ESc201: Introduction to Electronics

Basic Circuit Analysis

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Objectives

1. Solve circuits (i.e., find currents and voltages of interest) by combining resistances in series and parallel

2. Apply the voltage-division and current-division principles

3. Solve circuits by the node-voltage technique

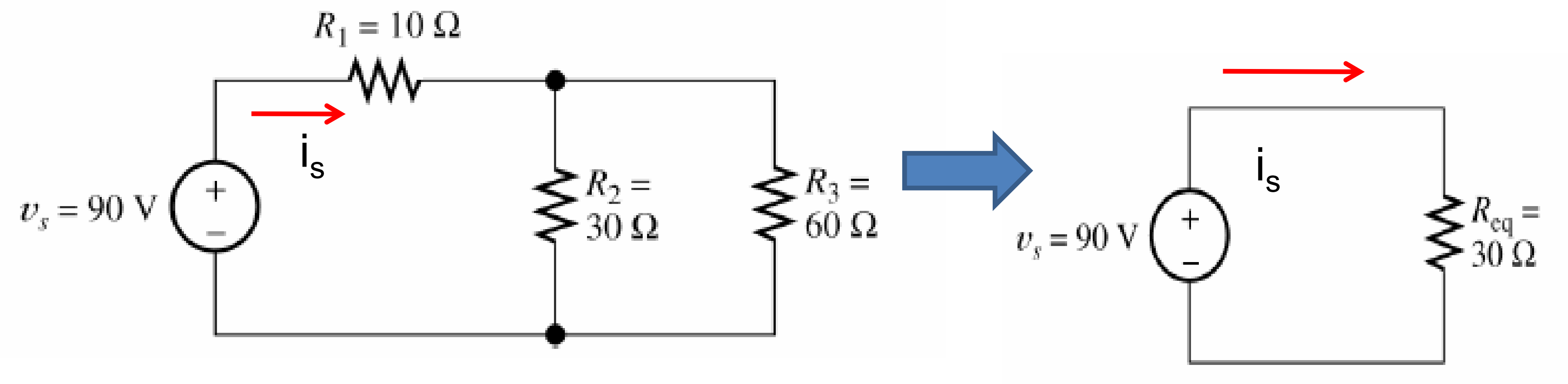
4. Solve circuits by the mesh-current technique

5. Find Thévenin and Norton equivalents and apply source transformations

6. Apply the superposition principle

Simplification Techniques

As engineers we like to be **efficient** : achieve the objective with minimum effort.



Concept of equivalent circuits

Two circuits are equivalent if they have the same current-voltage behavior

Analysis using REUSE methodology

Do not carry out analysis from scratch !

Analyze, Remember and Reuse

Example: we do not carry out multiplication from scratch using repeated addition !

$$\begin{array}{r} 3\ \ 4 \\ \underline{\times\ \ 3} \\ \underline{10\ 2} \end{array}$$

$3 \times 4 = 12$

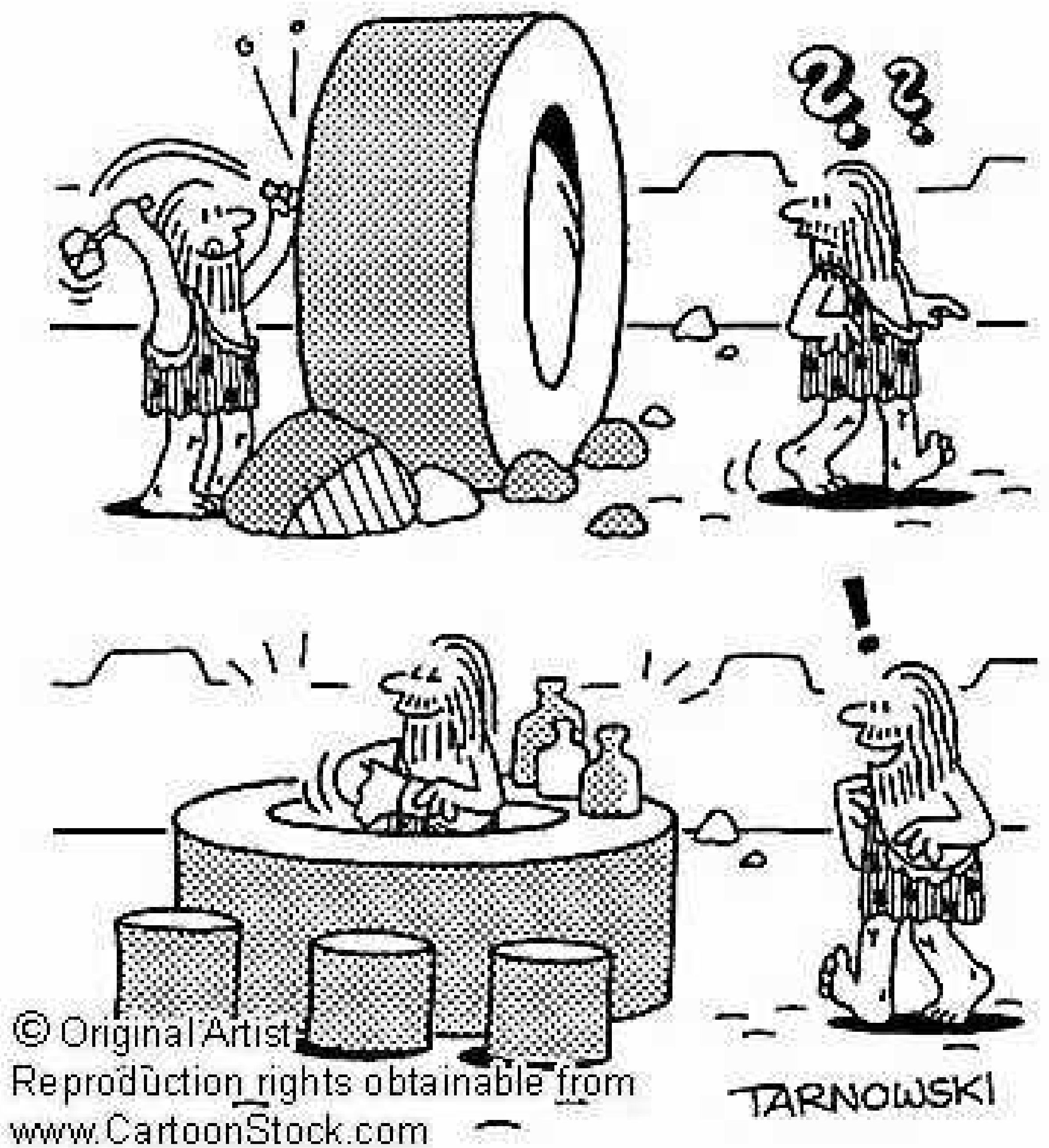
||| ||| ||| |||

You cannot carry out complex multiplication with ease using the first principle

$4 \times 1 = 4$
$4 \times 2 = 8$
$4 \times 3 = 12$
$4 \times 4 = 16$
....

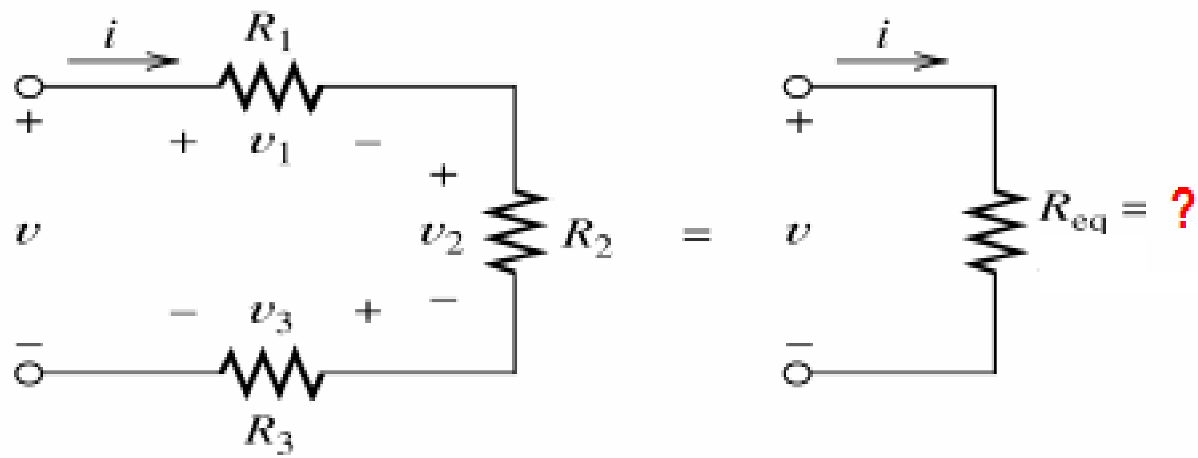
Memorize multiplication table and use it again and again

Creative Reuse !



Develop equivalent circuits by combining several resistors into a single equivalent resistor

Series Resistances



(a) Three resistances in series

(b) Equivalent resistance

From (a)

$$v_1 = R_1 i$$

$$v_2 = R_2 i$$

$$v_3 = R_3 i$$

Using KVL :

$$v = v_1 + v_2 + v_3$$

$$= (R_1 + R_2 + R_3)i$$

From (b)

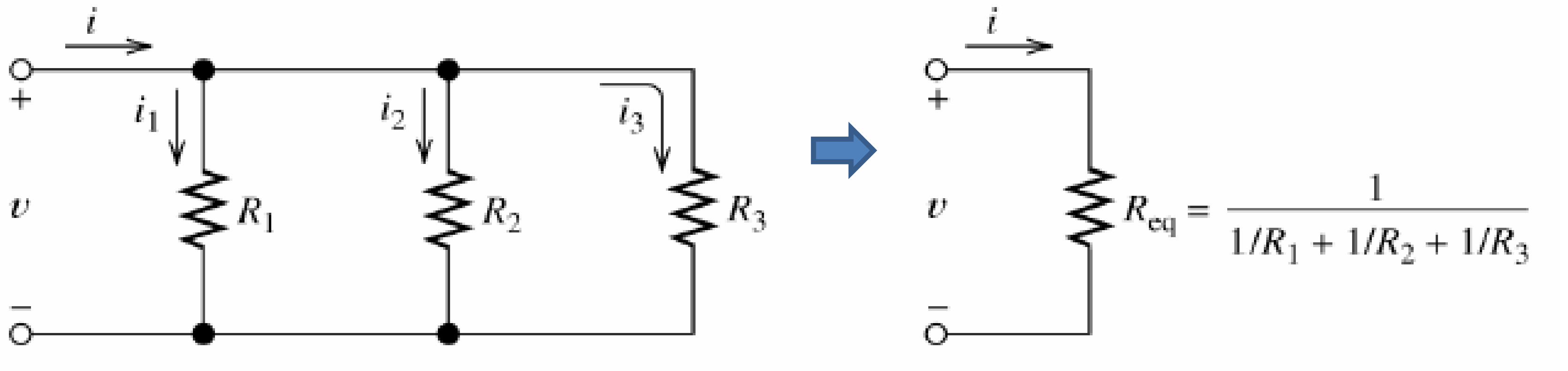
$$v = R_{eq} i$$

Thus,

$$R_{eq} = R_1 + R_2 + R_3$$

Both circuits are equivalent as far as ***v* vs. *i*** relation is concerned.

Parallel Resistances



(a) Three resistances in parallel

(b) Equivalent resistance

From (a):

$$i_1 = v / R_1$$

$$i_2 = v / R_2$$

$$i_3 = v / R_3$$

By KCL

$$i = i_1 + i_2 + i_3$$

$$= \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right) v$$

From (b)

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

Thus,

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

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

Special Case

- Two Resistors in Parallel R_1 and R_2

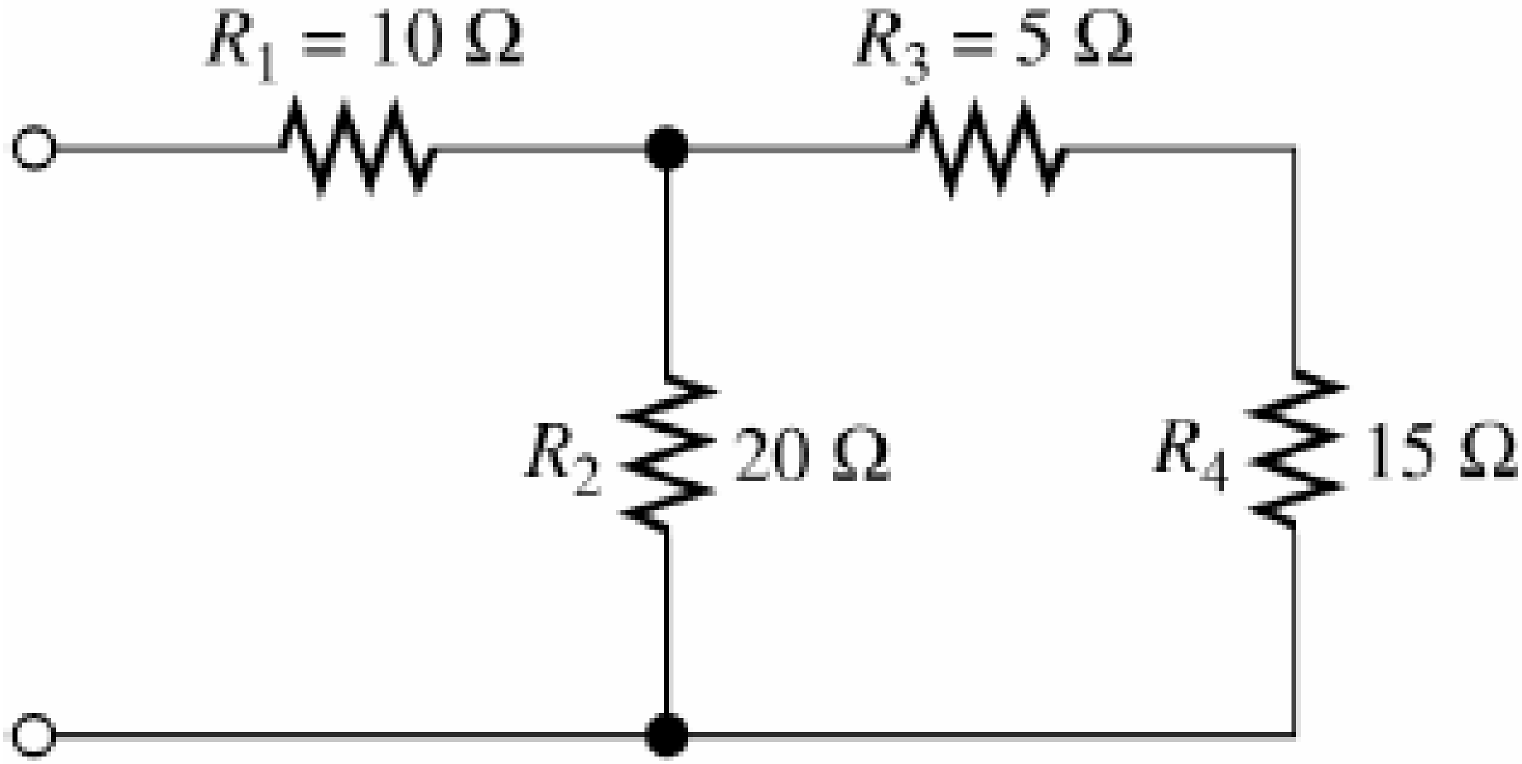
$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$

- Always R_{eq} is less than the smallest resistor

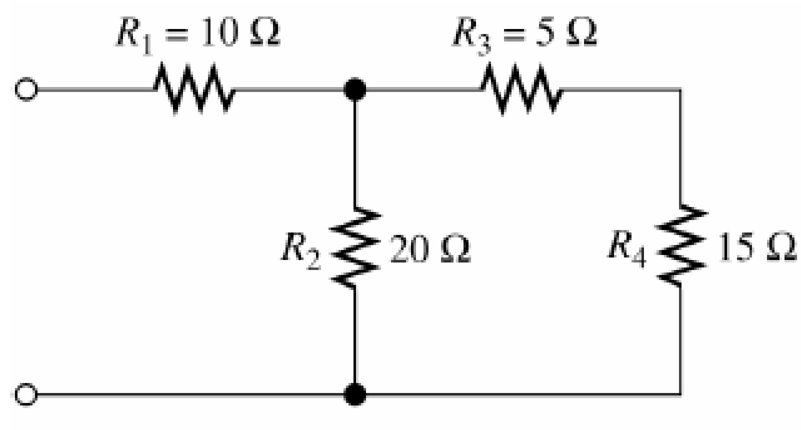
- If R_1 or R_2 is zero (short circuit), then $R_{eq} = 0$

Example

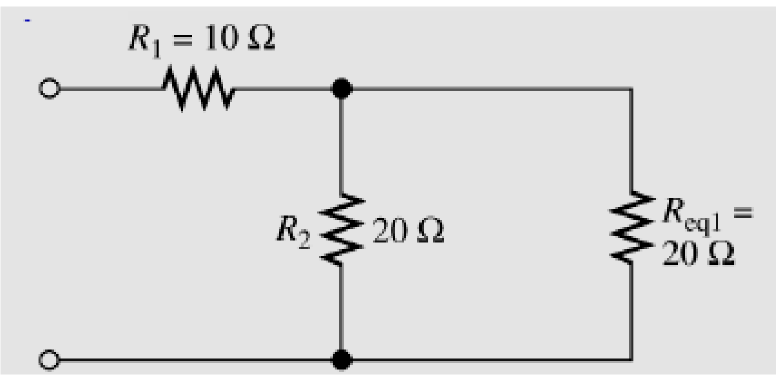
Use concept of series and parallel resistances to simplify

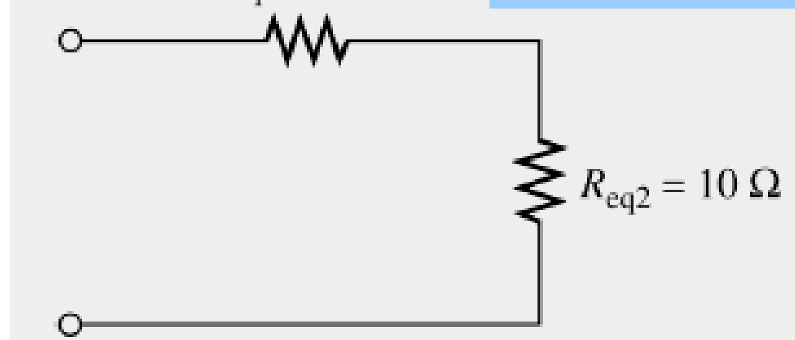


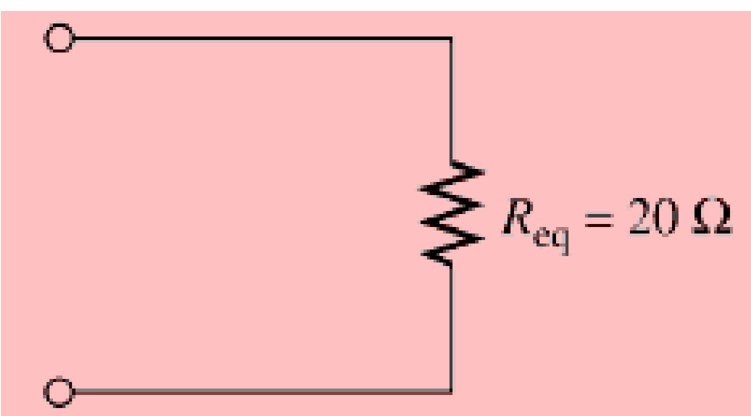
Example Use concept of series and parallel resistances to simplify



$$R_{eq2} = \frac{R_2 R_{eq1}}{R_2 + R_{eq1}}$$







$$R_{eq} = \{(R_4 + R_3) \| R_2\} + R_1$$

Circuit Analysis Using Series/Parallel Equivalents

1. Begin by locating a combination of resistances that are in series or parallel. Often the place to start with is the farthest from the source.

2. Redraw the circuit with the equivalent resistance for the combination found in step 1.

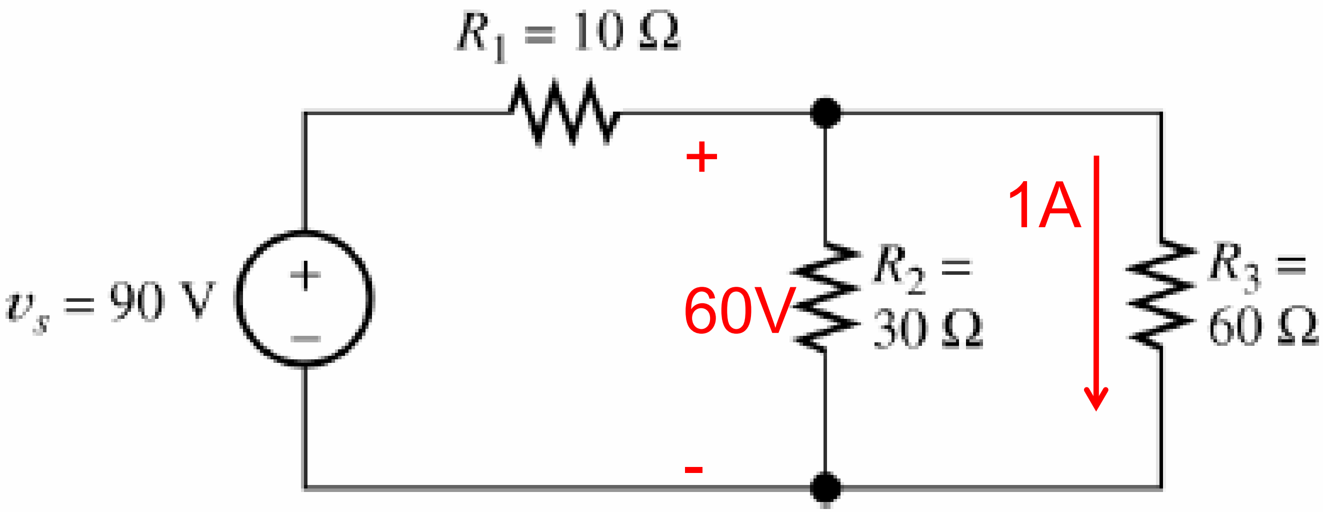
3. Repeat steps 1 and 2 until the circuit is reduced as far as possible. Often (but not always) we end up with a single source and a single resistance.

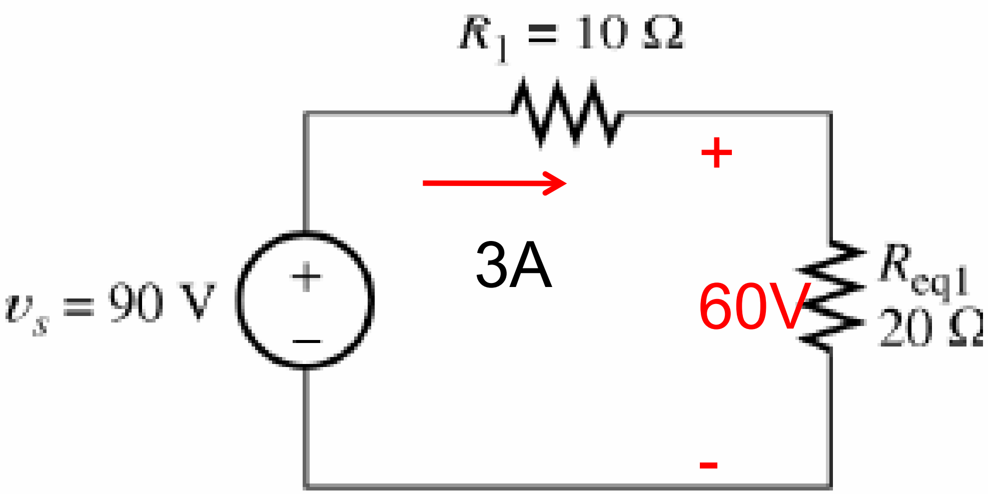
4. Solve for the currents and voltages in the final equivalent circuit. Then go back one step and solve for unknown voltages and current.

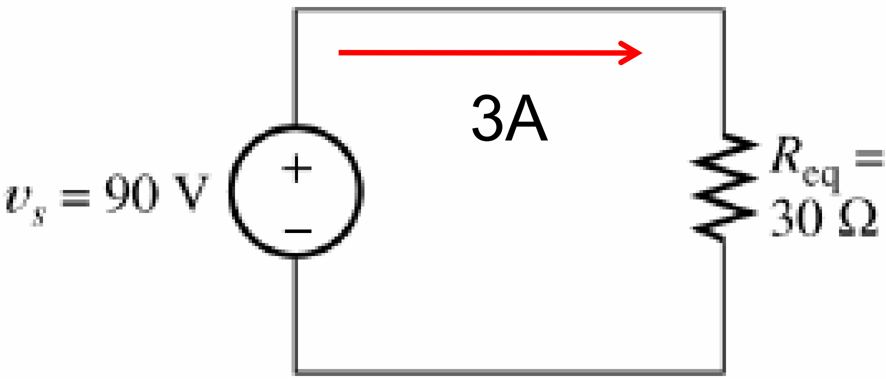
5. Repeat step 4 until the required current or voltage in the original circuit is found.

Example

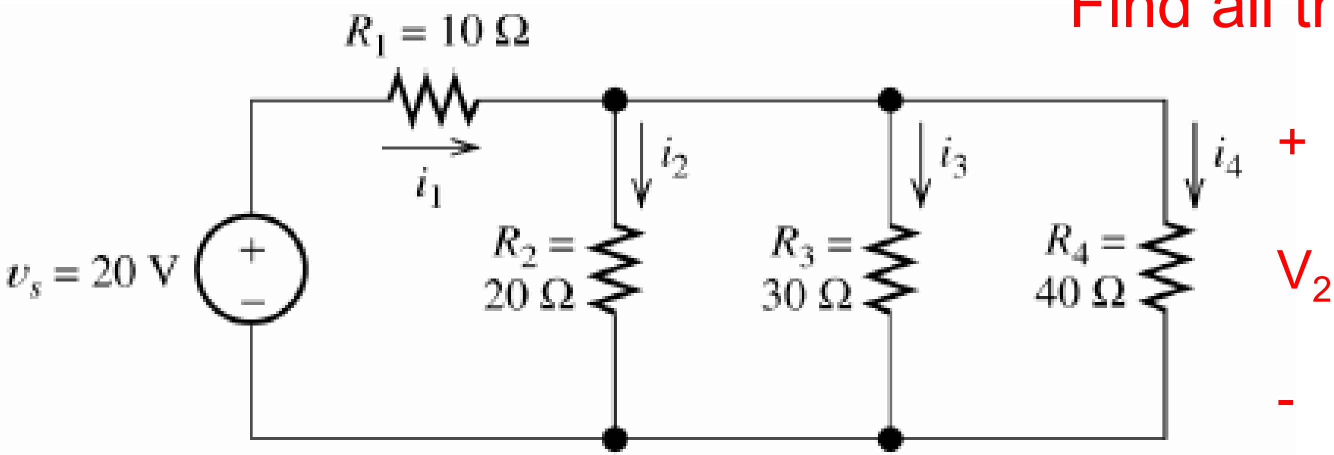
Find current in R_3



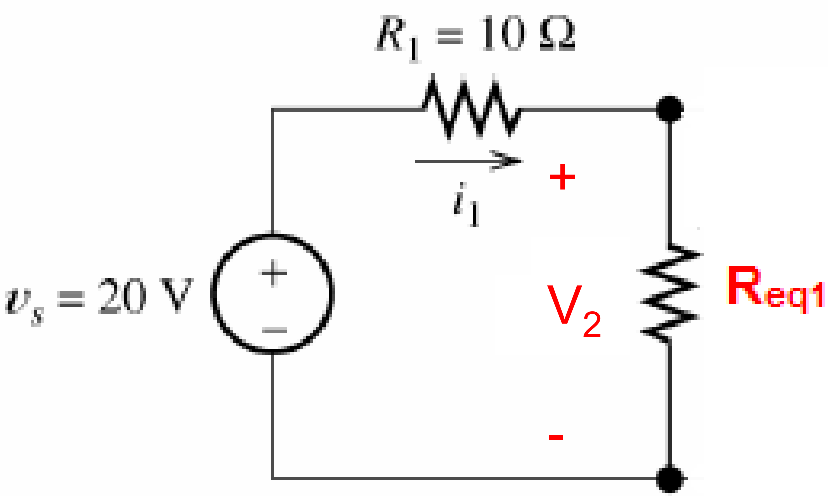


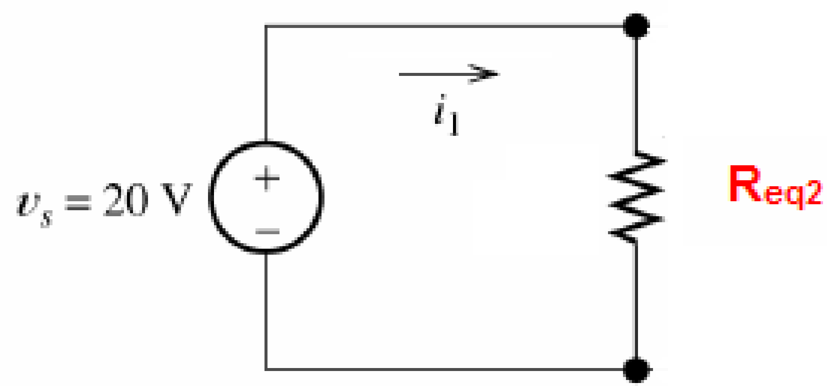


Find all the currents



Solve for i_2, i_3 and i_4





$$\mathrm{R}_{eq1} = R_2 \| R_3 \| R_4$$

Solve for V_2

$$\mathrm{R}_{eq2} = R_1 + R_{eq1}$$

Solve for i_1

Ans. i_1=1.04 A, i_2=0.48 A, i_3=0.32, i_4=0.24 A