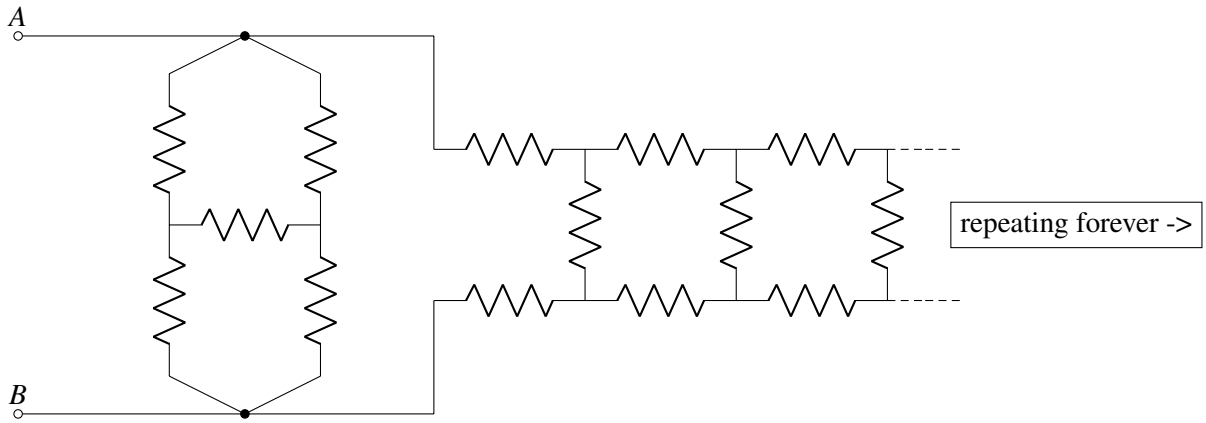
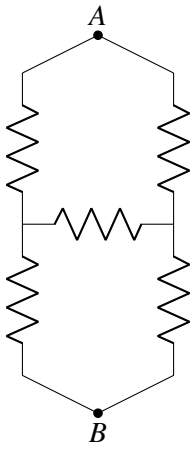
EECS 16A Designing Information Devices and Systems I
Spring 2023 Exam Prep 9B

1. Aid to the Resistance (Spring 2021 Midterm 2 Question 7)

The main ship of the Resistance Fleet is in trouble! They have recruited you to help fix the issue. The on-board technicians have determined that the resistor grid in the main console is faulty (one of the resistors must be fried). It is your job to replace the grid with something of equivalent resistance. However, because of severe budget cuts in the Resistance's EE department, you can only use a single resistor connected between nodes A and B to replace the resistor grid. The technicians hand you the diagram below of what the resistor grid looked like. All resistors in the diagram have resistance value R.

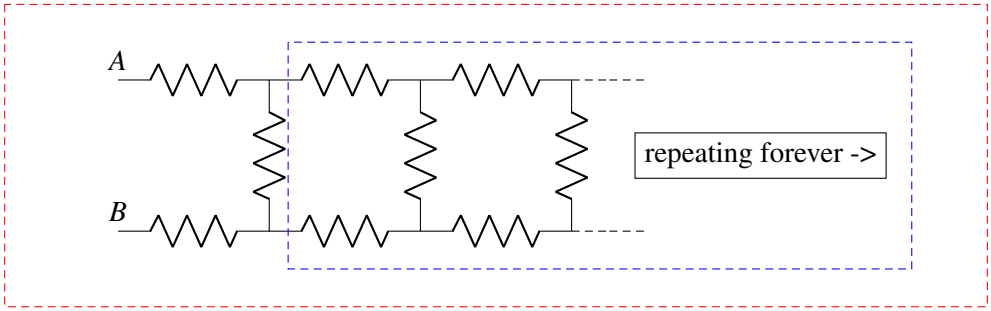


(a) Find the equivalent resistance of the following piece of the resistor grid between nodes A and B in terms of R.



(b) Find the equivalent resistance of the following piece of the resistor grid between nodes A and B in terms of R.

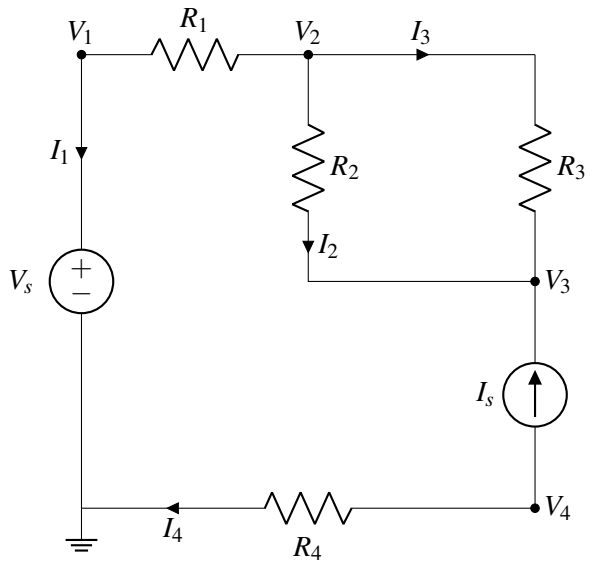
Hint: Because the pattern is infinite, the equivalent resistance of the circuit in the red box and the equivalent resistance of the circuit in the blue box are equal.



(c) Suppose the equivalent resistance for the piece of resistor grid in part (a) is αR, and the equivalent resistance for the piece of resistor grid in part (b) is βR, where α and β are known real numbers for this part. What should be the value of the resistor you use to replace the entire grid with, in terms of R, α, and β?

2. Linearity of Circuits (Spring 2020 Midterm 2 Question 7)

Consider the following circuit:



(a) In order to analyze this circuit, Nirmaan wrote down a system of equations for the circuit and then cast it into matrix-vector form. However, some of the entries of the matrix was smudged, and Nirmaan needs your help filling in the missing entries. Fill in the missing values in the matrix below.

$$\begin{bmatrix} 0 & 0 & 0 & 0 & (a) & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & (b) & (b) & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ (c) & 0 & 0 & 0 & 1 & -1 & 0 & 0 \\ 0 & (d) & 0 & 0 & 0 & -1 & 1 & 0 \\ 0 & 0 & R_3 & 0 & 0 & -1 & 1 & 0 \\ 0 & 0 & 0 & R_4 & 0 & 0 & 0 & -1 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \\ V_1 \\ V_2 \\ V_3 \\ V_4 \end{bmatrix} = \begin{bmatrix} V_s \\ 0 \\ I_s \\ -I_s \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

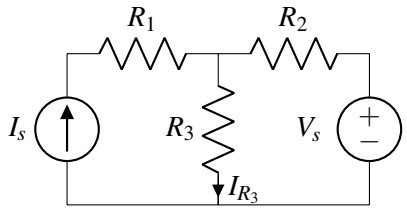
(b) When $V_s = 10V$, $I_s = 1A$, and $R_1 = R_2 = R_3 = R_4 = 1\,\Omega$, we have that the solution to the above system of equations is the vector

$$\begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \\ V_1 \\ V_2 \\ V_3 \\ V_4 \end{bmatrix} = \begin{bmatrix} 1.0 \\ -0.5 \\ -0.5 \\ -1.0 \\ 10.0 \\ 11.0 \\ 11.5 \\ -1.0 \end{bmatrix}$$

What is the power dissipated across the voltage source, and R_3 respectively?

3. Superposition (Spring 2020 Midterm 2 Question 8)

Consider the following circuit:



We will be using superposition to find the power dissipated across the R_3 resistor.

(a) With the current source turned on and the voltage source off, find the current I_{R_3}.

(b) With the voltage source turned on and the current source turned off, find the voltage V_{R_3}.

(c) Find the power dissipated across R_3.

