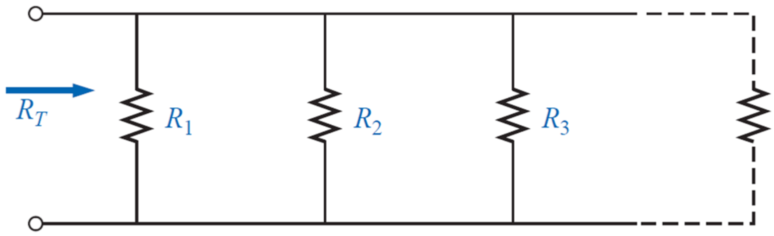
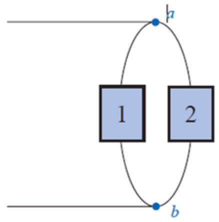
Parallel Circuits

PARALLEL ELEMENTS

Two elements, branches, or networks are in* parallel *if they have two points in common.





$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots \ldots + \frac{1}{R_N}$$

$$G_T = G_1 + G_2 + \cdots \ldots G_N$$

In parallel circuits

The voltage across parallel elements is the same.

Using this fact will result in

$E = V_1 = V_2$

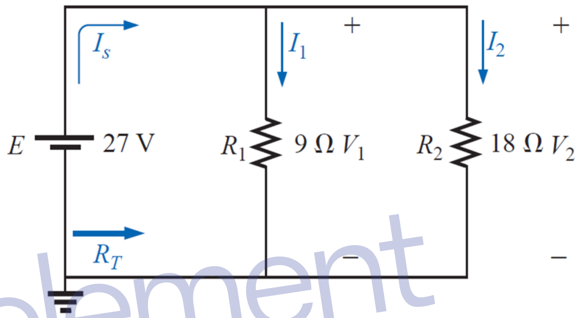
but

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

$\frac{E}{R_T} = \frac{E}{R_1} + \frac{E}{R_2}$

$\frac{E}{R_T} = \frac{V_1}{R_1} + \frac{V_2}{R_2}$

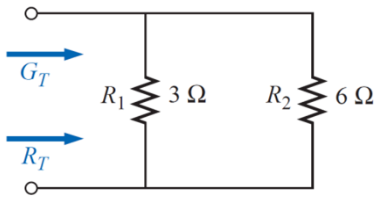
$I_s = I_1 + I_2$



Therefore, ***The total current equal to algebraic sum of branches current***

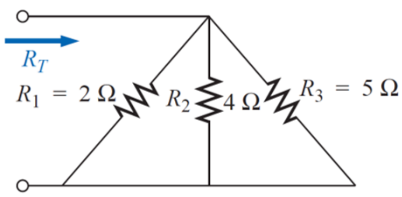
EXAMPLE 1

Determine the total conductance and resistance for the parallel network of Fig. shown below



EXAMPLE 2

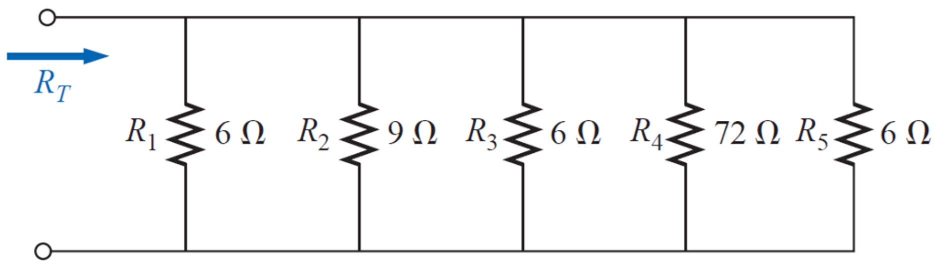
Determine the total conductance and resistance for the parallel network of Fig. shown below



The total resistance of parallel resistors is always less than the value of the smallest resistor.

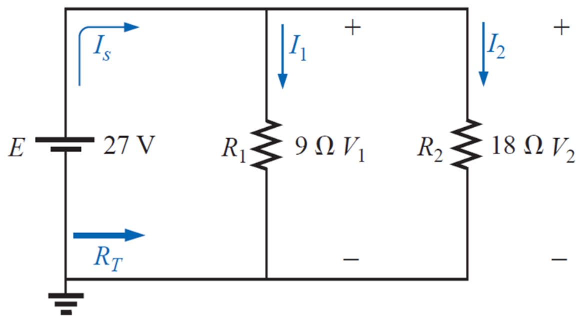
EXAMPLE 3

Determine the total conductance and resistance for the parallel network of Fig. shown below



EXAMPLE 4

For the following parallel network:



a. Calculate R_T.
b. Determine I_s.
c. Calculate I_1 and I_2, and demonstrate that $Is = I_1 + I_2$.
d. Determine the power to each resistive load.
e. Determine the power delivered by the source, and compare it to the total power dissipated by the resistive elements.

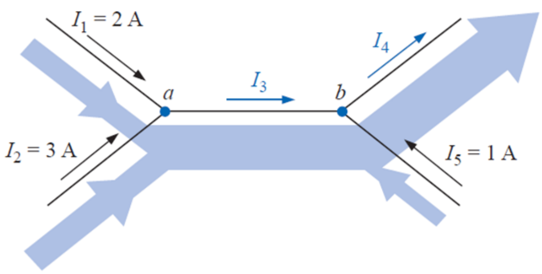
KIRCHHOFF'S CURRENT LAW

Kirchhoff's voltage law provides an important relationship among voltage levels around any closed loop of a network. We now consider
Kirchhoff's current law (KCL), which provides an equally important relationship among current levels at any junction.
Kirchhoff's current law (KCL) ***states that the algebraic sum of the currents entering and leaving an area, system, or junction is zero.***
In other words,
the sum of the currents entering an area, system, or junction must equal the sum of the currents leaving the area, system, or junction.
In equation form:

$$\Sigma\, I_{\text{entering}} = \Sigma\, I_{\text{leaving}}$$

EXAMPLE 5

Determine the currents I_3 and I_4

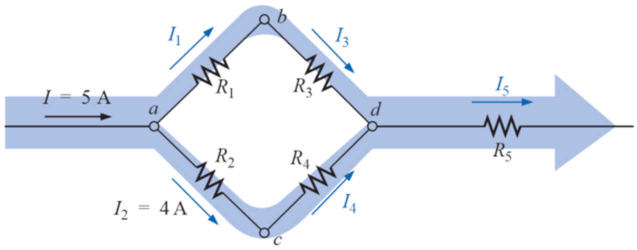


EXAMPLE 6

Find the magnitude and direction of the currents I_3, I_4, I_6, and I_7 for the network of following Figure. Even though the elements are not in series or parallel, Kirchhoff's current law can be applied to determine all the unknown currents.

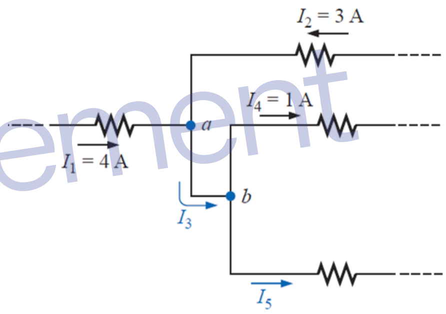
EXAMPLE 7

Determine I_1, I_3, I_4, and I_5 for the network shown below

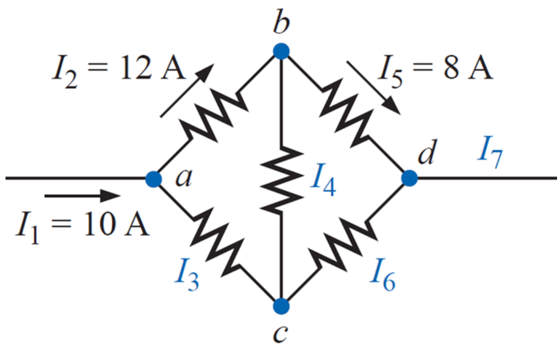


EXAMPLE 8

Determine the currents I_3 and I_5 of Fig. shown below through applications of Kirchhoff's current law.



EXAMPLE 9 Find the magnitude and direction of the currents I_3, I_4, I_6, and I_7 for the network shown below. Even though the elements are not in series or parallel, Kirchhoff's current law can be applied to determine all the unknown currents.



CURRENT DIVIDER RULE

The **current divider rule (CDR)** will determine how the current entering a set of parallel branches will split between the elements.

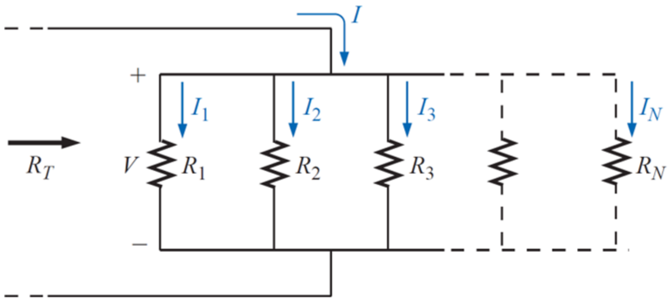
For two parallel elements of equal value, the current will divide equally.

For parallel elements with different values,

The smaller resistance has greatest value of current.

The current will split with a ratio equal to the inverse of their resistor values.

$$I_T = I_1 + I_2 + \cdots + I_N$$
$$E = V_1 = V_2 = V_N$$
$$I_T = \frac{E}{R_T} = \frac{I_1R_1}{R_T} = \frac{I_2R_2}{R_T} = \frac{I_NR_N}{R_T}$$
$$I_T = \frac{I_xR_x}{R_T}$$
$$I_x = I_T\frac{\frac{1}{R_x}}{\frac{1}{R_T}} = I_T\frac{R_T}{R_x}$$

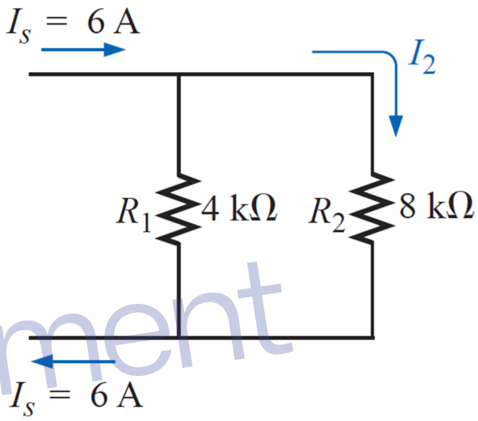


For the particular case of *two parallel resistors,*

$$I_1 = I_T\frac{\frac{1}{R_1}}{\frac{1}{R_T}} = I_T\frac{\frac{1}{R_1}}{\frac{1}{R_1}+\frac{1}{R_2}} = I_T\frac{\frac{1}{R_1}}{\frac{R_1+R_2}{R_1R_2}} = I_T\frac{R_2}{R_1+R_2}$$
$$I_2 = I_T\frac{\frac{1}{R_2}}{\frac{1}{R_T}} = I_T\frac{\frac{1}{R_2}}{\frac{1}{R_1}+\frac{1}{R_2}} = I_T\frac{\frac{1}{R_2}}{\frac{R_1+R_2}{R_1R_2}} = I_T\frac{R_1}{R_1+R_2}$$

EXAMPLE 10

Determine the current I_2 for the network shown below using the current divider rule.



EXAMPLE 11

Determine the current I_1 for the network shown below using the current divider rule.