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

2. Write acceleration in terms of its tangential and normal components for $\mathbf{r}(t) = (t + 1, 2t, t^2)$ at $t = 1.$

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

4. Find all second-order partial derivatives for $w = x^2 + y^2 + 3z.$

5. Evaluate $\frac{dw}{dt}$ 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 $z^3 - xz + yz + z^2 = 2$ at the point $(1,1,1).$

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

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

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

10. 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 $y = 2x.$

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

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

13. Sketch the region of integration and evaluate the integral $\int_0^1 \int_0^{y^2} 3y^3 e^{xy} \, dx \, dy.$

14. Change to polar coordinates and evaluate the integral $\int_{-\pi/2}^{\pi/2} \int_{0}^{\cosh^{-1}(1)} \sqrt{1-x^2} \, dy \, dx.$

15. Integrate the function $f(x, y) = 3 - 4x$ 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.

16. Find the volume of the region that lies inside the sphere $x^2 + y^2 + z^2 = 2$ and outside the cylinder $x^2 + y^2 = 1.$

17. Use the change of coordinates $x(u, v) = \frac{u}{v}, y(u, v) = uv$ to evaluate the integral $\int_{R} \left( \frac{\sqrt{y}}{x} + \sqrt{2y} \right) \, dA,$ where $R$ is the region in the first quadrant bounded by $xy = 1, xy = 0, y = x,$ and $y = 4x.$

18. 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 $0 \leq t \leq 1.$

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

20. Find the counterclockwise circulation and the outward flux of the field $\mathbf{F} = x\mathbf{i} + y\mathbf{j}$ around/through the unit circle centered at the origin.

21. Find the potential function for $\mathbf{F} = e^{y^2+2z}(\mathbf{i} + x\mathbf{j} + 2z\mathbf{k}).$

22. 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 $y = x.$

23. 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 $z = 6.$
24. 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 \( x = 3 - z \).

25. 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 \( S \).

26. 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
\[
\iint_S \mathbf{F} \cdot \mathbf{n} \, d\sigma,
\]
where \( \mathbf{F}(x, y, z) = 3xy^2 \mathbf{i} + 3x^2y \mathbf{j} + z^3 \mathbf{k} \).

27. 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 \( \mathbf{F}(x, y, z) = (2y, 4x, e^x) \). Use Stokes’ Theorem to evaluate the curl integral
\[
\iint_S (\nabla \times \mathbf{F}) \cdot \mathbf{n} \, d\sigma.
\]

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