1. Express $9\mathbf{i} - 2\mathbf{j} + 6\mathbf{k}$ as a product of its length and direction.

2. Given $P_1(1, -4, 7)$ and $P_2(3, -3, 2)$.
   a) Find the distance between $P_1$ and $P_2$.
   b) Find the direction of $\overrightarrow{P_1P_2}$.
   c) Find the midpoint of the line segment $P_1P_2$.

3. Find the center and radius of the sphere $x^2 + y^2 + z^2 + 4x - 6y - 2z - 1 = 0$. 

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4. Let \( \mathbf{v} = -\mathbf{i} + \mathbf{j} \) and \( \mathbf{u} = \sqrt{2}\mathbf{i} + \sqrt{3}\mathbf{j} + 2\mathbf{k} \).

   a) Find \( \mathbf{v} \cdot \mathbf{u} \), \( |\mathbf{v}| \), and \( |\mathbf{u}| \).

   b) Find the cosine of the angle between \( \mathbf{v} \) and \( \mathbf{u} \).

   c) Find the scalar component of \( \mathbf{u} \) in the direction of \( \mathbf{v} \).

   d) Find the vector proj, \( \mathbf{u} \).

4. Given \( P(1, 1, 1), \ Q(2, 1, 3), \) and \( R(3, -1, 1) \).

   a) Find the area of the triangle created by points \( P, \ Q, \) and \( R \).

   b) Find a unit vector perpendicular to plane \( PQR \).

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5. Find the volume of the parallelepiped formed by the vectors $\mathbf{u} = \langle 2, 1 \rangle$, $\mathbf{v} = \langle 2, -1, 1 \rangle$, and $\mathbf{w} = \langle 1, 0, 2 \rangle$.

6. Consider the following diagram.

Find the magnitude of the torque exerted by $\mathbf{F}$ on the bolt at $P$ if $|PQ| = 6$ inches and $|\mathbf{F}| = 50$ pounds. Answer in foot-pounds.

7. Find the vector and parametric equations for a line through $(0, -7, 0)$ and perpendicular to the plane $3x + 7y - 5z = 21$.

8. Find the an equation for the plane through $(2, 4, 5)$, $(1, 5, 7)$, and $(-1, 6, 8)$. 

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9. Find the plane determined by the intersecting lines.
   \[ L_1: x = t, \ y = 3 - 3t, \ z = -2t, \ -\infty < t < \infty. \]
   \[ L_2: x = 1 + s, \ y = 4 + s, \ z = -1 + s, \ -\infty < s < \infty. \]

10. Consider the following quadric surface. \[ \frac{x^2}{4} + \frac{y^2}{9} = \frac{z}{6}. \] A diagram follows.

   a. Which conic section results when we slice the above quadric surface with \( xy \)-plane?

   b. Which conic section results when we slice the above quadric surface with \( yz \)-plane?

   Continued on the next page.
11. Let \( \mathbf{r}(t) = (e^{-t}) \mathbf{i} + (2 \cos 3t) \mathbf{j} + (2 \sin 3t) \mathbf{k} \) be the position of a particle in space.

a. Find the particle’s velocity vector.

b. Find the particle’s acceleration vector.

c. Find the particle’s speed and direction of motion at time \( t = 0 \).

12. Let \( r(t) = (\sin t) \mathbf{i} + \mathbf{j} + (\cos t) \mathbf{k}, \ t \geq 0, \) be a position vector of a particle in space at time \( t \). Find the time or times in the given time interval when velocity and acceleration vectors are orthogonal.

13. Evaluate \( \int_0^1 \left[ \frac{2}{\sqrt{1-t^2}} \mathbf{i} + \frac{\sqrt{3}}{1+t^2} \mathbf{k} \right] dt. \)
14. Solve the following initial value problem for $\mathbf{r}$ as a vector function of $t$.

Differential Equation: \[ \frac{d^2 \mathbf{r}}{dt^2} = -(\mathbf{i} + \mathbf{j} + \mathbf{k}). \]

Initial Conditions: \[ \mathbf{r}(0) = 10\mathbf{i} + 10\mathbf{j} + 10\mathbf{k} \text{ and } \frac{d\mathbf{r}}{dt} \bigg|_{t=0} = 0. \]