# Math 317: Computer Lab 2

*NAME:*

**Instructions.**

- This assignment must be completed in the Carver 449 computer lab by 2pm on

  **Friday February 12.**

  Late submissions will not be accepted. Here is a summary of what it takes to complete each part of the lab. More detailed instructions appear on the following pages.

- **Part 1.** To complete this part, you must login to your account on the Math Department Sage server and demonstrate that you know how to input a matrix, augment a matrix with a vector, and compute the echelon form of an (augmented) matrix.

  Completing Part 1 is worth 1 point. If you are not interested in completing Part 2 of the assignment, you may turn in your paper and leave the lab after completing Part 1.
  **Make sure your name is on your paper and it was signed by the instructor.**

- **Part 2.** To complete Part 2, you must first download the Sage worksheet file Math317-Lab2.sws from either Blackboard or GitHub, load this worksheet into your Sage session and follow the instructions provided. You must then save your completed Sage worksheet to a file and upload the resulting sws file to Blackboard.

- When you have finished working or it is 2pm (whichever comes first):

  1. **stop your Sage worksheet** (Action → Save and quit worksheet; or use Stop button),
  2. **sign out of Sage**,
  3. **logout of your computer**,
  4. **write your name on your paper**,
  5. **hand it in to the instructor**.

## Part 1

In Homework 3, we proved that the vector $\mathbf{b} = (1, -1, 1, -1)$ is as a linear combination of the vectors $\mathbf{v}_1 = (1, 0, 1, -2)$, $\mathbf{v}_2 = (0, -1, 0, 1)$, and $\mathbf{v}_3 = (1, -2, 1, 0)$. Do you remember how we did this? That's right! We recognized that if the matrix $A$ has first column $\mathbf{v}_1$, second column $\mathbf{v}_2$, and third column $\mathbf{v}_3$, then writing $\mathbf{b}$ as a linear combination of the given vectors is the same as solving the system $A\mathbf{x} = \mathbf{b}$. That is, if we find $\mathbf{x} = (x_1, x_2, x_3)$ that solves this system, then $\mathbf{b} = x_1\mathbf{v}_1 + x_2\mathbf{v}_2 + x_3\mathbf{v}_3$ is the desired linear combination.

In this first part of this lab assignment, we will simply re-solve the above problem, but this time we will make Sage do the tedious work. Carry out the following steps:

1. Login to any machine in Carver 449, open up a browser (preferably Chrome) and navigate to

   https://sage.math.iastate.edu/

   Login to your account on the Math Department Sage server using the login information you were given for Lab 1. Once you are logged in, create a new worksheet and name it Lab2.

2. In the Lab2 worksheet, click the first cell and type the following:

   ```
   b = vector([1, -1, 1, -1]); print b
   ```

   Then type Shift+Enter or click 'evaluate'. Did Sage print what you expect? If so, move on. If not, try again and/or ask the instructor for help.

3. Click somewhere inside the next cell and enter the following expression:

   ```
   A = matrix(4, 3, [1, 0, 1, 0, -1, -2, 1, 0, 1, -2, 1, 0])
   print A
   ```

   What did Sage print? Is it a matrix with three columns, $\mathbf{v}_1$, $\mathbf{v}_2$, $\mathbf{v}_3$? If not, try again and/or your neighbor for help. Can you decypher the syntax we used to input this matrix $A \in \mathbb{R}^{4\times 3}$? If so, move on. If not, think a litter harder and/or discuss it with your neighbor.

4. Next, have Sage augment the matrix $A$ with the vector $b$ by entering the following into the next worksheet cell:

   ```
   Ab = A.augment(b, subdivide=True)
   print Ab
   ```

5. Ask Sage to put your augmented matrix in reduced-row echelon form:

   ```
   Ab.rref()
   ```

   You should now see two pivots (both equal to 1). Let the free variable $x_3 = s$ and write the vector $\mathbf{b}$ as a linear combination of the vectors $\mathbf{v}_1$, $\mathbf{v}_2$, $\mathbf{v}_3$ involving $s$.

$$\mathbf{b} = \begin{bmatrix} 1 \\ -1 \\ 1 \\ -1 \end{bmatrix} = \_\_\_\_\mathbf{v}_1 + \_\_\_\_\mathbf{v}_2 + \_\_\_\_\mathbf{v}_3.$$

If you want to stop here, ask the instructor to check your work and sign below then save and quit. Otherwise, move on to Part 2 by loading the Math317-Lab2.sws file into your Sage session.

Instructor signature: _____ (1 point)