1. Consider the line $X = P + t\vec{v}$ where $P = (2, 3, 2)$ and $\vec{v} = (2, -1, 2)$.
   Drop a perpendicular from the point $Q = (-1, 0, 5)$ to a point $R$ on the line. Then $R = \ldots$
   HINT: Draw a figure.
   a. $\left(\frac{2}{3}, \frac{1}{3}, \frac{2}{3}\right)$
   b. $\left(\frac{8}{3}, \frac{8}{3}, \frac{8}{3}\right)$
   c. $\left(\frac{2}{3}, -\frac{1}{3}, \frac{2}{3}\right)$
   d. $(4, 2, 4)$
   e. $\left(\frac{8}{3}, \frac{10}{3}, \frac{8}{3}\right)$

2. If $\vec{u}$ is 5 cm long and points 30° WEST of NORTH and $\vec{v}$ is 4 cm long and points 30° EAST of NORTH, then $\vec{u} \times \vec{v}$ is
   a. 10 cm long and points DOWN.
   b. 10 cm long and points UP.
   c. 10 cm long and points SOUTH.
   d. $10\sqrt{3}$ cm long and points DOWN.
   e. $10\sqrt{3}$ cm long and points SOUTH.

3. Find the point where the line $(x, y, z) = (3 - 2t, 2 - t, 1 + t)$ intersects the plane $x + y + 3z = 2$.
   At this point, $x + y + z =$
   a. 2
   b. 4
   c. 6
   d. 8
   e. The line does not intersect the plane.
4. The graph of the equation \( x^2 + 4x - y^2 + 4y + z^2 + 2z = -1 \) is a

a. hyperboloid of one sheet
b. hyperboloid of two sheets
c. cone
d. hyperbolic paraboloid
e. hyperbolic cylinder

5. For the helix \( \vec{r}(t) = (3t, \sin(4t), \cos(4t)) \), which of the following is FALSE?

a. \( \vec{v} = (3, 4 \cos(4t), -4 \sin(4t)) \)
b. \( \vec{a} = (0, -16 \sin(4t), -16 \cos(4t)) \)
c. \( \vec{j} = (0, -64 \cos(4t), 64 \sin(4t)) \)
d. speed = 25
e. arclength between (0,0,1) and (3\pi,0,1) is 5\pi

6. For the helix \( \vec{r}(t) = (3t, \sin(4t), \cos(4t)) \), which of the following is FALSE?

a. \( \hat{T} = \left( \frac{3}{5}, \frac{4}{5} \cos(4t), -\frac{4}{5} \sin(4t) \right) \)
b. \( \hat{N} = (0, -\sin(4t), -\cos(4t)) \)
c. \( \hat{B} = \left( -\frac{4}{5}, -\frac{3}{5} \cos(4t), -\frac{3}{5} \sin(4t) \right) \)
d. \( a_T = 0 \)
e. \( a_N = 16 \)
7. Which of the following is the contour plot of $f(x, y) = y^2 + x + 1$?

- a.
- b.
- c.
- d.
- e.

8. If $P(2, 3) = 5$ and $\frac{\partial P}{\partial x}(2, 3) = 0.4$ and $\frac{\partial P}{\partial y}(2, 3) = -0.3$, estimate $P(2.1, 2.8)$.

- a. 4.9
- b. 4.98
- c. 4.99
- d. 5.01
- e. 5.1
9. Currently for a certain box, the length \( L \) is 5 cm and increasing at 0.2 cm/sec, the width \( W \) is 4 cm and decreasing at 0.3 cm/sec, the height \( H \) is 3 cm and increasing at 0.1 cm/sec. Then currently, the volume \( V \) is

a. increasing at 0.1 cm/sec.
b. decreasing at 0.1 cm/sec.
c. increasing at 0.2 cm/sec.
d. decreasing at 0.2 cm/sec.
e. increasing at 0.3 cm/sec.

10. The temperature of a frying pan is \( T = \frac{1}{1 + x^2 + 4y^2} \). An ant is located at (2, 1). In what unit vector direction should the ant move to decrease the temperature as fast as possible?

a. \((-1, -2)\)
b. \((1, 2)\)
c. \((1, -2)\)
d. \(\left(\frac{-1}{\sqrt{5}}, \frac{-2}{\sqrt{5}}\right)\)
e. \(\left(\frac{1}{\sqrt{5}}, \frac{-2}{\sqrt{5}}\right)\)
11. (11 points) Find the mass of the helical wire $\vec{r}(t) = (3t, \sin(4t), \cos(4t))$ from $(0, 0, 1)$ to $(3\pi, 0, 1)$ if its linear density is $\rho = x^2 + y^2 + z^2$.

12. (11 points) A bead slides along the helix $\vec{r}(t) = (3t, \sin(4t), \cos(4t))$ from $(0, 0, 1)$ to $(3\pi, 0, 1)$ under the action of the force $\vec{F} = (x, xy, xz)$. Find the work done.
13. (11 points) Find the plane tangent to the graph of the function \( z = x^2y + y^3x \) at the point \((x, y) = (2, 1)\). Find the \( z \)-intercept.

14. (11 points) Find the plane tangent to the level surface \( x \sin z + y \cos z = 3 \) at the point \((x, y, z) = (3, 2, \frac{\pi}{2})\). Find the \( z \)-intercept.
15. (11 points) Determine whether or not each of these limits exists. If it exists, find its value.

a. \( \lim_{(x,y) \to (0,0)} \frac{xy^3}{x^2 + 3y^6} \)

b. \( \lim_{(x,y) \to (0,0)} \frac{x^6 + y^6}{(x^2 + y^2)^2} \)

c. \( \lim_{(x,y) \to (0,0)} \frac{x + xy^2}{x + x^3} \)