
EECS 16A Designing Information Devices and Systems I
Spring 2019 Homework 6

This homework is due March 8, 2019, at 23:59.

Self-grades are due March 12, 2019, 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)

Submit the file to the appropriate assignment on Gradescope.

1. Mechanical Diagonalization

All calculations in this problem are intended to be done by hand, but you can use a computer to check your work.

- (a) Diagonalize the matrices A and B , i.e. compute $P_A, P_A^{-1}, D_A, P_B, P_B^{-1}$, and D_B such that $A = P_A D_A P_A^{-1}$ and $B = P_B D_B P_B^{-1}$ and the D matrices are diagonal with the eigenvalues along the diagonal.

$$A = \begin{bmatrix} \frac{3}{2} & \frac{1}{2} \\ \frac{1}{2} & \frac{3}{2} \end{bmatrix} \quad B = \begin{bmatrix} 1 & 0 \\ -2 & -1 \end{bmatrix} \quad (1)$$

given that A has eigenvalues $\{1, 2\}$ and B has eigenvalues $\{1, -1\}$

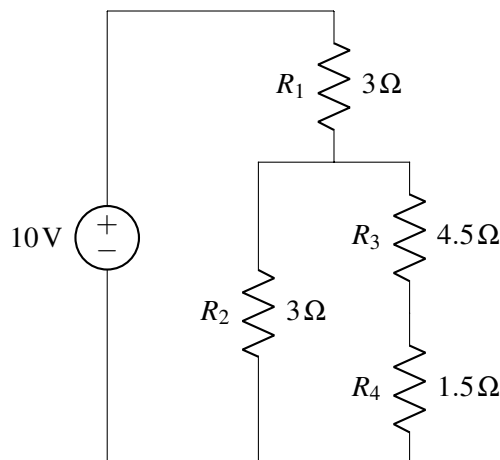
- (b) Diagonalize the matrix

$$\mathbf{A} = \begin{bmatrix} \frac{1}{2} & \frac{1}{2} & -\frac{1}{2} \\ -\frac{1}{2} & \frac{3}{2} & \frac{1}{2} \\ -1 & 1 & 1 \end{bmatrix}$$

given that \mathbf{A} has eigenvalues 1, 2, and 0.

2. Mechanical Circuits

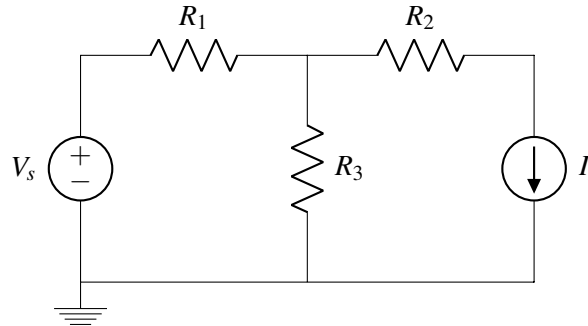
Find the voltages across and currents flowing through all of the resistors.



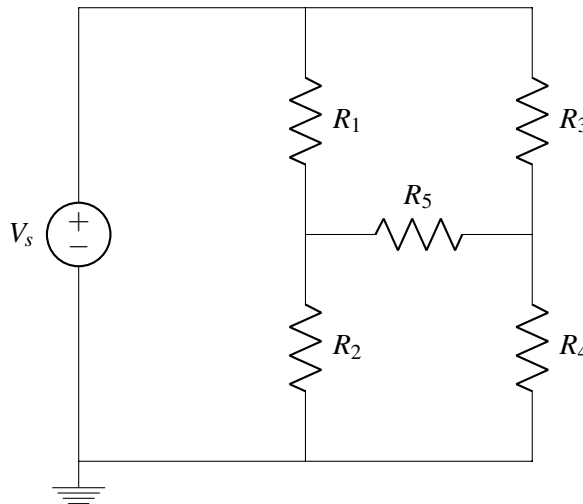
3. Circuit Analysis

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



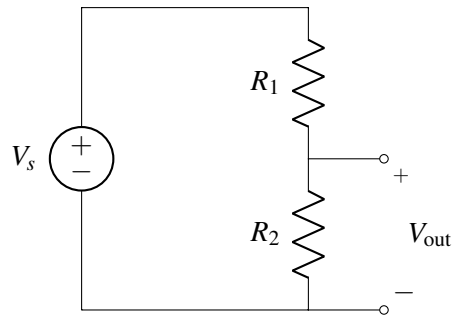
4. Temperature Sensor

Measuring quantities in the physical world is the job of sensors. This means somehow extracting that information from the world and then converting it into a form that can be observed and processed. Electrical circuits can be very useful for doing this.

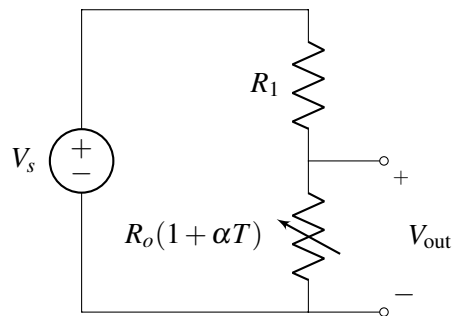
For most materials, resistance increases with increasing temperature; that is, a resistor has higher resistance when it is hot than when it is cold. This is often an annoyance to circuit designers who want their circuits to work the same way at different temperatures, but this fact can also be useful. It allows us to convert temperature, a “physical” quantity, into resistance, an “electrical” quantity, to build an electronic thermometer.

In this problem, we are going to explore how effective a particular circuit made out of various types of resistors is at allowing us to measure temperature.

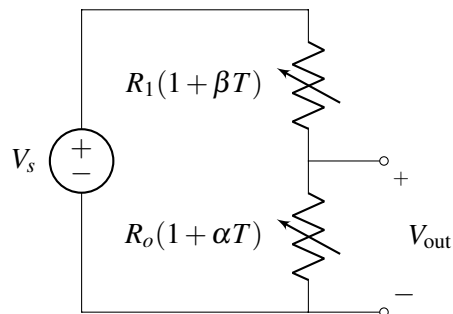
(a) Let’s begin by analyzing a common topology, the voltage divider shown below. Find an equation for the voltage V_{out} in terms of R_1 , R_2 , and V_s .



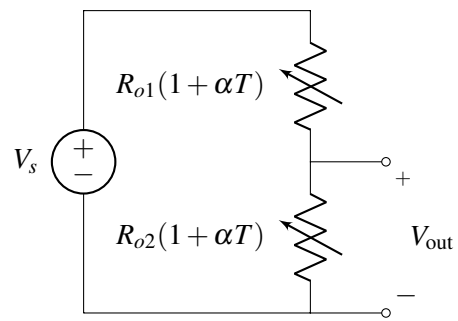
- (b) Now let's suppose that R_1 is an ideal resistor that does not depend on temperature, but R_2 is a temperature-dependent resistor whose resistance R is set by $R = R_o(1 + \alpha T)$, where T is the absolute temperature. Find an equation for the temperature T in terms of the voltage V_{out} , V_s , R_1 , R_o , and α .



- (c) It turns out that almost all resistors have some temperature dependence. Consider the same circuit as before, but now, R_1 has a temperature dependence given by $R_1' = R_1(1 + \beta T)$. Find an equation for the temperature T in terms of the voltage V_{out} , R_1 , R_o , V_s , α , and β .



- (d) Your colleague who has not taken EE16A thinks that they can improve this circuit's ability to measure temperature by making both resistors depend on temperature in the same way. He hence came up with the circuit shown below, where both R_1 and R_2 have nominally different values, but both vary with temperature as a function of $(1 + \alpha T)$. Can this circuit be used to measure temperature? Why or why not?



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?