1. True-False
   (a) T  F The vectors $<2, -1, 3>$ and $<4, -2, 6>$ are parallel.
   (b) T  F The vectors $<1, 2, 3>$ and $<1, -5, 3>$ are orthogonal.
   (c) T  F The vectors $<4, 1, 2>$ and $<-2, 4, 7>$ have the same length.
   (d) T  F The vector $<1, 1, 0>$ is a unit vector.
   (e) T  F The vector $<2, 1, -1>$ is normal (perpendicular) to the plane $2x + y - z = 3$.
   (f) T  F If $\mathbf{w} = \mathbf{u} \times \mathbf{v}$, then $\mathbf{w}$ is orthogonal to both $\mathbf{u}$ and $\mathbf{v}$.
   (g) T  F If $\mathbf{w} = 2\mathbf{u}$, then $||\mathbf{u} \times \mathbf{v}|| = 2 ||\mathbf{w} \times \mathbf{v}||$.

2. If $\mathbf{u}$ has length 3, $\mathbf{v}$ has length 2, and the angle between $\mathbf{u}$ and $\mathbf{v}$ is $60^\circ$, then $\mathbf{u} \cdot \mathbf{v} =$
   (a) $1/2$  (b) $6$  (c) $3$  (d) $3/2$  (e) $3\sqrt{3}$

3. If $\mathbf{u} = 2\mathbf{i} + 2\mathbf{j}$ and $\mathbf{v} = \mathbf{i} + \mathbf{j} + \mathbf{k}$, then $\text{proj}_\mathbf{v} \mathbf{u}$ (the projection of $\mathbf{u}$ onto $\mathbf{v}$) is
   (a) $\frac{4}{3} \mathbf{u}$  (b) $\frac{4}{3} \mathbf{v}$  (c) $2 \mathbf{v}$  (d) $2$  (e) $\sqrt{2} \mathbf{v}$

4. If $\mathbf{u} = (3, 0, 4)$ then the unit vector in the direction of $\mathbf{u}$ is
   (a) $\left\langle \frac{3}{5}, 0, \frac{1}{5} \right\rangle$  (b) $\left\langle \frac{5}{3}, 0, \frac{5}{3} \right\rangle$  (c) $\left\langle \frac{1}{2}, 1, \frac{2}{3} \right\rangle$  (d) $5$  (e) $\left\langle \frac{3}{5}, 0, \frac{4}{5} \right\rangle$

5. The surface whose equation in cylindrical coordinates is given by $r = 3$ is
   (a) a cone  (b) a cylinder  (c) a sphere  (d) a plane  (e) an ellipsoid

6. In cylindrical coordinates the point $(r, \theta, z) = (4, \pi/6, 3)$. This point in rectangular (cartesian) coordinates is
   (a) $(\sqrt{2}/2, \sqrt{2}/2, 3)$  (b) $(2, 1/2, 3)$  (c) $(2\sqrt{3}, 2, 3)$  (d) $(2\sqrt{3}, 2, 5)$  (e) $(2\sqrt{3}, 2, 9)$

7. The point of intersection of the line given by $\frac{x+2}{2} = \frac{y-1}{8} = z+2$ and the plane $y = 9$ is
   (a) $(3, 2, 1)$  (b) $(5, 9, 7)$  (c) $(1, 9, 5)$  (d) $(0, 9, -1)$  (e) $(1, 2, 5)$

8. Let $\mathbf{u} = \sqrt{2} \mathbf{j} - \mathbf{k}$, $\mathbf{v} = \sqrt{2} \mathbf{i} + \mathbf{k}$ and $\theta$ be the angle between these vectors. In this case, $\cos(\theta)$ is
   (a) $-\frac{1}{3}$  (b) $\frac{1}{\sqrt{2}}$  (c) $-\frac{1}{\sqrt{2}}$  (d) $\frac{1}{3}$  (e) $\sqrt{2}$
9. If \( \mathbf{u} = \langle 1, -1 \rangle \) and \( \mathbf{v} = \langle -1, 2 \rangle \) then \( ||\mathbf{u} + \mathbf{v}|| \) is
\[ \begin{align*}
\text{(a) } & \sqrt{13} \\
\text{(b) } & 1 \\
\text{(c) } & \sqrt{5} \\
\text{(d) } & 3 \\
\text{(e) } & \sqrt{2}
\end{align*} \]

10. A vector \( \mathbf{v} \) has magnitude 2 and makes an angle of \(-45^\circ\) with the positive \( x \)-axis. This vector in component form is then
\[ \begin{align*}
\text{(a) } & \left\langle -\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}} \right\rangle \\
\text{(b) } & \langle 2, -2 \rangle \\
\text{(c) } & \langle -\sqrt{2}, \sqrt{2} \rangle \\
\text{(d) } & \langle \sqrt{2}, -\sqrt{2} \rangle \\
\text{(e) } & \left\langle \frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}} \right\rangle
\end{align*} \]

11. Let \( \mathbf{u} = \langle 1, 0, 2 \rangle \) and \( \mathbf{v} = \langle 1, 1, 3 \rangle \). Find a unit vector that is orthogonal to both \( \mathbf{u} \) and \( \mathbf{v} \).

12. Let \( P(1,3,2), Q(3,1,1), R(-1,-2,3) \) be three points in \( \mathbb{R}^3 \).
\( \text{(a) Find the vector (in component form) from P to Q.} \)
\( \text{(b) Find the parametric equations for the line in space through points P and Q. Parametric } \)
\( \text{equations describe } x, y, \text{ and } z \text{ in terms of a parameter, usually } t. \)
\( \text{(c) Find a vector (in component form) that is orthogonal to } \overrightarrow{PQ} \text{ and } \overrightarrow{PR}. \)
\( \text{(d) Find an equation for the plane determined by the points P,Q, and R.} \)

13. Consider the surface defined by \( z - \frac{x^2}{4} - y^2 = 0. \)
\( \text{(a) Sketch the trace of the surface in the plane } z = 4. \text{ Label the axes and clearly indicate at least two points on the trace.} \)
\( \text{(b) Sketch the trace of the surface in the } yz\text{-plane. Label the axes and clearly indicate at least two points on the trace.} \)
\( \text{(c) Sketch the trace of the surface in the } xz\text{-plane. Label the axes and clearly indicate at least two points on the trace.} \)
\( \text{(d) Sketch the surface in 3-space. Label the axes.} \)

14. Consider the vector \( \mathbf{u} \) in the \( yz \)-plane of length 4 making an angle of \( 30^\circ \) with the positive \( y \)-axis.
\( \text{(a) Write the vector } \mathbf{u} \text{ in standard unit vector notation (as a linear combination of } i, j \text{ and } k). \)
\( \text{(b) Write the vector in component form.} \)
\( \text{(c) Sketch the vector } \mathbf{u}. \)

15. Consider the surface in 3-space defined by the equation \( x^2 + y^2 = 4y. \)
\( \text{(a) Sketch and describe the surface in 3-space.} \)
\( \text{(b) Convert the equation into cylindrical coordinates.} \)

16. **Bonus** Find the point \( (x_1, y_1, z_1) \) that results when the point \( (x_o, y_o, z_o) \) is projected onto the plane \( ax + by + cz + d = 0. \)