MAE40 - Linear Circuits - Fall 25
Midterm #2, November 18

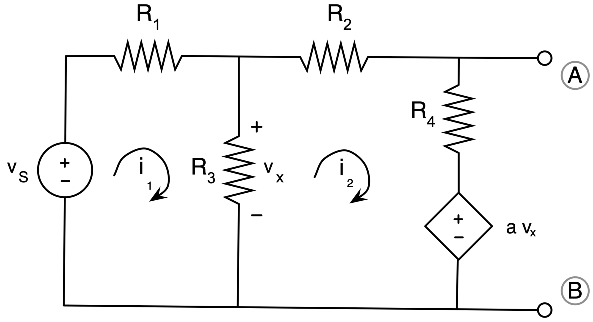

Figure 1: Circuit for Question 1.

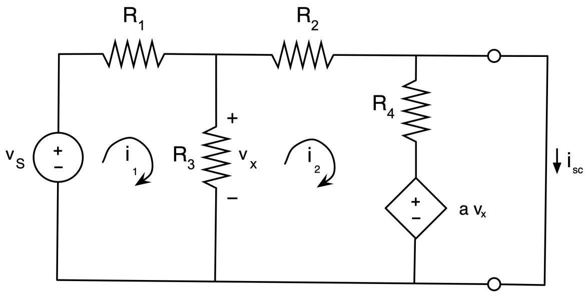

Figure 2: Circuit for Question 1.

Instructions

(i) You can use 2 two-sided 1-page handwritten cheatsheets.

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

(iii) You have from 2:00pm to 3:20pm to do the exam, but it should require less time to complete it.

(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 and write your name & PID at the top of each page.

Good luck!

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

Part I: [4 points] Formulate mesh-current equations for the circuit in Figure 1. Use the mesh labels provided and notice the presence of the dependent source. Clearly indicate the final equations and circuit variable unknowns. Write the final equations **in matrix form**. **Do not modify the circuit or the labels**. No need to solve any equations!

Part II: [4 points] Connect terminals (A) and (B) to obtain the circuit in Figure 2. Set up mesh-current equations to find the short-circuit current. Clearly indicate the final equations and circuit variable unknowns. Write the final equations **in matrix form**. **Do not modify the circuit or the labels**. No need to solve any equations!

Part III: [2 points] Say you found the solutions in Part I and Part II, obtaining

$$i_2 = \frac{(1-a)R_3 v_S}{R_1R_2 + (1-a)R_1R_3 + R_2R_3 + R_1R_4 + R_3R_4},$$
$$v_x = \frac{(R_2+R_4)R_3 v_S}{R_1R_2 + (1-a)R_1R_3 + R_2R_3 + R_1R_4 + R_3R_4}$$

in Part I, and $i_{sc} = \frac{R_3(aR_2+R_4)v_S}{(R_1R_2+R_1R_3+R_2R_3)R_4}$ in Part II. What is the Thévenin equivalent of the circuit in Figure 1?

Part IV: [Extra 2 points] Taking v_{AB} as the output and v_s as the input, and assuming the values of a and R_3 are similar and much larger than any of the others (R_1, R_2, R_4), what name of a basic op-amp building block would you associate to the circuit in Figure 1?

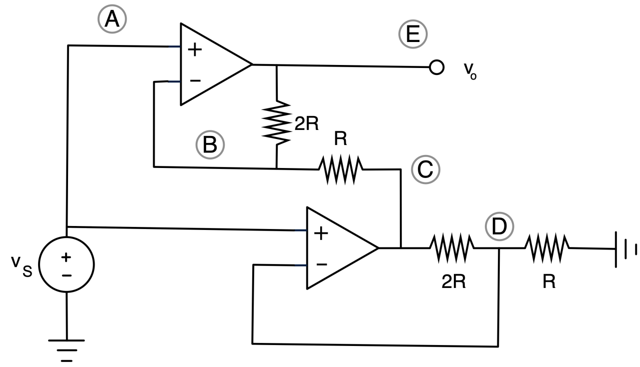

Figure 3: Circuit for Question 2.

2. **OpAmp circuit analysis and design**

Part I: [6 points] Use node-voltage analysis to determine the output voltage v_o in the circuit in Figure 3.

Part II: [2 points] With $v_S = 9\,V$, $v_{\text{CC}} = \pm 25\,V$ for the op-amp at the top, and $v_{\text{CC}} = \pm 50\,V$ for the op-amp at the bottom, an engineer connected a load resistor $R_L = 100\,\Omega$ between the output node and ground, and was surprised to measure its consumed power to be $6.25\,W$, which was about $1\,W$ less than expected. Can you explain why?

Part III: [2 points] Design your own circuit, using only 1 OpAmp, 2 resistors of value R and 1 resistor of value $R/2$, to generate the same output voltage as the circuit in Figure 3.