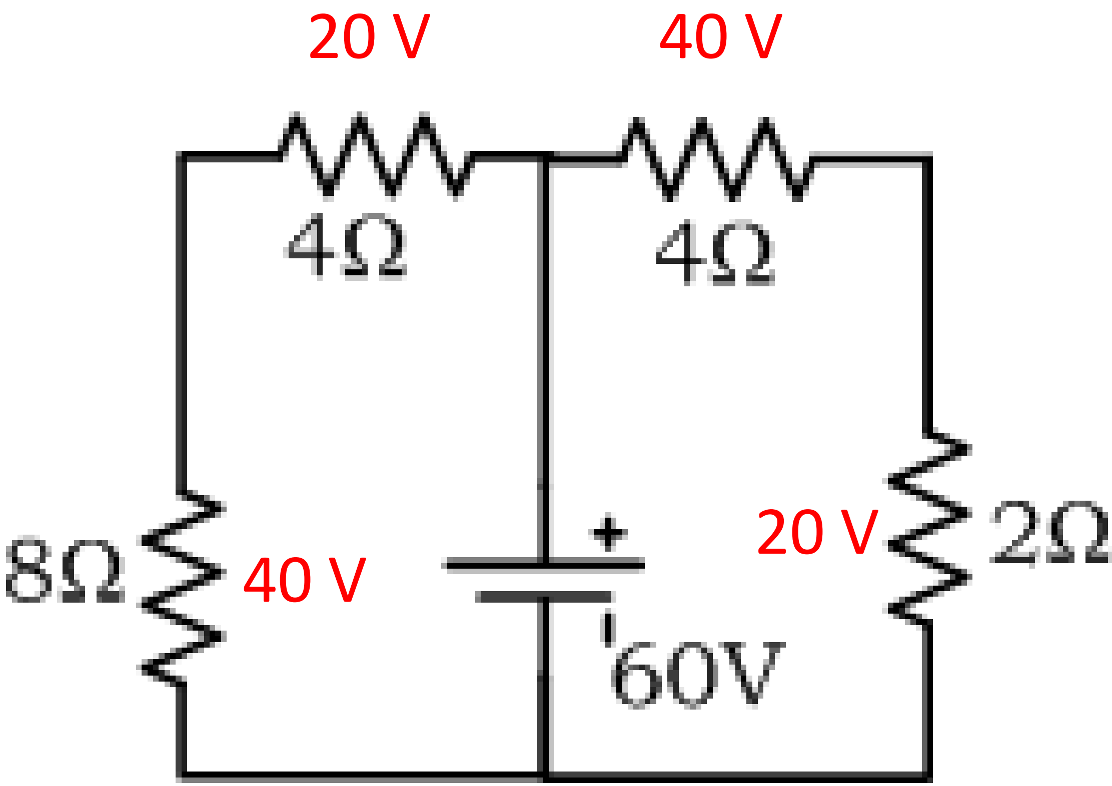
$$V_{2\Omega} = 60 \times \frac{2}{2+4} = 20\,V$$

$$V_{4\Omega} = 60 \times \frac{4}{2+4} = 40\,V$$

On left side branch:

$$V_{8\Omega} = 60 \times \frac{8}{8+4} = 40\,V \quad V_{4\Omega} = 60 \times \frac{4}{8+4} = 20\,V$$

In the circuit shown in figure , find the voltage across each element



On right side branch:

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