# CSC 225 - Assignment 3

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1. Let base for the n integers be $= b$

Let there be "d" number of digits in each of n integers

$\therefore$ Runtime for Radix sort $\Rightarrow O(d \times (n+b))$

Range of values $\Rightarrow 0 - n^2-1$, hence $d \Rightarrow O(\log_b(n))$.

$\therefore$ Total runtime $\Rightarrow O(O(\log_b(n)) \times (n+b))$

Set base "b" to "n" [# of integers].

$\longrightarrow O(O(\log_n(n)) \times (n+n))$

$\longrightarrow O(O(1) \times 2n))$

$\longrightarrow O(2n)$

$\longrightarrow O(n)$

2. $h(k) = (2k+5) \bmod 9$.

| | 5 | 28 | 19 | 15 | 20 | 33 | 12 | 17 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| After h(k) | 6 | 7 | 7 | 8 | 0 | 8 | 2 | 3 | 7 |

| | |
|---|---|
| 0 | 20 |
| 1 | |
| 2 | 12 |
| 3 | 17 |
| 4 | |
| 5 | |
| 6 | 5 |
| 7 | 10 → 19 → 28 |
| 8 | 33 → 15 |

3.

| | |
|---|---|
| 0 | 22 |
| 1 | 88 |
| 2 | |
| 3 | |
| 4 | 4 |
| 5 | 15 |
| 6 | 28 |
| 7 | 17 |
| 8 | 59 |
| 9 | 31 |
| 10 | 10 |

## Linear Probing

$h_1(k) = k \bmod t$

| 10 | 22 | 31 | 4 | 15 |
|---|---|---|---|---|
| ↓ | ↓ | ↓ | ↓ | ↓ |
| 10 | 0 | 9 | 4 | 5 |

| 28 | 17 | 88 | 59 |
|---|---|---|---|
| ↓ | ↓ | ↓ | ↓ |
| 6 | 7 | 1 | 8 |

## Quadratic Probing

$h_1(k) = k \bmod t$

| 10 | 22 | 31 | 4 | 15 |
|---|---|---|---|---|
| ↓ | ↓ | ↓ | ↓ | ↓ |
| 10 | 0 | 9 | 4 | 5 |

| 28 | 17 | 88 | 53 |
|---|---|---|---|
| ↓ | ↓ | ↓ | ↓ |
| 6 | 7 | 1 | 8 |

| | |
|---|---|
| 0 | 22 |
| 1 | 88 |
| 2 | |
| 3 | |
| 4 | 4 |
| 5 | 15 |
| 6 | 28 |
| 7 | 17 |
| 8 | 53 |
| 9 | 31 |
| 10 | 10 |

$15 \% 11 = 4$

$\Rightarrow (4 + 0^2) \% 11 = 4$

$\Rightarrow (4 + 1^2) \% 11 = 5$

$17 \% 11 = 6$

$\Rightarrow (6 + 0^2) \% 11 = 6$

$\Rightarrow (6 + 1^2) \% 11 = 7$

$88 \% 11 = 0$

$\Rightarrow (0 + 0^2) \% 11 = 0$

$\Rightarrow (0 + 1^2) \% 11 = 1$

$59 \% 11 = 4$

$\Rightarrow (4 + 0^2) \% 11 = 4$

$\Rightarrow (4 + 1^2) \% 11 = 5$

$\Rightarrow (4 + 2^2) \% 11 = 8$

# Double hashing

$h_1(k) = k \bmod t$

$h_2(k) = 1 + (k \bmod (t-1))$

$(h_1(k) + i\,h_2(k)) \bmod t$

| | |
|---|---|
| 0 | 22 |
| 1 | 59 |
| 2 | |
| 3 | 17 |
| 4 | 4 |
| 5 | 15 |
| 6 | 28 |
| 7 | 88 |
| 8 | |
| 9 | 31 |
| 10 | 10 |

$10 \rightarrow 10$

$22 \rightarrow 0$

$31 \rightarrow 9$

$4 \rightarrow 4$

$15 \rightarrow (4+6)\%11 \rightarrow (4+2\cdot6)\%11 \rightarrow 5$

$28 \rightarrow 6$

$17 \rightarrow (6+8)\%11 \rightarrow 3$

$88 \rightarrow (0+9)\%11 \rightarrow (0+2\cdot9)\%11 \rightarrow 7$

$59 \rightarrow (4+10)\%11 \rightarrow (4+2\cdot10)\%11 \rightarrow 2$

4. $h(k,i) = (\underbrace{h_1(k)}_{\text{Even or odd}} + \underbrace{i}_{\text{Even or odd}}\,\underbrace{h_2(k)}_{\text{Even}} \bmod \underbrace{t}_{\text{Even}})$

If $t$ is even and so is $h_2(k)$, it obviously means that they are multiples of 2. The probe sequence will examine at most examine half the table because there will be a value for $i \times h_2(k)$ which is a multiple of $t$. When $h_1(k)$ is odd, all the odd indices on the table are probed first (except for the $h_1(k)$ value, which would the last odd index to be probed). Same applies when $h_1(k)$ is even, excepting all the even indices will be visited first ($h_1(k)$ being the last). When $i \cdot h_2(k)$ is a multiple of $t$, the mod leaves only $h_1(k)$ behind.

eg:

*Imagine only free slot = $h_1(k)$*

$h_2(k) = 8$ ; $t = 14$

$h_1(k) = 6$

| $i=1$ | 2 | 3 | 4 | 5 | 6 | $7 \rightarrow t/2$ |
|---|---|---|---|---|---|---|
| 0 | 8 | 2 | 10 | 4 | 12 | 6 |

$0 \rightarrow 8 \rightarrow 2 \rightarrow 10 \rightarrow 4 \rightarrow 12 \rightarrow 6$