1. Let $f$ be a non-constant entire function on $\mathbb{C}$. Prove that $f$ is a polynomial if and only if $\lim_{|z| \to \infty} |f(z)| = \infty$.

2. Let $\Omega \subset \mathbb{C}$ be open and simply connected. If $f : \Omega \to \Omega$ is analytic and has two fixed points, show that either $\Omega = \mathbb{C}$, or else $f$ is the identity map on $\Omega$.

3. Determine the partial fraction expansion for $\frac{1}{\sqrt{z} \sin \sqrt{z}}$.

4. Evaluate $\int_{0}^{\infty} \frac{\sin(x)}{x(x^2 + 1)} \, dx$. 