MAE40 - Linear Circuits - Fall 23 - Section A00
Midterm #1, October 24

Instructions

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

(ii) The exam has 3 questions for a total of 23 points and 2 bonus points.

(iii) You have from 11:00am to 12:20pm to do the exam, but it should require less time for you 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, use only one side, and write your name & PID at the top of each page.

Good luck!

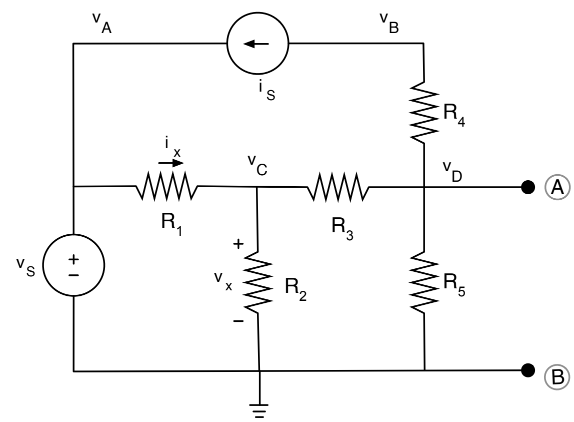

Figure 1: Circuit for questions 1 and 2.

1. **Circuit analysis**

   Part I: [6 points] Formulate node-voltage equations for the circuit in Figure 1. Use the node labels provided in the figure. Clearly indicate the final equations and circuit variable unknowns. 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: [2 points] Provide expressions for the voltage v_x and the current i_x in terms of node voltages.

   Part III: [2 points] A technician replaced the resistor R_4 by a short circuit. How did that affect the values of v_x and i_x?

2. **Linearity and equivalent circuits**
   For this question, assume $v_S = 10V$, $i_S = -1A$, $R_1 = R_2 = R_3 = R_5 = 5\,\Omega$.

   Part I: [3 points] Turn off all the sources in the circuit of Figure 1 and find the equivalent resistance as seen from terminals (A) and (B).

   Part II: [3 points] Turn off the current source and compute the open-circuit voltage as seen from terminals (A) and (B) using association of resistors, equivalent sources, and voltage division.

   Part III: [3 points] Turn off the voltage source and compute the open-circuit voltage as seen from terminals (A) and (B) using association of resistors, equivalent sources, and current division.

   Part IV: [1 point] Use superposition and your answers to Parts I-III to determine the Thévenin equivalent of the circuit as seen from terminals (A) and (B).

   Part V: [Extra 2 points] If we connect a $12\,\Omega$ resistor to terminals (A) and (B), what is the minimum power rating that this resistor should have?

3. **Real-world power supply** [3 points]
   For the real-world power supply in Figure 2 with an output specification of 24 VDC, 1A, indicate in the table below the voltage output from the power supply for the values of R.

R	voltage output from power supply
$100\,\Omega$	
$10\,\Omega$	
$1\,\Omega$	

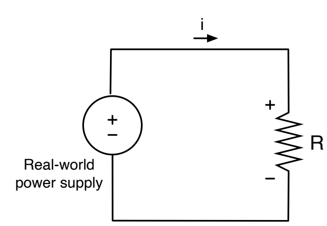

Figure 2: Circuit for question 3.