1. Let \( L \) be a line which is parallel to the plane \( 2x + y - z = 5 \) and perpendicular to the line \( x = 3 - t, y = 1 - 2t \) and \( z = 3t \).

(a) Find a vector parallel to the line \( L \).

(b) Find parametric equations for the line \( L \) if \( L \) passes through a point \( Q(a, b, c) \) where \( a < 0, b > 0, c > 0 \), and the distances from \( Q \) to the \( xy \)-plane, the \( xz \)-plane and the \( yz \)-plane are 2, 3 and 4 respectively.

2. Let \( z = f(x, y) = \ln(4x^2 + y^2) \).

(a) Use a linear approximation of the function \( z = f(x, y) \) at \( (0, 1) \) to estimate \( f(0.1, 1.2) \).

(b) Find a point \( P(a, b, c) \) on the graph of \( z = f(x, y) \) such that the tangent plane to the graph of \( z = f(x, y) \) at the point \( P \) is parallel to the plane \( 2x + 2y - z = 3 \).

3. Let \( z = f(x, y) \), where \( f(x, y) \) has continuous second-order partial derivatives, and

\[
\begin{align*}
  f_x(2, 1) &= 5, & f_y(2, 1) &= -2, & f_{xx}(2, 1) &= 2, & f_{xy}(2, 1) &= 1, & f_{yy}(2, 1) &= -4
\end{align*}
\]

Find \( \frac{d^2}{dx^2}z(x(t), y(t)) \) when \( x(t) = 2t^2, y(t) = t^3 \) and \( t = 1 \).

4. The temperature at a point \((x, y, z)\) is given by \( T(x, y, z) = 5e^{-2x^2 - y^2 - 3z^2} \), where \( T \) is measured in centigrade and \( x, y, z \) in meters.

(a) Find the rate of change of temperature at the point \( P(1, 2, -1) \) in the direction toward the point \((1, 1, 0)\).

(b) In which direction does the temperature decrease most rapidly?

(c) Find the maximum rate of decrease at \( P \).

5. Let \( C \) be the intersection of the plane \( x + y + z = 2 \) and the sphere \( x^2 + y^2 + z^2 = 2 \).

(a) Use Lagrange multipliers to find the maximum value of \( f(x, y, z) = z \) on \( C \).

(b) What are the coordinates of the lowest point on \( C \)?

6. (a) Combine the sum of the iterated integrals

\[
I = \int_0^1 \int_{-\sqrt{y}}^{\sqrt{y}} f(x, y) \, dx \, dy + \int_1^4 \int_{y-2}^{\sqrt{y}} f(x, y) \, dx \, dy
\]

into a single iterated integral with the order of integration reversed.

(b) Evaluate \( I \) if \( f(x, y) = \frac{e^x}{2-x} \).
7. The average distance of a point in a plane region \( D \) to a point \((a, b)\) is defined by

\[
\frac{1}{A(D)} \int \int_D \sqrt{(x-a)^2 + (y-b)^2} \, dx \, dy
\]

where \( A(D) \) is the area of the plane region \( D \). Let \( D \) be the unit disk \( 1 \geq x^2 + y^2 \). Find the average distance of a point in \( D \) to the center of \( D \).

8. Let \( E \) be the region in the first octant bounded by the coordinate planes, the plane \( x + y = 1 \) and the surface \( z = y^2 \). Evaluate \( \iiint_E z \, dV \).

9. Let \( E \) be the smaller of the two solid regions bounded by the surfaces \( z = x^2 + y^2 \) and \( x^2 + y^2 + z^2 = 6 \). Evaluate \( \iiint_E (x^2 + y^2) \, dV \).

10. Evaluate \( \iiint_{\mathbb{R}^3} [1 + (x^2 + y^2 + z^2)^3]^{-1} \, dV \).