

**Florida Gulf Coast University**  
**U. A. Whitaker College of Engineering**

BME 3506C Circuits for Bioengineers

Fall 2025

Exam #1

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You have 75 minutes to complete this exam. The questions should not take long to answer if you know the material. I recommend that you first read all the problems so that you can think about it as you work on other problems. Do the easier ones first so that you get the majority of the exam complete early.

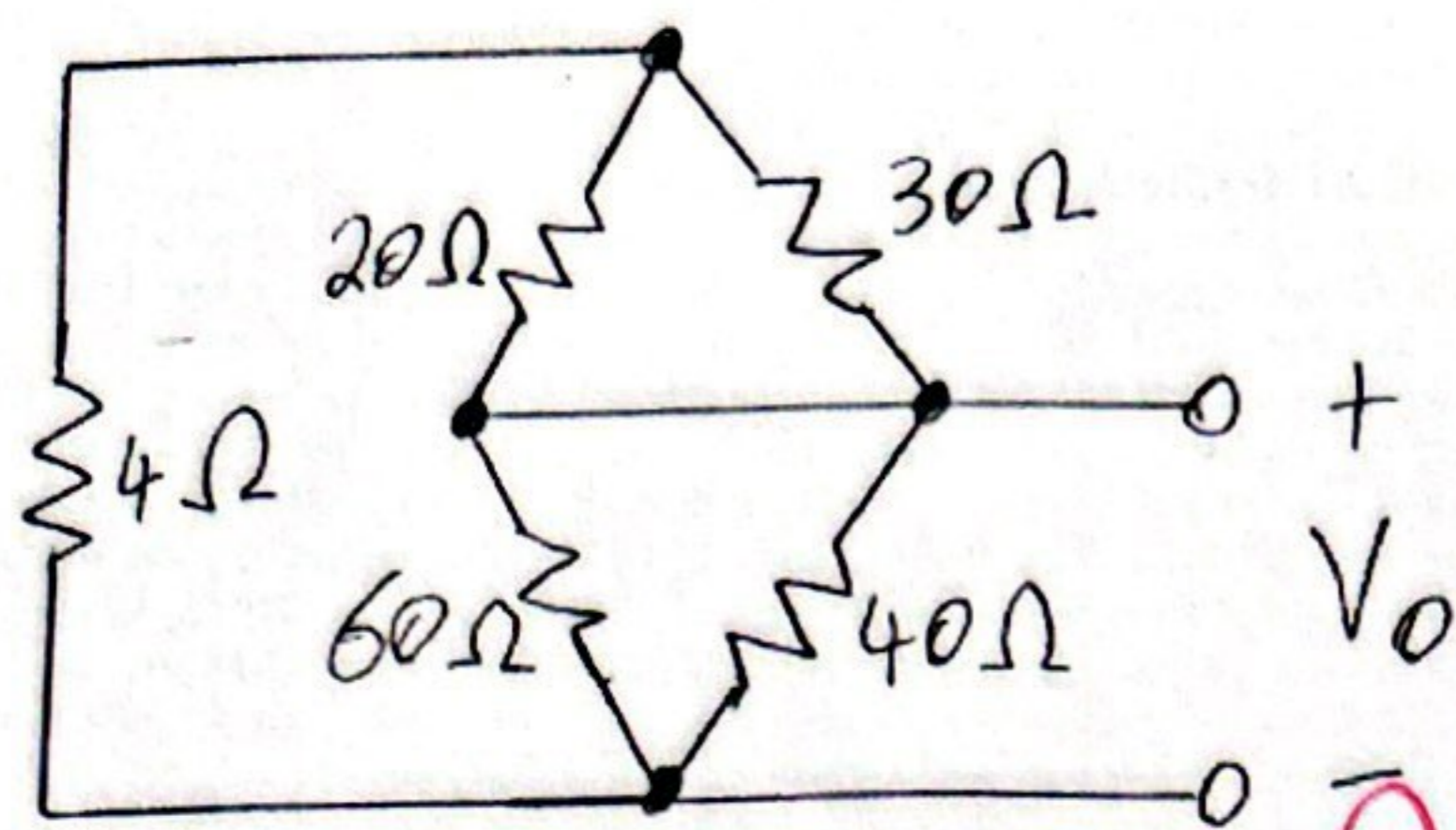
You are not to use any other electronic device besides your calculator.

There are some equations on the last page that you may find helpful.

Circle your answers.

**Turn off your phone, laptop, I-pad, I-pod, and any other electronic device.**

1. Given the following circuit, find the equivalent resistance at  $V_0$  by combining resistors in series and parallel.

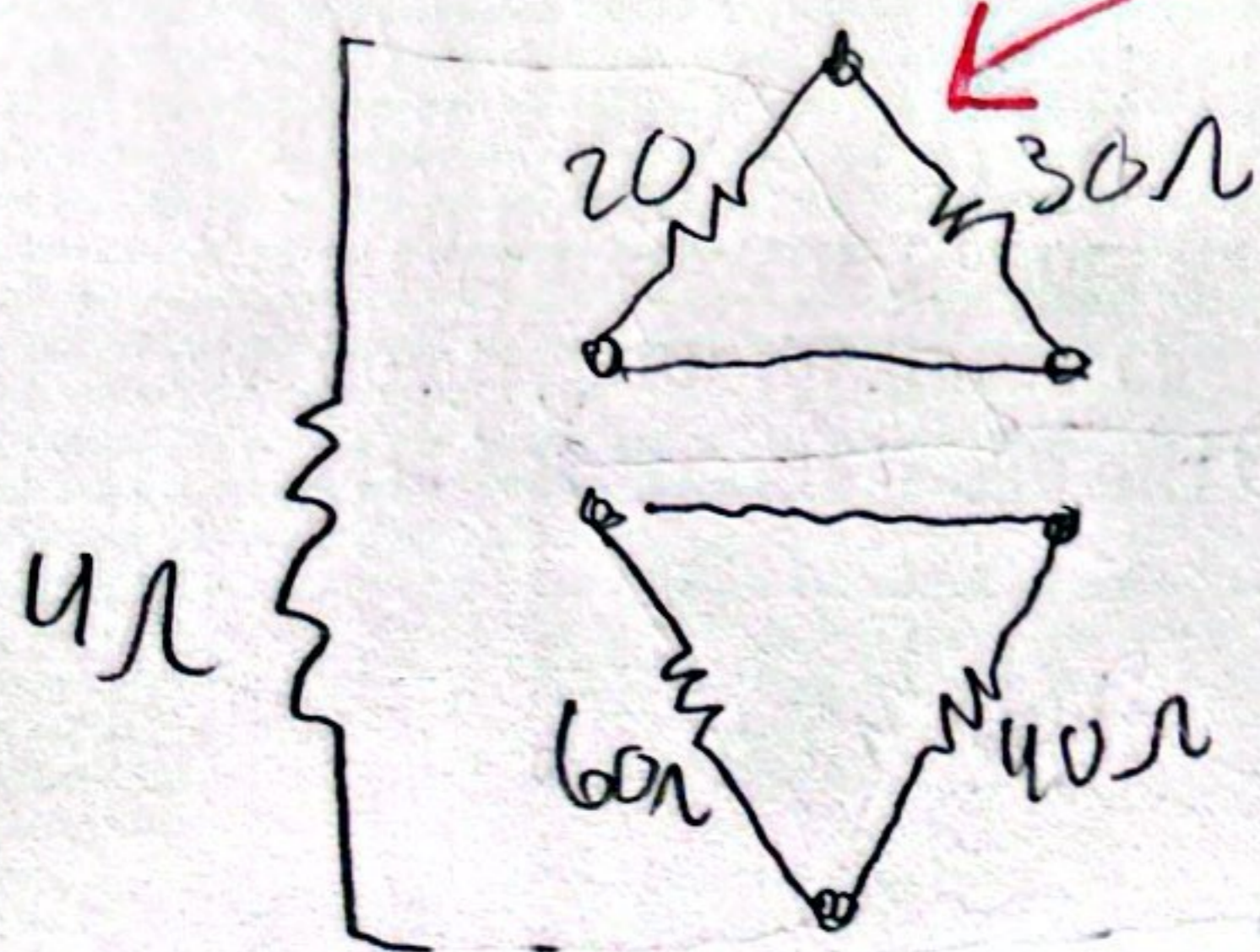


parallel  $20 \parallel 30$

$$R_{eq} = ((20 + 30) \parallel (60 + 40)) \parallel 4$$

$$20 + 30 = 50 \quad 60 + 40 = 100$$

$$R_{eq} = (50) \parallel (100) \parallel 4$$

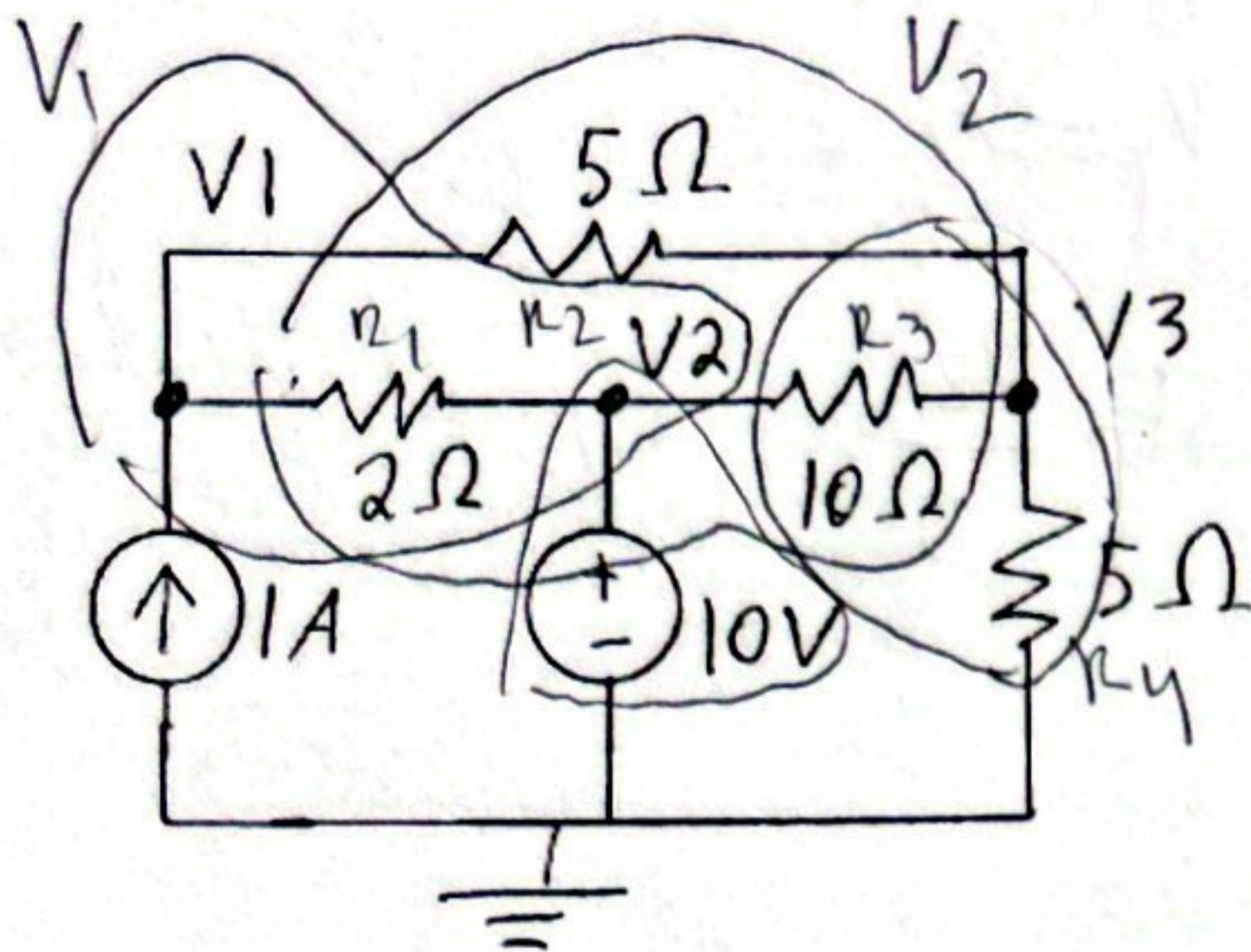


$$R_{eq\ 50, 100} = \frac{50 \cdot 100}{50 + 100} = \frac{5000}{150} = 33.33 \Omega$$

$$R_{eq} = \frac{(33.33)(4)}{(33.33 + 4)} = \frac{133.33}{37.33} = 3.5716 \Omega$$

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2. For the following circuit find  $V_1, V_2, V_3$ . Put the problem into matrix form but do not solve the simultaneous equations. I need to see the initial equations before simplifying as well as the numbers in the matrices.



$$V_1: \frac{V_1 - V_2}{2\Omega} + \frac{V_1 - V_3}{5\Omega} = 1 \quad \checkmark$$

$$V_2: 10V \text{ direct voltage source} \quad \checkmark$$

$$V_3: \frac{V_3 - V_1}{5} + \frac{V_3 - V_2}{10} + \frac{V_3}{5}$$

$$\frac{V_3 - V_1}{5} + \frac{V_3 - 10}{10} + \frac{V_3}{5} = 0 \quad \checkmark$$

$$\frac{V_1 - 10}{2\Omega} + \frac{V_1 - V_3}{5\Omega} = 1$$

$$\times 10 = 10$$

$$5(V_1 - 10) + 2(V_1 - V_3) = 10$$

$$5V_1 - 50 + 2V_1 - 2V_3 = 10$$

$$7V_1 - 2V_3 = 60$$

$$\frac{V_3 - V_1}{5} + \frac{V_3 - 10}{10} + \frac{V_3}{5} = 0$$

$$\times 10 = 10$$

$$2(V_3 - V_1) + (V_3 - 10) + 2V_3 = 0$$

$$2V_3 - 2V_1 + V_3 - 10 + 2V_3 = 0$$

$$5V_3 - 2V_1 - 10 = 0$$

$$-2V_1 + 5V_3 = 10$$

$$\begin{bmatrix} 7 & -2 \\ -2 & 5 \end{bmatrix} \begin{bmatrix} V_1 \\ V_3 \end{bmatrix} = \begin{bmatrix} 60 \\ 10 \end{bmatrix} \text{ and } V_2 = 10V$$

$$2(7V_1 - 2V_3 = 60)$$

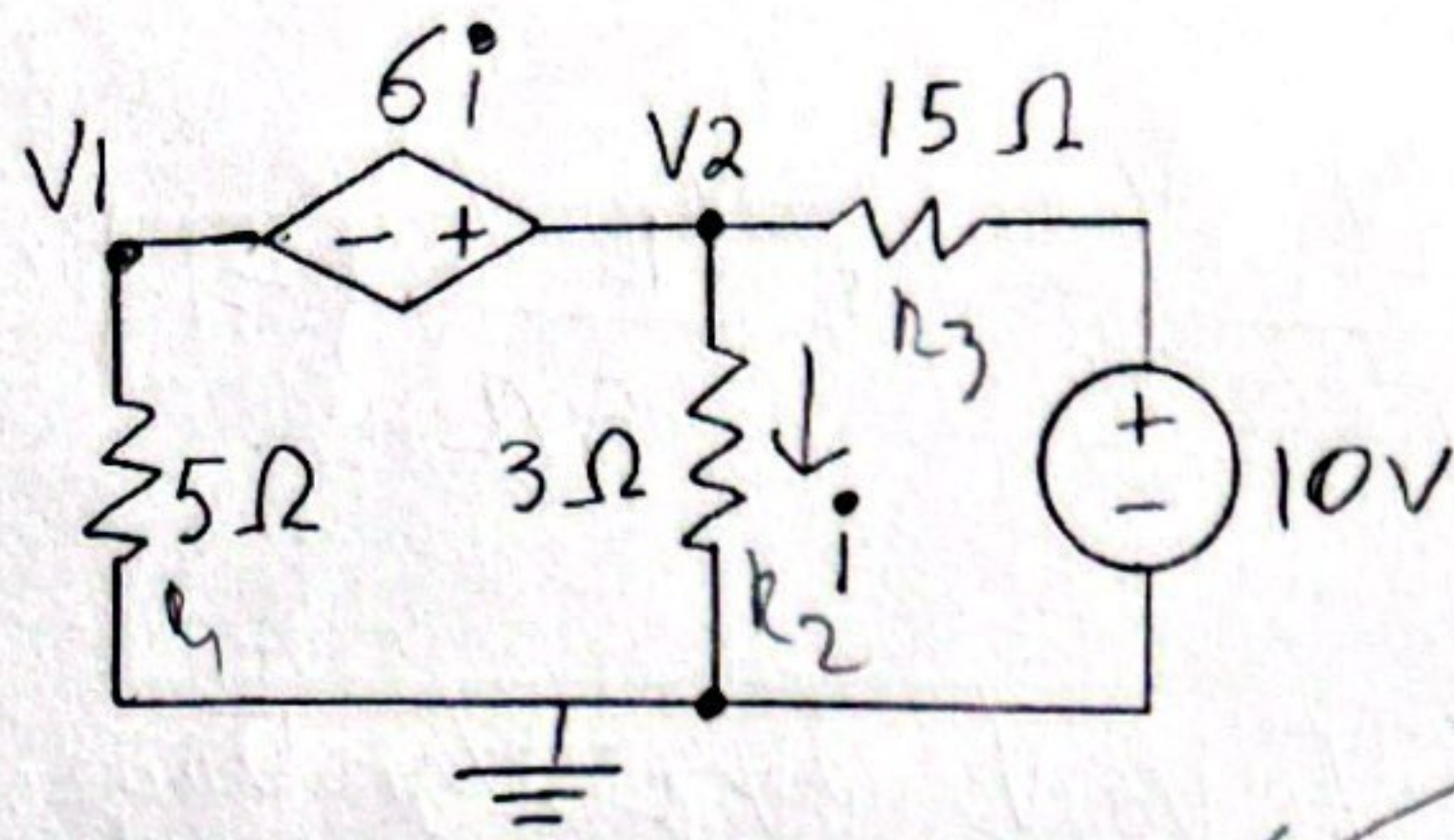
$$7(-2V_1 + 5V_3 = 10)$$

$$+14V_1 - 4V_3 = 120$$

$$-14V_1 + 35V_3 = 70$$

$$31V_3 = 50$$

3. Use the nodal analysis method to solve. Use a super-node around the dependent voltage source. Do not use the mesh analysis method since this is a super-node problem.



$$V_1 - V_2 = 6i \quad \checkmark$$

$$i = \frac{V_2}{3} \quad \checkmark$$

$$V_1 - V_2 = 6 \left( \frac{V_2}{3} \right) = 2V_2$$

$$\Rightarrow V_1 = V_2 + 2V_2 = 3V_2$$

$$V_1 \text{ to ground: } 5\Omega \frac{V_1}{5}$$

$$V_2 \text{ to ground: } 3\Omega \frac{V_2}{3}$$

$$V_2 \text{ to } 10V: 15\Omega \frac{V_2 - 10}{15}$$

$$\text{so } \frac{V_1}{5} + \frac{V_2}{3} + \frac{V_2 - 10}{15} = 0 \quad \checkmark$$

$$\Rightarrow V_1 = 3V_2$$

$$\text{or } \frac{3V_2}{5} + \frac{V_2}{3} + \frac{V_2 - 10}{15} = 0$$

$$4V_2 + 5V_2 + (V_2 - 10) = 0$$

$$15V_2 - 10 = 0$$

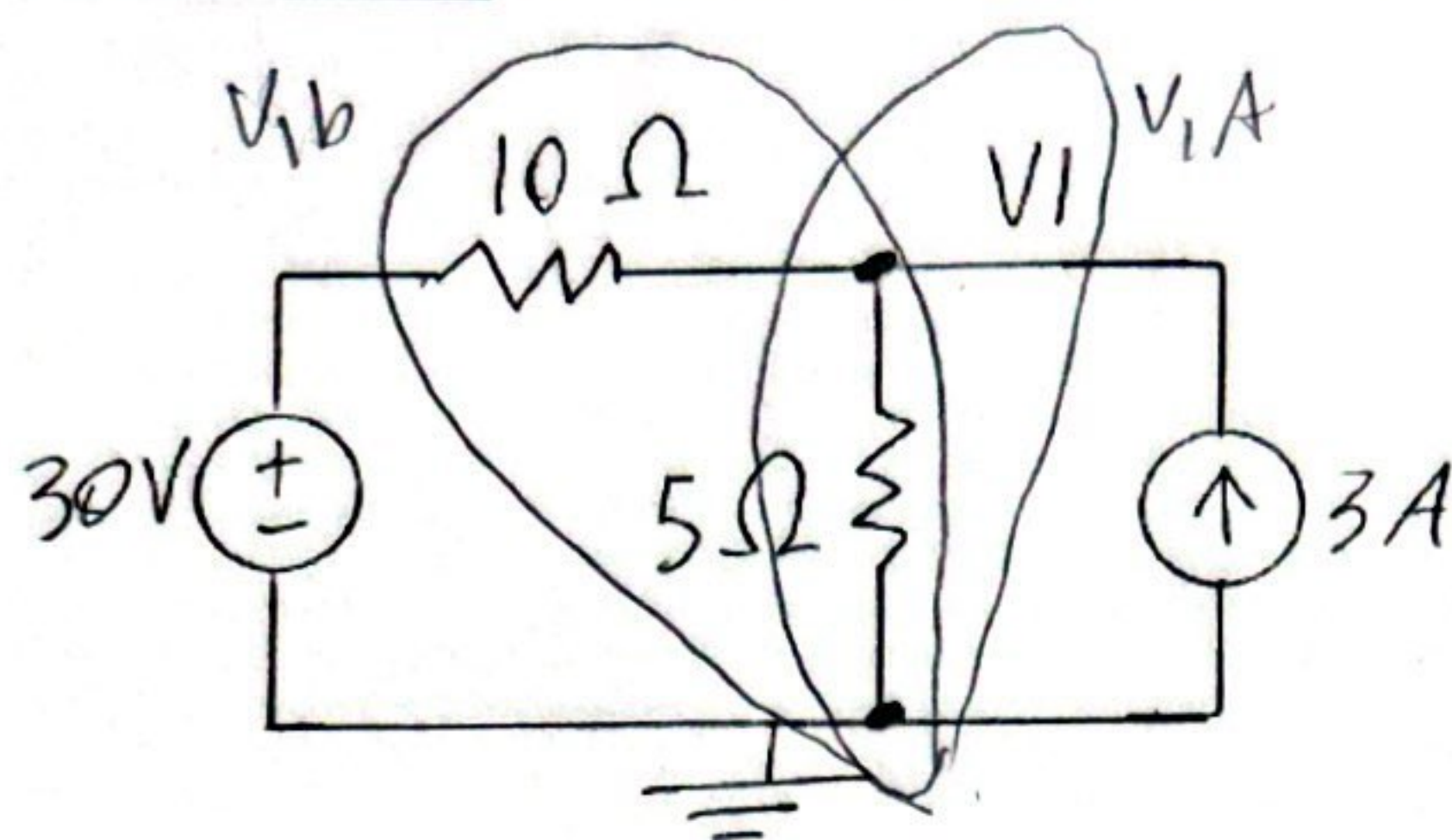
$$\boxed{V_2 = \frac{2}{3} V}$$

$$V_1 = 3V_2 = 3 \cdot \left( \frac{2}{3} \right) = 2V$$

$$\boxed{V_1 = 2V}$$

$$i = \frac{V_2}{3} = \frac{\frac{2}{3}}{3} = 0.22 \bar{2}$$

4. Solve using the superposition method. This is a superposition problem so you must use superposition even if there are easier ways to solve it.



$30V \rightarrow 10\Omega \rightarrow V_1 \rightarrow 5\Omega \rightarrow \text{ground}$

$$V_1 = 30 \cdot \frac{5}{10+5} = 30 \cdot \frac{5}{15}$$

$$30 \cdot \frac{1}{3} = \boxed{10V}$$

✓

node  $V_{1b}$ : to ground through  $5\Omega$

node  $V_{1a}$ : to ground through  $10\Omega$

$3A$  source

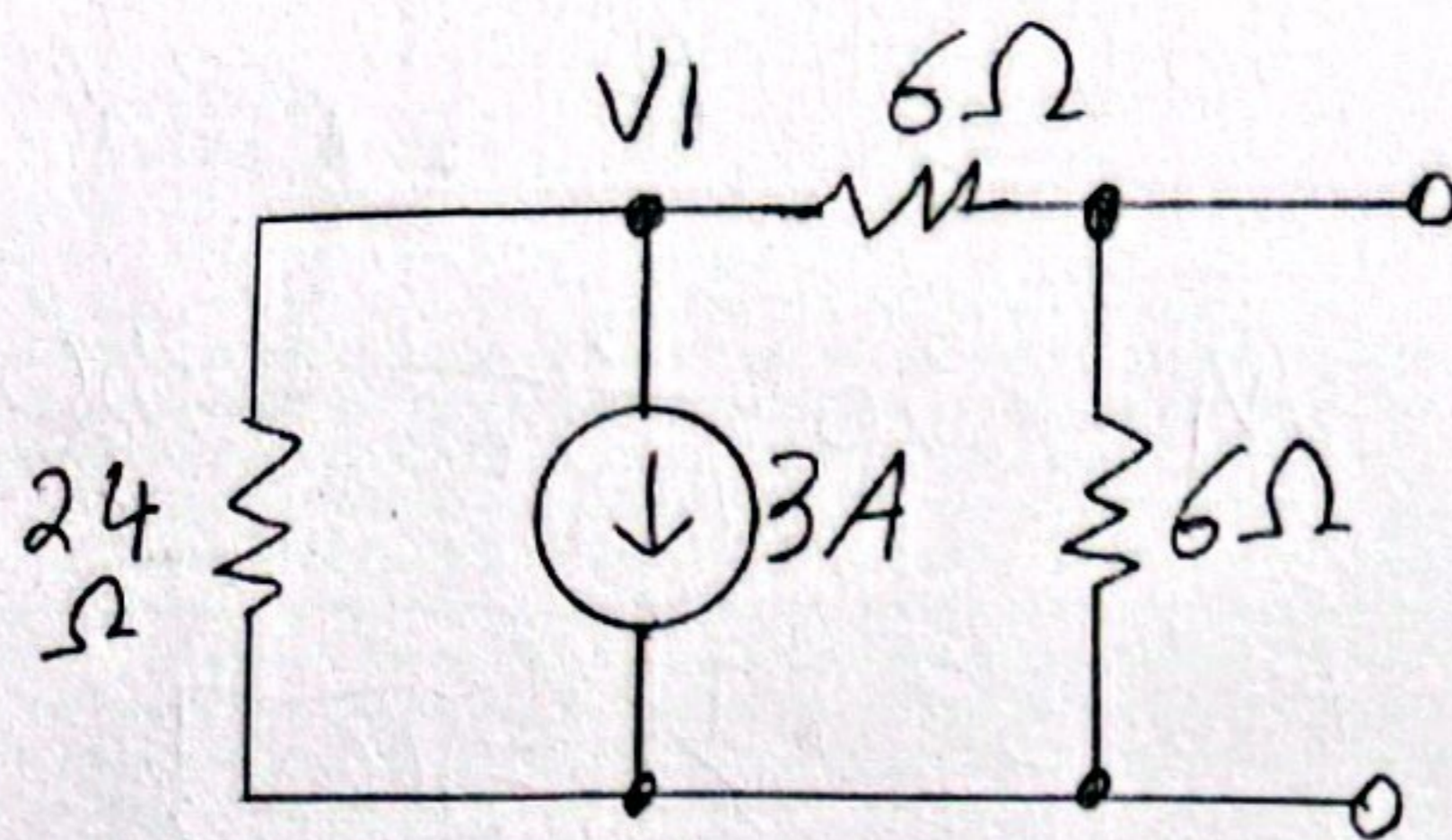
$$R_{eq} = \frac{5 \cdot 10}{5+10} = \frac{5}{1.5} = 3.33\Omega$$

$$V_{1b} = I \cdot R_{eq} = 3 \cdot 3.33 = \boxed{10V}$$

✓

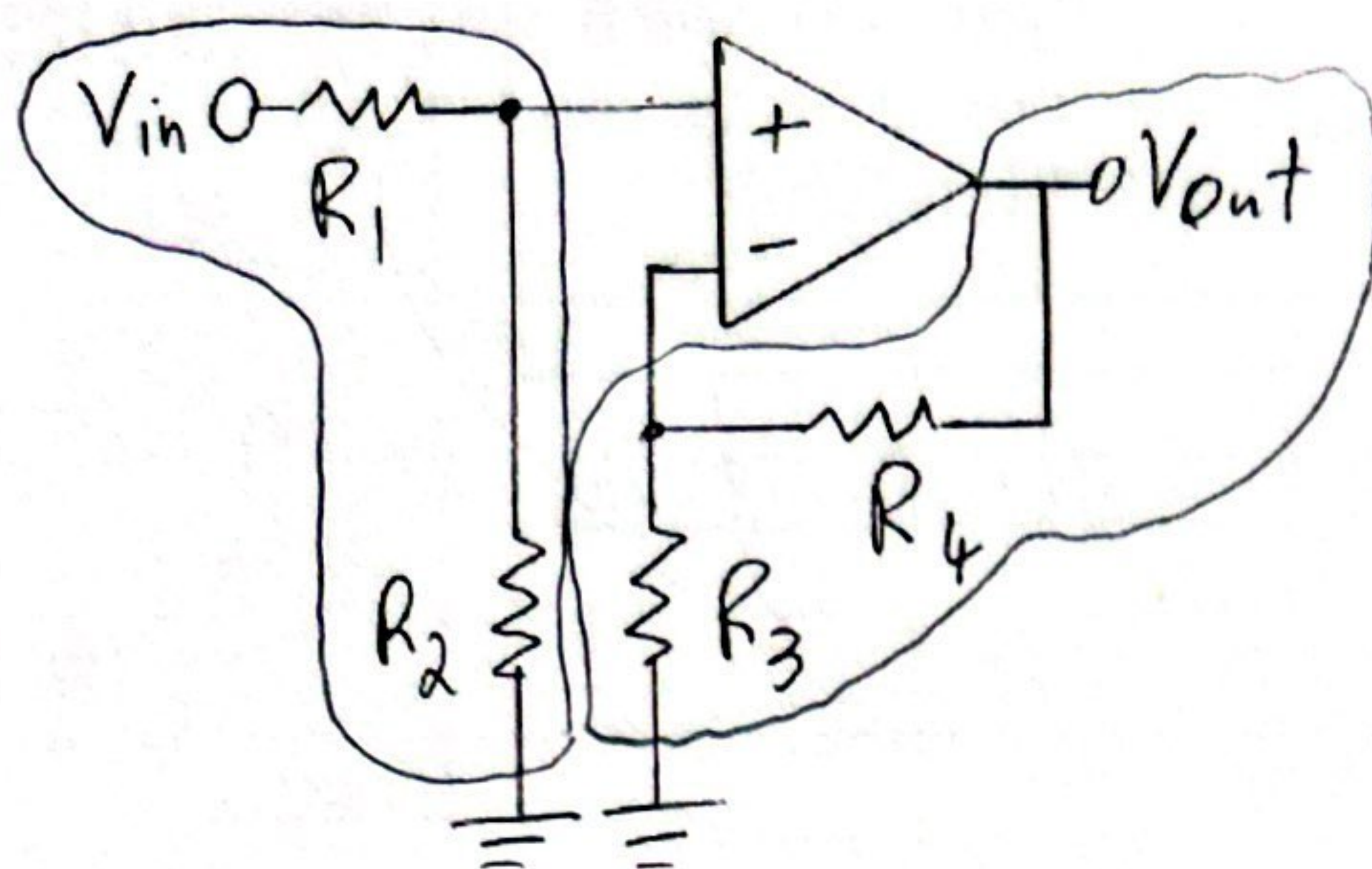
$$V_1 = V_{1a} + V_{1b} = 10 + 10 = \boxed{20V}$$

5. Find the Thevenin Equivalent circuit for the circuit below. Hint, find the equivalent resistance and the short circuit current. Using the open circuit voltage will result in having to solve simultaneous equations.



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6. Given the following circuit, find an expression for  $V_o$  in terms of  $R_1, R_2, R_3, R_4, V_{in}$ .



$$V_+ = V_{in} \cdot \frac{R_2}{R_1 + R_2} \quad \checkmark \quad V_- = V_{out}$$

$$V_- = V_+ \quad \checkmark$$

$$V_- = V_{out} \cdot \frac{R_3}{R_3 + R_4} \quad \checkmark$$

$$V_+ = V_- \quad \checkmark$$

$$V_{in} \cdot \frac{R_2}{R_1 + R_2} = V_{out} \cdot \frac{R_3}{R_3 + R_4}$$

$$V_{out} = V_{in} \cdot \frac{R_2}{R_1 + R_2} \cdot \frac{R_3 + R_4}{R_3}$$

$$V_{out} = (V_{in}) \left( \frac{R_2 (R_3 + R_4)}{R_3 (R_1 + R_2)} \right)$$