

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	
2	
3	562
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	

562 is at index 3.

• 456

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

0	
1	
2	
3	562
4	
5	
6	
7	
8	
9	456
10	
11	
12	
13	
14	

456 is at index 9.

• 563

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

0	
1	
2	
3	562
4	563
5	
6	
7	
8	
9	456
10	
11	
12	
13	
14	

563 is at index 4.

• 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

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

Again, next index to be checked is

$$(3 + 2^2) \% 15 = 7$$

No collision, so 576 is at index 7.

• 145

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

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

$$\begin{aligned}h(467) &= [467 \% 14 + 1] \% 15 \\&= (5+1) \% 15 \\&= 6\end{aligned}$$

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

$$\begin{aligned}h(645) &= [645 \% 14 + 1] \% 15 \\&= (1+1) \% 15 \\&= 2\end{aligned}$$

645 is at index 2.

• 534

$$\begin{aligned}h(534) &= [534 \% 14 + 1] \% 15 \\&= (2+1) \% 15 \\&= 3\end{aligned}$$

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	
2	645
3	562
4	563
5	
6	145

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
	1	44
• $26 \Rightarrow 26 \% 11 = 4$	2	56
	3	20
• $93 \Rightarrow 93 \% 11 = 5$	4	26
	5	93
• $17 \Rightarrow 17 \% 11 = 6$	6	17
	7	77
• $77 \Rightarrow 77 \% 11 = 0$	8	
	9	31
• $31 \Rightarrow 31 \% 11 = 9$	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, $(9 + 1^2) \% 11 = 10 \rightarrow \text{Collision \#4}$

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

$$(9 + 3^2) \% 11 = 1 \rightarrow \text{Collision \#6}$$

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

$$(9 + 5^2) \% 11 = 3 \rightarrow \text{No collision}$$

(ii) Using Quadratic Probing

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

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

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

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

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

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

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

Use quadratic probing,
 $(0 + 1^2) \% 11 = 1$

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

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

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