MAE140 - Linear Circuits - Winter 20
Midterm, February 6

Instructions

(i) This exam is open book. You may use whatever written materials you choose, including your class notes and textbook

(ii) You may use a hand calculator with no communication capabilities

(iii) You have 75 minutes

(iv) Do not forget to write your **name** and **student number**

(v) The exam has 3 questions, for a total of 30 points

Good luck!

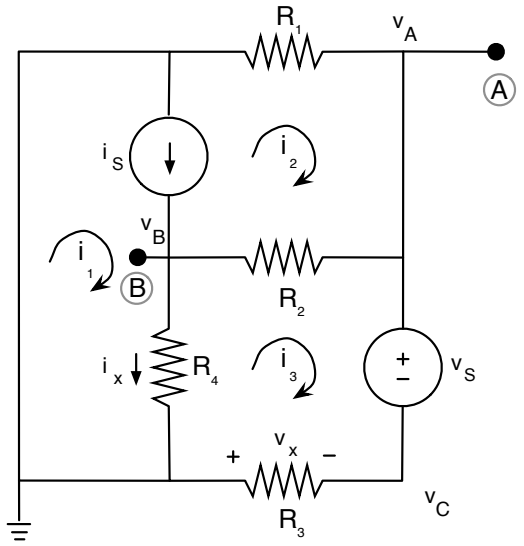

Figure 1: Circuit for all questions.

1. **Node voltage analysis**

   Part I: [5 points] Formulate node-voltage equations for the circuit in Figure 1. Use the node labels provided in the figure. Clearly indicate how you handle the presence of the voltage source. The final equations in matrix form must depend only on unknown node voltages. **Do not modify the circuit or the labels**. No need to solve any equations!

   Part II: [3 points] Provide expressions for the mesh currents i_1, i_2, and i_3 in terms of the node voltages.

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

2. **Mesh current analysis**

   Part I: [5 points] Formulate mesh-current equations for the circuit in Figure 1. Use the mesh currents shown in the figure and clearly indicate how you handle the presence of the current source. The final equations in matrix form should only depend on the unknown mesh currents. **Do not modify the circuit or the labels** (meaning source transformation or circuit re-drawing are not allowed). No need to solve any equations!

   Part II: [3 points] Provide expressions for the voltage v_x and the current i_x in terms of mesh currents.

   Part III: [2 points] If we were allowed to modify the circuit, could you have used source transformation to deal with the current source instead? Justify your answer.

3. **Equivalent circuits**

   Part I: [5 points] Turn off all the sources in the circuit of Figure 1 and find the equivalent resistance as seen from terminals Ⓐ and Ⓑ if $R_1 = R_2 = R_3 = 20\Omega$, $R_4 = 10\Omega$ (if you want, after turning off the sources, you can redraw the circuit –respecting its connectivity– to see things more clearly).

   Part II: [3 points] Assume that, if you solve for the node voltages with the current source turned off in Problem 1, you get $v_A = 6V$, $v_B = 2V$, and $v_C = -10V$; and if you solve for the node voltages with the voltage source turned off instead, you get $v_A = 3V$, $v_B = 9V$, $v_C = 3V$. Use this information to find the open-circuit voltage as seen from terminals Ⓐ and Ⓑ.

   Part III: [2 points] Use your answers to Parts I and II to determine the Thévenin equivalent of the circuit as seen from terminals Ⓐ and Ⓑ.