

## Linear Probing

$$h(k) = (5k + 3) \bmod 8$$

index	element
0	41
1	30
2	39
3	64
4	72
5	74
6	55
7	68

Insert 41:  $h(41) = (5 \cdot 41 + 3) \bmod 8 = 0 \rightarrow$  insert to 0

Insert 30:  $h(30) = (5 \cdot 30 + 3) \bmod 8 = 1 \rightarrow$  insert to 1

Insert 74:  $h(74) = (5 \cdot 74 + 3) \bmod 8 = 5 \rightarrow$  insert to 5

Insert 55:  $h(55) = (5 \cdot 55 + 3) \bmod 8 = 6 \rightarrow$  insert to 6

Insert 68:  $h(68) = (5 \cdot 68 + 3) \bmod 8 = 7 \rightarrow$  insert to 7

Insert 39:  $h(39) = (5 \cdot 39 + 3) \bmod 8 = (6 + 1 + 1 + 1 + 1) \bmod 8 = 2 \rightarrow$  insert to 2

Insert 64:  $h(64) = (5 \cdot 64 + 3) \bmod 8 = 3 \rightarrow$  insert to 3

Insert 72:  $h(72) = (5 \cdot 72 + 3) \bmod 8 = (3 + 1) = 4 \rightarrow$  insert to 4

## Quadratic Probing

$$h(k) = (3k + 1) \bmod 8$$

index	element
0	29
1	16
2	19
3	14
4	13
5	24
6	27
7	26

Insert 19:  $h(19) = (3 \cdot 19 + 1) \bmod 8 = 2 \rightarrow$  insert to 2

Insert 29:  $h(29) = (3 \cdot 29 + 1) \bmod 8 = 0 \rightarrow$  insert to 0

Insert 16:  $h(16) = (3 \cdot 16 + 1) \bmod 8 = 1 \rightarrow$  insert to 1

Insert 26:  $h(26) = (3 \cdot 26 + 1) \bmod 8 = 7 \rightarrow$  insert to 7

Insert 14:  $h(14) = (3 \cdot 14 + 1) \bmod 8 = 3 \rightarrow$  insert to 3

Insert 24:  $h(24) = (3 \cdot 24 + 1) \bmod 8 = 1 + 2 \cdot 1 = 3$  (occupied)

$1 + 2 \cdot 2 = 5 \rightarrow$  insert to 5

Insert 13:  $h(13) = (3 \cdot 13 + 1) \bmod 8 = 0 + 2 \cdot 1 = 2$  (occupied)

$0 + 2 \cdot 2 = 4 \rightarrow$  insert to 4

Insert 27:  $h(27) = (3 \cdot 27 + 1) \bmod 8 = 2 + 2 \cdot 1 = 4$  (occupied)

$2 + 2 \cdot 2 = 6$

# Double Hashing

After rehashing

index	element
0	40
1	75
2	30
3	49
4	36
5	
6	14
7	
8	56
9	
10	50
11	
12	
13	
14	
15	

$$h_1(k) = (3k) \bmod 8, \quad h_2(k) = ((5k+3) \bmod 7) + 1$$

$$\text{insert } 30: h_1(30) = (3 \cdot 30) \bmod 8 = 2 \rightarrow \text{insert to } 2$$

$$\text{insert } 14: h_1(14) = (3 \cdot 14) \bmod 8 = 2 + 1 \cdot h_2(14) = 2 + [(5 \cdot 14 + 3) \bmod 7 + 1]$$

$$= 2 + 4 = 6$$

$\rightarrow$  insert to 6

$$\text{insert } 40: h_1(40) = (3 \cdot 40) \bmod 8 = 0 \rightarrow \text{insert to } 0$$

$$\text{insert } 36: h_1(36) = (3 \cdot 36) \bmod 8 = 4 \rightarrow \text{insert to } 4$$

$$\text{insert } 56: h_1(56) = (3 \cdot 56) \bmod 8 = 0 + 1 \cdot h_2(56) = 0 + [(5 \cdot 56 + 3) \bmod 7 + 1]$$

$$= 4 \bmod 16$$

$$= 4$$

$$0 + 2 \cdot h_2(56) = 0 + 2 \cdot 4$$

$$= 8$$

$\rightarrow$  insert to 8

$$\text{insert } 75: h_1(75) = (3 \cdot 75) \bmod 8 = 1 \rightarrow \text{insert to } 1$$

$$\text{insert } 49: h_1(49) = (3 \cdot 49) \bmod 8 = 3 \rightarrow \text{insert to } 3$$

$$\text{insert } 50: h_1(50) = (3 \cdot 50) \bmod 8 = 6 + 1 \cdot h_2(50) = 6 + [(5 \cdot 50 + 3) \bmod 7 + 1]$$

$$= 6 + 2$$

$$= 8$$

$$= 6 + 2 \cdot h_2(50) = 6 + 2 \cdot 2$$

$$= 10$$

$\rightarrow$  insert to 10



# Cuckoo Hashing

$$h_1(k) = (3k+1) \bmod 7, \quad h_2(k) = (\text{floor}(5k/2) + 3) \bmod 7$$

table (1)

index	element
0	23
1	
2	12
3	10
4	85
5	
6	46

table (2)

index	element
0	24
1	
2	22
3	17
4	
5	
6	

insert 10 :  $h_1(10) = (3 \cdot 10 + 1) \bmod 7 = 3 \rightarrow$  insert at 3 in table 1

insert 22 :  $h_1(22) = (3 \cdot 22 + 1) \bmod 7 = 4 \rightarrow$  insert at 4 in table 1

insert 24 :  $h_1(24) = (3 \cdot 24 + 1) \bmod 7 = 3 \rightarrow$  insert at 3 in table 1  $\rightarrow h_2(10) = 0$   
 $\rightarrow$  insert at 0 in table 2

insert 17 :  $h_1(17) = (3 \cdot 17 + 1) \bmod 7 = 3 \rightarrow$  insert at 3 in table 1  $\rightarrow h_2(24) = 0$   
 $\rightarrow$  insert at 0 in table 2  $\rightarrow h_1(10) = 3 \rightarrow$  insert at 3 in table 1  
 $\rightarrow h_2(17) = 3 \rightarrow$  insert at 3 in table 2

insert 85 :  $h_1(85) = (3 \cdot 85 + 1) \bmod 7 = 4 \rightarrow$  insert at 4 in table 1  $\rightarrow h_2(22) = 2$   
 $\rightarrow$  insert at 2 in table 2

insert 23 :  $h_1(23) = (3 \cdot 23 + 1) \bmod 7 = 0 \rightarrow$  insert at 0 in table 1

insert 12 :  $h_1(12) = (3 \cdot 12 + 1) \bmod 7 = 2 \rightarrow$  insert at 2 in table 1

insert 46 :  $h_1(46) = (3 \cdot 46 + 1) \bmod 7 = 6 \rightarrow$  insert at 6 in table 1