1) Consider the function $f(x, y) = 3xy - x^2y - xy^2$.

   a) Find the four critical points for f .

   b) Find $f_{xx}(x, y),\ f_{xy}(x, y),\ and\ f_{yy}(x, y)$.

   c) Use the second derivative test to find the local maximum and minimum values and saddle points of f if any exist.

2) a) Evaluate the integrals:

i) $\int_0^2 \int_0^{\sqrt{2y-y^2}} \sqrt{x^2+y^2}\, dxdy$ ii) $\int_0^1 \int_{\sqrt{y}}^1 \frac{ye^{x^2}}{x^3}\, dx\, dy.$

b) Evaluate $\iiint_E xy\, dV$, where $E = \{(x,y,z): 0 \leq x \leq 3, 0 \leq y \leq x,\ \ 0 \leq z \leq x+y\}.$

3) Find the distance between the point $P_0(1,1,1)$ and the plane passing through the points $P_1(2,1,-1), P_2(1,0,-2)$ and $P_3(1,1,-3)$.

4) For the matrix $A = \begin{bmatrix} 1 & 3 \\ 1 & -1 \end{bmatrix}$ find an invertible matrix P and a diagonal matrix D such that $P^{-1}AP = D$. Then, calculate A^{10}.

5) Consider the linear operator $T: R^3 \rightarrow R^3$ defined by $T(x, y, z) = (w_1, w_2, w_{3)}, w_1 = x + y + z,$ $w_2 = -x - y - z$ and $w_3 = 2x + 2y + 2z$. Show that T is not one to one and find a basis and the dimension for the kernel of T.

6) Find the eigenvalues for the matrices $A = \begin{bmatrix} 4 & 0 & 1 \\ 2 & 3 & 2 \\ 1 & 0 & 4 \end{bmatrix}$, $B = \begin{bmatrix} 5 & 0 & 1 \\ 2 & 4 & 2 \\ 1 & 0 & 5 \end{bmatrix}$ and A^{-1}.

7) Show that the set $S = \{\boldsymbol{u_1}, \boldsymbol{u_2}, \boldsymbol{u_3}\}$, $\boldsymbol{u_1} = (4,2,1)$, $\boldsymbol{u_2} = (0,3,0)$, $\boldsymbol{u_3} = (1,2,4)$, is basis for R^3. Then, find the vector $\boldsymbol{w}$ such that $(\boldsymbol{w})_S = (1,-1,3)$.