**Hashing Worksheet**

1. Given input [4371, 1323, 6173, 4199, 4344, 9679, 1989] and a hash function *h(x) = x mod 10*, show the resulting:
   1. Separate chaining hash table,
   2. Hash table using linear probing,
   3. Hash table using quadratic probing,
   4. Hash table with second hash function *h2(x) = 7 – (x mod 7)*.
2. Write a program to compute the number of collisions required in a long random sequence of insertions using linear probing, quadratic probing, and double hashing.
3. Suppose instead of quadratic probing, we use cubic probing, here the ith probe is the *hash(x) + i3*. Does cubic probing improve on quadratic probing?
4. A large number of deletions in a separate chaining hash table can cause the table to be fairly empty, which wastes space. In this case, we can rehash to a table half as large. Assume that we rehash to a larger table when there are twice as many elements as the table size. How empty should the table be before we rehash to a smaller table?
5. What is the worst case running time for inserting n key value entries into an initially empty array HT that is implemented with open hashing? What is the best case?
6. What is the worst case asymptotic running time for performing n correct remove() operations on a map, implemented with an ordered search table, that initially contains 2n entries?
7. Give the code of an insertion into a hash table that uses quadratic robing to resolve collisions, assuming that we are using the trick of replacing deleted entries with a special “tombstone” entry.