1. Let \( f, g : X \rightarrow Y \) be continuous maps, where \( X \) is a topological space and \( Y \) is a Hausdorff space. Prove that the set \( S = \{ x \in X | f(x) = g(x) \} \) is closed.

2. Let \( X \) and \( Y \) be topological spaces and let \( p : X \rightarrow Y \) be a quotient map, and suppose that each fiber \( p^{-1}(y) \) is connected and \( Y \) is connected. Prove that \( X \) is connected.

3. Prove that if \( X \) is a topological space and \( Y \) is a compact space then the projection \( \pi_1 : X \times Y \rightarrow X \) is a closed map. (You may use the Tube Lemma without proving it.)

4. In the plane, let \( X \) be the union of the coordinate axes and the line \( x + y = 1 \), and let \( Y \) be the union of \( X \) and the positive quadrant. Prove that there is no retraction of \( Y \) onto \( X \).

5. Draw a subset \( Z \) of the plane homeomorphic to the one-point compactification of \( Y \) from the preceding problem. How many connected components does the complement of \( Z \) have, and how many of these are bounded?

6. Let \( E \) and \( B \) be topological spaces and let \( p : E \rightarrow B \) be a two-sheeted cover. Describe a non-identity homeomorphism \( h : E \rightarrow E \) satisfying \( h \circ h = id \) and prove that \( h \) is a homeomorphism.

7. Consider the space \( X \) consisting of a sphere glued, along its equator, into the hole of a torus. Use Seifert-van Kampen to compute the fundamental group of \( X \).