

Department of Computer Science and Engineering (CSE)
BRAC University

Fall 2023

CSE250 - Circuits and Electronics

SOURCE TRANSFORMATION

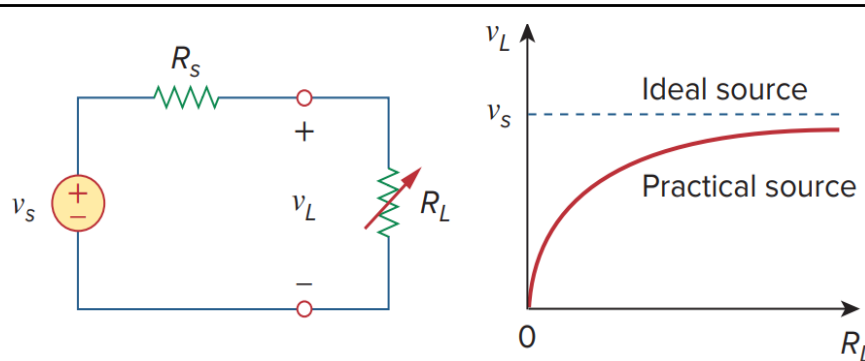


PRITHU MAHMUD, LECTURER
Department of Computer Science and Engineering (CSE)
BRAC University

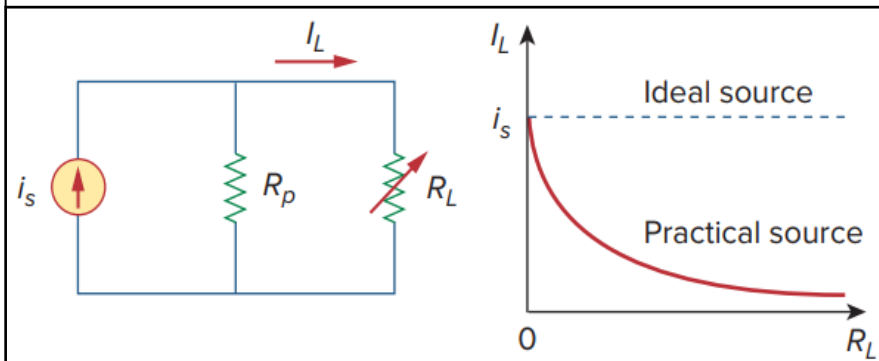
Ideal and non-ideal sources

- An *ideal voltage source* provides a constant voltage irrespective of the current drawn by the load, while an *ideal current source* supplies a constant current regardless of the load voltage.
- Practical* voltage and current sources are not ideal, due to their *internal resistances* or *source resistances* R_s and R_p . They become ideal as $R_s \rightarrow 0$ and $R_p \rightarrow \infty$.

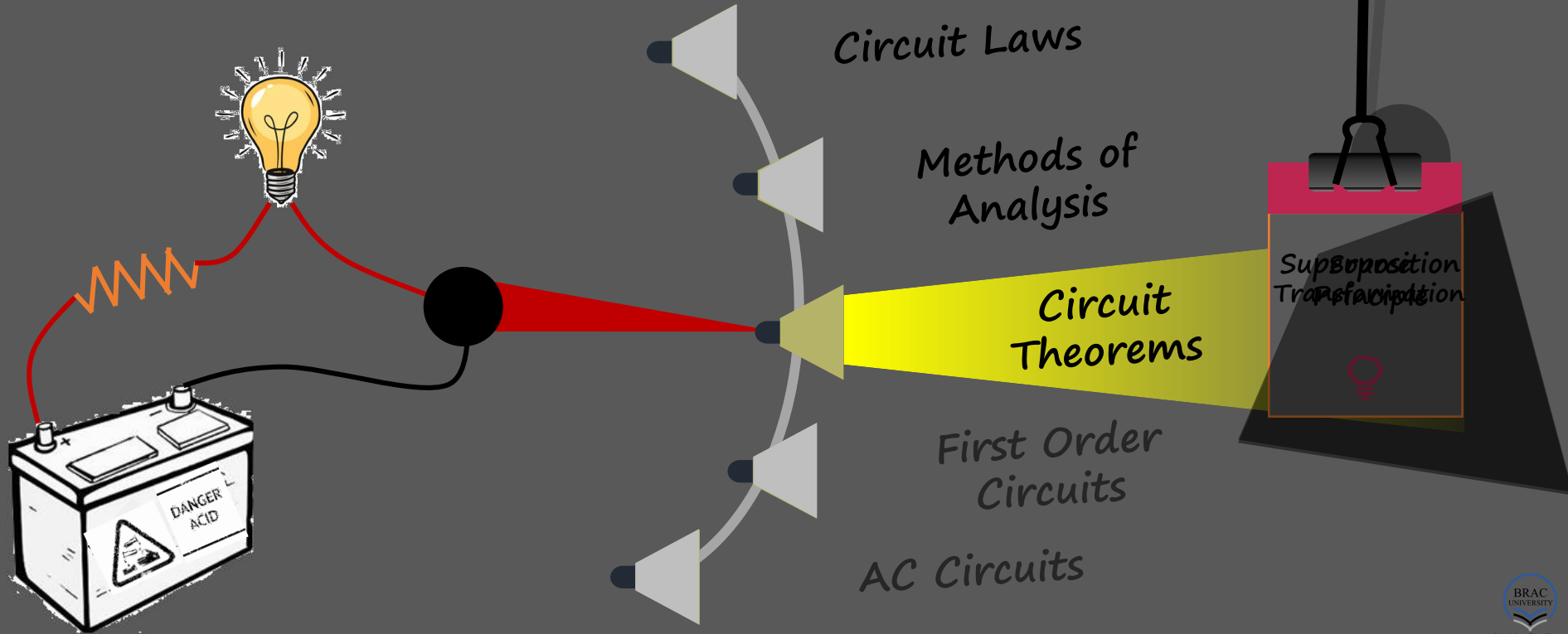
$$v_L = \frac{R_L}{R_s + R_L} v_s, \text{ if } R_s \ll R_L \text{ or } R_L = \infty, v_L \rightarrow v_s$$



$$i_L = \frac{R_p}{R_p + R_L} i_s, \text{ if } R_p \gg R_L \text{ or } R_p \rightarrow \infty, i_L \rightarrow i_s$$

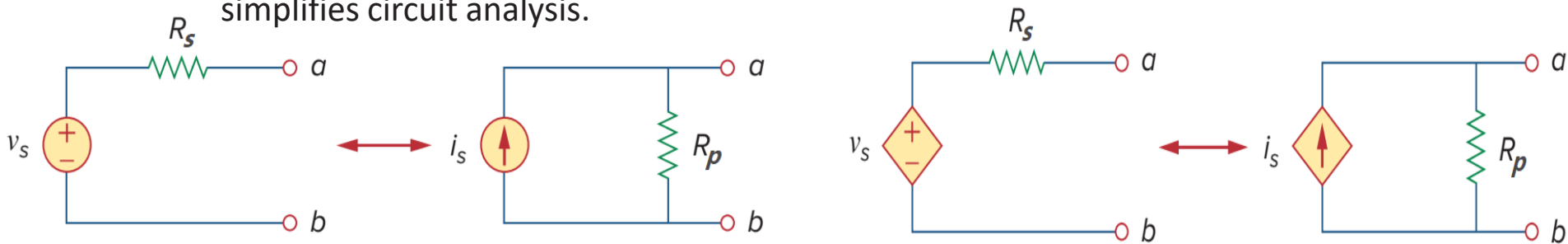


Course Outline: broad themes



Source Transformation

- A **source transformation** is the process of replacing a voltage source v_s in series with a resistor R by a current source i_p in parallel with a resistor R , or vice versa.
- The transformation does not affect the remaining part of the circuit but greatly simplifies circuit analysis.



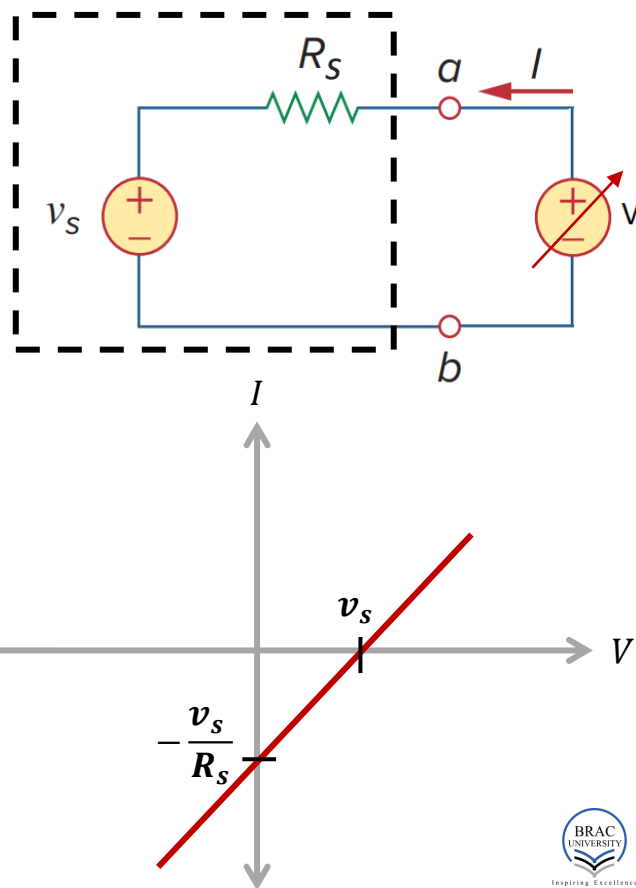
- Note that the arrow of the current source is directed toward the positive terminal of the voltage source.
- The source transformation is not possible when $R = 0$ and $R = \infty$ (see next slide), which are the cases with an ideal voltage and current source respectively. However, for a practical, nonideal voltage source, $R \neq 0$, and for a practical, nonideal current source, $R \neq \infty$.

V in series with a R

- We recall that *an equivalent circuit is one whose $I - V$ characteristics are identical with the original circuit*. Let's see what conditions make the two circuits to have the same $I - V$ relations at terminals $a - b$.
- Let's say we have a configuration of a voltage source (v_s) in series with a resistor (R_s) between terminals a and b . To determine the configuration's $I - V$ characteristics, if applying a voltage V gives rise to a current I , we can write,

$$V = v_s + IR_s$$
$$\Rightarrow I = \frac{1}{R_s}V - \frac{v_s}{R_s}$$

- The equation results in a linear I vs V plot that intersects the axes at v_s and $-\frac{v_s}{R_s}$.



I in parallel with a R

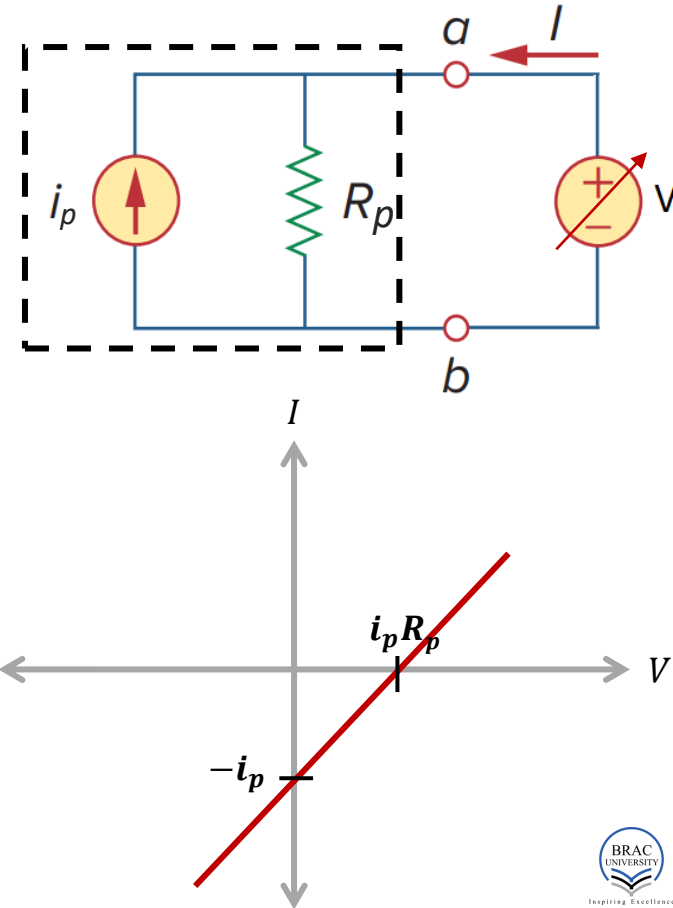
- For the other configuration: a current source (i_p) in parallel with a resistor (R_p) between terminals a and b , if applying a voltage V gives rise to a current I , using KCL the current through the resistor is,

$$I + i_p$$

- So, the voltage across the resistor can be written as,

$$(I + i_p) R_p = V$$
$$\Rightarrow I = \frac{1}{R_p} V - i_p$$

- The equation results in a linear I vs V plot that intersects the axes at $i_p R_p$ and $-i_p$.

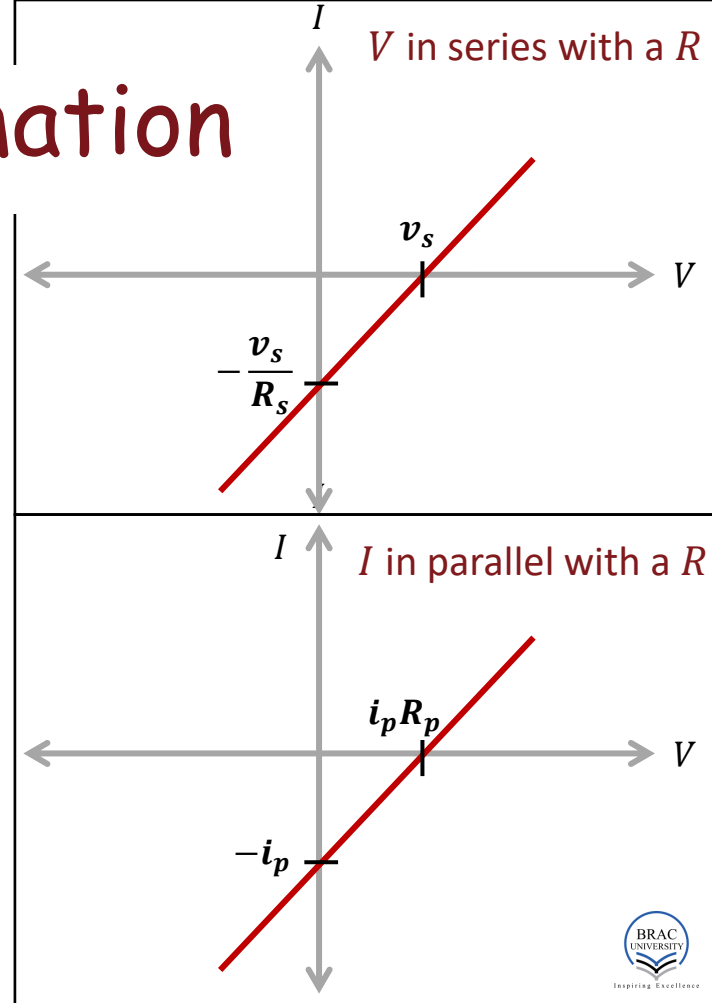
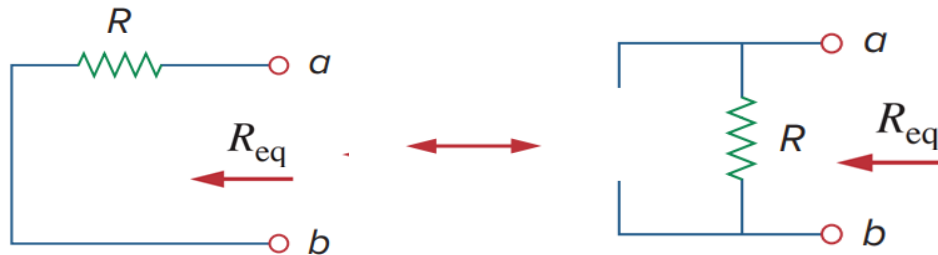


Conditions for transformation

- The two configurations will be equivalent to each other if their $I - V$ characteristics are similar. It can be said by looking at the two plots, they will indeed be similar if the intersecting points are same, that is, if $v_s = i_p R_p$ and $-\frac{v_s}{R_s} = -i_p$. This requires $R_s = R_p = R$. Both the equations result in an ohmic relation,

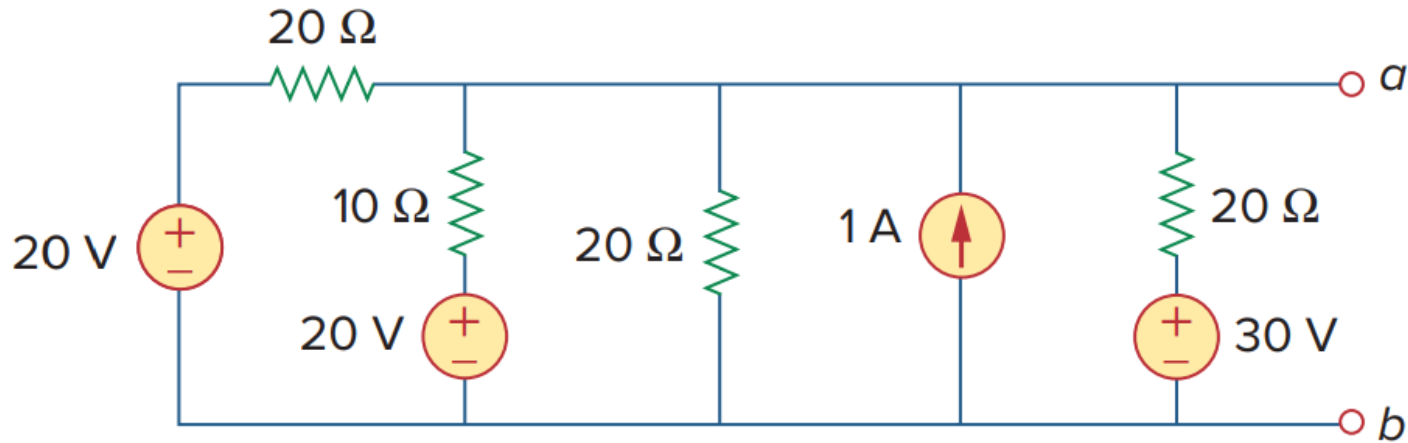
$$v_s = i_p R \text{ or } i_p = \frac{v_s}{R}$$

- So, if the sources are turned off, the equivalent resistance at terminals $a - b$ in both circuits is R .

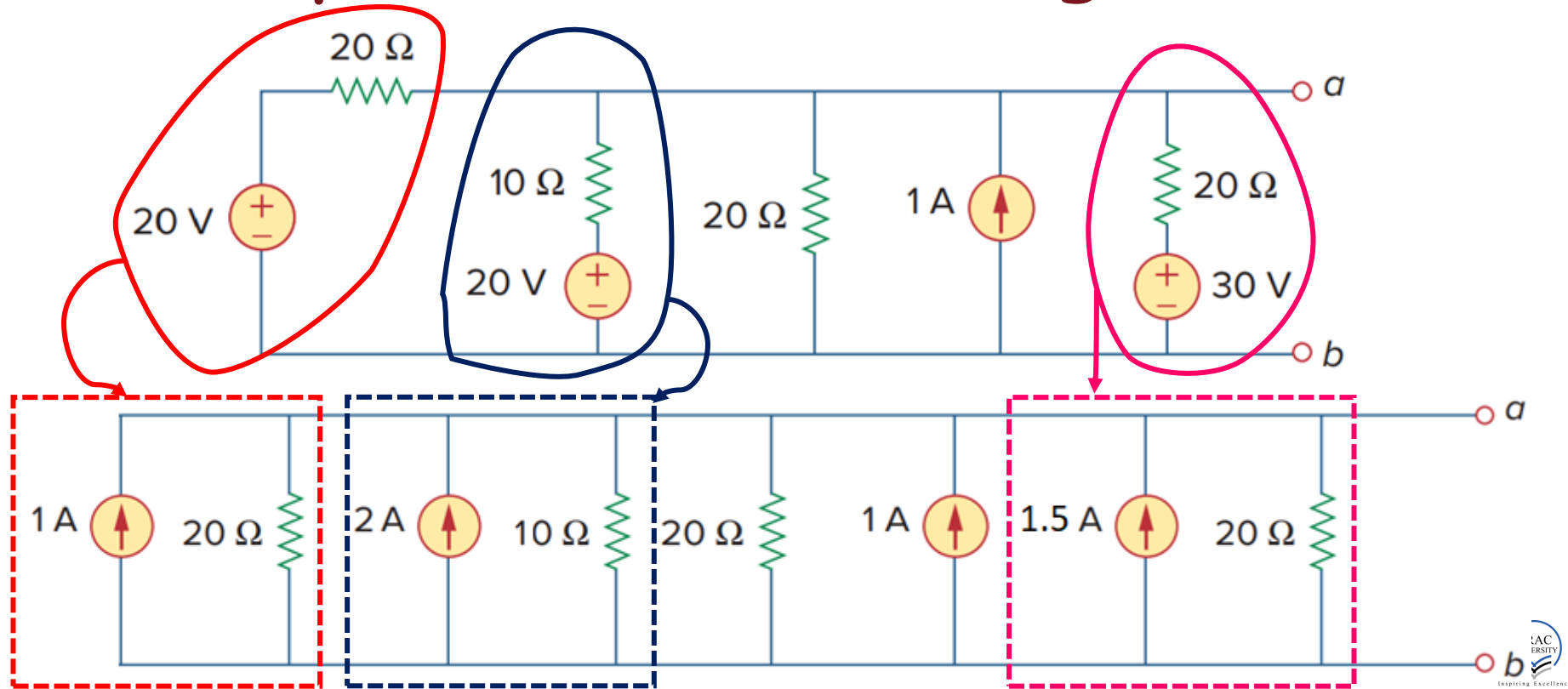


Example 1

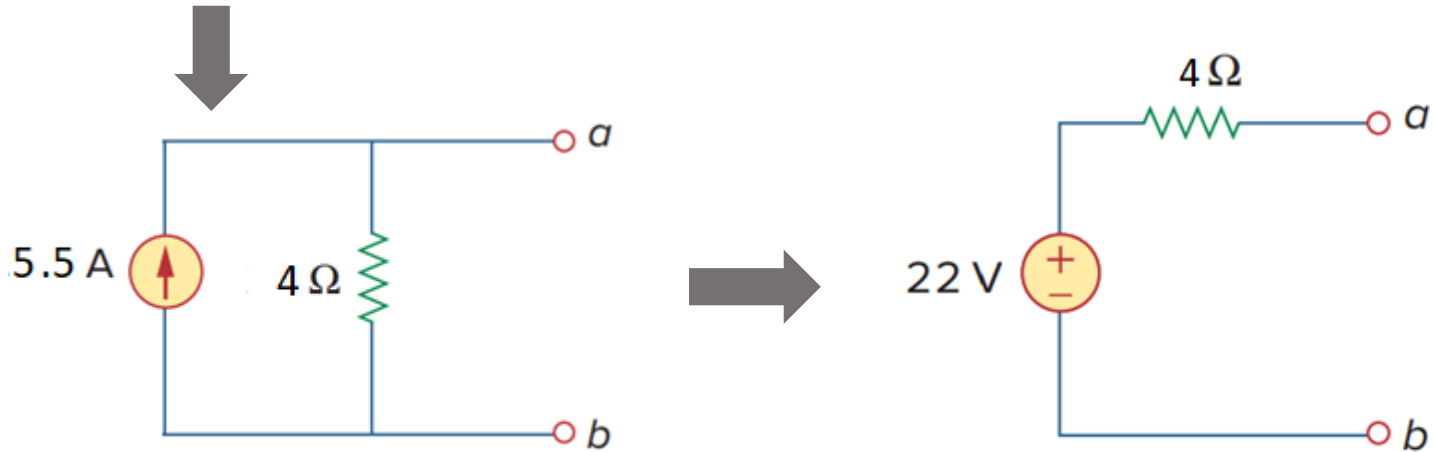
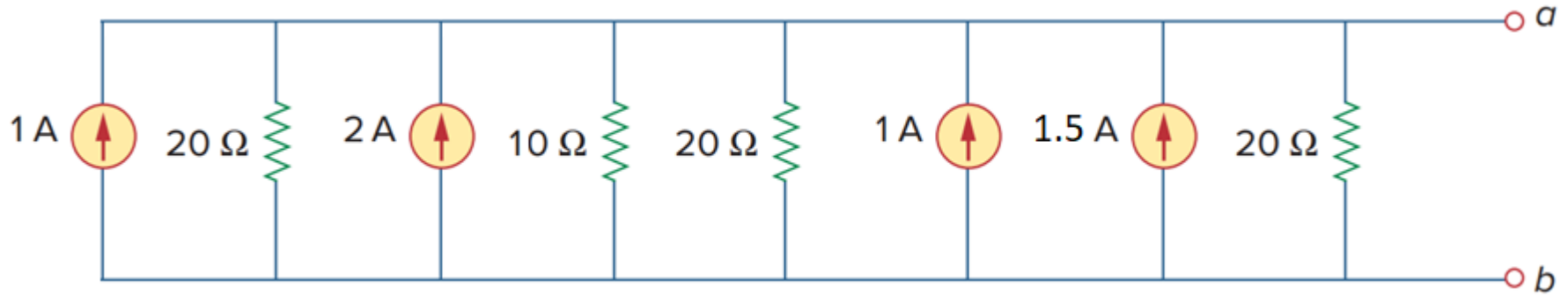
- Use source transformation to reduce the circuit between terminals a and b shown to a single voltage source in series with a single resistor.



Example 1: transforming sources

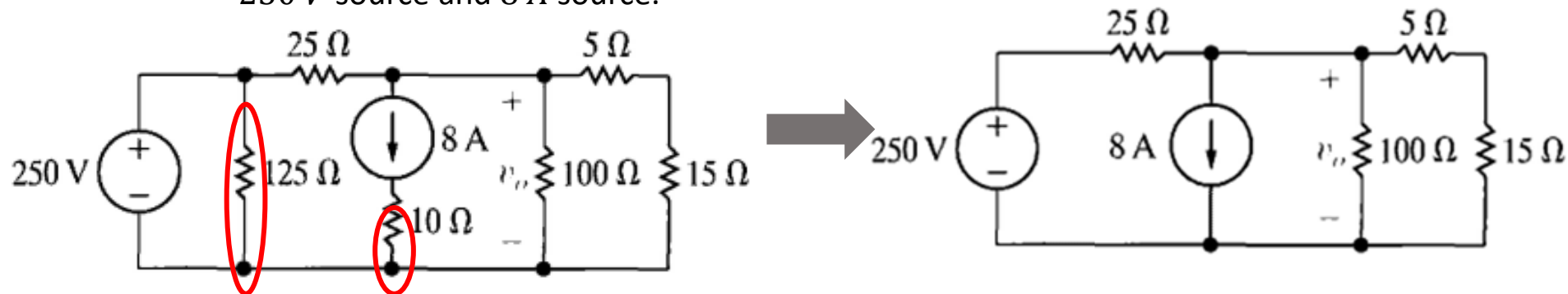


Example 1 (contd ... 2)



Problem 1

- Use source transformation to find the voltage v_0 . Find the power developed by the 250 V source and 8 A source.

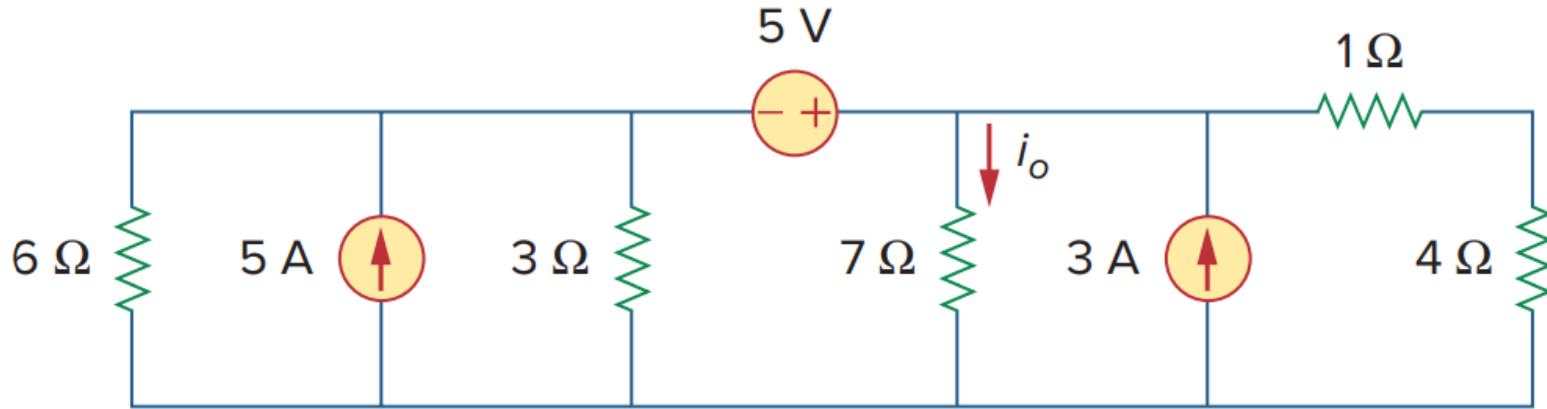


A resistor in series with a current source is redundant, as is a resistor in parallel with a voltage source. We can remove them; this will have no effect on the circuit except for the sources. Opening a resistor parallel to a voltage source will **reduce** the current supplied by the source. Similarly, shorting a resistor in series with a current source **increases** the voltage across the current source. We have to keep in mind those facts while calculating parameters for the sources.

Ans: $v_0 = 20 \text{ V}$; $P_{250\text{V}} = -2.8 \text{ kW}$; $P_{8\text{A}} = +480 \text{ W}$

Problem 2

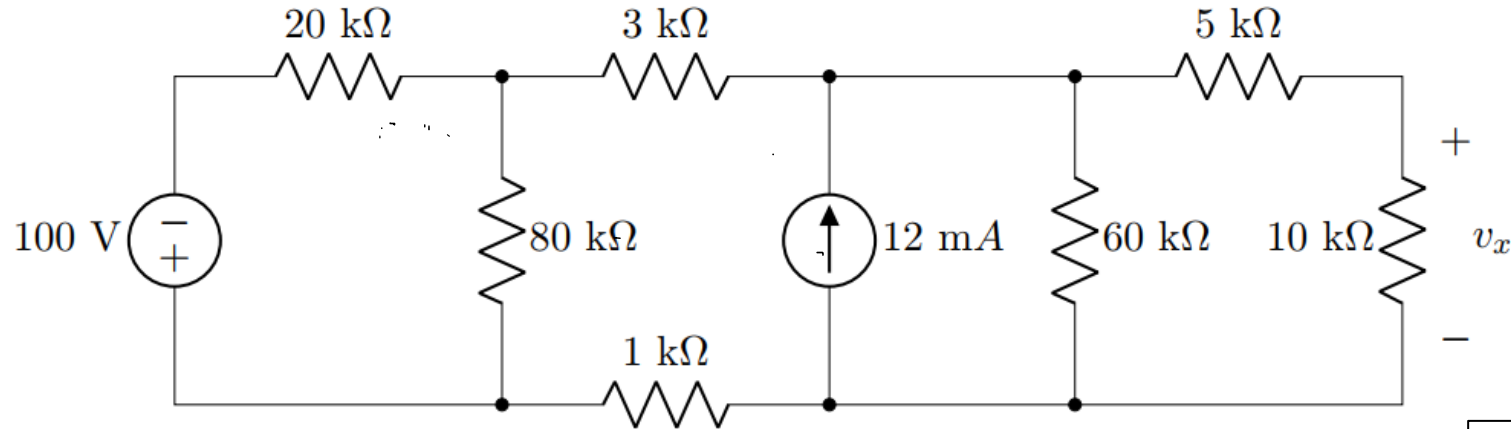
- Find i_o in the circuit using source transformation.



Ans: $i_o = 1.78 \text{ A}$

Problem 3

- Determine the voltage v_x across the $10\text{ k}\Omega$ resistor by performing a succession of appropriate Source Transformations.

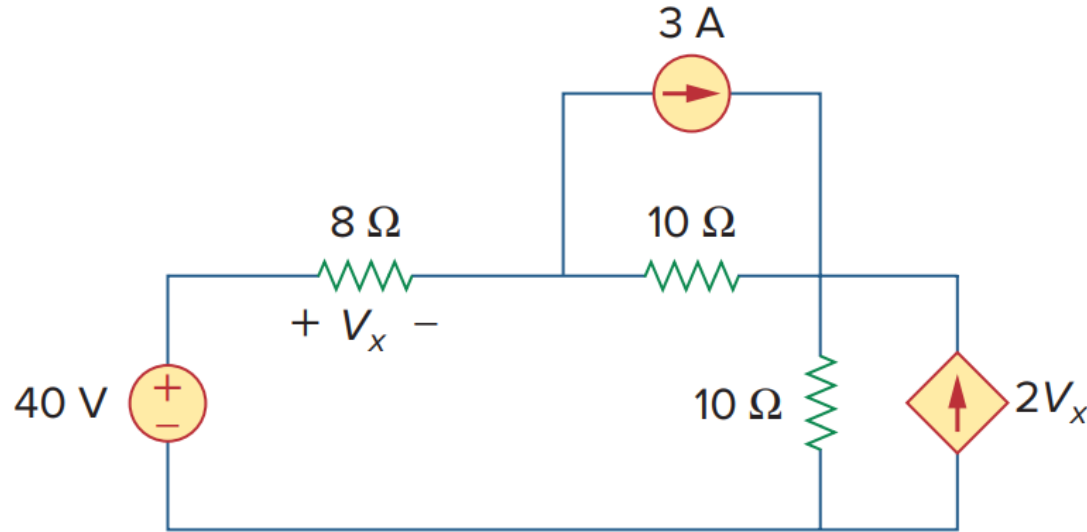


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Ans: $v_x = 40\text{ V}$

Problem 4

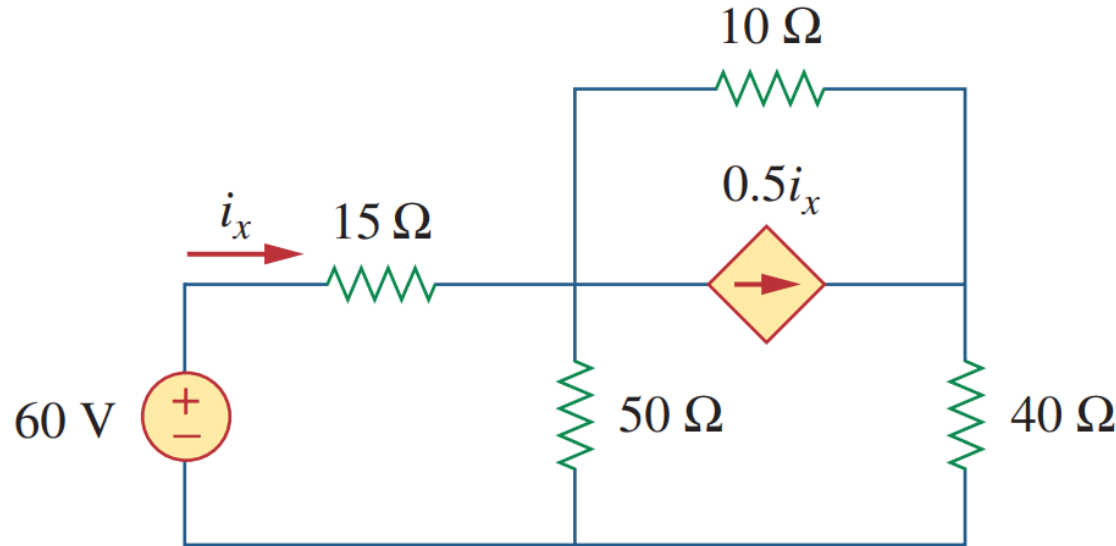
- Use source transformation to find V_x .



Ans: $V_x = 2.98\text{ V}$

Problem 5

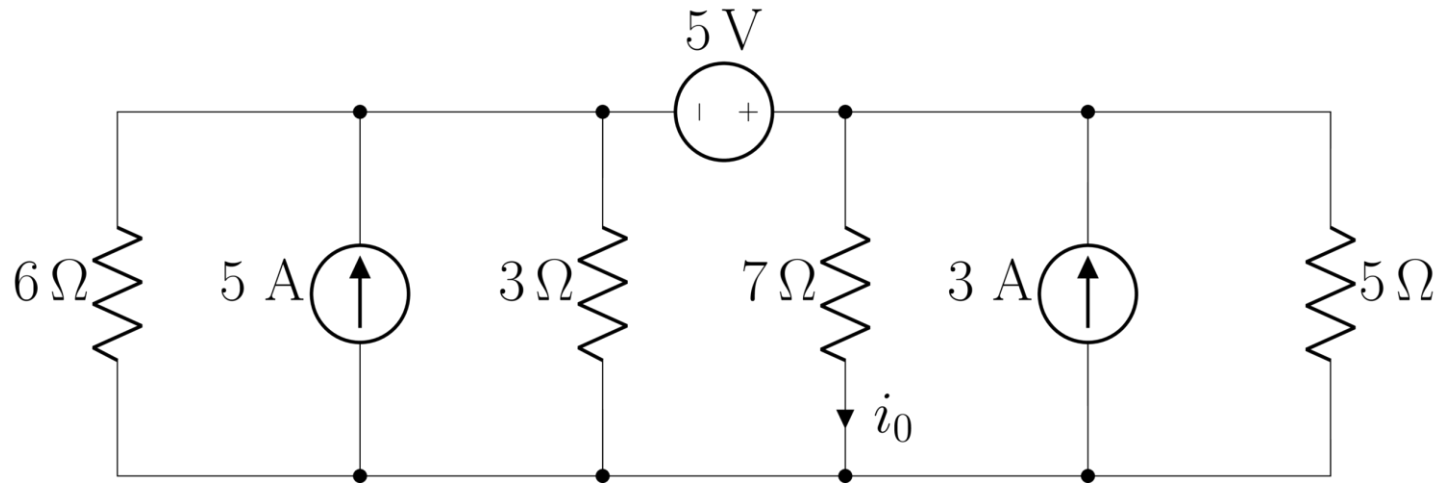
- Use source transformation to find i_x in the following circuit.



Ans: $i_x = 1.6 \text{ A}$

Problem 6

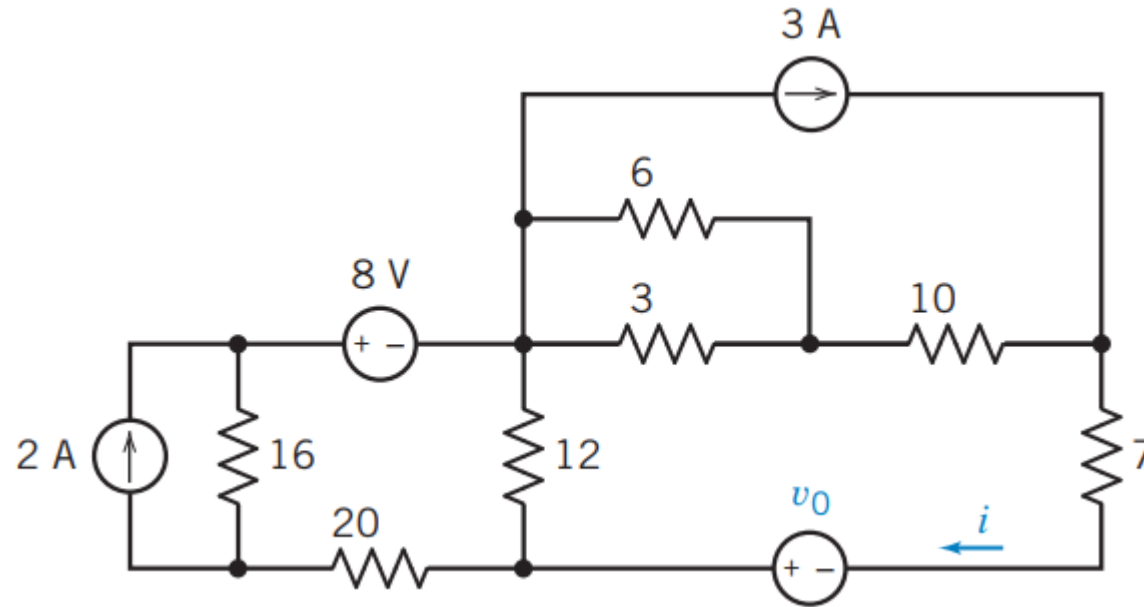
- Reduce the circuit to a single loop. Then determine i_0 .



Ans: $i_0 = 1.78\text{ A}$

Problem 7

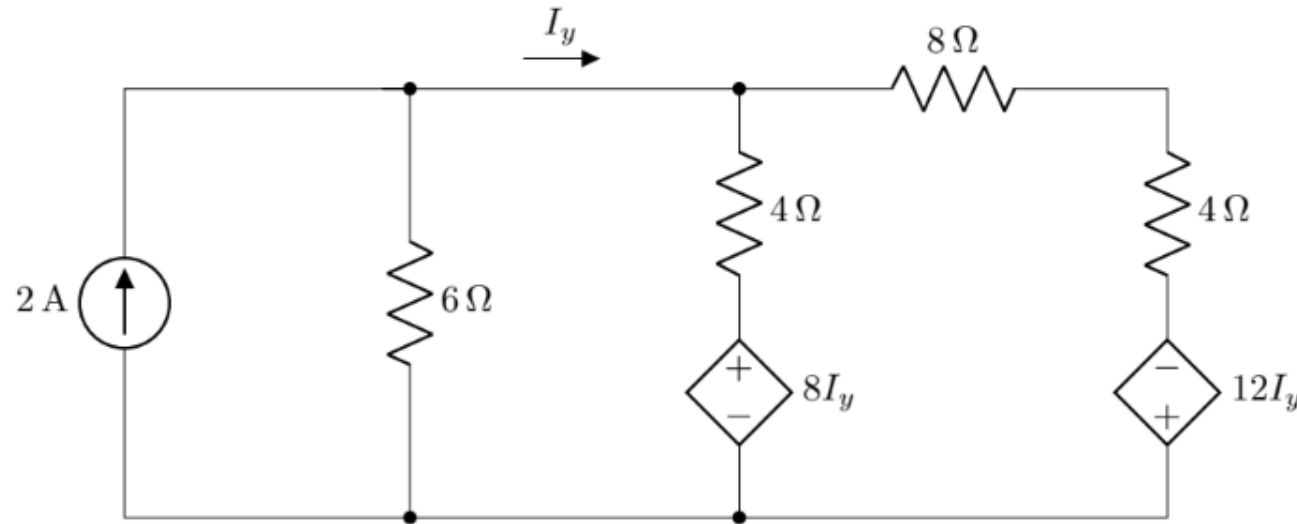
- Reduce the circuit to a single loop. Then determine v_0 .



Ans: $i_0 = 28 \text{ V}$

Problem 8

- Reduce the circuit to a single loop. Then determine I_y .



Ans: $I_y = 9\text{ A}$

Practice Problems

- Additional recommended practice problems: [here](#)
- Other suggested problems from the textbook: [here](#)

Thank you for your attention

Course Outline: broad themes

