Q1. Given $\vec{F}(x, y, z) = e^x \vec{i} + z^2 \vec{j} + 2yz\vec{k}$,
   a) Is $\vec{F}$ conservative? Describe your answer.
   b) If $\vec{F}$ conservative, find its potential function,
   c) Calculate $\int_C \vec{F} \cdot d\vec{r}$, where $C$ is any curve connecting the points $(2, -1, 3)$ and $(-1, 3, 1)$.

Q2. Consider the region $R$ bounded by the curves;
   $y = x, y = \frac{x}{3}, xy = 2, xy = 4$. Let $T$ be the transformation $\{u = \frac{x}{y}, v = xy\}$.
   Calculate $\int_{R} \int_{\frac{x}{y}}^{x} f(x, y) \, dx \, dy$.

Q3. Change the order of the integration; $\int_{0}^{1} \int_{x^2 - 1}^{x} f(x, y) \, dy \, dx$.

Q4. Find the local maximum, local minimum and saddle points of the function $f(x, y) = (x - 1)(y + 1)(x + y - 3)$.

Q5. Using Lagrange Multiplier’s Method, find the maximum (minimum) values that $f(x, y) = xy$ takes on the ellipse $\frac{x^2}{8} + \frac{y^2}{2} = 1$.

Q6 (Bonus). Let $w$ be a differentiable function of two variables $x, y$ and $x = 2r - 3s, y = 4s + r$. Find $w_{rs}$.