

Department of Computer Science and Engineering (CSE)
BRAC University

Fall 2023

CSE250 - Circuits and Electronics

SUPERPOSITION PRINCIPLE

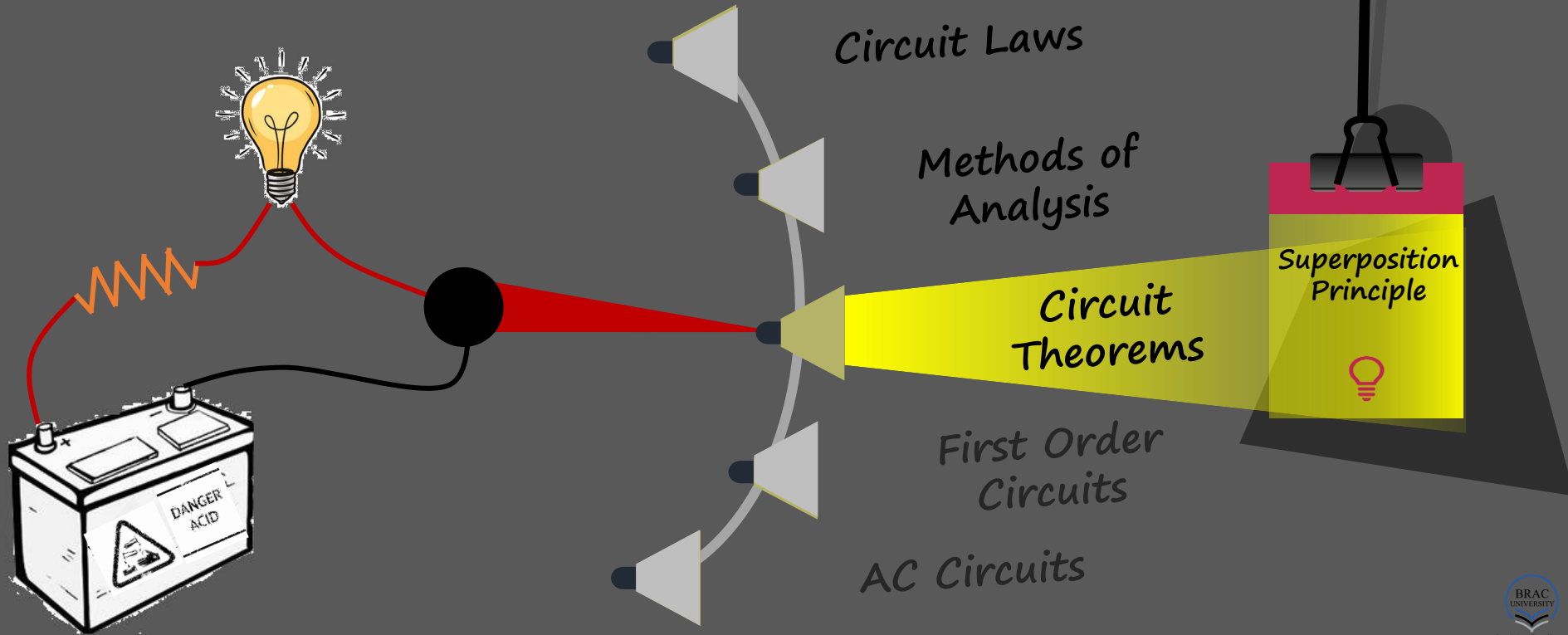


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Linearity property

- **Linearity** is the property of an element describing a linear relationship between cause and effect. The property is a combination of both the **homogeneity** (scaling) property and the **additivity** property.
- **Homogeneity property**
For a resistor, for example, Ohm's law relates the input i to the output v as $v = iR$. If the current is increased by a constant k , then the voltage increases correspondingly by k ; that is, $kv = (ki)R$.
- **Additivity property**
If applying v_1 & v_2 separately to a resistor gives rise to currents i_1 & i_2 respectively, then applying $(v_1 + v_2)$ should give rise to the current $(i_1 + i_2)$.
- A **linearity circuit** is one whose output is linearly related (or directly proportional) to its input.

Course Outline: broad themes



Superposition Principle

- The *superposition principle* states that the voltage across (or current through) an element in a linear circuit is the algebraic sum of the voltages across (or currents through) that element due to each independent source acting alone.
- Keep in mind that superposition is based on linearity. For this reason, it is not applicable to the effect on power due to each source.

$$P_{Total}^2 \neq P_1^2 + P_2^2 + \dots + P_N^2$$

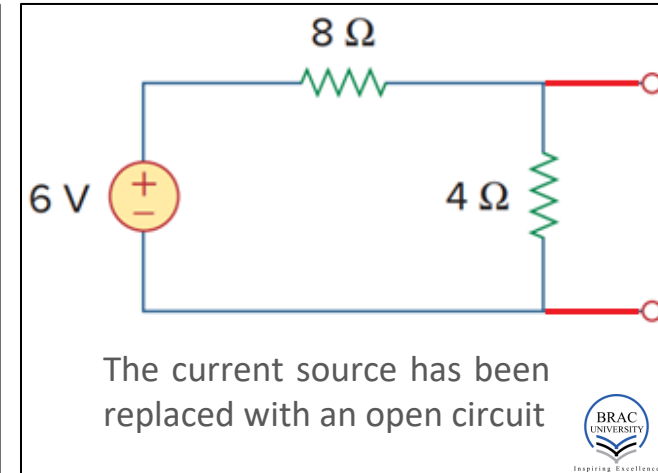
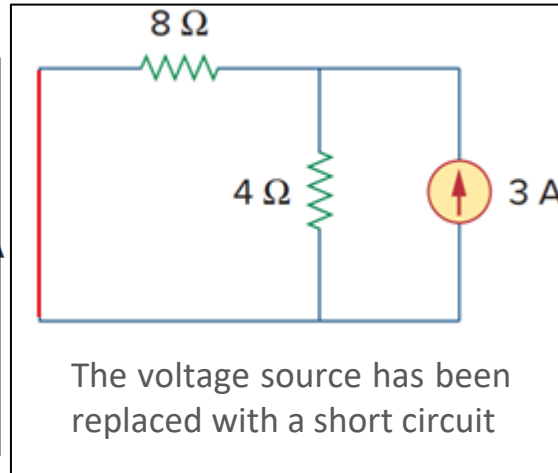
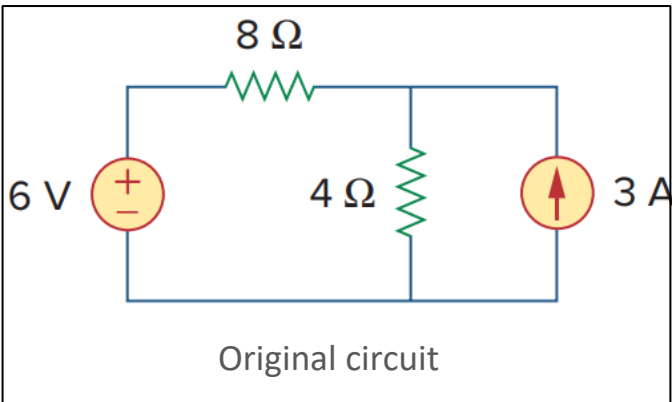
- If the power value is needed, the current through (or voltage across) the element must be calculated first using superposition.

Steps to Apply Superposition Principle:

1. Turn off all independent sources except one source. Find the output (voltage or current) due to that active source using the techniques covered in Chapters 2 and 3.
2. Repeat step 1 for each of the other independent sources.
3. Find the total contribution by adding algebraically all the contributions due to the independent sources.

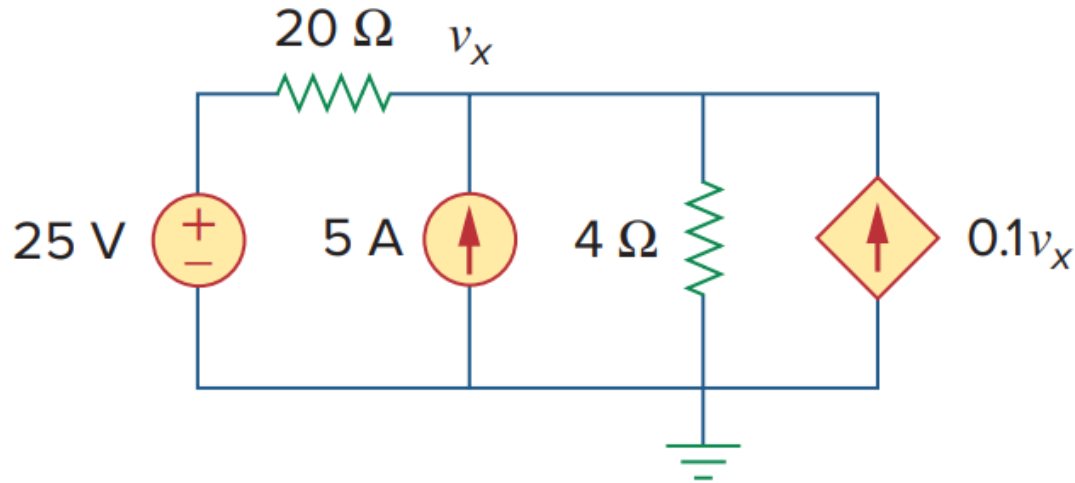
Equivalence with inactive I/V sources

- In superposition principle, we consider one independent source at a time while all other independent sources are turned off. This implies that we replace every voltage source by 0 V (or a short circuit), and every current source by 0 A (or an open circuit).
- Dependent sources are left intact because they are controlled by circuit variables.



Example 1

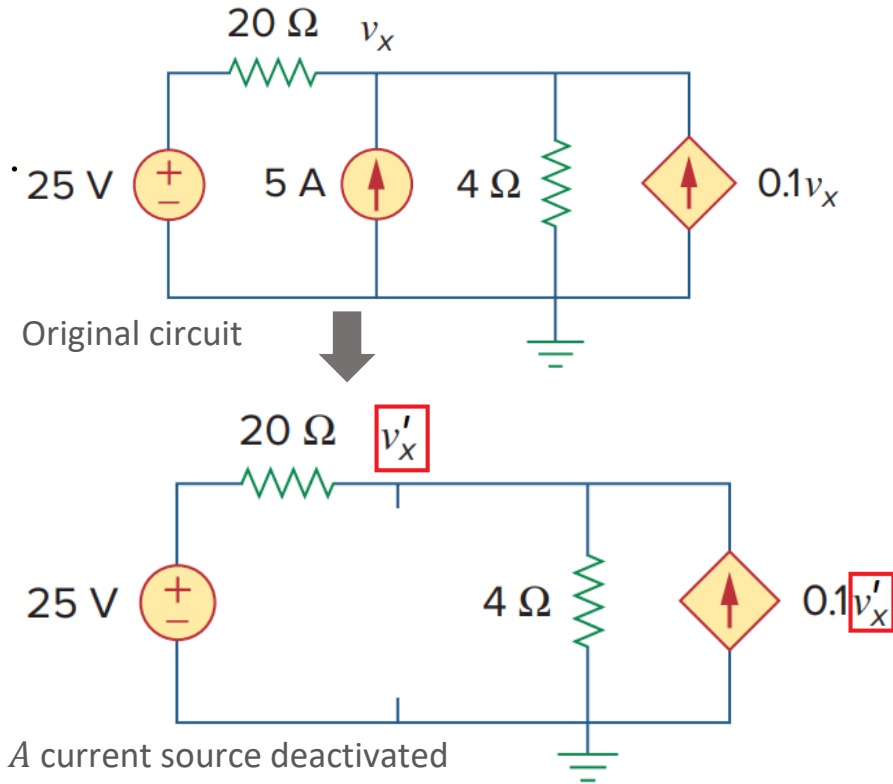
- Use Superposition Principle to find v_x .



There are two independent and one dependent sources. The principle requires us to determine the individual contributions of the two independent sources to the node voltage v_x . If v'_x and v''_x are the contributions from the 25 V voltage source and 5 A current source respectively, then

$$v_x = v'_x + v''_x.$$

Example 1: 25 V source is active



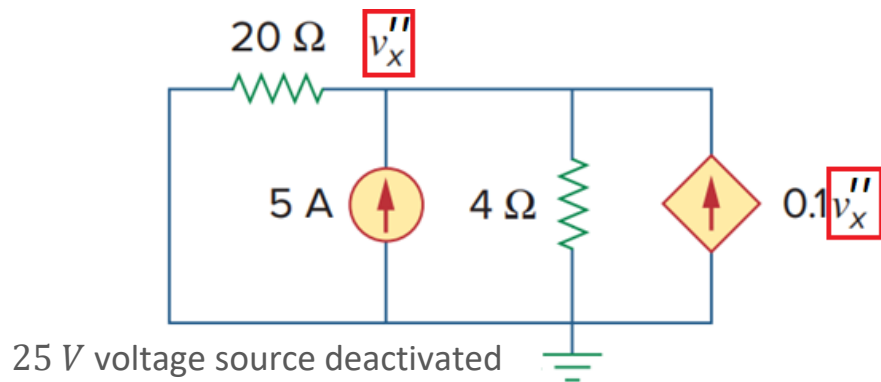
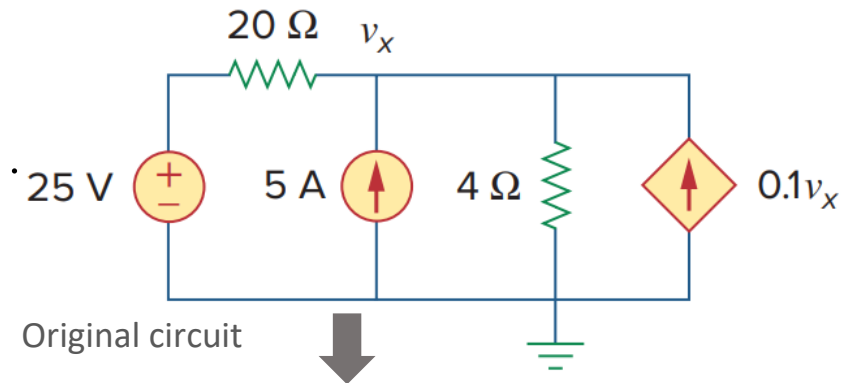
- The 5 A current source has been replaced by an open circuit. The notation v_x is replaced by v'_x .
- Different circuit solving techniques (nodal analysis or mesh analysis or source transformation or voltage division) can be applied to solve for v'_x . Nodal analysis may be the easiest one.

- KCL at the node v'_x ,

$$\frac{v'_x - 25}{20} + \frac{v'_x}{4} = 0.1v'_x$$

Simplification yields, $v'_x = 6.25 \text{ V}$

Example 1: 5 A source is active



- The 25 V voltage source has been replaced by a short circuit. The notation v_x is replaced by v_x'' .

- KCL at the node v_x'' ,

$$\frac{v_x''}{20} + \frac{v_x''}{4} = 5 + 0.1v_x''$$

Simplification yields, $v_x'' = 25 \text{ V}$

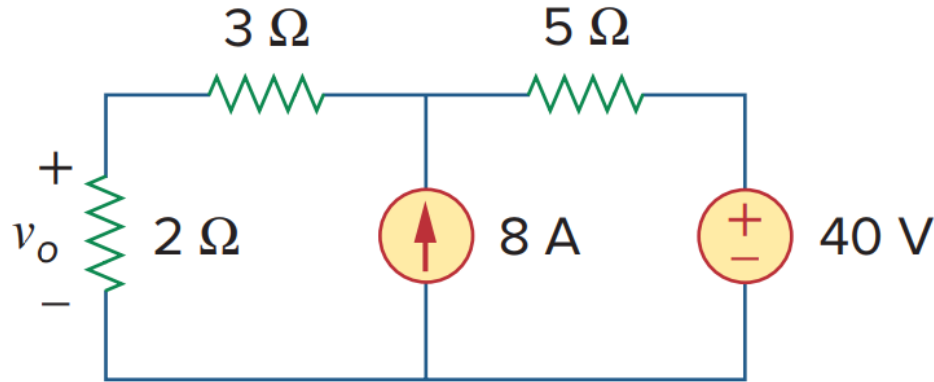
So, according to the Superposition Principle,

$$v_x = v_x' + v_x''$$

$$\Rightarrow v_x = 6.25 + 25 = 31.25 \text{ V}$$

Problem 1

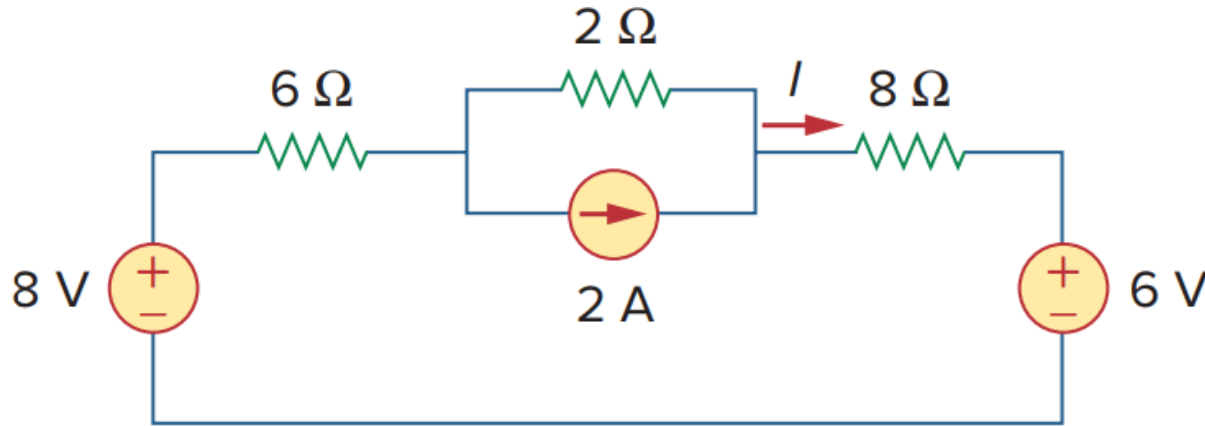
- Using the Superposition Theorem, find v_o .



Ans: $v_o = 16\text{ V}$

Problem 2

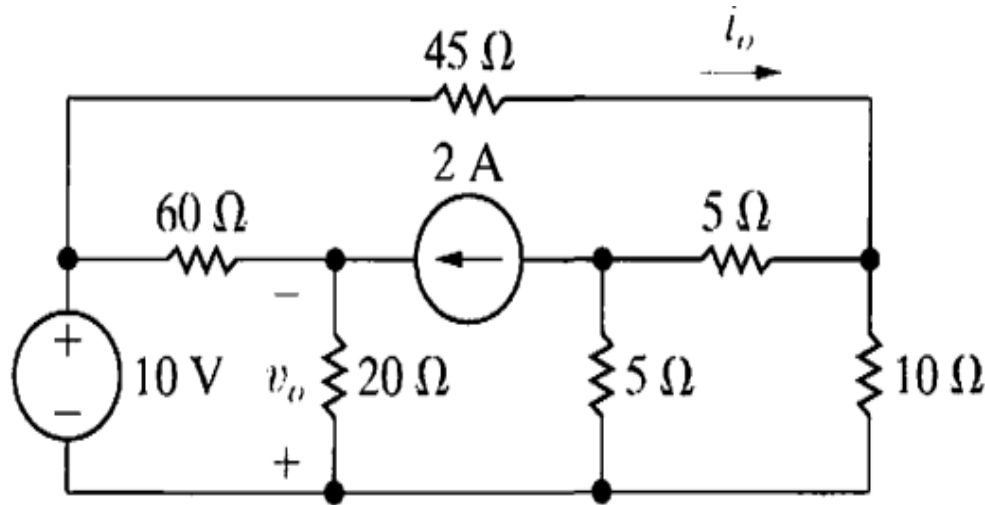
- Find I in the circuit using the Superposition Principle.



Ans: $i_0 = 0.375\text{ A}$

Problem 3

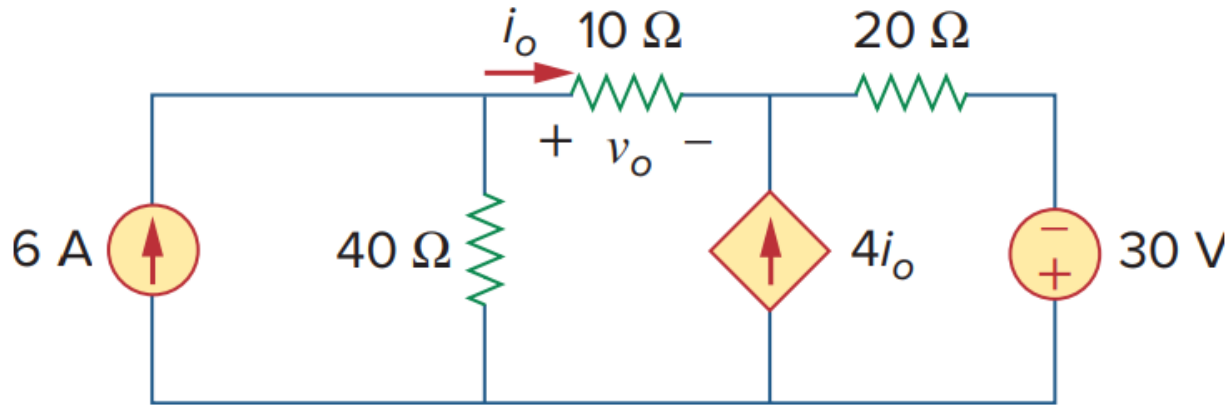
- Use Superposition Principle to solve for i_0 and v_0 .



Ans: $i_0 = 0.2 + 0.1 = 0.3 \text{ A}$; $v_0 = -2.5 - 30 \text{ V} = -32.5 \text{ V}$

Problem 4

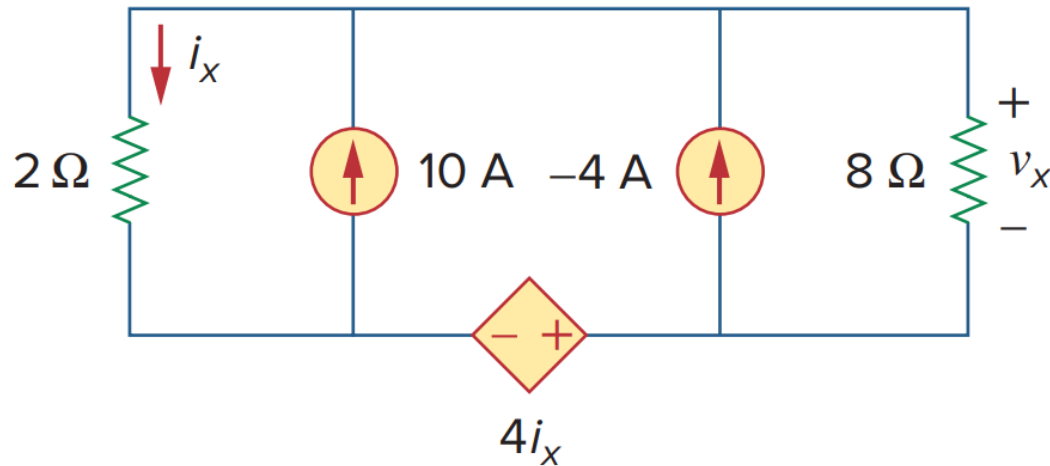
- Use the Superposition Principle to find i_o and v_o .



Ans: $i_o = 1.8 \text{ A}$; $v_o = 18 \text{ V}$

Problem 5

- Use Superposition Principle to solve for v_x .



Ans: $v_x = -16\text{ V}$

Practice Problems

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

Thank you for your attention