1- Let \( \mathbf{p}_1 = \begin{bmatrix} 1 \\ 1 \\ 3 \\ 0 \end{bmatrix}, \quad \mathbf{p}_2 = \begin{bmatrix} 0 \\ 1 \\ -1 \\ 0 \end{bmatrix}, \quad \mathbf{p}_3 = \begin{bmatrix} 2 \\ -1 \\ 2 \\ 0 \end{bmatrix}, \quad \mathbf{p}_4 = \begin{bmatrix} 2 \\ 4 \\ 3 \\ -1 \end{bmatrix} \), determine a set of orthonormal vectors spanning the same space, using the vectors in the given order.

2- Consider the vectors in Problem 1. We want to represent
\[ \hat{\mathbf{p}}_4 = c_1 \mathbf{p}_1 + c_2 \mathbf{p}_2 + c_3 \mathbf{p}_3, \quad p_4 = \hat{p}_4 + e \]
Find the coefficients (and \( e \)) using:
   a) \( p_4, p_1, p_2, p_3 \) given as above
   b) orthonormal vectors obtained from \( p_1, p_2, p_3 \) in Problem 1-.

3- Prove that a covariance matrix is a positive semi-definite matrix.