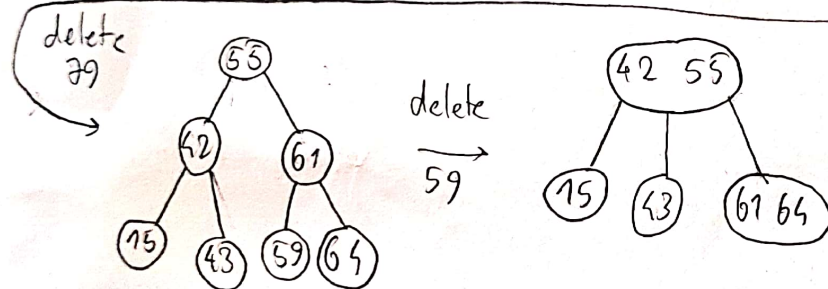
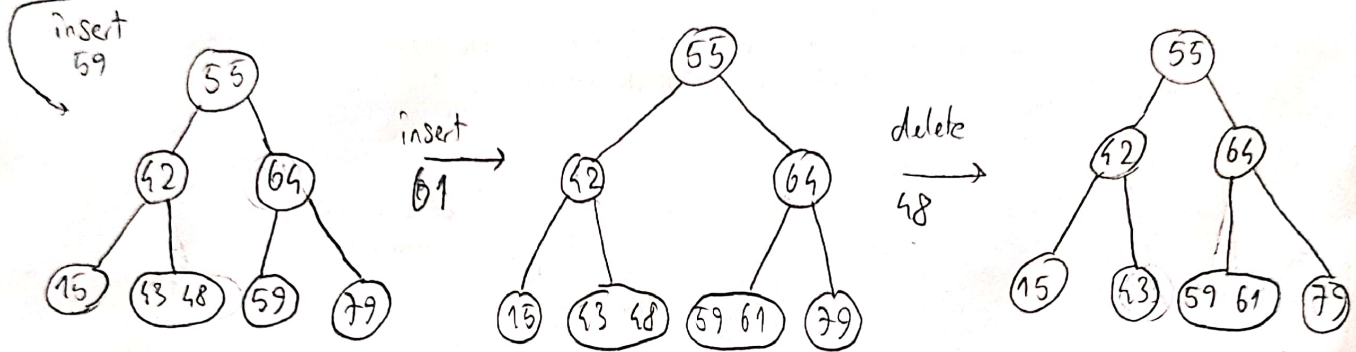
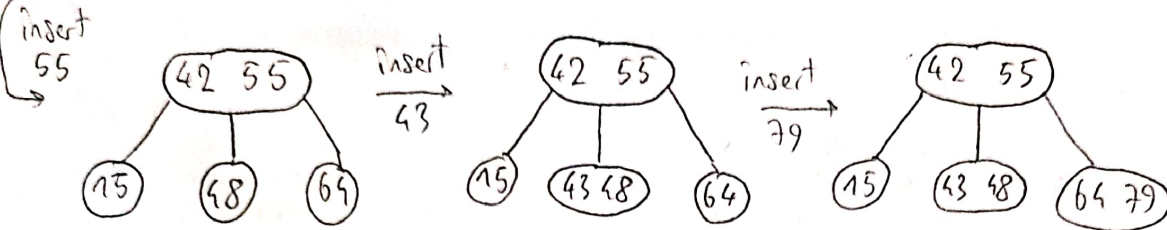
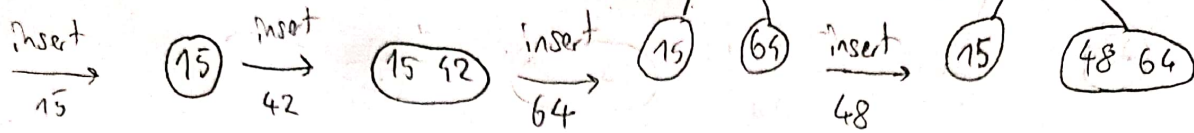
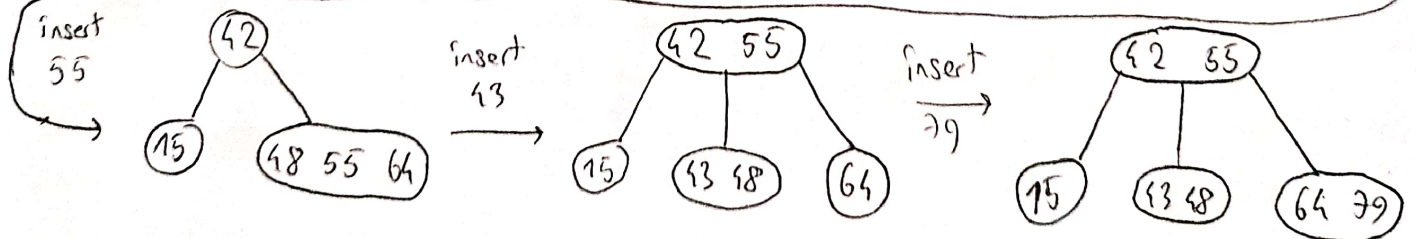
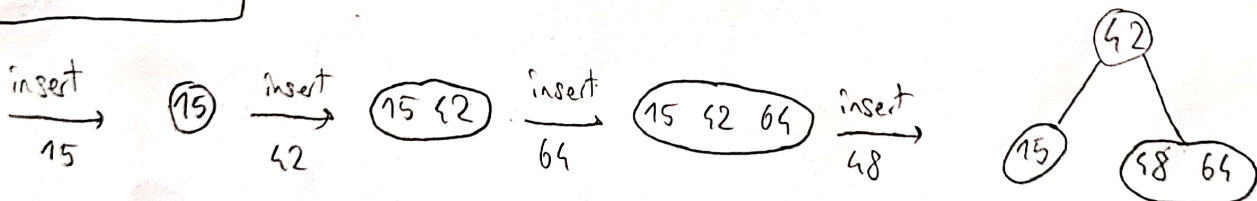


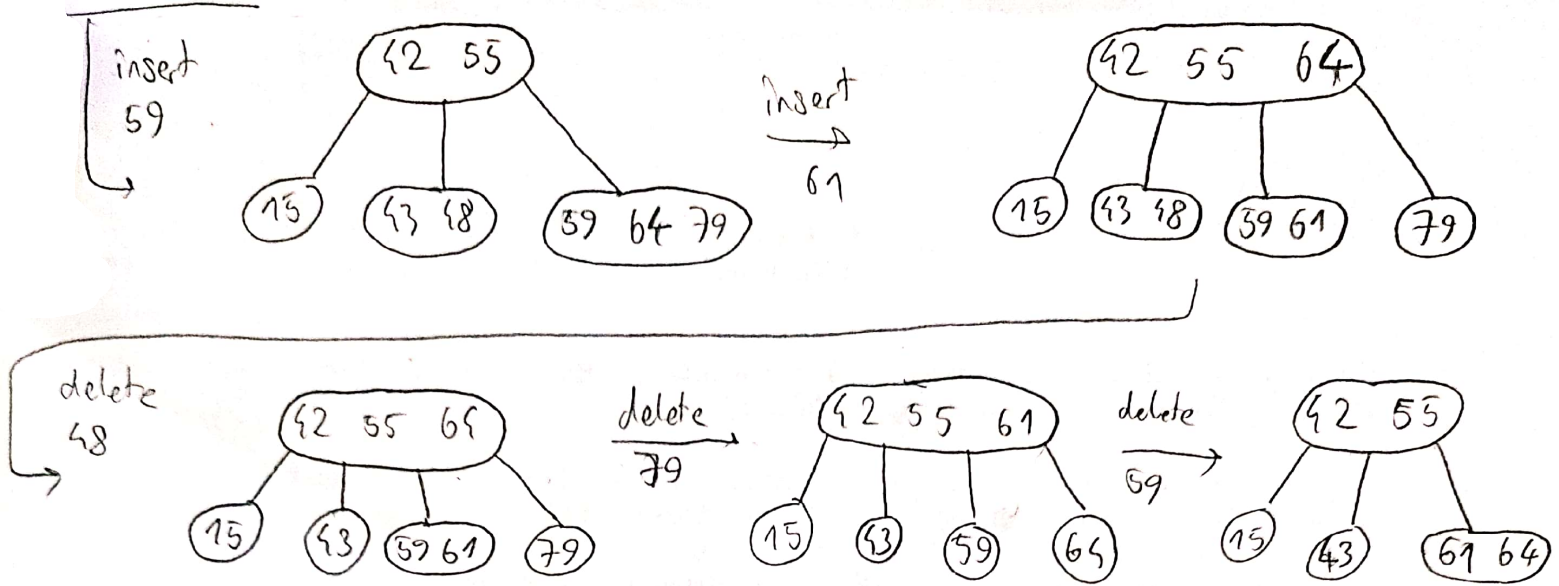
# Question 1:

## 2-3 tree

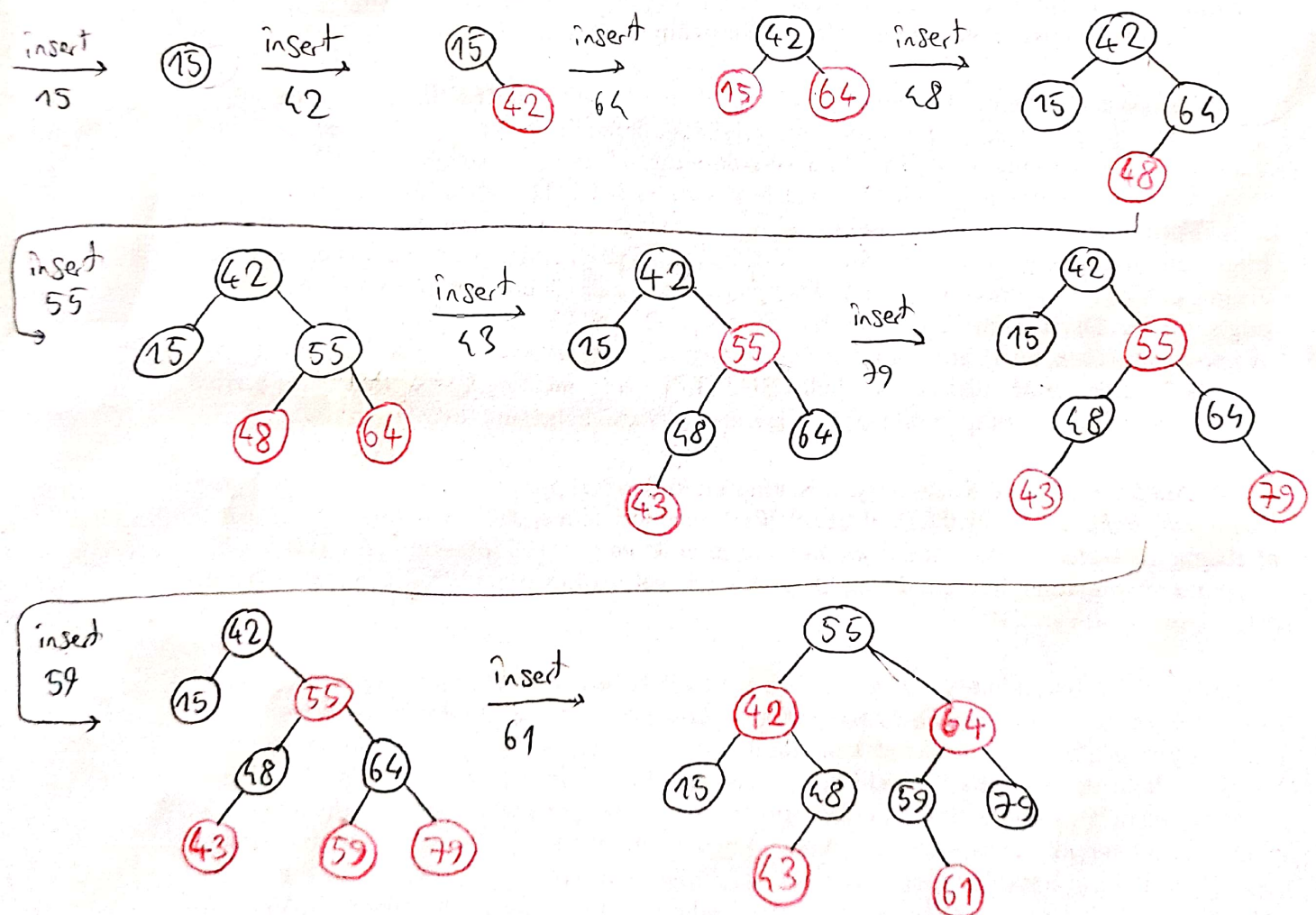


## 2-3-4 tree





## Red-Black Trees



## Question 2:

### Linear probing

$$22 \bmod 17 = 5$$

$$23 \bmod 17 = 6$$

$$24 \bmod 17 = 7$$

$$39 \bmod 17 = 5 \neq 7 \neq 8$$

$$40 \bmod 17 = 6 \neq 7 \neq 9$$

$$26 \bmod 17 = 9 \neq 10$$

$$41 \bmod 17 = 7 \neq 8 \neq 10 \neq 11$$

$$43 \bmod 17 = 9 \neq 10 \neq 11 \neq 12$$

$$26 \bmod 17 = 9 \neq 10 \neq 11 \neq 12 \neq 13$$

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

### Quadratic Probing

$$22 \bmod 17 = 5$$

$$23 \bmod 17 = 6$$

$$24 \bmod 17 = 7$$

$$39 \bmod 17 = 5, 5+1^2, 5+2^2 = 9$$

$$40 \bmod 17 = 6, 6+1^2, 6+2^2 = 10$$

$$26 \bmod 17 = 9, 9+1^2, 9+2^2 = 13$$

$$41 \bmod 17 = 7, 7+1^2, 7+2^2 = 11$$

$$43 \bmod 17 = 9, 9+1^2, 9+2^2, 9+3^2 \bmod 17 = 1$$

$$26 \bmod 17 = 9, 9+1^2, 9+2^2, 9+3^2, 9+4^2 \bmod 17 = 8$$

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



# Separate chaining

$$22 \bmod 17 = 5$$

$$23 \bmod 17 = 6$$

$$24 \bmod 17 = 7$$

$$39 \bmod 17 = 5$$

$$40 \bmod 17 = 6$$

$$26 \bmod 17 = 9$$

$$41 \bmod 17 = 7$$

$$43 \bmod 17 = 9$$

$$26 \bmod 17 = 9$$

