

**CMSC 204 - Hashing Lab: Calculations**  
**Module 13 - “Searching & Hashing”**

**Key Values:**

15 54 13 10 135 114 49 174 27 24

**Linear Probing:**

N = 13

Array Index	Key Value	Reasoning
0	13	$13 \% 13 = \mathbf{0}$
1	27	$27 \% 13 = \mathbf{1}$
2	15	$15 \% 13 = \mathbf{2}$
3	54	$54 \% 13 \rightarrow (2 + (1 \text{ collision})) \% 13 = \mathbf{3}$
4	24	$24 \% 13 \rightarrow (11 + (6 \text{ collisions})) \% 13 = \mathbf{4}$
5	135	$135 \% 13 = \mathbf{5}$
6	174	$174 \% 13 \rightarrow (5 + (1 \text{ collision})) \% 13 = \mathbf{6}$
7		
8		
9		
10	10	$10 \% 13 = \mathbf{10}$
11	114	$114 \% 13 \rightarrow (10 + (1 \text{ collision})) \% 13 = \mathbf{11}$
12	49	$49 \% 13 \rightarrow (10 + (2 \text{ collisions})) \% 13 = \mathbf{12}$

**Key Values:**

15 54 13 10 135 114 49 174 27 24

**Quadratic Probing:**

N = 13

Array Index	Key Value	Reasoning
0	13	$13 \% 13 = 0$
1	49	$49 \% 13 = 10 \rightarrow (10 + (2 \text{ collisions})^2) \% 13 = 1$
2	15	$15 \% 13 = 2$
3	54	$54 \% 13 = 2 \rightarrow (2 + (1 \text{ collision})^2) \% 13 = 3$
4	27	$27 \% 13 = 1 \rightarrow (1 + (4 \text{ collisions})^2) \% 13 = 4$
5	135	$135 \% 13 = 5$
6	174	$174 \% 13 = 5 \rightarrow (5 + (1 \text{ collision})^2) \% 13 = 6$
7		
8		
9		
10	10	$10 \% 13 = 10$
11	114	$114 \% 13 = 10 \rightarrow (10 + (1 \text{ collision})^2) \% 13 = 11$
12	24	$24 \% 13 = 11 \rightarrow (11 + (1 \text{ collision})^2) \% 13 = 12$

**Key Values:**

15 54 13 10 135 114 49 174 27 24

**Linear-Quotient:**

$N = 13, 4k + 3 = 19$

Array Index	Key Value	Reasoning
0	13	$13 \% 13 = 0$
1	27	$27 \% 13 = 1$
2	15	$15 \% 13 = 2$
3	49	$49 \% 13 = 10 \rightarrow q = 49 / 13 = 3 \rightarrow$ $(10 + 3) \% 13 = 0 \rightarrow (0 + 3) \% 13 = 3$
4		
5	135	$135 \% 13 = 5$
6	54	$54 \% 13 = 2 \rightarrow q = 54 / 13 = 4 \rightarrow$ $(2 + 4) \% 13 = 6$
7		
8	114	$114 \% 13 = 10 \rightarrow q = 114 / 13 = 8 \rightarrow$ $(10 + 8) \% 13 = 5 \rightarrow (5 + 8) \% 13 = 0 \rightarrow$ $(0 + 8) \% 13 = 8$
9		
10	10	$10 \% 13 = 10$
11	174	$174 \% 13 = 5 \rightarrow q = 174 / 13 = 13 \rightarrow$ $q \% 13 = 0 \rightarrow \text{offset} = 4k + 3 = 19 \rightarrow$ $(5 + 19) \% 13 = 11$
12	24	$24 \% 13 = 11 \rightarrow q = 24 / 13 = 1 \rightarrow$ $(11 + 1) \% 13 = 12$

**Key Values:**

15   54   13   10   135   114   49   174   27   24

**Bucket Hashing:**

$N = 10, i_p = p_k \% N$

Array Index	Key Value
0	10
1	
2	
3	13
4	54 → 114 → 174 → 24
5	10 → 135
6	
7	27
8	
9	49

**Key Values:**

15 20 42 35 16 26 21 78 50 30 17 58 46 120 152

**Linear-Quotient (self-challenge):** $N = 21, 4k + 3 = 7$ 

Array Index	Key Value	Reasoning
0	42	$42 \% 21 = 0$
1	58	$58 \% 21 = 16 \rightarrow q = 58 / 21 = 2 \rightarrow$ $(16 + 2) \% 21 = 18 \rightarrow (18 + 2) \% 21 = 20 \rightarrow$ $(20 + 2) \% 21 = 1$
2		
3		
4	46	$46 \% 21 = 4$
5	26	$26 \% 21 = 5$
6		
7	21	$21 \% 21 = 0 \rightarrow q = 21 / 21 = 0 \rightarrow$ $q \% 21 = 0 \rightarrow \text{offset} = 4k + 3 = 7 \rightarrow$ $(0 + 7) \% 21 = 7$
8	50	$50 \% 21 = 8$
9	30	$30 \% 21 = 9$
10		
11		
12	152	$152 \% 21 = 5 \rightarrow q = 152 / 21 = 7 \rightarrow$ $(5 + 7) \% 21 = 12$
13		
14	35	$35 \% 21 = 14$
15	15	$15 \% 21 = 15$
16	16	$16 \% 21 = 16$

17	17	$16 \% 21 = \mathbf{17}$
18	78	$78 \% 21 = 15 \rightarrow q = 78 / 21 = 3 \rightarrow$ $(15 + 3) \% 21 = \mathbf{18}$
19	120	$120 \% 21 = 15 \rightarrow q = 120 / 21 = 5 \rightarrow$ $(15 + 5) \% 21 = 20 \rightarrow (20 + 5) \% 21 = 4 \rightarrow$ $(4 + 5) \% 21 = 9 \rightarrow (9 + 5) \% 21 = 14 \rightarrow$ $(14 + 5) \% 21 = \mathbf{19}$
20	20	$20 \% 21 = \mathbf{20}$