# HOMEWORK #7

**1.** Construct a surjective map $S^n \to S^n$ of degree zero, for each $n \geq 1$.

**2.** Let $f : S^n \to S^n$ be a map of degree zero. Show that there exist points $x, y \in S^n$ with $f(x) = x$ and $f(y) = -y$.

**3.** Let $f : S^{2n} \to S^{2n}$ be a continuous map. Show that there is a point $x \in S^{2n}$ so that either $f(x) = x$ or $f(x) = -x$.

**4.** A map $f : S^n \to S^n$ satisfying $f(x) = f(-x)$ for all $x$ is called an *even map*. Show that an even map has even degree, and this degree is in fact zero when $n$ is even. When $n$ is odd, show there exist even maps of any given even degree.

**5.** Describe a cell structure on $S^n \vee S^n \vee \cdots \vee S^n$ and calculate $H_*(S^n \vee S^n \vee \cdots \vee S^n)$.

**6.** Let $f : S^n \to S^n$ be a map of degree $m$. Let $X = S^n \cup_f D^{n+1}$ be a space obtained from $S^n$ by attaching a $(n+1)$-cell via $f$. Compute the homology of $X$.

**7.** Let $G$ be a finitely generated abelian group, and fix $n \geq 1$. Construct a CW-complex $X$ such that $H_n(X) \cong G$ and $\tilde{H}_i(X) = 0$ for all $i \neq n$. (Hint: Use the calculation of the previous exercise, together with know facts from Algebra about the structure of finitely generated abelian groups.) More generally, given finitely generated abelian groups $G_1, G_2, \cdots, G_k$, construct a CW-complex $X$ whose homology groups are $H_i(X) = G_i$, $i = 1, \cdots, k$, and $\tilde{H}_i(X) = 0$ for all $i \notin \{1, 2, \cdots, k\}$.

**8.** Using our notation from the classification of compact surfaces, first describe the CW structure of $T_n$ and respectively $P_n$, then use the cellular homology to calculate the homology of these spaces.

**9.** Show that $\mathbb{RP}^5$ and $\mathbb{RP}^4 \vee S^5$ have the same homology and fundamental group. Are these spaces homotopy equivalent?

**10.** Let $0 \leq m < n$. Compute the homology of $\mathbb{RP}^n/\mathbb{RP}^m$.