1. Find the angle between \( \mathbf{u} = (-2, 0, 2) \) and \( \mathbf{v} = (1, 1, 0) \).

2. Let \( P = (1, -1, 1) \), \( Q = (1, 2, 1) \), and \( R = (-1, 0, 1) \). Find the area of the triangle with vertices \( P, Q, \) and \( R \).

3. Find arc length of the parametric curve \( C \) given by \( (t^3, t, \frac{\sqrt{6}}{2} - t^2), 1 \leq t \leq 3 \).

4. Find an equation of the tangent plane to the graph of \( z = x^2y + xy^3 \) at the point \((-1, 1, 0)\).

5. Locate all relative extrema and saddle points of the function \( f(x, y) = x^3 + y^3 - 3xy \).

6. Let \( f(x, y, z) = ye^{x+z} + ze^{y-x} \). At the point \((2, 2, -2)\), find the unit vector pointing in the direction of most rapid increase of \( f \).

7. Find a nonzero vector \( \mathbf{u} \) such that \( \mathbf{u} \times \mathbf{u} = \mathbf{u} \). If not possible, explain.

8. Build up a triple integral representing the volume of the unit sphere \( x^2 + y^2 + z^2 = 1 \).

9. Find the distance between the parallel planes \( x + y + z = 1 \) and \( x + y + z = 3 \).

10. Find the directional derivative of \( f(x, y) = e^{x^2y^2} \) at \( P = (1, -1) \) in the direction toward \( Q = (2, 3) \).

11. Use Lagrange multipliers to minimize \( f(x, y) = 3x^2 + y^2 \) subject to \( xy = 1 \). (You may use methods in Calculus I.)

12. Compute \( \int_0^2 \int_{\sqrt{4-y^2}}^{\sqrt{4-y^2}} \frac{1}{\sqrt{x^2 + y^2}} \, dx \, dy \). (Hint: convert to polar coordinates.)

13. Let \( C \) be the triangle with vertices \((0, 0), (1, 0), (1, 1)\) traversed in the counterclockwise direction. Evaluate \( \int_C \sin^3 x + 2y \, dx + (x^2 y + \cos^3 y) \, dy \). (Green's theorem is helpful.)

14. Compute the double integral \( \iint_D e^{x/y} \, dA \), where \( D = \{(x, y) | 1 \leq y \leq 2, y \leq x \leq y^3\} \).

15. Among four functions and three equations defined below:

   (A) \( z = 3(x+y) \tan(x + 2y) \)  (B) \( z = \log_3(1 + (x - y)^2) \)  (C) \( z = e^{-x} \sin y \)  (D) \( z = (\cos x) \, e^y \)

   (1) \( \frac{\partial z}{\partial x} = \frac{\partial^2 z}{\partial y^2} \)  (2) \( \frac{\partial^2 z}{\partial x^2} + \frac{\partial^2 z}{\partial y^2} = 0 \)  (3) \( \frac{\partial z}{\partial x} = \frac{\partial^2 z}{\partial y^2} \),

   which satisfies equation (1)? which satisfies equation (2)?

   which satisfies equation (3)? which satisfies none? (Show work to support your answers.)