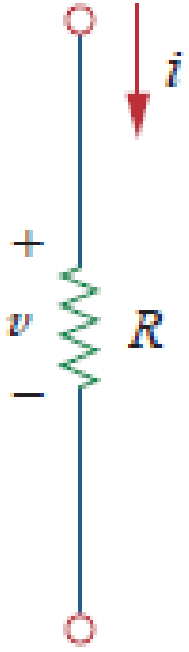
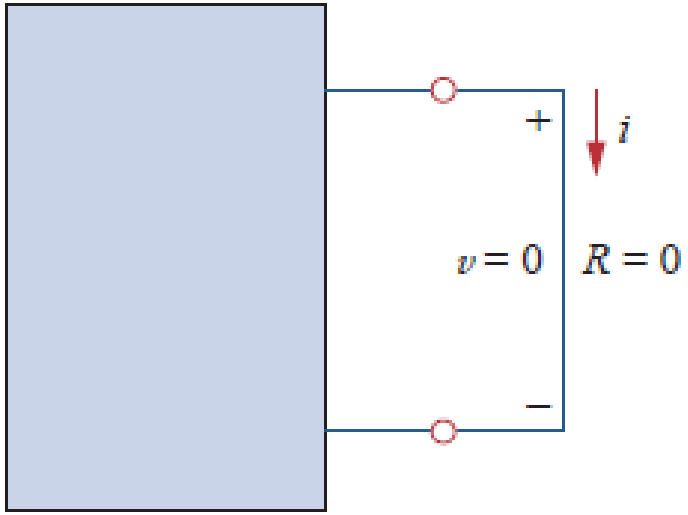
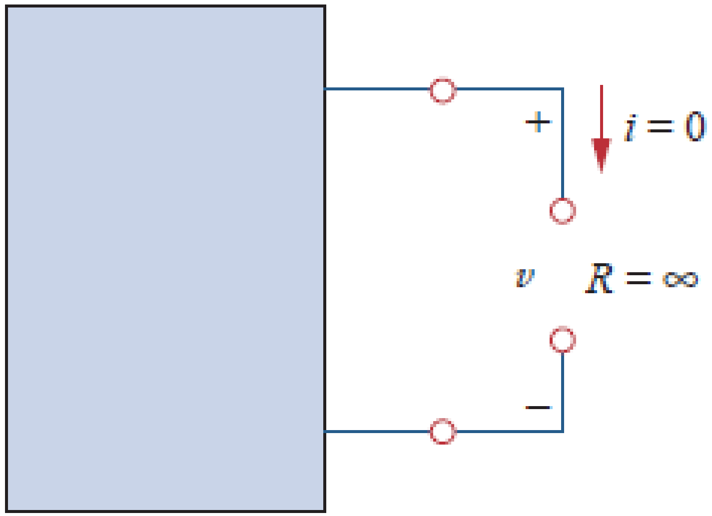
To apply Ohm's law, we must pay careful attention to the current direction and voltage polarity.



Open Circuit & Short Circuit





$$v = iR = 0$$

A **short circuit** is a circuit element with resistance approaching zero.

$$i = \lim_{R \to \infty} \frac{v}{R} = 0$$

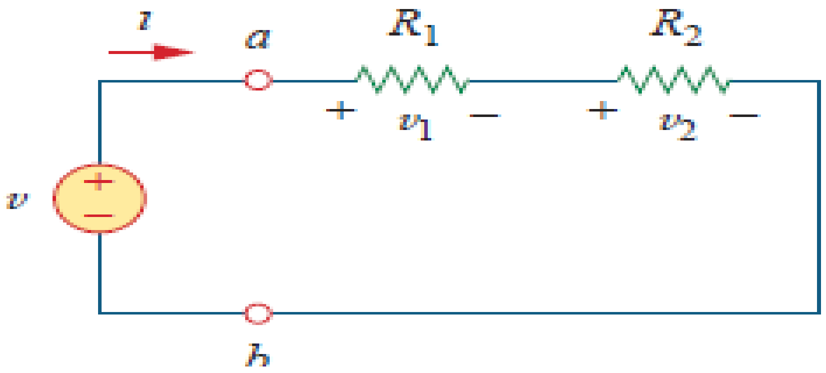
An **open circuit** is a circuit element with resistance approaching infinity.

Conductance

Conductance is the ability of an element to conduct electric current; it is measured in mhos (℧) or siemens (S).

$$\boxed{G = \frac{1}{R} = \frac{i}{v}}$$

Series Resistors and Voltage Division



Ohm's law to each of the resistors, we obtain

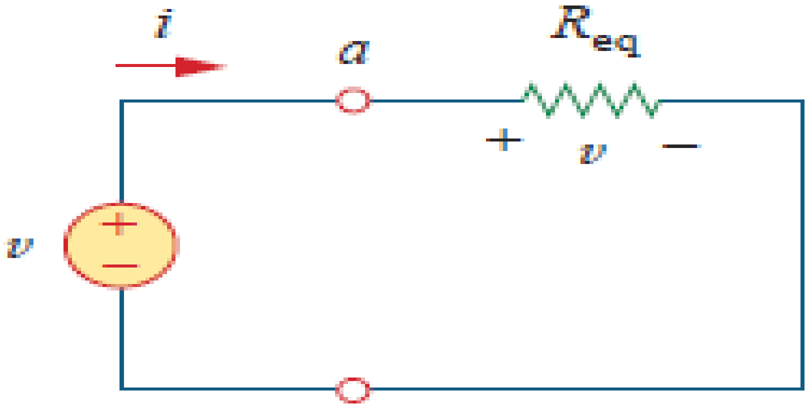
$$v_1 = iR_1, \qquad v_2 = iR_2$$

KVL to the loop (moving in the clockwise direction)

$$-v + v_1 + v_2 = 0$$

$$v = v_1 + v_2 = i(R_1 + R_2)$$

$$i = \frac{v}{R_1 + R_2}$$



$$v = iR_{eq} \qquad R_{eq} = R_1 + R_2$$

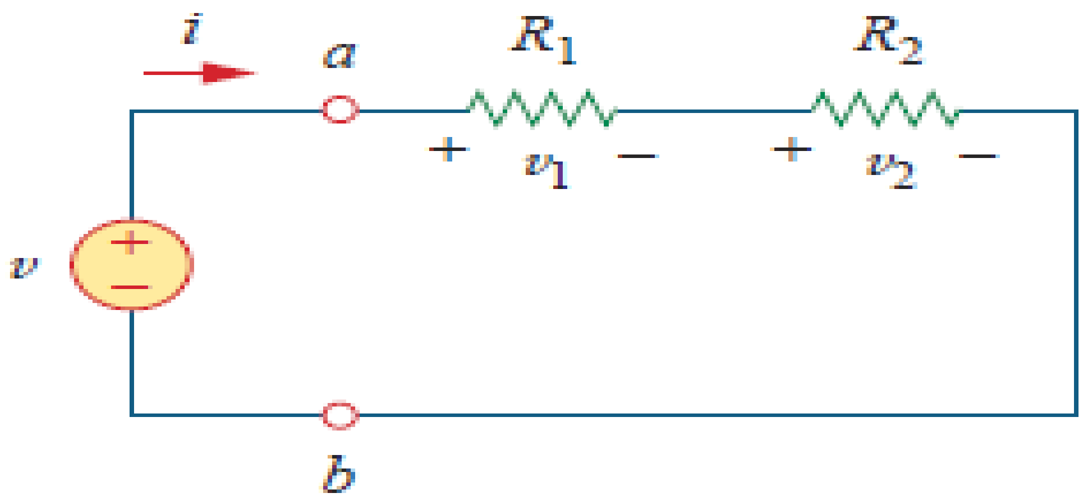
The **equivalent resistance** of any number of resistors connected in series is the sum of the individual resistances.

For N resistors in series then,

$$\boxed{R_{eq} = R_1 + R_2 + \cdots + R_N = \sum_{n=1}^{N} R_n}$$

$$v_1 = iR_1, \qquad v_2 = iR_2$$

$$\boxed{v_1 = \frac{R_1}{R_1 + R_2} v, \qquad v_2 = \frac{R_2}{R_1 + R_2} v}$$

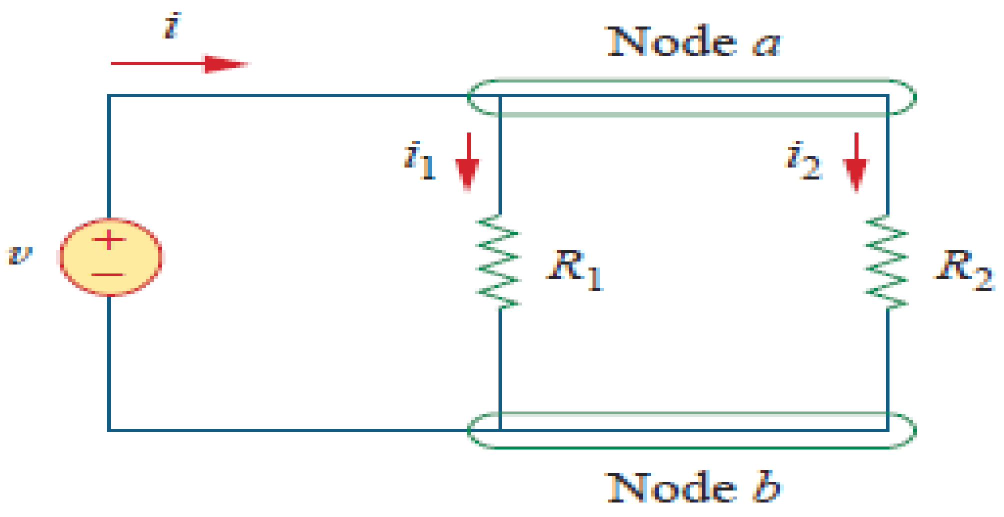


the *principle of voltage division*,

voltage divider.

$$v_n = \frac{R_n}{R_1 + R_2 + \cdots + R_N} v$$

Parallel Resistors and Current Division



$$v = i_1 R_1 = i_2 R_2$$

$$i_1 = \frac{v}{R_1}, \qquad i_2 = \frac{v}{R_2}$$

KCL at node a gives the total current i as

$$i = i_1 + i_2$$

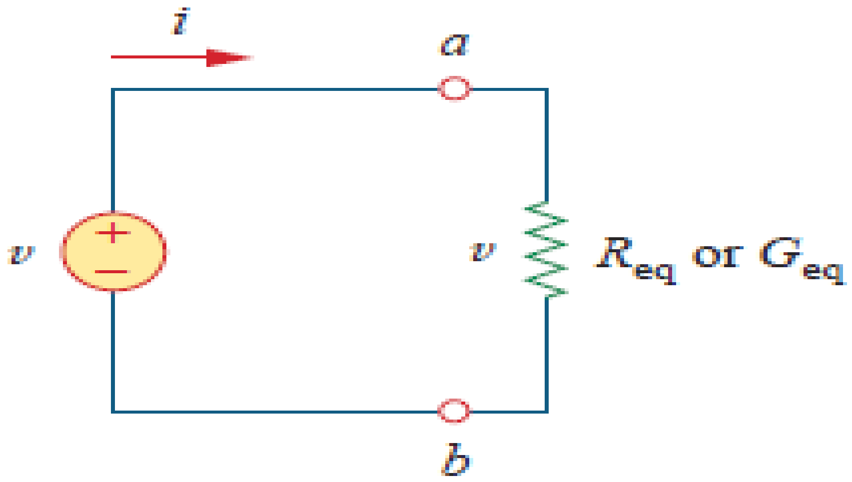
$$i = \frac{v}{R_1} + \frac{v}{R_2} = v\left(\frac{1}{R_1} + \frac{1}{R_2}\right) = \frac{v}{R_{eq}}$$

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

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

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

The **equivalent resistance** of two parallel resistors is equal to the product of their resistances divided by their sum.



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

$$G_{eq} = G_1 + G_2 + G_3 + \cdots + G_N$$

The **equivalent conductance** of resistors connected in parallel is the sum of their individual conductances.

equivalent conductance G_{eq} of N resistors in series

$$\frac{1}{G_{eq}} = \frac{1}{G_1} + \frac{1}{G_2} + \frac{1}{G_3} + \cdots + \frac{1}{G_N}$$

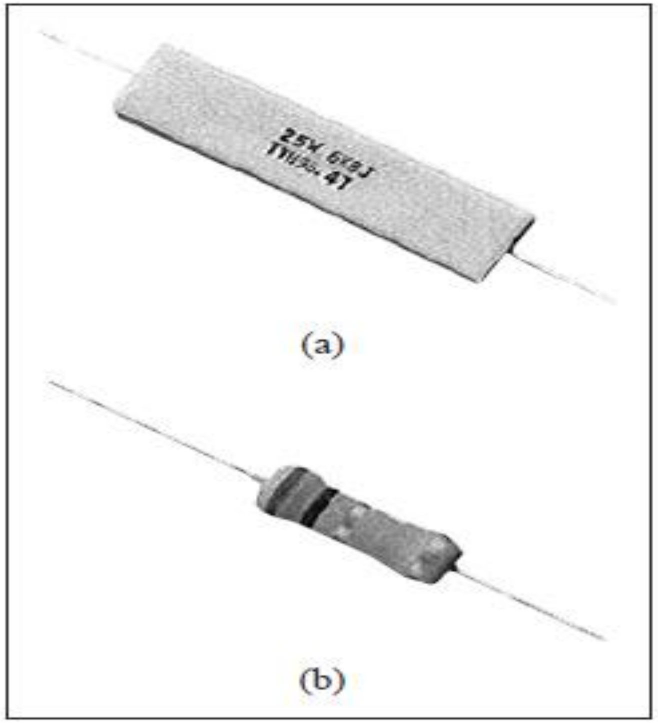


Figure 2.3
Fixed resistors: (a) wirewound type, (b) carbon film type.
Courtesy of Tech America.

(a) (b)

Figure 2.4
Circuit symbol for: (a) a variable resistor in general, (b) a potentiometer.

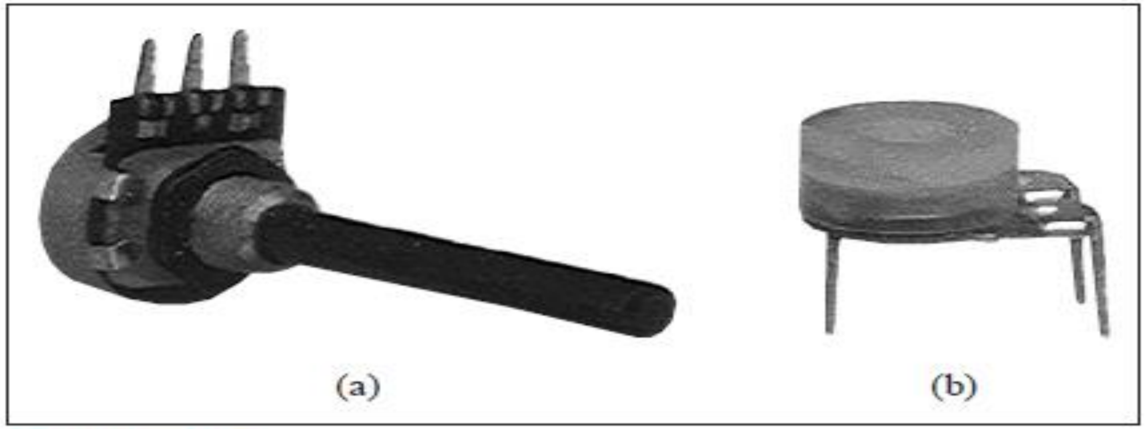


Figure 2.5
Variable resistors: (a) composition type, (b) slider pot.
Courtesy of Tech America.

$$\boxed{G = \frac{1}{R} = \frac{i}{v}}$$

$$1\ \mathrm{S} = 1\ \mho = 1\ \mathrm{A/V}$$

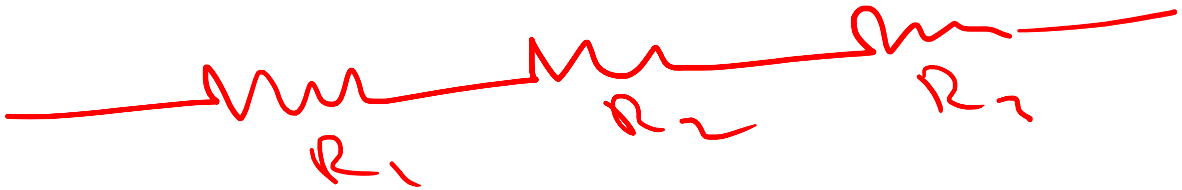
Conductance is the ability of an element to conduct electric current; it is measured in mhos ($\mho$) or siemens (S).

$$i = Gv$$

$$p = vi = i^2R = \frac{v^2}{R}$$

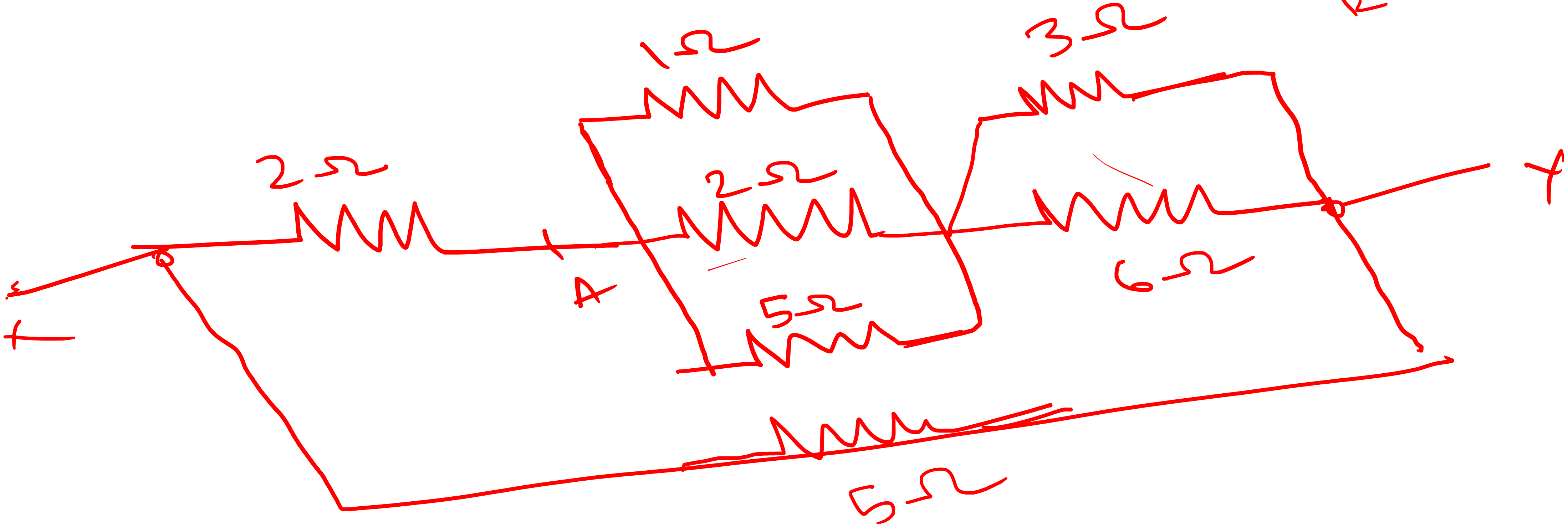
$$p = vi = v^2G = \frac{i^2}{G}$$

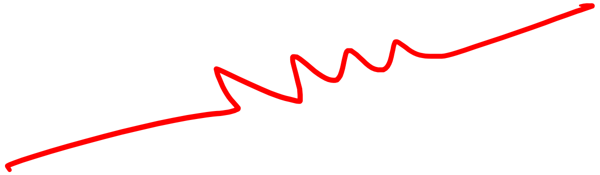
1. The power dissipated in a resistor is a nonlinear function of either current or voltage.
2. Since R and G are positive quantities, the power dissipated in a resistor is always positive. Thus, a resistor always absorbs power from the circuit. This confirms the idea that a resistor is a passive element, incapable of generating energy.

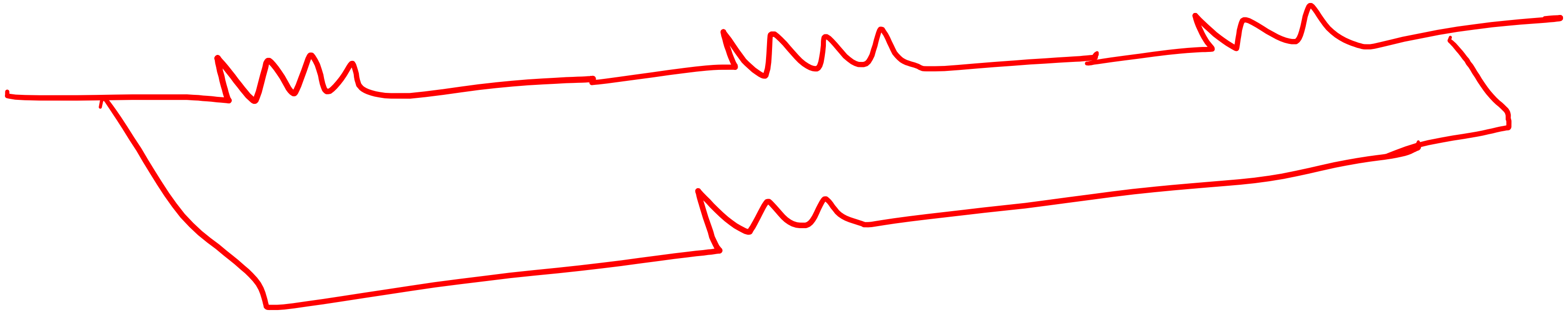


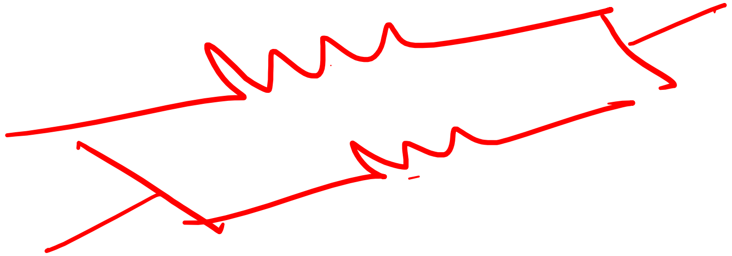
$R_1 + R_2 + R_3$

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

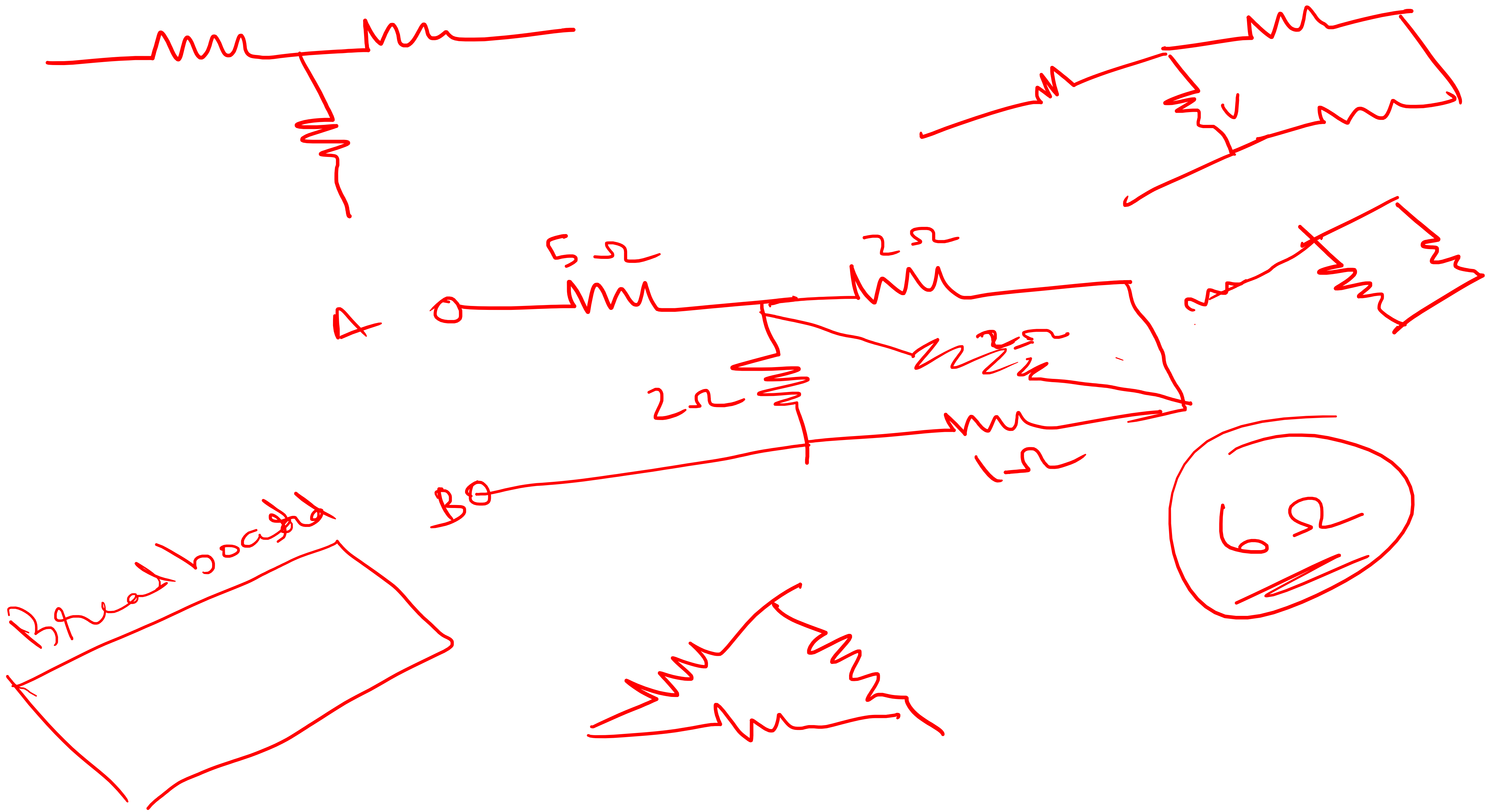




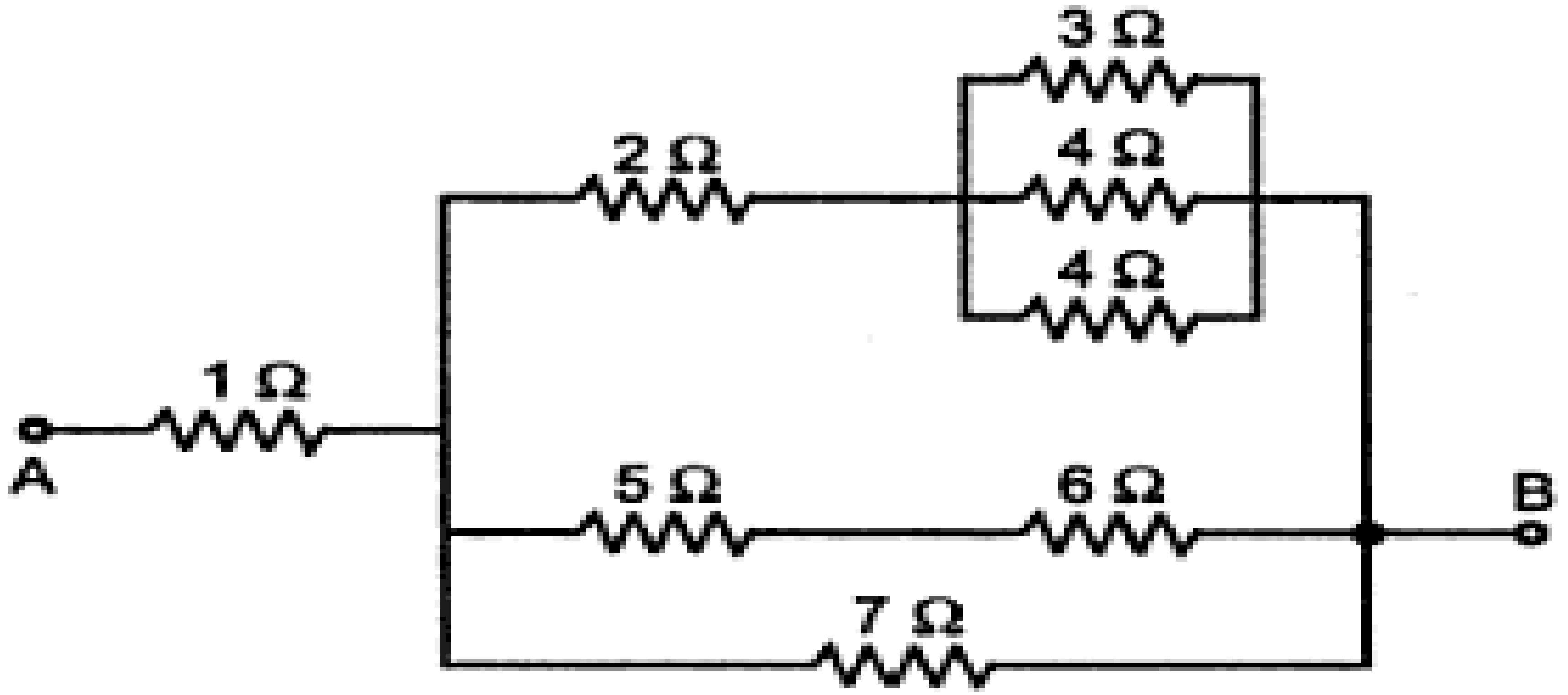




$2.39\,\Omega$


5Ω
2Ω
A
2Ω
2Ω
1Ω
B
6Ω
Breadboard

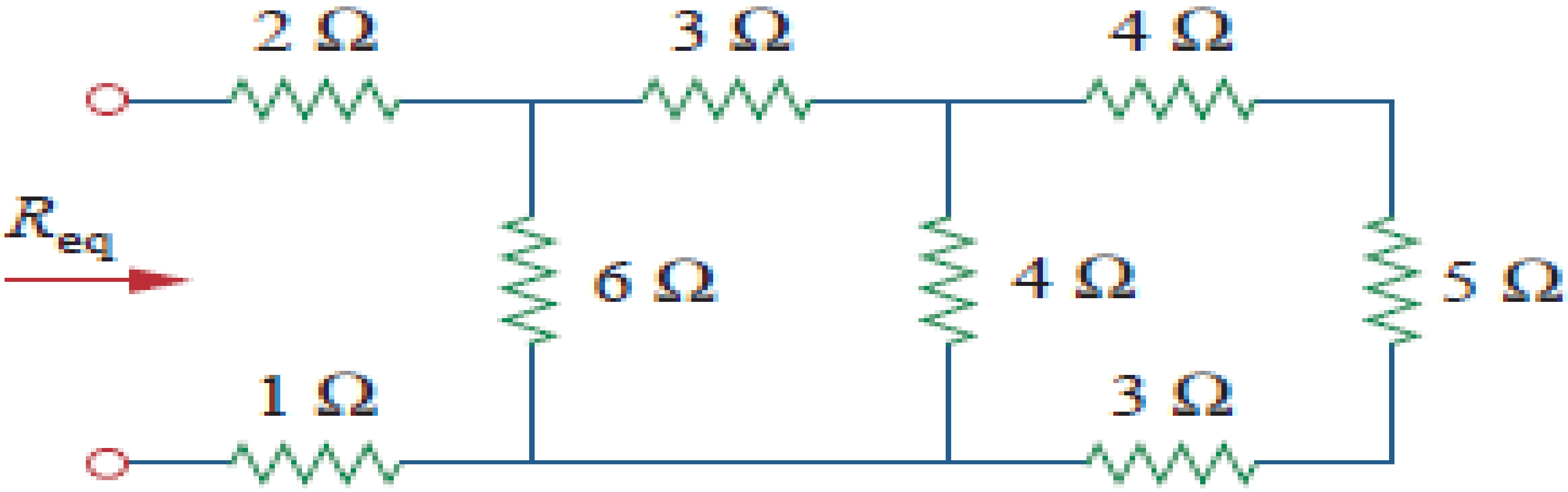
Find the equivalent resistance between the two points A & B



Find the equivalent resistance between the two points A & B

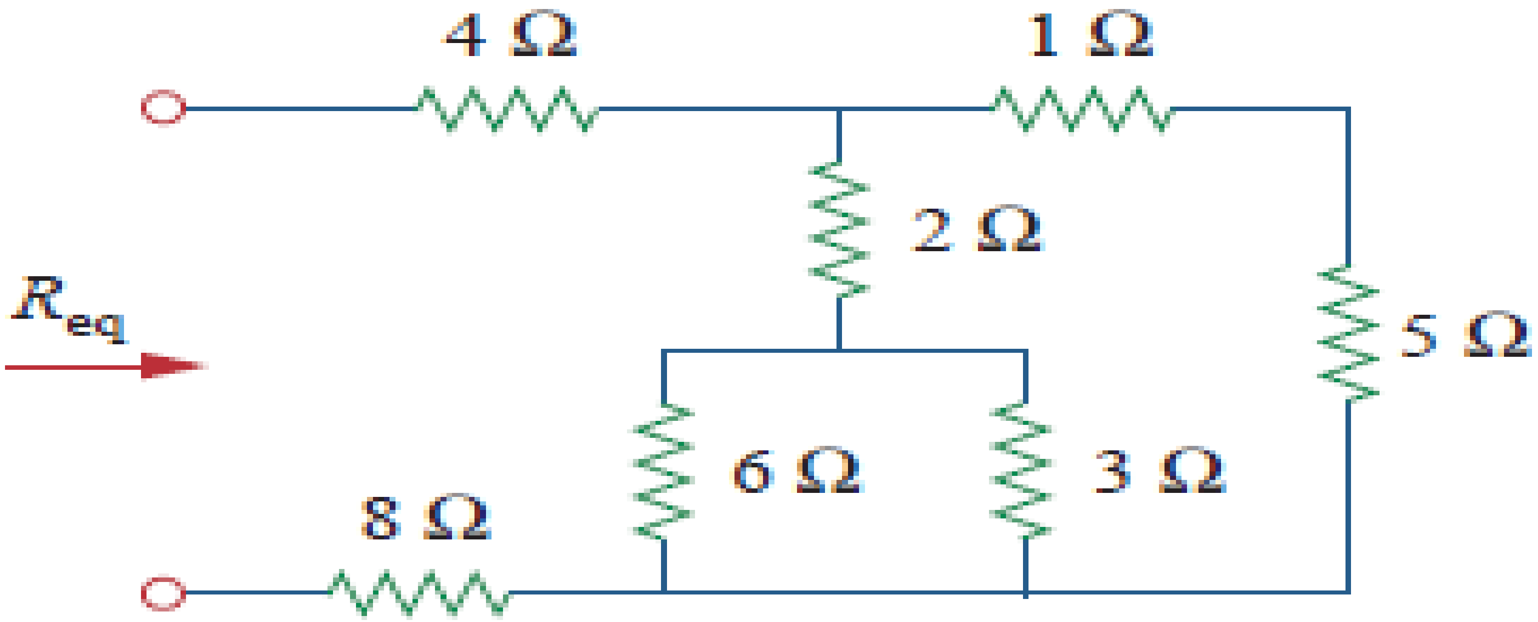
Ans : 2.8 Ohms

Find the equivalent resistance for the circuit shown in figure

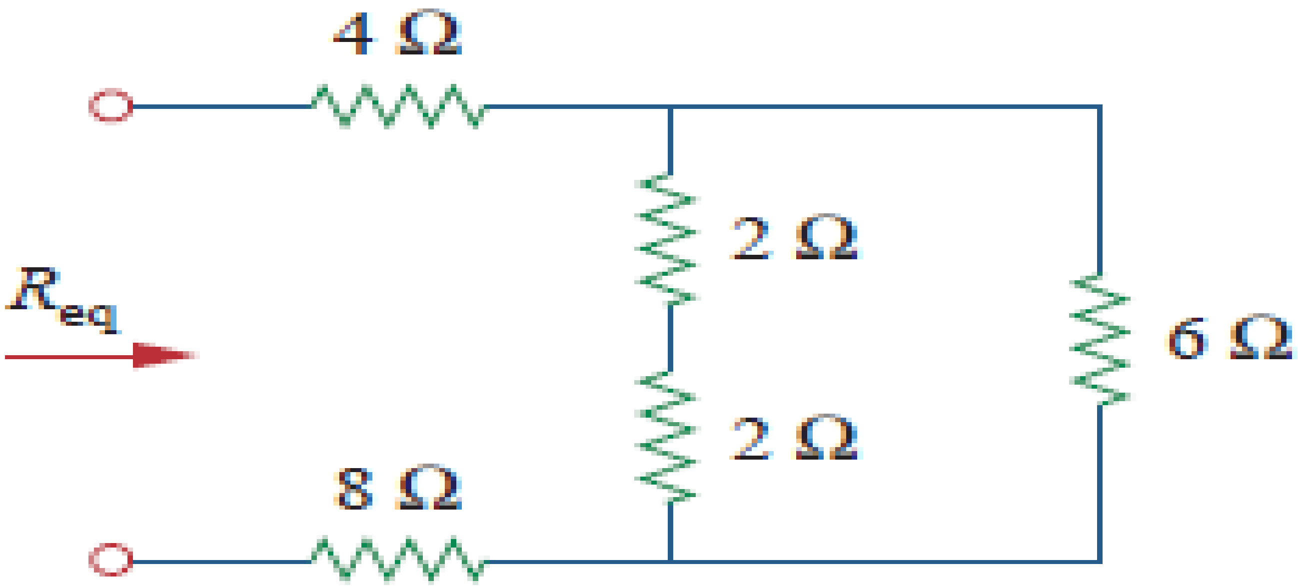


Find the equivalent resistance for the circuit shown in figure
Ans: 6 Ohms

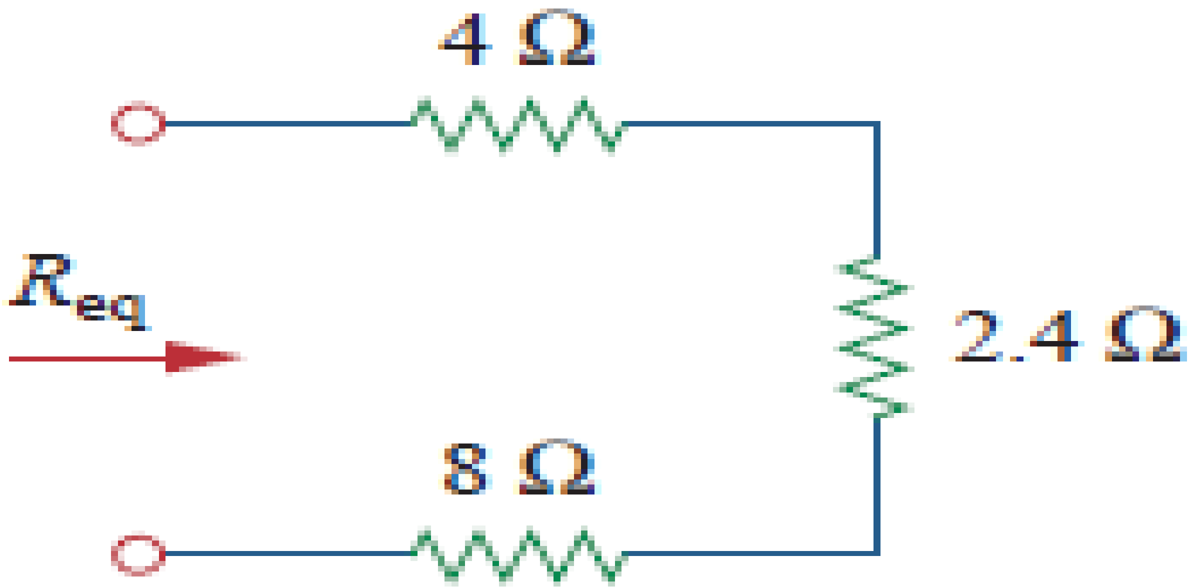
Find the equivalent resistance for the circuit shown in figure



Find the equivalent resistance for the circuit shown in figure

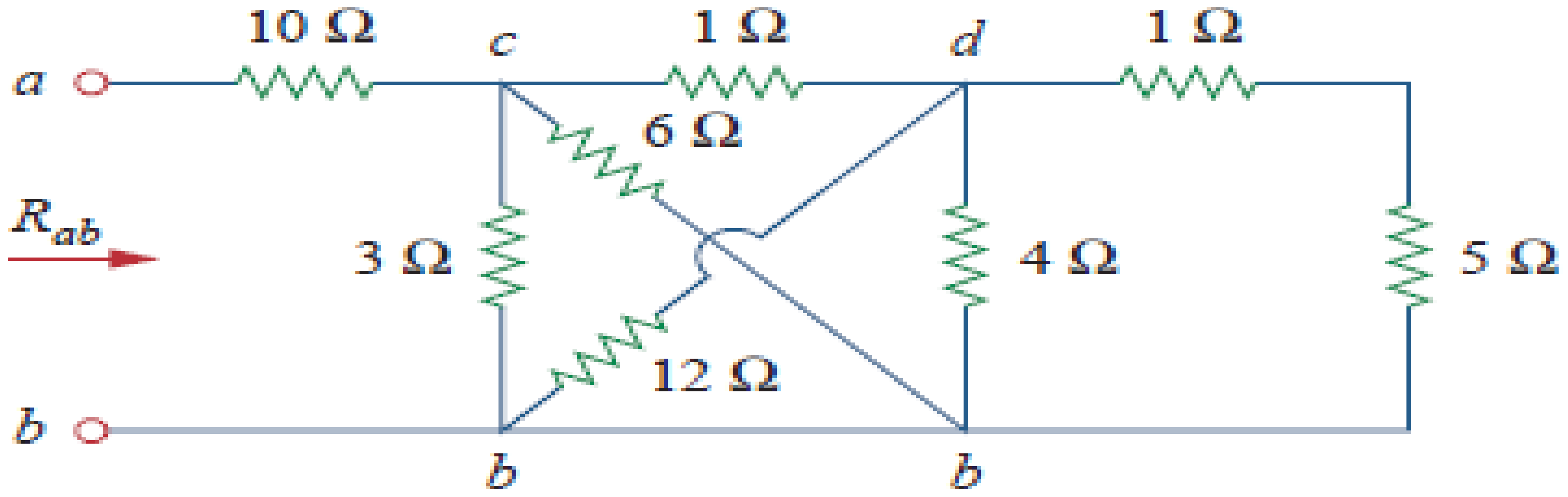


Find the equivalent resistance for the circuit shown in figure

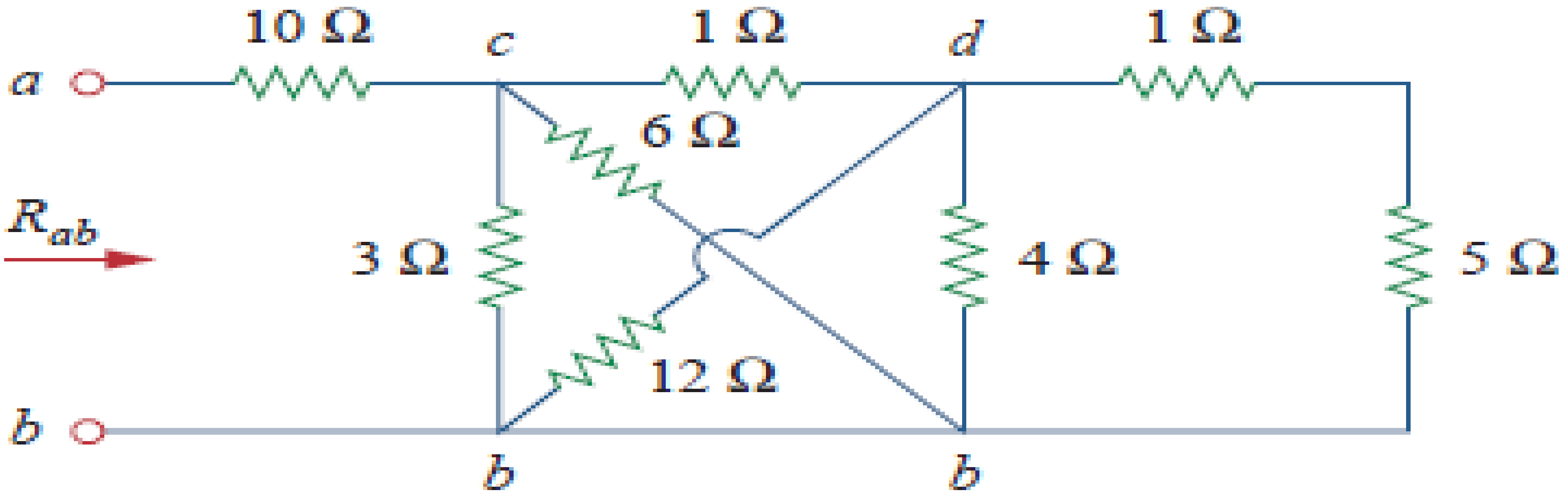


Ans: 14.4 Ohms

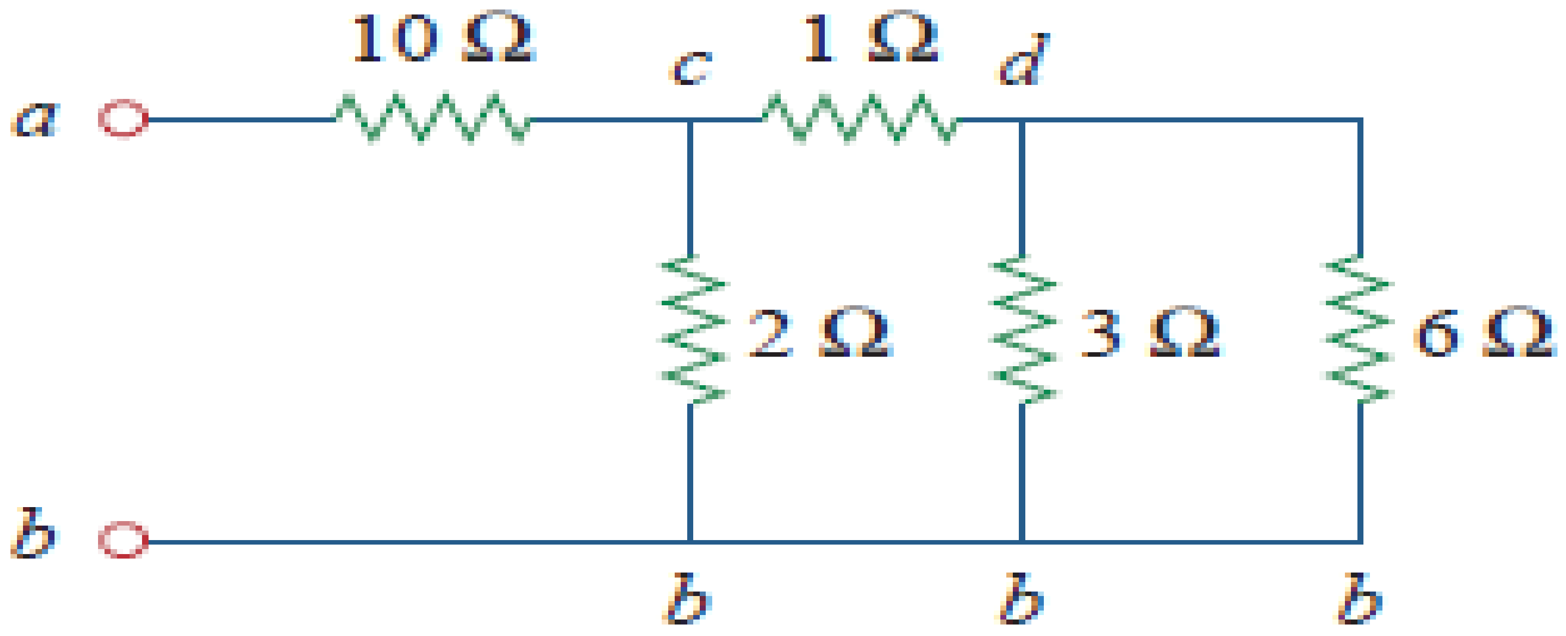
Find the equivalent resistance for the circuit shown in figure



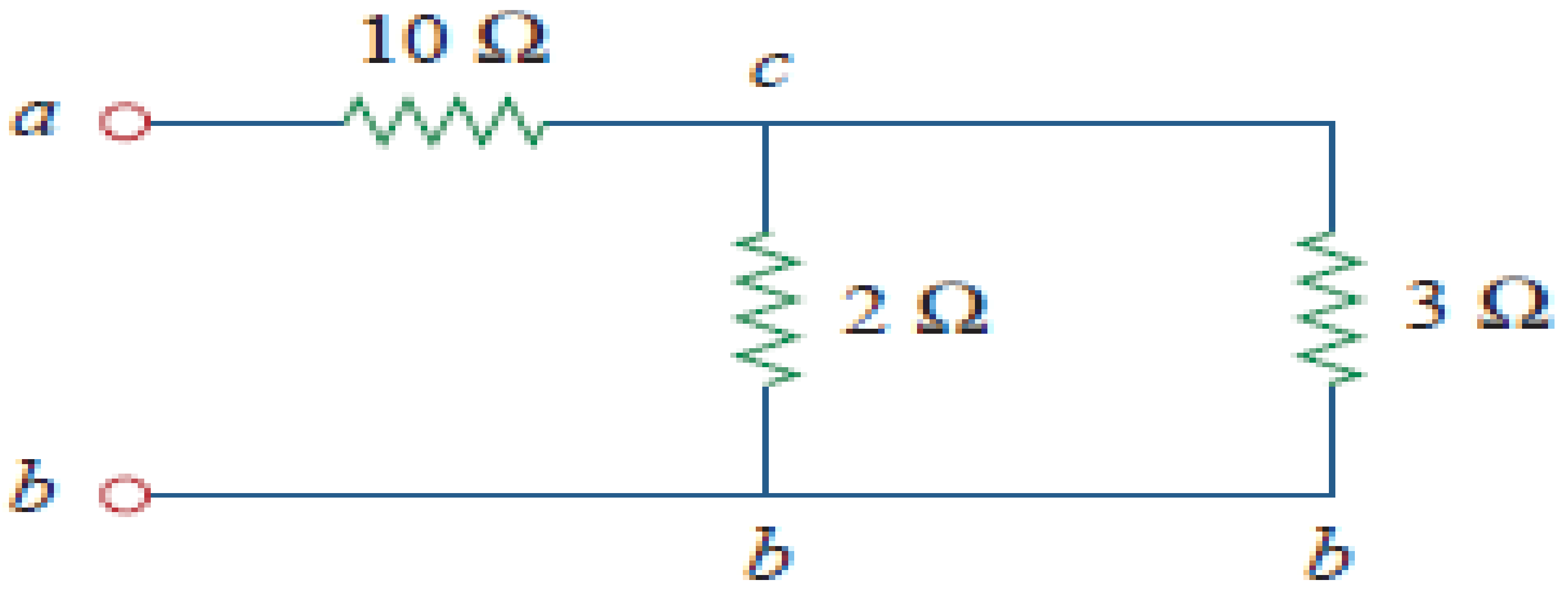
Find the equivalent resistance for the circuit shown in figure



Find the equivalent resistance for the circuit shown in figure

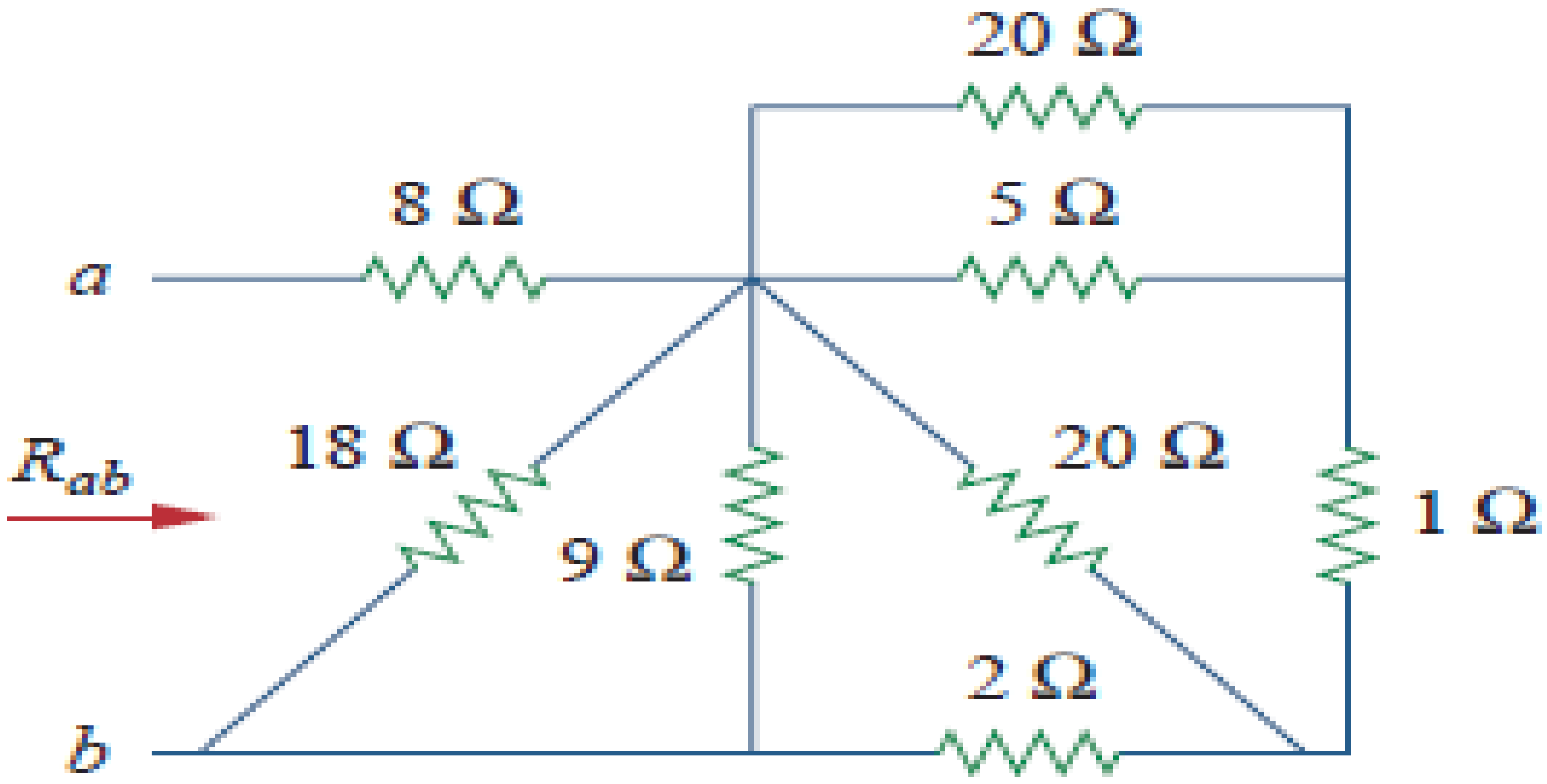


Find the equivalent resistance for the circuit shown in figure



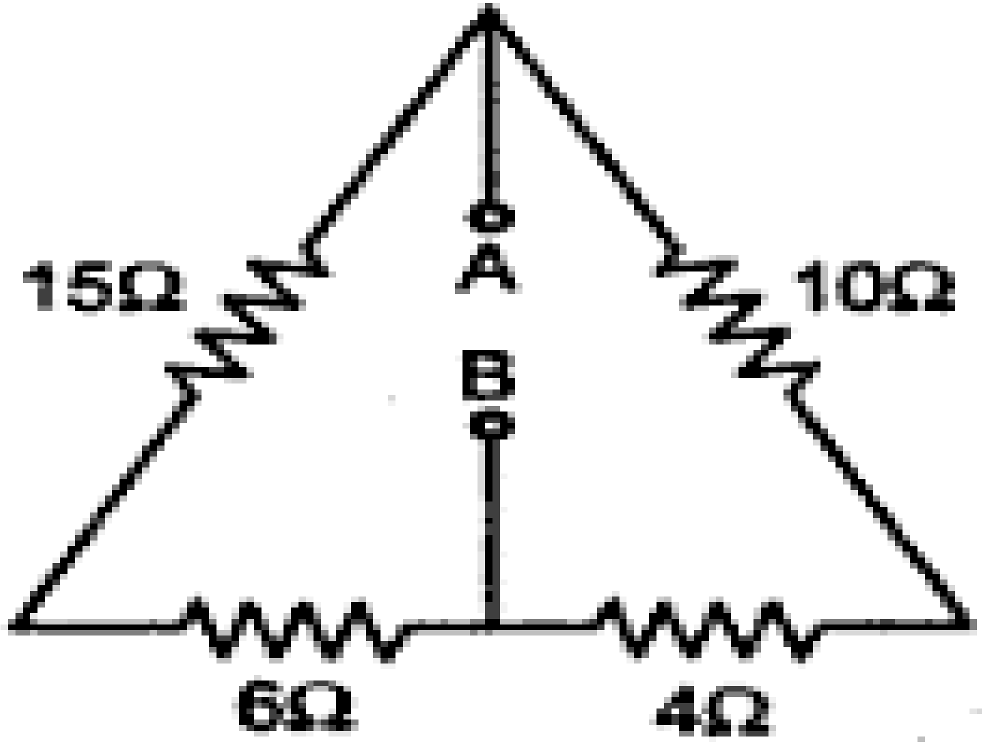
Ans: 11.2 Ohms

Find the equivalent resistance for the circuit shown in figure

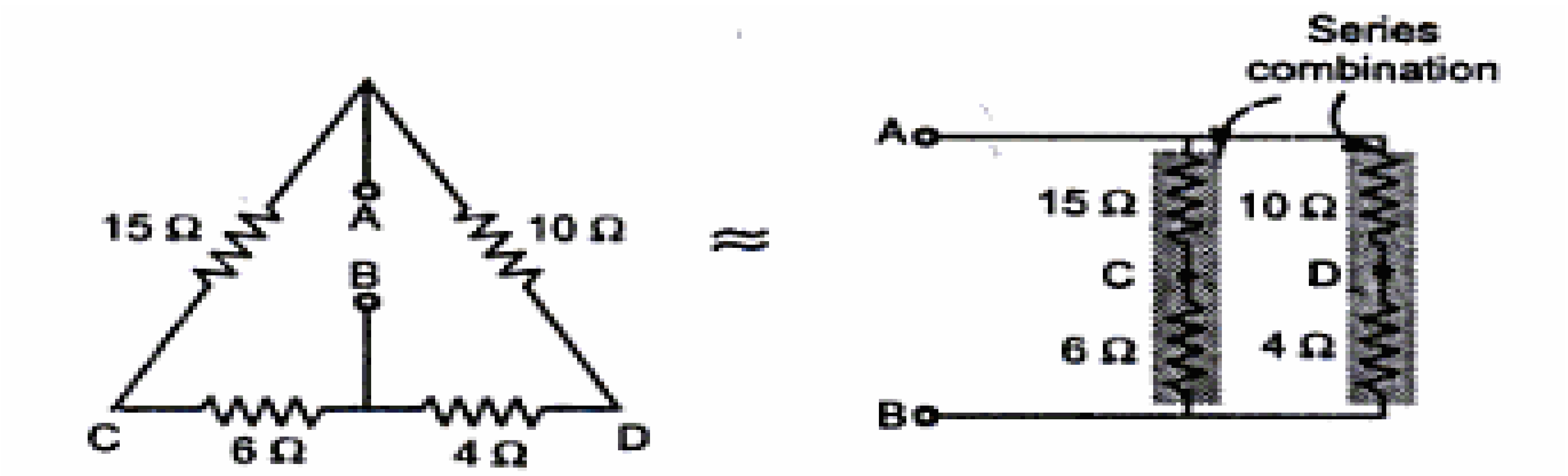


Ans: 11 Ohms

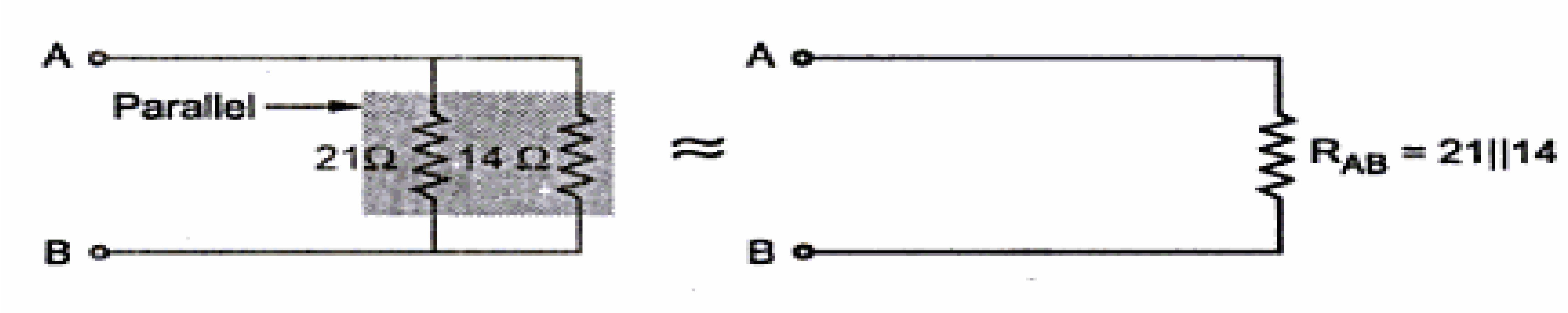
Find the equivalent resistance for the circuit shown in figure



Find the equivalent resistance for the circuit shown in figure

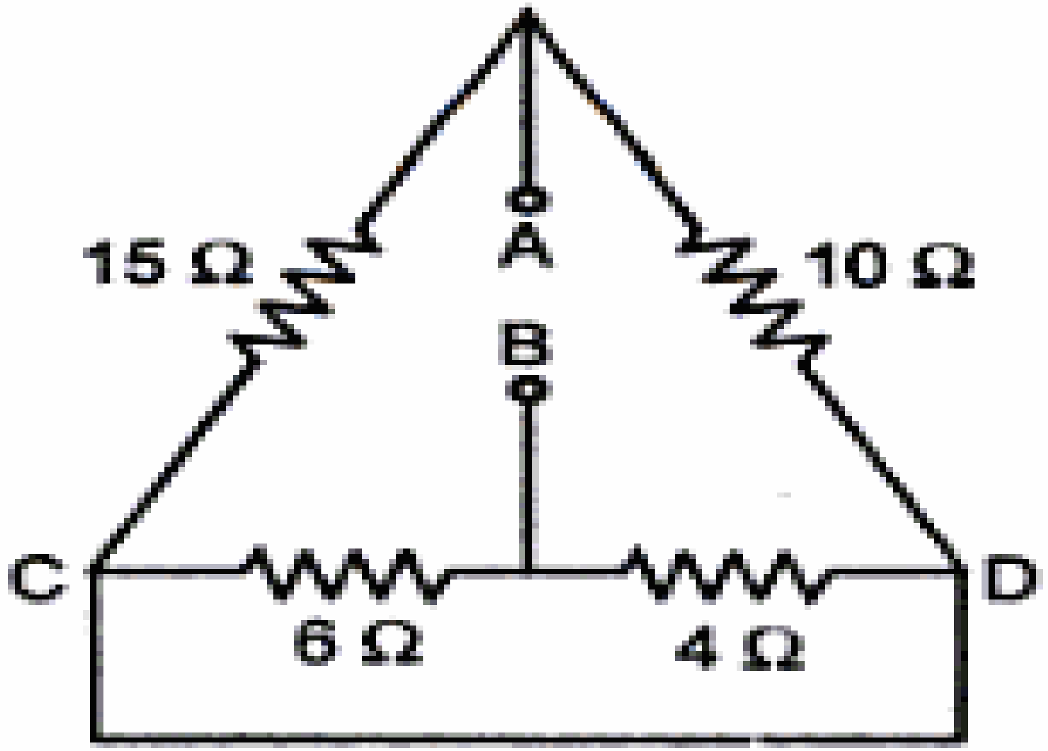


Find the equivalent resistance for the circuit shown in figure

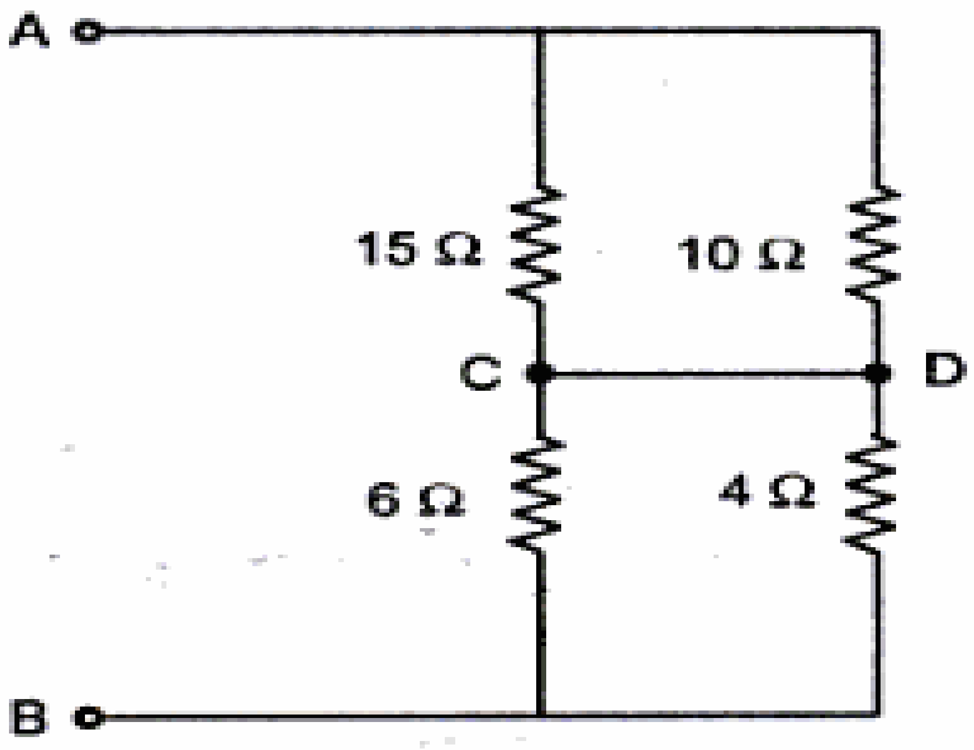


$$R_{AB} = \frac{21 \times 14}{21 + 14} = 8.4\ \Omega$$

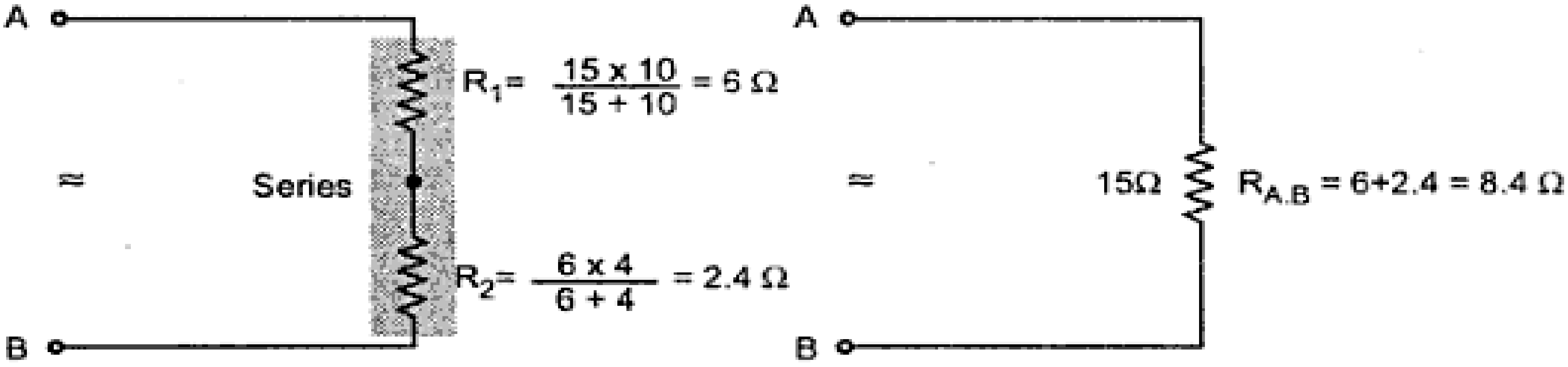
Find the equivalent resistance for the circuit shown in figure



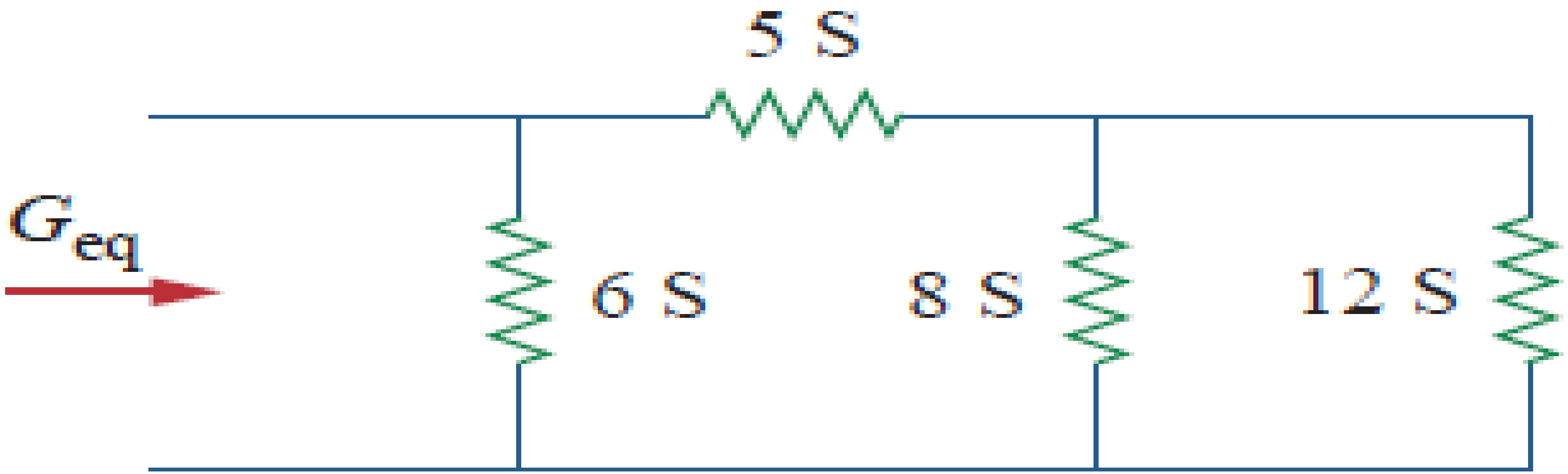
Find the equivalent resistance for the circuit shown in figure



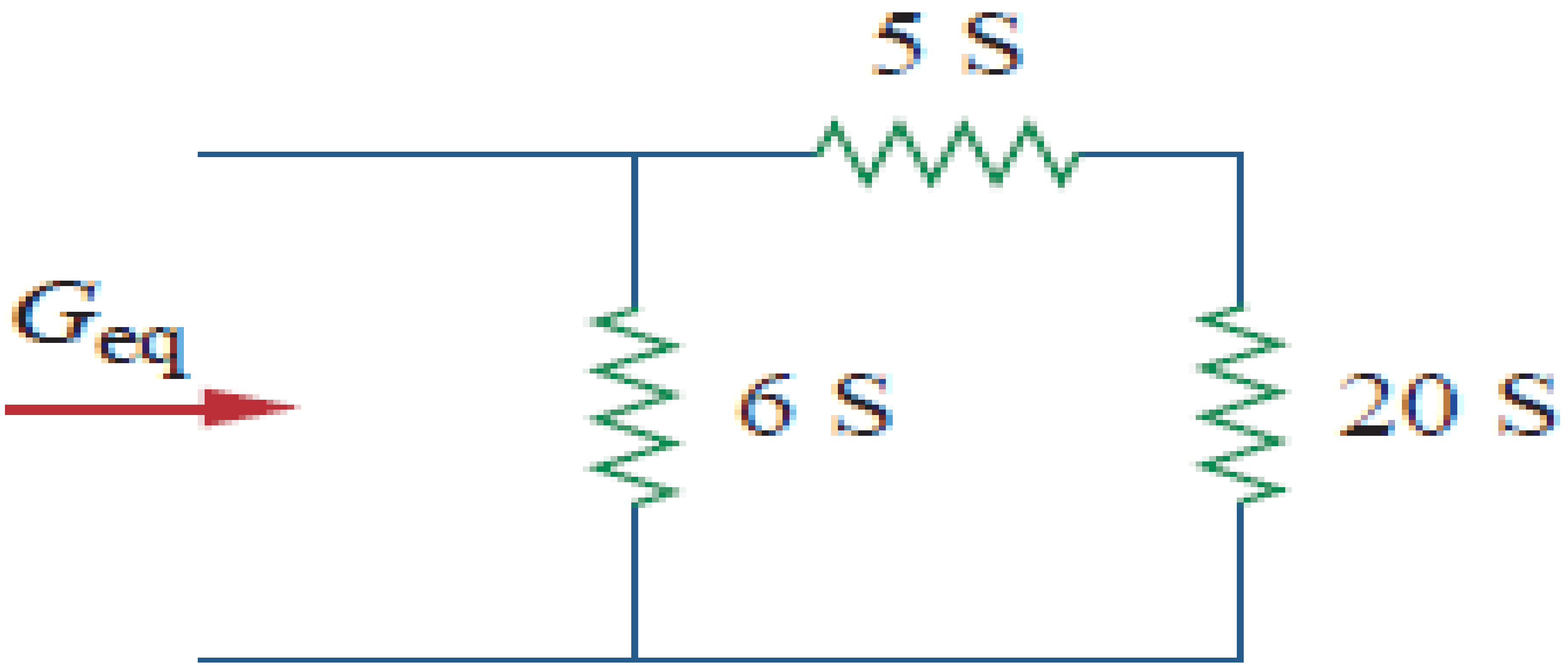
Find the equivalent resistance for the circuit shown in figure



Find the equivalent conductance for the circuit shown in figure

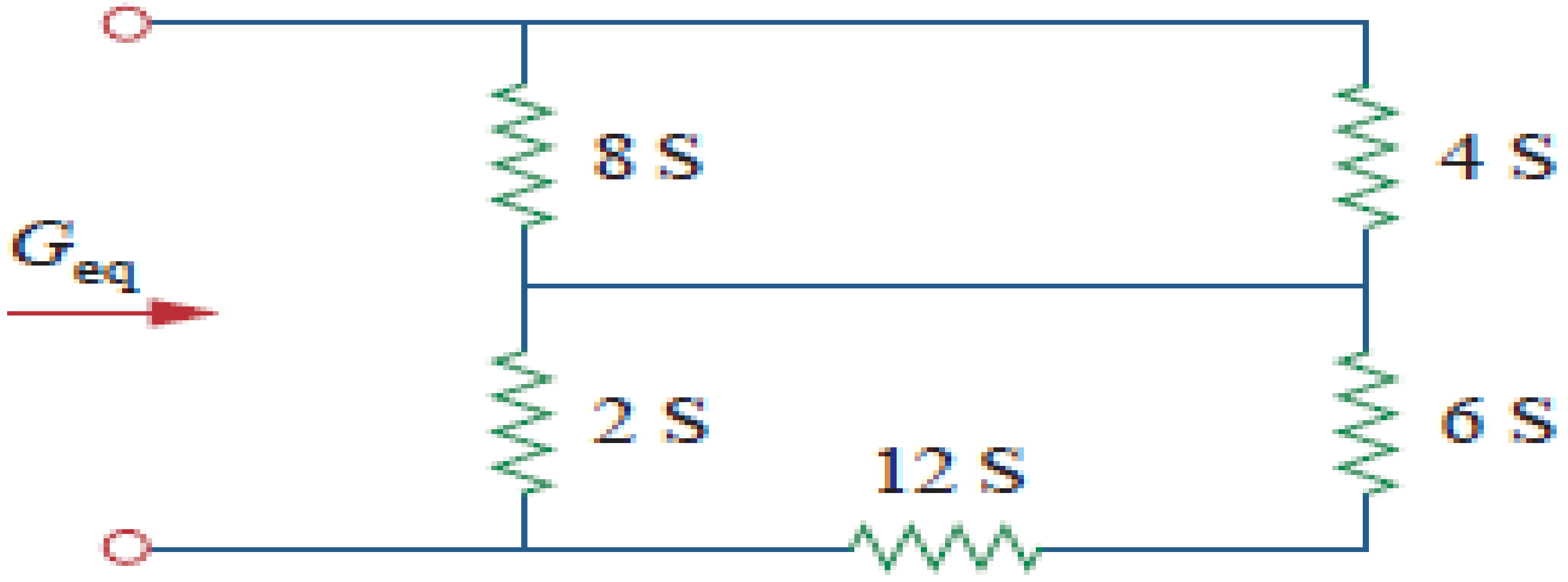


Find the equivalent conductance for the circuit shown in figure



Ans: 10 S

Find the equivalent conductance for the circuit shown in figure



Ans: 4 S

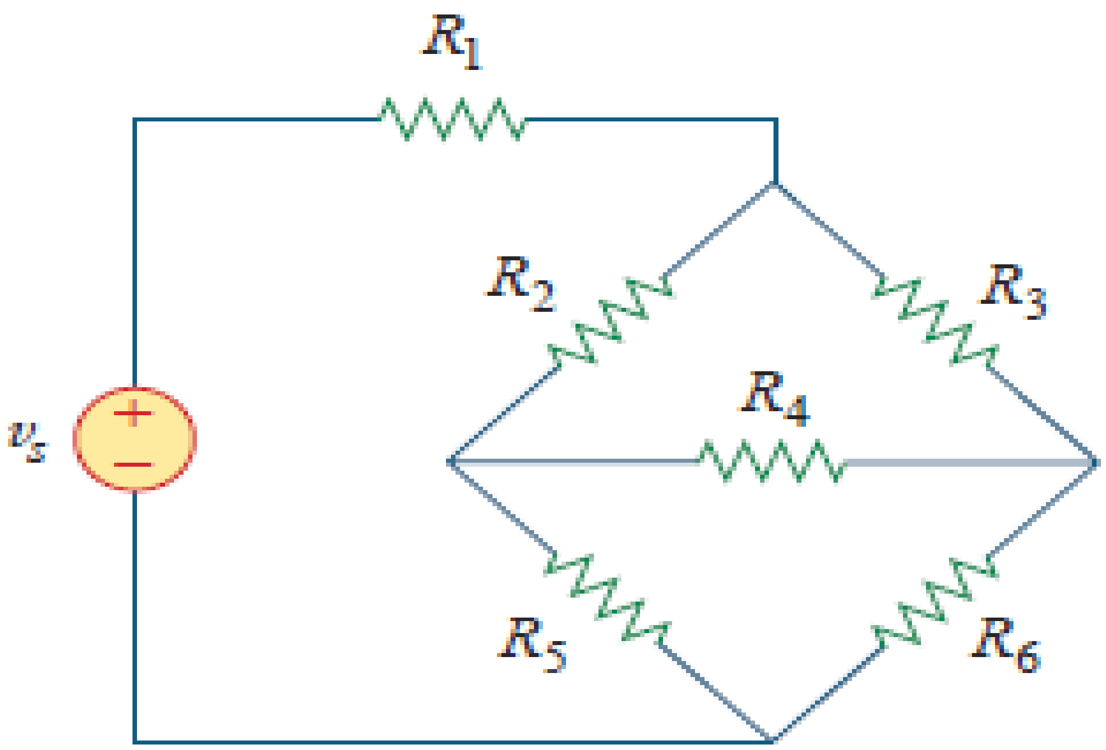
Wye-Delta Transformations

Delta to Wye Conversion

Wye to Delta Conversion

circuit analysis when the resistors are neither in parallel nor in series.

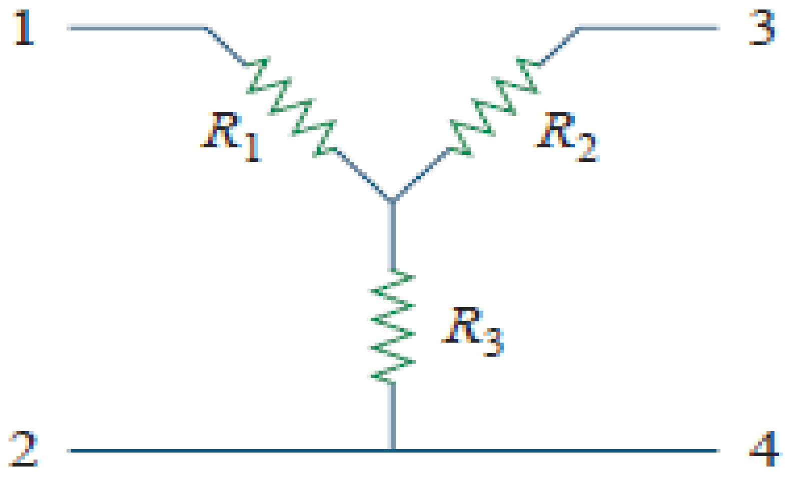
Wye-Delta Transformations



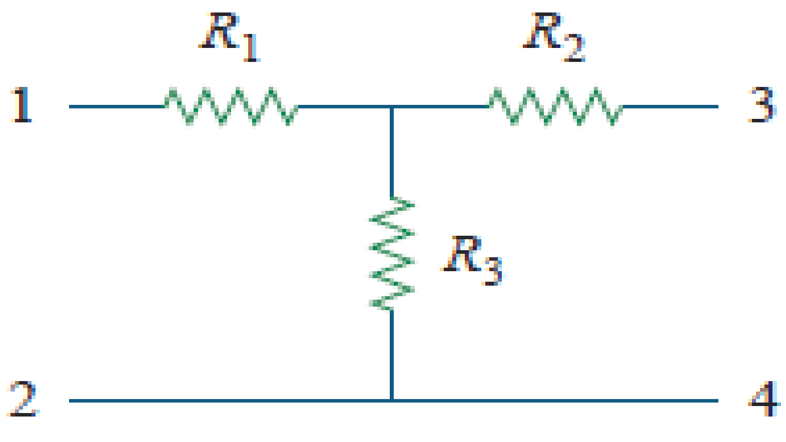
The bridge network.

How do we combine resistors R_1 through R_6 when the resistors are neither in series of parallel ?

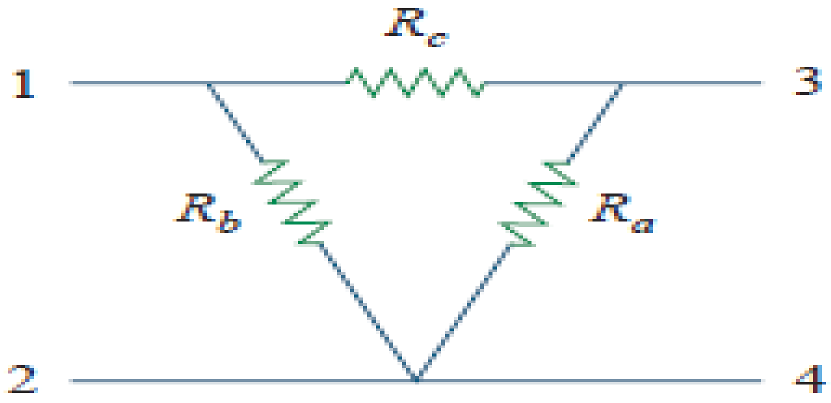
Many circuits of the type can be simplified by using three-terminal networks



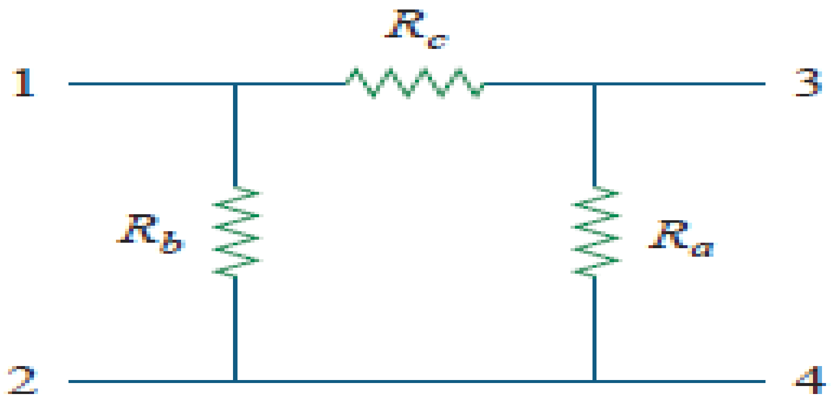
(a)

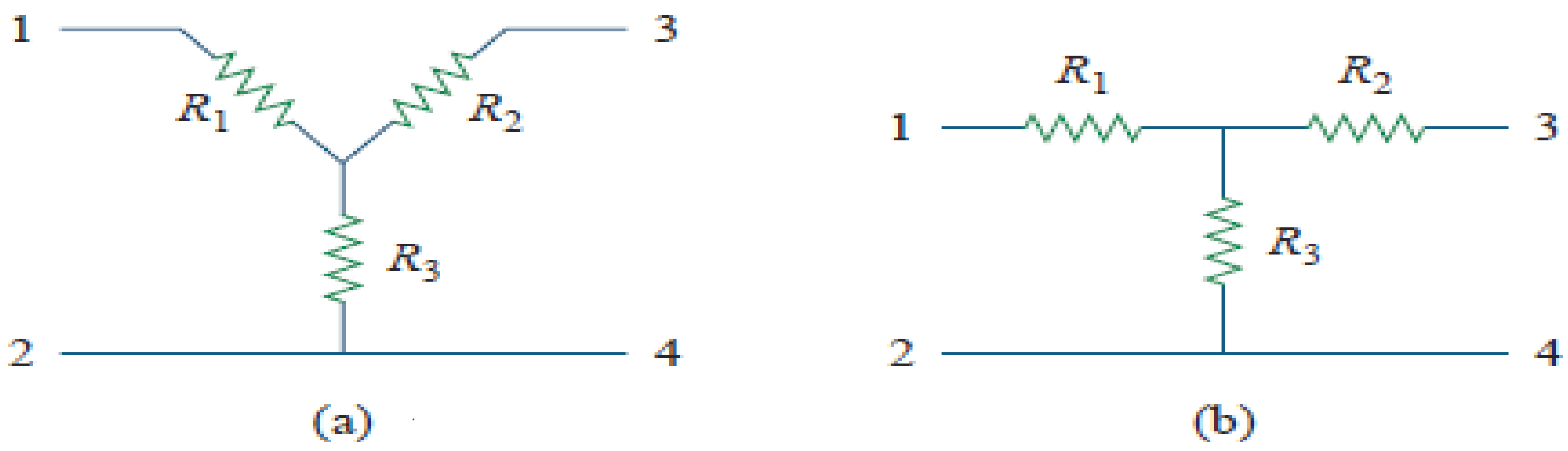


(b)

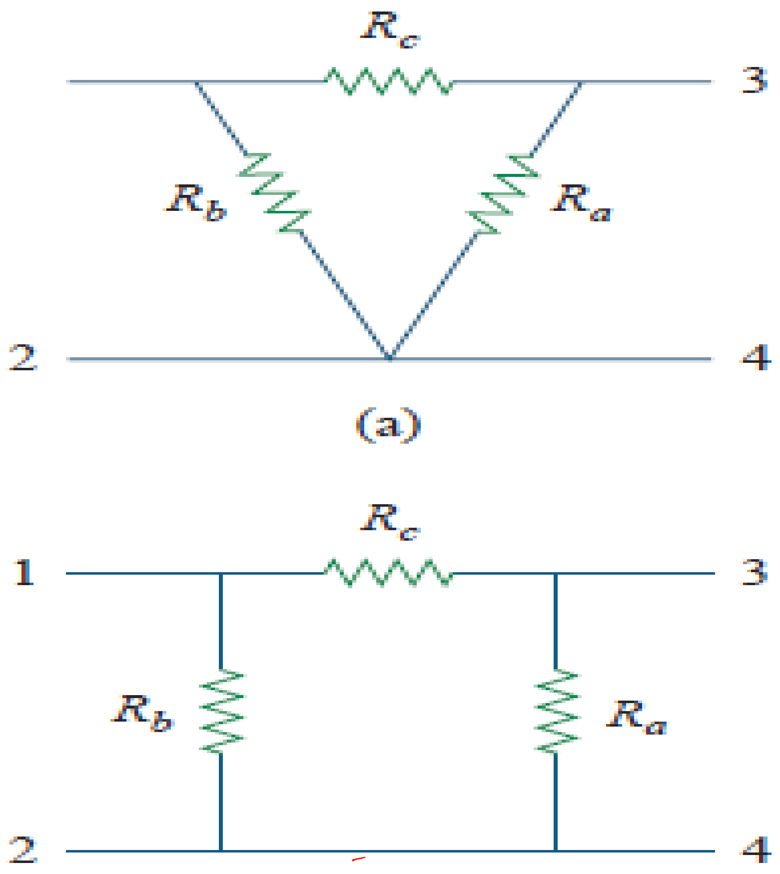


(a)



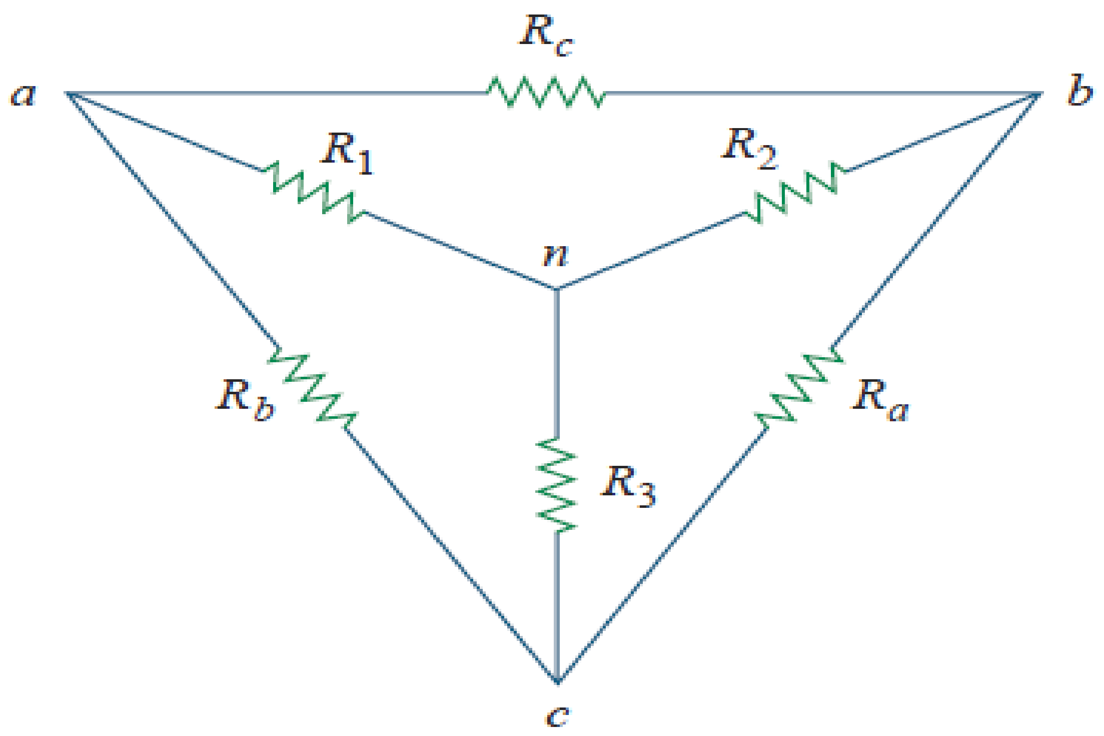


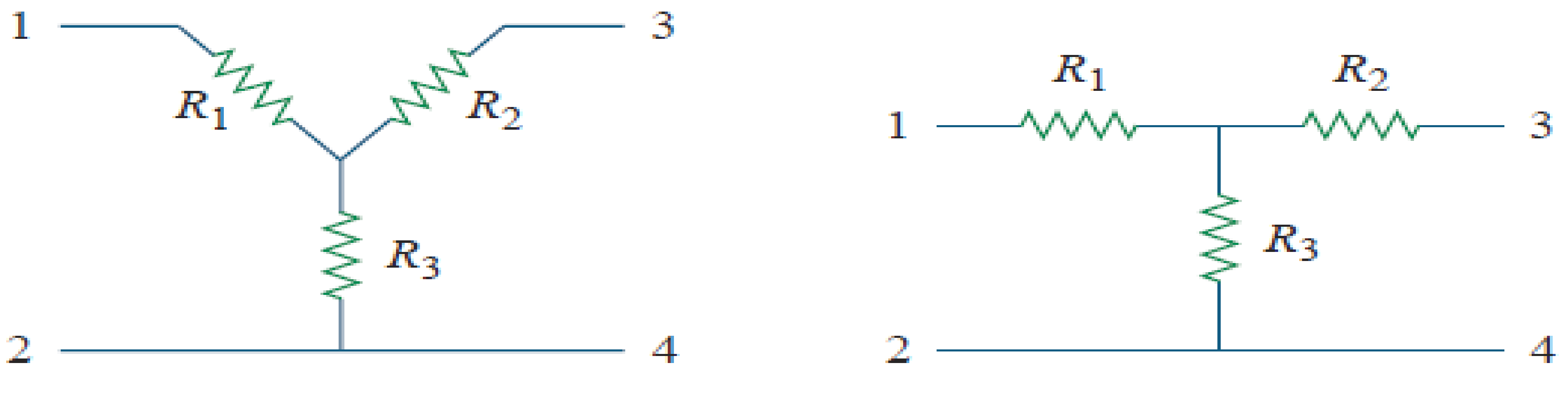
Two forms of the same network: (a) Y, (b) T.



Two forms of the same network: (a) Δ, (b) Π.

- These networks occur by themselves or a as part of a larger network
- To identify them when they occur as a part of a network and how to apply wye-delta transformation in the analysis of that network
- Convenient to work with a wye network in a place where the the circuit contains delta configuration



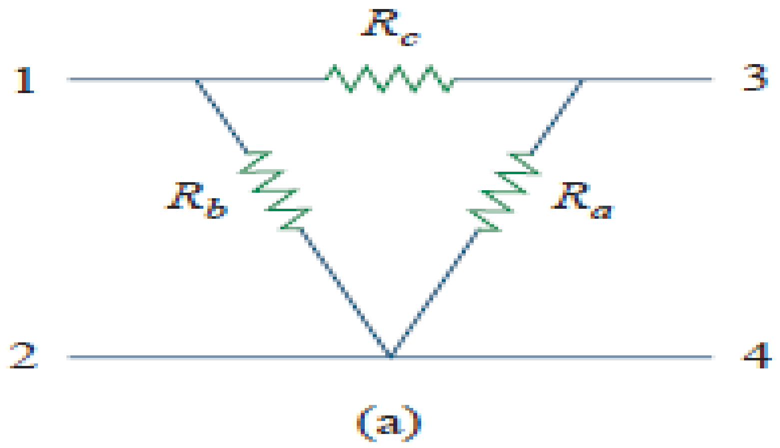


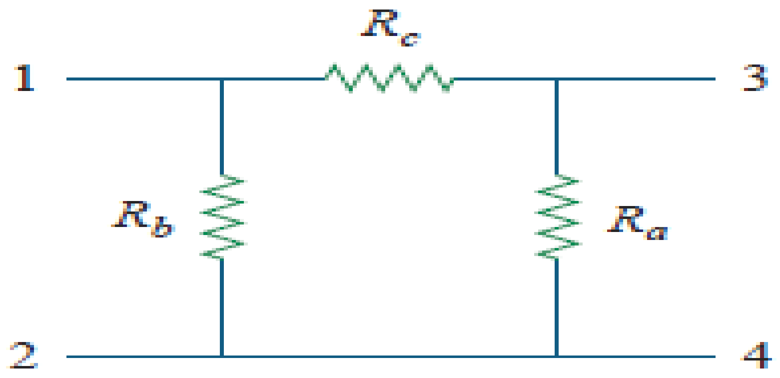
(a) (b)

$$R_{12}(Y) = R_1 + R_3$$

$$R_{13} = R_1 + R_2$$

$$R_{34} = R_2 + R_3$$





$$R_{12}(\Delta) = R_b \parallel (R_a + R_c)$$
$$= \frac{R_b(R_a + R_c)}{R_a + R_b + R_c}$$

$$R_{13} = \frac{R_c(R_a + R_b)}{R_a + R_b + R_c}$$

$$R_{34} = \frac{R_a(R_b + R_c)}{R_a + R_b + R_c}$$

Delta to Wye Conversion

Setting $R_{12}(Y) = R_{12}(\Delta)$ gives

$$R_{12} = R_1 + R_3 = \frac{R_b(R_a + R_c)}{R_a + R_b + R_c}$$

Similarly,

$$R_{13} = R_1 + R_2 = \frac{R_c(R_a + R_b)}{R_a + R_b + R_c}$$

$$R_{34} = R_2 + R_3 = \frac{R_a(R_b + R_c)}{R_a + R_b + R_c}$$

$$R_1 - R_2 = \frac{R_c(R_b - R_a)}{R_a + R_b + R_c}$$

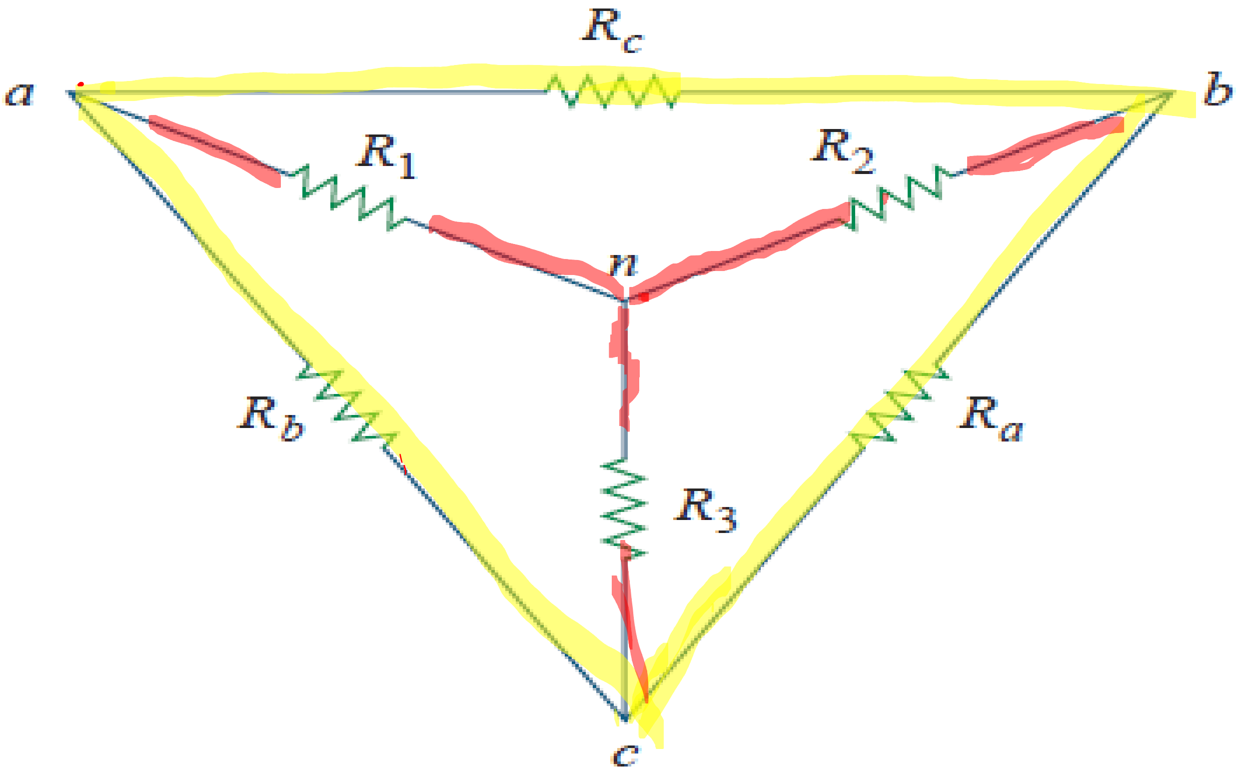
$$\boxed{R_1 = \frac{R_b R_c}{R_a + R_b + R_c}}$$

$$\boxed{R_2 = \frac{R_c R_a}{R_a + R_b + R_c}}$$

$$\boxed{R_3 = \frac{R_a R_b}{R_a + R_b + R_c}}$$

$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c}$$

$$R_2 = \frac{R_c R_a}{R_a + R_b + R_c}$$



$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c}$$

Each resistor in the Y network is the product of the resistors in the two adjacent Δ branches, divided by the sum of the three Δ resistors.

Wye to Delta Conversion

$$R_1R_2 + R_2R_3 + R_3R_1 = \frac{R_aR_bR_c(R_a + R_b + R_c)}{(R_a + R_b + R_c)^2}$$

$$= \frac{R_aR_bR_c}{R_a + R_b + R_c}$$

Dividing Eq. by each of Eqs.

$$\boxed{R_1 = \frac{R_bR_c}{R_a + R_b + R_c}}$$

$$\boxed{R_2 = \frac{R_cR_a}{R_a + R_b + R_c}}$$

$$\boxed{R_3 = \frac{R_aR_b}{R_a + R_b + R_c}}$$

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

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

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

Each resistor in the Δ network is the sum of all possible products of Y resistors taken two at a time, divided by the opposite Y resistor.

The Y and Δ networks are said to be *balanced* when

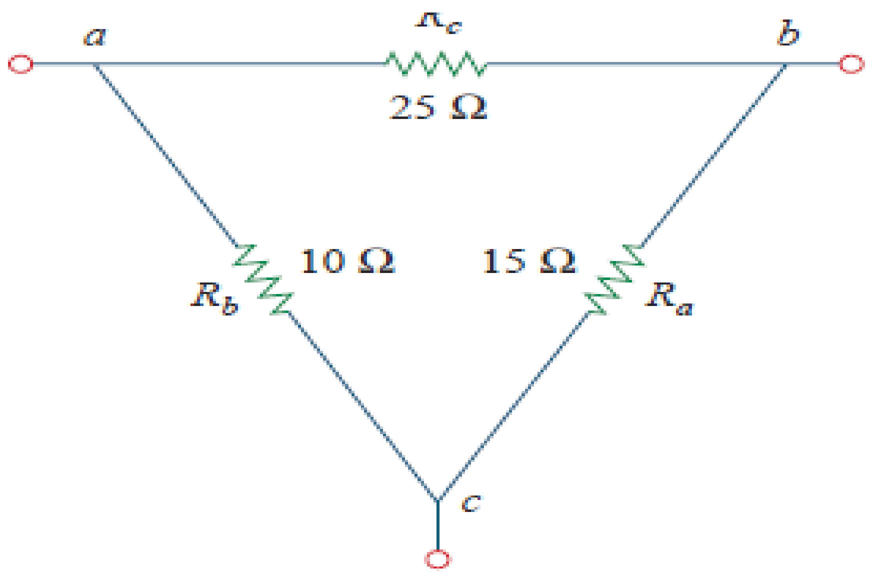
$$R_1 = R_2 = R_3 = R_Y, \qquad R_a = R_b = R_c = R_\Delta$$

Under these conditions, conversion formulas become

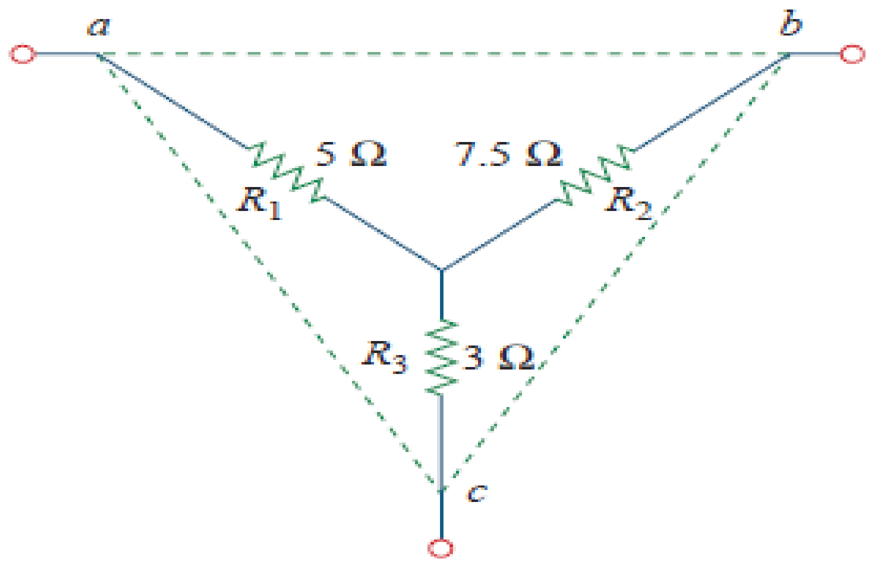
$$\boxed{R_Y = \frac{R_\Delta}{3} \qquad \text{or} \qquad R_\Delta = 3R_Y}$$

One may wonder why R_Y is less than R_Δ. Well, we notice that the Y-connection is like a "series" connection while the Δ-connection is like a "parallel" connection.

Example



(a)



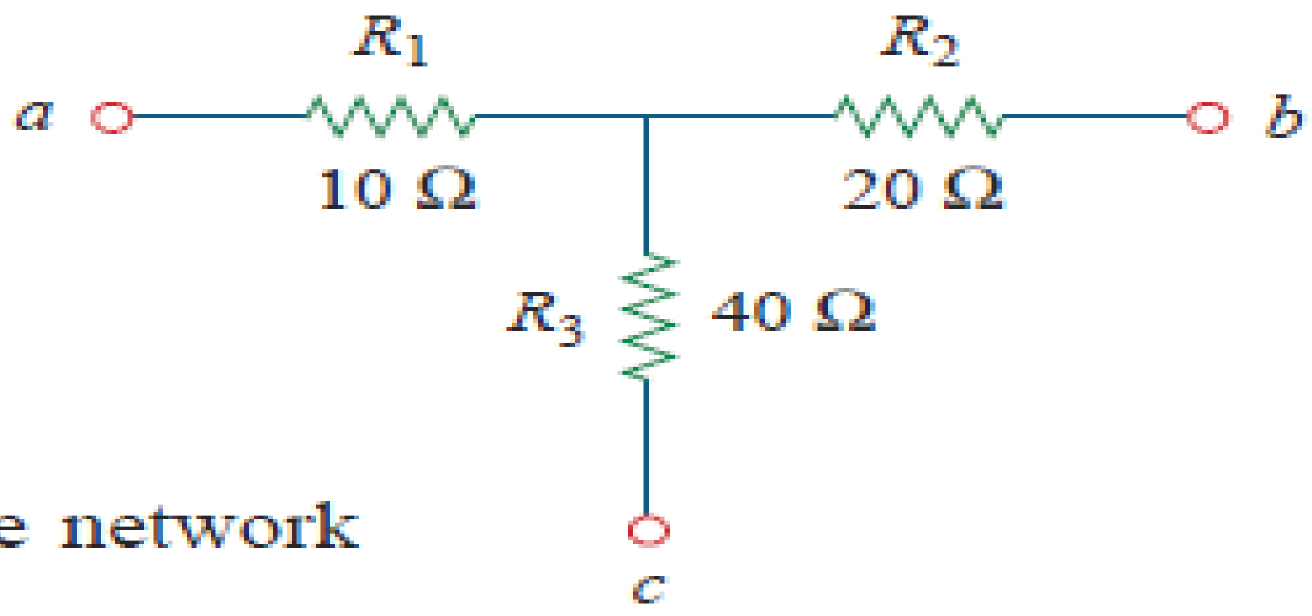
(b)

$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c}$$

$$R_2 = \frac{R_c R_a}{R_a + R_b + R_c}$$

$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c}$$

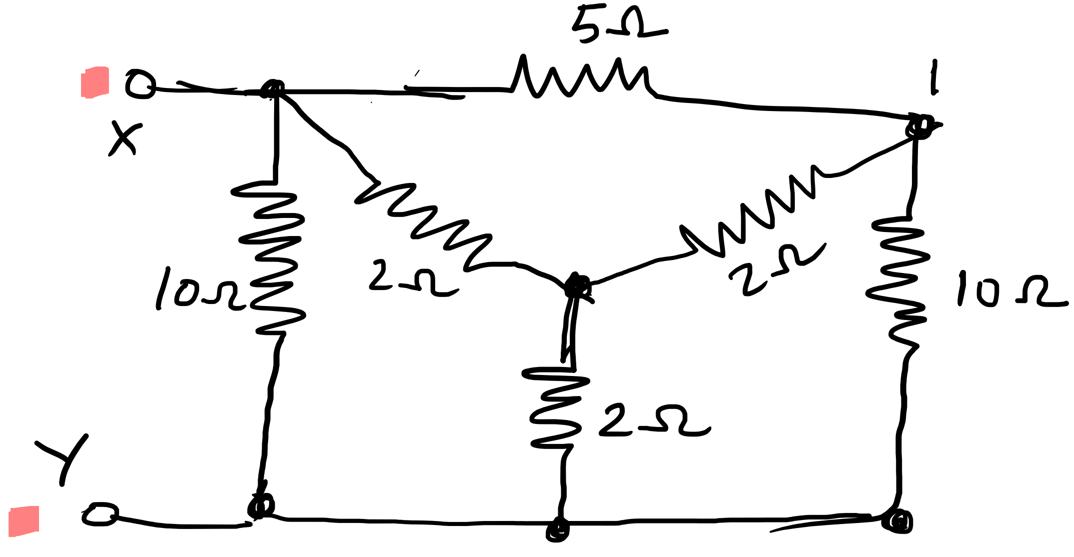
Example

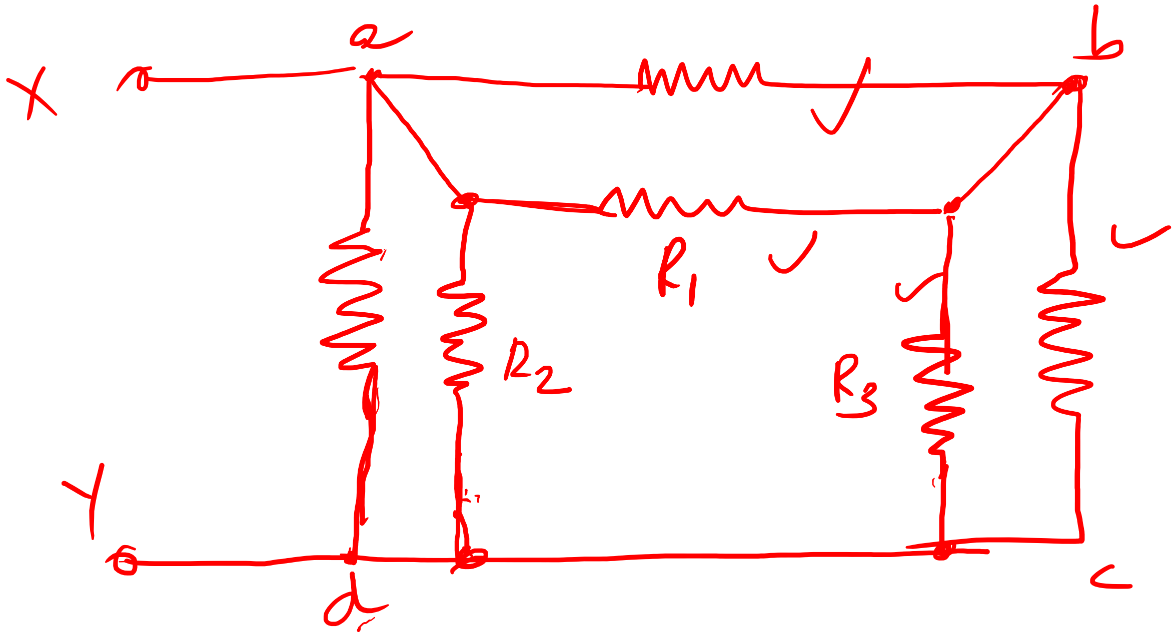


Transform the wye network to a delta network.

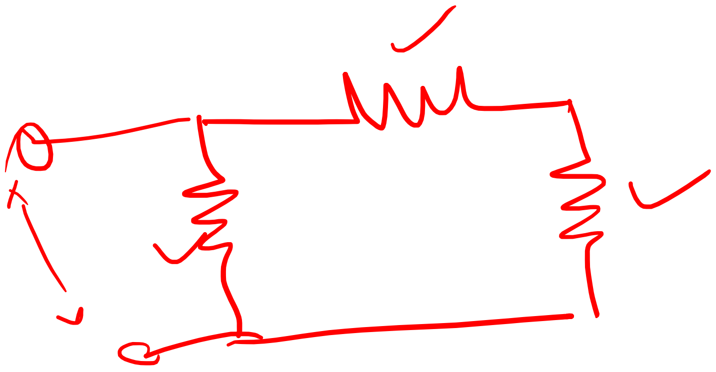
Answer: $R_a = 140\ \Omega$, $R_b = 70\ \Omega$, $R_c = 35\ \Omega$.

Find the equivalent resistance between terminals x - y in the resistive network in fig

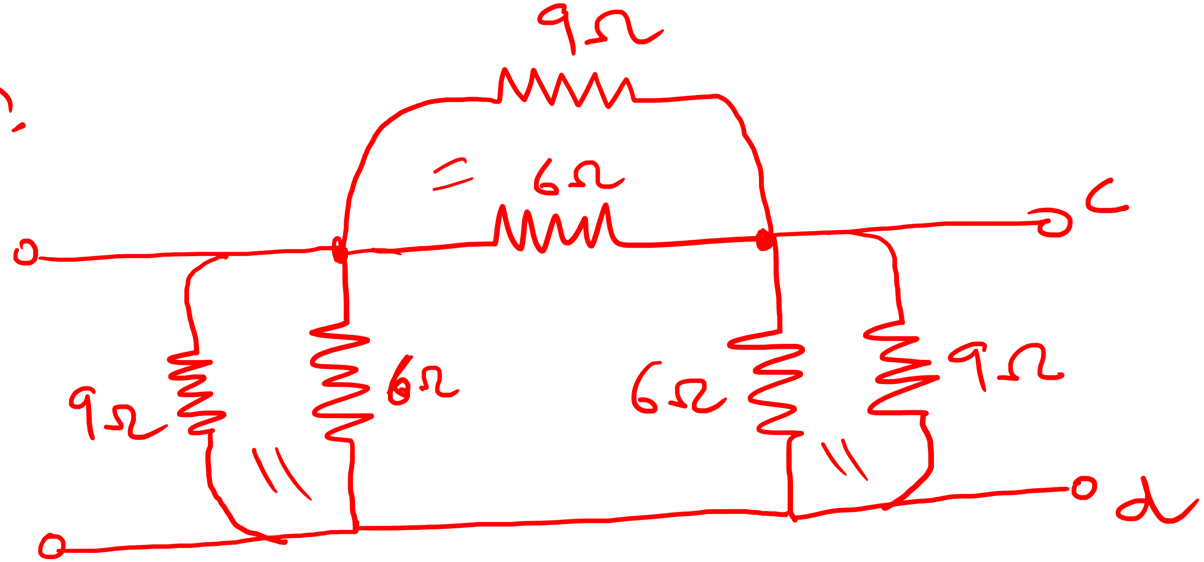




$$2.375\ \Omega$$



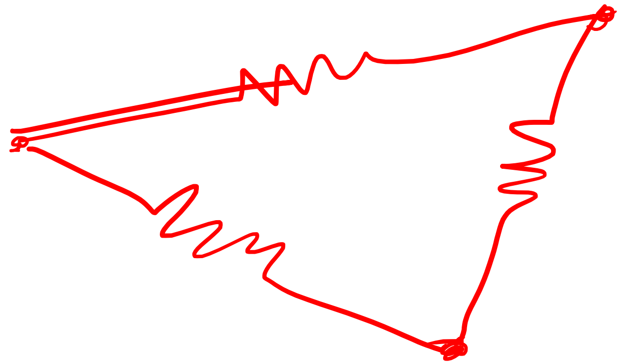
Find Equivalent Star network?

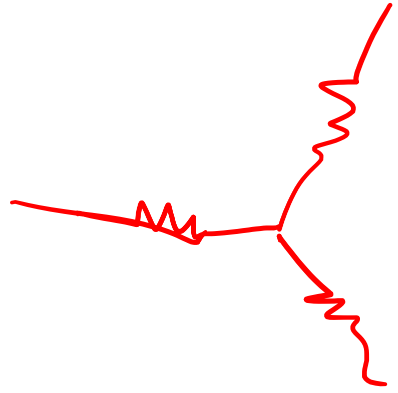


1.2Ω

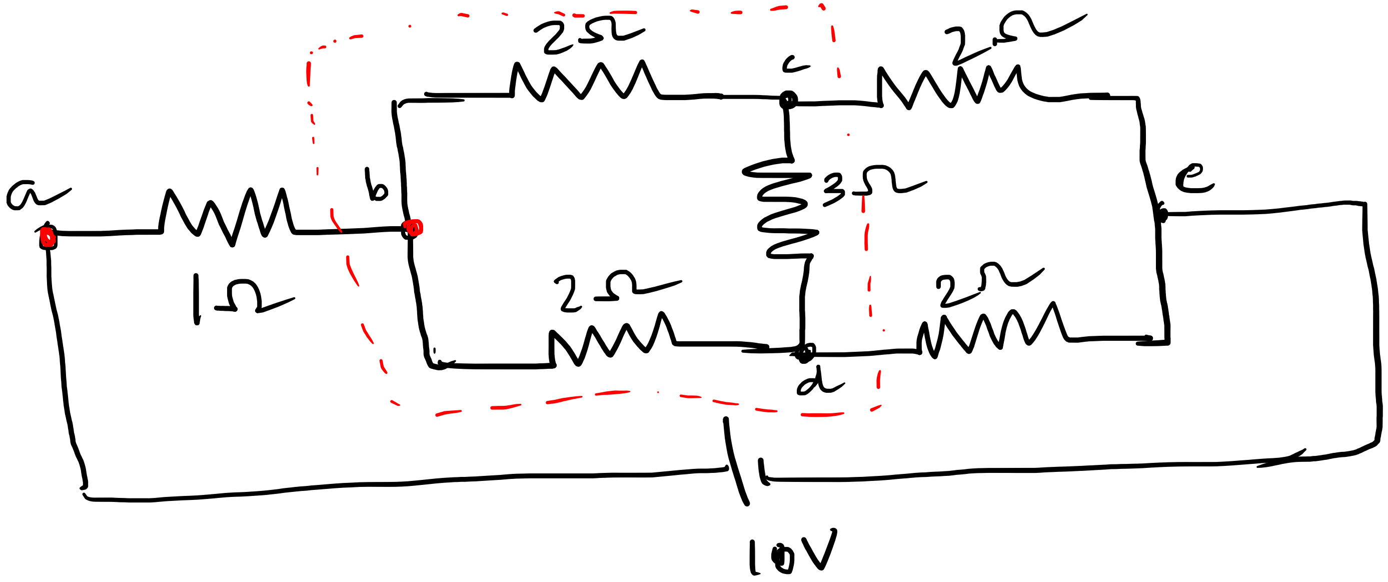
1.2Ω

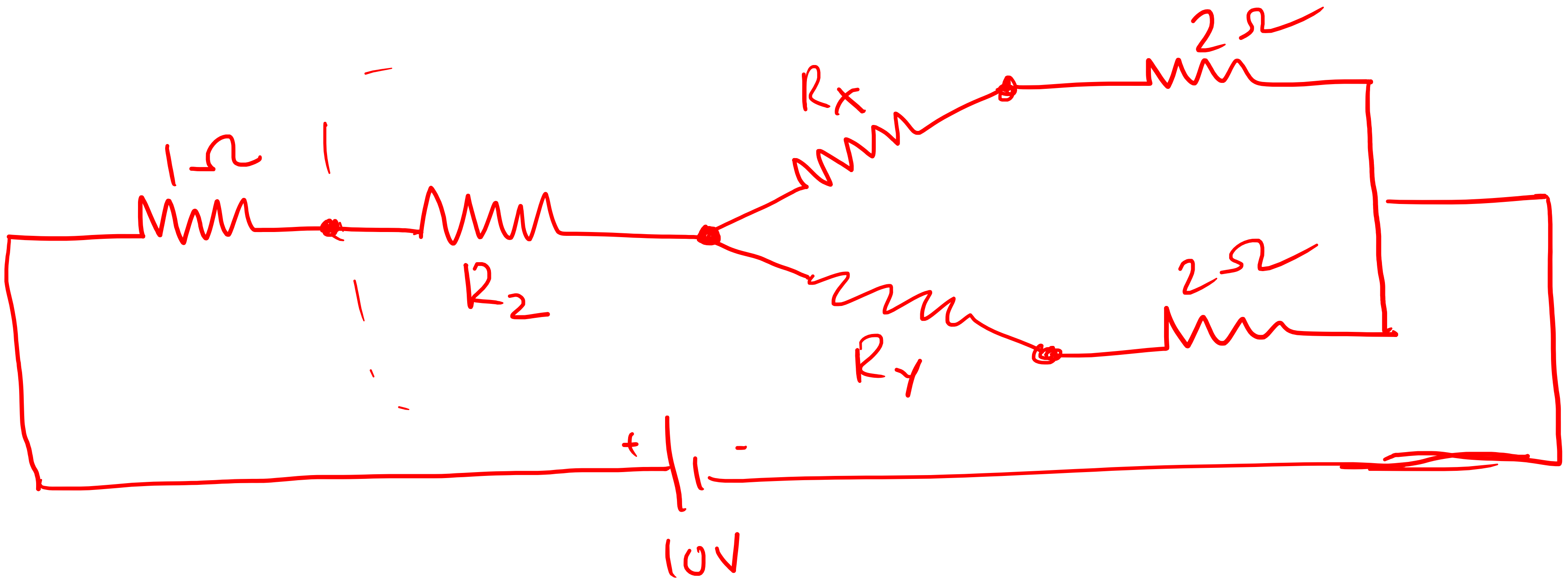
1.2Ω





Find the power loss in 1Ω resistor

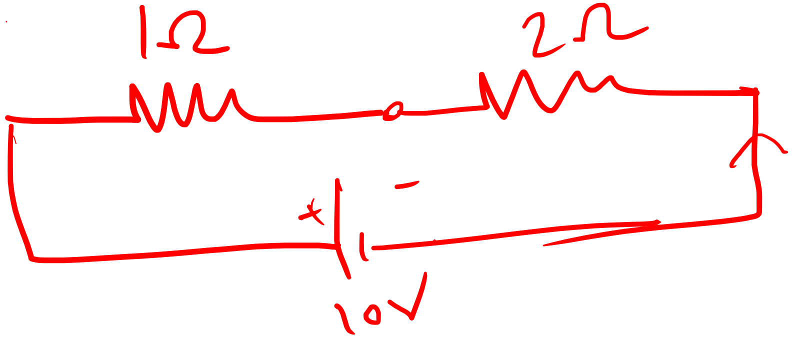




$R_x = 0.86\,\Omega$

$R_y = 0.86\,\Omega$

$R_2 = 0.57\,\Omega$



$I = \frac{10V}{1+2}\ A$

I^2R