1. Find the $2 \times 2$ matrix which reflects across the line $3x - y = 0$.

2. Find the $3 \times 3$ matrix which vanishes on the plane $4x + 2y + z = 0$, and maps the vector $(1, 1, 1)$ to itself.

3. Find the $3 \times 3$ matrix which vanishes on the vector $(1, 1, 0)$, and maps each point on the plane $x + 2y + 2z = 0$ to itself.

4. Find the $3 \times 3$ matrix that projects orthogonally onto the line

$$
\begin{bmatrix}
  x \\
  y \\
  z \\
\end{bmatrix}
= \begin{bmatrix}
  1 \\
  -2 \\
  3 \\
\end{bmatrix} t
$$

5. Find the $3 \times 3$ matrix that projects orthogonally onto the plane

$$x + 2y + 3z = 0$$

6. Find the row space and the column space of the matrix

$$
\begin{bmatrix}
  0 & 0 & 1 & 1 & 1 \\
  0 & 0 & 1 & 2 & 3 \\
  0 & 0 & 1 & 3 & 6 \\
\end{bmatrix}
$$

7. By least squares, find the equation of the form $y = ax + b$ that best fits the data

$$
\begin{bmatrix}
  x_1 & y_1 \\
  x_2 & y_2 \\
  x_3 & y_3 \\
\end{bmatrix}
= \begin{bmatrix}
  0 & 1 \\
  1 & 0 \\
  2 & 3 \\
\end{bmatrix}
$$

8. Find an orthogonal basis for the subspace $V$ of $\mathbb{R}^4$ spanned by the vectors

$$(1, 2, 0, 0) \quad (0, 1, 2, 0) \quad (1, 3, 3, 2) \quad (0, 0, 1, 2) \quad (1, 3, 3, 2)$$

Extend this basis to an orthogonal basis for $\mathbb{R}^4$.

9. Let $V$ be the vector space of all polynomials of degree $\leq 2$ in the variable $x$ with coefficients in $\mathbb{R}$. Let $W$ be the subspace consisting of those polynomials $f(x)$ such that $f(-1) = 0$. Find the orthogonal projection of the polynomial $x + 1$ onto the subspace $W$, with respect to the inner product

$$\langle f, g \rangle = \int_{-1}^{1} f(x)g(x) \, dx$$