2. $A = \begin{pmatrix} -1 & 0 & 3 \\ 2 & 1 & 2 \\ -1 & 0 & 1 \end{pmatrix}$ and $2B = \begin{pmatrix} 2 & 6 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 2 \end{pmatrix}$. Since these matrices are the same size, we can add them. So $A + 2B = \begin{pmatrix} 1 & 6 & 3 \\ 2 & 3 & 2 \\ -1 & 0 & 3 \end{pmatrix}$.

3. $2C = \begin{pmatrix} 2 & 0 \\ 4 & 2 \\ 2 & 6 \end{pmatrix}$ is a 3X2 matrix and $D = \begin{pmatrix} 3 & -1 & 0 \\ 2 & 1 & 2 \end{pmatrix}$ is a 2X3 matrix. Since they are not the same size, we cannot add or subtract them.

4. $A$ is a 3X3 matrix, and $B$ is a 3X3 matrix, so since the number of columns of $A$ is equal to the number of rows of $B$, the product $AB$ exists and is a 3X3 matrix.

5. $\begin{pmatrix} -1 & 0 & 3 \\ 2 & 1 & 2 \\ -1 & 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 3 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} -1 & -3 & 3 \\ 2 & 7 & 2 \\ -1 & -3 & 0 \end{pmatrix}$

6. $C$ is a 3X2 matrix and $D$ is a 2X3 matrix, so since the number of columns of $C$ is equal to the number of rows of $D$, $CD$ exists and is a 3X3 matrix.

7. $\begin{pmatrix} 1 & 0 \\ 2 & 1 \\ 1 & 3 \end{pmatrix} \begin{pmatrix} 3 & -1 & 0 \\ 2 & 1 & 2 \end{pmatrix} = \begin{pmatrix} 3 & -1 & 0 \\ 8 & -1 & 2 \\ 9 & 2 & 6 \end{pmatrix}$

8. $A$ is a 3X3 matrix and $D$ is a 2X3 matrix, so $AD$ does not exist since the number of columns of $A$ does not match the number of rows of $D$.

17. a) If $AB$ is a 6X5 then $A$ has 6 rows and $B$ has 5 columns.

    b) If $AB$ is a 4X7 matrix then $A$ has 4 rows and $B$ has 7 columns.

    c) If $A$ is a 2X6 matrix and $AB$ is a 2X4 matrix, then $B$ has 6 rows and 4 columns.

44. Yes, let $A = \begin{pmatrix} 1 & 0 \\ 0 & 0 \end{pmatrix}$ and $B = \begin{pmatrix} 0 & 0 \\ 0 & 1 \end{pmatrix}$ then $AB = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}$
51. If $A$ had a square root, then there would exist a matrix \[
\begin{pmatrix}
a & b \\
c & d
\end{pmatrix}
\] such that \[
\begin{pmatrix}
a & b \\
c & d
\end{pmatrix}
\begin{pmatrix}
a & b \\
c & d
\end{pmatrix} = \begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix}.
\] Multiplying out the left hand side, we get \[
\begin{pmatrix}
a^2 + bc & ab + bd \\
ac + dc & bc + d^2
\end{pmatrix} = \begin{pmatrix} a^2 + bc & b(a + d) \\ c(a + d) & bc + d^2 \end{pmatrix}.
\] Since the bottom right entry must be equal to 1, then $(a + d)$ cannot be 0. And since $a + d$ is not equal to 0, and the bottom left entry is 0, then $c = 0$. If $c = 0$, then the top left entry and bottom right entry are equal to $a^2$ and $d^2$ respectively, which would imply that $a = 0 = d$, which is a contradiction, since $a + d \neq 0$. Hence $A$ has no square roots.

If $C = \begin{pmatrix} 1 & 0 \\ k & -1 \end{pmatrix}$, then $C^2 = \begin{pmatrix} 1 & 0 \\ k & -1 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ k & -1 \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ for any choice of $k$. Hence there are an infinite number of square roots of $B$. 