1. Consider the following matrix.

\[
T = \begin{bmatrix}
3 & 0 & 0 \\
0 & 2 & 1 \\
0 & 1 & 2
\end{bmatrix}
\]

Determine nonsingular matrix \( P \) and diagonal matrix \( D \) such that \( T = PDP^{-1} \).

2. Prove that for any vectors \( u \) and \( v \) the following is true:
\( u + v \) and \( u - v \) are orthogonal if and only if \( ||u|| = ||v|| \).

3. True/False. Justify your answer.
   
   (a) A matrix and its inverse have the same eigenvalues.
   
   (b) If two matrices are similar, then they have the same characteristic polynomial.
   
   (c) If \( W \) is any set of vectors, then \( (W^\perp)^\perp = W \).
   
   (d) Every vector space has an orthonormal basis.

4. For the vectors \( a = (1, 2, 3) \) and \( b = (-2, 0, 5) \), determine the projection of each onto the other.

5. Give an orthonormal basis of \( \mathbb{R}^2 \) that includes a vector that is orthogonal to \( (1, 1) \).