1. (20 pts.)
   
   (a) Find a basis for the vector space 
   \[ \{x \hat{i} + y \hat{j} + z \hat{k} \in \mathbb{R}^3 : x + 2y + 5z = 0 \}, \]
   
   (b) Calculate the projection of the vector \((5, 4, 2) \in \mathbb{R}\) in the direction given by \((1, -1, 0)\). (Note: The answer should be a vector)

2. (25 pts.) Let \( \vec{F} = (x^2 - 2xy) \hat{i} + (y^2 - 2xy) \hat{j} \). Calculate the curve integral of \( \vec{F} \) along the parabola \( y = x^2 \) from \((-1, 1)\) to \((1, 1)\). Draw the curve first.

3. (25 pts.) Let \( \vec{F} = x \hat{i} + y \hat{j} \). Calculate the surface integral of \( \vec{F} \) over the surface determined by \( x^2 + y^2 + z^2 = 1 \), \( z \geq 0 \). Draw the surface first.

4. (30 pts.) Let \( \vec{F} = x^5 \hat{i} + y^5 \hat{j} + z^5 \hat{k} \). Let \( C \) be a curve given in cylindrical coordinates \((\rho, \theta, z)\) by 
\[ \rho = \sin \theta, \ 0 \leq \theta \leq \pi, \ z = \pi \theta - \theta^2 \]
   
   (a) Calculate the Jacobian matrix of \( \vec{F} \). What is the trace (sum of the diagonal entries) of the Jacobian matrix? What is it equal to in this case?
   
   (b) Calculate \( \nabla \times \vec{F} \).
   
   (c) Draw the curve \( C \). What is the line integral of \( \vec{F} \) along this curve?