1. Consider the points $P = (2, -5, -1)$ and $Q = (4, 1, 1)$.
   
   (a) Find the distance from $P$ to $Q$.
   
   (b) Find the midpoint between $P$ and $Q$.
   
   (c) Find a parametrization of the line through $P$ and $Q$.
   
   (d) Find the equation of the sphere that has the line segment from $P$ to $Q$ as a diameter.
   
   (e) Sketch the points $P$ and $Q$, the midpoint, and the line.

2. Consider the plane given by the equation $6x + 3y + z = 6$.
   
   (a) Find the $x$-, $y$-, and $z$-intercepts of the plane.
   
   (b) Find a vector $\mathbf{n}$ perpendicular (normal) to the plane.
   
   (c) Sketch the plane along with its normal vector.

3. Consider the curve in $\mathbb{R}^3$ given by
   
   $$r(t) = \left< \sqrt{3} \sin(t^2), \sin(t^2), 2 \cos(t^2) \right>.$$ 

   (a) Find the arclength of $r(t)$ from $t = 0$ to $t = \sqrt{\pi}$.
   
   (b) Compute the derivative $r'(t)$ and second derivative $r''(t)$ of the curve $r(t)$.
   
   (c) Find the point $r = r(\sqrt{\pi})$, the tangent vector $r' = r'(\sqrt{\pi})$, and the acceleration vector $r'' = r''(\sqrt{\pi})$ at time $t = \sqrt{\pi}$.
   
   (d) Find the unit tangent vector $T$ at time $t = \sqrt{\pi}$.
   
   (e) Find the tangential component $a_T$ of the acceleration at time $t = \sqrt{\pi}$.
   
   (f) Find the normal component $a_N$ of the acceleration at time $t = \sqrt{\pi}$.
   
   (g) Find the unit normal vector $N$ at time $t = \sqrt{\pi}$.
   
   (h) Find the binormal vector $B$ at time $t = \sqrt{\pi}$.
   
   (i) Find the curvature $\kappa$ at time $t = \sqrt{\pi}$.

4. Consider the parabola in $\mathbb{R}^2$ given by
   
   $$r(t) = \left< t^2 - 2t + 1, 4t - 4 \right>.$$ 

   (a) Carefully sketch the curve from $t = 0$ to $t = 3$. Label the point $p = r(2)$.
   
   (b) Find the tangent vector $v$ to the curve at $t = 2$. Sketch the tangent vector on the graph in part (a) starting from the point $p$.
   
   (c) Find the parametric equation of the tangent line to the curve at $t = 2$. Sketch the line on the graph in part (a).
   
   (d) Find the acceleration vector $a$ to the curve at $t = 2$. Sketch the acceleration vector on the graph in part (a) starting from the point $p$.
   
   (e) Compute the curvature at $t = 2$. 
5. The following is the equation of a sphere. Find its center and radius.
\[ x^2 + y^2 + z^2 + 8x - 2y - 10z = 0. \]

6. Consider the vectors \( \mathbf{u} = (-1, 2, 3) \) and \( \mathbf{v} = (2, 1, 1) \).
   (a) Find a vector \( \mathbf{a} \) which is perpendicular to both \( \mathbf{u} \) and \( \mathbf{v} \).
   (b) Find the equation of the plane through the origin that contains both of the vectors \( \mathbf{u} \) and \( \mathbf{v} \).
   (c) Find the equation of the plane parallel to the one from part (b) that goes through the point \( (2, -1, 4) \).

7. Find the equation of the plane through the points \( (3, 2, 0) \), \( (0, 1, -2) \), and \( (-2, 0, 5) \).

8. Suppose that a surface has the following level curves from \( z = 0 \) to \( z = 4 \). Describe and sketch the surface.

9. Find and sketch the level curves of the surface \( z = y - x^2 \) for \( z \)-values \( z = -2, -1, 0, 1, 2 \).

10. Consider the surface given by \( 9x^2 + y^2 - 4z^2 = 36 \).
    (a) Find and sketch the equation of the curve obtained by intersecting the surface with the \( xy \)-plane.
    (b) Find and sketch the equation of the curve obtained by intersecting the surface with the \( yz \)-plane.
    (c) Find and sketch the equation of the curve obtained by intersecting the surface with the \( xz \)-plane.
    (d) For a \( z \)-value fixed to be constant, \( z = k \), find the equation of the level curve and identify what type of curve it is.
    (e) Draw a rough sketch of the surface.

11. Convert the equations for the following surfaces from spherical coordinates to both cylindrical and Cartesian coordinates. Use the Cartesian coordinate representation to identify the surface.
    (a) \( \rho \sin \phi = 2 \cos \theta \)
    (b) \( \rho = 6 \sin \phi \sin \theta \)

12. Convert the equations for the following surfaces from Cartesian coordinates to both cylindrical and spherical coordinates.
    (a) \( x^4 + x^2y^2 + x^2z^2 = y^2 \)
    (b) \( x^2 + y^2 - z^2 = 0 \)

13. Consider the vectors \( \mathbf{u} = (3, -1) \) and \( \mathbf{v} = (2, 1) \).
    (a) Find the projection of \( \mathbf{u} \) onto \( \mathbf{v} \).
    (b) Find the projection of \( \mathbf{v} \) onto \( \mathbf{u} \).
    (c) Find the angle between \( \mathbf{u} \) and \( \mathbf{v} \).
    (d) Sketch the vectors \( \mathbf{u}, \mathbf{v} \), and the projections.