Department of Computer Science and Engineering (CSE)
BRAC University

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CSE250 - Circuits and Electronics

SOURCE TRANSFORMATION

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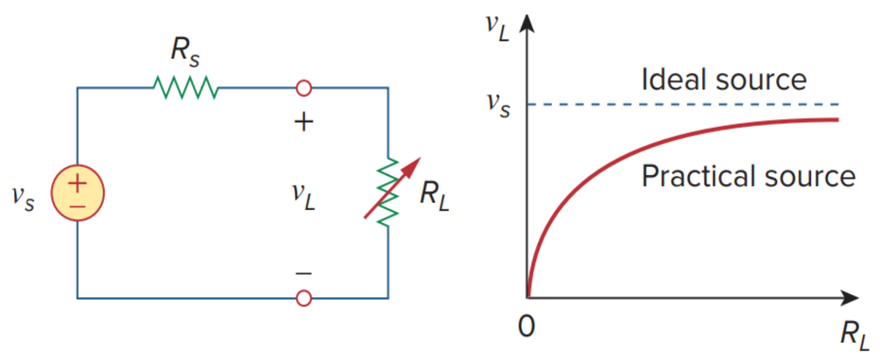
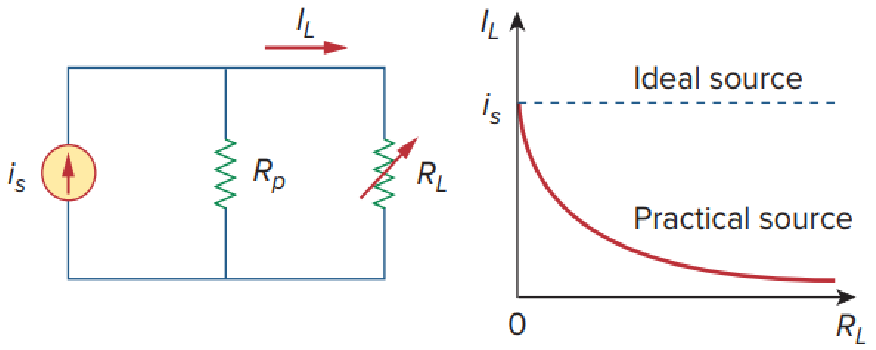
Ideal and non-ideal sources

- 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 $R_s \to 0$ and $R_p \to \infty$.

$v_L = \frac{R_L}{R_s+R_L} v_s$, if $R_s \ll R_L$ or $R_L = \infty, v_L \to v_s$	$i_L = \frac{R_p}{R_p+R_L} i_s$, if $R_p \gg R_L$ or $R_p \to \infty, i_L \to i_s$





Circuit laws, methods of analysis, & theorems

Circuit Laws

- Ohm's Law
- Kirchhoff's Current Law
- Kirchhoff's Voltage Law

Methods of analysis

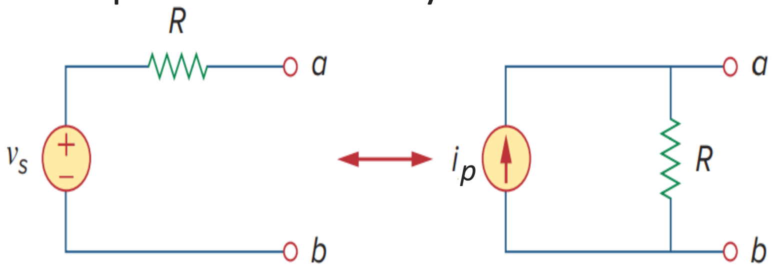
- Nodal Analysis
- Mesh Analysis

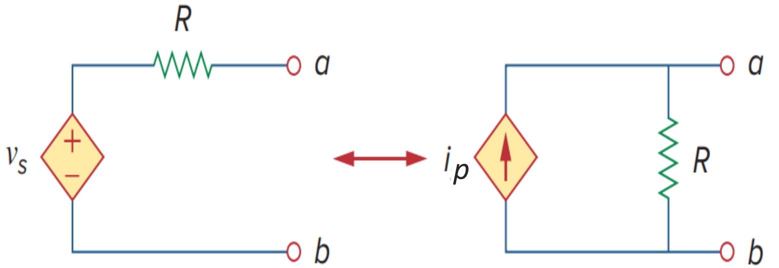
Circuit Theorems

- Superposition Theorem
- **Source Transformation**
- Thevenin's Theorem
- Norton's Theorem
- Maximum Power Transfer Theorem

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

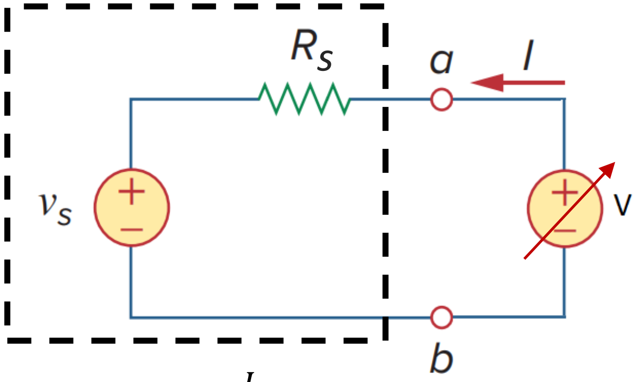
- We recall that *an equivalent circuit is one whose $I - V$ characteristics are identical with the original circuit*. Let's see what conditions make the two circuits to have the same $I - V$ relations at terminals $a - b$.

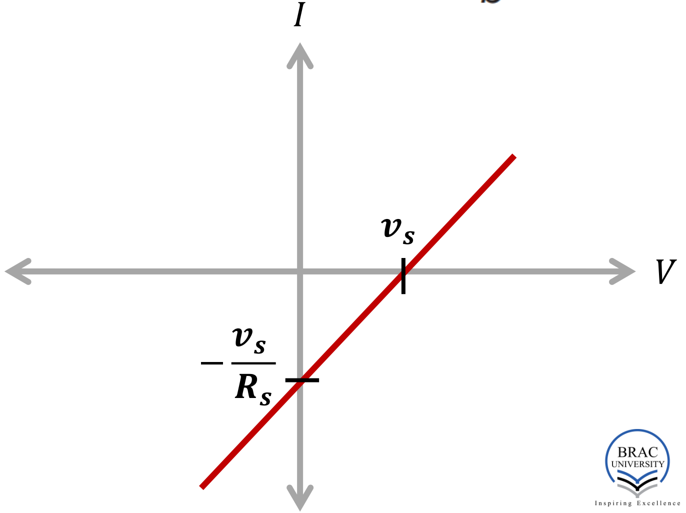
- Let's say we have a configuration of a voltage source (v_s) in series with a resistor (R_s) between terminals a and b. To determine the configuration's $I - V$ characteristics, if applying a voltage V gives rise to a current I, we can write,

$$V = v_s + IR_s$$

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

- 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,

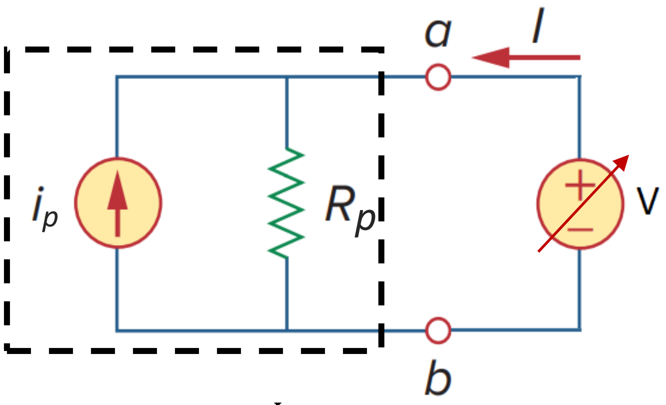
$$I + i_p$$

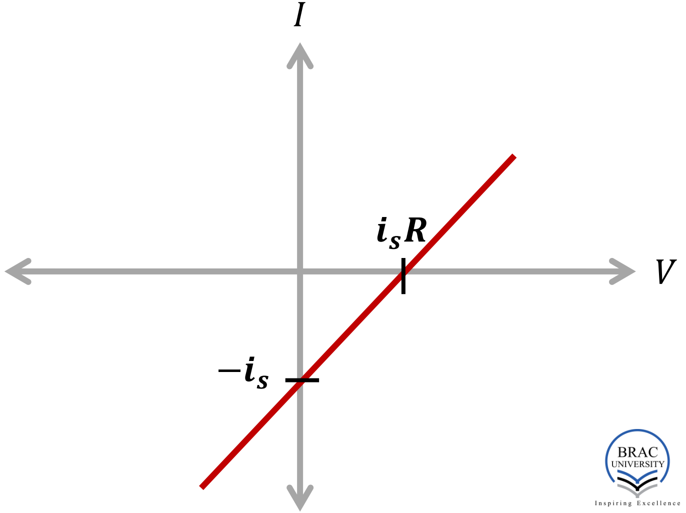
- So, the voltage across the resistor can be written as,

$$\left(I + i_p\right) R_p = V$$

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

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



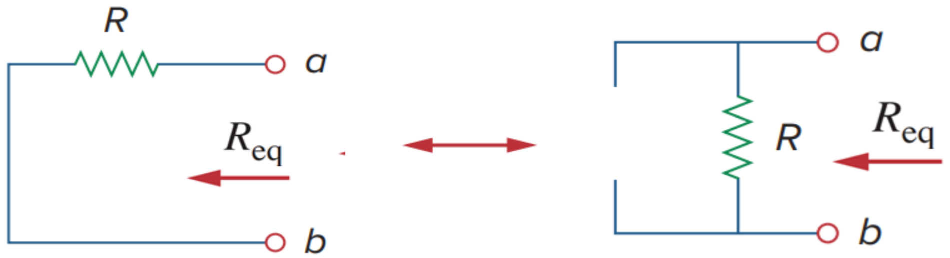


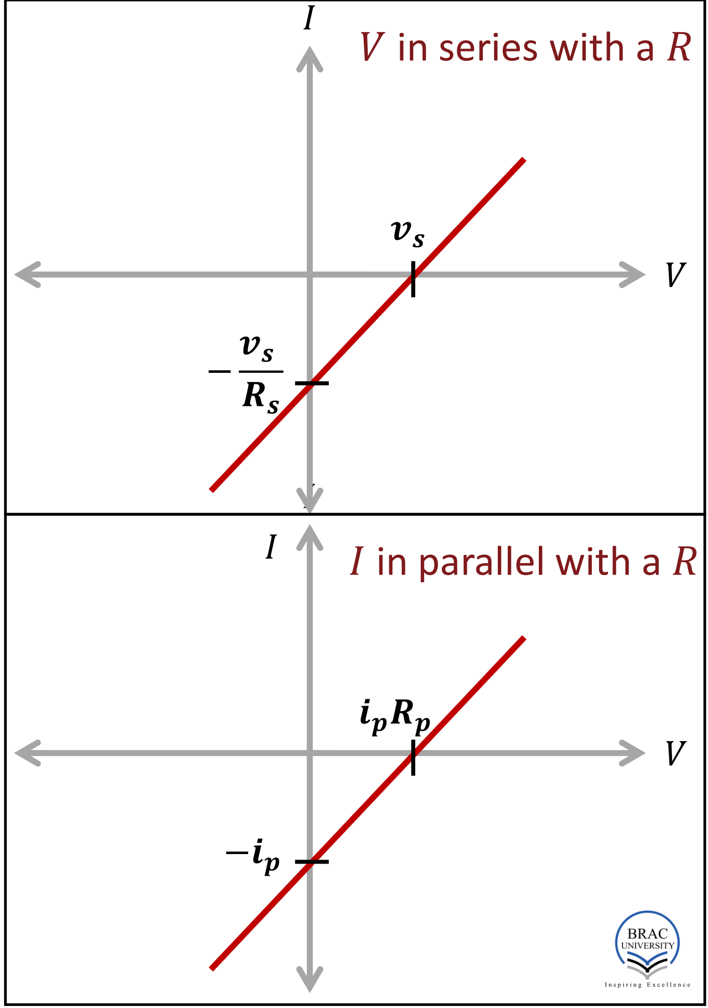
Circuit equivalency

- 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,

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

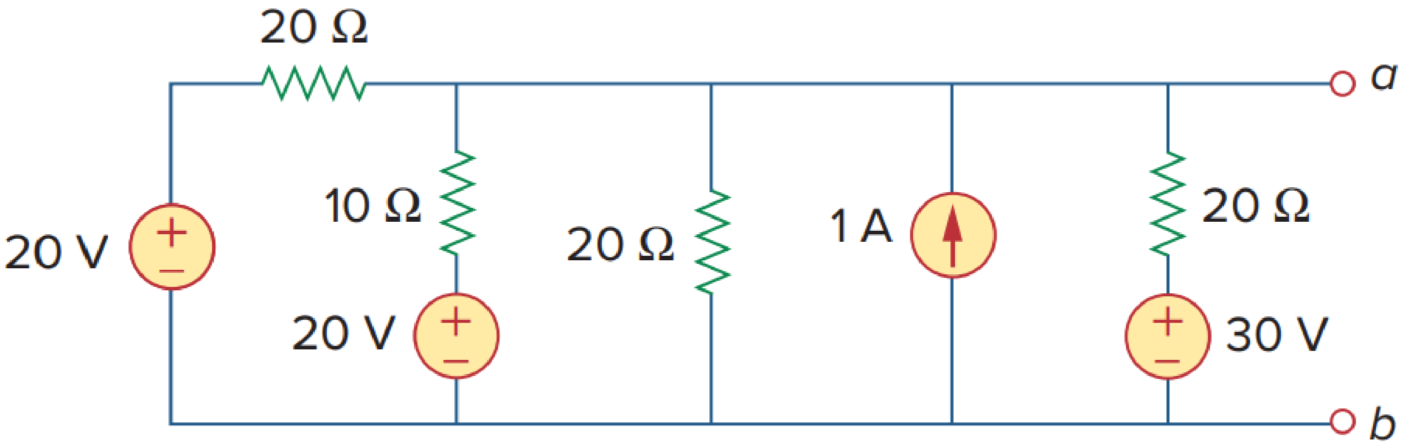
- So, if the sources are turned off, the equivalent resistance at terminals $a - b$ in both circuits is R.



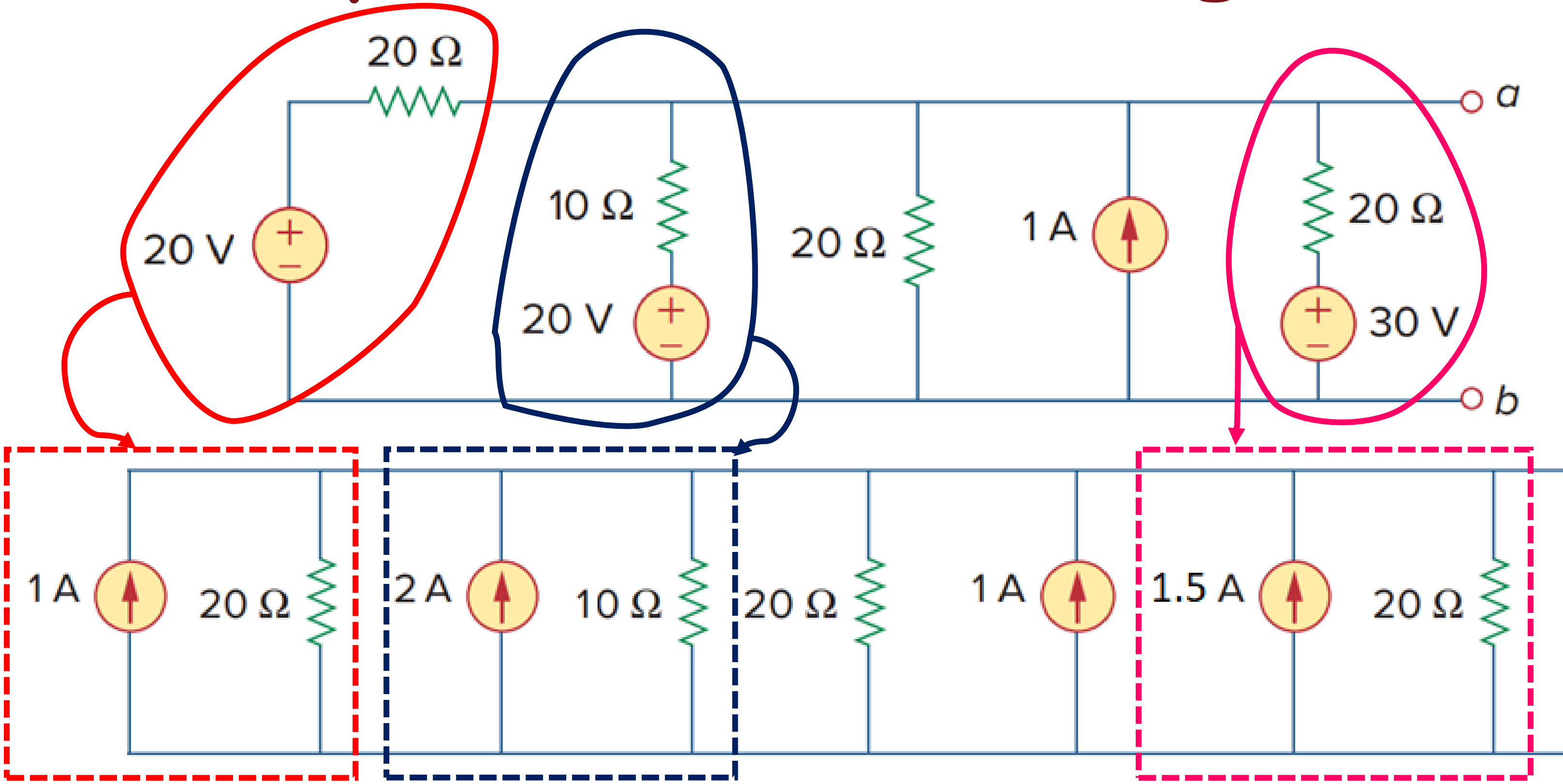


Example 1

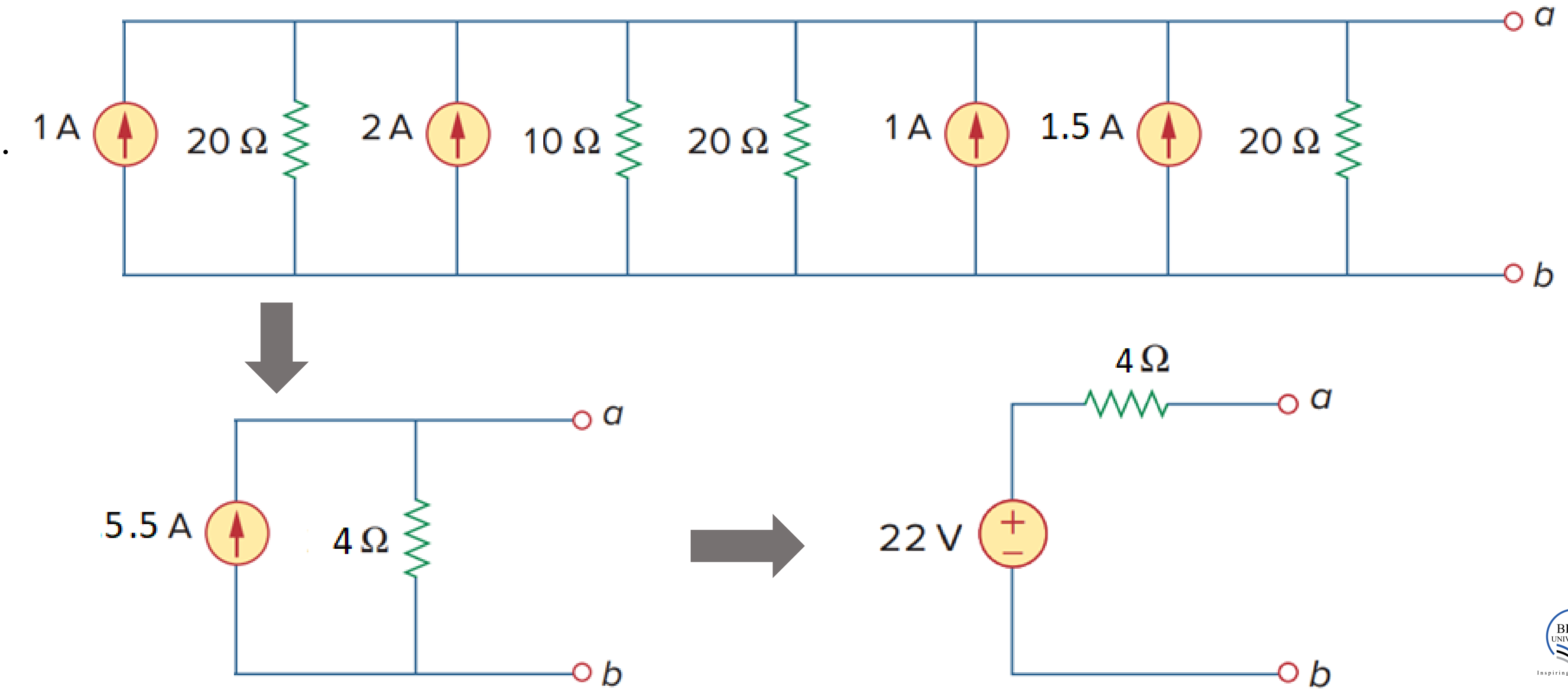
- Use source transformation to reduce the circuit between terminals *a* and *b* shown to a single voltage source in series with a single resistor.



Example 1: transforming sources

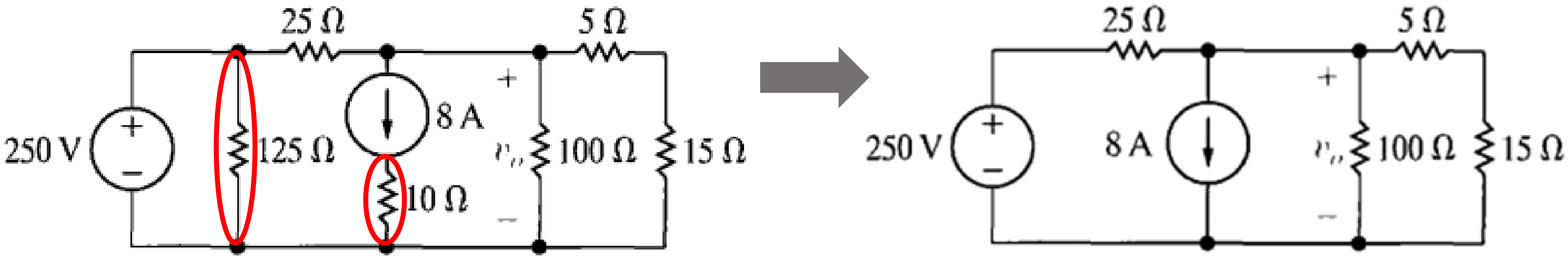


Example 1 (contd … 2)



Problem 1

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

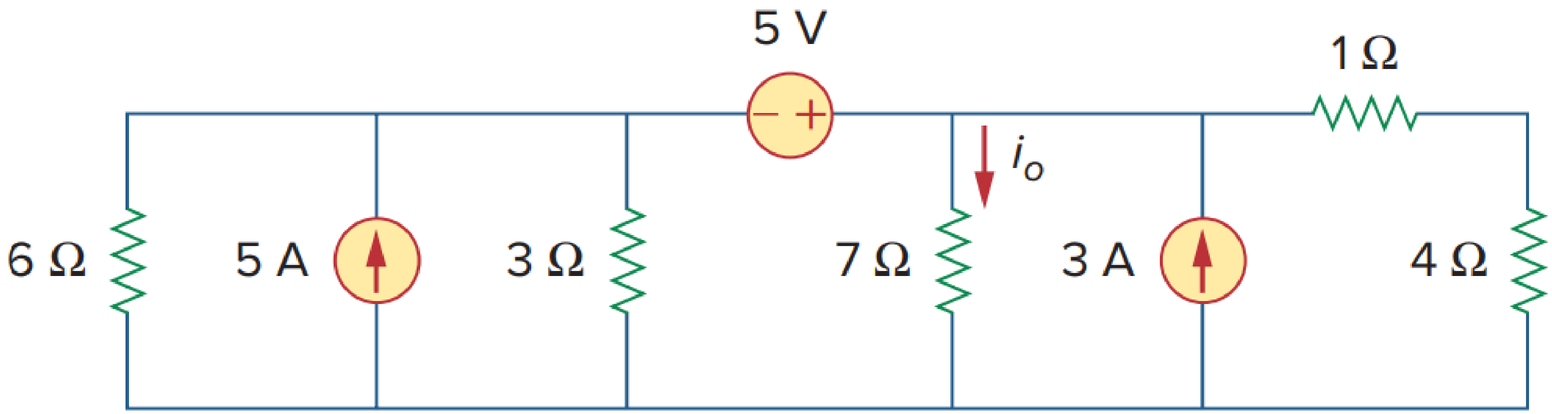


A resistor in series with a current source is redundant, as is a resistor in parallel with a voltage source. We can remove them; this will have no effect on the circuit.

Ans: $v_0 = 20\ V$; $P_{250V} = -2.3\ kW$; $P_{8A} = +160\ W$

Problem 2

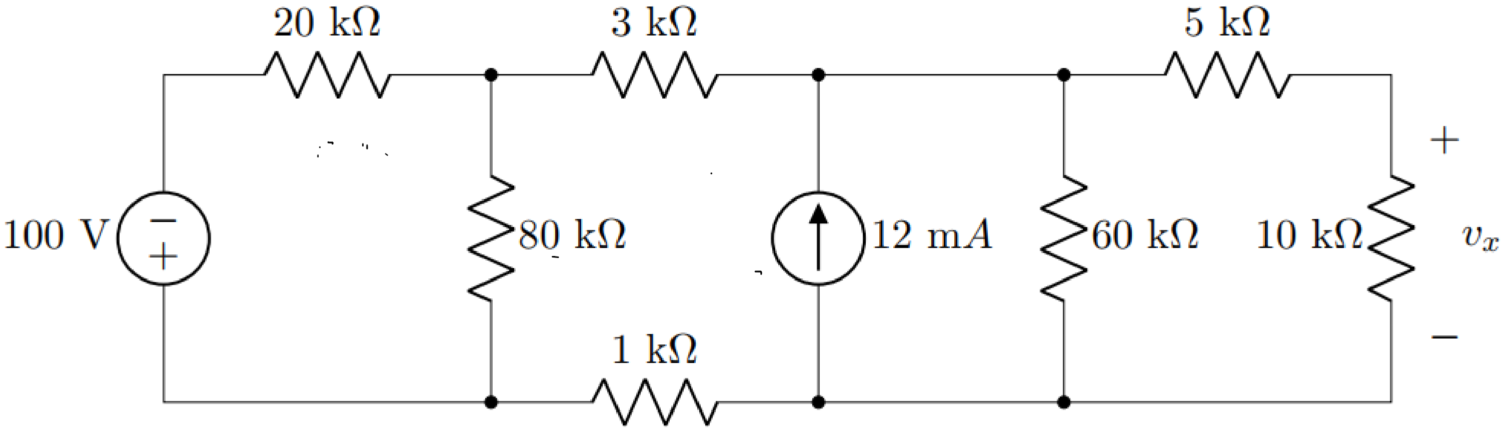
- Find i_o in the circuit using source transformation.



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

Problem 3

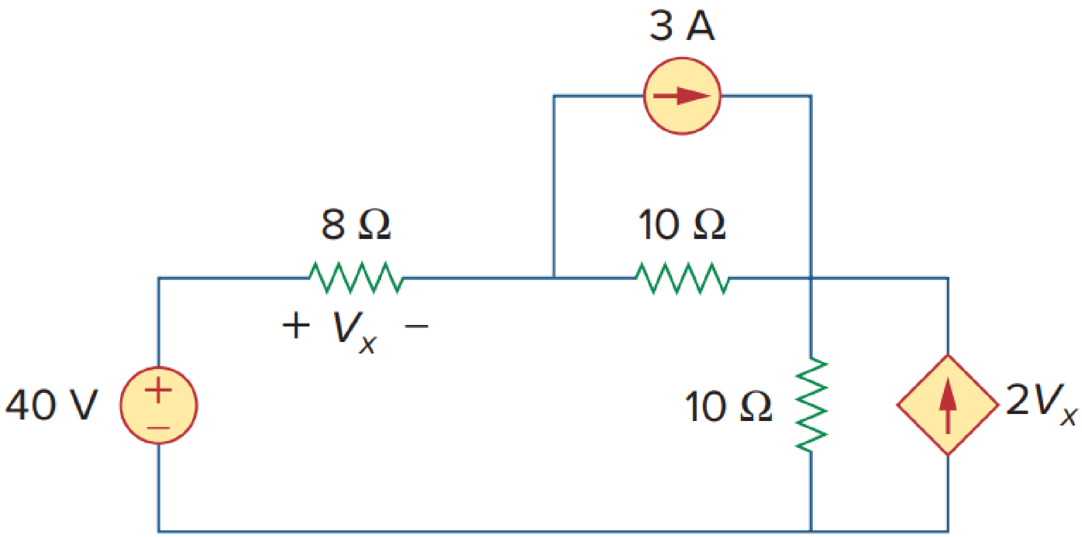
- Determine the voltage v_x across the $10\ k\Omega$ resistor by performing a succession of appropriate Source Transformations.



Ans: $v_x = 40\ V$

Problem 4

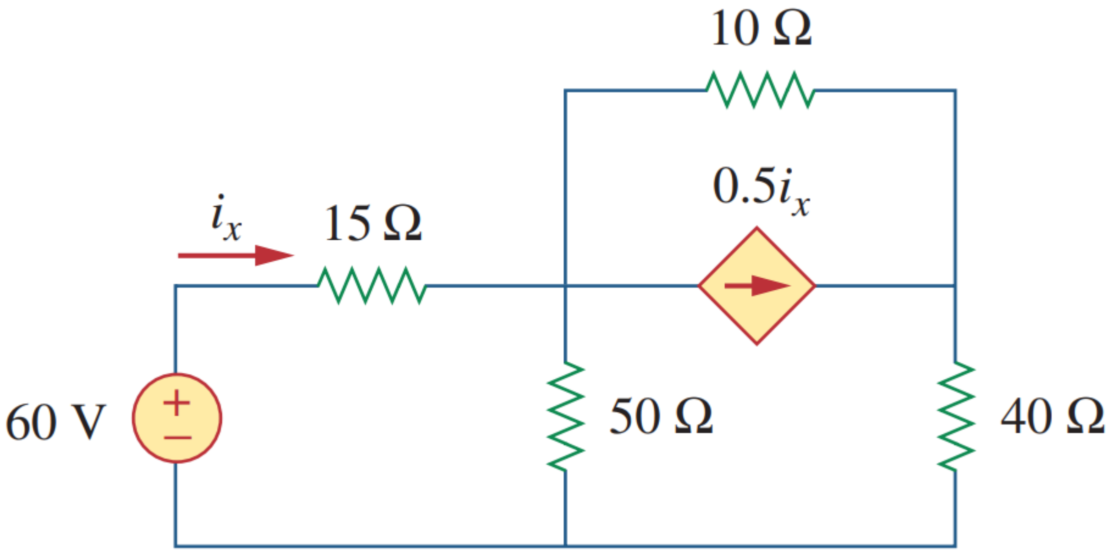
- Use source transformation to find V_x.



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

Problem 5

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



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

Practice Problems

- Additional practice problems can be found [here]()

Thank you for your attention