1. Let \( f: U \to \mathbb{R}^3 \) be a surface element. Suppose that the image of \( f \) lies in the region \( \{(x, y, z) \mid z > 0\} \), and the tangent plane to \( f \) at \( u = 0 \in \mathbb{R}^2 \) is parallel to the plane \( z = 0 \). Show that the principal curvatures of \( f \) at \( f(0) \) satisfy \( \kappa_1 \kappa_2 \geq 0 \).

2. Let \( f: U \to \mathbb{R}^3 \) be a surface element. Define the parallel surface element at distance \( \epsilon \) by \( \tilde{f}(s, t) = f(s, t) + \epsilon \nu(s, t) \).

Show that the principal curvatures of \( f \) and \( \tilde{f} \) are related by the following formula
\[
\tilde{\kappa}_i = \frac{\kappa_i}{1 - \epsilon \kappa_i}, \quad (i = 1, 2).
\]
(You may assume that \( \epsilon \) is as small as you like.)

3. Let \( f: U \to \mathbb{R}^3 \) be a surface element and let \( X_1 \) be a unit eigenvector in \( T_p f \) for the first principal curvature \( \kappa_1 \) at \( p = f(u) \). Let \( X(\theta) \) be the unit vector in \( T_p f \) which makes an angle \( \theta \) with \( X_1 \). Prove that the mean curvature of \( f \) at \( p \), \( H(p) \), satisfies
\[
H(p) = \frac{1}{2\pi} \int_0^{2\pi} \kappa_{X(\theta)} \, d\theta.
\]
(Recall that \( \kappa_X = II(X, X) \).)