**Instructions:** This quiz is closed book, closed note, and an individual effort. Electronic devices are not allowed on your person (e.g., no cell phones or calculators). Answer each question. **Show all work to receive full credit.** Unless the question specifies, you should provide an exact answer. If you get stuck, please attempt to explain what you want to do. This may give more partial credit.

**WRITE THIS PARAGRAPH ON WHAT YOU SUBMIT ALONG WITH A SIGNATURE AND DATE.**

I, ________________________, will not under any circumstance use an online source, my peers, my notes, or any other resource besides my own knowledge to complete this quiz. I will show all my work to demonstrate my knowledge on the topic.

1. Use the matrix, $A$, and vector, $b$, to answer the below questions.

$$A = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 2 & 3 \\ 1 & 3 & 6 \end{bmatrix}, \mathbf{b} = \begin{bmatrix} 5 \\ 7 \\ 11 \end{bmatrix}$$

   a. Find the matrices $U$ and $L$ such that $U$ is upper triangular, $L$ is lower triangular, and $A = LU$ If you are stuck here, email me and you will lose full points on this part, but I will give you the solution to move forward).

   b. Solve the system $L\mathbf{c} = \mathbf{b}$ for $\mathbf{c}$.

   c. Solve the system $U\mathbf{x} = \mathbf{c}$ for $\mathbf{x}$.

   d. Show this is correct by solving the system $A\mathbf{x} = \mathbf{b}$ by elimination (You can do full row reduction or stop at the upper triangle and solve).

2. Write all possible 3 x 3 permutation matrices.

3. Which of the matrices you found above is $P$ in the below.

$$PA = P \begin{bmatrix} 1 & 2 & 3 \\ -1 & 3 & -2 \\ 3 & 2 & 1 \end{bmatrix} = \begin{bmatrix} -1 & 3 & -2 \\ 3 & 2 & 1 \\ 1 & 2 & 3 \end{bmatrix}$$

4. Let $A$ and $B$ be the following matrices:

$$A = \begin{bmatrix} a & b \\ b & c \end{bmatrix}, B = \begin{bmatrix} d & e \\ e & f \end{bmatrix}.$$

   Show that if $AB$ is symmetric then $AB = BA$.

5. Suppose you are given the following:

$$\begin{aligned} x + 3y + 3z &= 1 \\ 2x + 6y + 9z &= 5 \\ -x - 3y + 3z &= 5 \end{aligned}$$

a. Write the following system as a matrix equation, $A\mathbf{x} = \mathbf{b}$.

b. Determine the rank of the matrix $A$.

c. Determine the generator(s) (spanning vectors) of the column space of the matrix $A$.

d. Determine the generator(s) (spanning vectors) and dimension of the null space of the matrix $A$.

e. Give the complete solution of the system $A\mathbf{x} = \mathbf{b}$ as $\mathbf{x} = \mathbf{x}_p + \mathbf{x}_n$.