Linear Algebra: Numerical Experiment (Circuit Design)*

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Our analysis in Example 1 from "Linear Algebra: Circuit Analysis"[1] and Problem 1 from "Linear Algebra: Circuit Analysis"[2] indicates that not enough current will flow through the lamp to make it glow. We now wish to change the resistance of the 100 ohm resistor to a new value so that the lamp will glow. We replace 100 in the equations with an unknown resistance R. Equation 2[3] is unchanged, but Equation 6[4] becomes

$$\begin{aligned} & \tfrac{(v_2-v_1)}{50} + \tfrac{v_2}{300} + \tfrac{(v_2-v_3)}{R} = 0 \\ \Rightarrow \quad & 6R\left(v_2-v_1\right) + Rv_2 + 300\left(v_2-v_3\right) = 0 \\ \Rightarrow \quad & -6Rv_1 + \left(7R+300\right)v_2 - 300v_3 = 0. \end{aligned} \tag{1}$$

Equation 7 from "Linear Algebra: Circuit Analysis"[5] becomes

$$\begin{aligned} & \tfrac{(v_3-v_2)}{R} + \tfrac{v_3}{2} = 0 \\ \Rightarrow \quad & 2\left(v_3-v_2\right) + Rv_3 = 0 \\ \Rightarrow \quad & 0v_1 - 2v_2 + \left(R+2\right)v_3 = 0. \end{aligned} \tag{2}$$

The matrix form of these equations is

$$\begin{bmatrix} 1 & & 0 & 0 \\ -6R & 7R & +300 & -300 \\ 0 & & -2 & R+2 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} = \begin{bmatrix} 5 \\ 0 \\ 0 \end{bmatrix}. \tag{3}$$

Write a MATLAB function file called `builda` to accept R as an input and return the matrix A in Equation 3 (3) as an output. The first line of your function file should be

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[1] "Linear Algebra: Circuit Analysis", Example 1 <http://cnx.org/content/m21447/latest/#fs-id18415900>
[2] "Linear Algebra: Circuit Analysis", Exercise 1 <http://cnx.org/content/m21447/latest/#fs-id18417230>
[3] "Linear Algebra: Circuit Analysis", (2) <http://cnx.org/content/m21447/latest/#eip-902>
[4] "Linear Algebra: Circuit Analysis", (6) <http://cnx.org/content/m21447/latest/#id2262071>
[5] "Linear Algebra: Circuit Analysis", (7) <http://cnx.org/content/m21447/latest/#id2262391>

```
function A = builda(R);
```

Now choose several values for R. For each choice, use your function *builda* and solve the resulting matrix equation $Av = b$ for the voltages. Each time you choose a different R to build a different matrix A, check the determinant of A to be sure the equations have a unique solution:

```
≫ det(A)
```

Make a table of R and the corresponding values of v_3:

R	v_3	

Figure 1

Now add a column to your table for the current through the lamp $i = v_3/2$. Add rows to your table until you have found a value of R for which the lamp will glow. (i needs to be between 0.05 and 0.075 ampere.)