1. Given a square matrix $A = \begin{bmatrix} 0 & 1 & 0 \\ 1 & -2 & 0 \\ 0 & 0 & 3 \end{bmatrix}$.

   (1) Find its eigenvalues and the associated eigenvectors.

   (2) Show if the matrix A is diagonalizable.

2. Given a quadratic form $F = x_1^2 + 2x_1x_2 + 6x_2^2$.

   (1) Find a matrix A such that quadratic form is X^tAX with $X^t = [x_1\ x_2]$.

   (2) Show that matrix A is a symmetric matrix.

   (3) Find the standard form of the quadratic form.

3. Find the general solution of the following homogeneous system of linear differential equations.

   $$\begin{pmatrix} x_1' \\ x_2' \end{pmatrix} = \begin{bmatrix} 3 & 3 \\ 1 & 5 \end{bmatrix}\begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$$

4. Given: A curve C has parametric equations $x=2t^2$, $y=3t^2$, $z=4t^2$ for $1 \le t \le 3$.

   (1) Write the position vector $\vec{F}(t)$ and tangent vector $\vec{F}'(t)$ for curve C.

   (2) Find the length function s(t) and calculate the length of curve C.

   (3) Find the curvature κ of curve C.

5. Given a vector field $\vec{F}(x, y, z) = e^z\vec{i} - x^2\vec{k}$.

   (1) Compute $\text{curl}\vec{F}$.

   (2) Compute $\text{div}\vec{F}$.

   (3) Find the streamlines of the vector field $\vec{F}$.

6. Calculate the work done by the force $\vec{F} = \vec{i} - y\vec{j} + xyz\vec{k}$ in moving a particle from (0, 0, 0) to (1, -1, 1) along the curve $x = t$, $y = -t^2$, $z = t$ for $0 \le t \le 1$.