CS240 Tutorial 9

1. **Hash Table Operations**
   Consider a hash table of size 7. For each of the following scenarios insert the keys 14, 10, 20, 13, 7, 17. Then delete 14 and search for 13.
   a) Linear Probing with $h(k) = k \bmod 7$
   b) Double Hashing with $h_0(k) = k \bmod 7$ and $h_1(k) = (k \bmod 5) + 1$
   c) Cuckoo Hashing with $h_0(k) = k \bmod 7$ and $h_1(k) = (k \bmod 5) + 1$

2. **Quadtrees**
   Let $S \subset \mathbb{R}^2$ such that all points in S have non-negative x and y coordinates. Assume further that $(0,0) \in S$. Let M be the greatest distance between any 2 points in S and let m be the minimum distance between any 2 points in S. Show that if we have that $\frac{M}{m} \in O(\sqrt{n})$ then the height of the quadtree which stores the points in S will have height in $O(\log n)$

3. **Quadratic Probing**
   Another possible way to create a probe sequence is to have

   $$h(k, i) = \left(h(k) + i^2\right) \bmod M$$

   This technique is known as quadratic probing. Using this strategy, show that the probe sequence $h(k, 0), h(k, 1), ..., h(k, M - 1)$ contains at most $\left\lceil \frac{M+1}{2} \right\rceil$ unique values from $\{0, ..., M - 1\}$