1. (a) Eliminate the parameter to find a cartesian (rectangular) equation of the curve whose parametric equations are \( x = 2 \sin^2 t \) and \( y = 4 \sec t \), \( -\frac{\pi}{2} < t < \frac{\pi}{2} \).

(b) Find an equation of the tangent line to the curve in part (a) at \( t = \frac{\pi}{4} \).
2. (a) Find \( \frac{dy}{dx} \) and \( \frac{d^2y}{dx^2} \) for the curve given by

\[
x = t + t^2 \quad \text{and} \quad y = t - t^2.
\]

(b) Find the values of \( t \) for which the curve given in part (a) is concave down.
3. (a) Find the area of the surface obtained by rotating about the $x$-axis the curve given by

\[ x = \sqrt{7} \cos^3 \theta \quad \text{and} \quad y = \sqrt{7} \sin^3 \theta \quad 0 \leq \theta \leq \frac{\pi}{2}. \]

(b) On the same polar coordinate system, draw the unit circle centered at the origin and plot the points whose polar coordinates are \( \left( 2, \frac{3\pi}{4} \right) \), \( \left( -\frac{3}{2}, \frac{\pi}{2} \right) \), and \( \left( -\frac{1}{2}, -\frac{7\pi}{6} \right) \).
4. (a) Sketch on the same polar coordinate system the curves

\[ r = \sqrt{3} \sin \theta \quad \text{and} \quad r = 1 + \cos \theta. \]

and determine polar coordinates of the intersection point(s) if any.
(b) Find the area of the region that lies inside the curve \( r = \sqrt{3} \sin \theta \) and outside the curve \( r = 1 + \cos \theta \).
5. (a) Find an equation of the sphere whose diameter has endpoints \((2, 1, 4)\) and \((4, 3, 10)\).

(b) Describe in words and sketch the region of the three-dimensional space represented by \(z^2 = 4\).
6. (a) Given the points \( A(1, 0, -1) \), \( B(2, 1, 0) \), find the coordinates of the point \( C \) such that \( \overrightarrow{AC} \) and \( \overrightarrow{AB} \) have opposite directions and \(|\overrightarrow{AC}| = 3|\overrightarrow{AB}|\).

(b) Consider the vectors \( \vec{u} = \langle \sin x, 2, 1 \rangle \) and \( \vec{v} = \langle 1, \cos x, \sin x \rangle \), \( 0 \leq x \leq 2\pi \).

Find the values of \( x \) for which the two vectors \( \vec{u} \) and \( \vec{v} \) are orthogonal.
7. (a) Find the volume of the parallelepiped with adjacent edges $DA, DB,$ and $DC,$ where $A(3, 0, 1), B(1, 2, 0), C(2, 1, 0), D(0, -1, 0)$.

(b) Consider the vectors 

$$\vec{a} = \langle -2, 1, 3 \rangle \text{ and } \vec{b} = \langle 3, 3, 4 \rangle.$$ 

If $\vec{u} = \text{proj}_{\vec{a}}\vec{b}$ and $\vec{v} = \vec{b} - \vec{u}$, find the vector $\vec{w}$

$$\vec{w} = \frac{1}{2} \vec{u} + (5\vec{a} \cdot \vec{v})\vec{v} - \vec{a} \times (2\vec{u}).$$