EECS 16A Designing Information Devices and Systems I
Spring 2020 Homework 6

This homework is due March 6, 2020, at 23:59.
Self-grades are due March 9, 2020, at 23:59.

Submission Format

Your homework submission should consist of **one** file.

- `hw6.pdf`: A single PDF file that contains all of your answers (any handwritten answers should be scanned) as well as your IPython notebook saved as a PDF.

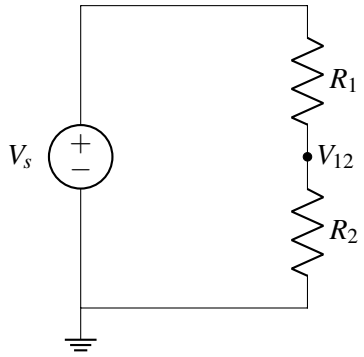
  If you do not attach a PDF "printout" of your IPython notebook, you will not receive credit for problems that involve coding. Make sure that your results and your plots are visible. Assign the IPython printout to the correct problem(s) on Gradescope.

Submit the file to the appropriate assignment on Gradescope.

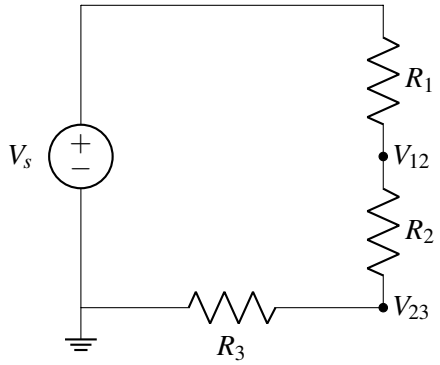
1. Voltage divider

In the following parts, $V_s = 10\,\text{V}$. Choose resistance values such that the current through each element is $\leq 1\text{A}$.

(a) Select values for R_1 and R_2 in the circuit below such that $V_{12} = 5\,\text{V}$.



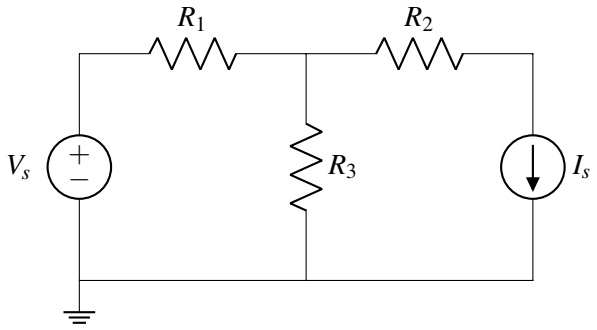
(b) Select values for R_1, R_2, R_3 in the circuit below such that $V_{12} = 5V$ and $V_{23} = 3V$.



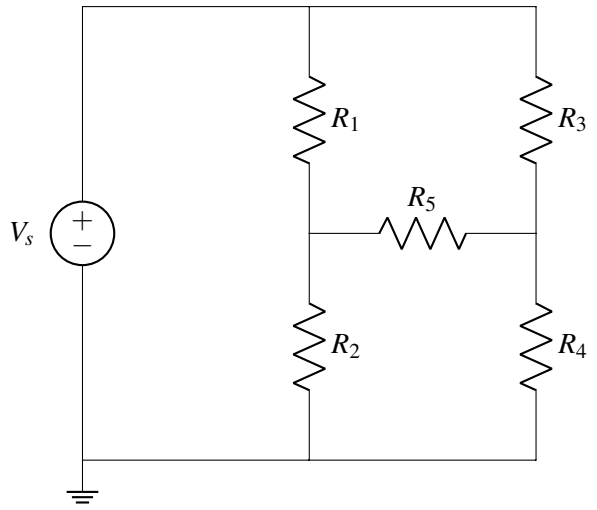
2. Circuit Analysis

Using the steps outlined in lecture, solve the following circuits for the currents through each branch and the voltages at each node. Use the ground node labelled for you. You may use a numerical tool, such as IPython.

(a) $V_s = 5\,\text{V}, I_s = 2\,\text{A}, R_1 = R_2 = 2\,\Omega, R_3 = 4\,\Omega$

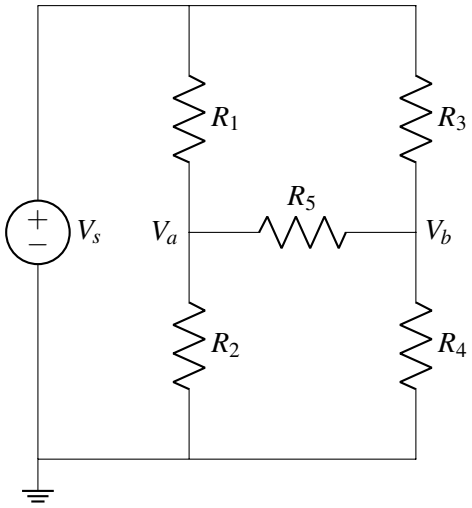


(b) $V_s = 5\,\text{V}, R_1 = 1\,\Omega, R_2 = 2\,\Omega, R_3 = 3\,\Omega, R_4 = 4\,\Omega, R_5 = 5\,\Omega$



3. Volt and ammeter

Use the following numerical values in your calculations: $R_1 = 1\,\text{k}\Omega$, $R_2 = 2\,\text{k}\Omega$, $R_3 = 3\,\text{k}\Omega$, $R_4 = 4\,\text{k}\Omega$, $R_5 = 5\,\text{k}\Omega$, $V_s = 5V$.



(a) Redraw the circuit diagram shown in Figure 1 by adding a voltmeter (letter V in a circle and plus and minus signs indicating direction) to measure voltage V_{ab} from node V_a (positive) to node V_b (negative). Calculate the value of V_{ab}.
Hint: You have analyzed a very similar circuit elsewhere in this assignment, reuse the result.

(b) Suppose you inadvertently connected an ammeter in part (a) above, rather than a voltmeter (we all goof sometimes). Calculate the value of V_{ab} with the ammeter connected. Note: it differs from the value calculated in part (a).

(c) Redraw the circuit diagram shown in Figure 1 by adding an ammeter (letter A in a circle and plus and minus signs indicating direction) to measure the current I_{R_5} through resistor R_5. Calculate the value of I_{R_5}.

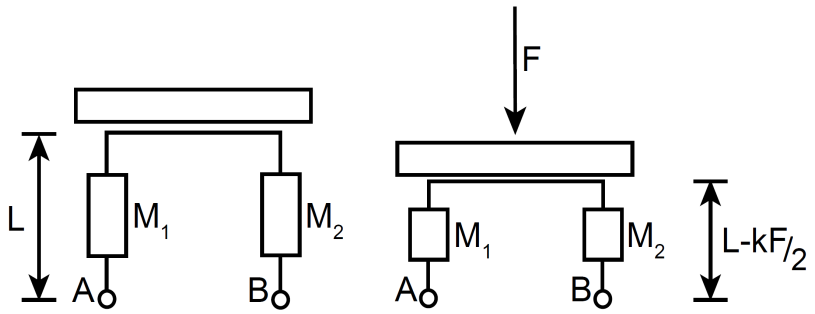
(d) Your friend inadvertently connected a voltmeter in part (c) above, rather than an ammeter. Calculate the value of I_{R_5} with the voltmeter connected. Note: it differs from the value calculated in part (c).

4. Fruity Fred

Fruity Fred just got back from Berkeley Bowl with a bunch of mangoes, pineapples, and coconuts. He wants to sort his mangoes in order of weight, so he decides to use his knowledge from EECS16A to build a scale.

He finds two identical bars of material (M_1 and M_2) of length L (meters) and cross-sectional area A_c (meters^2), which are made of a material with resistivity ρ. He knows that the length of these bars decreases by k meters per Newton of force applied, while the cross-sectional area remains constant.

He builds his scale as shown below, where the top of the bars are connected with an ideal electrical wire. The left side of the diagram shows the scale at rest (with no object placed on it), and the right side shows it when the applied force is F (Newtons), causing the length of each bar to decrease by $kF/2$ meters. Fred's mangoes are not very heavy, so $L \gg kF/2$.



(a) Let R_{AB} be the resistance between nodes A and B. Write an expression for R_{AB} as a function of A_c, L, ρ, F, and k.

(b) Fred's scale design is such that the resistance R_{AB} changes depending on how much weight is placed on it. However, he really wants to measure a voltage rather than a resistance.

Design a circuit for Fred that outputs a voltage that is some function of the weight. Your circuit should include R_{AB}, and you may use any number of voltage sources and resistors in your design. Be sure to label where the voltage should be measured in your circuit. Also provide an expression relating the output voltage of your circuit to the force applied on the scale.

5. Homework Process and Study Group

Who else did you work with on this homework? List names and student ID's. (In case of homework party, you can also just describe the group.) How did you work on this homework?