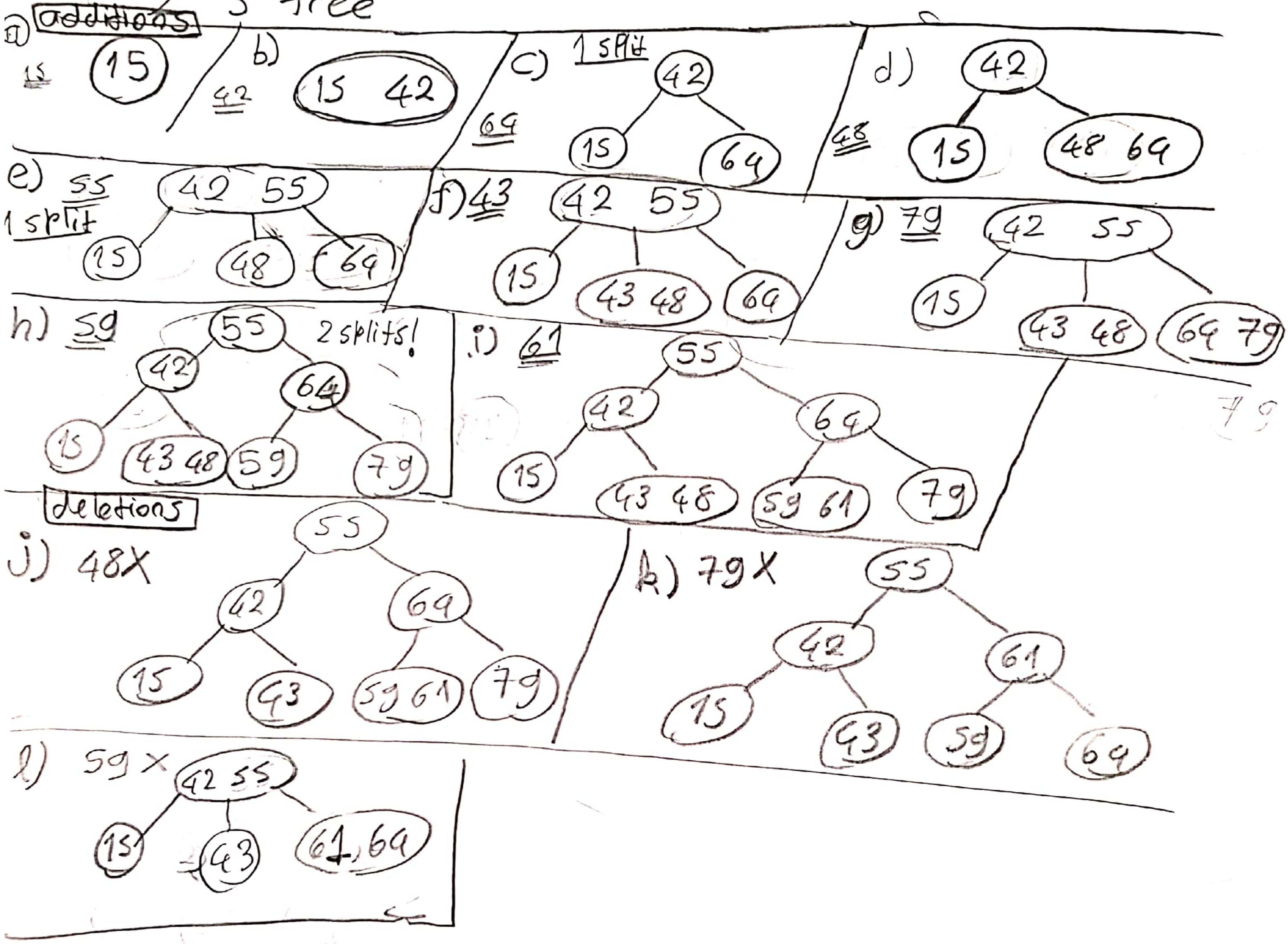
Q1 | N. Onur Vural - 21902330 | CS 202 - HW4

insert 15, 42, 64, 48, 55, 43, 79, 59, 61

delete 48, 79, 59

1. 2-3 tree

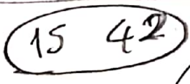


2. 2-3-4 tree → When a 4 node is encountered, split before insertion!

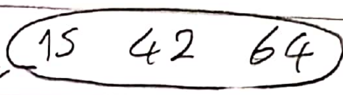
addditions

@ 15

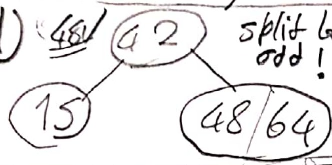
b) 42



c) 64

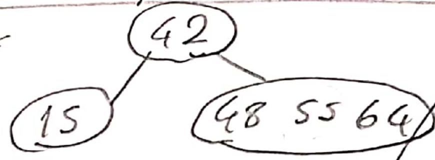


d) 48



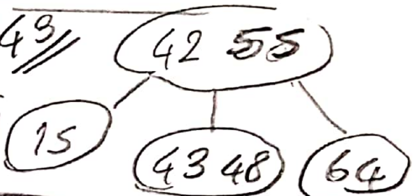
split before add!

e) 55

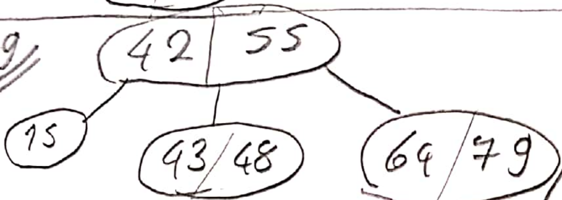


f) 43

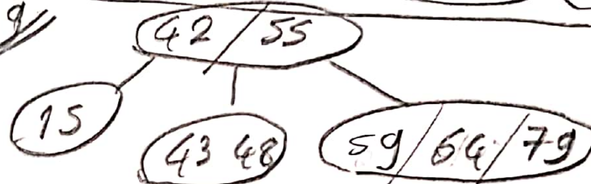
split before!



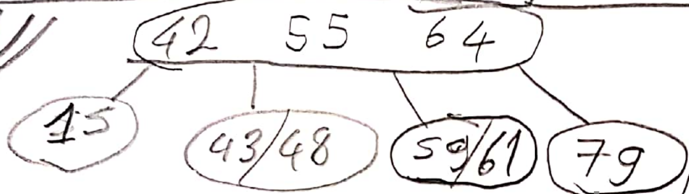
g) 79



h) 59



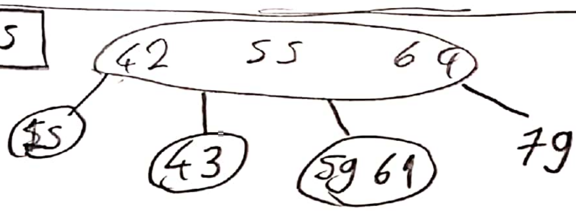
i) 61



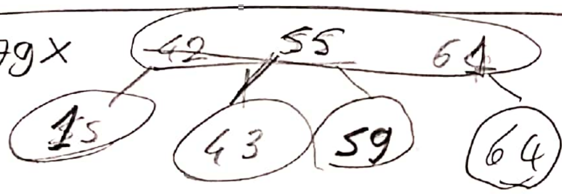
⇒ deletion: When encountering a 2 node on path transfer it to 3 or 4 node depending on the siblings

deletions

j) 48 x

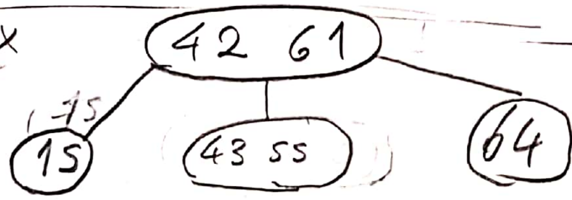


k) 79 x



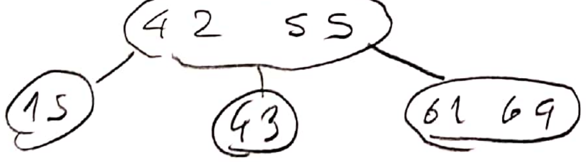
⇒ it checks the left sibling first which was 59,61 then it transfers 61 to parent, 64 to 79 node where it finally deletes 79!

l) 59 x



⇒ since sibling (first checks left sibling) is 2 node, we merge parent and two into a four node!

NOTE: If algorithm checks the right subtree first, the resulting tree would be



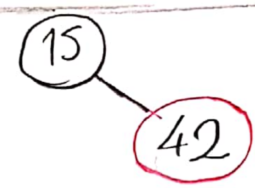
It depends on checking the left OR right sibling first!

3. Red-Black Tree (Top down)

Addition

a) 15//

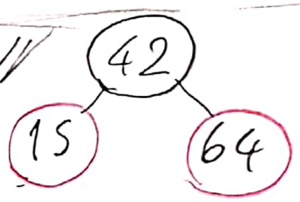
b) 42//



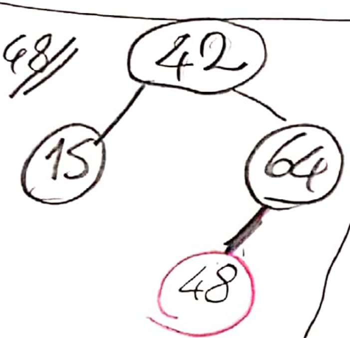
c) 64//

Violation

Fix

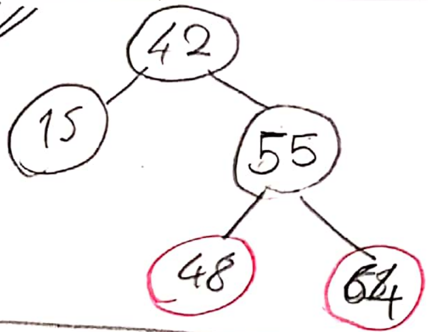


d) 48//

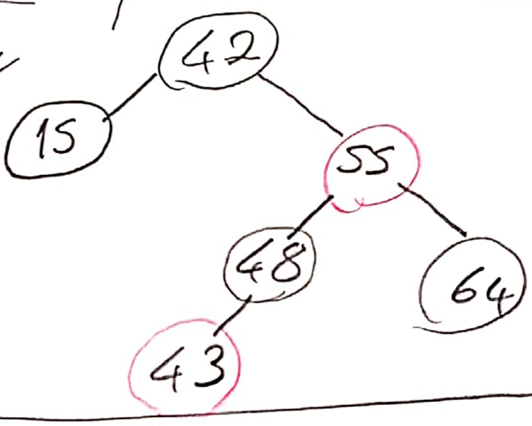


e) 55//

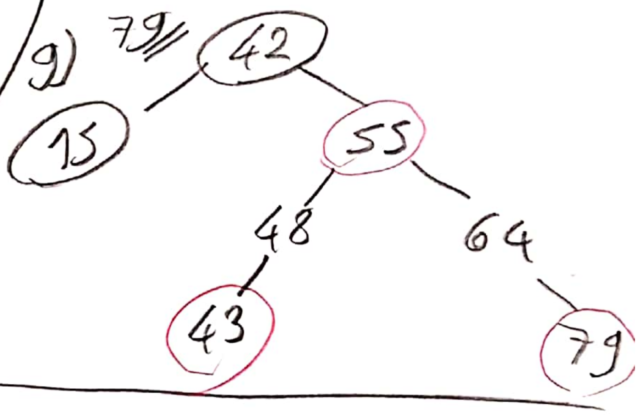
case 4:
Double rot!



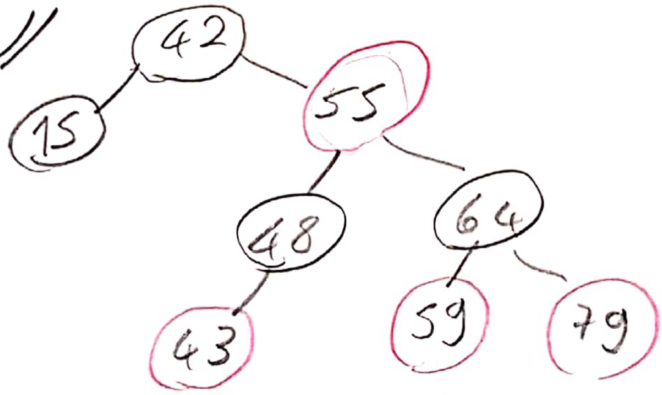
f) 43//



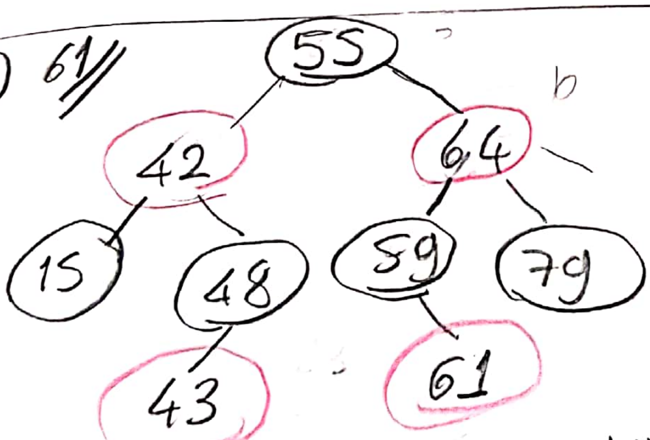
g) 79//



h) 59//

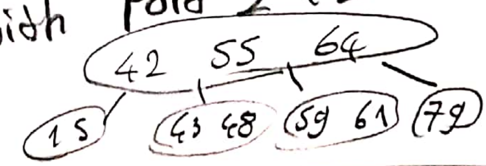


i) 61//



1) 64 has two red children
reverse colors
2) Parent of 64 is red
Left rot at grandparent (G)
42
Color (G) 42 as red
Color Parent 55 as black

→ resulting tree same with Part 2 (2-3-4)!



Page 3

Q2 N.Onur Vural 21902330 – CS 202 HW4

insert keys: 22, 23, 24, 39, 40, 26, 41, 43, 26

1. open adressing with linear probing:

- 22 mod 17 = 5 / Probe = 1
- 23 mod 17 = 6 / Probe = 1
- 24 mod 17 = 7 / probe = 1
- 39 mod 17 = 5, 6, 7, 8 / Probe = 4
- 40 mod 17 = 6, 7, 8, 9 / Probe = 4
- 26 mod 17 = 9, 10 / Probe = 2
- 41 mod 17 = 7, 8, 9, 10, 11 / Probe = 5
- 43 mod 17 = 9, 10, 11, 12 / Probe = 4
- 26 mod 17 = 9, 10 / Probe = 2

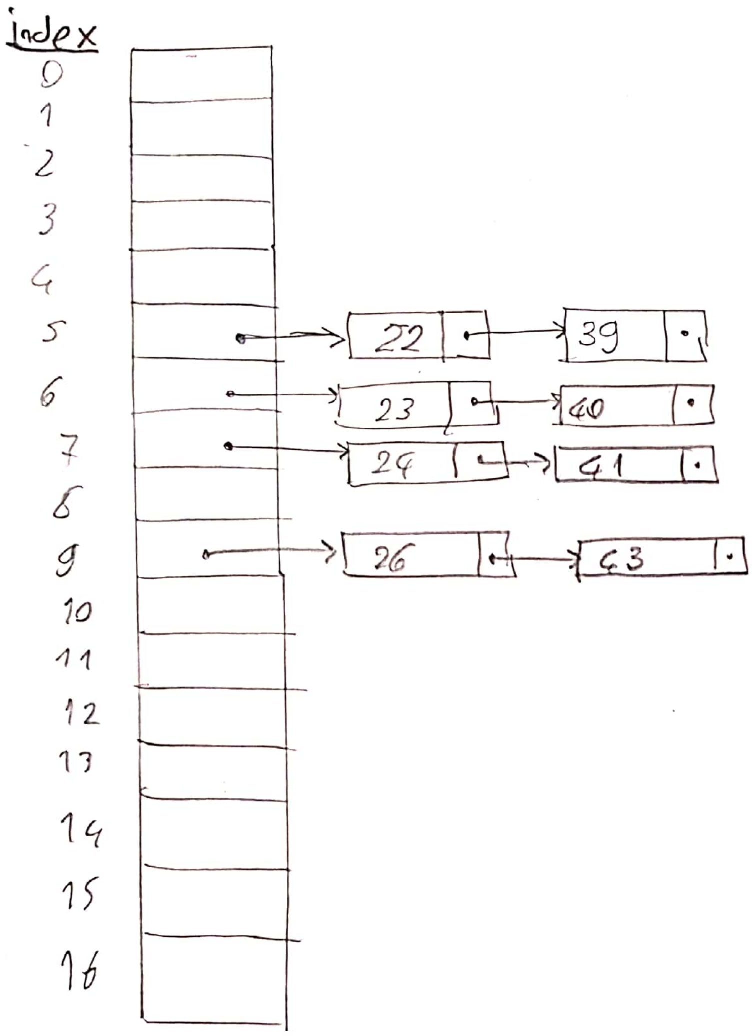
	index
	0
	1
	2
	3
	4
22	5
23	6
24	7
39	8
40	9
26	10
41	11
43	12
	13
	14
	15
	16

2. open addressing with Quadratic Probing: → i, $i+1^2$, $i+2^2$, $i+3^2$, $i+4$

- $22 \bmod 17 = 5$ / Probe = 1
- $23 \bmod 17 = 6$ / Probe = 1
- $24 \bmod 17 = 7$ / Probe = 1
- $39 \bmod 17 = 5$, $\underbrace{5+1^2}_{6}$, $\underbrace{5+2^2}_{9}$ / Probe = 3
- $40 \bmod 17 = 6$, $\underbrace{6+1^2}_{7}$, $\underbrace{6+2^2}_{10}$ / Probe = 3
- $26 \bmod 17 = 9$, $\underbrace{9+1^2}_{10}$, $\underbrace{9+2^2}_{13}$ / Probe = 3
- $41 \bmod 17 = 7$, $\underbrace{7+1^2}_{8}$ // Probe = 2 3
- $43 \bmod 17 = 9$, $\underbrace{9+1^2}_{10}$, $\underbrace{9+2^2}_{13}$, $\underbrace{9+3^2}_{17}$ Probe = 4
- $26 \bmod 17 = 9$ / $\underbrace{9+1^2}_{10}$, $\underbrace{9+2^2}_{13}$, Probe = 3

	index
	0
	1
43	2
	3
	4
22	5
23	6
24	7
41	8
39	9
40	10
	11
	12
26	13
	14
	15
	16

3. Seperate Chaining :



- 22 mod 17 = 5
- 23 mod 17 = 6
- 24 mod 17 = 7
- 39 mod 17 = 5
- 40 mod 17 = 6
- 26 mod 17 = 9
- 41 mod 17 = 7
- 43 mod 17 = 9

- 26 mod 17 = 9 #already exists!