

- The pressure, volume, and temperature of a mole of an ideal gas are related by the equation $PV = 8.31T$ where P is measured in kilopascals, V in liters, and T in kelvins. Use the differentials to find the approximate change in the pressure if the volume increases from 12 L to 12.3 L, and the temperature decreases from 310 K to 305 K.
- Find an equation of the tangent plane to the surface $xyz + 2x + 3y + 3z + 2 = 0$ at the point $(1, 2, -2)$.
 - Find parametric equations of the normal line to the surface $xyz + 2x + 3y + 3z + 2 = 0$ at the point $(1, 2, -2)$.
- Find all maxima, minima, and saddle points if any, for $f(x, y) = x^3 + 3xy + y^3$
 - Find the absolute maxima and minima of the function $f(x, y) = x^2 + xy + y^2 - 6x + 2$ on the region $0 \leq x \leq 1, -3 \leq y \leq 0$.
- Let $f(x, y, z) = \ln(2x + 3y + 6z)$. Find the unit vector in the direction in which f decreases most rapidly at the point $P(-1, -1, 1)$ and find the derivative (rate of change) of f in this direction.
- Given: $w = \sin(2x - y)$, $x = r + \tan s$, $y = rs^2$. Find $\frac{\partial w}{\partial r}$ by using the Chain Rule. Express the answer in terms of r and s .
- Find the volume of the solid lying under the elliptic paraboloid $z = x^2 + 4y^2$ and above the square $R = [1, 2] \times [0, 1]$

7. Evaluate

$$\int_0^4 \int_{y/2}^2 e^{x^2} dx dy$$

8. A particle moves along a curve parametrized by

$$\vec{r}(t) = t\vec{i} - t^2\vec{j} + t^3\vec{k}, \quad 0 \leq t \leq 1$$

under a force given by $\vec{F}(x, y, z) = 2z\vec{i} - y\vec{j} + x\vec{k}$. Calculate the work done on the particle by the force.

- Show that the field $\vec{F}(x, y) = (xy^2 + 3x^2y)\vec{i} + (x + y)x^2\vec{j}$ is conservative.
 - find the potential function.
 - Evaluate the integral $\oint_C \vec{F} \cdot d\vec{r}$ where C consists of line segments from $(1, 1)$ to $(0, 2)$ to $(3, 0)$
- Set up a triple integral to find the volume of the solid bounded by the surfaces $x = 0$, $y = 0$, $z = 0$, and $x + 2y + 3z = 1$.

b) Sketch the solid whose volume in cylindrical coordinates is given by

$$\int_0^{2\pi} \int_0^2 \int_{r^2}^4 r \, dz \, dr \, d\theta$$

and find the volume.

c) Represent the volume of the sphere $x^2 + y^2 + z^2 = 4$ as i) a double integral in rectangular coordinates. ii) triple integral in rectangular coordinates. iii) triple integral in spherical coordinates. Evaluate this integral to find the volume of the sphere.

11. Evaluate the following line integral: $\int_C yz \, ds$ where C is the curve with the parametrization $\vec{r}(t) = t\vec{i} + 3t\vec{j} + 2t\vec{k}$, $1 \leq t \leq 2$
12. Use Green's theorem to evaluate $\int_C -y^3 \, dx + x^3 \, dy$, where C is the circle $x^2 + y^2 = 4$ with counterclockwise orientation.
13. Verify Stokes Theorem for the upper hemisphere $z = \sqrt{1 - x^2 - y^2}$ and the radial vector field $\vec{F}(x, y, z) = x\vec{i} + y\vec{j} + z\vec{k}$
14. Evaluate $\iint_S \vec{F} \cdot d\vec{S}$, where $\vec{F} = 3x\vec{i} + 3y\vec{j} + 3z\vec{k}$ and S is the surface of the unit sphere.