1. (10 points) Let $x^2 + y^2 = 9$.
   
   (a) Describe or sketch the set of points in $\mathbb{R}^3$ that satisfy the above given equation.

   (b) Write the given equation in spherical coordinates.

   (c) Is the point $(0, -3, 5)$ on the surface represented by the given equation? Explain.

   (d) Give cylindrical coordinates of the point $(0, -3, 5)$. 
2. (8 points) Describe the curve in which the two surfaces $z = 6 - x^2 - y^2$ and $z = x^2 + y^2$ intersect. Write a parametrization for this curve.
3. **(10 points)** Let $L$ be the line given by $x = 2 - t$, $y = t$, $z = t + 1$ and let $P$ be the plane given by the equation $5x - y + 7z = 21$.

(a) Find the coordinates of two points on the line $L$.

(b) Find a point on the $y$-axis that is on the plane $P$.

(c) Find a normal vector to the plane $P$ that has length 3.

(d) Does the line $L$ intersect the plane $P$? If so, where?
4. (10 points) Let $L_1 : x = 1 + 2t, y = 2 + 3t, z = 3 + 4t$
and $L_2 : x = 2 - t, y = 5, z = 3 - 4t$ be two lines.

(a) Find the angle between the two lines.

(b) Find the equation of the plane containing the two lines.
5. **(10 points)** Two ropes are attached to an object placed at the origin. One rope is pulled with a force of 100 newtons in a direction 60 degrees north of east. The other rope is pulled with a force of 70 newtons in the west direction. Find the total force acting on the object. Assume the positive x-axis points in the east direction and the positive y-axis points in the north direction.
6. **(10 points)** Let \( v(t) = (2t^2 + 5)\vec{i} - (t + 1)\vec{j} + t^2\vec{k} \) be the velocity function of an object.

(a) Find the position function \( r(t) \) that satisfies the initial condition \( r(0) = \vec{i} - \vec{j} + \vec{k} \).

(b) Find a parametrization for the line tangent to the path \( r(t) \) at \( t = 1 \). (Use the \( r(t) \) that you find in part (a).)
7. **(9 points)** Consider the following linear transformation \( T \) on \( \mathbb{R}^3 \):
Dilation by a factor of 2 followed by clockwise rotation about the \( z \)-axis by 30 degrees.

(a) Write a matrix for \( T \).

(b) Is \( T \) invertible? Explain.

(c) Let \( P \) be a parallelepiped in \( \mathbb{R}^3 \) such that Volume \( T(P) = 100 \). Find Volume \( (P) \).
8. (8 points) Let $p(x, y, z) = 2x^2 + 3y^2 + 5z^2 + 8xz + 6yz$ be a quadratic form on $\mathbb{R}^3$.

(a) Find the symmetric matrix that represents the quadratic form.

(b) Categorize the quadratic form as positive definite, negative definite, indefinite, or none of these.