Please let me (Saul) know if any of the problems are unclear or have typos. Please turn in a solution to one of Exercises 1.2, 1.3, or 1.6 by 13:00 on 2017-10-12, to the dropoff box in front of the undergraduate office. If you collaborate with other students, please include their names.

Exercise 1.1. Suppose that X is a topological space. Define $\mathrm{Homeo}(X)$ to be the set of homeomorphisms $f\colon X \to X$. Show that $\mathrm{Homeo}(X)$ is a group if we take the group operation to be function composition.

Give an example of a space X where $\mathrm{Homeo}(X)$ is the trivial group.

Exercise 1.2. Show that the relation $X \cong Y$ of being homeomorphic is an equivalence relation on topological spaces. Now consider the capital letters of the alphabet A, B, C, ... in a sans serif font. Each of these gives a graph in the plane. Sort these into homeomorphism classes. (The partition may depend on the font! In particular, K can be tricky.)

Exercise 1.3. We equip $[0,1) \subset \mathbb{R}$ and $S^1 \subset \mathbb{C}$ with their usual subspace topologies. Consider the map $p\colon [0,1) \to S^1$ given by $p(t) = \exp(2\pi i t)$. Show that p is a continuous bijection. Show that p is not a homeomorphism.

Exercise 1.4. We equip $[0,1] \subset \mathbb{R}$ and $S^1 \subset \mathbb{C}$ with their usual subspace topologies. Show that the quotient space

$$X = {}^{[0,1]}\!/_{0 \sim 1}$$

is homeomorphic to S^1.

Exercise 1.5. For three of the following pairs (X, Y) show that X is not homeomorphic to Y.

- The graph X and the graph Y.
- $(0,1)$ and $[0,1]$: the open and closed intervals.
- S^1 and $[0,1]$: the circle and the closed interval.
- S^1 and S^2: the circle and the sphere.
- $\mathbb{R}^1$ and $\mathbb{R}^2$: the line and the plane.
- $\mathbb{R}^2$ and $\mathbb{R}^3$: the plane and three-space (harder).
- S^2 and $T^2 = S^1 \times S^1$: the sphere and the torus (harder).

Exercise 1.6. Suppose X and Y are topological spaces. We call a function $f\colon X \to Y$ an *embedding* if f is a homeomorphism from X to $f(X)$, equipped with the subspace topology. Give an example of a space X that does not embed in $\mathbb{R}^n$, for any n.