

Q1. Using hash function $h(x) = [(x \bmod 14) + 1] \bmod 15$
 store the keys below in array with size 15.

562, 456, 563, 145, 576, 145, 467, 645, 534,
 and 982

If there is a collision it will be resolved using quadratic probing. Determine the number of collisions occur.

Answer

- 562

$$\begin{aligned}
 h(562) &= [562 \% 14 + 1] \% 15 \\
 &= (2+1) \% 15 \\
 &= 3
 \end{aligned}$$

0	
1	
3	562
4	

562 is at index 3.

- 456

$$\begin{aligned}
 h(456) &= [456 \% 14 + 1] \% 15 \\
 &= (8+1) \% 15 \\
 &= 9
 \end{aligned}$$

0	
3	562
4	
9	456
15	

456 is at index 9.

- 563

$$\begin{aligned}
 h(563) &= [563 \% 14 + 1] \% 15 \\
 &= (3+1) \% 15 \\
 &= 4
 \end{aligned}$$

563 is at index 4.

0	
3	562
4	563
9	456
14	

• 145

$$\begin{aligned} h(145) &= [145 \% 14 + 1] \% 15 \\ &= (5+1) \% 15 \\ &= 6 \end{aligned}$$

145 is at index 6.

• 576

$$\begin{aligned} h(576) &= [576 \% 14 + 1] \% 15 \\ &= (2+1) \% 15 \\ &= 3 \end{aligned}$$

This is collision #1 as 562 is present at index 3. Using quadratic probing, next index to be checked is

$$(3+1^2)\% 15 = 4. \text{ Collision } \#2$$

Again, next index to be checked is
 $(3+2^2)\% 15 = 7$

No collision, so 576 is at index 7.

• 145

$$\begin{aligned} h(145) &= [145 \% 14 + 1] \% 15 \\ &= (5+1) \% 15 \\ &= 6 \end{aligned} \quad \text{Collision } \#3$$

So, check for next index

$$(6+1^2)\% 15 = 7 \quad \text{Collision } \#4$$

$$(6+2^2)\% 15 = 10$$

No collision, so 145 is at index 10

• 467

$$h(467) = [467 \% 14 + 1] \% 15$$

$$= (5+1) \% 15$$

$$= 6$$

Collision #5

So, next probes will be at

$$(6 + 1^2) \% 15 = 7 \quad \text{Collision } \#6$$

$$(6 + 2^2) \% 15 = 10 \quad \text{Collision } \#7$$

$$(6 + 3^2) \% 15 = 0$$

No collision, so 467 is at index 0.

• 645

$$h(645) = [645 \% 14 + 1] \% 15$$

$$= (1+1) \% 15$$

$$= 2$$

645 is at index 2.

• 534

$$h(534) = [534 \% 14 + 1] \% 15$$

$$= (2+1) \% 15$$

$$= 3$$

Collision #8

So, next probes will be at

$$(3 + 1^2) \% 15 = 4 \quad \text{Collision } \#9$$

$$(3 + 2^2) \% 15 = 7 \quad \text{Collision } \#10$$

$$(3 + 3^2) \% 15 = 12$$

534 is at index 12 as there is no collision

- 982

$$h(982) = [982 \% 14 + 1] \% 15$$

$$= (2+1) \% 15$$

$$= 3 \quad \text{Collision \#11}$$

So, next probes will be at

$$(3 + 1^2) \% 15 = 4 \quad \text{Collision \#12}$$

$$(3 + 2^2) \% 15 = 7 \quad \text{Collision \#13}$$

$$(3 + 3^2) \% 15 = 12 \quad \text{Collision \#14}$$

$$(3 + 4^2) \% 15 = 4 \quad \text{Collision \#15}$$

$$(3 + 5^2) \% 15 = 13$$

No, collision, so 982 is at index 13.

index	value
0	467
1	645
2	562
3	563
4	145
5	
6	

index	value
7	576
8	
9	456
10	145
11	
12	534
13	982
14	

Total number of collisions = 15

Q2 Using hash function $h(x) = x \% 11$, insert the following keys in an array with size 11.

54, 26, 93, 17, 77, 31, 44, 56, 20

- (i) Use linear probing to resolve collision
- (ii) Use quadratic probing to resolve collision
- (iii) Mention collisions in each (i) and (ii)

(i) Using linear probing

• 54 $\Rightarrow 54 \% 11 = 10$	0	77
• 26 $\Rightarrow 26 \% 11 = 4$	1	44
• 93 $\Rightarrow 93 \% 11 = 5$	2	56
• 17 $\Rightarrow 17 \% 11 = 6$	3	20
• 77 $\Rightarrow 77 \% 11 = 8$	4	26
• 31 $\Rightarrow 31 \% 11 = 9$	5	93
• 44 $\Rightarrow 44 \% 11 = 0 \rightarrow$ Collision #1 Use linear probing,	6	17
	7	44
	8	03
	9	31
	10	54

• 44 $\Rightarrow 44 \% 11 = 0 \rightarrow$ Collision #1

Use linear probing,

$$(0+1) \% 11 = 1$$

• 56 $\Rightarrow 56 \% 11 = 1 \rightarrow$ Collision #2

Use linear probing,

$$(1+1) \% 11 = 2$$

• 20 $\Rightarrow 20 \% 11 = 9 \rightarrow$ Collision #3

Use linear probing, $(9+1^1) \% 11 = 10 \rightarrow \text{Collision } \#4$

$(9+2^1) \% 11 = 0 \rightarrow \text{Collision } \#5$

$(9+3^1) \% 11 = 1 \rightarrow \text{Collision } \#6$

$(9+4^1) \% 11 = 2 \rightarrow \text{Collision } \#7$

$(9+5^1) \% 11 = 3 \rightarrow \text{No collision}$

(ii) Using Quadratic Probing

$$\bullet 54 \Rightarrow 54 \% 11 = 10$$

0	77
1	44
2	56
3	
4	26
5	93
6	17
7	20
8	
9	31
10	54

$$\bullet 26 \Rightarrow 26 \% 11 = 4$$

$$\bullet 93 \Rightarrow 93 \% 11 = 5$$

$$\bullet 17 \Rightarrow 17 \% 11 = 6$$

$$\bullet 77 \Rightarrow 77 \% 11 = 0$$

$$\bullet 31 \Rightarrow 31 \% 11 = 9$$

$$\bullet 44 \Rightarrow 44 \% 11 = 0 \rightarrow \text{Collision } \#1$$

Use quadratic probing,

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

$$\bullet 56 \Rightarrow 56 \% 11 = 1 \rightarrow \text{Collision } \#2$$

Use quadratic probing,

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

$$\bullet 20 \Rightarrow 20 \% 11 = 9 \rightarrow \text{Collision } \#3$$

Use quadratic probing,

$$(9+1^2) \% 11 = 10 \rightarrow \text{Collision } \#4$$

$$(9+2^2) \% 11 = 2 \rightarrow \text{Collision } \#5$$

$$(9+3^2) \% 11 = 7$$

(ii) Number of collisions using
linear probing = 7
quadratic probing = 5