MAE40 - Linear Circuits - Winter 21
Midterm #2, February 25

Instructions

(i) Prior to the exam, you must have completed the Academic Integrity Pledge at `https://academicintegrity.ucsd.edu/forms/form-pledge.html`

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

(iii) Collaboration is not permitted. Your answers must be the result only of your own work.

(iv) The exam has 3 questions for a total of 30 points and 2 bonus points.

(v) You have from 11:00am to 12:20pm to do the exam. Allow sufficient time to post your answers in Canvas (submission closes at 12:25pm).

(vi) If there is any clarification needed for a statement, post your question in the "Discussions" tab of the class Canvas webpage ("Clarifications on question statements of midterm2")

Good luck!

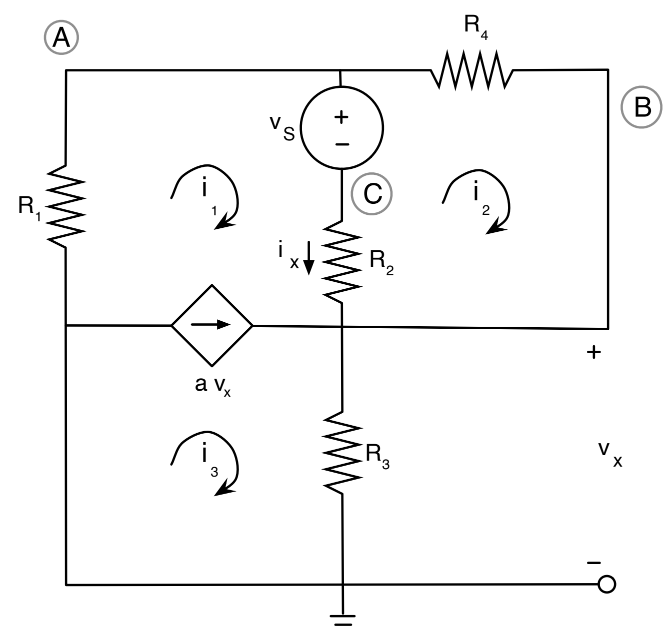


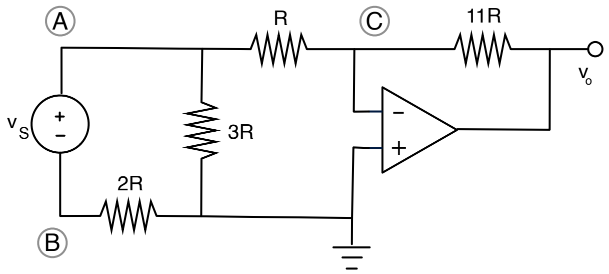
Figure 1: Circuit for Question 1.

1. **Circuit analysis with dependent sources**

   Part I: [6 points] Formulate mesh-current equations for the circuit in Figure 1. Use the labels provided in the figure. Clearly indicate the final equations and circuit variable unknowns. Make sure your final answer has the same number of independent equations as unknown variables (notice the presence of the dependent source). No need to solve any equations!

   Part II: [2 points] Provide expressions of node voltages v_A, v_B, v_C in terms of the mesh currents i_1, i_2, i_3.

   Part III: [2 points] Express the current i_x and the voltage v_x in terms of the node voltages.



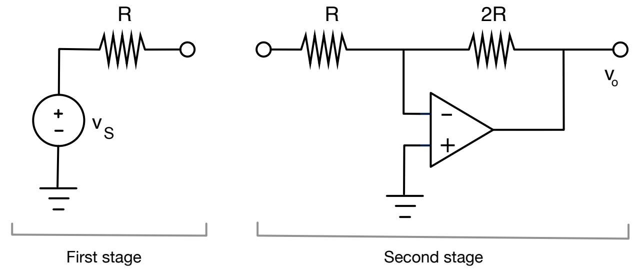


Figure 2: (a) circuit for Question 2 and (b) circuit for Question 3.

2. **OpAmp circuit analysis**

Part I: [6 points] Two engineers used different methods to compute the output voltage for the circuit in Figure 2(a). Their responses were

$$v_o = -3v_s \qquad v_o = -6.6v_s$$

Use node-voltage analysis to determine which one was right.

Part II: [4 points] The engineer who got the answer right did not use node-voltage analysis. Instead, the engineer computed the Thévenin equivalent circuit of the source circuit composed by the voltage source and the resistors R, $2R$, $3R$, and then relied on knowledge about basic building blocks to compute v_o. Replicate this reasoning and show that you get the same answer you got in Part I.

Part III: [Extra 2 points] The engineer who got the answer right used an input voltage of $v_s = 4$V and connected a resistor load of 6 KOhms at the output node, and was surprised to see that the current through it was -1 mA. What is the value of the external power supply $-v_{\rm CC}$ to which the Op-Amp is connected that explains this value of the current?

3. **OpAmp circuit design**

Part I: [4 points] An instructor with a rusty recollection of MAE40 connected the two stages in Figure 2(b) expecting to obtain

$$v_o = -2v_s.$$

Why is this expectation wrong? What did the instructor actually get?

Part II: [4 points] If you could add a stage in-between the two stages in Figure 2(b), what circuit you would design so that, once interconnected, the instructor's expectation became true?

Part III: [2 points] Using the first stage in Figure 2(b), as many resistors of value R as you want, and one op-amp, design a circuit that implements instead the operation

$$v_o = 2v_s.$$