1. Find $T, N$, and the curvature $\kappa$ for $r(t) = 3\sin(t)i + 3\cos(t)j + 4k$.

2. Find the limit: 
$$\lim_{(x,y) \to (0,0)} \frac{3x^2 - y^2 + 5}{x^2 + y^2 + 2}$$

3. **True** or **False**: Suppose 
$$\lim_{(x,y) \to (a,b)} f(x, y) = 5$$ along the lines $x = a$ and $y = b$ and $f(a, b) = 5$. Then $f$ must be continuous at $(a, b)$.

4. Find all second-order partial derivatives for $w = x\sin(x^2 y)$.

5. Evaluate $dw/dt$ for $w = 2ye^x - \ln(z)$ if 
$$x(t) = \ln(t^2 + 1), y = \arctan(t), z = e^t$$ at $t = 1$.

6. Find $\frac{\partial z}{\partial x}$ and $\frac{\partial z}{\partial y}$ for the surface $z^3 - xy + yz + y^3 - 2 = 0$ at the point $(1, 1, 1)$.

7. Based on the contour plot below for a function $f(x, y)$, determine the sign $(+, -, 0)$ of

(a) $f_x(0, 2)$
(b) $f_y(2, -2)$
(c) the rate of change of $f$ at $(-2, 0)$ in the direction towards $(-3, 3)$
(d) $Df(\sqrt{2}, 1, 1\sqrt{2})(-1, -1)$
(e) the rate of change of $f$ in the direction tangent to the level curve through $(0, 1)$

8. Find the derivative of the function $f(x, y) = 2xy - 3y^2$ in the direction $4i + 3j$ at the point $(5, 5)$.

9. Find the tangent plane and normal line at $(2, 0, 2)$ of the surface $2z = x^2 = 0$.

10. Find all local maxima, local minima, and saddle points for $f(x, y) = x^2 + xy + y^2 + 3x - 3y + 4$.

11. Find the absolute maximum and minimum of $f(x, y) = 2x^2 - 4x + y^2 - 4y + 1$ on the closed triangular region bounded by the lines $x = 0, y = 2$, and $y = 2x$.

12. Find the maximum value of $f(x, y) = 49 - x^2 - y^2$ on the line $x + 3y = 10$.

13. Write an iterated integral using (a) vertical cross-sections and (b) horizontal cross-sections whose region of integration is the region bounded by $y = \sqrt{x}, y = 0, x = 9$.

14. Sketch the region of integration and evaluate the integral $\int_0^1 \int_0^\sqrt{y} 3y^3e^{xy} \, dx \, dy$.

15. Change to polar coordinates and evaluate the integral $\int_{-1}^1 \int_0^{\sqrt{1-x^2}} dy \, dx$.

16. Integrate the function $f(x, y, z) = 3 - 4x$ over the region below $z = 4 - xy$ and above the rectangle $0 \leq x \leq 2, 0 \leq y \leq 1$ in the $xy$-plane.
17. Find the volume of the region that lies inside the sphere \( x^2 + y^2 + z^2 = 2 \) and outside the cylinder \( x^2 + y^2 = 1 \).

18. Use the change of coordinates \( x(u, v) = \frac{u}{v}, y(u, v) = uv \) to evaluate the integral \( \iint_R \left( \sqrt{\frac{y}{x}} + \sqrt{xy} \right) \, dA \), where \( R \) is the region in the first quadrant bounded by \( xy = 1, xy = 9, y = x \), and \( y = 4x \).

19. Evaluate the line integral \( \int_C(xy + y + z) \, ds \) along the curve \( \mathbf{r}(t) = 2t \mathbf{i} + t \mathbf{j} + (2 - 2t) \mathbf{k} \) for \( 0 \leq t \leq 1 \).

20. Find the flow of the field \( \mathbf{F} = \langle -4xy, 8y, 2 \rangle \) along the curve \( \mathbf{r}(t) = (t, t^2, 1), 0 \leq t \leq 2 \).

21. Find the counterclockwise circulation and the outward flux of the field \( \mathbf{F} = xi + yj \) around/through the unit circle centered at the origin.

22. Find the potential function for \( \mathbf{F} = e^{y+2z}(i + xj + 2zk) \).

23. Use Green’s Theorem to find counterclockwise circulation and outward flux of the field \( \mathbf{F} = (y^2 - x^2, x^2 + y^2) \) for the curve \( C \) enclosing the region bounded by \( y = 0, x = 3 \), and \( y = x \).

24. Let \( f \) be a function of three variables and let \( \mathbf{F} \) and \( \mathbf{G} \) be vector fields in \( \mathbb{R}^3 \). Which of the following expressions make mathematical sense? If you can compute any of them, do so.

   (a) \( \text{curl} (\text{div}(\mathbf{F})) \)
   (b) \( \text{curl}(\nabla f) \)
   (c) \( \text{div}(\mathbf{G}) \)
   (d) \( \text{curl}(\text{div}(f)) \)
   (e) \( \text{div}(\text{curl}(\mathbf{G})) \)
   (f) \( \text{div}(\nabla f) \)

25. Use a parameterization to write a double integral for the area of the surface \( S \) which is the portion of the cone \( z = 2\sqrt{x^2 + y^2} \) between the planes \( z = 2 \) and \( z = 6 \).

26. Evaluate \( \iint_S 2y \, d\sigma \) over the surface \( S \) which is the part of the cylinder \( y^2 + z^2 = 4 \) between \( x = 0 \) and \( x = 3-z \).

27. Let \( S \) be the surface that consists of the part of the paraboloid \( z = 4 - x^2 - y^2 \) above the \( xy \)-plane and below the cone \( z = 3\sqrt{x^2 + y^2} \).

   (a) Sketch \( S \).
   (b) Find a parameterization of \( S \).
   (c) Calculate the area of \( S \).

28. Let \( S \) be the surface consisting of the top half \( z \geq 0 \) of the sphere \( x^2 + y^2 + z^2 = 9 \), together with the disk \( x^2 + y^2 \leq 9, z = 0 \), its base in the \( xy \)-plane. Use the Divergence Theorem to evaluate \( \iiint_S \mathbf{F} \cdot \mathbf{n} \, d\sigma \), where \( \mathbf{F}(x, y, z) = 3xy^2 \mathbf{i} + 3x^2y \mathbf{j} + z^3 \mathbf{k} \).

29. Let \( S \) be the part of the surface \( z = 4x^2 + y^2 - 4 \) beneath the plane \( z = 5 \). Let \( C \) be the bounding curve of \( S \) in the plane \( z = 5 \), traversed counterclockwise and suppose \( S \) is oriented accordingly (normals towards the \( z \)-axis). Let \( \mathbf{F}(x, y, z) = (2y, 4x, e^z) \). Use Stokes’ Theorem to evaluate the curl integral

\[
\iint_S (\nabla \times \mathbf{F}) \cdot \mathbf{n} \, d\sigma.
\]

30. Let \( S \) be the surface of the cylinder defined by \( y^2 + z^2 = 4 \) between the planes \( x = -1 \) and \( x = 3 \). Let \( \mathbf{F}(x, y, z) = e^{y^2} \mathbf{i} + e^z \mathbf{j} + e^z \mathbf{k} \).

   (a) Sketch \( S \).
   (b) Find a parameterization of \( S \).
   (c) Let \( \mathbf{n} \) be an outward pointing unit normal for \( S \). Evaluate

\[
\iint_S \mathbf{F} \cdot \mathbf{n} \, d\sigma
\]

   by direct calculation (do not use the Divergence Theorem).