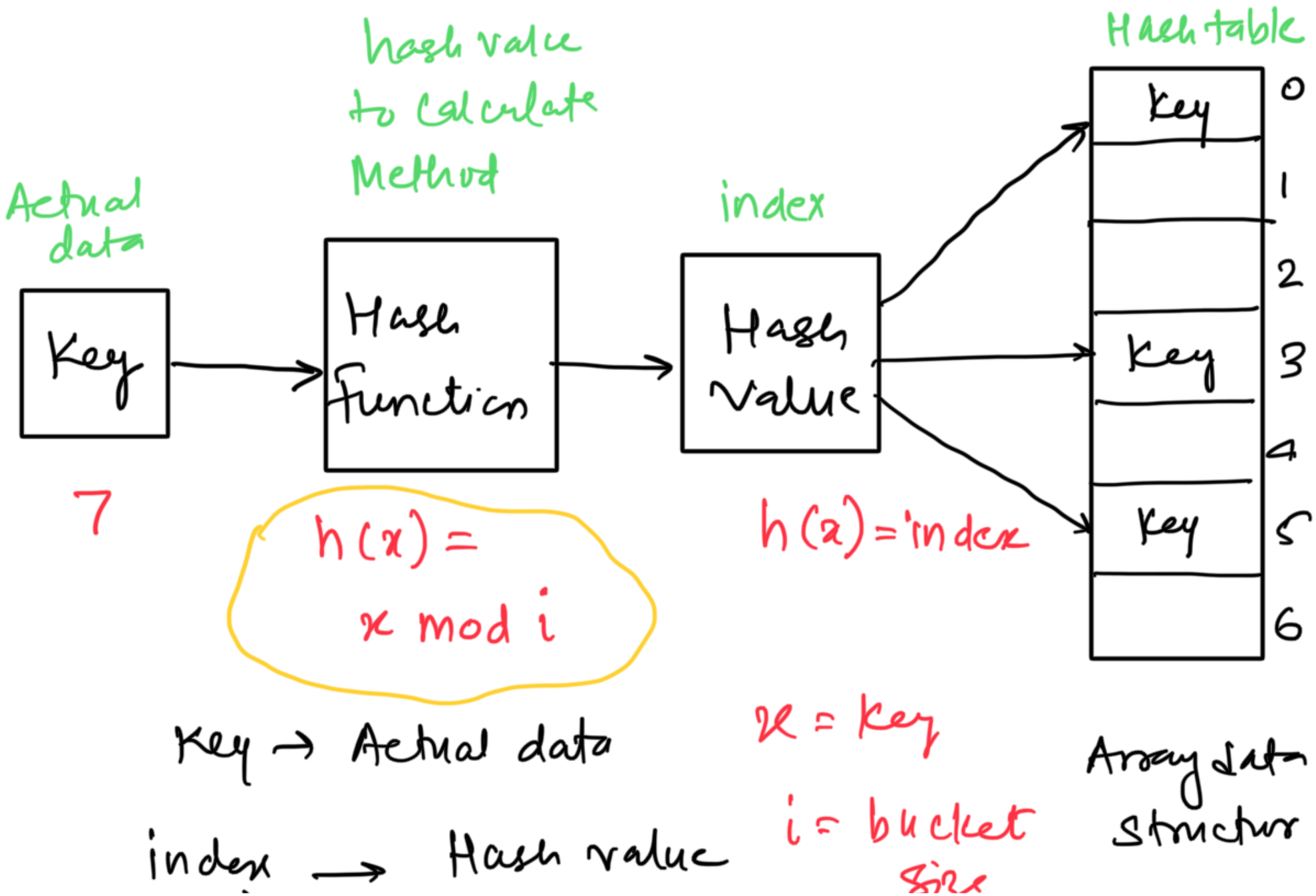
Hashing :

- A technique that determines an index or location for storage of an item/element in a data structure



(0-6)

(Size of Array)

Hash table - data structure that store elements & allows operations (insertion, search, delete)

Operation on Hash table -

1. Insertion — hash value → index → insert
2. Deletion — key index → delete
3. Search — hash value → index → found

Insert → h(k) → directly the position

of that element

O(1)

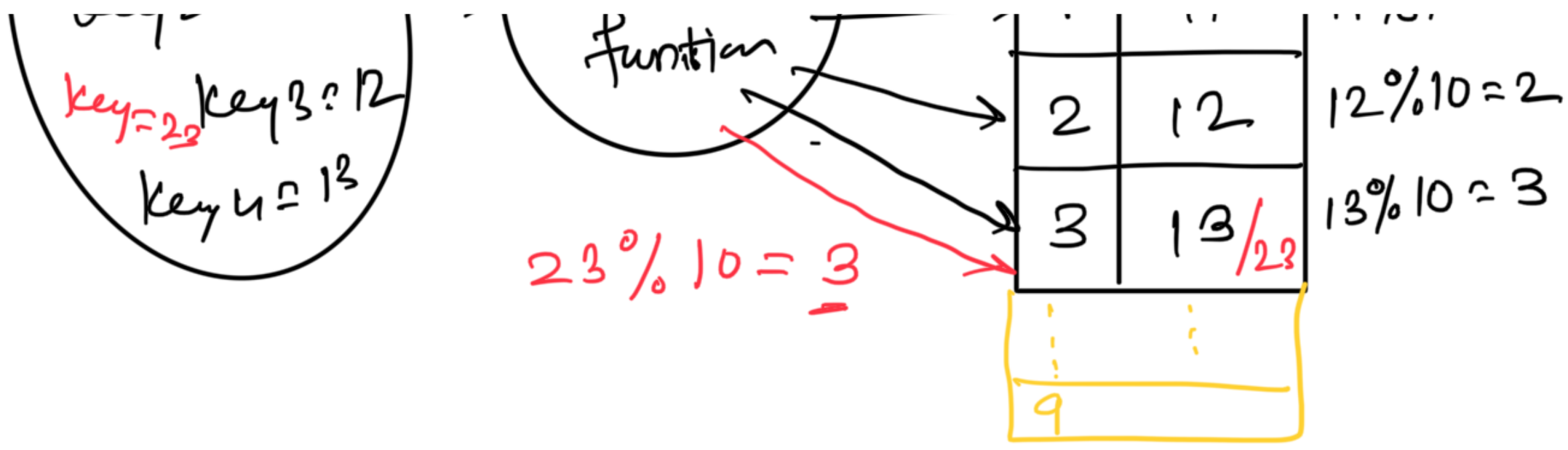
Delete → h(k) → directly we can delete the position of delete

O(1)

Search → h(k) → directly element will be found

O(1)

$h(x) = key \% 10$ → Division Method %



1 Key ⟶ 1 Index

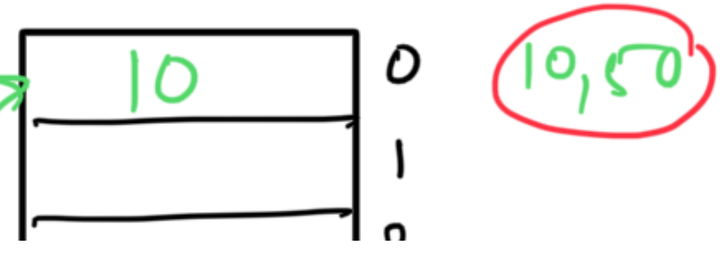
Mapping — 1 key ⟶ 1 Index

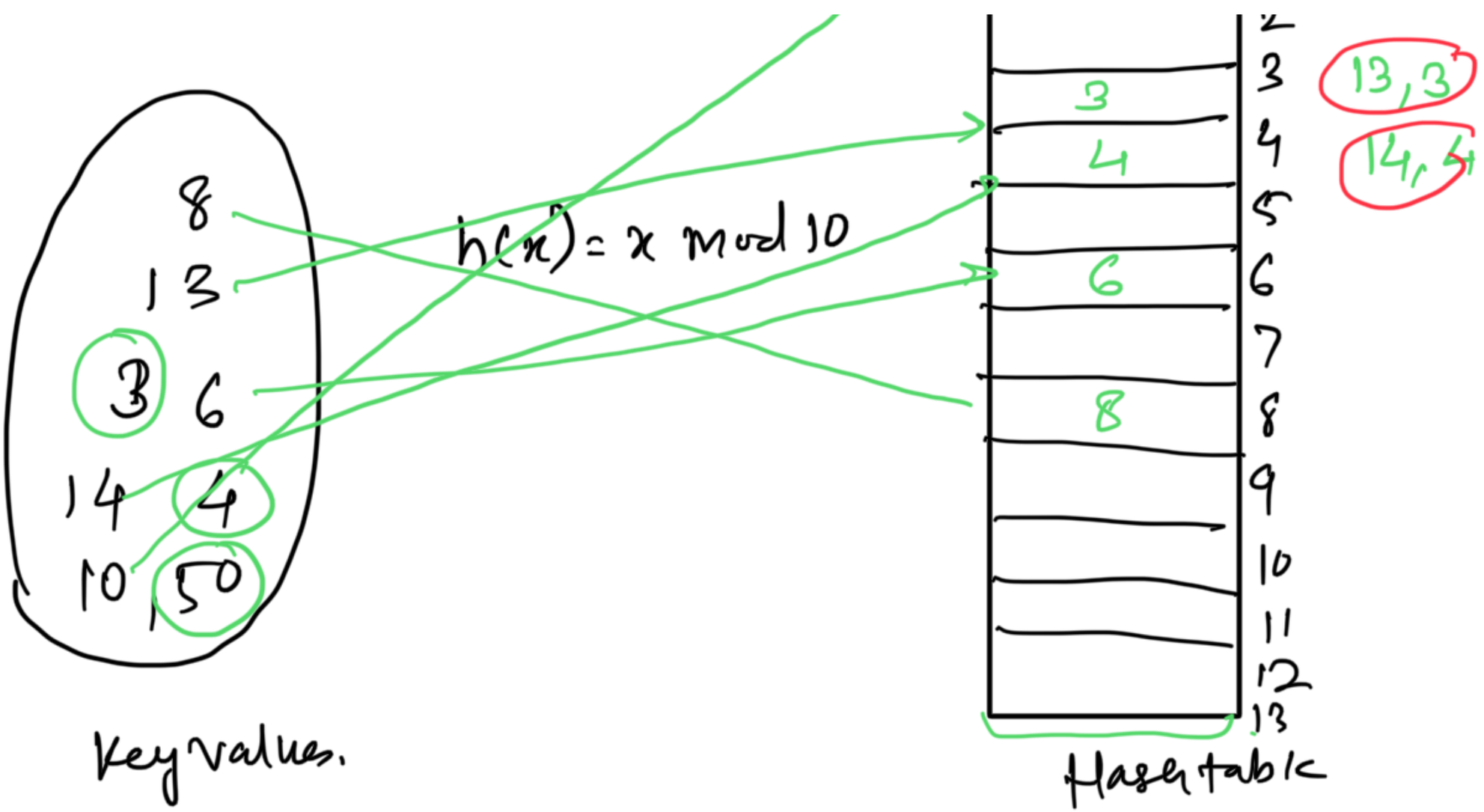
one to one mapping

Multiple keys ⟶ 1 Index

Many ⟶ one Mapping

Example :





Key values.

Many to one Mapping

Multiple key ⟶ Same index

Collision ⟶ Important

Solution — ? (To handle collision)

Collision Resolution Methods –

1. Open Hashing (Separate-chained hash table)
   — chaining (linked list)

2. Closed Hashing (Open address hash tables)
   — Linear Probing (1D Array)
   — Quadratic Probing (next index identify)

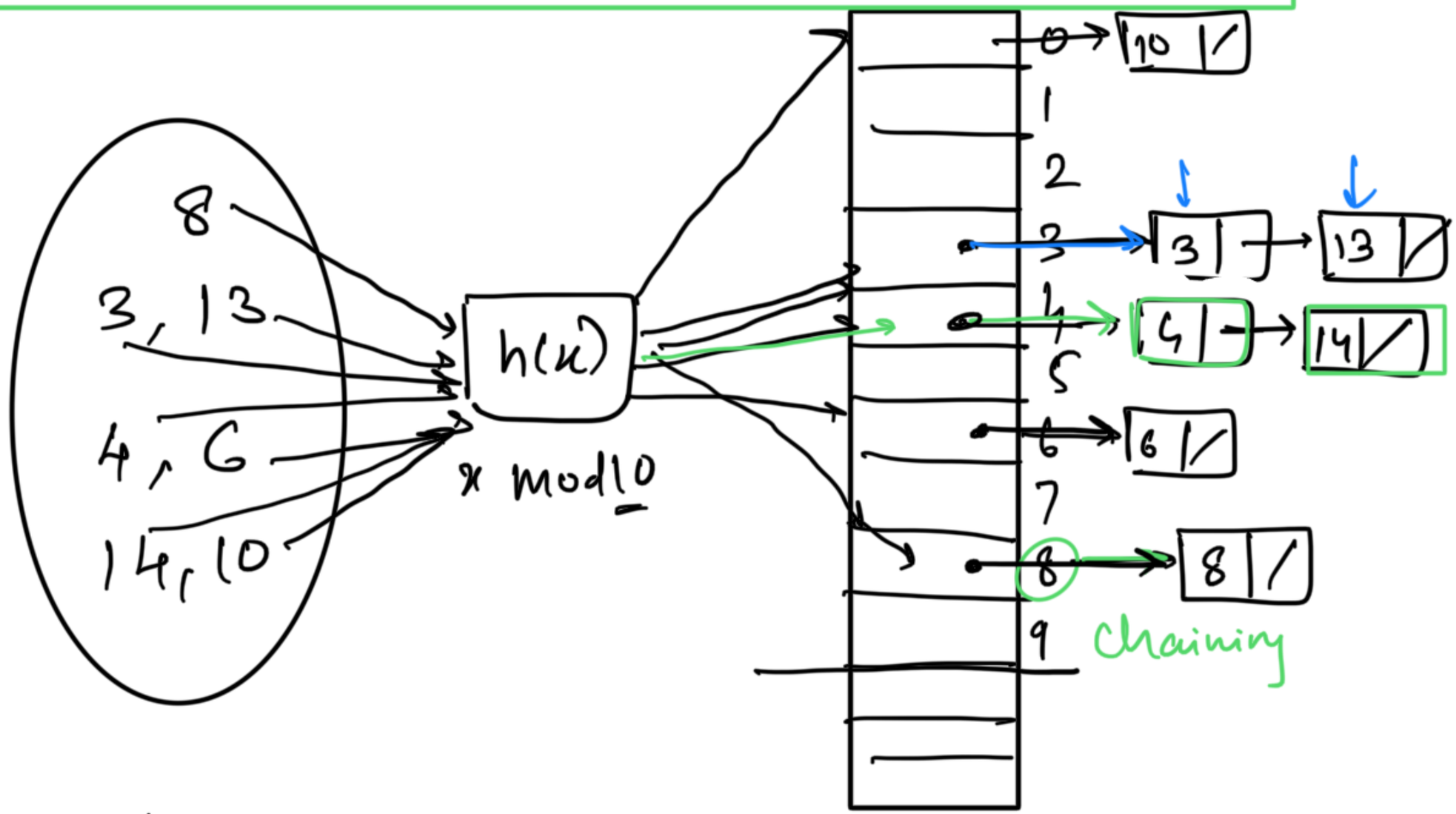
Open Addressed Hash table –

One-dimensional array indexed by integer values that are computed by an index function called as hash function

Separate Chained Hash Table (open hashing)

One dimensional array of linked list indexed by integer values that are computed by an index function called a hash function.

Example → Open Hashing (Chaining)



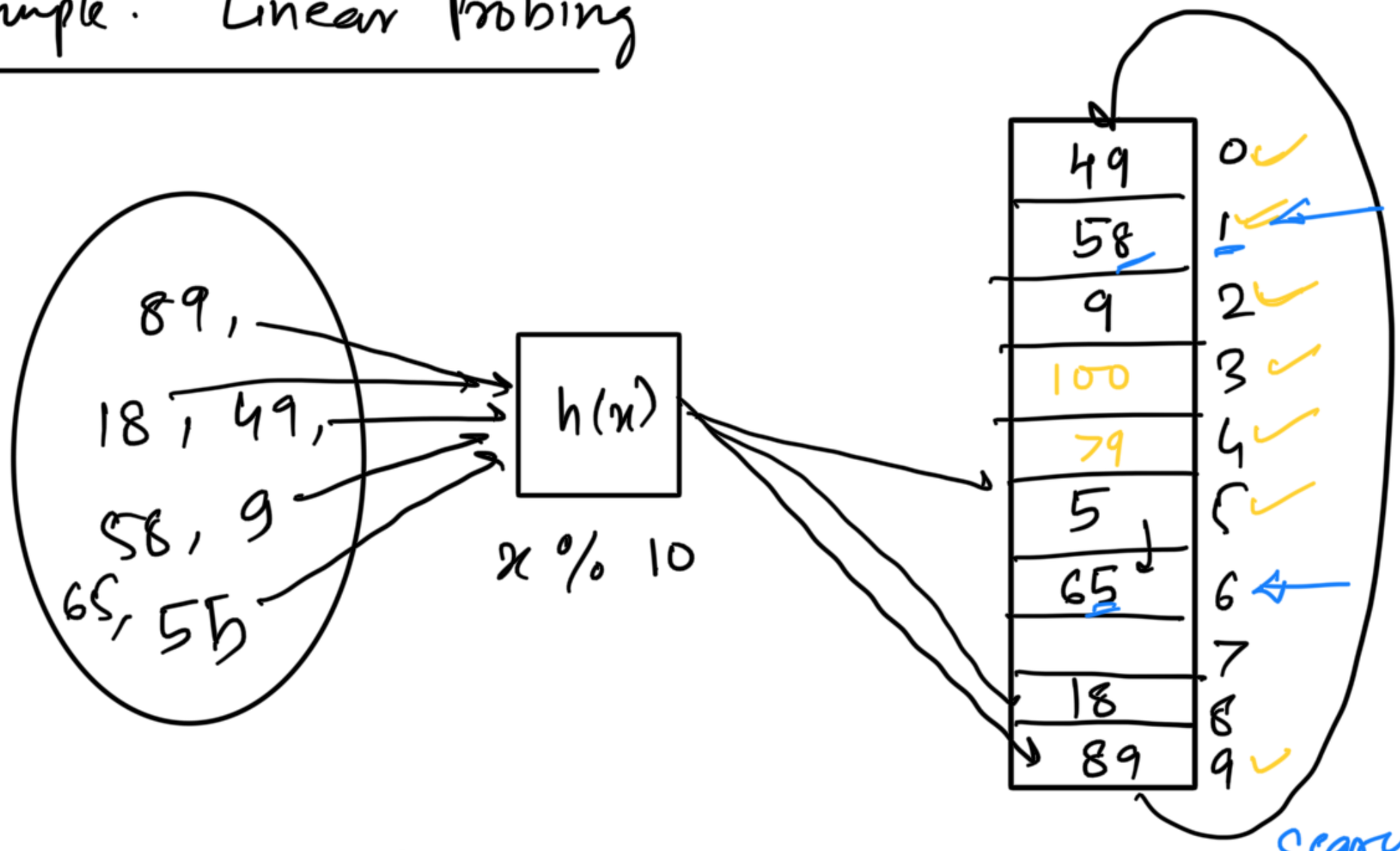
key → index → ?

HW → Keys = 0, 1, 4, 9, 16, 25, 36, 49, 64, 81

Represents the keys in hash table using separate

Chaining with bucket size 11.

Example: Linear Probing



(89, 10) → 9

(18, 10) → 8

(49, 10) → 9

Linear probing

(58, 10) → 8 ✓

(9, 10) → 9

(14, 10) → 4 →

Disadvantage → linear probing

Deletion → O(n)

Q Quadratic probing -

$$h(x) = x \mod i^2$$

$x \mod 1^2 = 3$ ✗

$x \mod 2^2 = 4$ → insert

Example

Table = i = 11

Hash function = $h(x) = x \bmod 11$

Key ⇒ 20, 30, 2, 13, 25, 24, 10, 9

$20 \bmod 11 = 9$

$30 \bmod 11 = 8$

$2 \bmod 11 = 2$

Collision → $13 \bmod 11 = 2 \rightarrow 2 + 1^2 = 3$

$25 \bmod 11 = 3 \rightarrow 3 + 1^2 = 4$

$\rightarrow 10 \bmod 11 = 10$

$\rightarrow 9 \bmod 11 = 9 \rightarrow$ Improve mau $9 + 1^2 = 10$

$9 + 2^2 = 13$

LP ⇒ +1, 2, ..., 2^2

$(a + x^2) \bmod 11 =$

	0
	1
2	2
13	3
25	4
	5
	6
9	7
30	8
20	9
10	10

Q) $P \rightarrow +1^2 / +2 / +3$

$(9+2)$

$13 \mod 11 = 2$

$(9+3^2) \Rightarrow 18$

$18 \mod 11 = 7$

Time Complexity

	Best / Average	Worst
Insert →	O(1)	O(n)
Delete →	O(1)	O(n)
Search →	O(1)	O(n)

Space Complexity

Hash Table → Array[n] →

Average
Worst
} O(n)