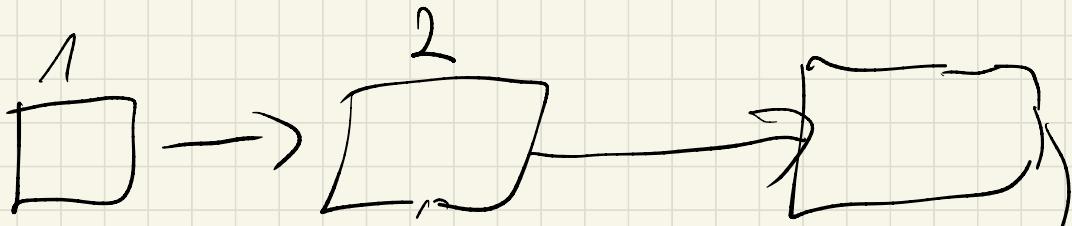
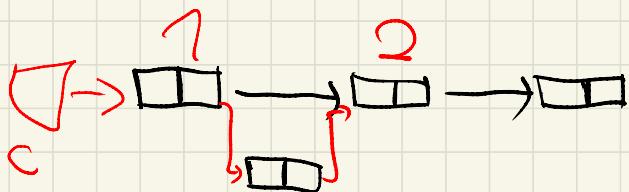
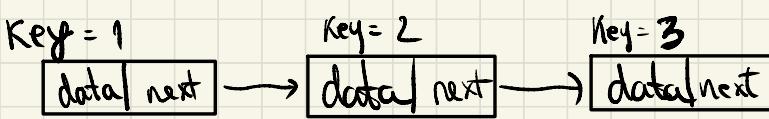


$i = 0$
 $\text{Prev} = \text{null}$



$\rightarrow \text{NULL}$
 LAST

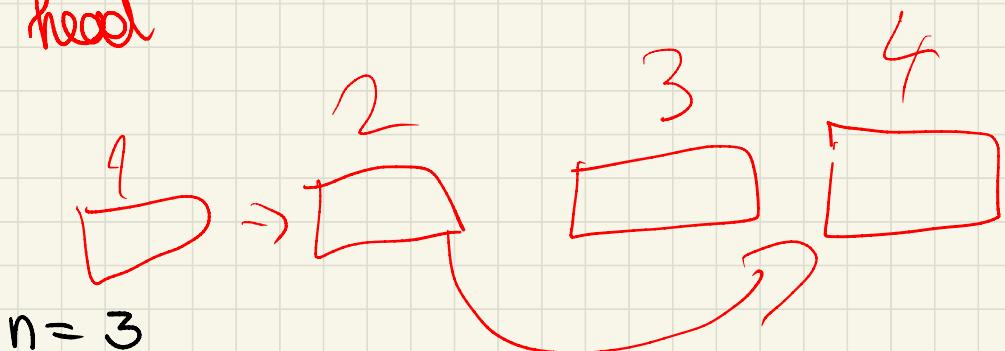
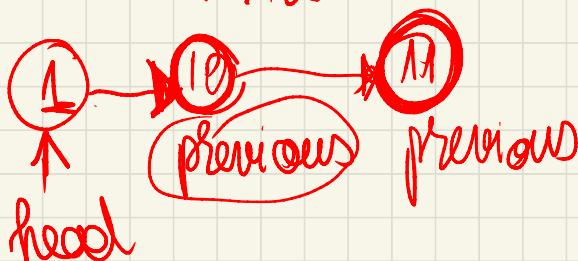




$i = 3$

$m = 3$

$x = 1011$
 $i = 12?$



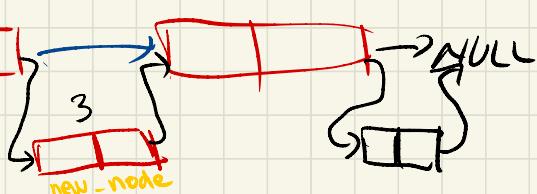
cheie = key = 0



cheie = key = 1



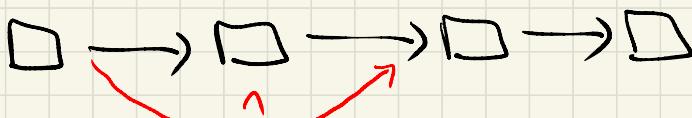
cheie = key = 2

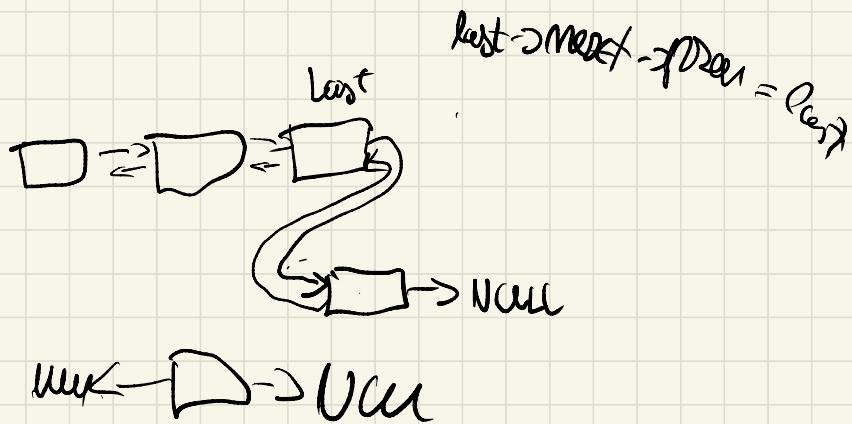
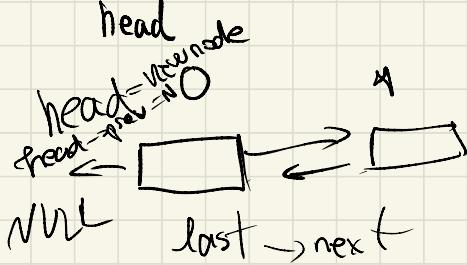
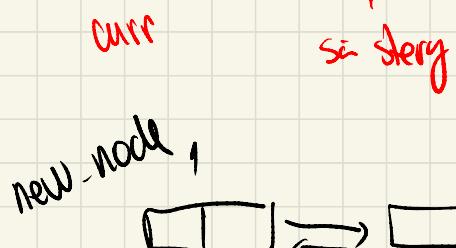


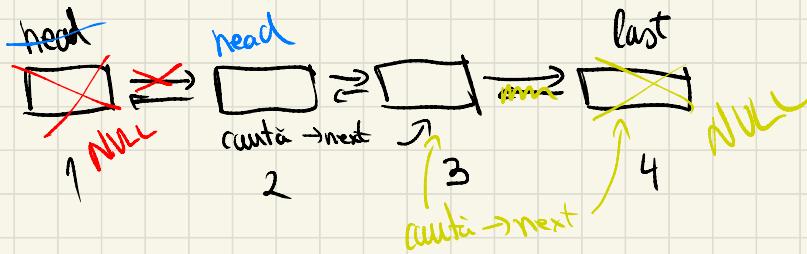
int prev-node

$\text{new_node} \rightarrow \text{next} = \text{prev_node} \rightarrow \text{next}$
 $\text{prev_node} \rightarrow \text{next} = \text{new_node}$

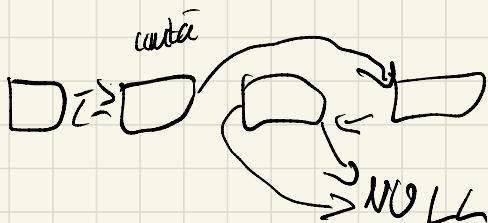
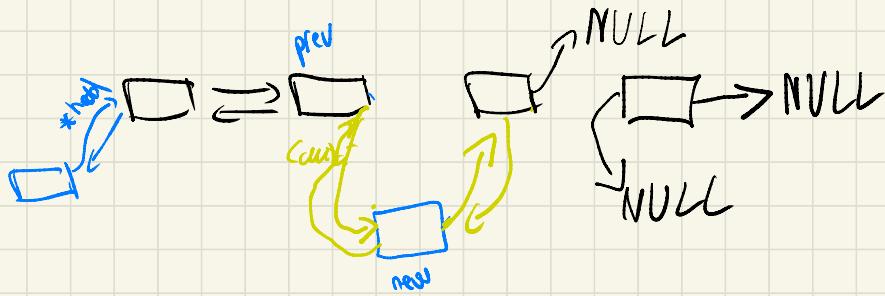
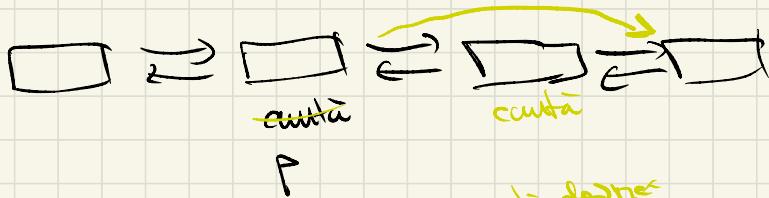
head
data -> next \rightarrow key \mapsto cheie

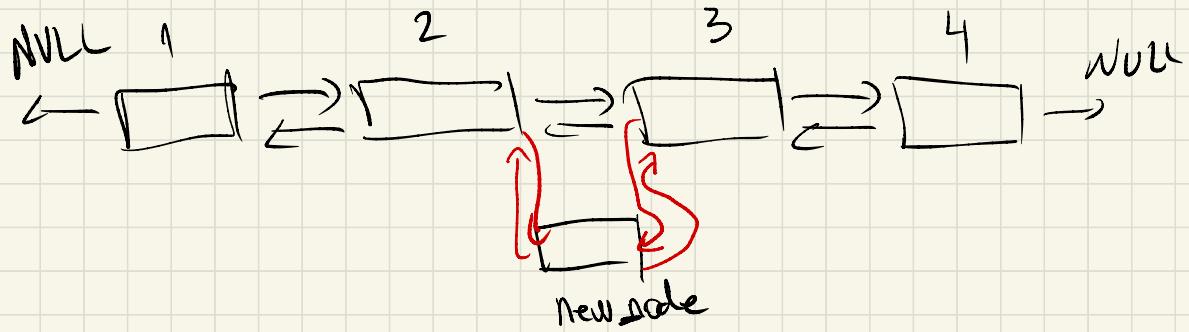
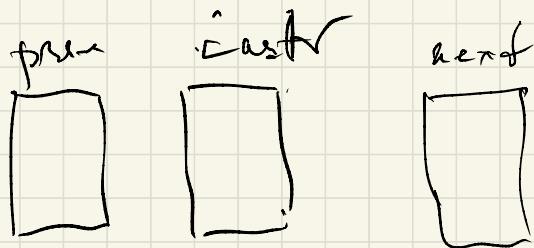
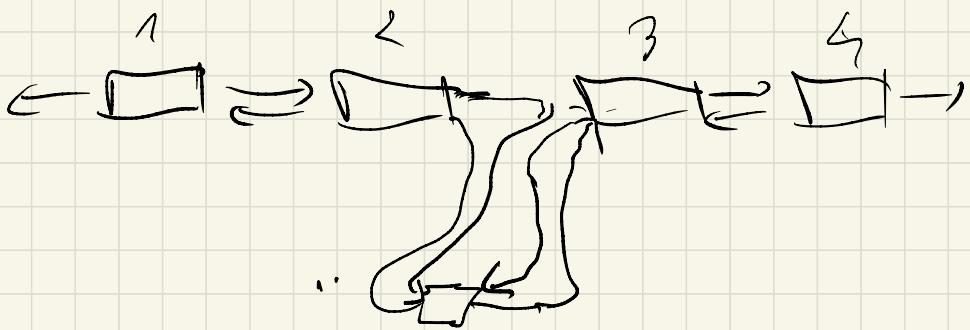


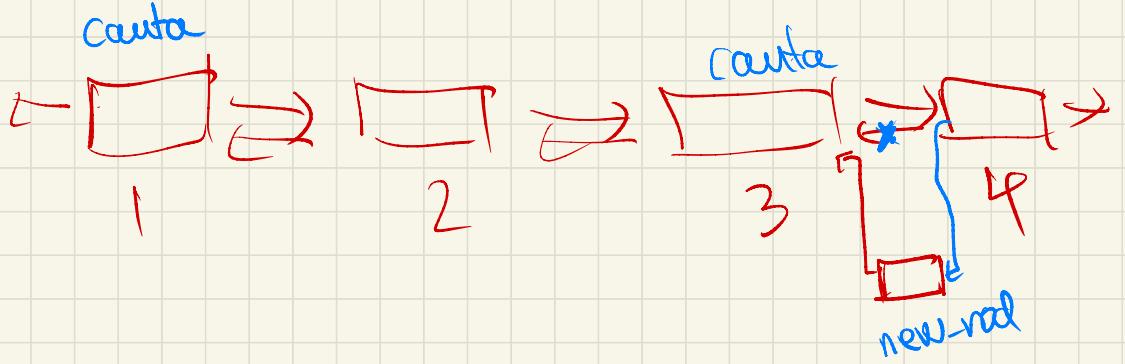




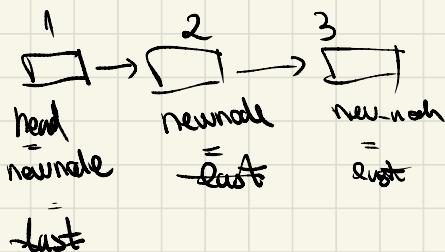
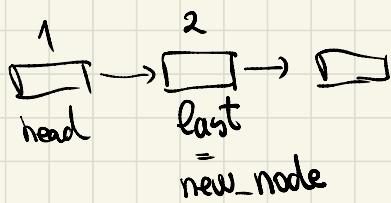
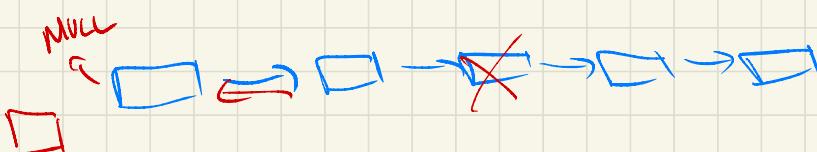
$p = curr$
 $curr \rightarrow curr \rightarrow next$

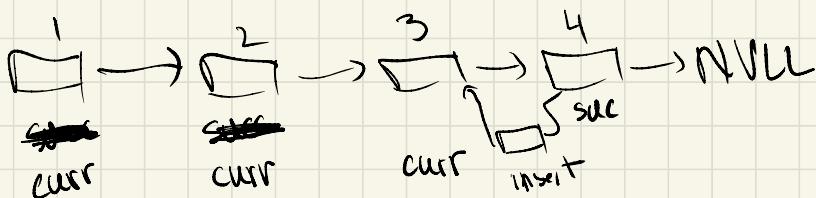
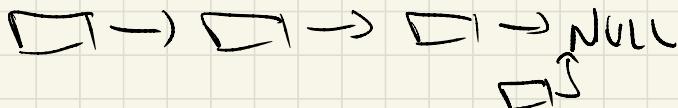
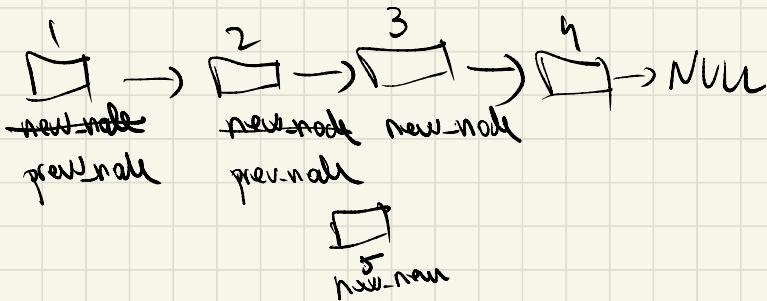
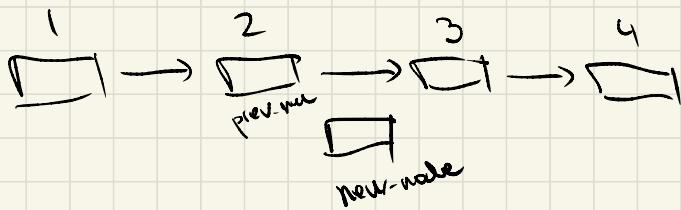




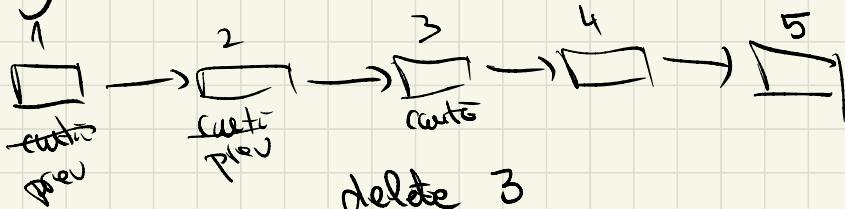


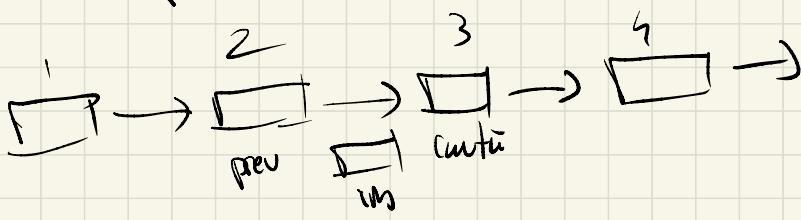
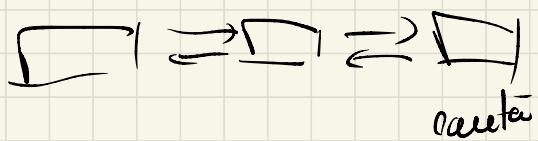
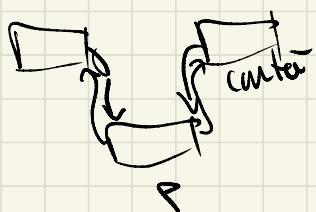
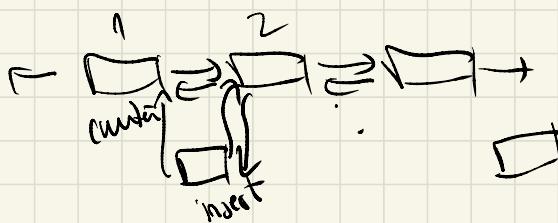
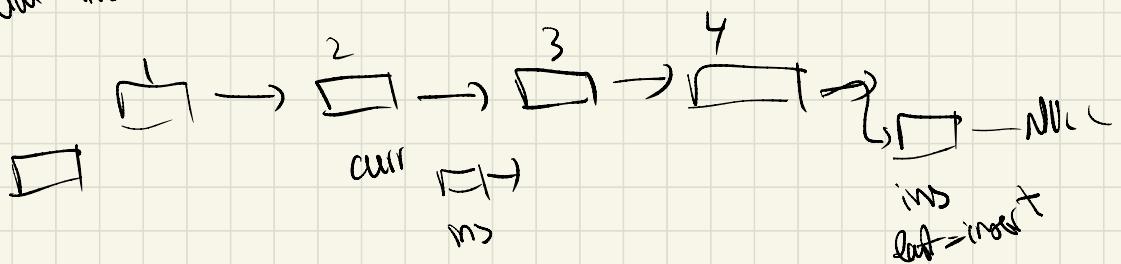
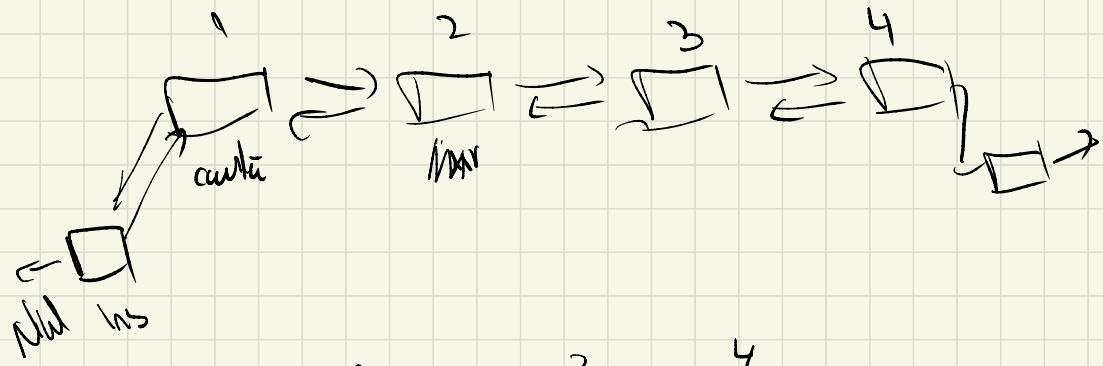
Key \Rightarrow





$\forall i \in (1, n)$





insert Before 3



0	1	2	3	4	5	6	7
1	26	6	33	7	66	23	8

n

$$i = 0$$

$$j = 0$$

$$i = 0 = 1$$

$$j = 0 = 1$$

$$1 > 26 \text{ F } j++$$

$$i = 0 = 1$$

$$j = 1 = 26$$

$$26 > 6 \text{ T}$$

1	6	26	33	4	66	23	8
---	---	----	----	---	----	----	---

$$i = 0 = 1$$

$$j = 2 = 26$$

$$26 > 33 \text{ F } j++$$

$$i = 0 = 1$$

$$j = 3 = 33$$

$$33 > 4 \text{ T}$$

1	6	26	4	33	66	23	8
---	---	----	---	----	----	----	---

$$i = 0$$

$$j = 4$$

$33 > 66$ F j^{++}

$i=0 = \perp$

$j=5 = 66$

3 16 2 5 4

$i=0 = 3$

$3 > 16$ F

$i=1 = 16$

$16 > 2$ T

3 2 16 5 4
j

$i=2$

$16 > 5$ T

3 2 5 16 4

$i=3$

$16 > 4$ T

3 2 5 4 16

$i=0$

$3 > 2$ T

2 3 5 4 16
j

$i=1$

$3 > 5$ F

$i = 2$

$5 > 4 \top$

2 3 4 5 10
j

$i = 3$

$5 > 16 \text{ F}$

$j = 2$

12 1 8 3

$i = 0 = 12$

$12 > 1 \top$

1 12 8 3
 $\alpha = 0$

$i = 1 = 12$

$12 > 8 \top$

1 8 12 3

$i = 2 = 12$

$12 > 3 \top$

1 8 3 12
 $\alpha = 0$

$\bar{j} = 1$

$\overline{i = 0} = 1$

$1 > 8 \text{ F}$

$$i = 1 = 8$$
$$8 > 3 \quad A$$

1 3 8 12

BUBBLE SORT

0 1 2 3 4
6 10 12 2 5

$$i = 0 = 6$$

$$6 > 0 \quad F$$

6 10 12 2 5 ✓

$$i = 1 = 10$$

$$10 > 12 \quad F$$

6 10 12 2 5 ✓

$$i = 2 = 12$$

$$12 > 2 \quad A$$

6 10 2 12 5 ✓

$$i = 3 = 12$$

$$12 > 5 \quad A$$

6 10 2 5 12 ✓

$$i = 0 = 6$$

$$6 > 10 \quad F$$

6 10 2 5 12 ✓

$$i = 1 = 10$$

$$10 > 2 \quad A$$

6 2 10 5 12 ✓

$$i = 2 = 10$$

$$10 > 5 \quad A$$

6 2 5 10 12 ✓

$$i = 3$$
,

$$i = 0 = 6$$

$b > 2 \text{ A}$

2 5 10 12 ✓

$i = 1 = b$

$b > 5 \text{ A}$

2 5 6 10 12 ✓

$i = 2, i = 3 \quad \checkmark$

SELECTION SORT

0 1 2 3 4

6 10 12 5 2

$i \quad j$

$\min = 6$

$\text{pos} = 0$

$b > 10 \text{ F}$

6 10 12 5 2 ✓

$b > 12 \text{ F}$

6 10 12 5 2

$b > 5 \text{ A } \min = 5, \text{ pos} = 3$

$5 > 2 \text{ A } \min = 2, \text{ pos} = 4$

2 10 12 5 6 ✓

$\min = 10$

$\text{pos} = 1$

$10 > 12 \text{ F}$

2 10 12 5 6

$10 > 5 \text{ A } \min = 5, \text{ pos} = 3$

2 5 10 12 6 ✓

$\min = 12$

$\text{pos} = 2$

$12 > 10 \rightarrow \min = 10$ $\text{pos} = 3$
 $10 > 6 \rightarrow \min = 6$ $\text{pos} = 4$

2 5 6 10 12 ✓

BUBBLE SORT, SELECTION SORT (MIN),
INSERTION SORT, SHELL SORT, MERGE SORT,
QUICK SORT, HEAP SORT, RADIX SORT,
COUNTING SORT, BUCKET SORT

BUBBLE SORT

0 1 2 3
13 27 5 16
↓

13 > 27 F

13 27 5 16 ✓

27 > 5 T

13 5 27 16 ✓

27 > 16 T

13 5 16 27 ✓

13 > 5 T

5 13 16 27 ✓

$13 > 16 \ F$

$5 \ 13 \ 16 \ 27 \ \checkmark$

$5 > 13 \ F$

$5 \ 13 \ 16 \ 27 \ \checkmark$

SELECTION SORT

$13 \ 27 \ 5 \ 16$

$\min = 13$

$pos = 0$

$13 > 27 \ F$

$13 \ 27 \ 5 \ 16$



$13 > 5 \ T$

$\min = 5$

$pos = 2$

$5 > 16 \ F$



$\min = 27$

$pos = 1$

$27 > 13 \ T$

$\min = 13$

$pos = 2$

$13 > 16 \ F$



$5 \ 13 \ 27 \ 16$

$$\text{mn} = 27$$

$$\text{pz} = 2$$

$$27 > 16 \quad T$$

$$\text{mn} = 16$$

$$\text{pz} = 3$$

5 13 16 27



INSERTION SORT

13 27 5 16
j i

$$\text{aux} = 27$$

$j >= 0 \quad \& \quad 27 < 13 \quad F$

13 27 5 16
j i

$$\text{aux} = 5$$

$j >= 0 \quad \& \quad 5 < 27$

13 27 27 16
j i

$j >= 0 \quad \& \quad 5 < 13$

13 13 27 16



5 13 27 16 ✓
j i

j = 0 88 16 < 27

5 13 27 27 ✓
j j i

j = 0 88 16 < 13 P

j = 0 88 16 < 5 F

5 13 16 27 ✓

INSERTION SORT

16 3 5 12
j i

$\text{aux} = 3$

$j >= 0 \quad 88 \quad 3 < 16$

$3 \ 16 \ 5 \ 12$
 $j \ i$

$j >= 0 \quad 88 \quad 5 < 16 \quad A$

$3 \ 5 \ 16 \ 12$
 $j \ i$

$3 \ 5 \ 12 \ 16$

$$A = \{10, 23, 11, 48, 5, 77, 18, 14, 31, 50, 44\}$$

$$A_1 = [10, 23] \{11\} [48, 5) \{7\}$$

$$A_2 = [10] [23] \{11\} [48] \{5\} \{7\}$$

$$A_3 = [10] [23] \{11\} \{5\} \{48\} \{7\} \text{ SOLVE}$$

$$A_1 = [10, 23] \{11\} [5, 48] \{7\}$$

$$A_2 = [10, 11, 23] [5, 7, 48]$$

$$A_3 = \{5, 7, 10, 11, 23, 48\}$$

10, 23, 11, 48, 5, 77 | 8, 14, 31, 50, 44

/ \

10 23 11 | 48 5 77 8 14 31 | 50 44

/ \ / \ / \ / \

11 23 11 48 5 77 8 14 31 50 44

/ \ / \ / \ / \ / \ / \

10 23 11 48 5 77 8 14 31 50 44

Counting Sort

$$A = \underline{6} \underline{6} \underline{3} \underline{1} \underline{5} \underline{2} \underline{2} \underline{4} \underline{6} \underline{9} \underline{8} \underline{1} \underline{3}$$

$$C = \underbrace{\begin{matrix} 2 & 2 & 2 & 1 & 1 & 3 & 0 & 1 & 1 \end{matrix}}_{\text{de cate ori apare in vector}} \rightarrow \text{astfel toate numerele din vector gen vector de la cel mai mic la cel mai mare}$$

de cate ori apare in vector
[vector de frecvență]

$$C' = \begin{matrix} 2 & 4 & 6 & 7 & 8 & 11 & 11 & 12 & 13 \\ 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \end{matrix} \rightarrow \text{si cu cati fata pe ce pozitie merge fiecare numar din vector}$$

$$\bigcirc = \bigcirc + \bigcirc$$

$$\bigcirc = \bigcirc + \bigcirc$$

astreia sunt numerele din vectorul tau (1-9)

$$B = \begin{matrix} 1 & 1 & 2 & 2 & 3 & 3 & 4 & 5 & 6 & 6 & 6 & 8 & 9 \\ 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 & 13 \end{matrix}$$

B 0 sau fata in in \bigcirc valoare

* avem 1 patru pe indexul 2 in vectorul B

* avem 2 patru pe indexul 4 in vectorul B

* avem 3 patru pe indexul 6 in vectorul B

* avem 4 patru pe indexul 7 in vectorul B

$A = [6, 3, 29, 8, 1, 21, 18, 19, 28]$

BUBBLE SORT

6 3 29 8 1 21 17 19 28

i=0, j=0, 6 > 3 swap

3 6 29 8 1 21 18 19 28 ✓

i=0, j=1 6 < 29

3 6 29 8 1 21 18 19 28

i=0, j=2

3 6 8 29 1 21 18 19 28 ✓

i=0, j=3

3 6 8 1 29 21 18 19 28 ✓

i=0, j=4

3 6 8 1 21 29 18 19 28 ✓

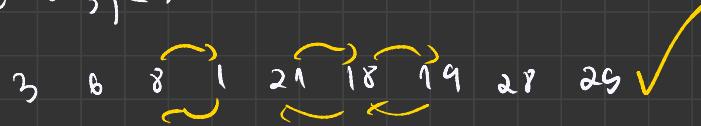
i=0, j=5

3 6 8 1 21 18 29 19 28 ✓

i=0, j=6

3 6 8 1 21 18 19 29 28 ✓

$i=0, j=7$



$i=1, j=\overline{0, 6}$



$i=2, j=\overline{0, 5}$



$i=3, j=\overline{0, 4}$



Complexity

$O(n^2)$ - avg time

$O(1)$ - space

elementary method

SELECTION

$O(n^2)$ avg

Column

6 3 29 8 1 21 18 19 28

$i=0$

$\min = 6 \quad 6 < 3, 3 < 1$

1 3 29 8 6 21 18 19 28 ✓

$i=1$

$\min = 3$

1 3 29 8 6 21 18 19 28 ✓

$i=2$

$\min = 29, 29 > 6$

1 3 6 8 29 21 18 19 28

$i=3$

$\min = 29$

1 3 6 8 18 21 29 19 28

min = 21

1 3 6 8 18 19 29 21 28

min = 28

1 3 6 8 18 19 21 29 28

min = 28

1 3 6 8 18 19 21 28 29

INSERTION SORT

$\Theta(n^2)$ avg time $\Theta(1)$ space elem

6 3 29 8 1 21 18 19 28

i=1, j=0 3 < 6

3 6 29 8 1 21 18 19 28

i=2, j=1 29 > 6, 29 > 3

i=3, j=2 8 < 29, 8 > 6

3 6 8 29 1 21 18 19 28

i=4, j=3 1 < 29, 1 < 8, < 6, < 3

1 3 6 8 29 21 18 19 28

i=5, j=4 21 < 29, 21 > 8

1 3 6 8 21 29 18 19 28

i=6, j=5 18 < 29, 18 < 21, 18 > 8

1 3 6 8 18 21 29 19 28

1 3 6 8 18 19 21 29 28

1 3 6 8 18 19 21 27 29

✓

6 3 29 8 1 | 21 18 19 28

[6, 3, 29] [8, 1] [21, 18] [19, 28]

[6, 3, 29] [8, 1] [21, 18] [19, 28]

[6, 3] [29] [8] [1] [21] [18] [19] [28]

[6] [3]

[3, 6]

[3, 6, 29] [1, 8] [18, 21] [19, 28]

[1, 3, 6, 8, 29] [18, 19, 21, 28]

[1, 3, 6, 8, 18, 19, 21, 28, 29]

O(nlogn) avg
O(n) spa
Divide et impbia

$$\textcircled{6} \quad \begin{matrix} 3 & 29 & 8 & 1 & 21 & 18 & 19 & 28 \\ [3, 1] & 6 & [29, 8, 21, 18, 19, 28] \end{matrix}$$

$$[1] \quad 3 \quad 6 \quad [8, 21, 18, 19, 28] \quad 29$$

$$1 \quad 3 \quad 6 \quad 8 \quad [21, 18, 19, 28] \quad 29$$

$$1 \quad 3 \quad 6 \quad 8 \quad 21 \quad [18, 19, 28] \quad 29$$

:

$O(n \log n)$ avg
 $O(n \log n)$ space
 Divide et impera

$n=3$

$$\underline{6} \quad \underline{3} \quad \underline{29} \quad \underline{8} \quad \underline{1} \quad \underline{21} \quad \underline{18} \quad \underline{19} \quad \underline{28}$$

$$\{6, 1, 28\} \quad \{3, 21\} \quad \{29, 18\} \quad \{8, 19\}$$

$$\{1, 6, 28\} \quad \{3, 21\} \quad \{18, 29\} \quad \{8, 19\}$$

$$\{1, 3, 6, 21, 28\} \quad \{8, 18, 19, 29\}$$

$$\{1, 3, 6, 8, 18, 19, 21, 28, 29\}$$

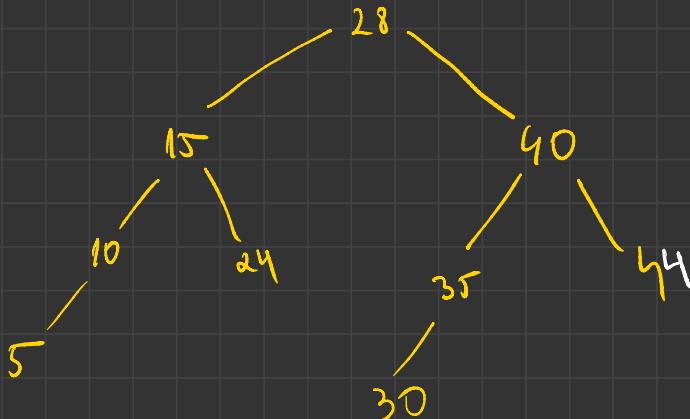
$O(n \log n^2)$ time

$O(1)$ Space

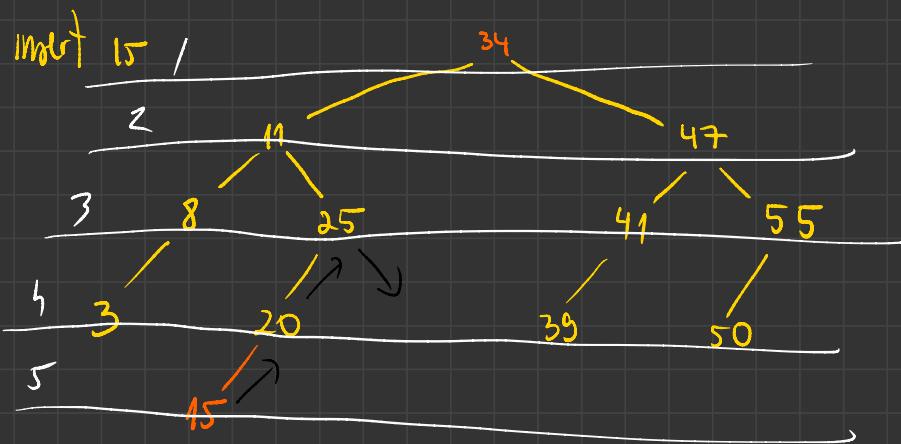
$n/2 + 1$

ARBORI

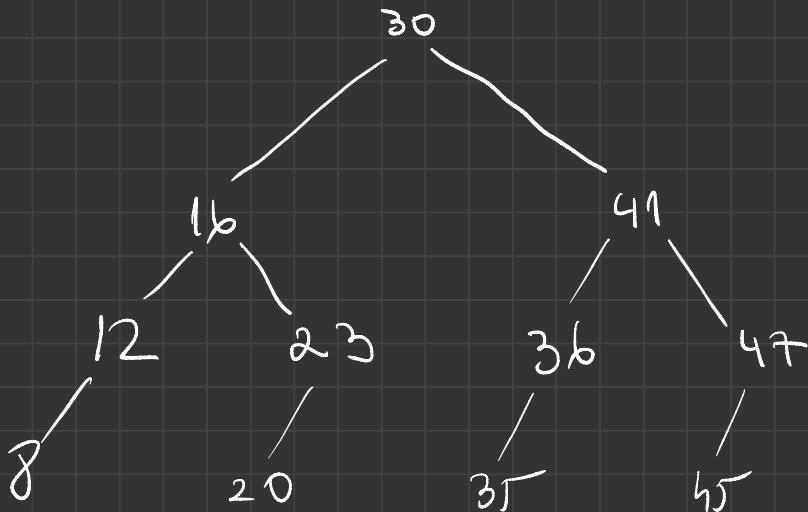
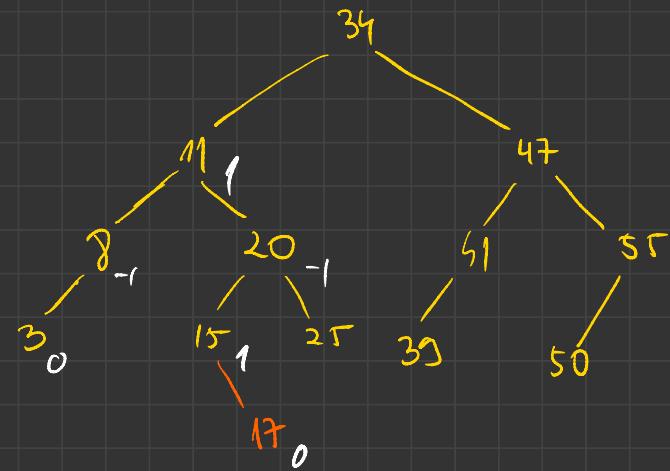
5	, 10		<u>15</u>	, 24		<u>28</u>		30	, 35		<u>40</u>		44
---	------	--	-----------	------	--	-----------	--	----	------	--	-----------	--	----



3 8 11 20 25 34 39 41 47 50 55

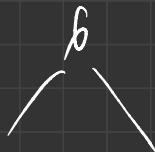


insert 17

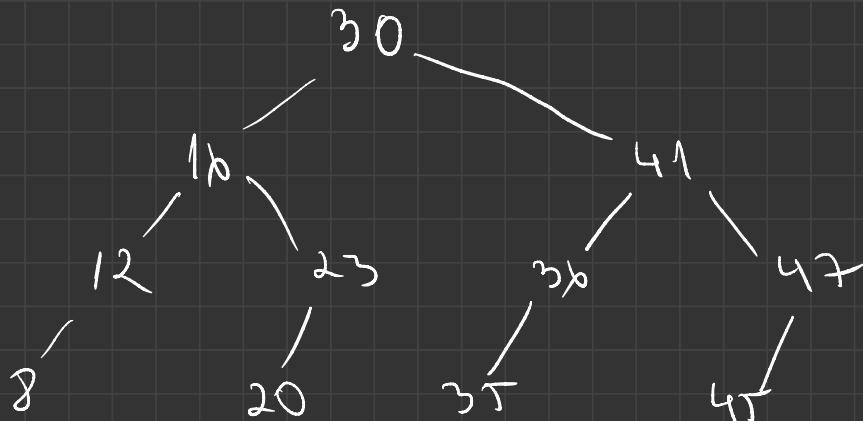


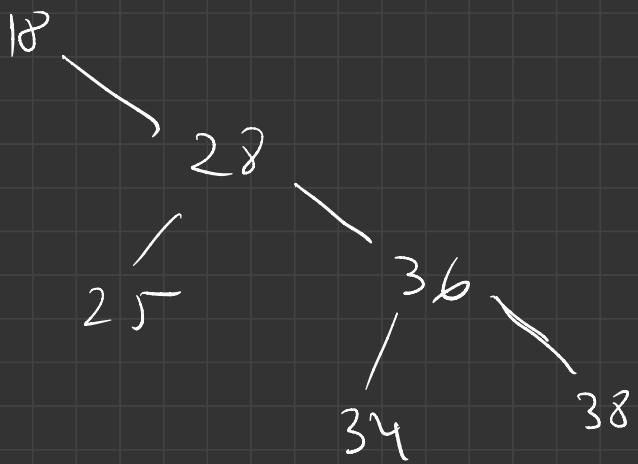
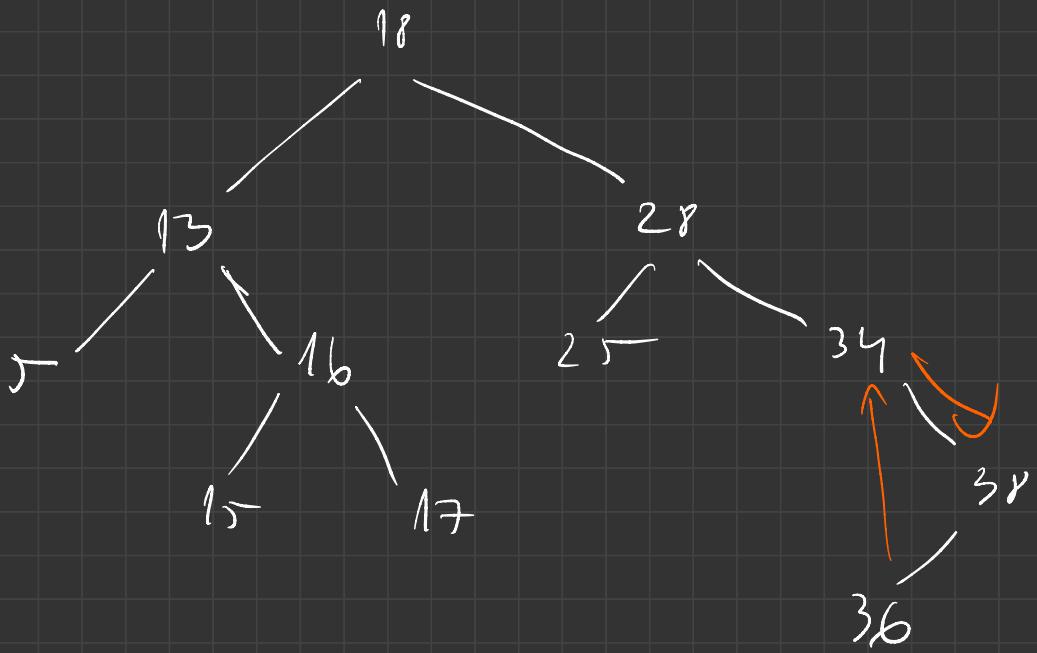
11 20 26 29 41 50 65

2 3 5 6 9 10

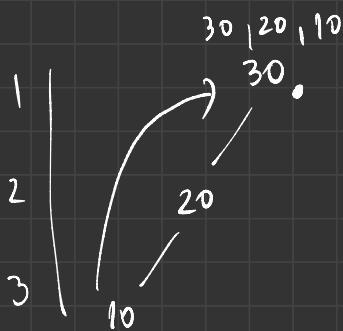


8 12 | 16 | 20 23 | 30 | 35 36 | 41 | 45 47

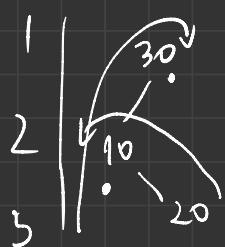




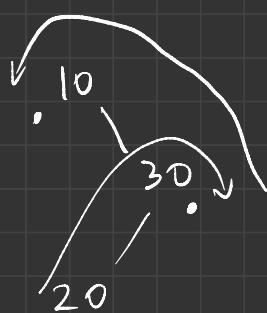
Keys - 30, 20, 10



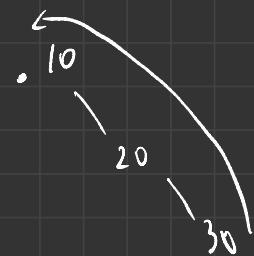
30, 10, 20

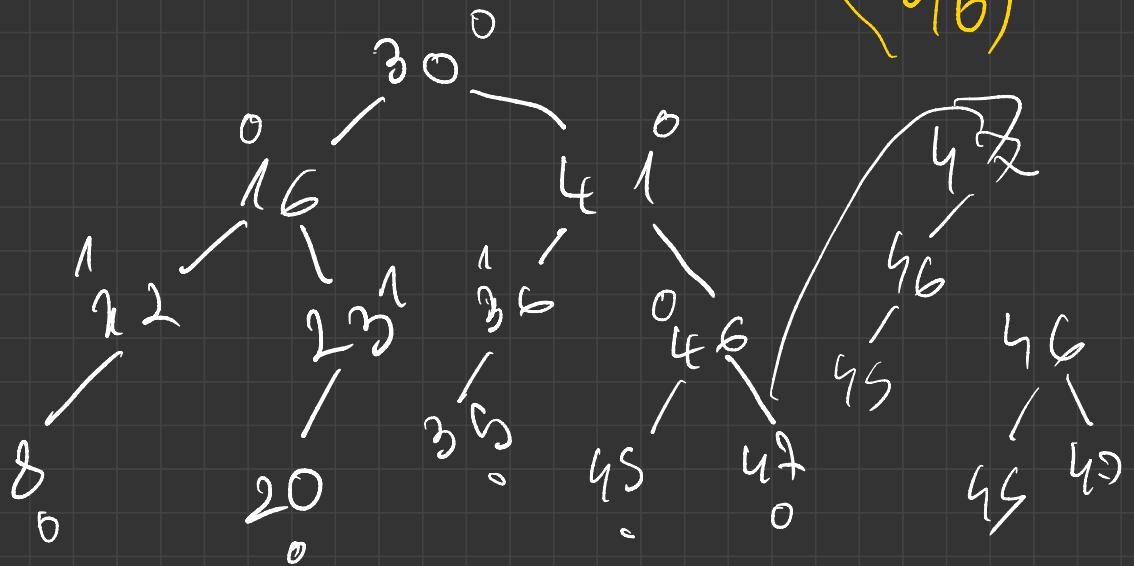
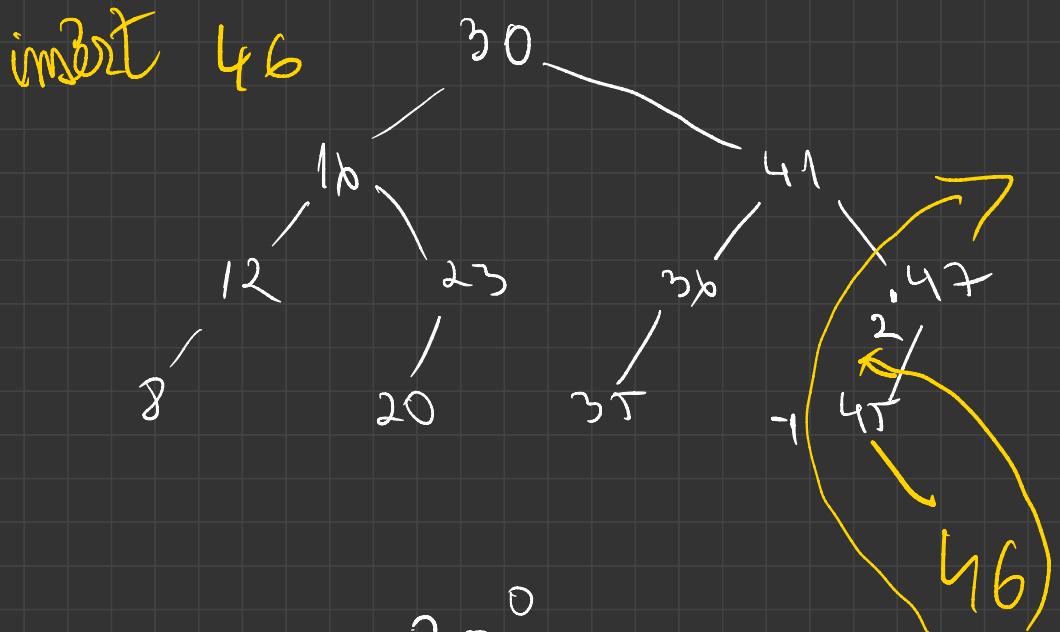


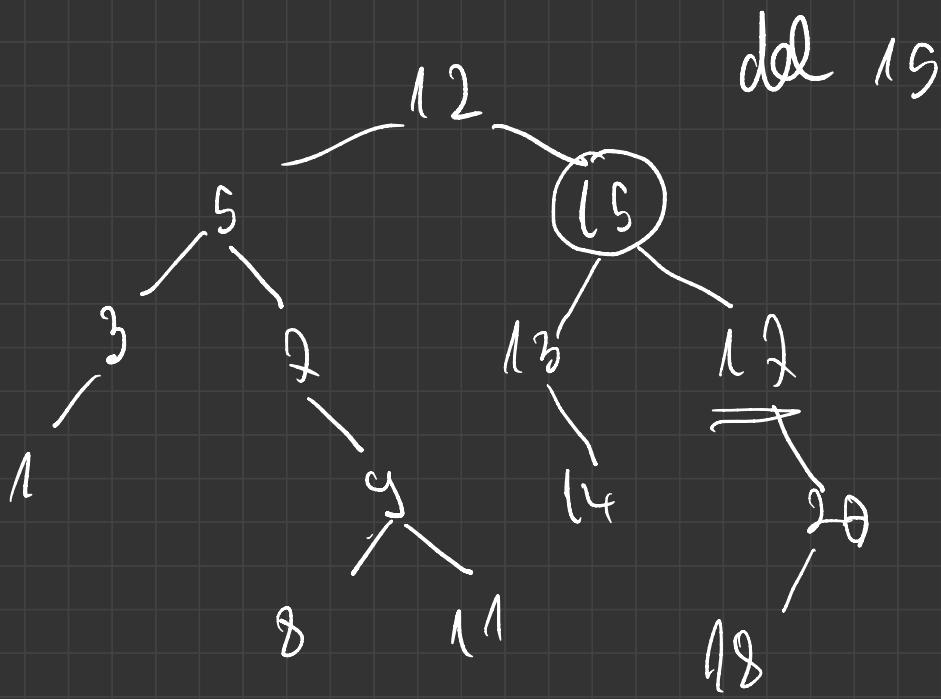
10, 30, 20



10, 20, 30





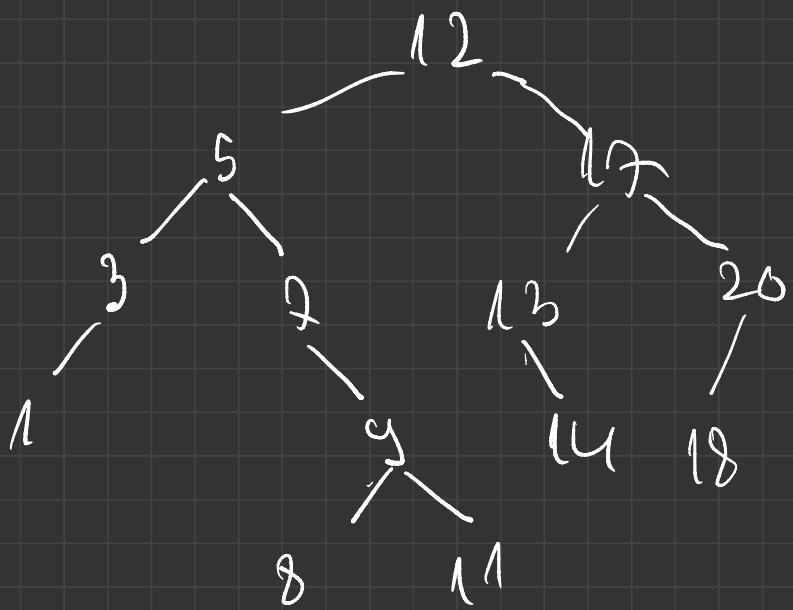


Alegem cel mai mare din stanga

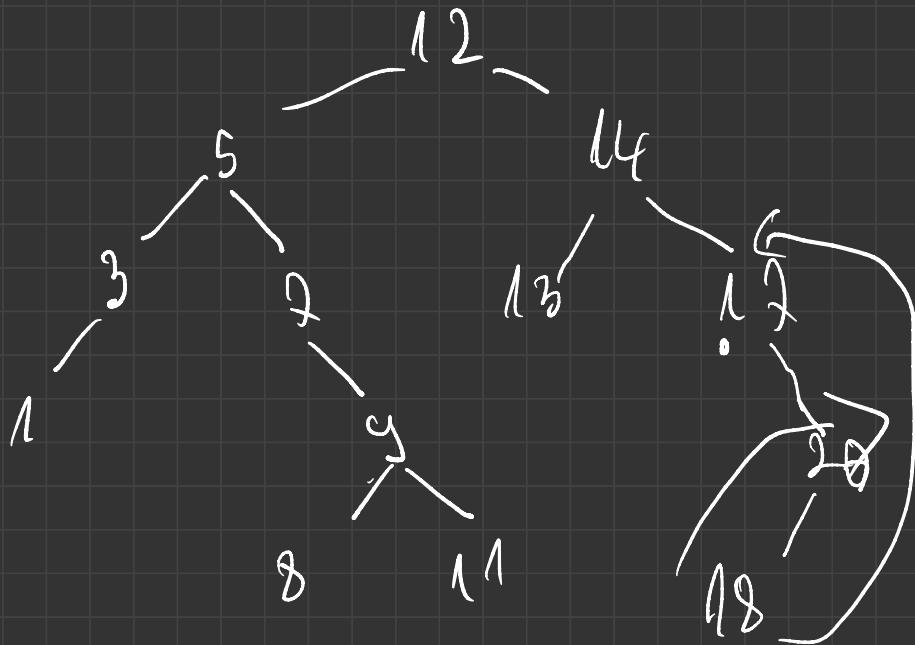
Dacă

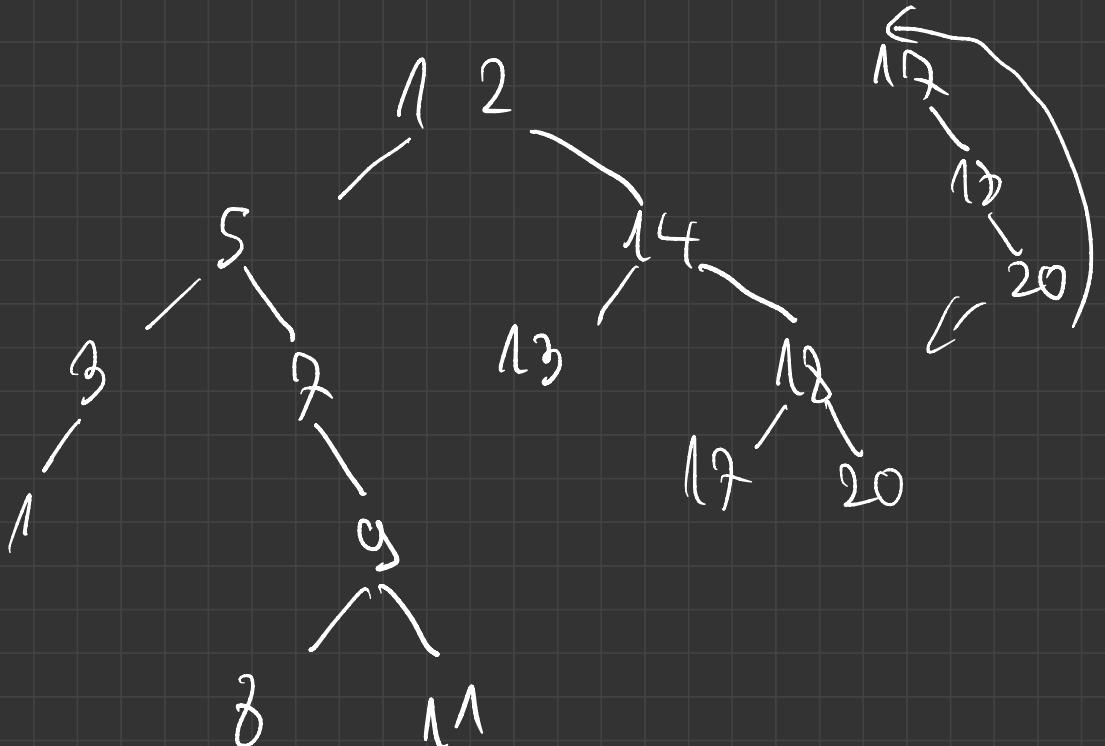
cel mai mic din dreapta

alegem 17 - mic dreapta

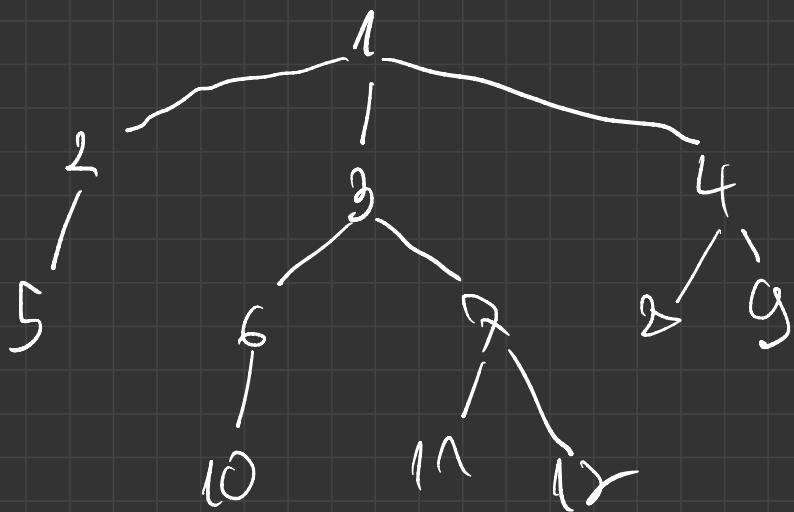


Allgemein 14 muss im Stammbaum





Decrease and



PREORDER → Le pui mormel cum ce
gandit logic de seur im
jou - stamya la dreapta

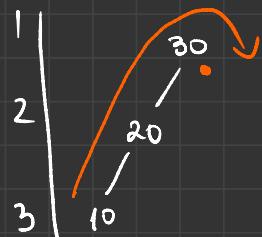
⇒ 1 2 5 3 6 10 7 11 12 4 8 9

POSTORDER → Le peremul de jou im
seur numai la mormel 1
de la stanga la dreapta

⇒ 5 2 10 6 11 12 7 3 8 9 4 1

COPACI

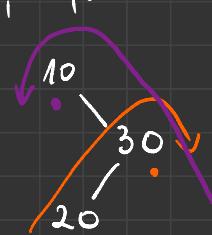
30, 20, 10



30, 10, 20



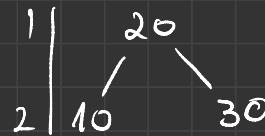
10, 30, 20



10, 20, 30

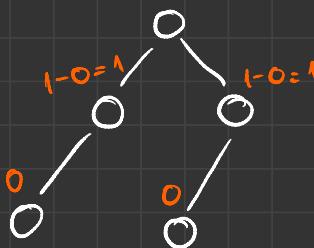


20, 10, 30
20, 30, 10

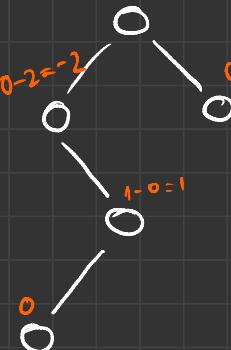


balance factor = inälltme stånga subtree - inälltme dr. subtree

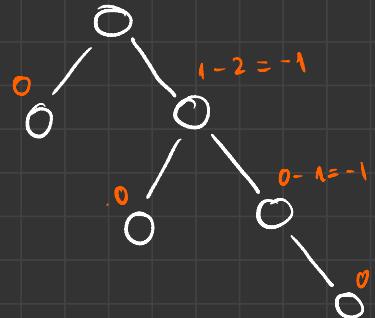
$$2-2=0$$

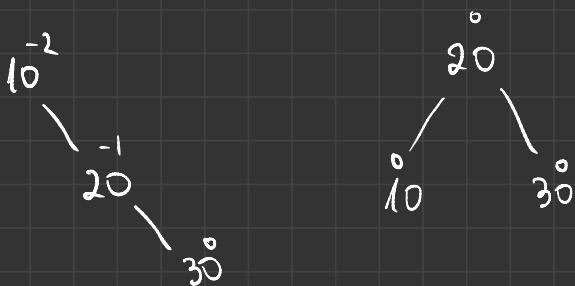
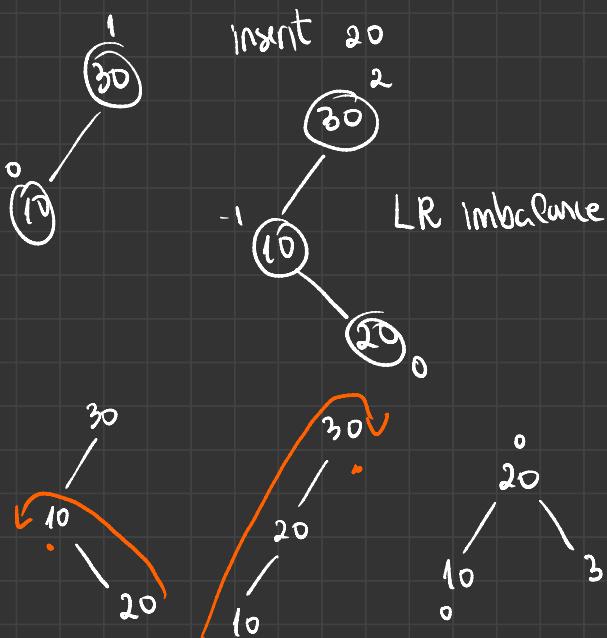
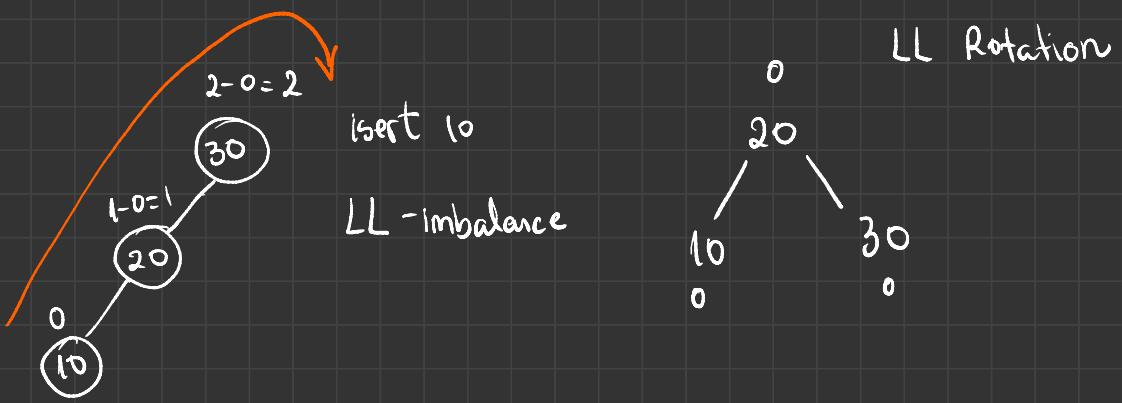


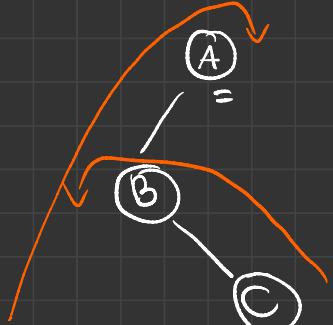
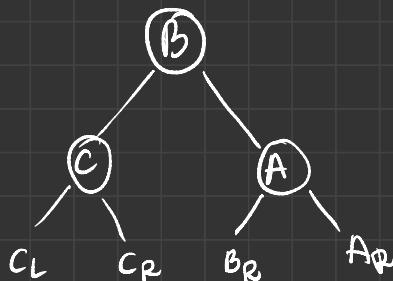
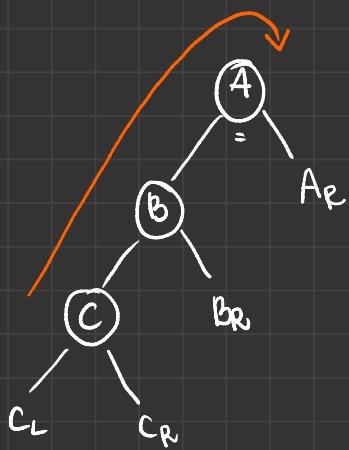
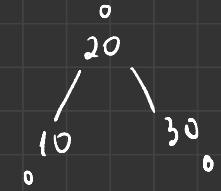
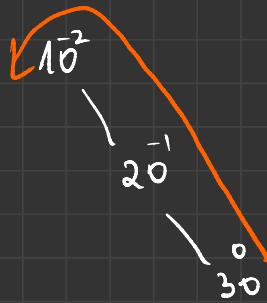
$$3-1=2$$

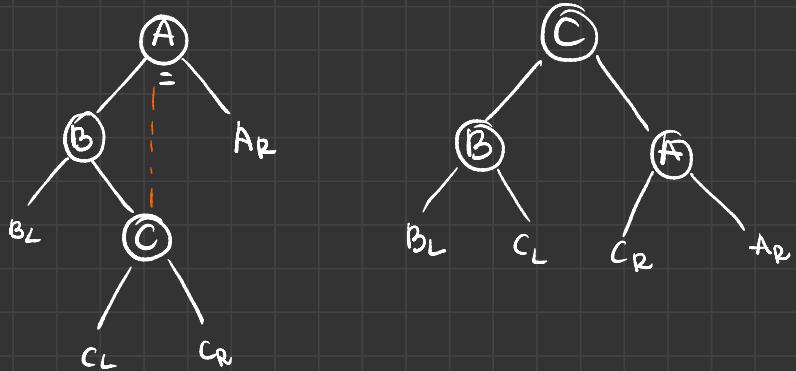


$$1-3=-2$$

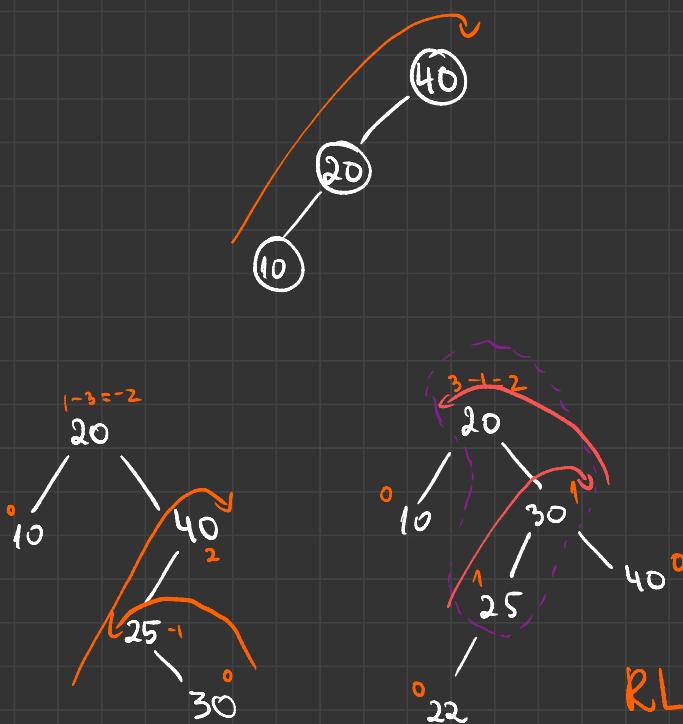








Keys - 40, 20, 10, 25, 30, 22, 50

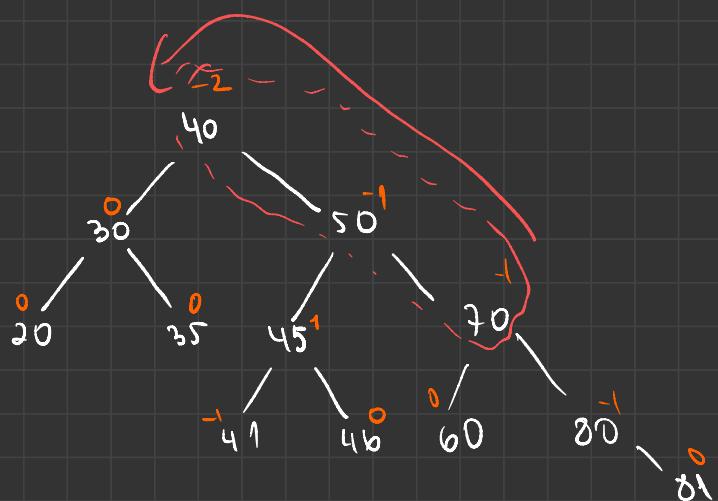
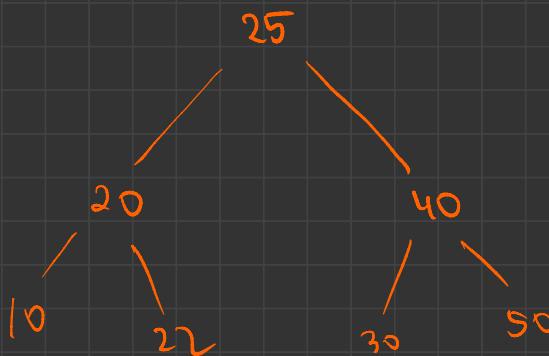


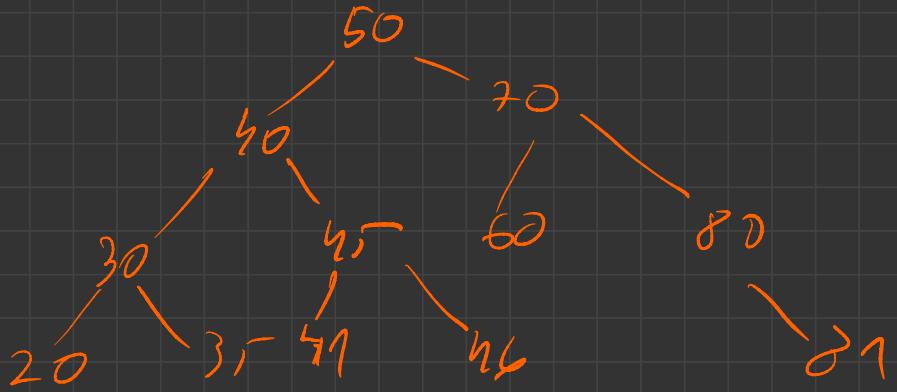


$10 \mid 20 \mid 22 \mid 25 \mid 30 \mid 40 \mid 50$

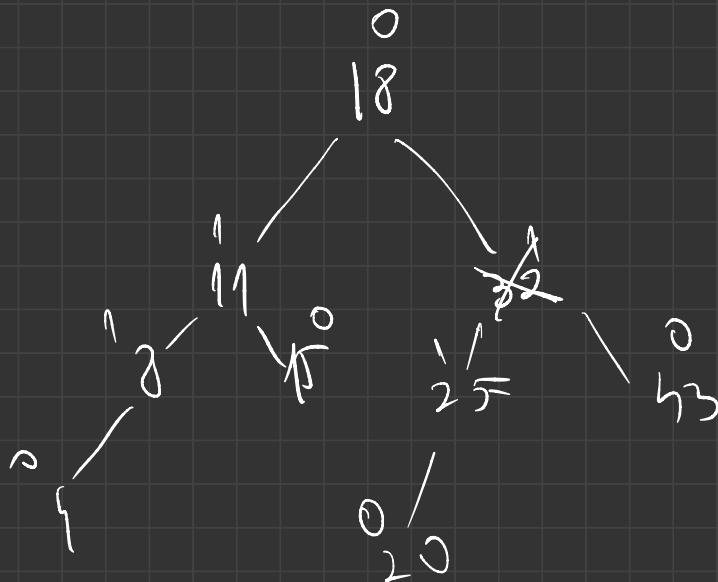
$$6/2 = 3$$

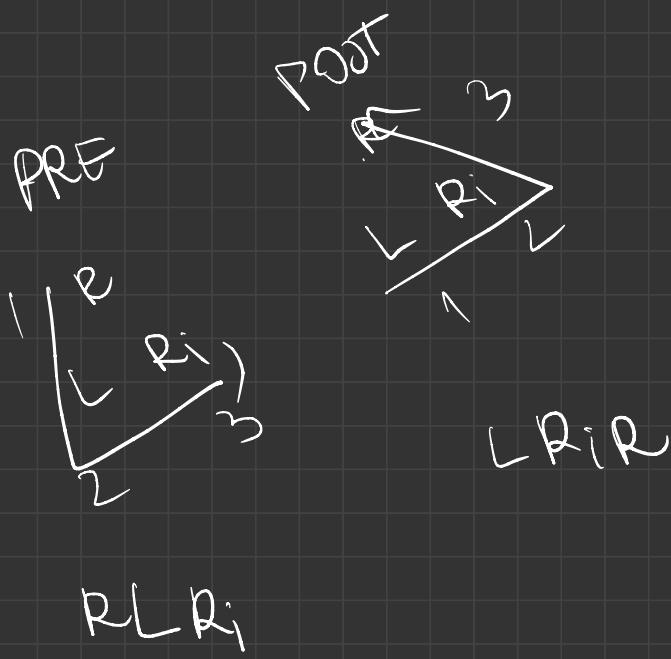
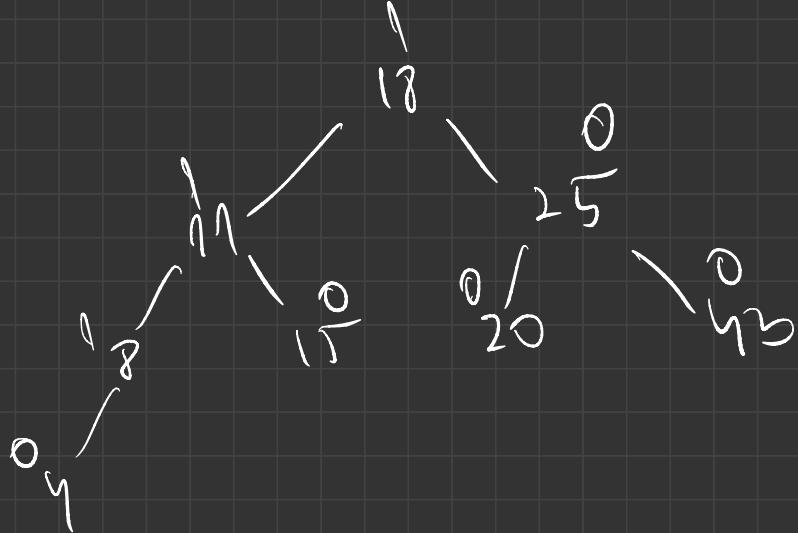
$$3/2 = 1$$

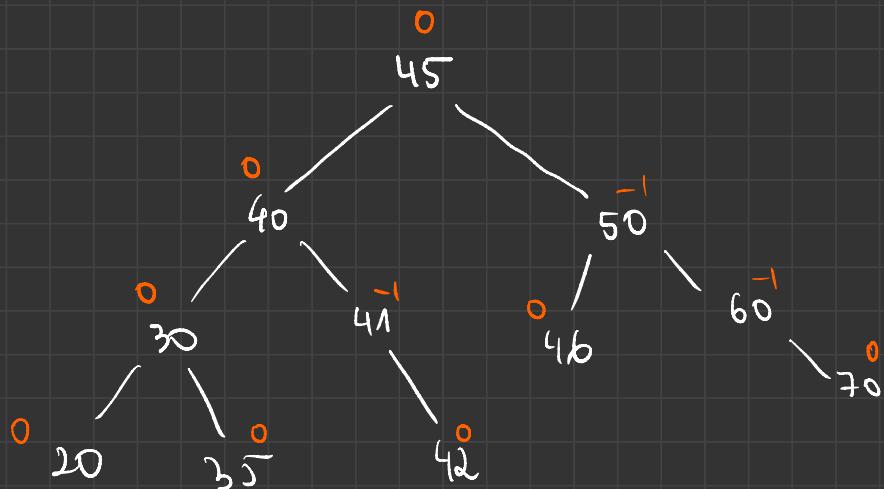


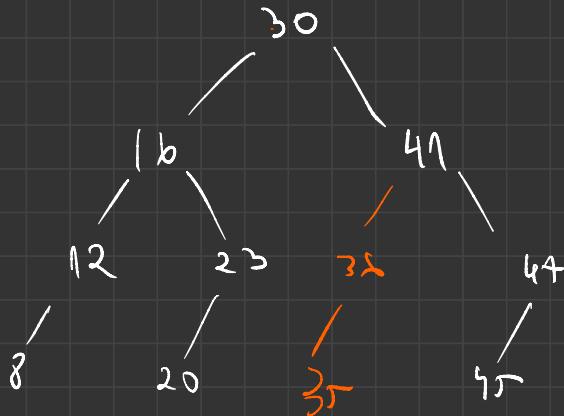


$$\begin{array}{c}
 0 \quad 1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \\
 | \quad |
 \\ 1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \\
 | \quad |
 \\ 11 \quad 12 \quad 13 \quad 14 \quad 15 \quad 16 \quad 17 \quad 18 \quad 19
 \end{array}$$

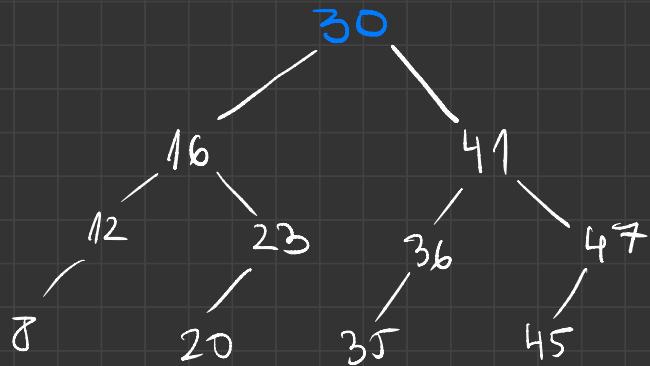




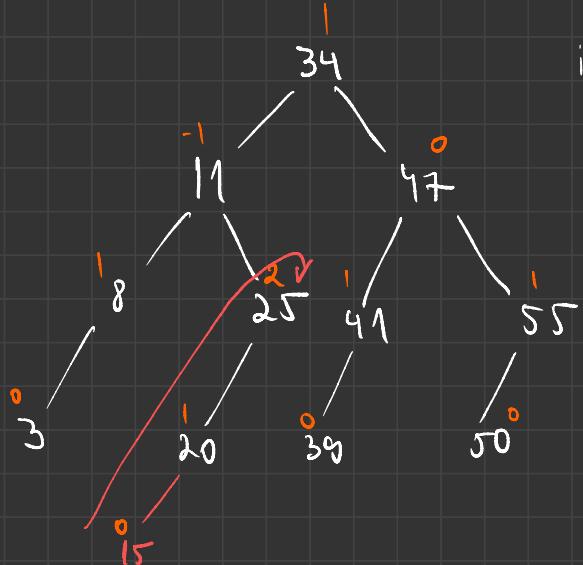


$$\left| \begin{array}{c} 8, 12 \\ 16 \\ \hline 20, 25 \end{array} \right| \left| \begin{array}{c} 30 \\ 35 \\ \hline 38 \end{array} \right| \left| \begin{array}{c} 41 \\ \hline 45, 47 \end{array} \right|$$


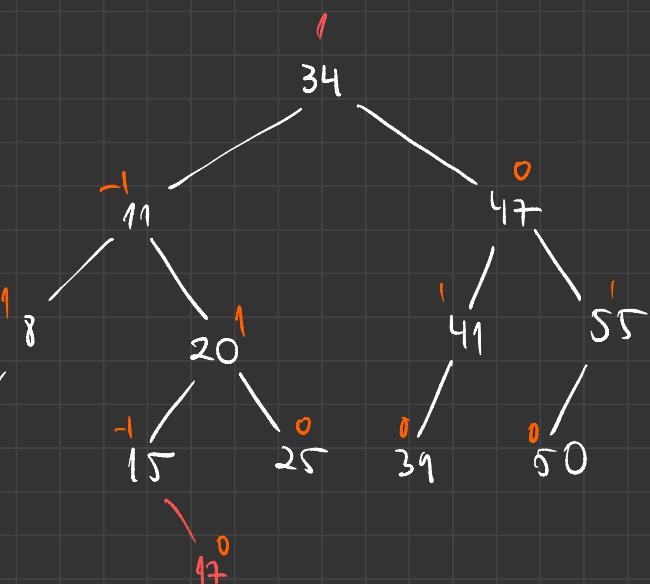
$$\begin{array}{c}
 0 \ 1 \quad \left| \begin{array}{c} 2 \\ 8, 12 \end{array} \right. \quad \left| \begin{array}{cc} 3 & 4 \\ 16 & , 20, 23 \end{array} \right. \quad \left| \begin{array}{c} 5 \\ 30 \end{array} \right. \quad \left| \begin{array}{cc} 6 & 7 \\ 35 & , 38 \end{array} \right. \quad \left| \begin{array}{c} 8 \\ 41 \end{array} \right. \quad \left| \begin{array}{cc} 9 & 10 \\ 45 & , 47 \end{array} \right.
 \end{array}$$



0	1	2	3	4	5	6	7	8	9	10
3	8	11	20	25	34	39	41	47	50	55

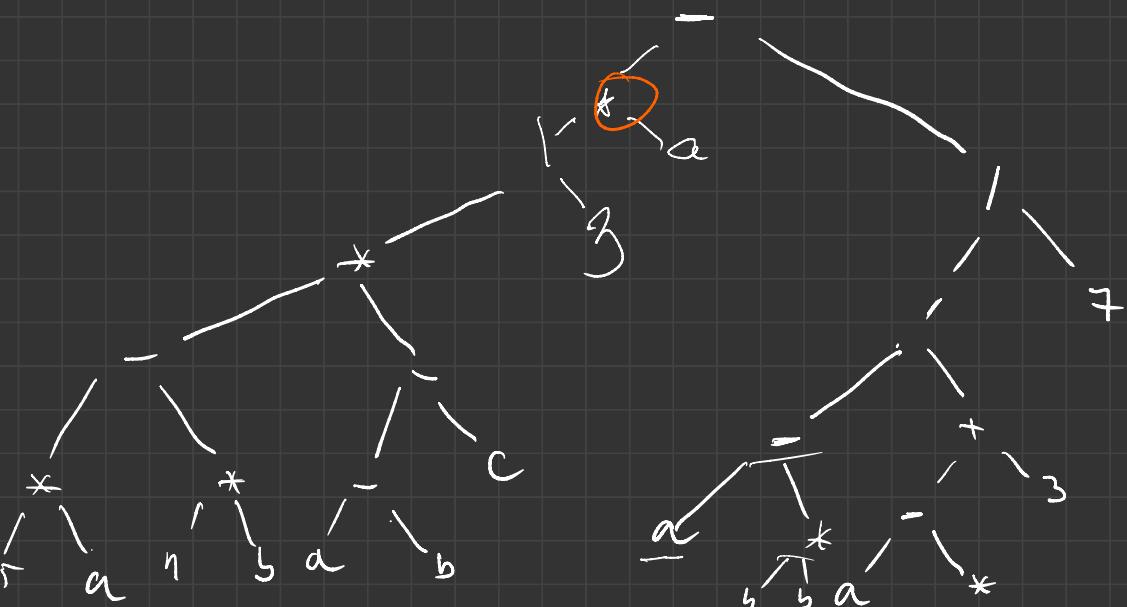
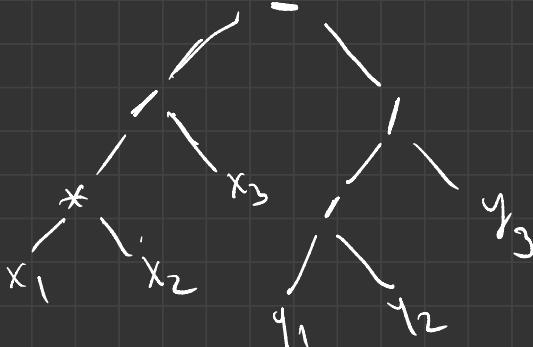


insert 45



balanced XD

$$\frac{(5^*a - 4^*b)^* (a-b-c) / 3^*a}{x_1 x_2 x_3} - \frac{(a-b^*b) / (a-5^*c+3)}{y_1 y_2 y_3} / 7$$

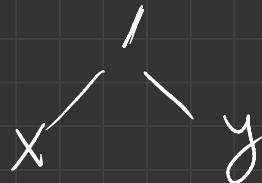


POSTORDER : LR; R

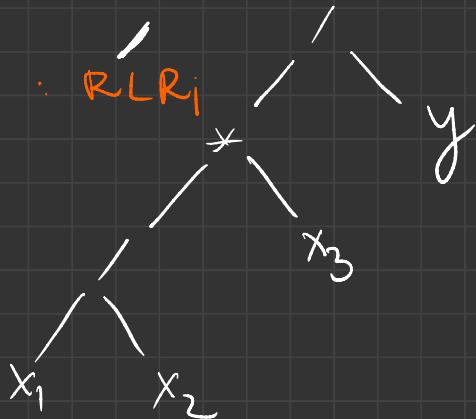


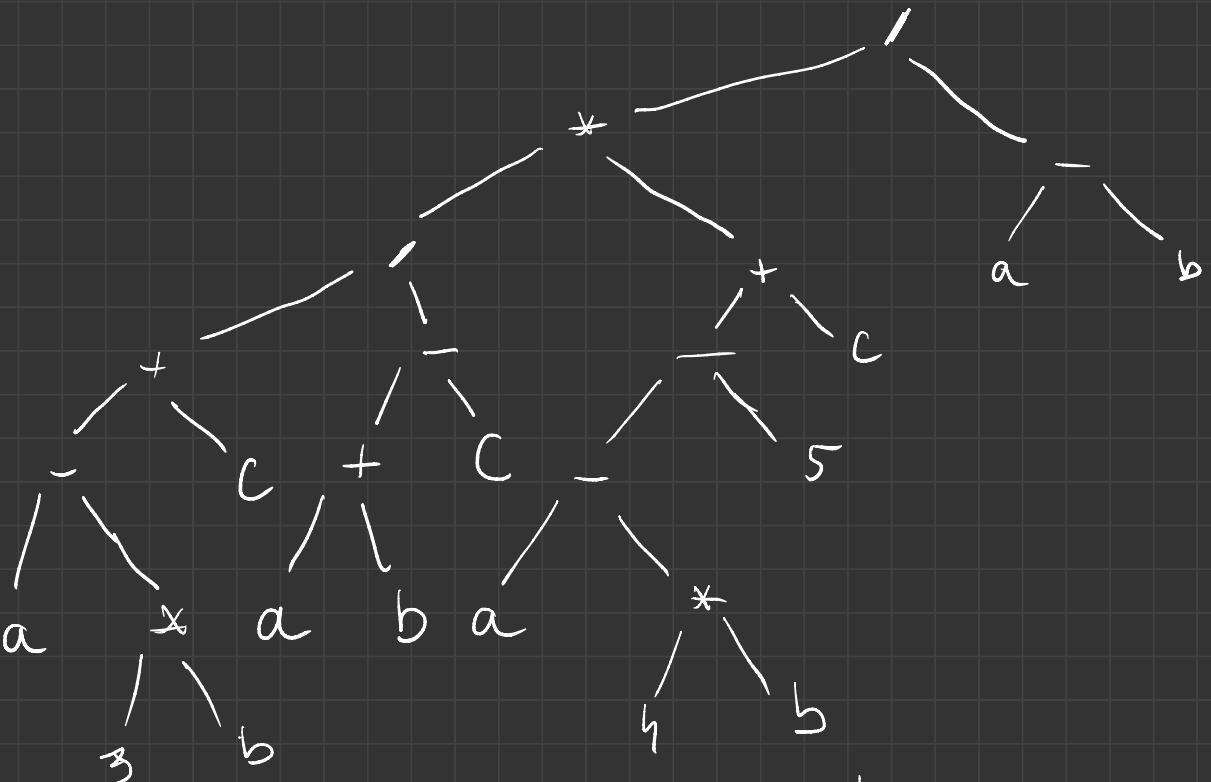
$$5a * 4b * - ab - c - * 3 / a * \underline{a} \underline{4b} * = a$$
$$5c * - 3 + / \neq / - \quad \checkmark$$

$$\underbrace{(a - 3 * b + c) / (a + b - c)}_{x} * \underbrace{(a - 4 * b - 5 + c) / (a - b)}_{y}$$



PREFORDER : RLRI

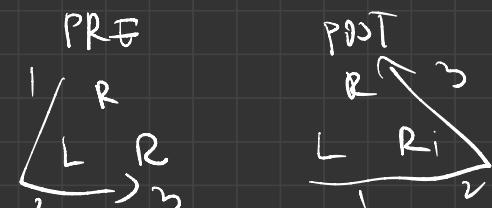




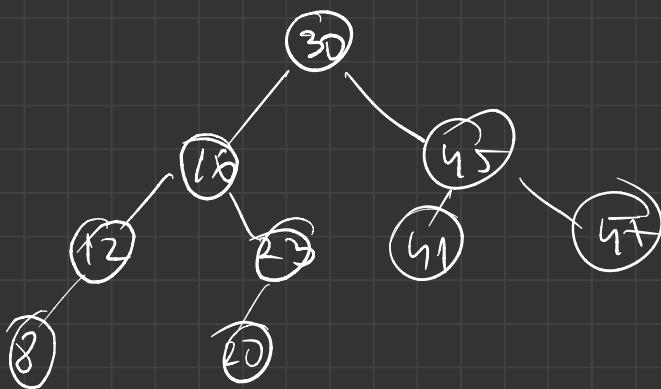
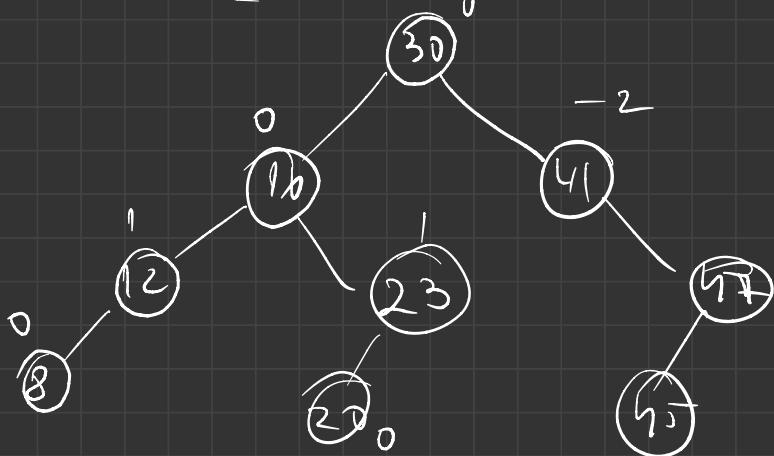
POSTORDER : $a^3b * - c + ab + c - / a b * - 5 - c + *$
 $a b - /$

PREFORDER : RLR_i

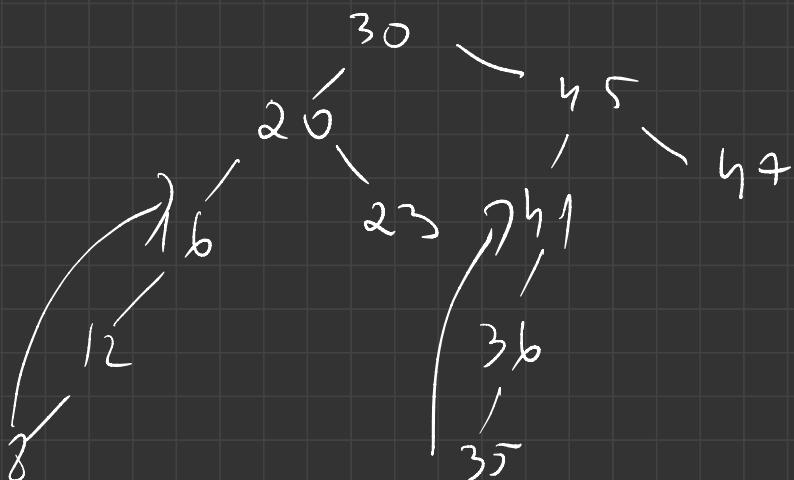
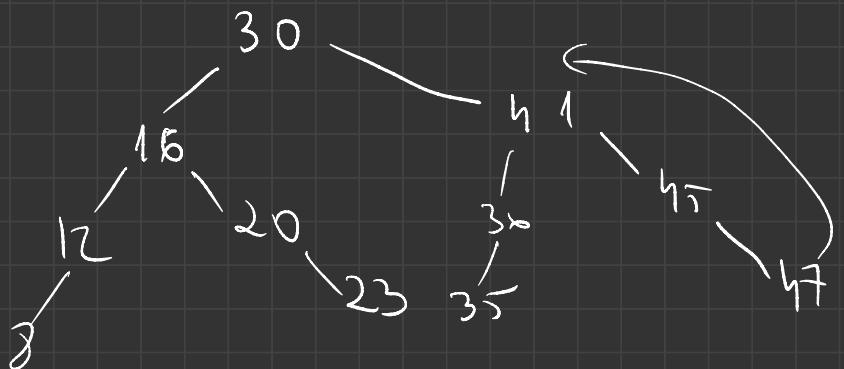
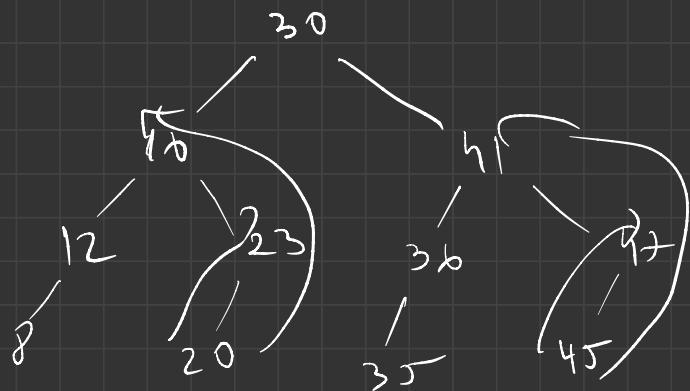
/ * / + - a * 3 b c - + a b c + --
 $a * 4 b^5 c - a b$

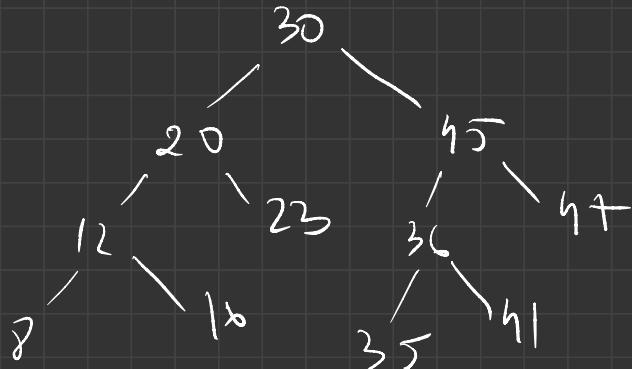
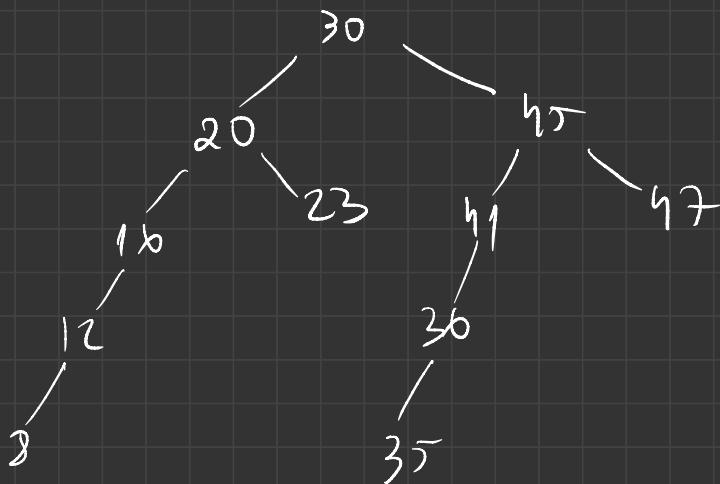
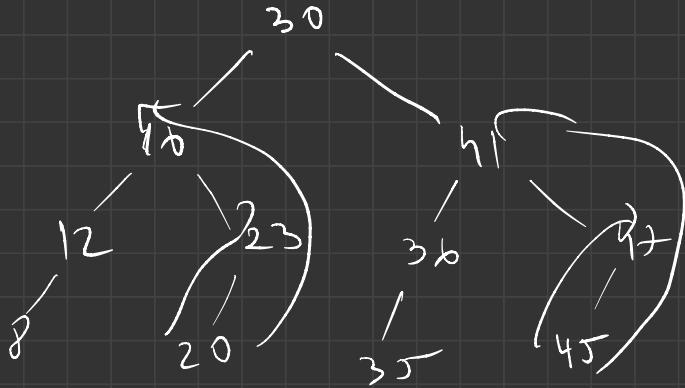


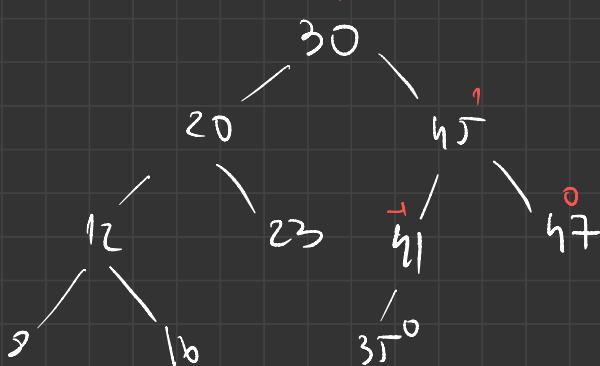
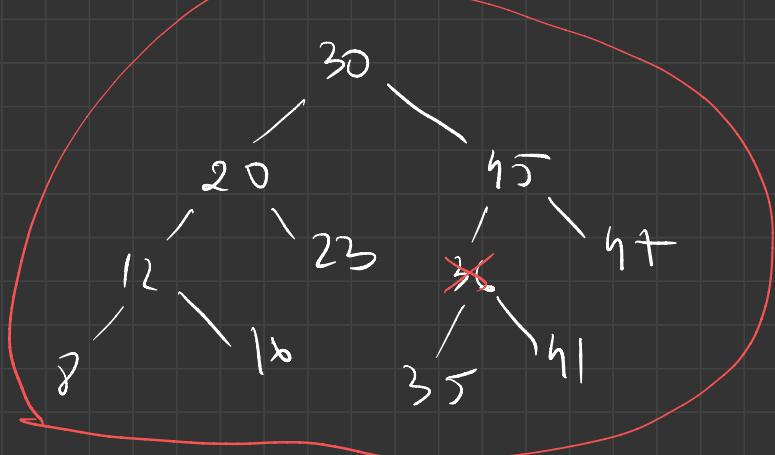
8	12	16	20	23	30	35	36	41	45	47
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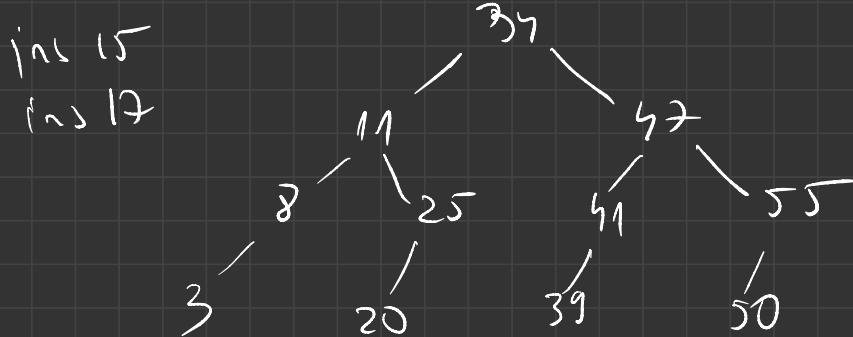
8	12	16	20	23	30	35	36	41	45	47
---	----	---------------	----	----	---------------	----	----	---------------	----	----

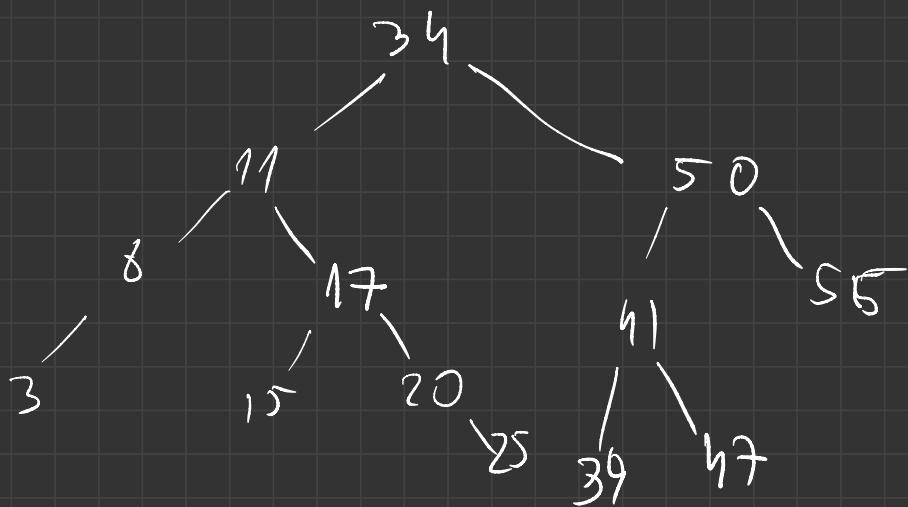
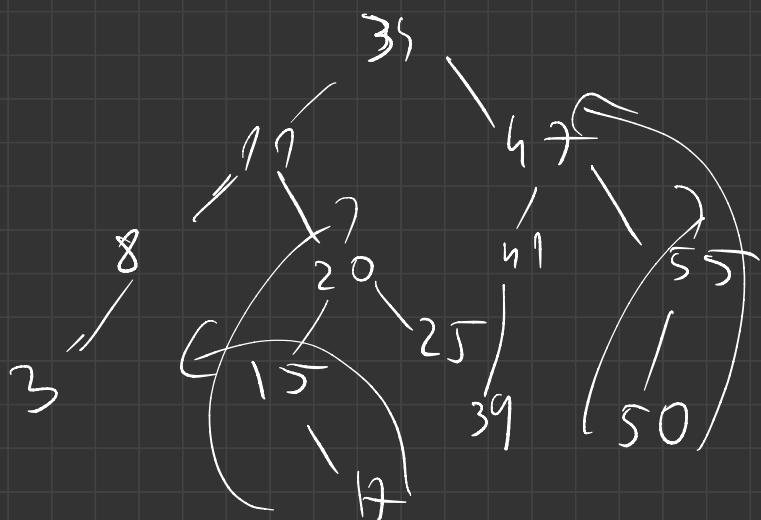


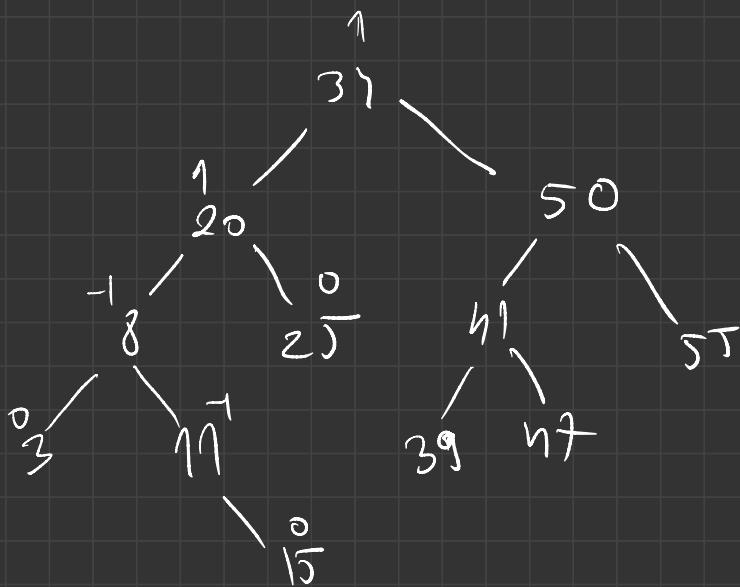
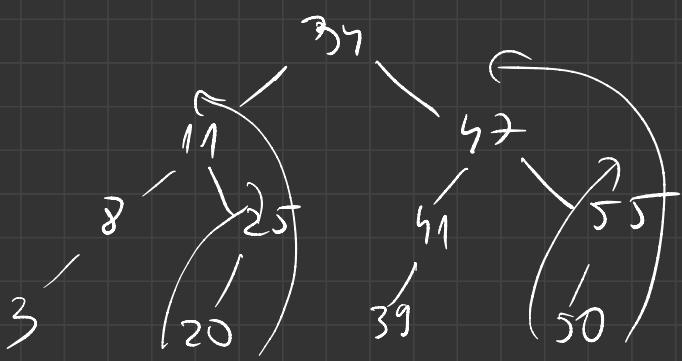




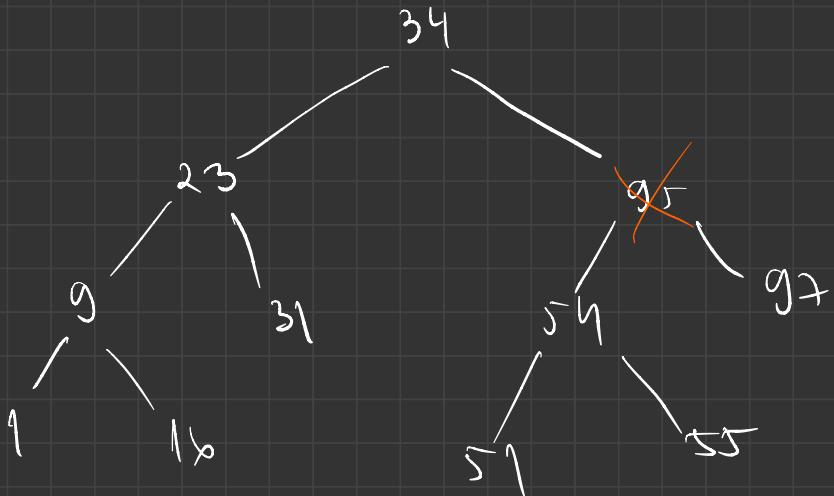
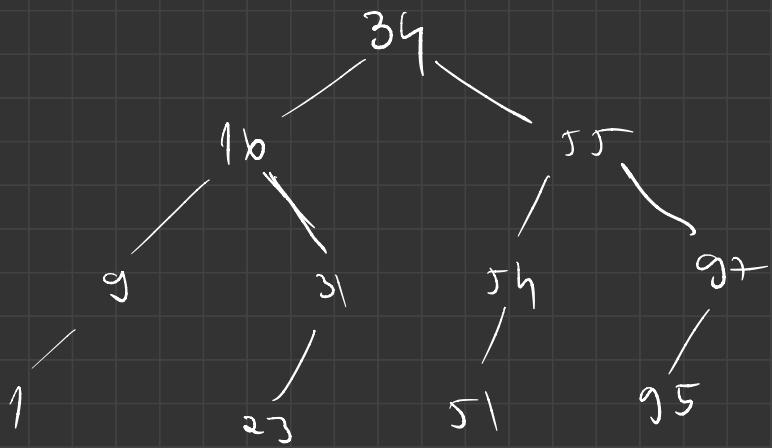
$(3 \ 8 \ 11 \ | \ 20 \ 25 \ | \ 31 \ | \ 39 \ 41 \ | \ 47 \ | \ 50 \ 55)$

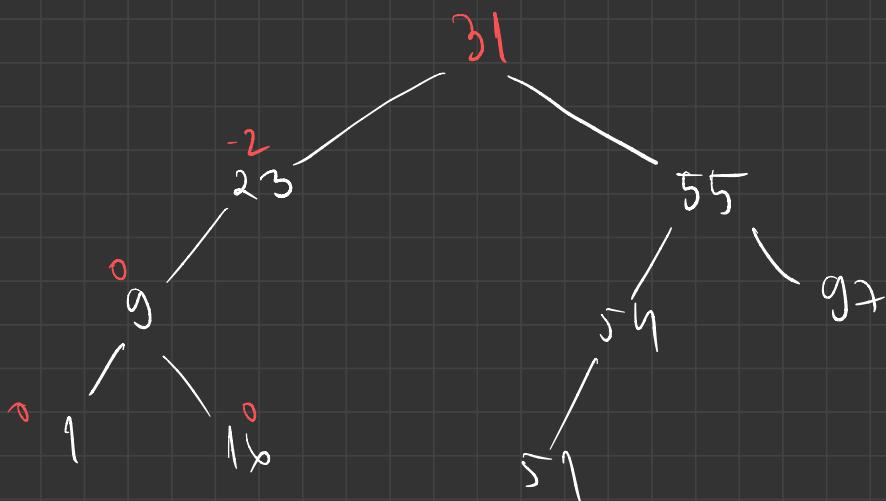
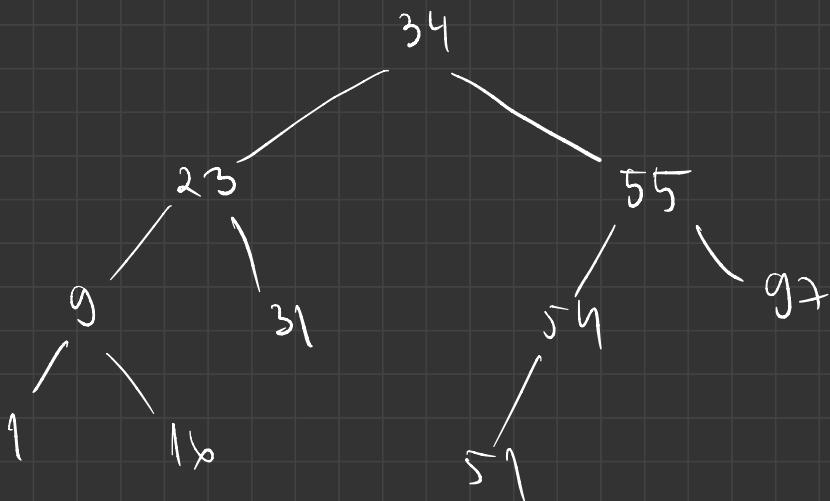


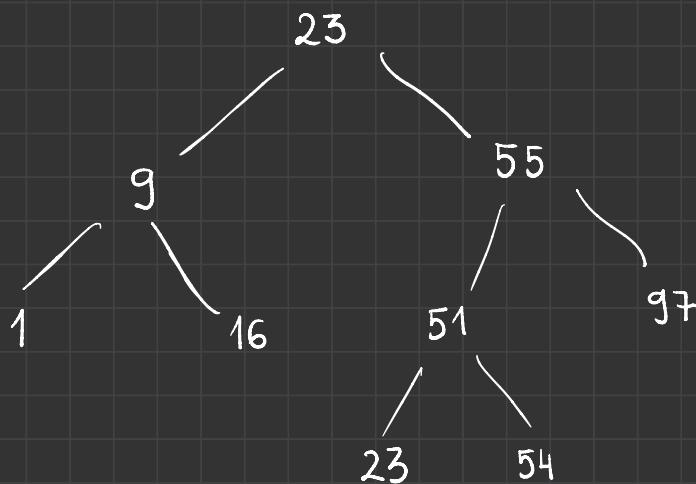
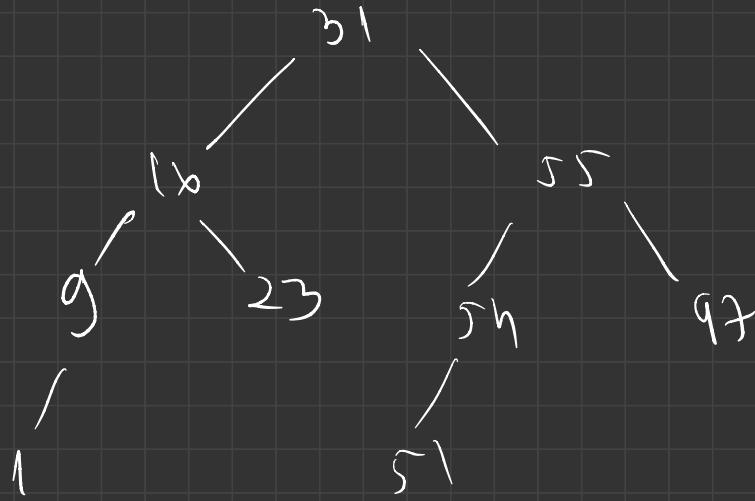




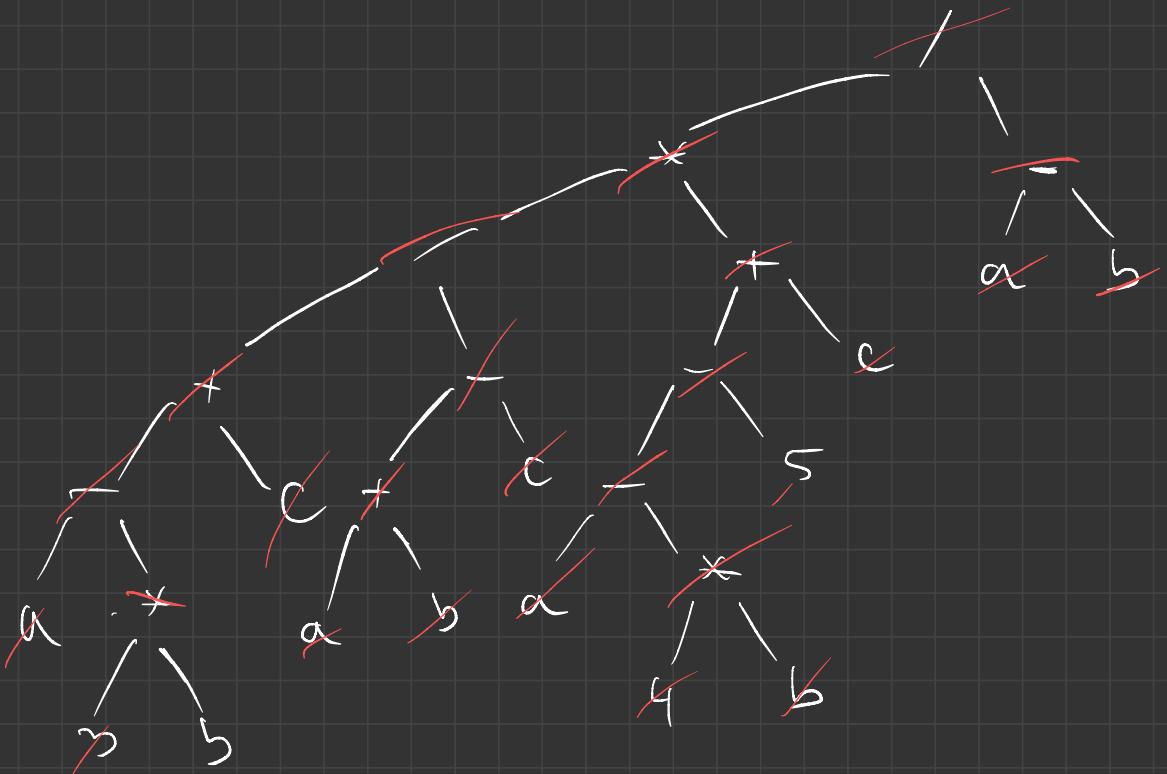
0 1 9 2 3 5 7 6 8 1 9 10
1 9 16 23 31 34 51 54 55 95 97





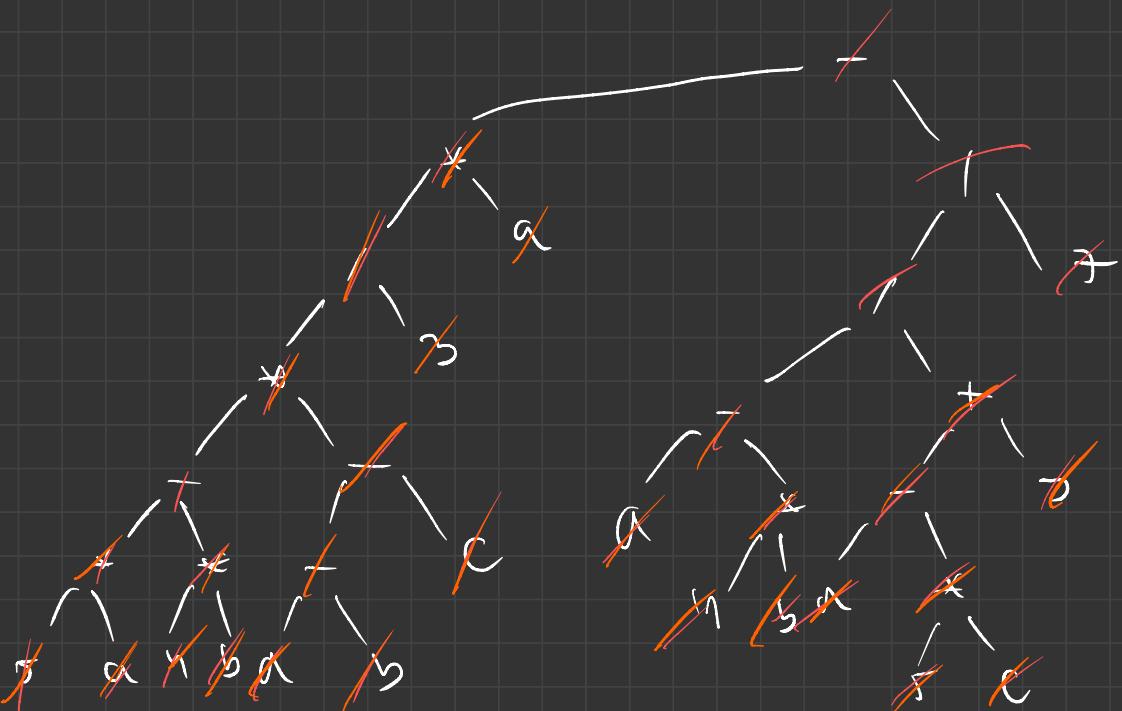


$$\underbrace{(a-3^*b+c)}_{x}/\underbrace{(a+b-c)^*}_{y}\underbrace{(a-4^*b-5+c)}/\underbrace{(a-b)}$$



PREORDER /* / + - a * 3 b c - + a b c
 + - - a * 1 b 5 c - a b

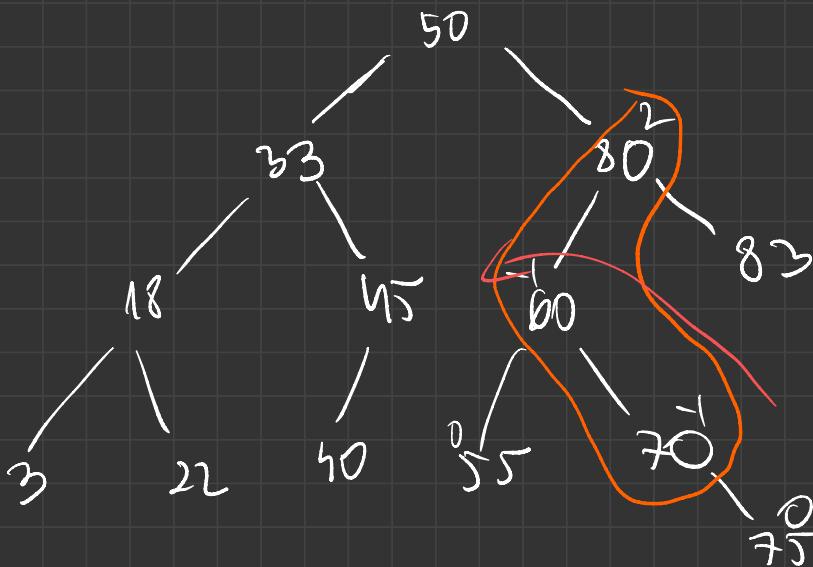
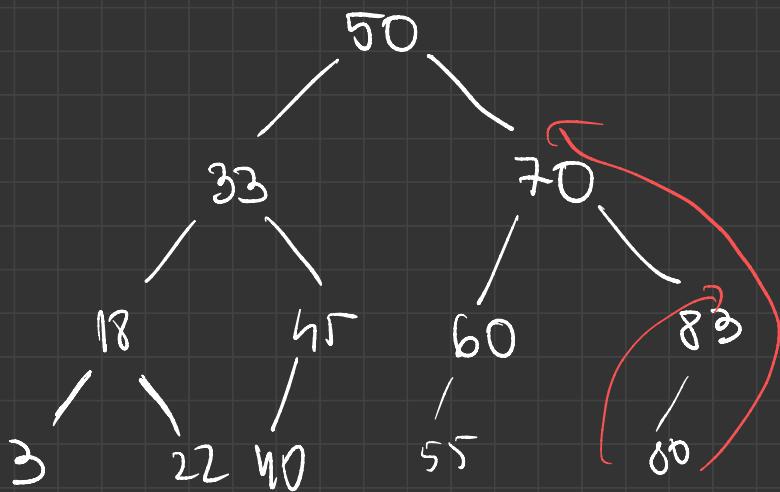
$$\frac{(5^*a - 4^*b)^*}{x_1} \frac{(a-b-c) / 3^*a}{x_2 x_3} - \frac{(a-4^*b)}{y_1} \frac{/(a-5^*c+3)}{y_2 y_3} +$$

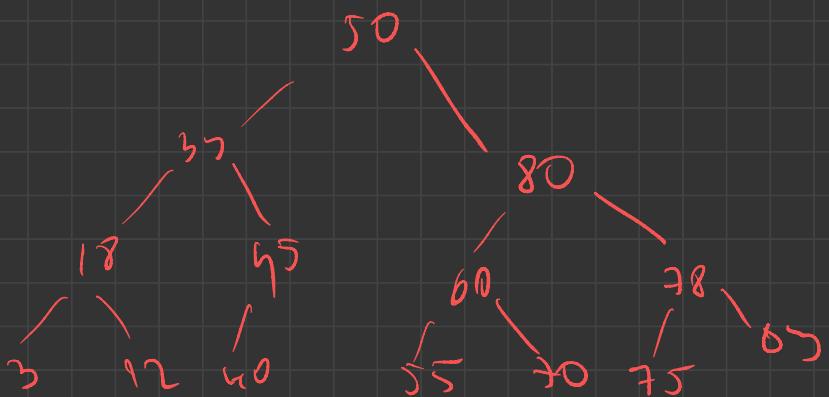
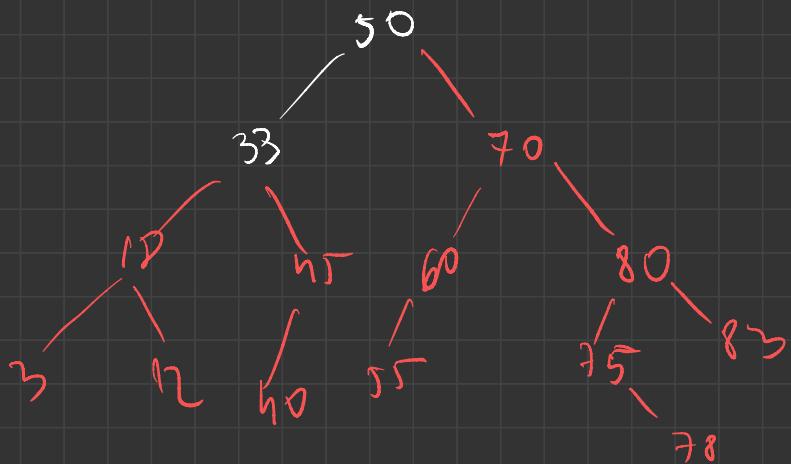


PREORDER : $- * / + - * 5a * 4b - - ab c$
 $/ / - a * 5b + - a * 5c 3 +$

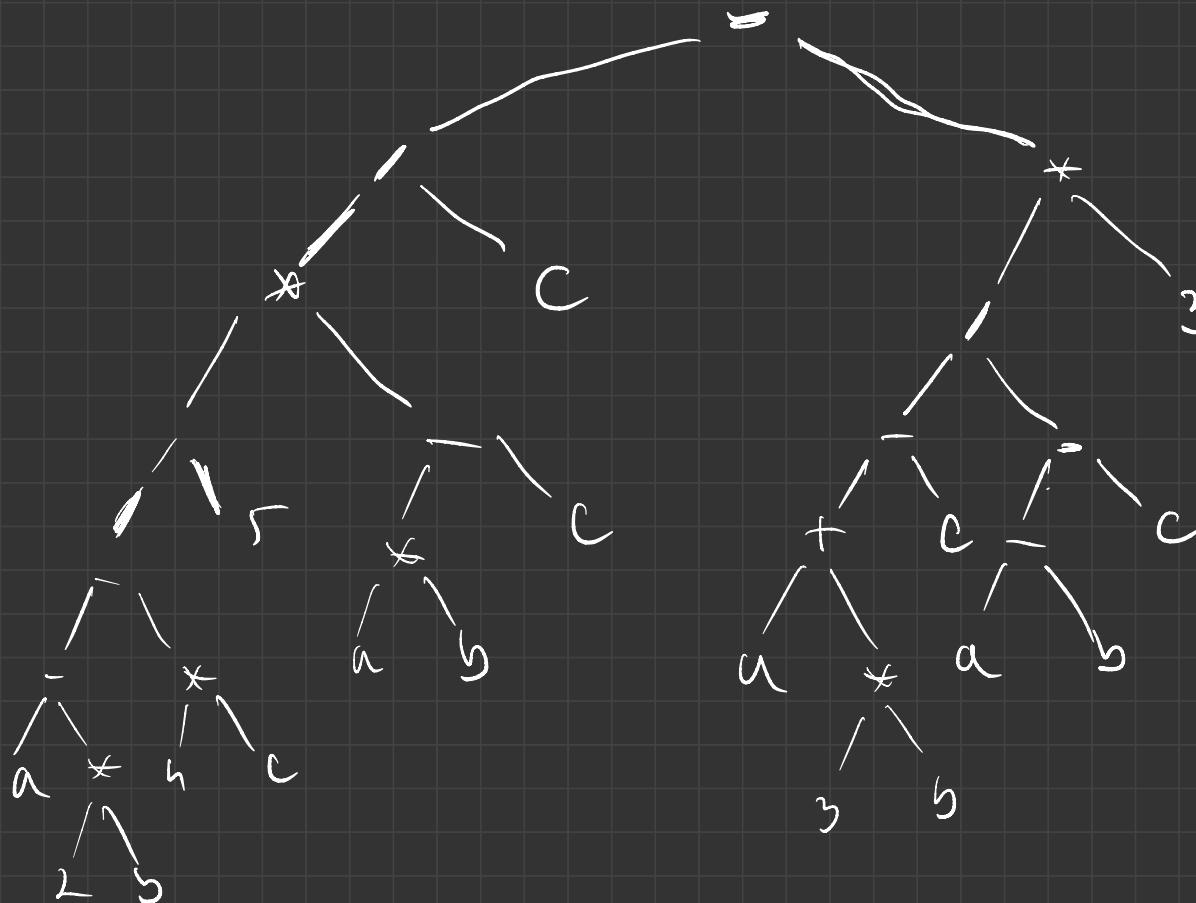
POSTORDER : $5a * 4b - - ab c - * 3 / a * a$
 $4b * - a 5c + - 7 + / 7 / -$

<u>3</u>	<u>18</u>	<u>22</u>	<u>33</u>	<u>40</u>	<u>45</u>	<u>50</u>	<u>55</u>	<u>60</u>	<u>70</u>	<u>80</u>	<u>83</u>
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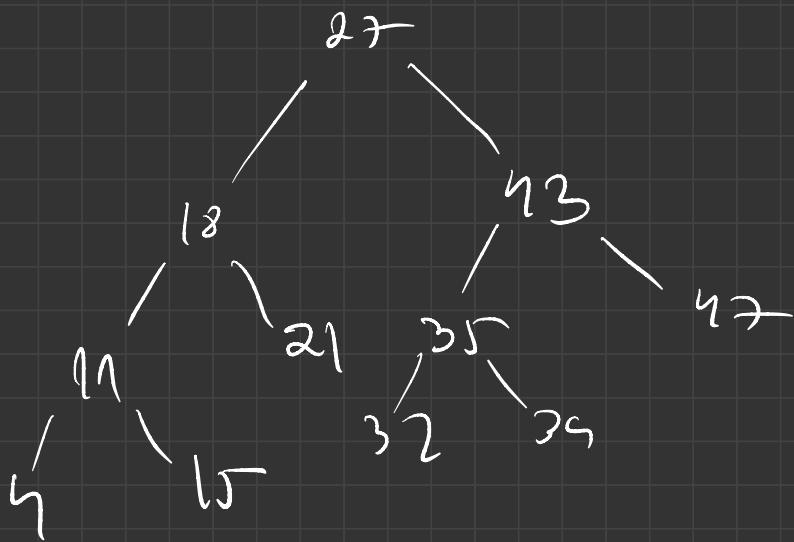
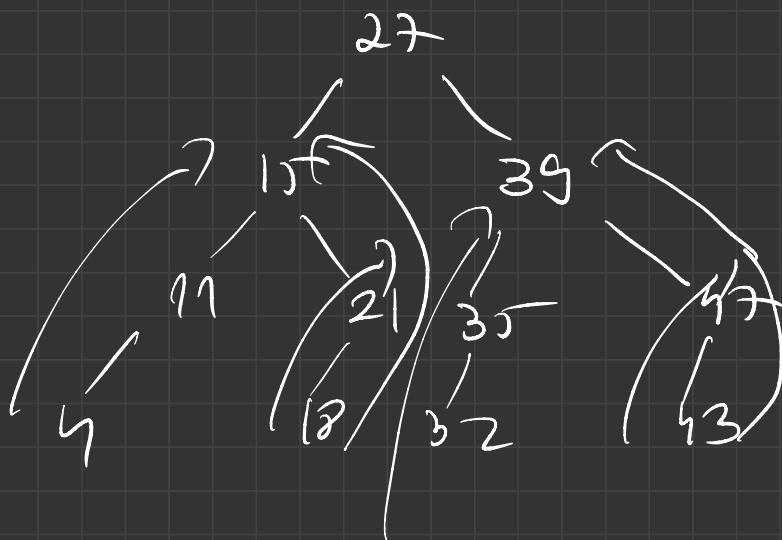


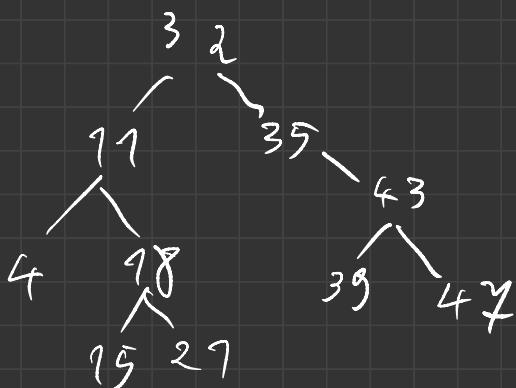
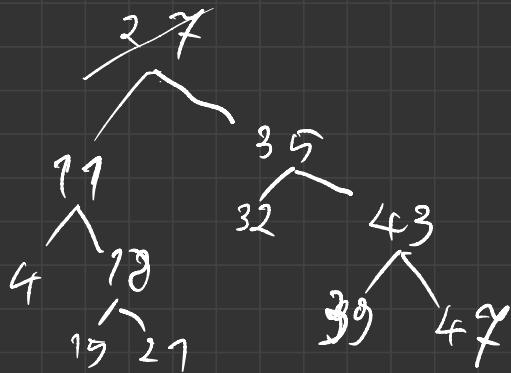
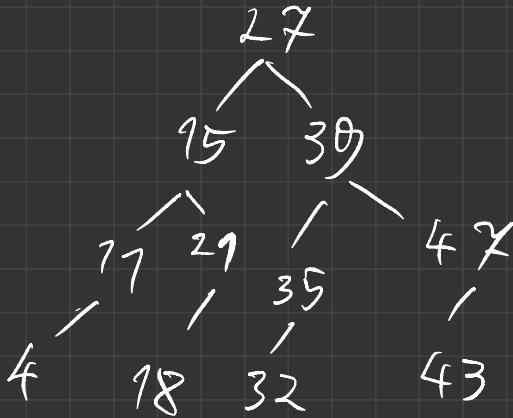


$$\frac{(a - 2^*b - h^*c)}{s} * \frac{(a * b - c)}{c} - \frac{(a + b * c)}{(a - b * c)} * 3$$



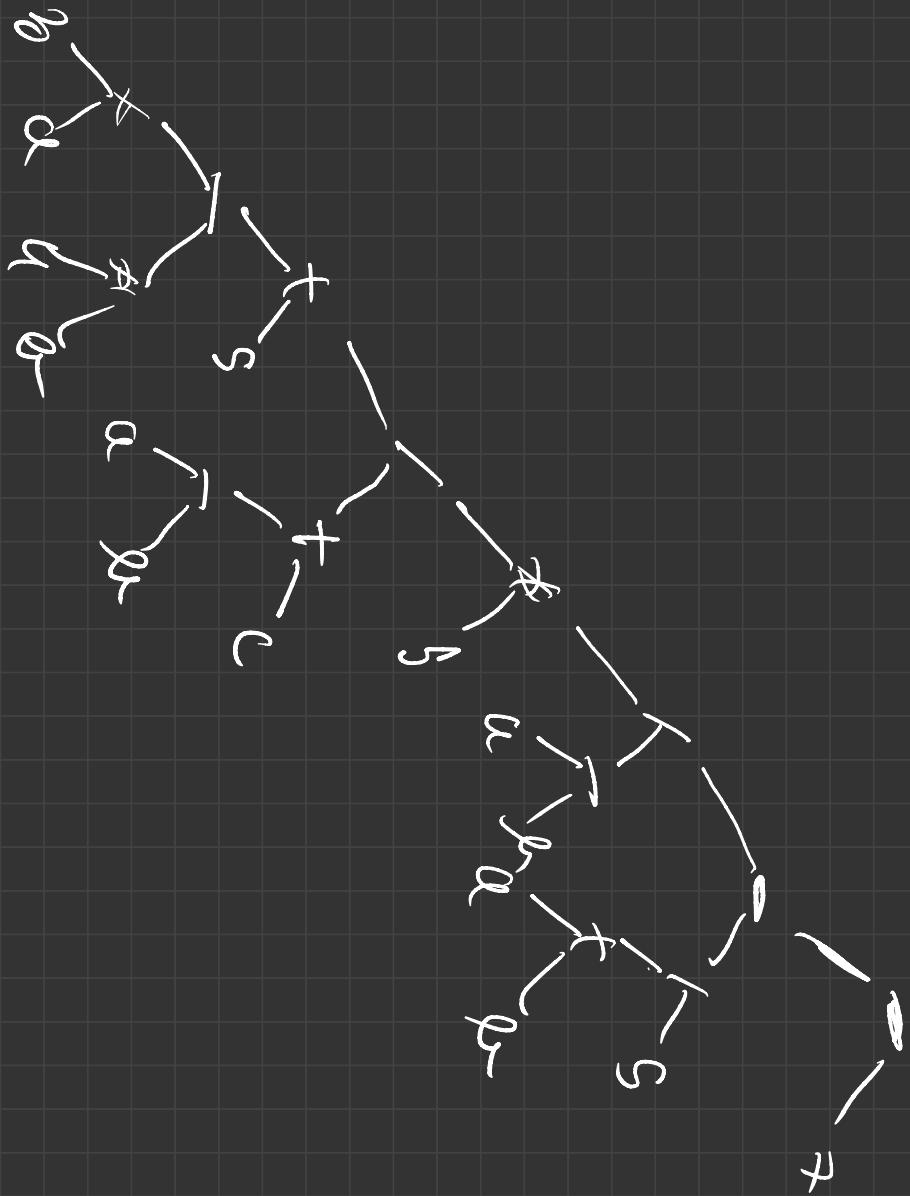
4 11 15 18 21 | 27 32 35 39 43 47



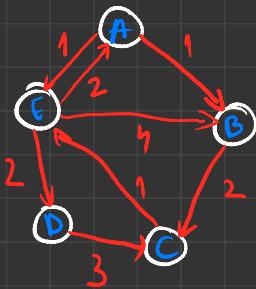


2 7
3 5
4 3

$$(3^*a - 4^*b + 5) / (a - b + c) * 5 / (a - b) - (a + b) / 5 - +$$



*



2.1 LA

	A	B	C	D	E
A	0	1	∞	∞	1
B	∞	0	2	∞	∞
C	∞	∞	0	∞	1
D	∞	∞	3	0	∞
E	2	4	∞	2	0

$$A : \{(B, 1), (E, 1)\}$$

$$B : \{(C, 2)\}$$

$$C : \{(E, 1)\}$$

$$D : \{(C, 3)\}$$

$$E : \{(A, 2), (B, 4), (D, 2)\}$$

2.2 DFT - A

start A

A	B	C	D	E
$*_0$	$*_1$	$*_2$	$*_4$	$*_5$

A - B - C - E - D

BFT - A

start A

A	B	C	D	E
$*_0$	$*_1$	$*_2$	$*_2$	$*_9$

A - B - C
E - D