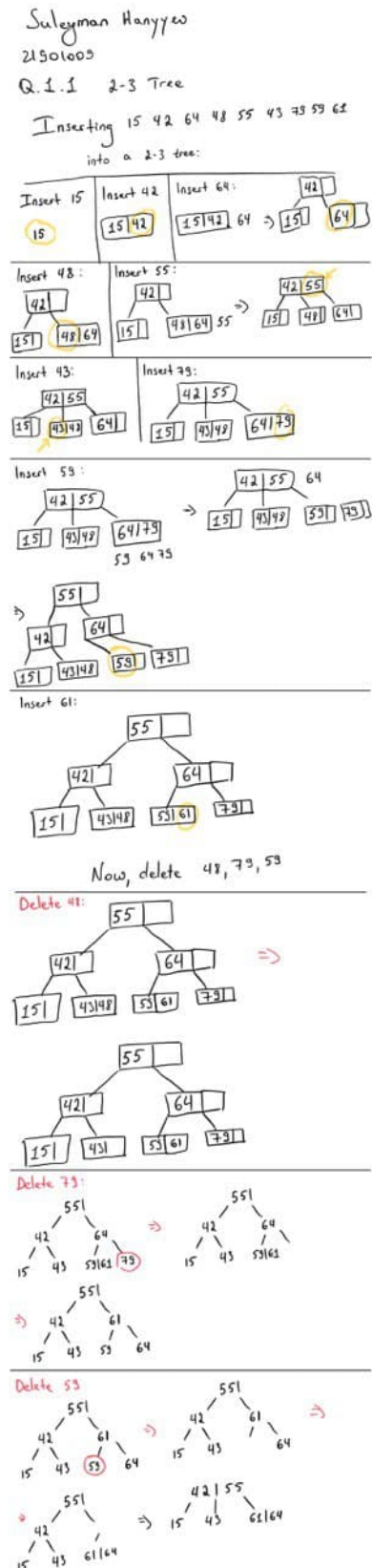


Title: Balanced Search Trees, Hashing and Graphs  
 Author: Suleyman Hanyev  
 ID: 21901009  
 Section: 1  
 Assignment: 4  
 Description: PDF with answers for Q1 and Q2

Q1, part 1:  
 2-3 tree



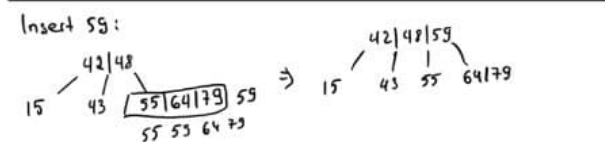
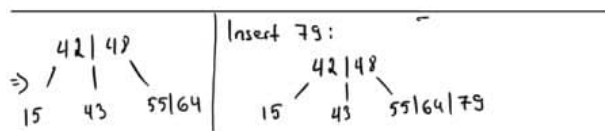
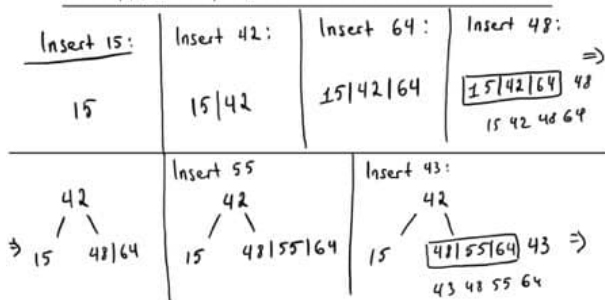
Q1, part 2:  
2-3-4 tree:

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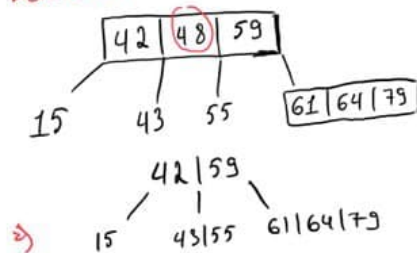
Q.1.2

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

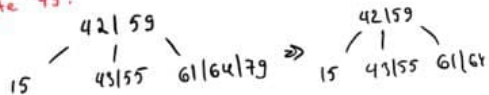


Now, delete 48, 79, 59

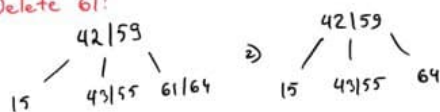
Delete 48



Delete 79:



Delete 61:



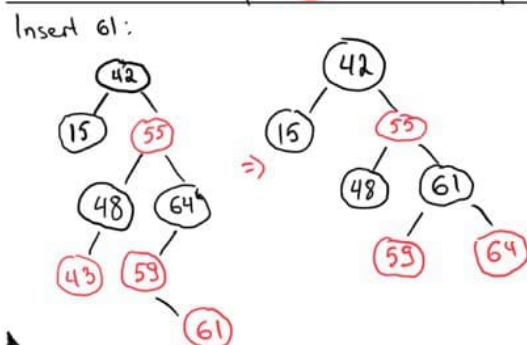
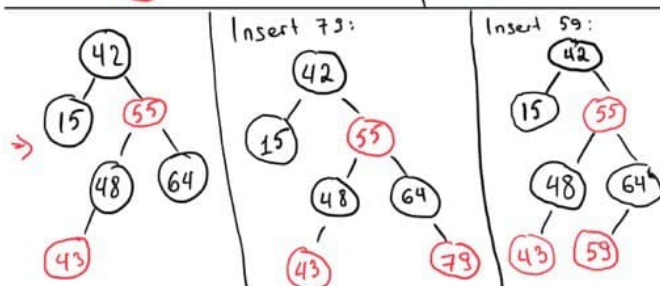
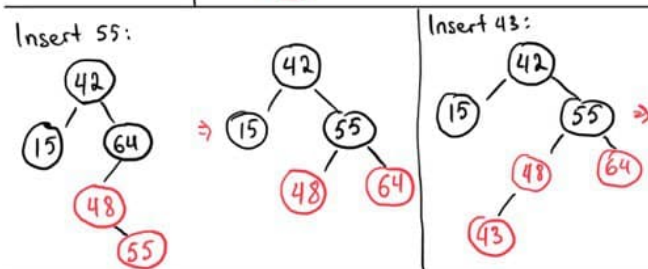
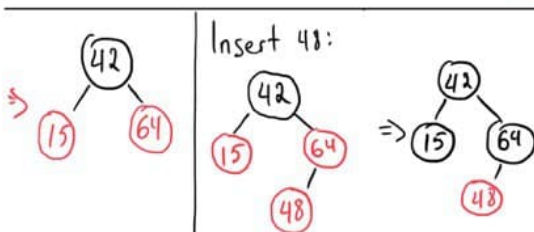
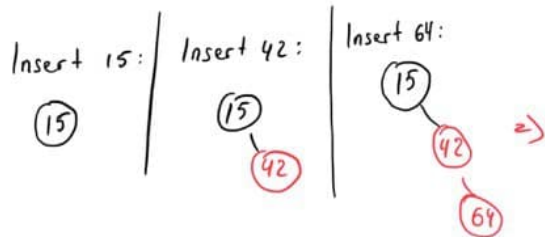
Q1, part 3  
Red-Black tree:

Suleyman Hanyyev

21301003

Q.1.3

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



Q2, part 1:  
Linear Probing:

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21901009 hash table size  $\rightarrow 17$ . (0..16)  
HW 4. Q2.

$$h(x) = x \% 17$$

Keys:

22

23

24

39

40

26

41

43

26

$\uparrow$  duplicate

Hash Table

	0
	1
	2
	3
	4
22	5
23	6
24	7
<u>39</u> l.p	8
40	9
26	10
41	11
43	12
	13
	14
	15
	16

Q2, part 2:  
Quadratic probing:

$$h(x) = x \% 17$$

$$h'(x) = (h(x) + p(x)) \% 17$$

$$p(x) = i^2$$

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

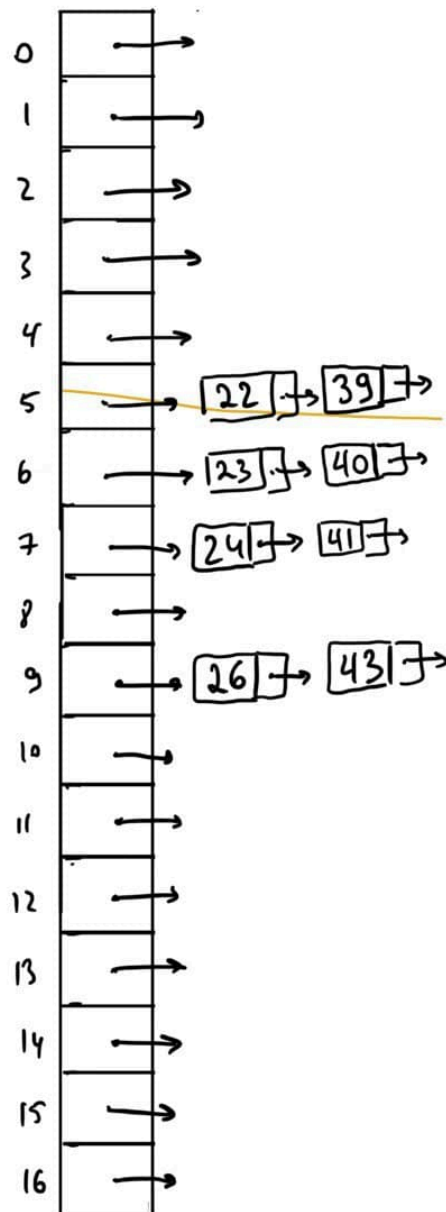
↑  
duplicate

depends on the implementation, might replace 26 on 13<sup>th</sup> pos., or program will check if such key already exists

Q2, part 3:  
Separate Chaining:

22  
23  
24  
39  
40  
26  
41  
43  
26

↑ duplicate



Lastly, I wanted to elaborate:

l.p -> linear probing

q.p -> quadratic probing

Also, in my representation of q2 I just mentioned that 26 is a duplicate. There are two ways to deal with it and it depends on the coder: either checking if such number exists, or overwriting the old