CS 240: Data Structures and Data Management **Winter 2021**

Tutorial 7: March 15

1. Consider a hash table of size 7. For each of the scenarios below, 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. Suppose that we use double hashing to resolve collisions, i.e., we use the hash function $h(k,i) = (h_0(k) + ih_1(k)) \bmod M$. Show that if M and $h_1(k)$ have greatest common divisor $d \geq 1$ for some key k, then an unsuccessful insertion for key k examines $\frac{1}{d}^{th}$ of the hash table before returning to slot $h_0(k)$.

Thus, when $d = 1$, i.e., M and $h_1(k)$ are relatively prime, then the insertion of k can only fail if every entry of the hash table is occupied.

3. Design a dictionary data structure to store key-value-pairs with uniformly distributed integer keys such that the operations for search, insert, and delete have $O(\log n)$ worst-case runtime and $O(1)$ worst-case expected runtime.