EECS 16A   Designing Information Devices and Systems I
Fall 2018
Homework 6

This homework is due October 5th, 2018, at 23:59.

Self-grades are due October 9th, 2018, at 23:59.

Submission Format

Your homework submission should consist of **two** files.

- `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 of your IPython notebook, you will not receive credit for problems that involve coding. Make sure that your results and your plots are visible.

- `hw6.ipynb`: A single IPython notebook with all of your code in it.

  In order to receive credit for your IPython notebook, you must submit both a "printout" and the code itself.

Submit the file to the appropriate assignment on Gradescope.

1. **Circuit Analysis**

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

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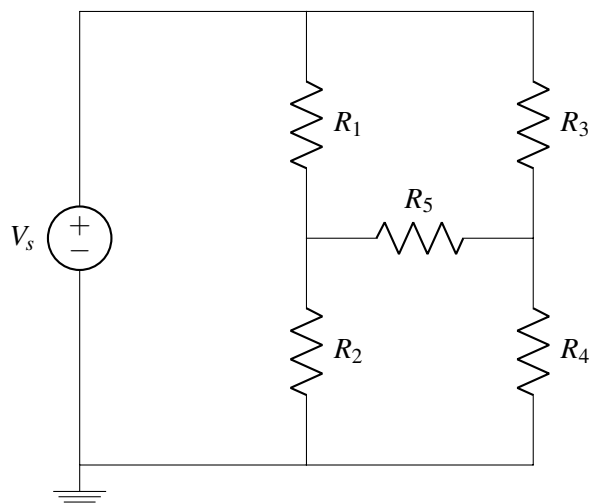
Solution:

Here, we will skip showing all of the individual steps. Below is the circuit with our choice of ground and current directions.
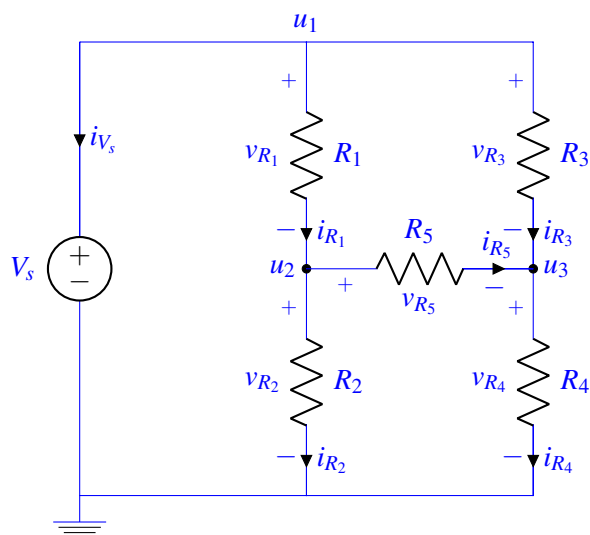
From the above circuit, we get the following KCL equations:

$$i_{V_s} + i_{R_1} + i_{R_3} = 0$$
$$-i_{R_1} + i_{R_2} + i_{R_5} = 0$$
$$-i_{R_3} + i_{R_4} - i_{R_5} = 0$$

Using the *IV* relations for each element, we find 6 more equations:

$$u_1 - 0 = V_s$$
$$u_1 - u_2 - i_{R_1} R_1 = 0$$
$$u_2 - 0 - i_{R_2} R_2 = 0$$
$$u_1 - u_3 - i_{R_3} R_3 = 0$$
$$u_3 - 0 - i_{R_4} R_4 = 0$$
$$u_2 - u_3 - i_{R_5} R_5 = 0$$

Note that we now have 9 equation for 9 unknowns. Thus, we set up the following matrix relation:

$$
\begin{bmatrix}
1 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
0 & -1 & 1 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & -1 & 1 & -1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
0 & -R_1 & 0 & 0 & 0 & 0 & 1 & -1 & 0 \\
0 & 0 & -R_2 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & -R_3 & 0 & 0 & 1 & 0 & -1 \\
0 & 0 & 0 & 0 & -R_4 & 0 & 0 & 0 & 1 \\
0 & 0 & 0 & 0 & 0 & -R_5 & 0 & 1 & -1
\end{bmatrix}
\begin{bmatrix}
i_{V_s} \\
i_{R_1} \\
i_{R_2} \\
i_{R_3} \\
i_{R_4} \\
i_{R_5} \\
u_1 \\
u_2 \\
u_3
\end{bmatrix}
=
\begin{bmatrix}
0 \\
0 \\
0 \\
V_s \\
0 \\
0 \\
0 \\
0 \\
0
\end{bmatrix}
$$

Finally, we plug in the values we were given into the matrix above and use Gaussian elimination to find the

vector of unknowns.

$$\begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 1 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 1 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 & 0 & 1 & -1 & 0 \\ 0 & 0 & -2 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -3 & 0 & 0 & 1 & 0 & -1 \\ 0 & 0 & 0 & 0 & -4 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & -5 & 0 & 1 & -1 \end{bmatrix} \begin{bmatrix} i_{V_s} \\ i_{R_1} \\ i_{R_2} \\ i_{R_3} \\ i_{R_4} \\ i_{R_5} \\ u_1 \\ u_2 \\ u_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 5 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$\begin{bmatrix} i_{V_s} \\ i_{R_1} \\ i_{R_2} \\ i_{R_3} \\ i_{R_4} \\ i_{R_5} \\ u_1 \\ u_2 \\ u_3 \end{bmatrix} = \begin{bmatrix} -2.38 \\ 1.709 \\ 1.645 \\ 0.677 \\ 0.741 \\ 0.0645 \\ 5 \\ 3.29 \\ 2.968 \end{bmatrix}$$

2. **Midterm Problem 3**
   Redo Midterm Problem 3.

   (a) **Solution:** See midterm solutions.

   (b) **Solution:** See midterm solutions.

   (c) **Solution:** See midterm solutions.

3. **Midterm Problem 4**
   Redo Midterm Problem 4.

   (a) **Solution:** See midterm solutions.

   (b) **Solution:** See midterm solutions.

   (c) **Solution:** See midterm solutions.

4. **Midterm Problem 5**
   Redo Midterm Problem 5.

   (a) **Solution:** See midterm solutions.

   (b) **Solution:** See midterm solutions.

   (c) **Solution:** See midterm solutions.

   (d) **Solution:** See midterm solutions.

5. **Midterm Problem 6**
   Redo Midterm Problem 6.

   (a) **Solution:** See midterm solutions.

   (b) **Solution:** See midterm solutions.

   (c) **Solution:** See midterm solutions.

   (d) **Solution:** See midterm solutions.

   (e) **Solution:** See midterm solutions.

   (f) **Solution:** See midterm solutions.

   (g) **Solution:** See midterm solutions.

6. **Midterm Problem 7**
   Redo Midterm Problem 7.

   (a) **Solution:** See midterm solutions.

   (b) **Solution:** See midterm solutions.

   (c) **Solution:** See midterm solutions.

   (d) **Solution:** See midterm solutions.

   (e) **Solution:** See midterm solutions.

7. **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?

   Solution:

   I worked on this homework with...

   I first worked by myself for 2 hours, but got stuck on problem 5, so I went to office hours on...

   Then I went to homework party for a few hours, where I finished the homework.