RESISTIVE CIRCUITS

- SERIES/PARALLEL RESISTOR COMBINATIONS - A TECHNIQUE TO REDUCE THE COMPLEXITY OF SOME CIRCUITS

- LEARN TO ANALYZE THE SIMPLEST CIRCUITS
- THE VOLTAGE DIVIDER
- THE CURRENT DIVIDER

- WYE - DELTA TRANSFORMATION - A TECHNIQUE TO REDUCE COMMON RESISTOR CONNECTIONS THAT ARE NEITHER SERIES NOR PARALLEL

SERIES PARALLEL RESISTOR COMBINATIONS

UP TO NOW WE HAVE STUDIED CIRCUITS THAT CAN BE ANALYZED WITH ONE APPLICATION OF KVL(SINGLE LOOP) OR KCL(SINGLE NODE-PAIR)

WE HAVE ALSO SEEN THAT IN SOME SITUATIONS IT IS ADVANTAGEOUS TO COMBINE RESISTORS TO SIMPLIFY THE ANALYSIS OF A CIRCUIT

NOW WE EXAMINE SOME MORE COMPLEX CIRCUITS WHERE WE CAN SIMPLIFY THE ANALYSIS USING THE TECHNIQUE OF COMBINING RESISTORS…

… PLUS THE USE OF OHM'S LAW

SERIES COMBINATIONS

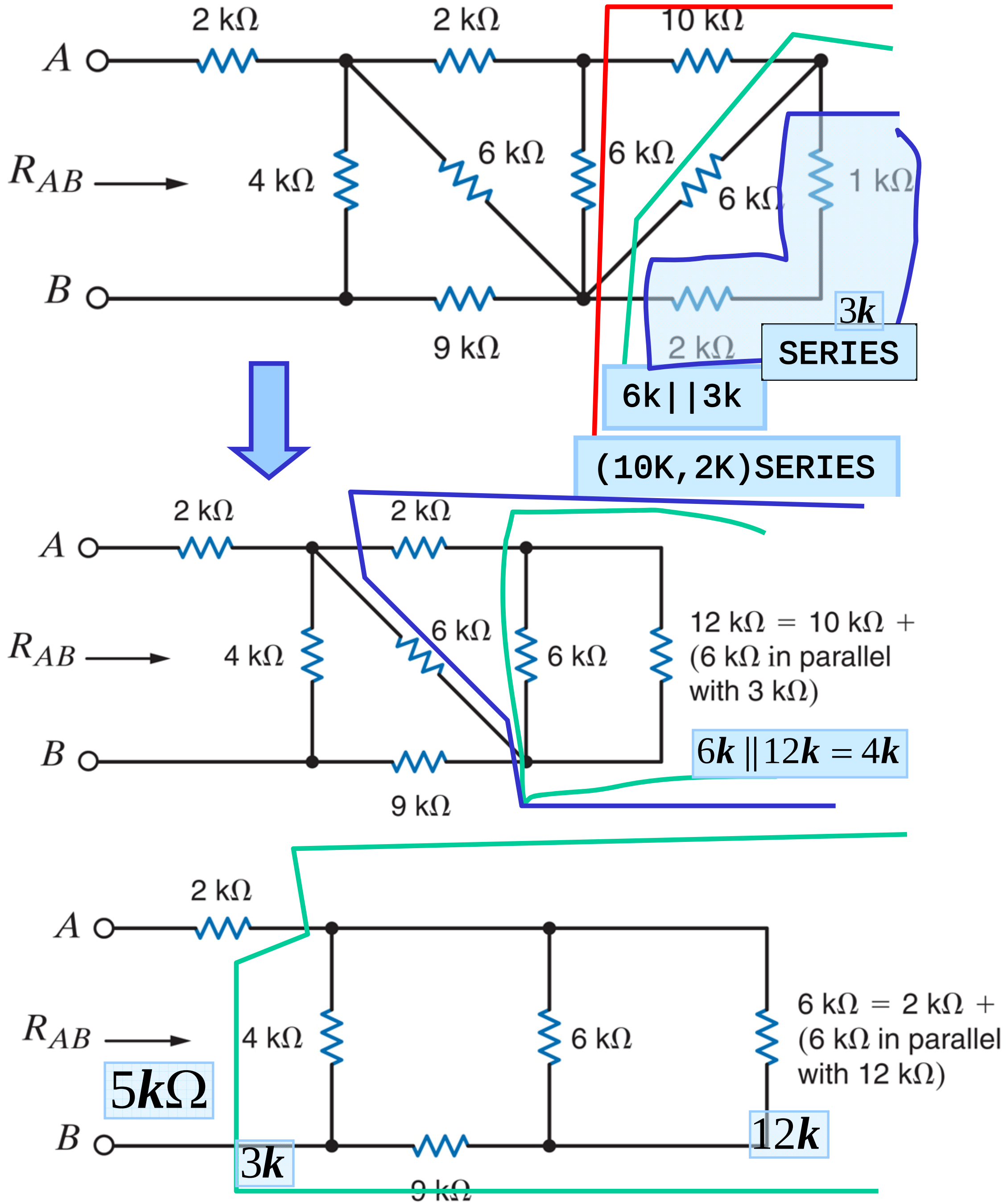
$$R_S = R_1 + R_2 + \cdots + R_N$$

PARALLEL COMBINATION

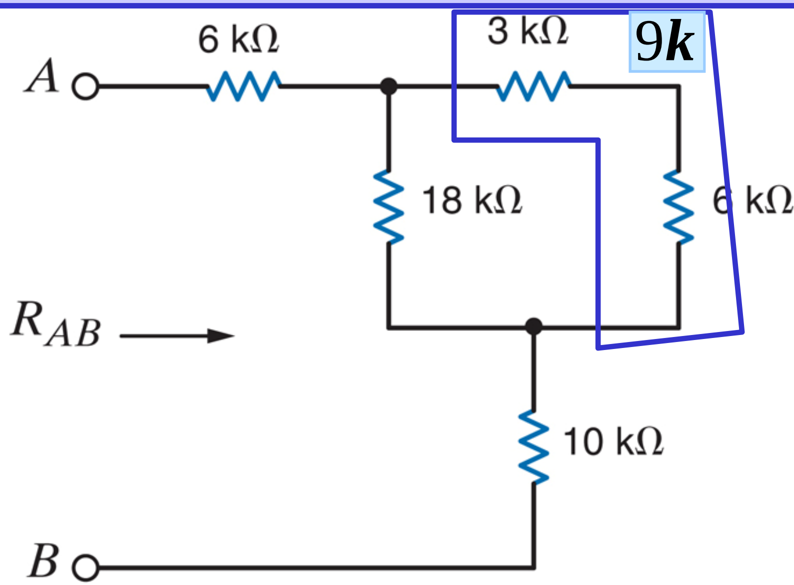
$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_N}$$

$$G_p = G_1 + G_2 + \ldots + G_N$$

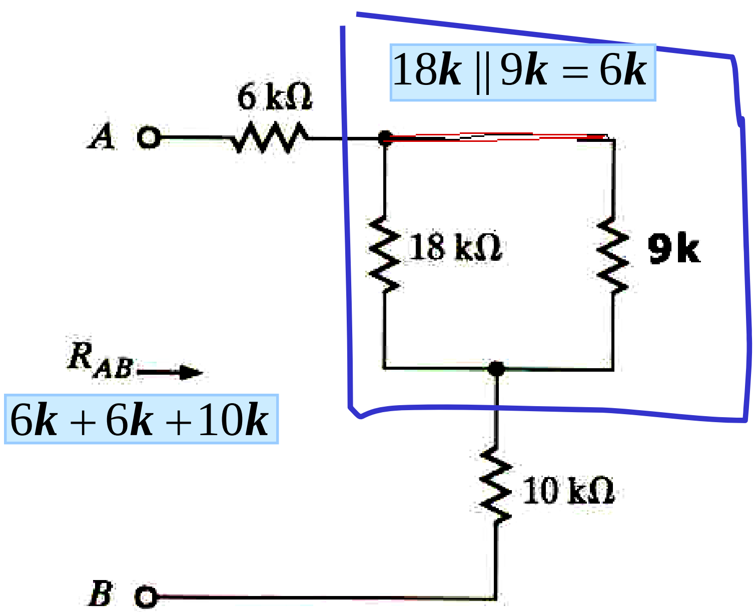
FIRST WE PRACTICE COMBINING RESISTORS



EXAMPLES COMBINATION SERIES-PARALLEL



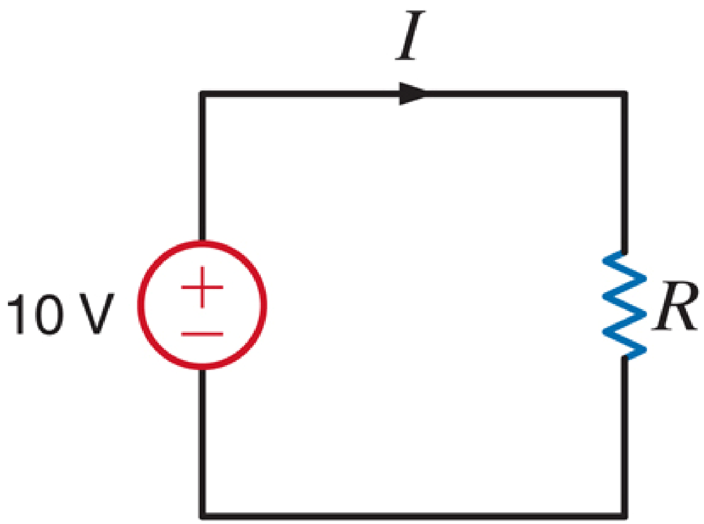
If the drawing gets confusing…
Redraw the reduced circuit
and start again



RESISTORS ARE IN SERIES IF THEY CARRY EXACTLY THE SAME CURRENT

RESISTORS ARE IN PARALLEL IF THEY ARE CONNECTED EXACTLY BETWEEN THE SAME TWO NODES

EFFECT OF RESISTOR TOLERANCE



NOMINAL RESISTOR VALUE: $2.7\text{k}\Omega$

RESISTOR TOLERANCE: 10%

RANGES FOR CURRENT AND POWER?

NOMINAL CURRENT: $\bar{I} = \frac{10}{2.7} = 3.704\,mA$

NOMINAL POWER: $\bar{P} = \frac{(10)^2}{2.7} = 37.04\,mW$

MINIMUM CURRENT: $I_{\min} = \frac{10}{1.1 \times 2.7} = 3.367\,mA$

MAXIMUM CURRENT: $I_{\max} = \frac{10}{0.9 \times 2.7} = 4.115\,mA$

MINIMUM POWER $(VI_{\min})$: $33.67\,mW$

MAXIMUM POWER: $41.15\,mW$

CIRCUIT WITH SERIES-PARALLEL RESISTOR COMBINATIONS

THE COMBINATION OF COMPONENTS CAN REDUCE THE COMPLEXITY OF A CIRCUIT AND RENDER IT SUITABLE FOR ANALYSIS USING THE BASIC TOOLS DEVELOPED SO FAR.

COMBINING RESISTORS IN SERIES ELIMINATES ONE NODE FROM THE CIRCUIT.
COMBINING RESISTORS IN PARALLEL ELIMINATES ONE LOOP FROM THE CIRCUIT

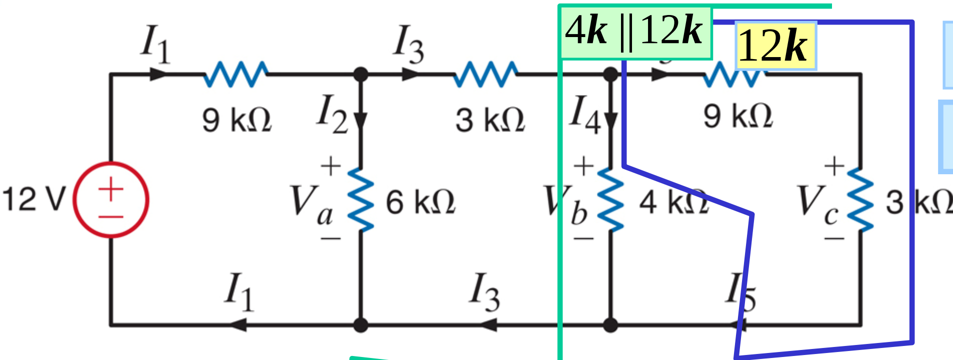
<u>GENERAL STRATEGY</u>:

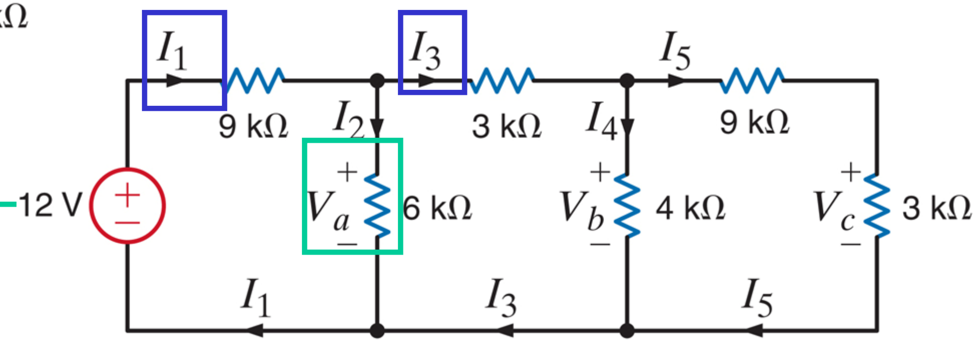
- REDUCE COMPLEXITY UNTIL THE CIRCUIT BECOMES SIMPLE ENOUGH TO ANALYZE.
- USE DATA FROM SIMPLIFIED CIRCUIT TO COMPUTE DESIRED VARIABLES IN ORIGINAL CIRCUIT - HENCE ONE MUST KEEP TRACK OF ANY RELATIONSHIP BETWEEN VARIABLES

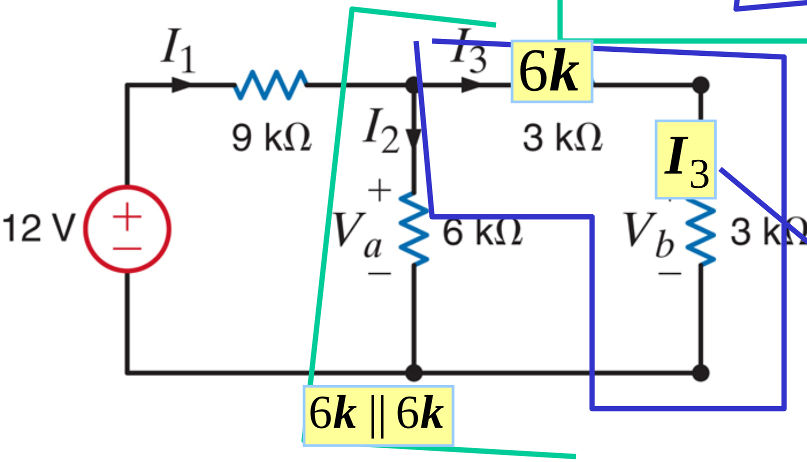
We wish to find all the currents and voltages labeled in the ladder network shown

FIRST REDUCE IT TO A SINGLE LOOP CIRCUIT

SECOND: "BACKTRACK" USING KVL, KCL OHM'S







KCL: $I_1 - I_2 - I_3 = 0$

OHM'S: $I_2 = \frac{V_a}{6k}$

OHM'S: $V_b = 3k * I_3$

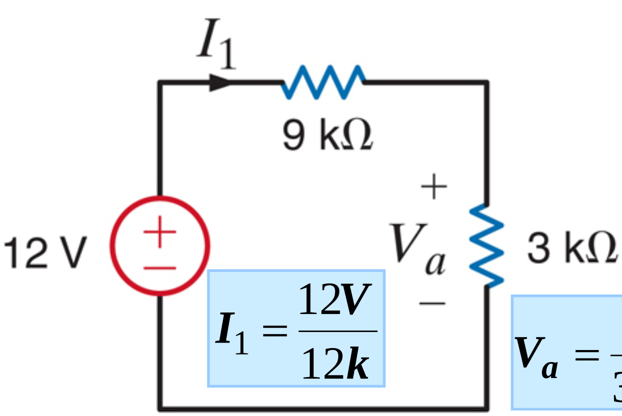
...OTHER OPTIONS...

$I_4 = \frac{12}{4+12} I_3$

$V_b = 4k * I_4$

KCL: $I_5 + I_4 - I_3 = 0$

OHM'S: $V_C = 3k * I_5$

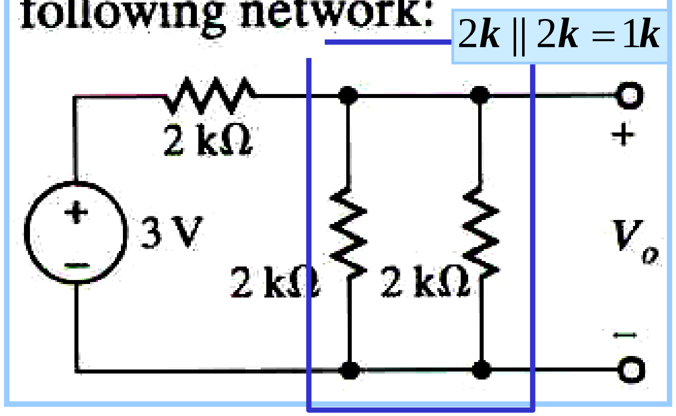


$I_1 = \frac{12V}{12k}$

$V_a = \frac{3}{3+9}(12)$

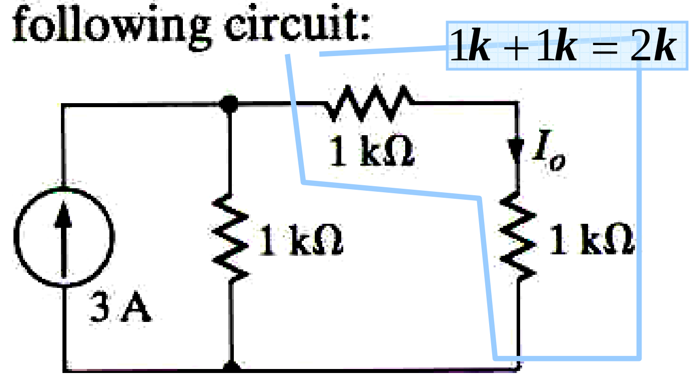
LEARNING BY DOING

Find V_o in the following network:



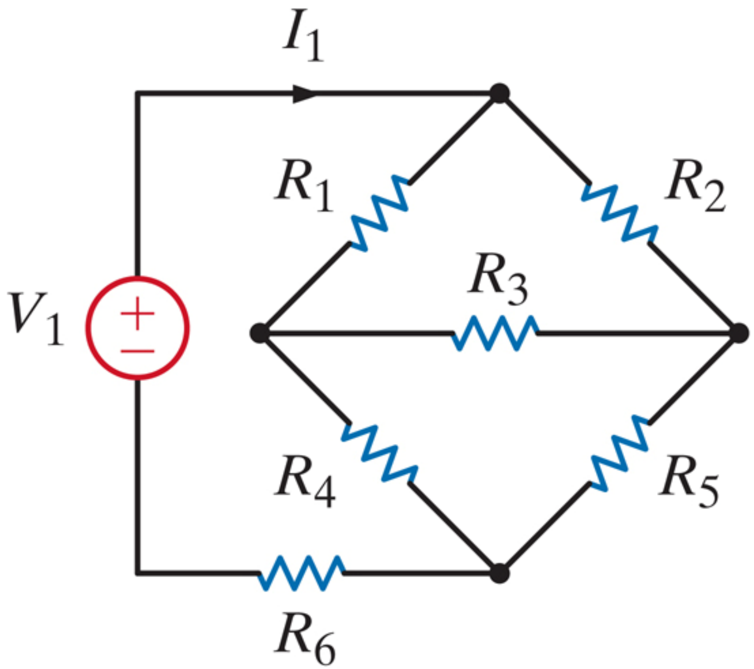
VOLTAGE DIVIDER : $V_o = \frac{1k}{1k + 2k}(3V) = 1V$

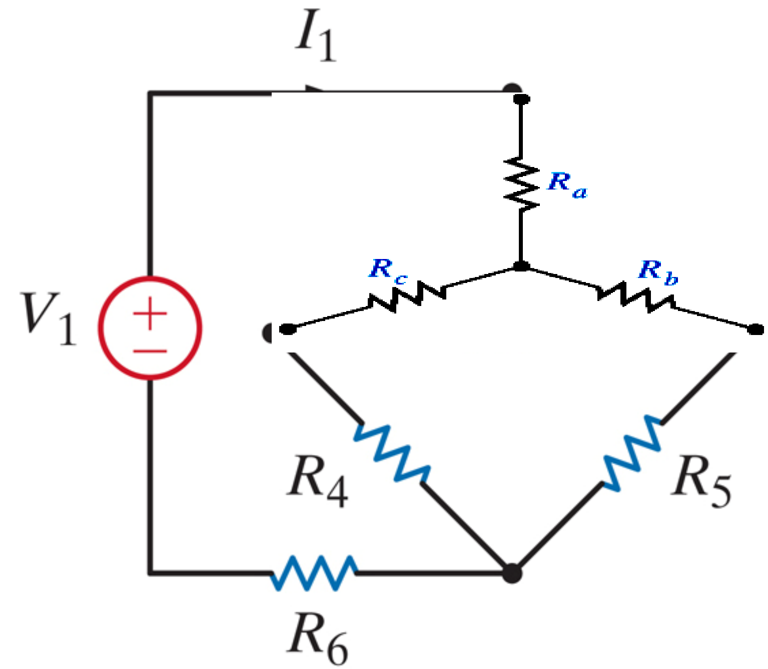
Find I_o in the following circuit:



CURRENT DIVIDER : $I_o = \frac{1k}{1k + 2k}(3A) = 1A$

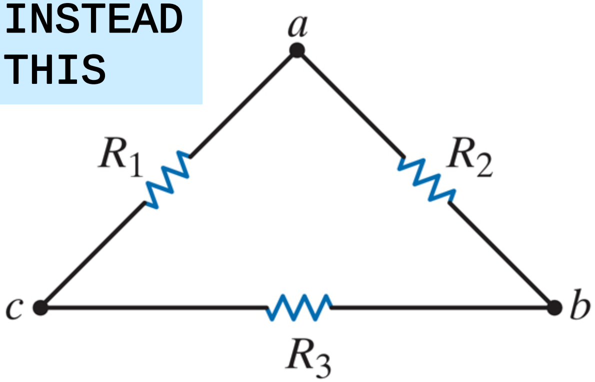
$Y - \Delta$ TRANSFORMATIONS



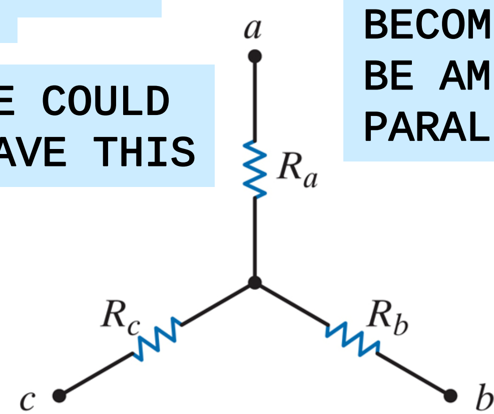


THIS CIRCUIT HAS NO RESISTOR IN SERIES OR PARALLEL

IF INSTEAD OF THIS

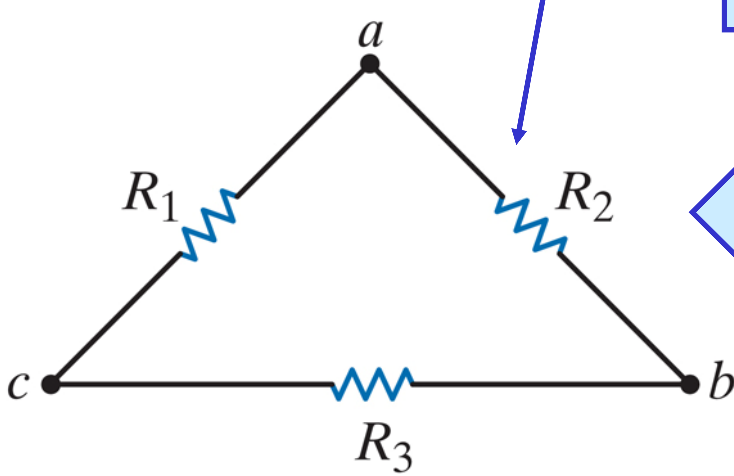


WE COULD HAVE THIS



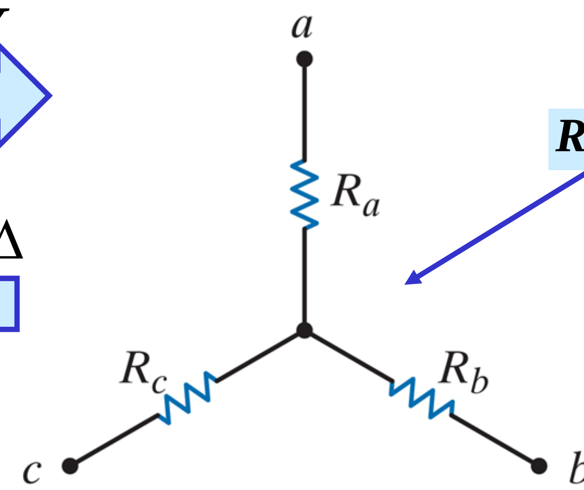
THEN THE CIRCUIT WOULD BECOME LIKE THIS AND BE AMENABLE TO SERIES PARALLEL TRANSFORMATIONS

$R_{ab} = R_2 \| (R_1 + R_3)$



$\Delta \rightarrow Y$

$Y \rightarrow \Delta$



$R_{ab} = R_a + R_b$

$$R_a + R_b = \frac{R_2(R_1 + R_3)}{R_1 + R_2 + R_3}$$

$$R_b + R_c = \frac{R_3(R_1 + R_2)}{R_1 + R_2 + R_3}$$

$$R_c + R_a = \frac{R_1(R_2 + R_3)}{R_1 + R_2 + R_3}$$

SUBTRACT THE FIRST TWO THEN ADD TO THE THIRD TO GET Ra

$$R_a = \frac{R_1 R_2}{R_1 + R_2 + R_3}$$

$$R_b = \frac{R_2 R_3}{R_1 + R_2 + R_3}$$

$$R_c = \frac{R_3 R_1}{R_1 + R_2 + R_3}$$

$$\Delta \rightarrow Y$$

$$\frac{R_a}{R_b} = \frac{R_1}{R_3} \Rightarrow R_3 = \frac{R_b R_1}{R_a}$$

$$\frac{R_b}{R_c} = \frac{R_2}{R_1} \Rightarrow R_2 = \frac{R_b R_1}{R_c}$$

REPLACE IN THE THIRD AND SOLVE FOR R1

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

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

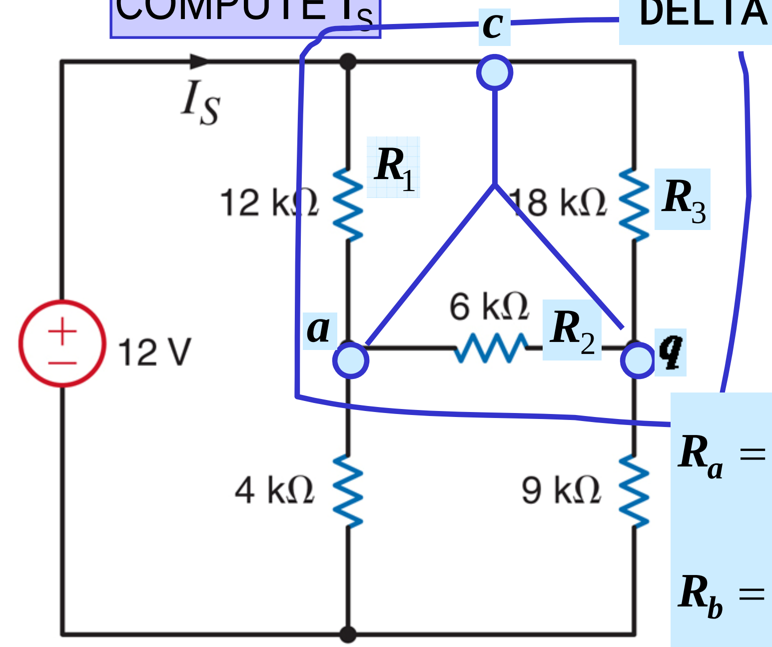
$$R_3 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_a}$$

$$Y - \Delta$$

LEARNING EXAMPLE: APPLICATION OF WYE-DELTA TRANSFORMATION

COMPUTE I_S

DELTA CONNECTION

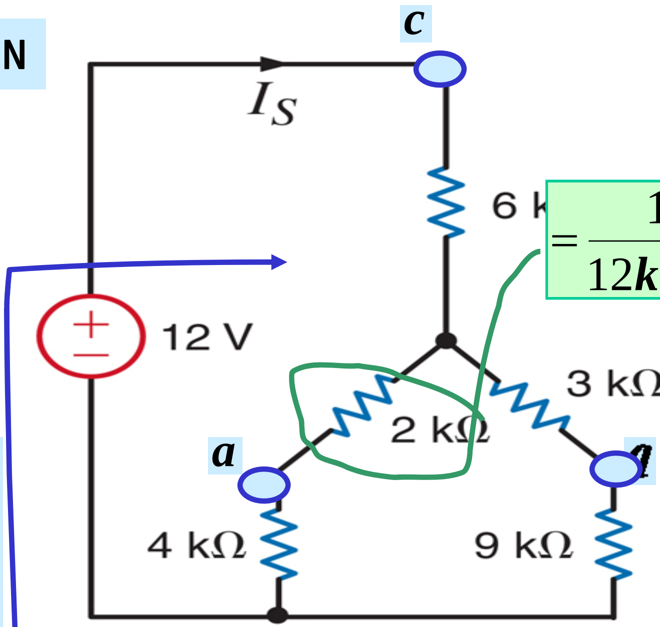


$$R_a = \frac{R_1 R_2}{R_1 + R_2 + R_3}$$

$$R_b = \frac{R_2 R_3}{R_1 + R_2 + R_3}$$

$$R_c = \frac{R_3 R_1}{R_1 + R_2 + R_3}$$

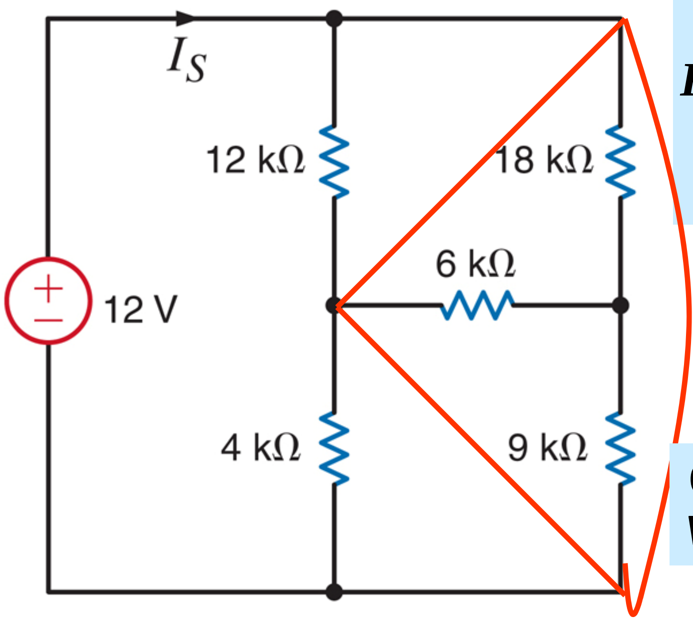
$$\Delta \to Y$$



$$= \frac{12k \times 6k}{12k + 6k + 18k}$$

$$R_{EQ} = 6k + (3k + 9k) \| (2k + 4k) = 10k$$

$$I_S = \frac{12V}{10k} = 1.2mA$$



ONE COULD ALSO USE A
WYE - DELTA TRANSFORMATION ...