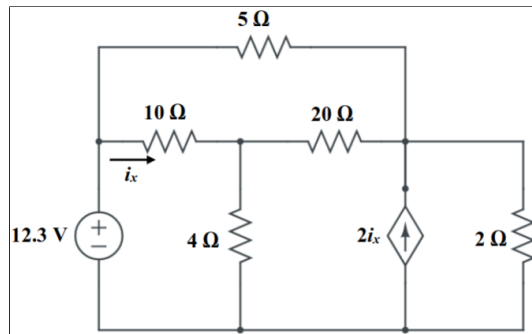


## EXAMPLES OF CIRCUIT DIAGRAM RECOGNITION AND UNDERSTANDING

The following example shows that GPT-4o provides unreliable information when asked to list the elements in a circuit diagram and explain how these elements are connected.

Note: For the responses of GPT-4o, we mark the incorrect parts with a **red** background and the dubious contents with a **yellow** background. In addition, we mark with the **green** background the response segments that we would like to highlight as correct.

User



Now you play the role of an expert in circuit analysis. Can you explain how many elements are in the attached circuit diagram and how these elements are connected with each other?

GPT-4o

The given circuit diagram consists of several elements, and they are connected as follows:

### Elements:

1. Voltage Source:
  - One voltage source of 12.3 V.
2. Resistors:
  - **Six resistors** with the following values:
  - 5  $\Omega$
  - 10  $\Omega$
  - 20  $\Omega$
  - 4  $\Omega$
  - 2  $\Omega$  (**two resistors** of this value)
3. Dependent Current Source:
  - One dependent current source with a value of  $2i_x$ , where  $i_x$  is the current through the 10  $\Omega$  resistor.

### Connections:

1. Voltage Source:
  - The positive terminal of the 12.3 V voltage source is connected to one end of the 4  $\Omega$  resistor and the 10  $\Omega$  resistor.
2. 10  $\Omega$  Resistor:
  - One end is connected to the positive terminal of the voltage source, and the other end is connected to the 20  $\Omega$  resistor, where the current  $i_x$  is defined.
3. 20  $\Omega$  Resistor:
  - One end is connected to the 10  $\Omega$  resistor, and the other end is connected to a node that connects to the dependent current source and one of the 2  $\Omega$  resistors.
4. 4  $\Omega$  Resistor:
  - One end is connected to the positive terminal of the voltage source, and the other end is connected to the bottom node (ground).
5. 5  $\Omega$  Resistor:
  - Connected between the top node (the junction of the 10  $\Omega$  and 20  $\Omega$  resistors) and the bottom node (ground).
6. Dependent Current Source ( $2i_x$ ):
  - The positive terminal is connected to the bottom node (ground), and the negative terminal is connected to a node that also connects to the 20  $\Omega$  resistor and one of the 2  $\Omega$  resistors.
7. First 2  $\Omega$  Resistor:
  - One end is connected to the node where the 20  $\Omega$  resistor and the dependent current source meet, and the other end is connected to the bottom node (ground).
8. Second 2  $\Omega$  Resistor:
  - One end is connected to the node where the 4  $\Omega$  resistor connects to the voltage source and the other end is connected to the bottom node (ground).

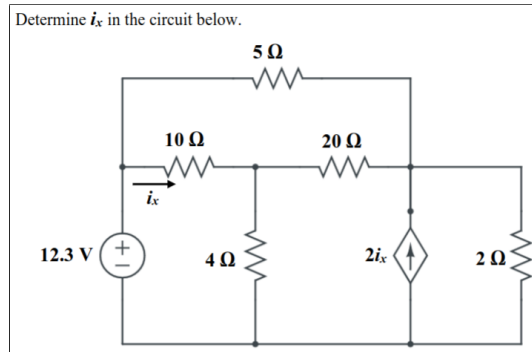
The circuit consists of six resistors, one independent voltage source, and one dependent current source. The resistors and sources are interconnected as described, forming a network with multiple branches and nodes.

The example above demonstrates that GPT-4o is unable to reliably identify the circuit elements in the circuit diagram. Since these diagrams contain most of the problem information<sup>1</sup>, GPT-4o lacks the necessary context to evaluate a student's solution accurately if no additional information about the specific problem is provided. This is where the official solutions, along with their final answers, play a critical role in the LLM prompt. They offer detailed information for specific problems and serve as reference benchmarks for homework assessment, enabling LLMs to understand what each problem requires without having to infer it.

<sup>1</sup>In this example, the text portion of the problem description is simply, "Determine  $i_x$  in the circuit below."

The following example demonstrates that GPT-4o cannot solve a provided circuit analysis problem, which is expected since GPT-4o cannot even understand the associated circuit diagram, as illustrated in the previous example. However, we note that GPT-4o does recognize that KCL should be applied to different nodes.

User



Now you play the role of an expert in circuit analysis. Can you solve the circuit analysis problem in the attached image?

GPT-4o

Sure, I can help you analyze this circuit. Let's follow these steps to find  $i_x$ :

1. Label the Nodes and Write Node-Voltage Equations:
  - Let's label the node where the 12.3V source is connected as  $V_1$ .
  - Let's label the node where the  $10\ \Omega$  and  $20\ \Omega$  resistors meet as  $V_2$ .
  - Let the voltage at the bottom of the circuit be 0V (ground).
2. Apply Kirchhoff's Current Law (KCL) at each Node:

– At node  $V_1$ :

$$\frac{V_1 - 12.3}{10} + \frac{V_1 - V_2}{4} + \frac{V_1}{5} = 0$$

– At node  $V_2$ :

$$\frac{V_2 - V_1}{4} + \frac{V_2}{20} + \frac{V_2}{2} = 2i_x$$

Since  $i_x = \frac{V_1 - 12.3}{10}$ , substitute  $i_x$  in the above equation.

$$2i_x = 2 \cdot \frac{V_1 - 12.3}{10}$$

3. Simplify and Solve the Equations:

– First Equation:

$$\frac{V_1 - 12.3}{10} + \frac{V_1 - V_2}{4} + \frac{V_1}{5} = 0$$

Simplifying,

$$\frac{V_1 - 12.3}{10} + \frac{V_1 - V_2}{4} + \frac{V_1}{5} = 0$$

$$\frac{V_1 - 12.3}{10} + \frac{V_1 - V_2}{4} + \frac{2V_1}{10} = 0$$

$$\frac{V_1 - 12.3}{10} + \frac{2.5V_1 - 2.5V_2}{10} = 0$$

$$V_1 - 12.3 + 2.5V_1 - 2.5V_2 = 0$$

$$3.5V_1 - 2.5V_2 = 12.3$$

$$7V_1 - 5V_2 = 24.6 \quad (\text{Equation 1})$$

– Second Equation:

$$\frac{V_2 - V_1}{4} + \frac{V_2}{20} + \frac{V_2}{2} = 2 \cdot \frac{V_1 - 12.3}{10}$$

Simplifying,

$$\frac{V_2 - V_1}{4} + \frac{V_2}{20} + \frac{V_2}{2} = \frac{2(V_1 - 12.3)}{10}$$

$$\frac{V_2 - V_1}{4} + \frac{V_2}{20} + \frac{V_2}{2} = \frac{V_1 - 12.3}{5}$$

$$5(V_2 - V_1) + V_2 + 10V_2 = 4(V_1 - 12.3)$$

$$16V_2 - 5V_1 = 4V_1 - 49.2$$

$$16V_2 - 9V_1 = -49.2$$

$$9V_1 - 16V_2 = 49.2 \quad (\text{Equation 2})$$

4. Solve the System of Linear Equations:

– We now have two equations:

$$7V_1 - 5V_2 = 24.6 \quad (\text{Equation 1})$$

$$9V_1 - 16V_2 = 49.2 \quad (\text{Equation 2})$$

Let's solve these equations for  $V_1$  and  $V_2$ :

From Equation 1,

$$V_2 = \frac{7V_1 - 24.6}{5}$$

Substitute  $V_2$  into Equation 2:

$$9V_1 - 16\left(\frac{7V_1 - 24.6}{5}\right) = 49.2$$

$$9V_1 - \frac{112V_1 - 393.6}{5} = 49.2$$

$$45V_1 - 112V_1 + 393.6 = 246$$

$$-67V_1 = -147.6$$

$$V_1 = \frac{147.6}{67} \approx 2.204$$

Now, substitute  $V_1$  back into Equation 1:

$$V_2 = \frac{7(2.204) - 24.6}{5} \approx -1.676$$

Finally, we find  $i_x$ :

$$i_x = \frac{V_1 - 12.3}{10} = \frac{2.204 - 12.3}{10} \approx -1.01 \text{ A}$$

Thus,  $i_x$  is approximately  $-1.01 \text{ A}$ .