1. (30 pts) Consider the two planes described by $2y + z = 1$ and $-x + 2y + 2z = 3$.
   (a) Is the point $P(-1, 0, 1)$ on both planes, one of the planes, or neither?
   (b) Find the angle formed by the two planes.
   (c) Find equations for the line of intersection of these two planes. Express your answer in parametric and symmetric forms.
   (d) What is the shortest distance between the point $Q(0, 1, 3)$ and the line of intersection?

2. (16 pts) A particle is moving in the direction $\mathbf{v} = \mathbf{i} + \mathbf{j}$ when a force of $\mathbf{F} = 3\mathbf{j} + 4\mathbf{k}$ is applied to it.
   (a) Decompose the vector $\mathbf{F}$ into a sum of 2 vectors: one vector parallel to the particle's direction of motion and the other vector orthogonal.
   (b) Find a unit vector that is orthogonal to $\mathbf{F}$.

3. (30 pts) Consider the surface $3x^2 + 6x + y + 3z^2 + 3 = 0$.
   (a) Write the equation in standard form.
   (b) For each of the two planes listed below,
   - identify the shape of the trace of the surface in the plane, and
   - find the (x, y, z) coordinates of either the center or the vertex of the trace.

   i. $y = -2$ plane
   ii. xy-plane

   (c) Identify the given surface.
   (d) Find a vector equation for the line along which the surface is centered.

4. (24 pts) A particle travels along the following path, starting at $t = 0$.

$$\mathbf{r}(t) = (3\cos t)\,\mathbf{i} + (3\sin t)\,\mathbf{j} + \left(\sqrt{7}\,t\right)\mathbf{k}$$

   (a) Find the velocity vector $\mathbf{v}(t)$ of the path.
   (b) Find the unit tangent vector $\mathbf{T}(t)$. Simplify your answer.
   (c) At $t = \pi$, how far is the particle from its starting position?
   (d) At $t = \pi$, how far has the particle traveled along the path?