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

1. Calculate the directional derivative of $f$ is the direction of $\mathbf{a} = \langle 1, 2 \rangle$ at the point $(1, 2)$. Does it correspond to the direction of maximum rate of change?

2. Use linear approximation to approximate $f(0.9, 1.1)$.

3. Find the critical points of $f$.

4. Classify all the critical points of $f$ as local maximum, local minimum or saddle point.

Problem 2: Find the extremas of the function $f(x, y, z) = xyz$ on the sphere of equation $x^2 + y^2 + z^2 = 3$. 