1. Evaluate the following limit (or explain why the limit does not exist):
\[
\lim_{x \to 0} \frac{1}{x^4} \int_0^{x^2} \sin(t^2) \, dt
\]

2. Determine whether this series converges or diverges. (Be sure to explain your reasoning.)
\[
\sum_{n=2}^{\infty} \ln\left(\frac{n \sin\left(\frac{1}{n}\right)}{n}\right)
\]

3. Evaluate the following limit (or explain why the limit does not exist):
\[
\lim_{(x,y) \to (0,0)} \frac{\cos(x) + \frac{1}{2}x^2 - 1}{x^4 + y^4}
\]

4. Find all functions \( f(x, y) \) for which \( \nabla f(x, y) = (y, -x) \).

5. Consider the surface
\[
S = \{(x, y, z) \mid xyz = 27, \ x > 0, \ y > 0, \ z > 0\}
\]
Show that all pyramids formed by the three coordinate planes and a plane tangent to the surface \( S \) have the same volume.