MAE40 - Linear Circuits - Winter 24 - Section A00
Midterm #2, February 27

Instructions

(i) The exam is open book. You may use your class notes and textbook.

(ii) The exam has 2 questions for a total of 20 points and 2 bonus points.

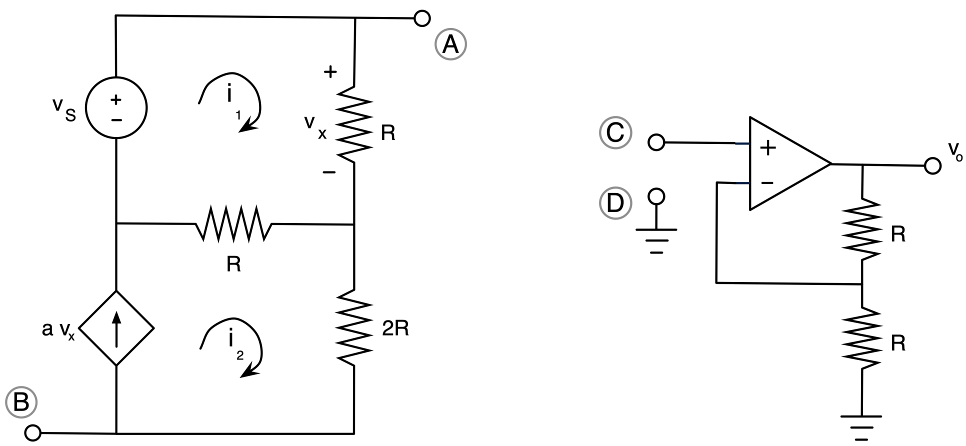
(iii) You have from 9:30am to 10:50am to do the exam – but it should require less time to complete!

(iv) You can use a calculator with no communication capabilities.

(v) In your responses, clearly articulate your reasoning, and properly justify the steps.

(vi) **Important:** start each part below on a separate page, use only one side, and write your name & PID at the top of each page.

Good luck!



(a) (b)

Figure 1: Circuits for Question 1.

1. **Mesh-current analysis with dependent sources**

Part I: [4 points] For the circuit in Figure 1(a), use mesh-current analysis to find the open-circuit voltage as seen from terminals Ⓐ and Ⓑ (use the labels provided and notice the presence of the dependent source).

Part II: [2 points] Turn off the independent voltage source in the circuit of Figure 1(a) and explain what happens to the dependent source. Compute the equivalent resistance as seen from terminals Ⓐ and Ⓑ.

Part III: [3 points] Find the short-circuit current that results from connecting the terminals Ⓐ and Ⓑ in Figure 1(a), using again mesh-current analysis.

Part IV: [1 point] Given your answers to Parts I and III, can you tell what the Thevenin equivalent of this circuit is? Why is $R_T = R_N$ not equal to the equivalent resistance you computed in Part II?

Part V [+Extra 2 points] Use your answer to Part IV to determine the output voltage v_0 if you connect the circuits in Figure 1(a) and Figure 1(b) (terminal Ⓐ with Ⓒ, and terminal Ⓑ with Ⓓ).

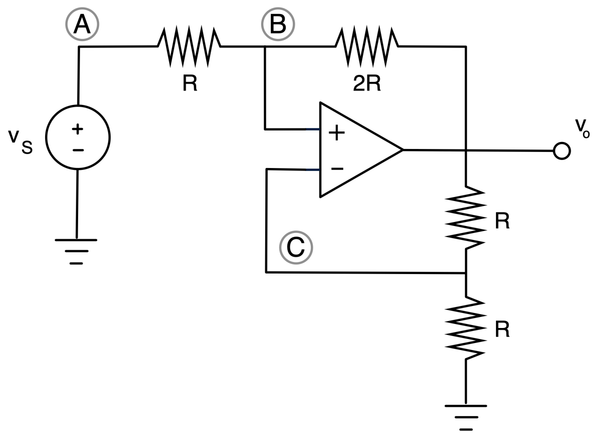


Figure 2: Circuit for Question 2.

2. **OpAmp circuit analysis and design**

   Part I: [5 points] Use node-voltage analysis to determine the output voltage in the circuit in Figure 2.

   Part II: [3 points] With $R = 100\,\Omega$ and $\pm v_{\text{CC}} = 10V$, an engineer connected a load resistor $R_L = 10\,\Omega$ between the output node and ground. With a voltage source of $v_S = 3V$, what was the power consumed by the load resistor? Can you explain why? What is the range of values for the voltage source v_S so that the op-amp operates linearly?

   Part III: [2 points] Design your own circuit, using only basic OpAmp building blocks and resistors with value R, that generates the same output voltage as the circuit in Figure 2.

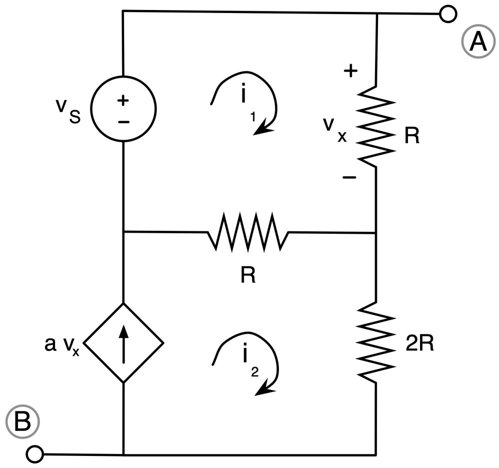


Figure 1(a): Circuit for question 1.

Q1. Part I: [4 points] For the circuit in Figure 1(a), use mesh-current analysis to find the open-circuit voltage as seen from terminals (A) and (B) (use the labels provided and notice the presence of the dependent source).

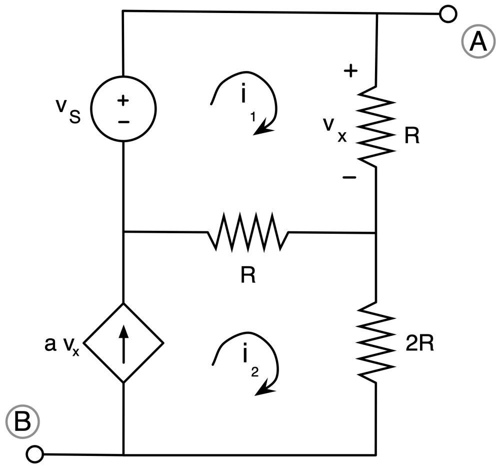


Figure 1(a): Circuit for question 1.

Q1. Part II: [2 points] Turn off the independent voltage source in the circuit of Figure 1(a) and explain what happens to the dependent source. Compute the equivalent resistance as seen from terminals (A) and (B).

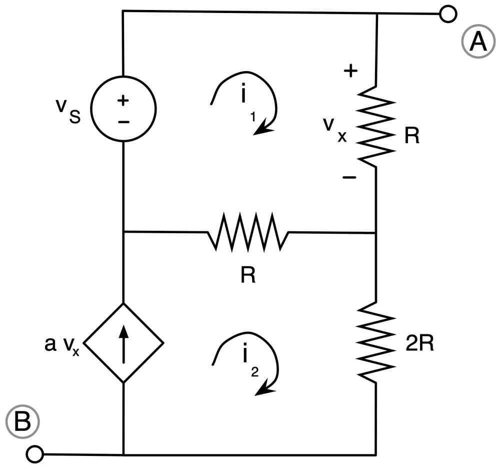
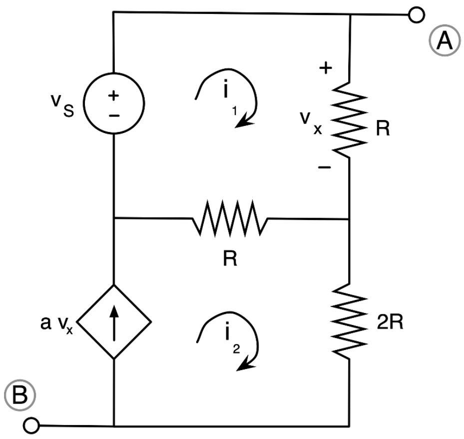


Figure 1(a): Circuit for question 1.

Q1. Part III: [3 points] Find the short-circuit current that results from connecting the terminals (A) and (B) in Figure 1(a), using again mesh-current analysis.

Q1. Part IV: [1 point] Given your answers to Parts I and III, can you tell what the Thevenin equivalent of this circuit is? Why is $R_T = R_N$ not equal to the equivalent resistance you computed in Part II?



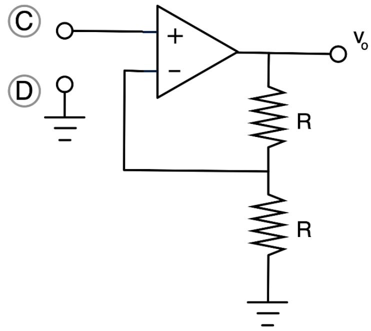


Figure 1: Circuits for question 1.

Q1. Part V: [+Extra 2 points] Use your answer to Part IV to determine the output voltage v_0 if you connect the circuits in Figure 1(a) and Figure 1(b) (terminal (A) with (C), and terminal (B) with (D)).

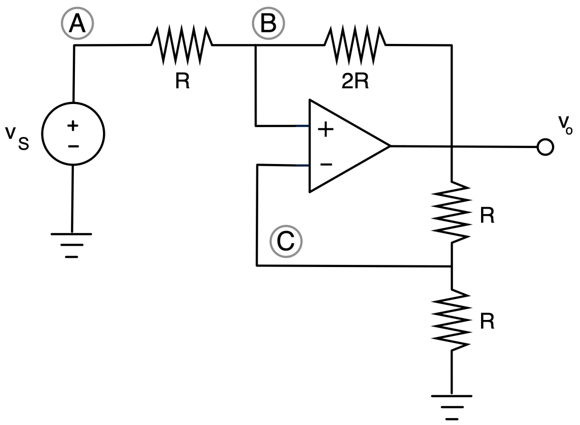


Figure 2: Circuit for question 2.

Q2. Part I: [5 points] Use node-voltage analysis to determine the output voltage in the circuit in Figure 2.

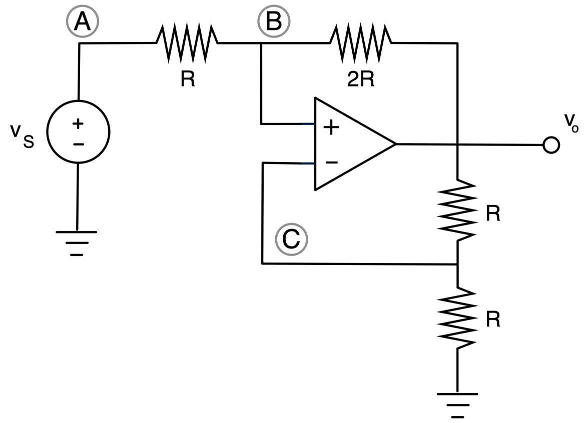


Figure 2: Circuit for question 2.

Q2. Part II: [3 points] With $R = 100\,\Omega$ and $\pm v_{\mathrm{CC}} = 10V$, an engineer connected a load resistor $R_L = 10\,\Omega$ between the output node and ground. With a voltage source of $v_S = 3V$, what was the power consumed by the load resistor? Can you explain why? What is the range of values for the voltage source v_S so that the op-amp operates linearly?

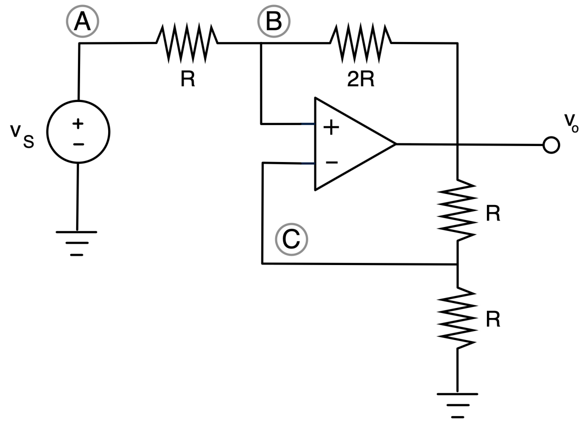


Figure 2: Circuit for question 2.

Q2. Part III: [2 points] Design your own circuit, using only basic OpAmp building blocks and resistors with value R, that generates the same output voltage as the circuit in Figure 2.