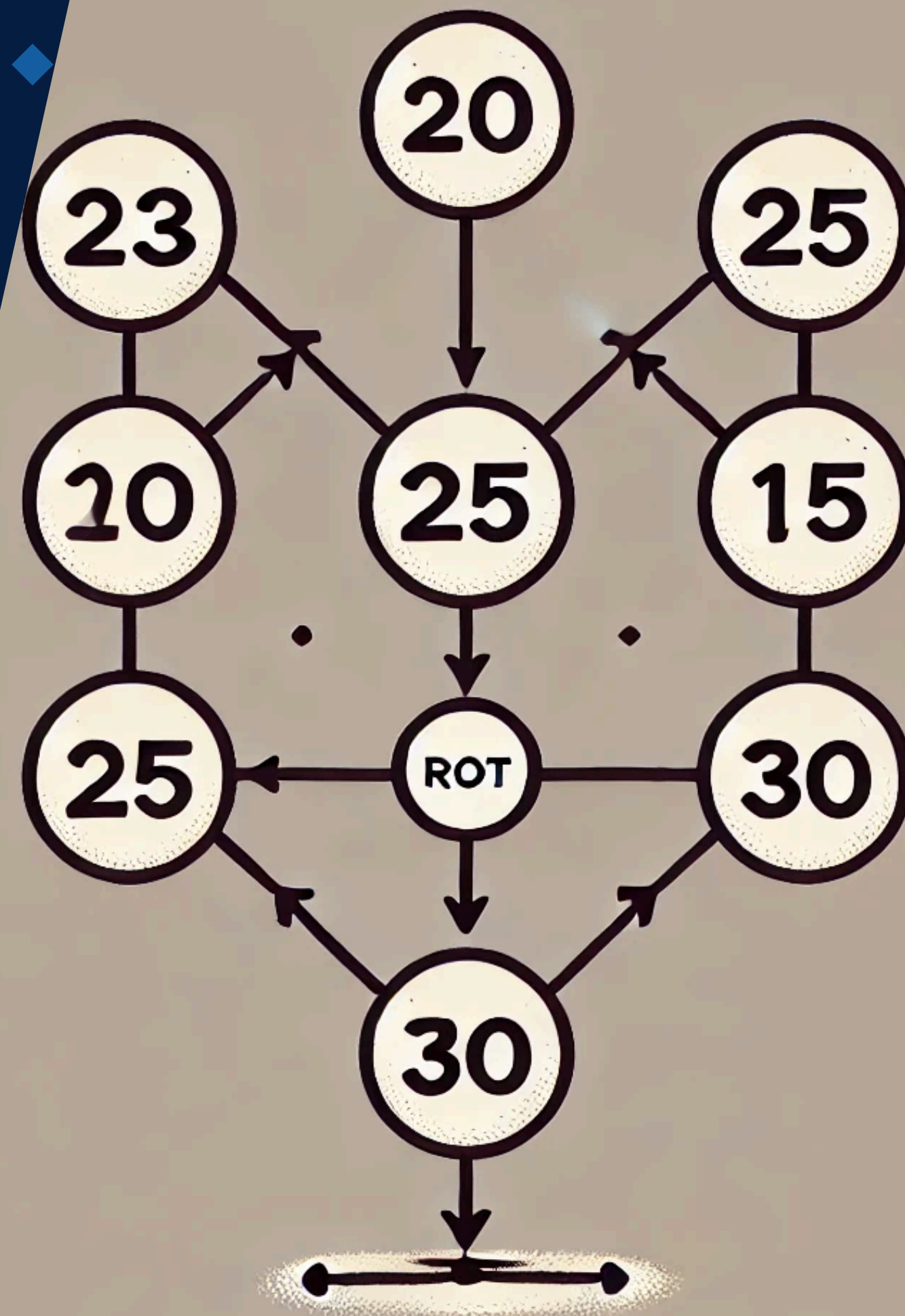


ÁRVORE


2 3 4

Camilly, Geovana, Rafaela





DEFINIÇÃO



A árvore 2-3-4 é uma estrutura de dados balanceada onde cada nó pode ter 2, 3 ou 4 filhos e armazenar até 3 chaves.



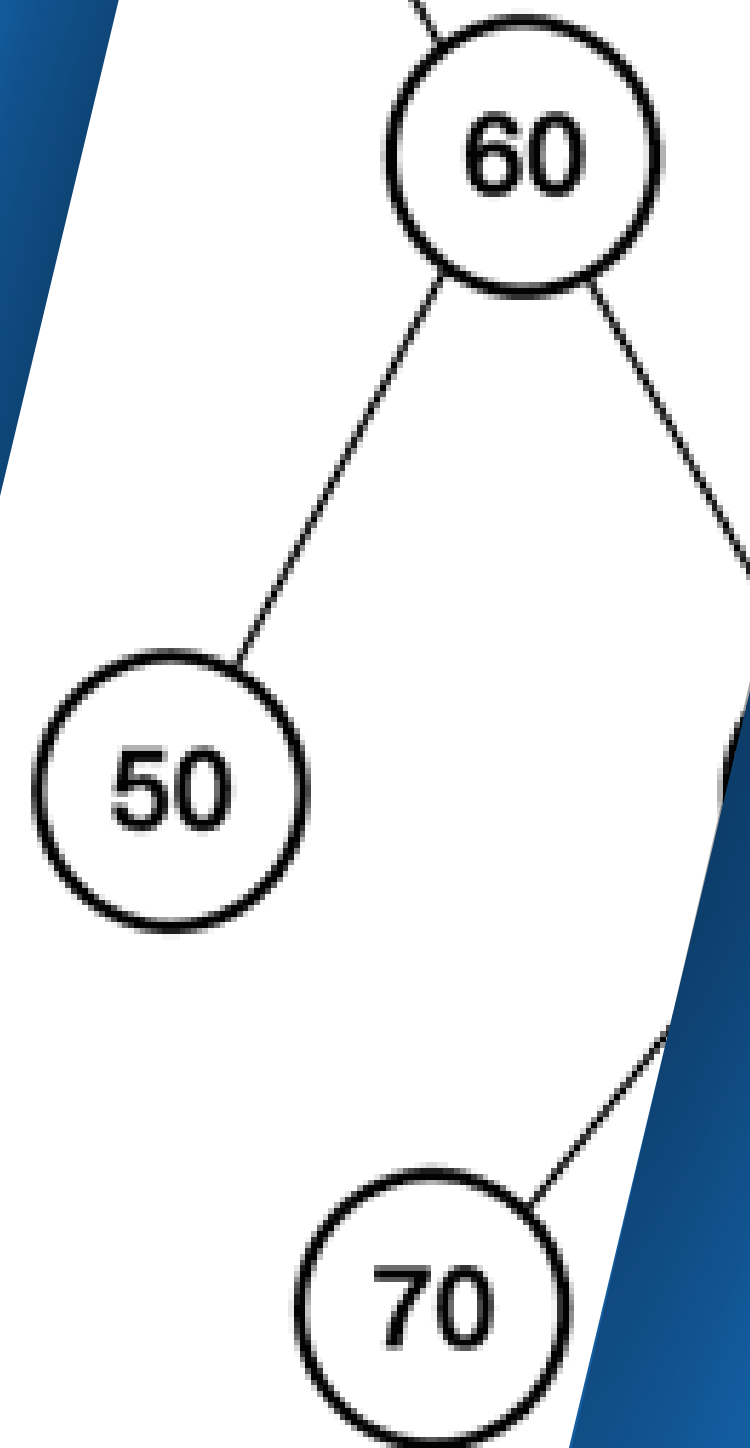
COMPARAÇÃO

ÁRVORE BINÁRIA

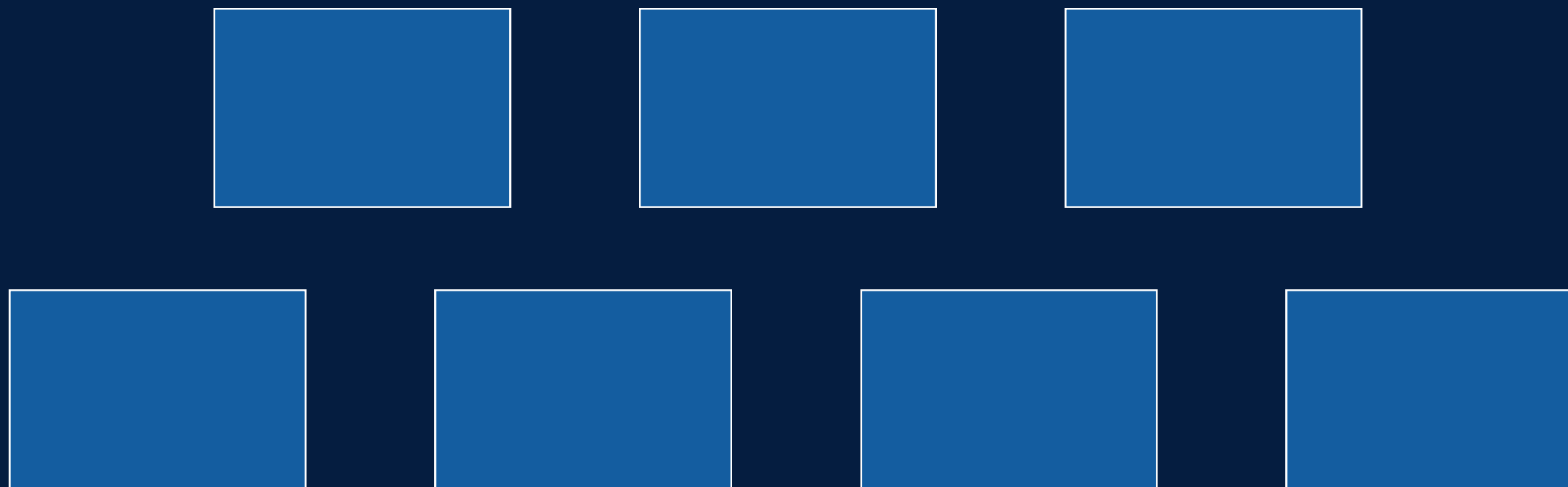
- Cada nó tem dois ponteiros
- Muito alta, muito extensa
- 1 campo de informação
- 2 ponteiros

ÁRVORE 2-3-4

- Três campos de informação
- Ex: Se sua árvore for de números cada nó guarda até 3 números.
- 3 campos de informação
- 4 ponteiros



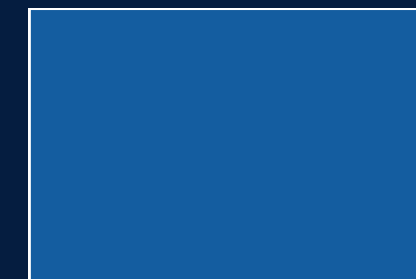
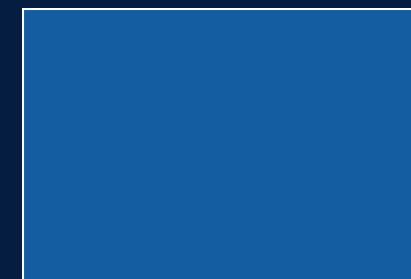
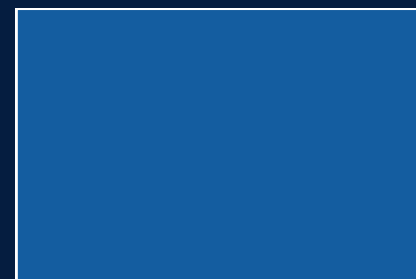
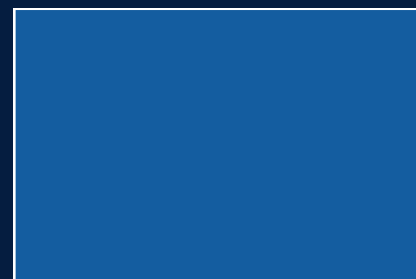
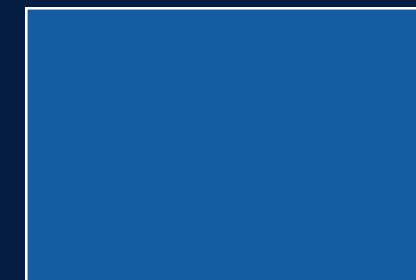
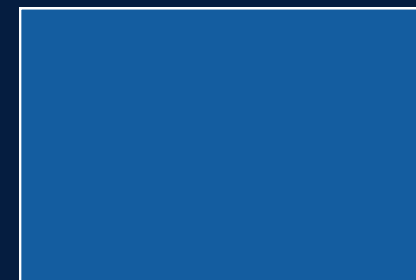
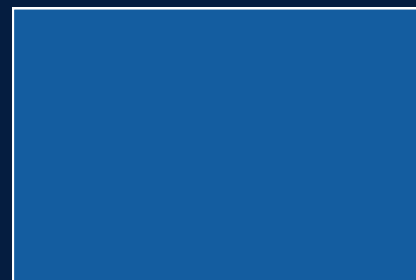
INSERÇÃO



- 3 CAMPOS DE INFORMAÇÃO
- 4 PONTEIROS(FILHOS)

INSERÇÃO

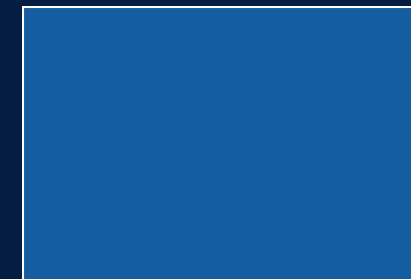
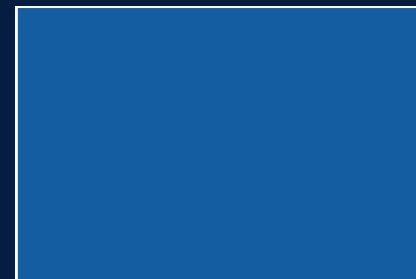
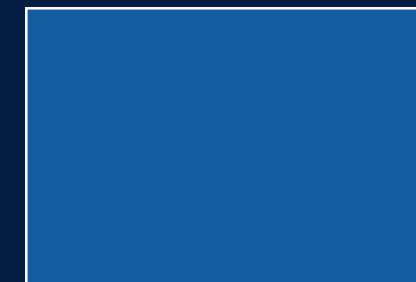
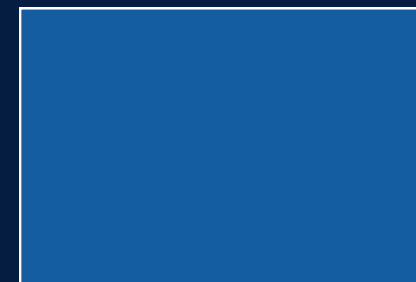
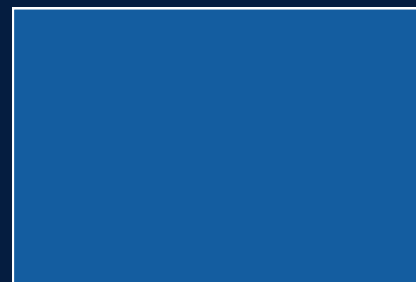
CAMPO CHAVE



- Menores para a esquerda e maiores para a direito

INSERÇÃO

CAMPO CHAVE



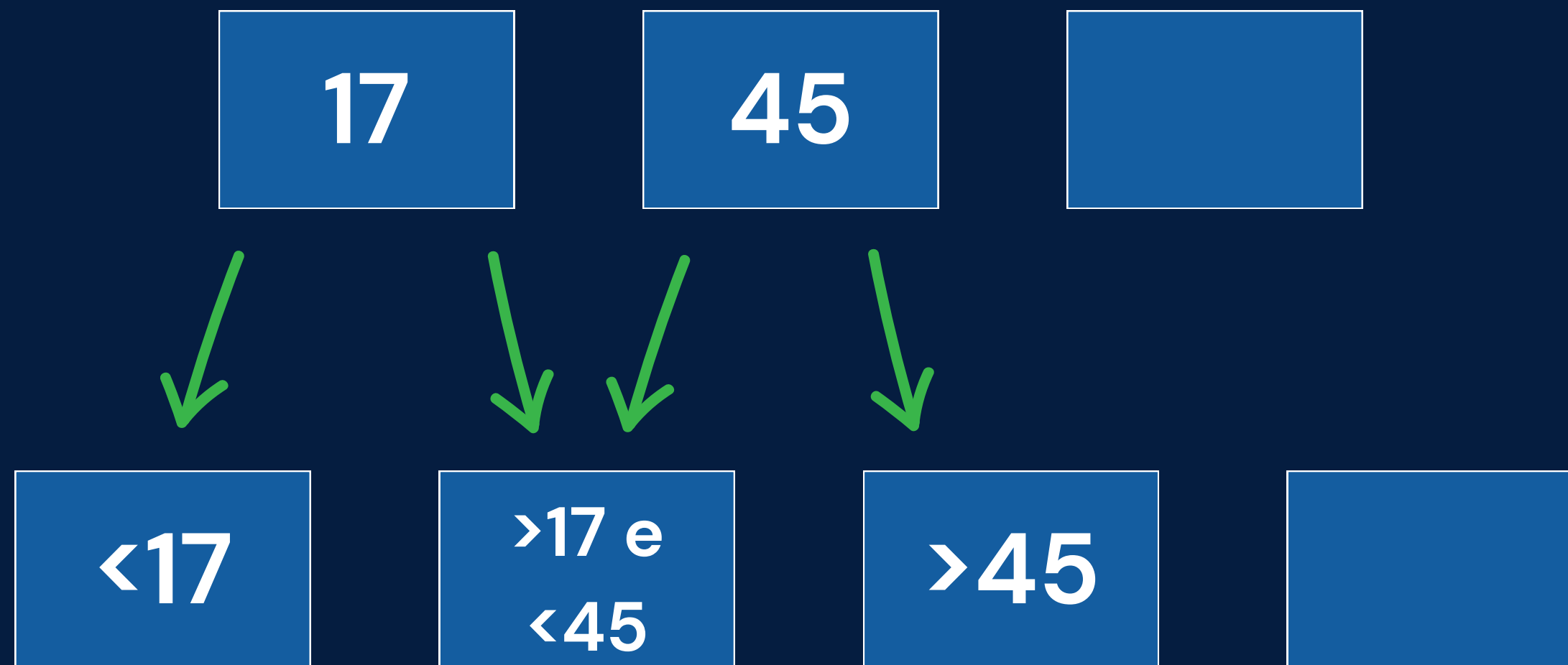
- Menores para a esquerda e maiores para a direita
- Além de menores e maiores temos o intermediário

INSERÇÃO



- Cada informação, tem que ter dois ponteiros

INserção



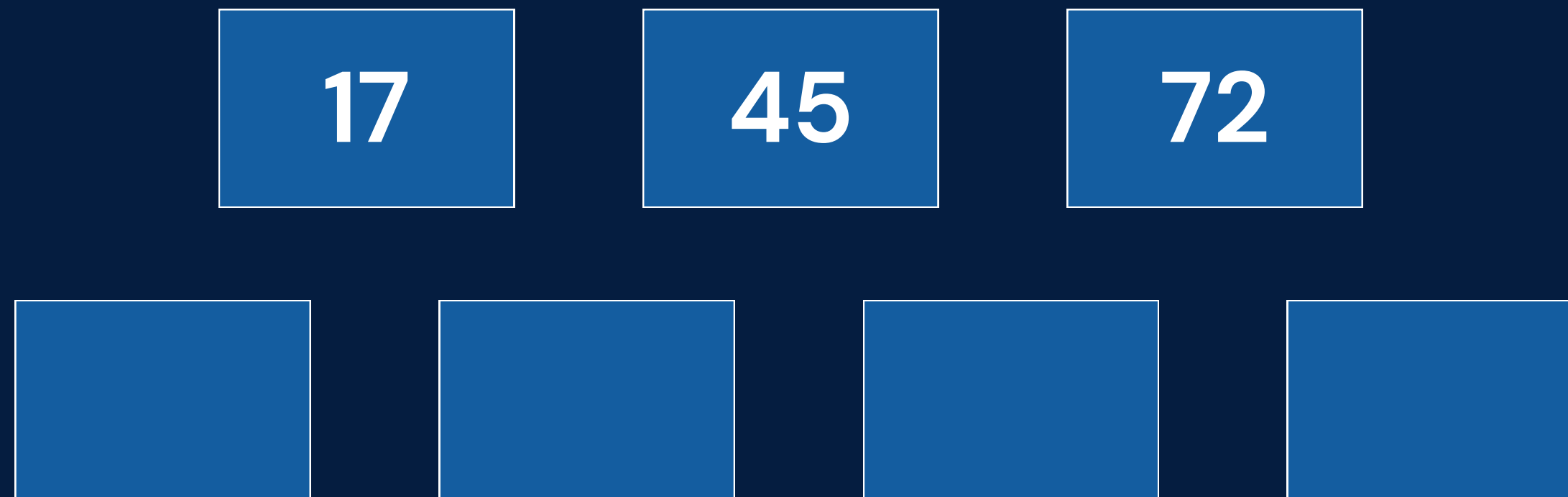
INSERÇÃO

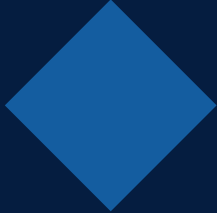


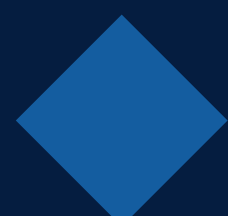
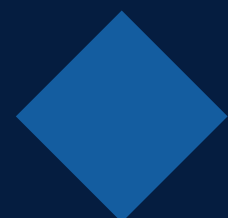
- Toda inserção dentro do nó deve ser feita de forma ordenada



INSERÇÃO

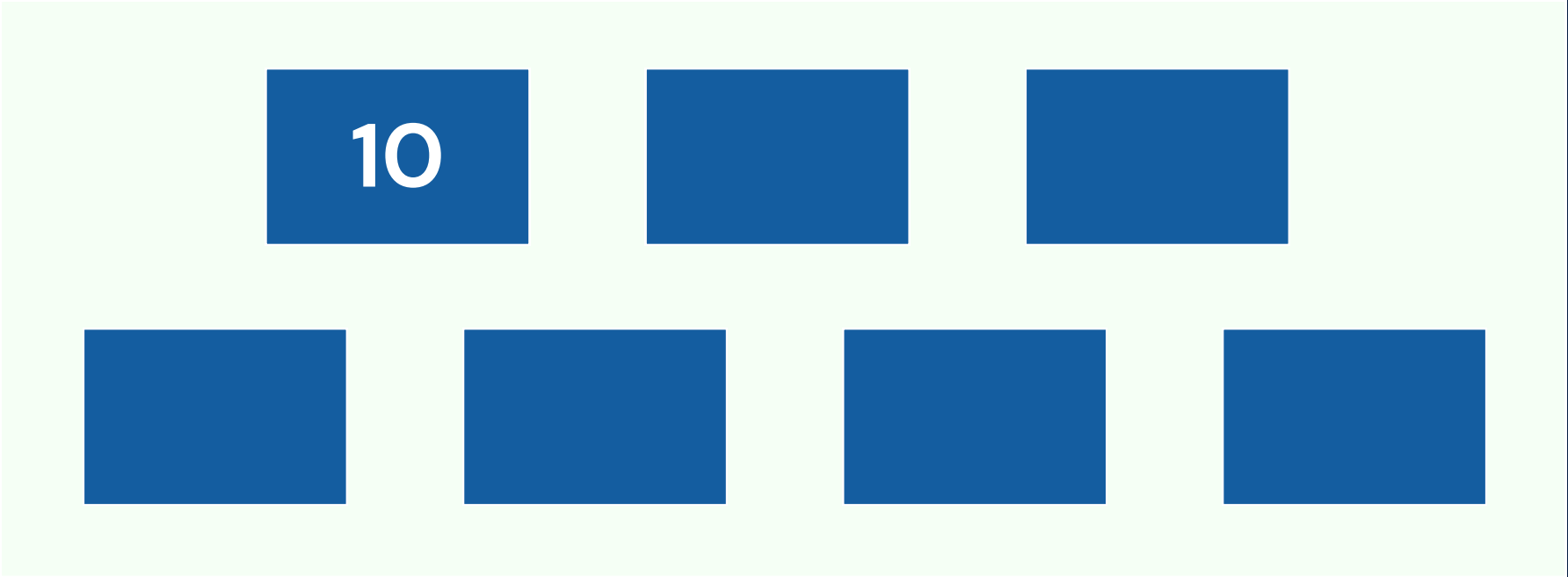
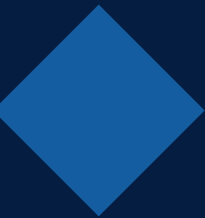
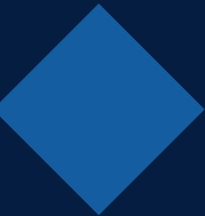


- Toda inserção ocorre em um nó folha (nó que não possui nenhum filho)
 - Já é uma árvore balanceada por natureza
- 



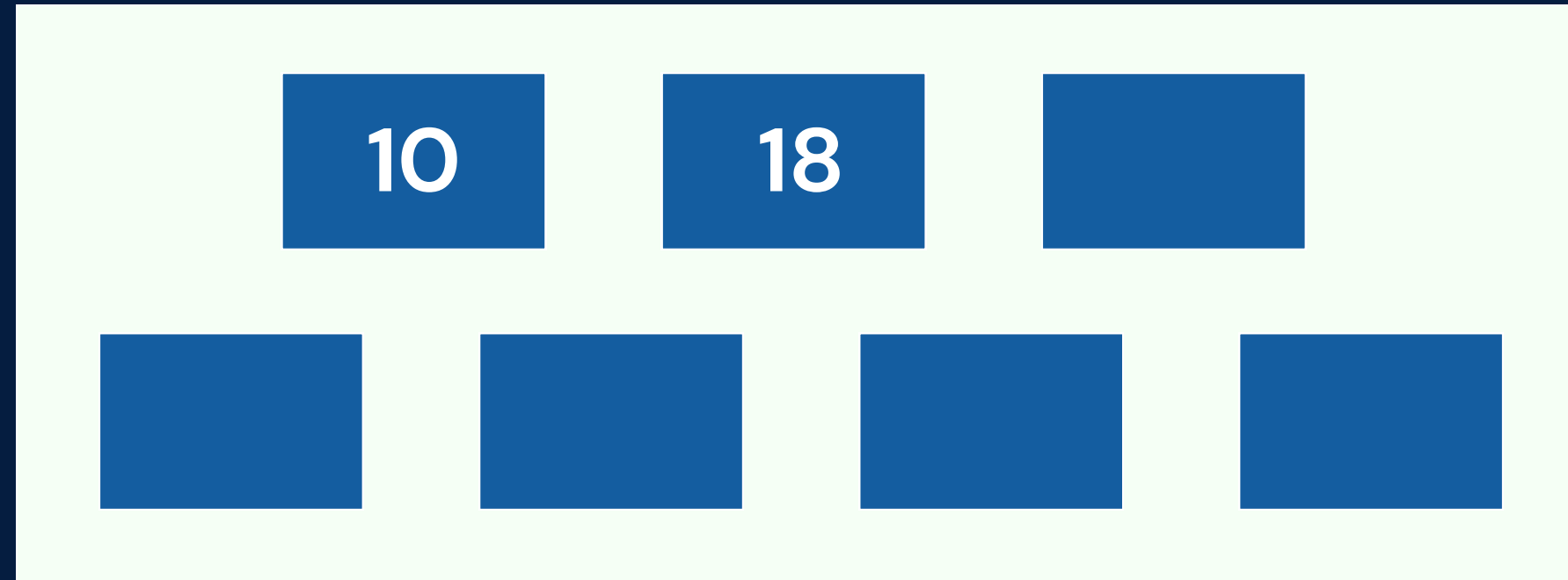
ÁRVORE = NULL

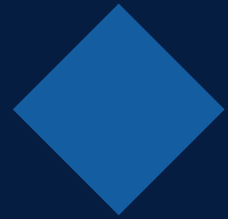
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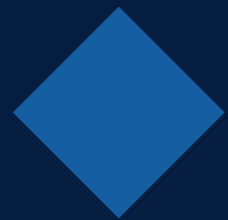
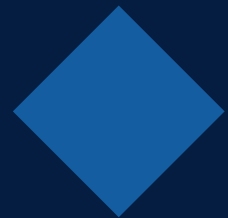
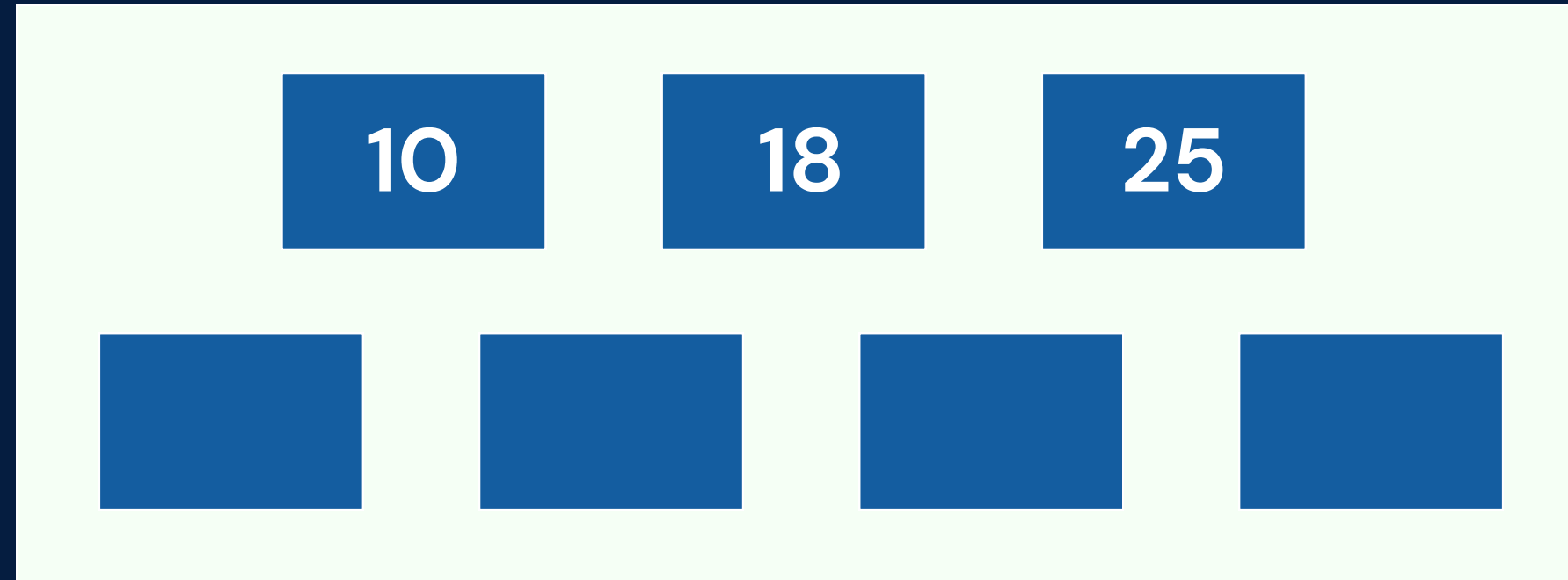


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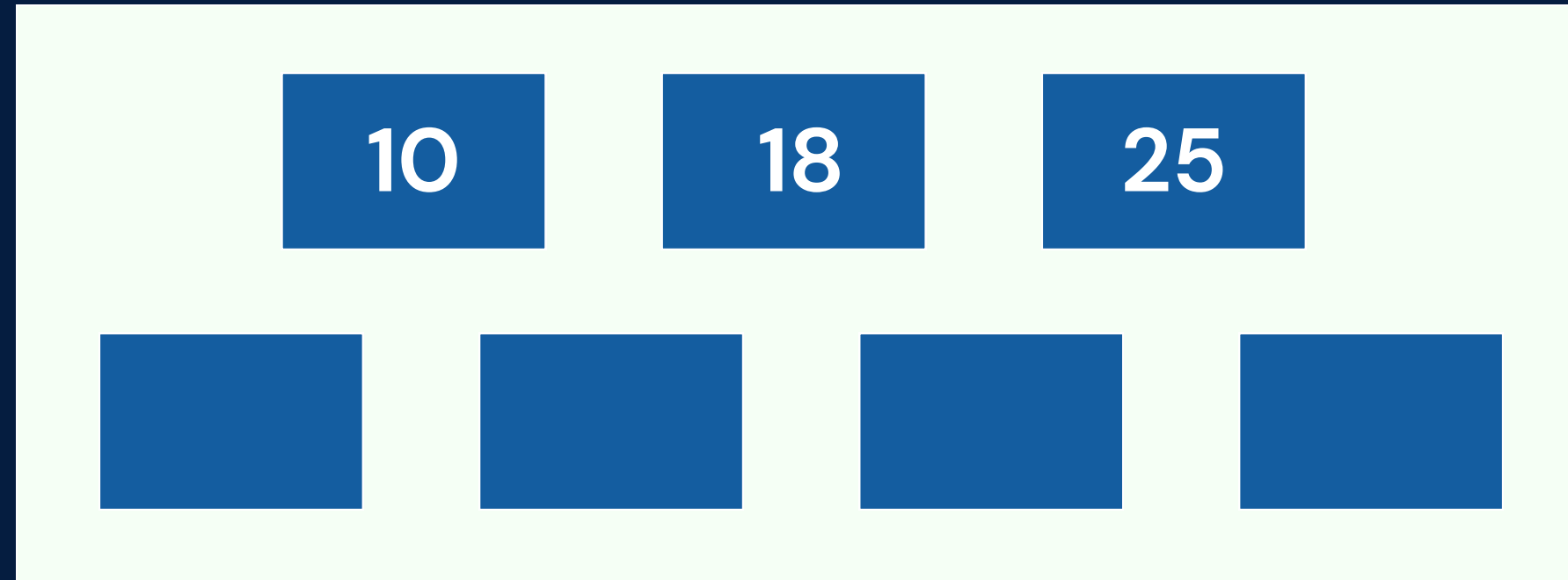


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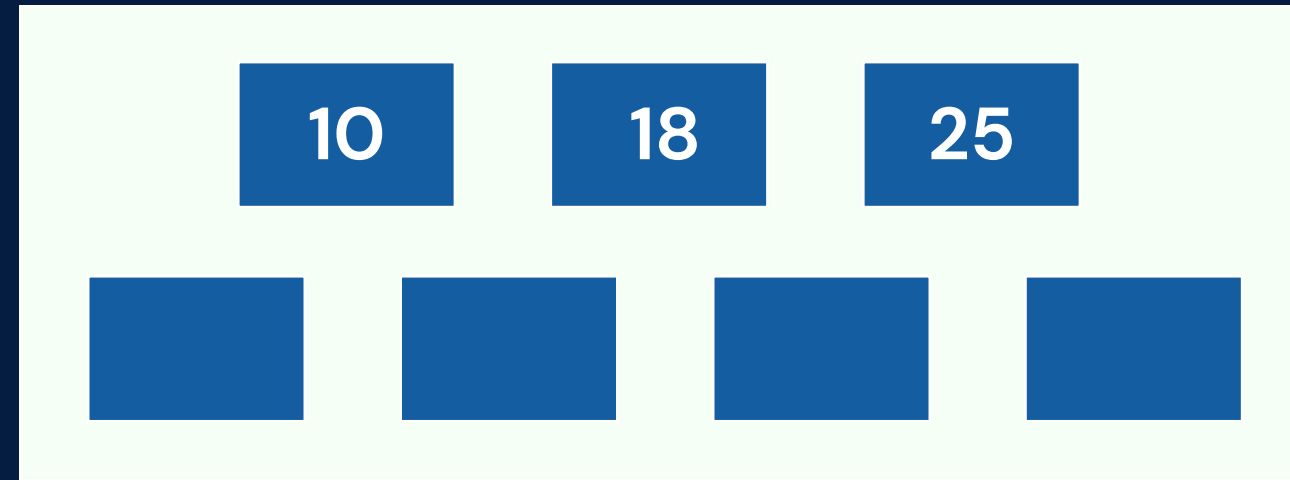


SPLIT



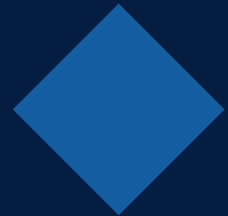
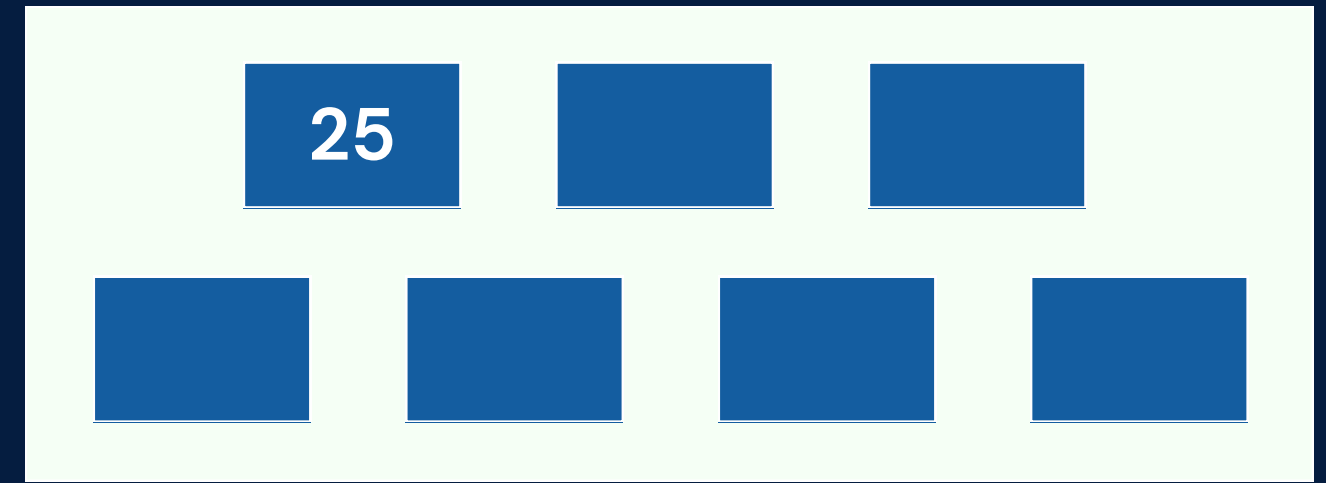
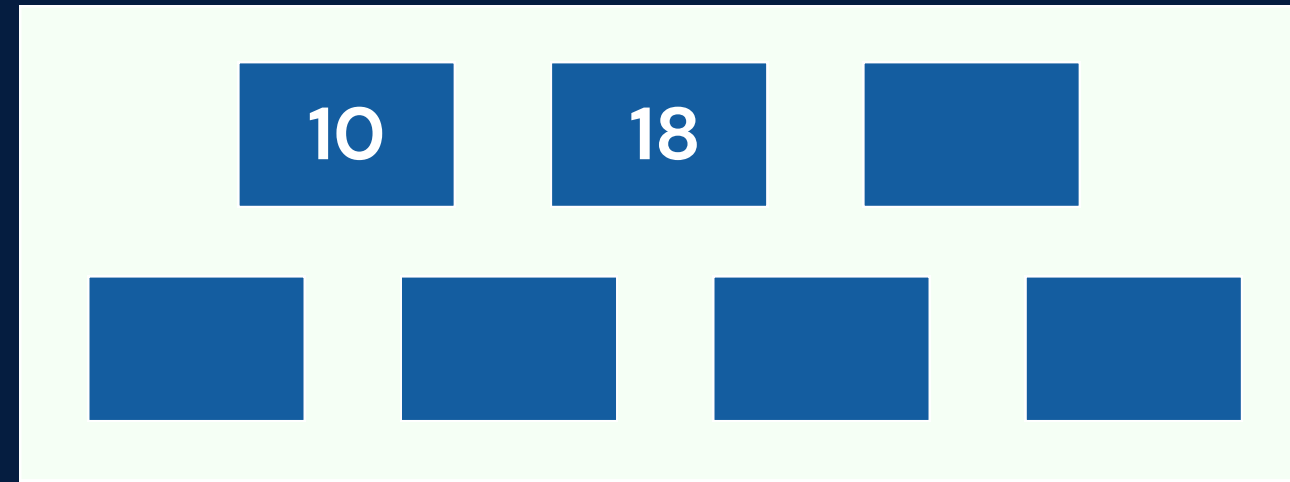


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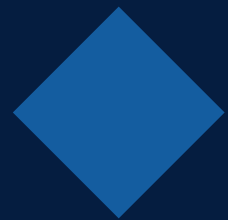
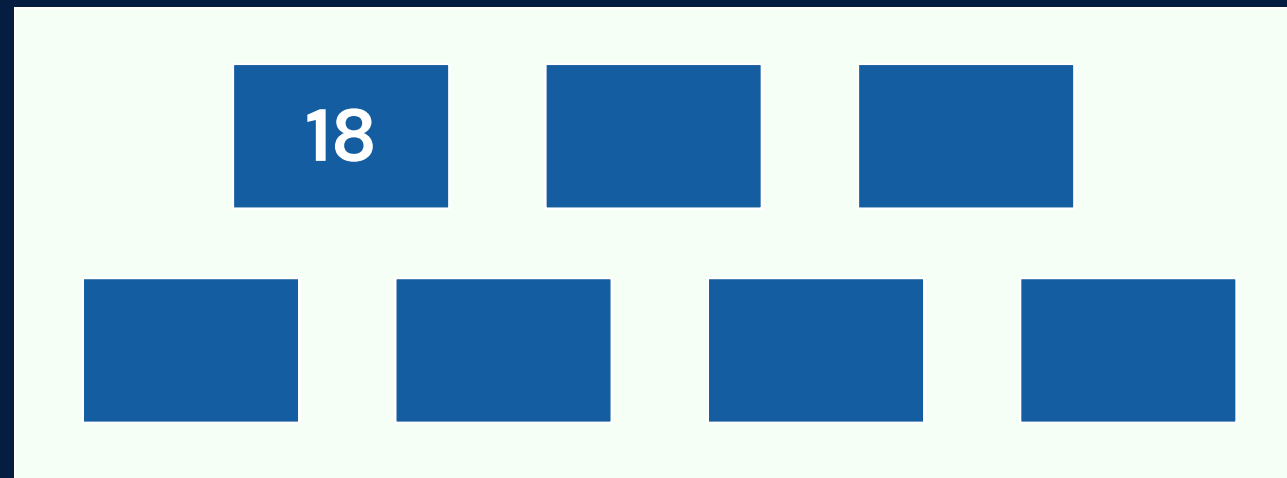
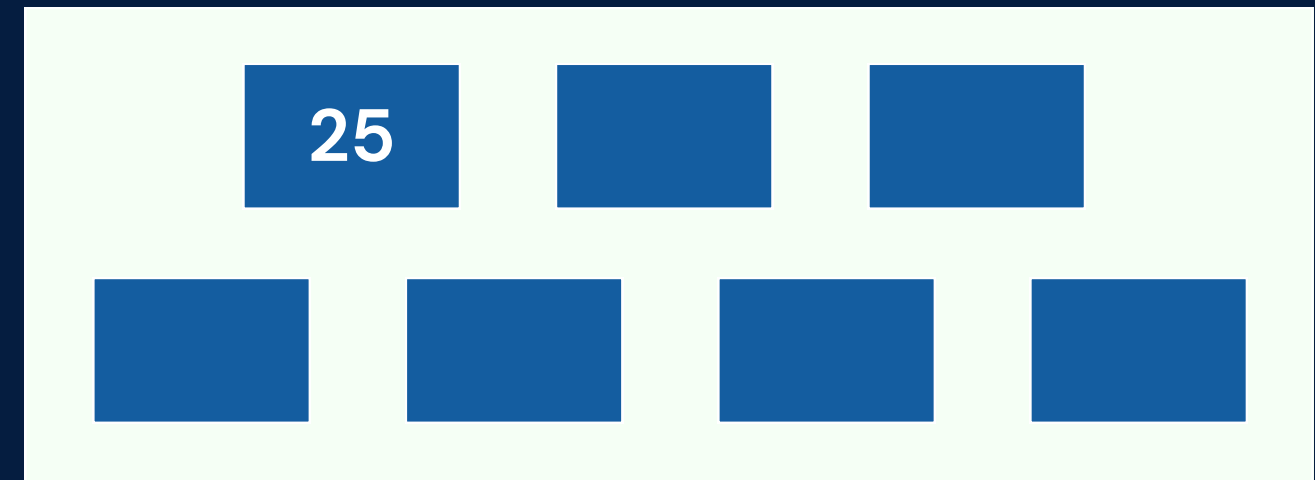
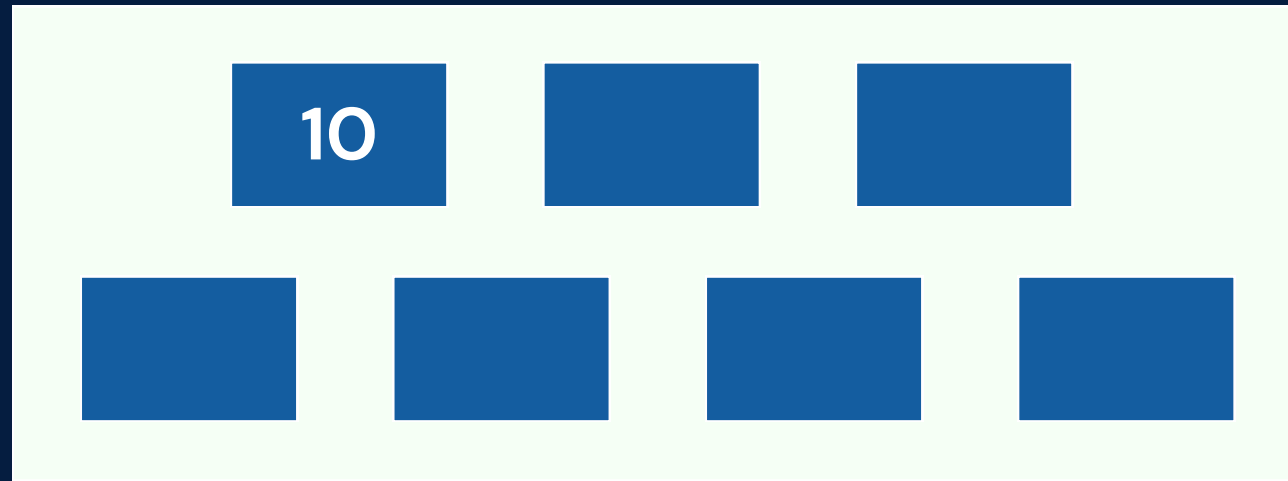
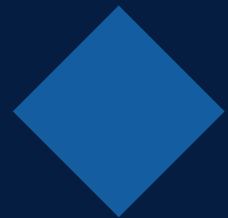


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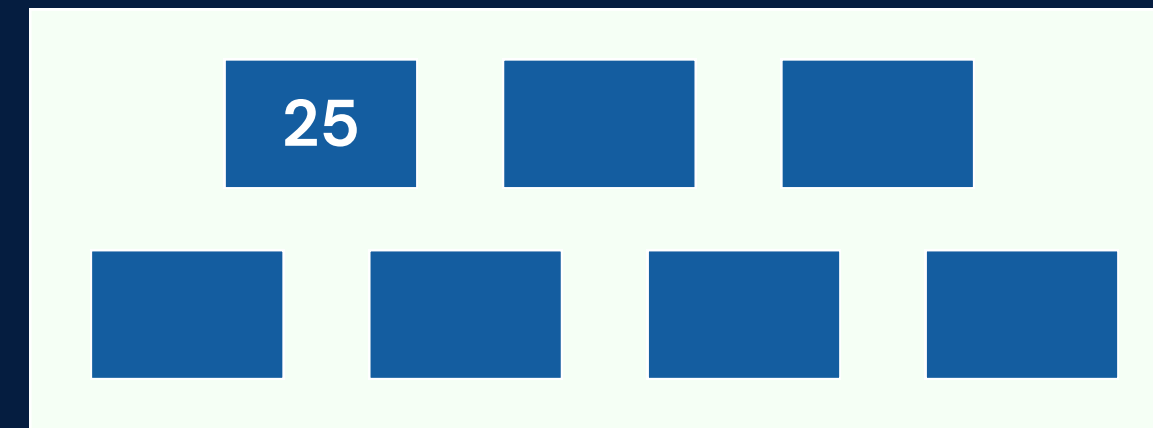
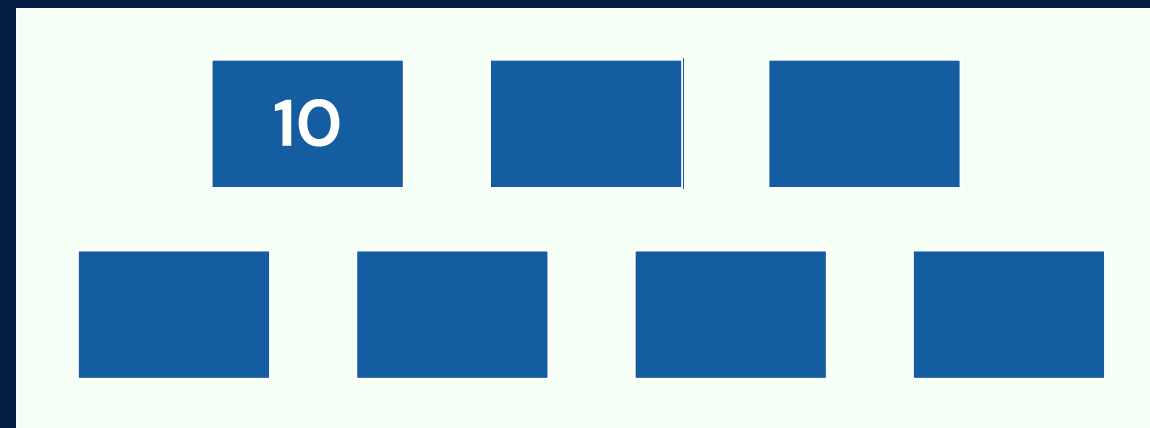
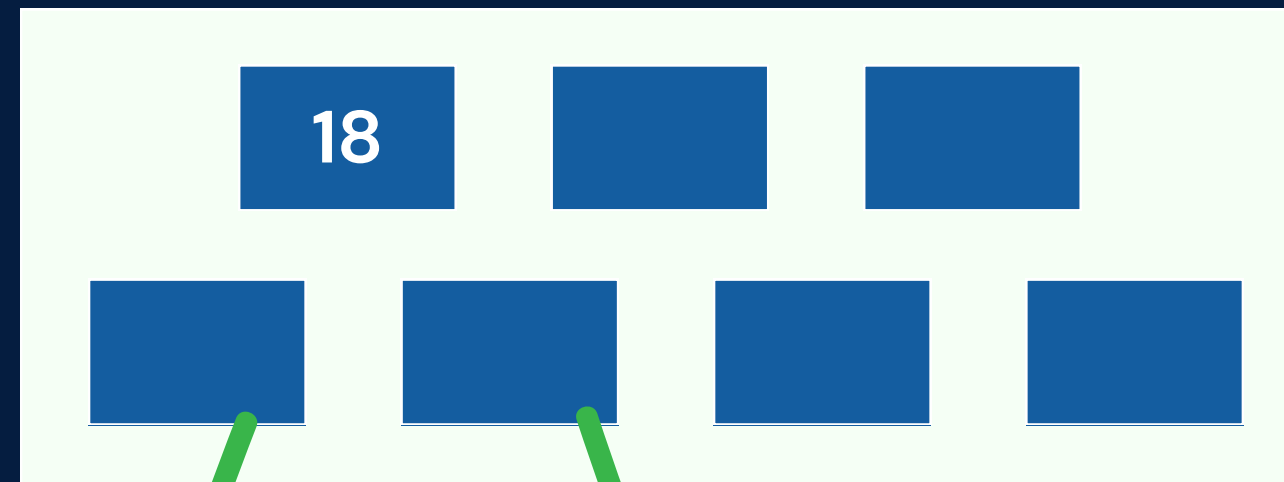




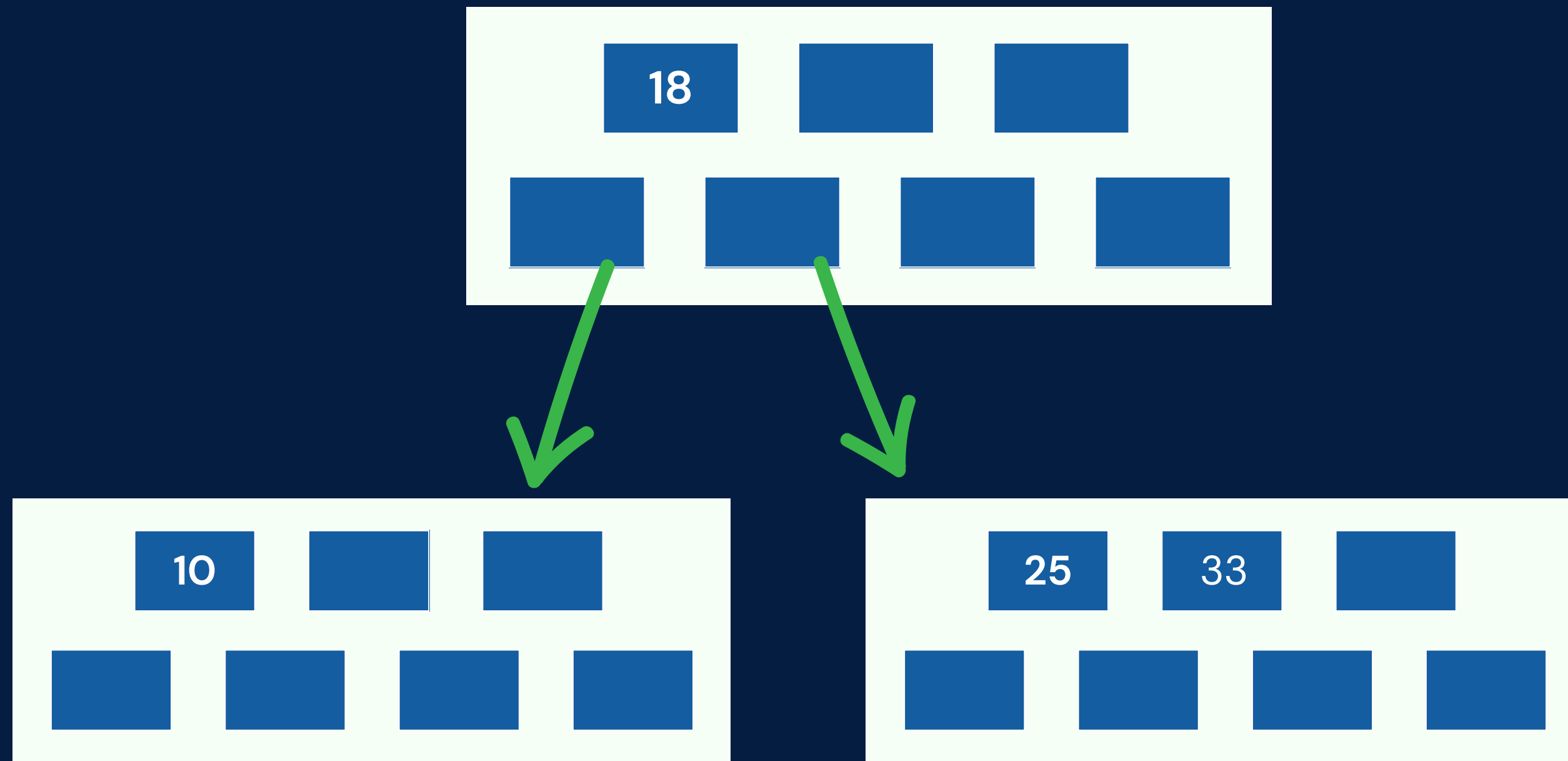
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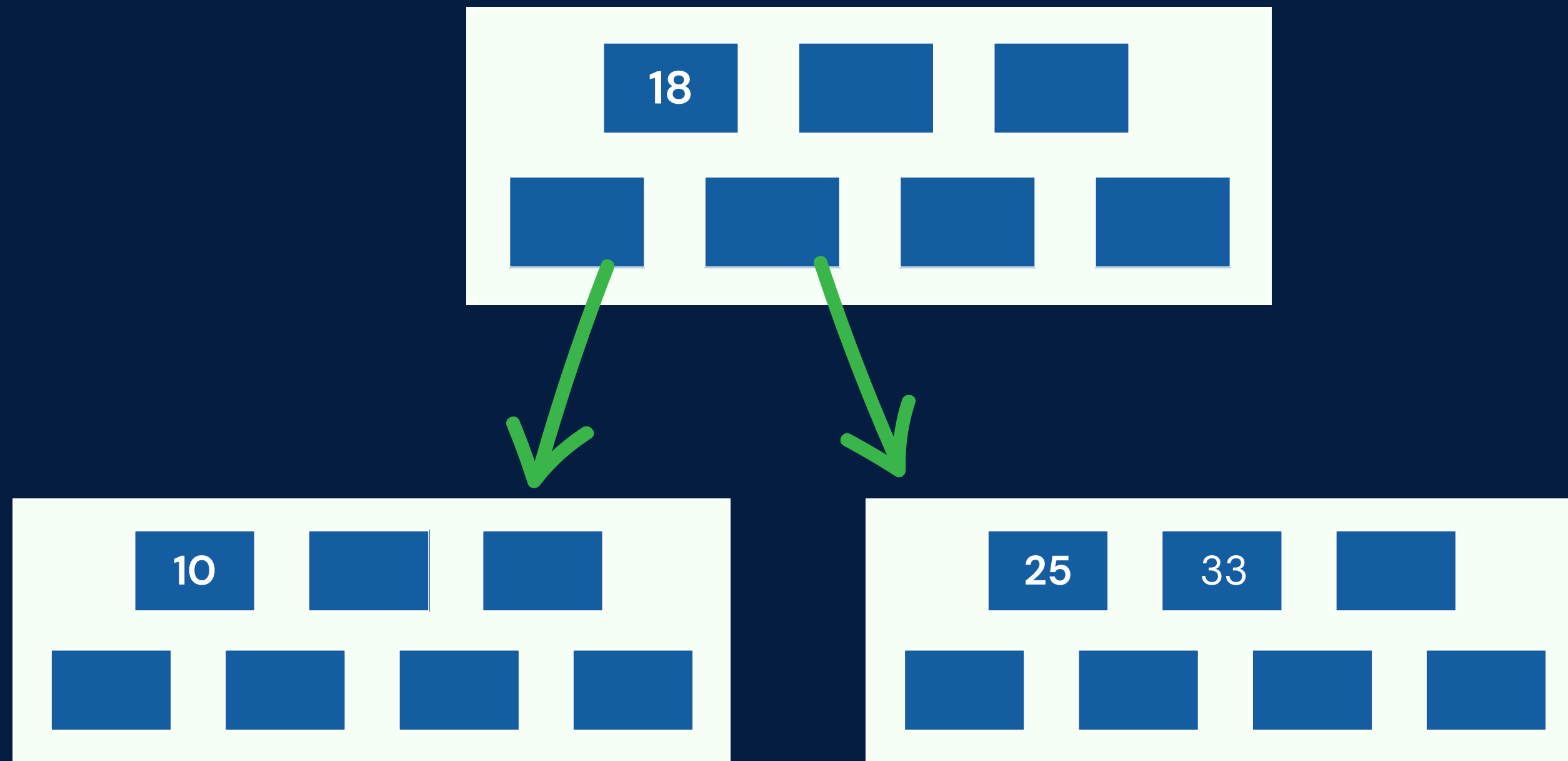
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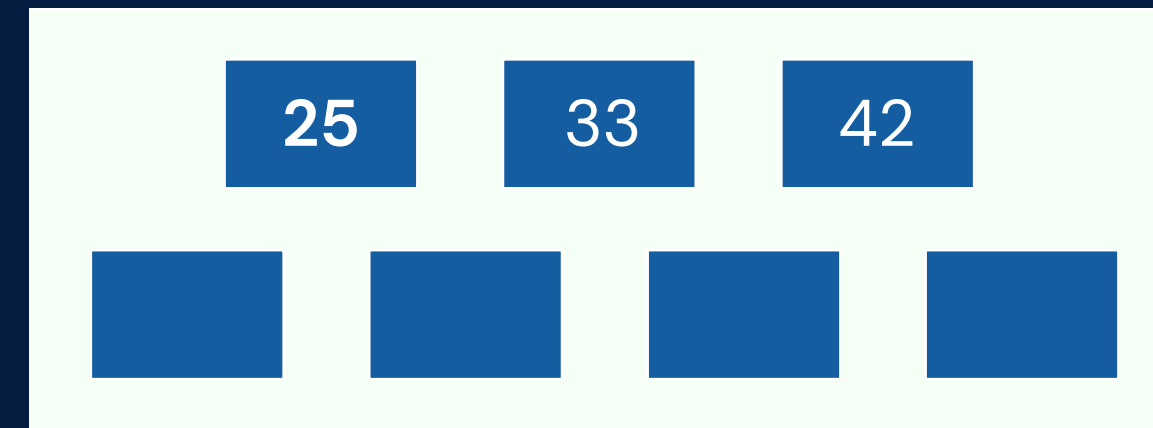
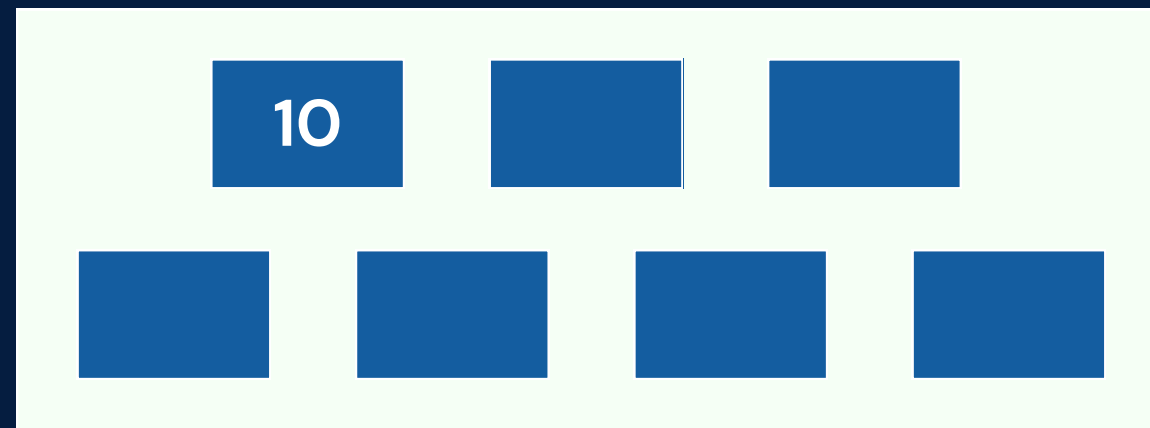
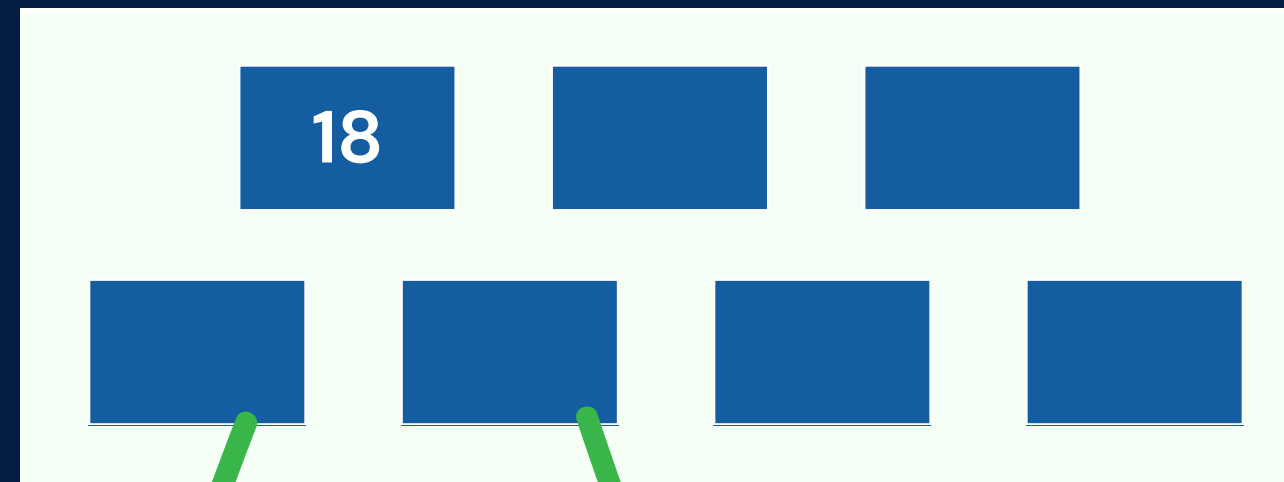
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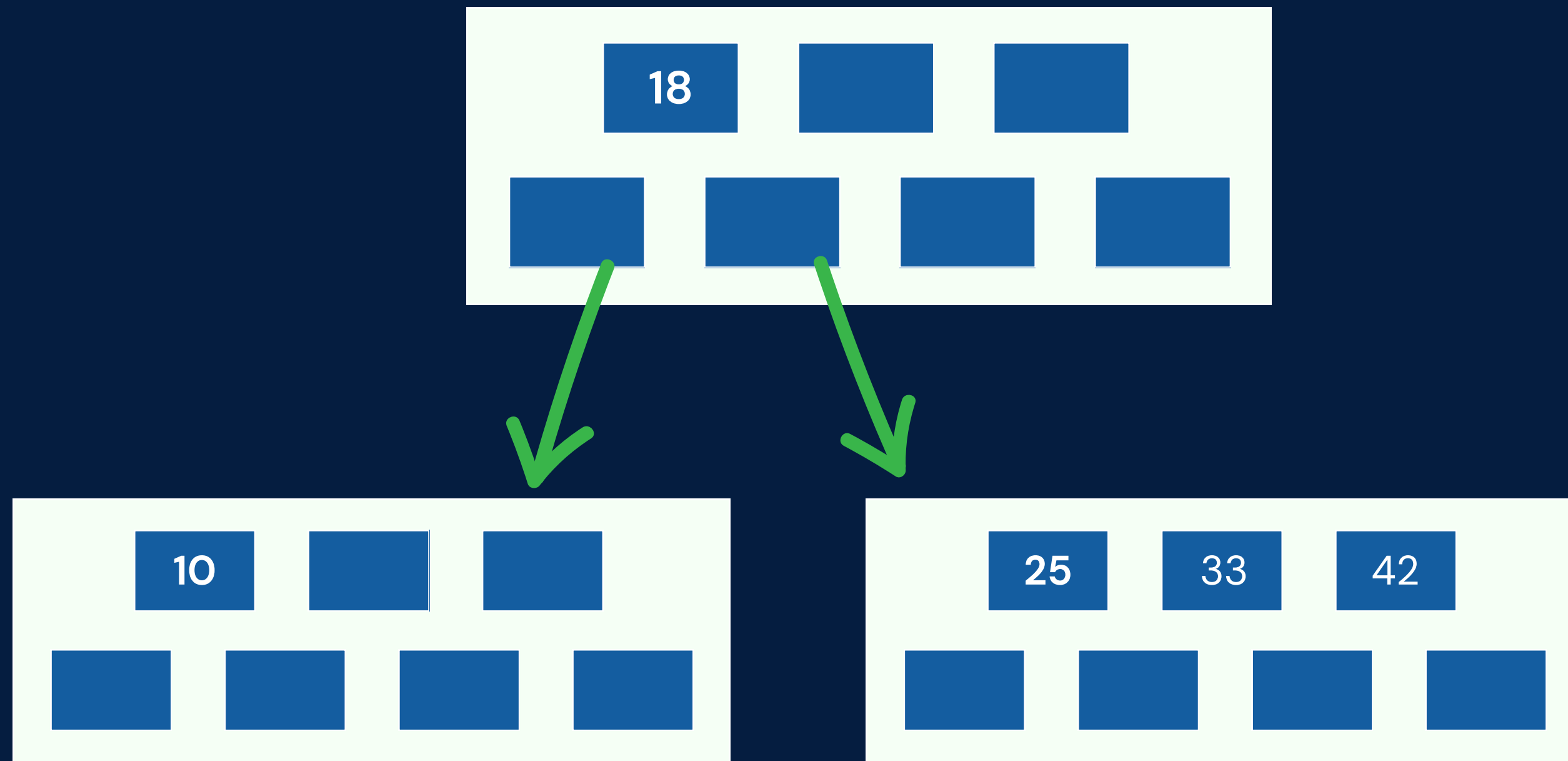
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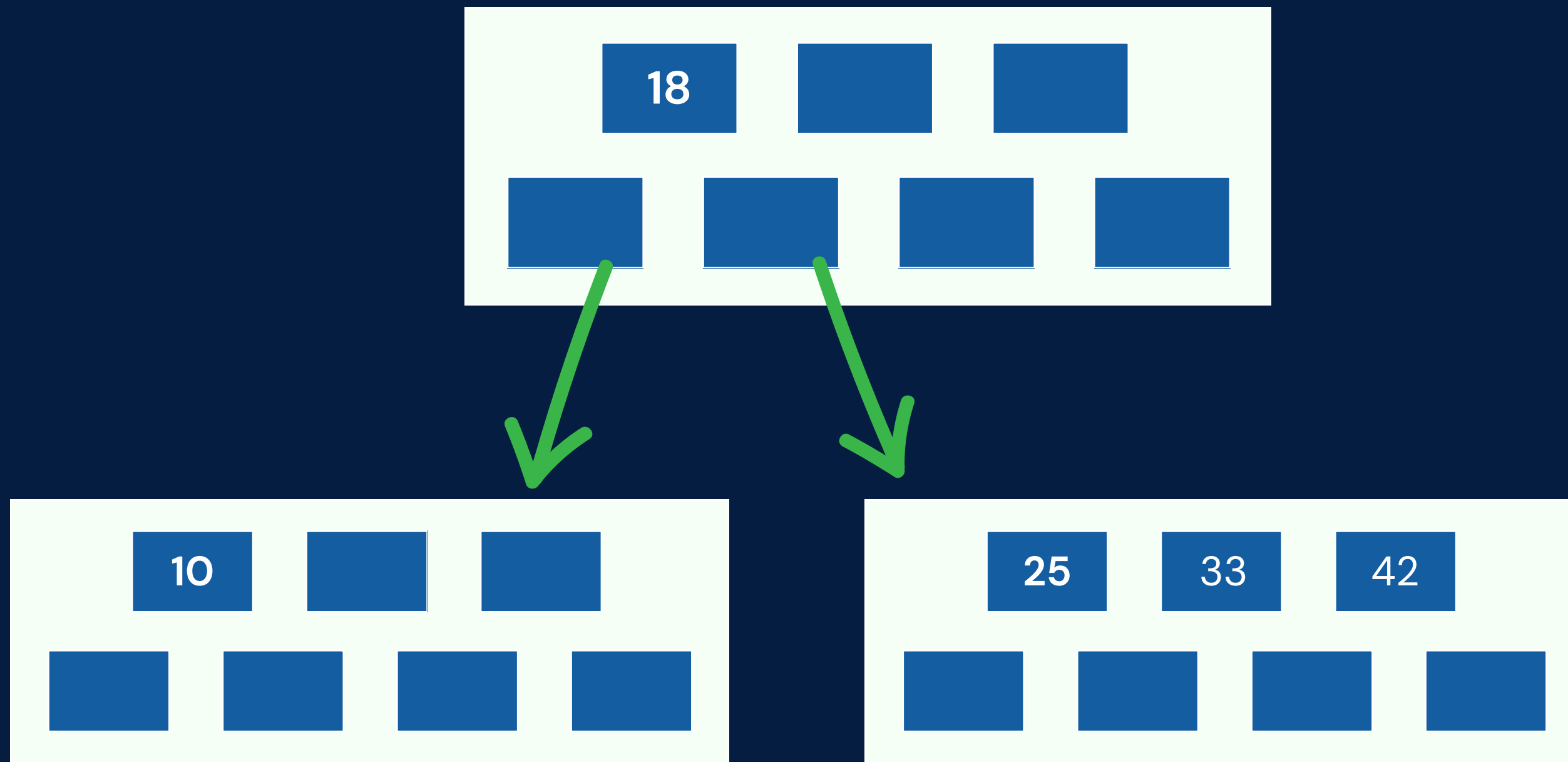
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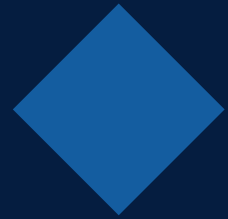
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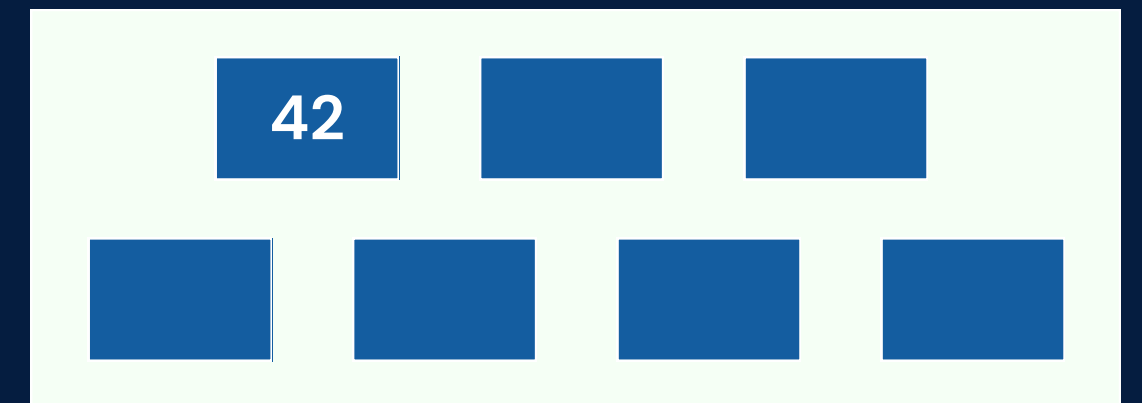
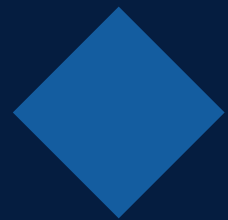
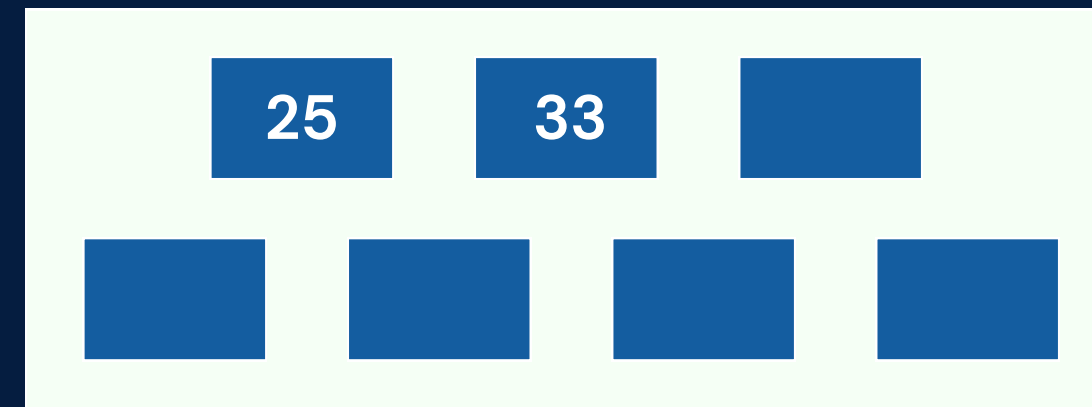
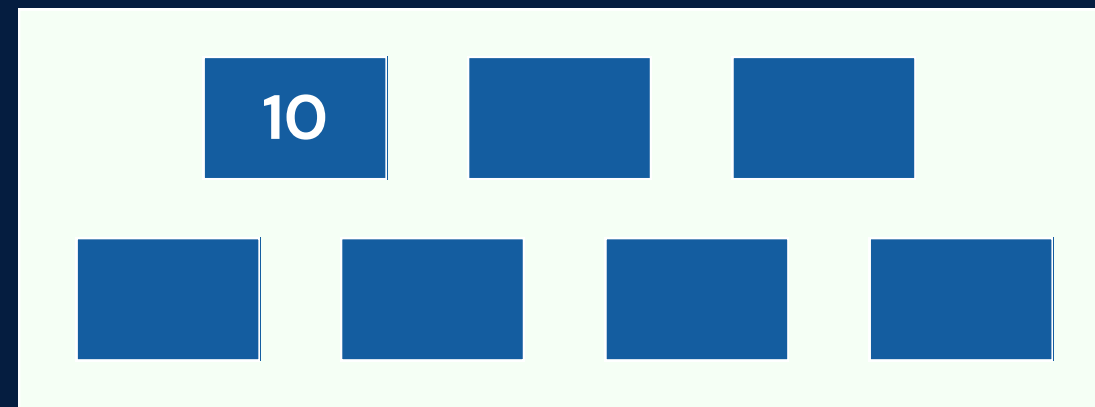
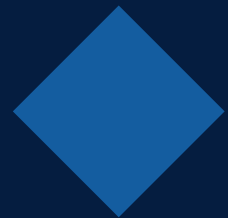
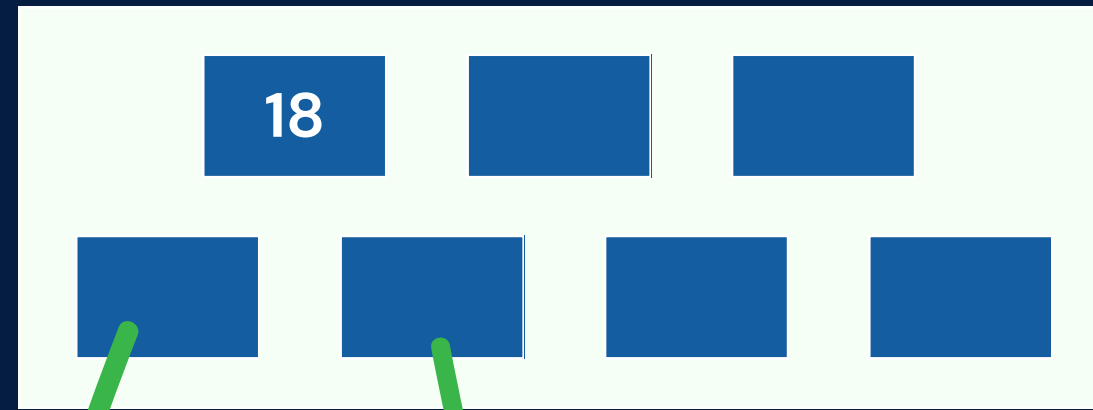
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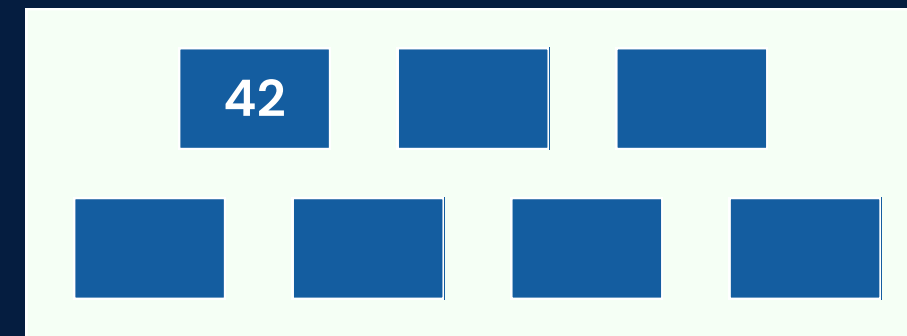
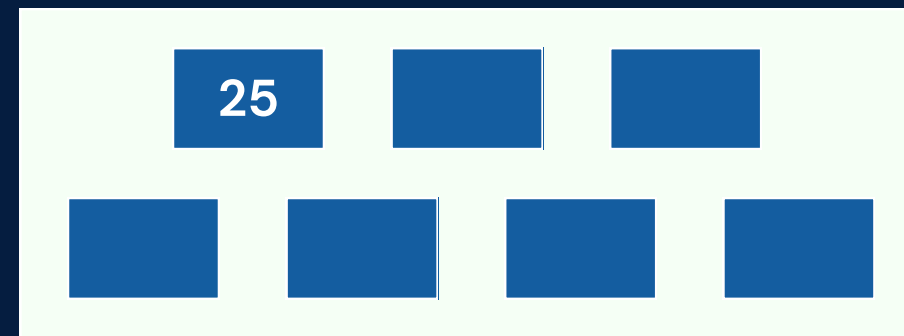
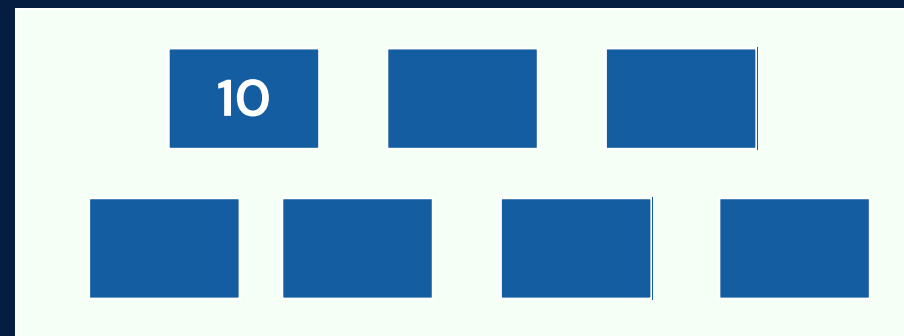
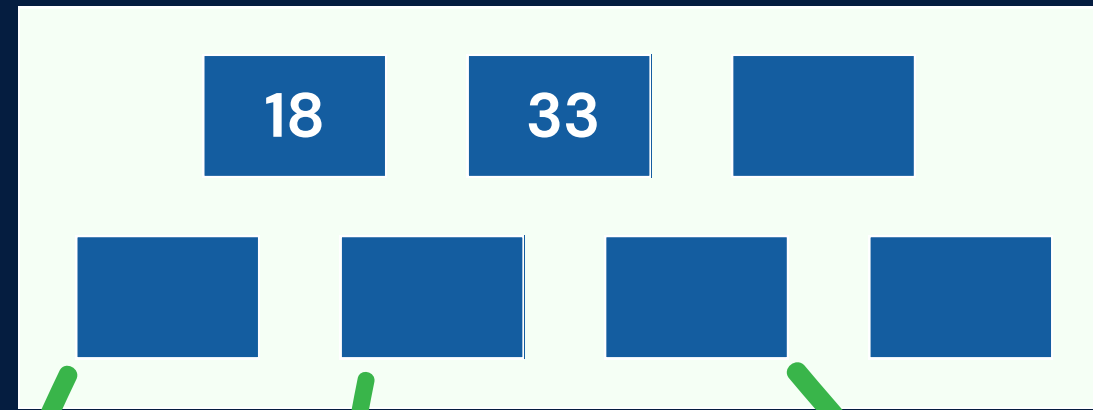
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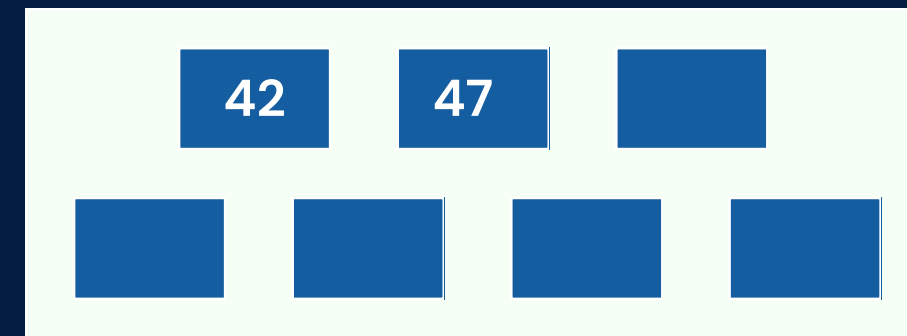
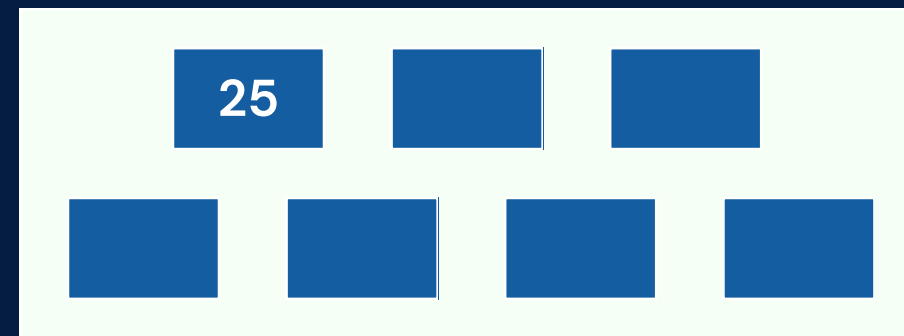
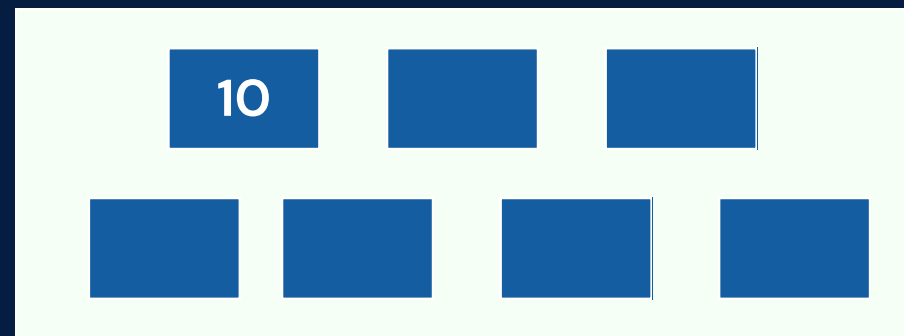
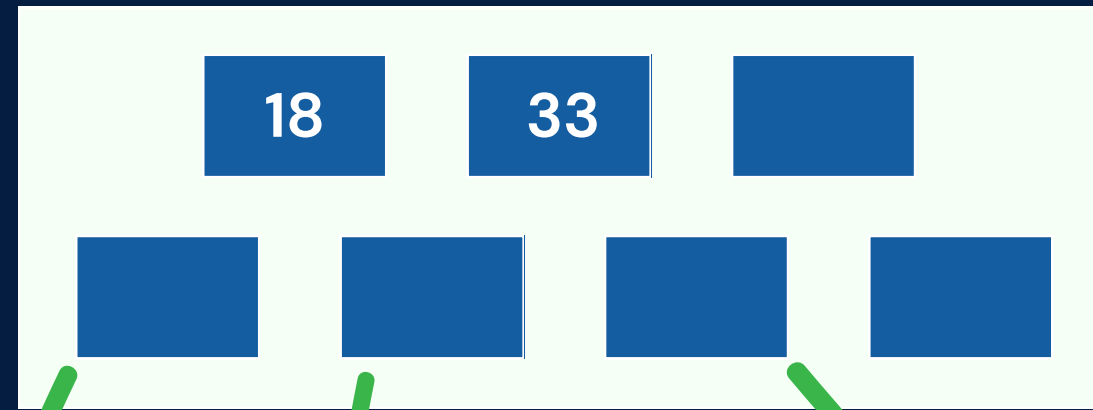
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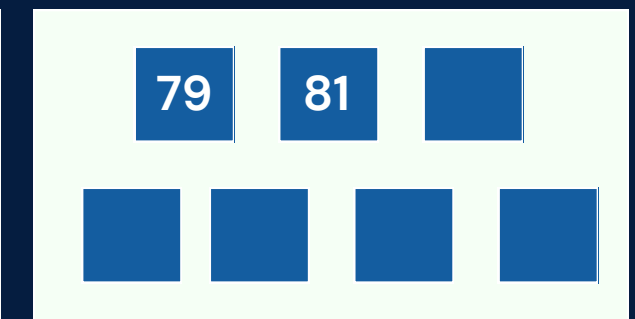
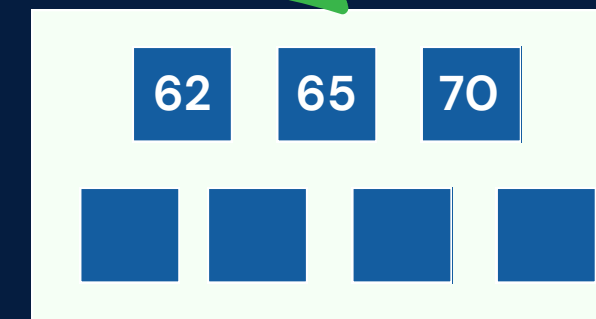
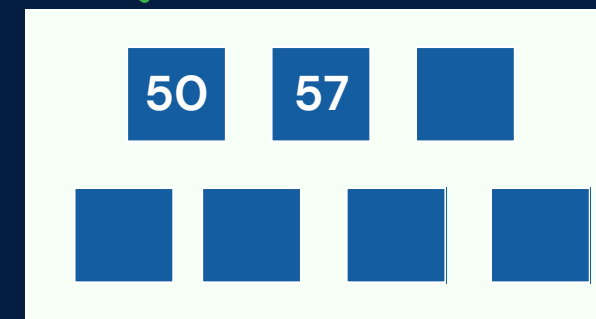
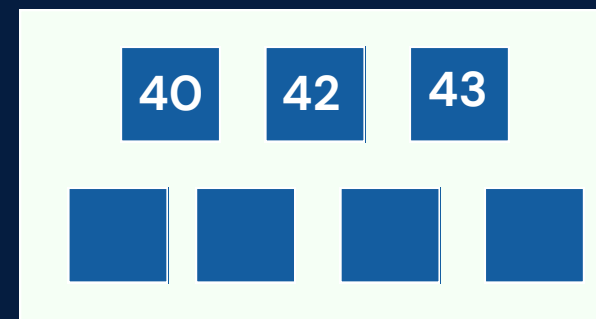
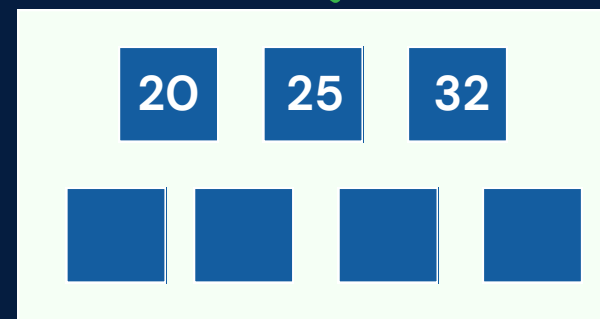
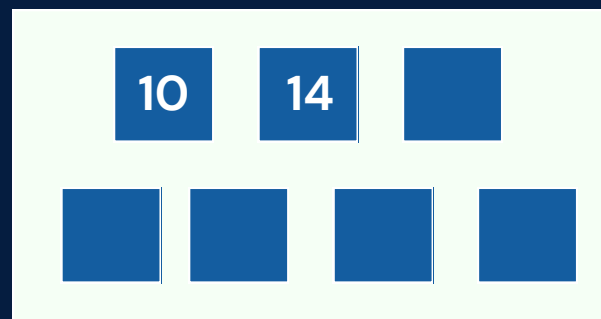
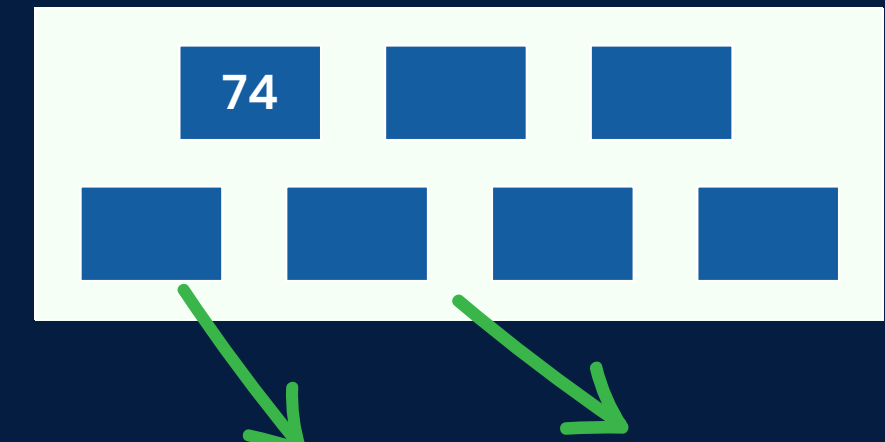
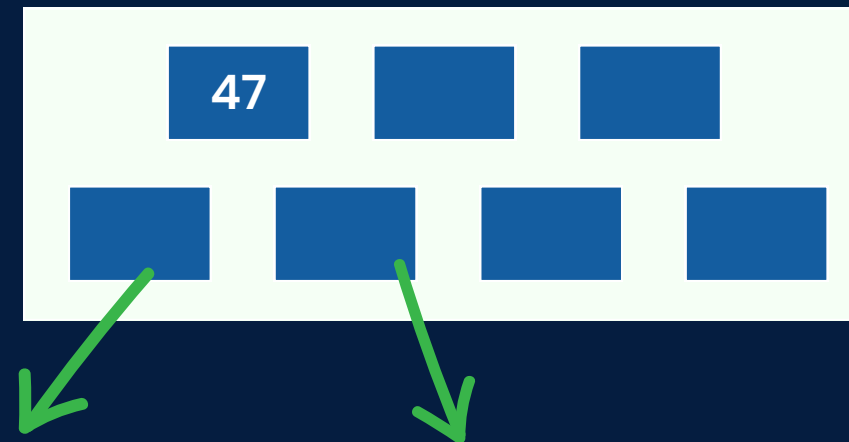
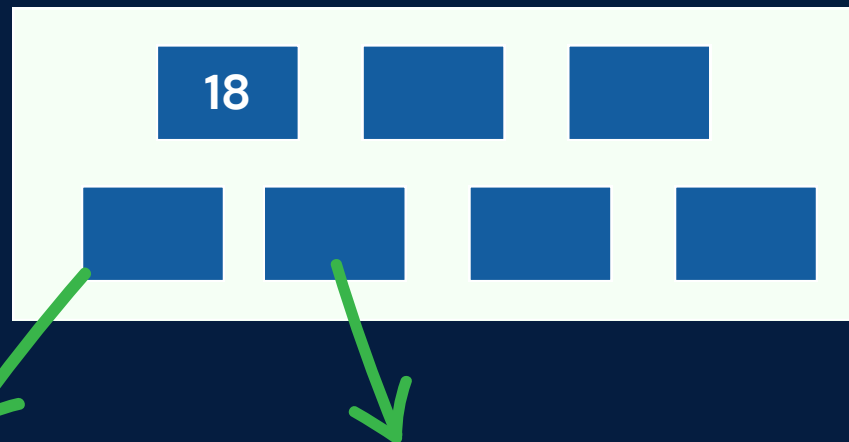
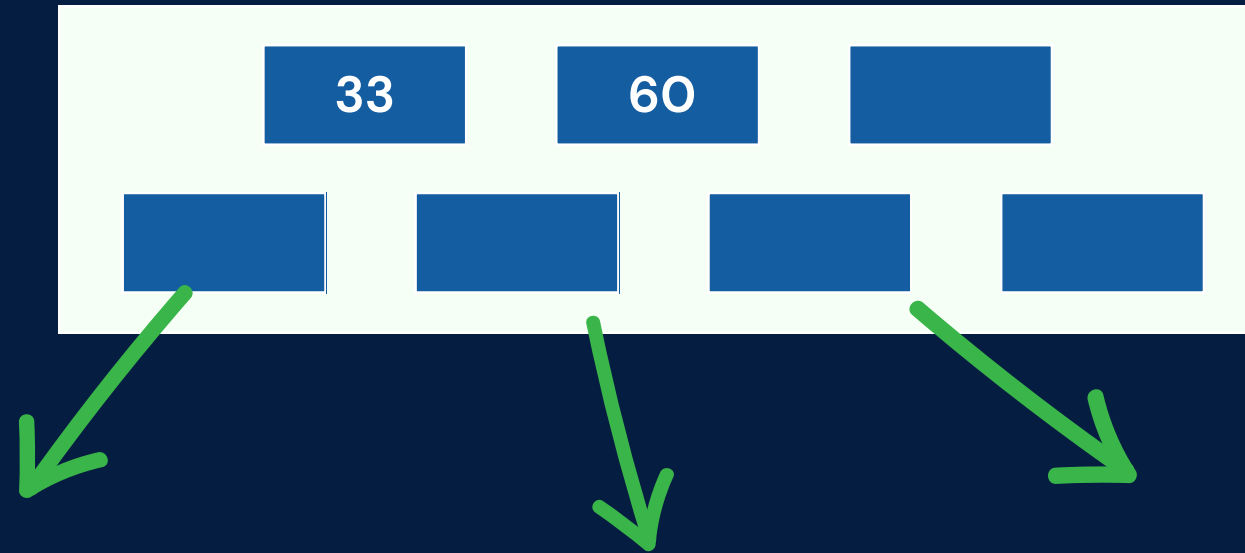
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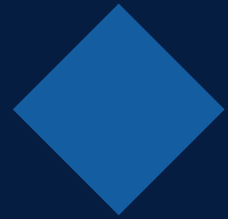


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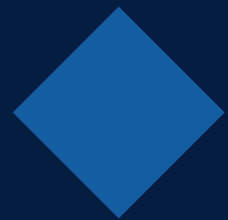
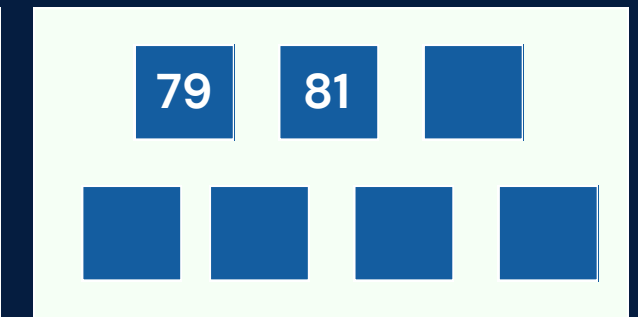
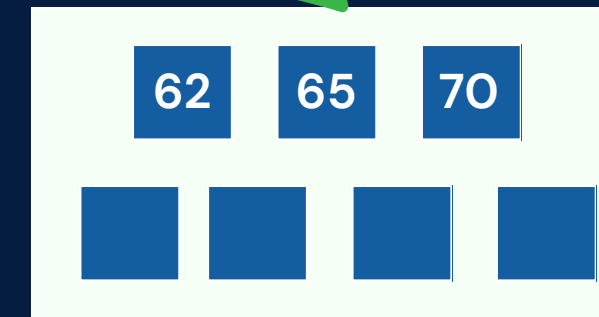
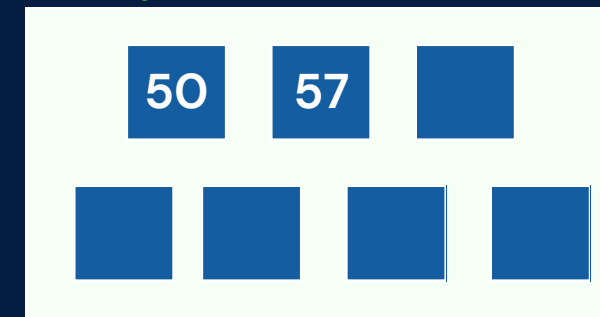
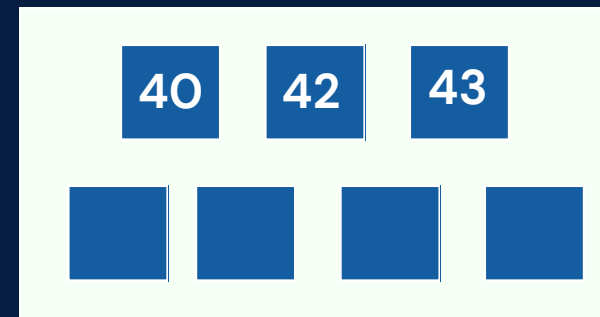
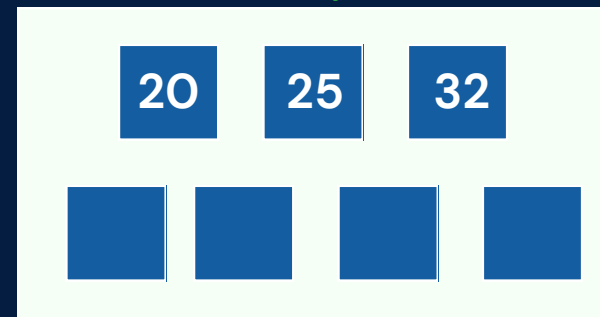
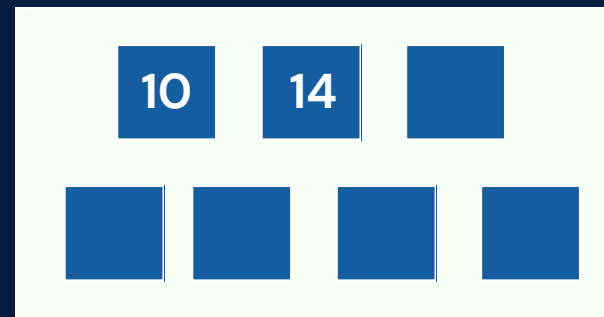
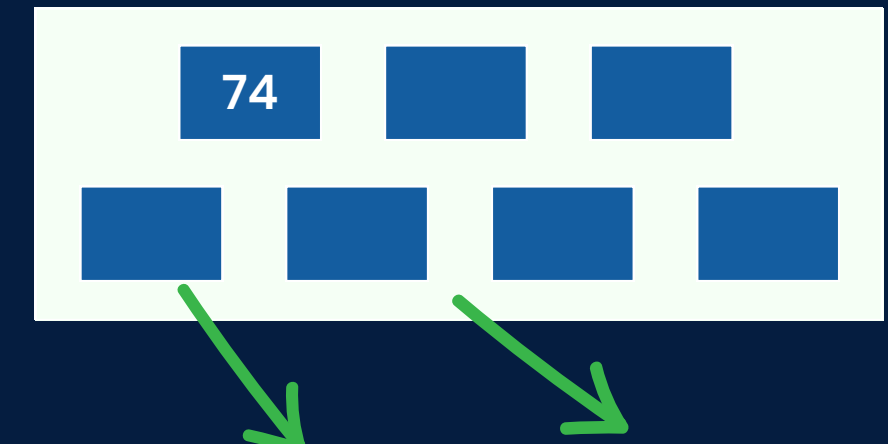
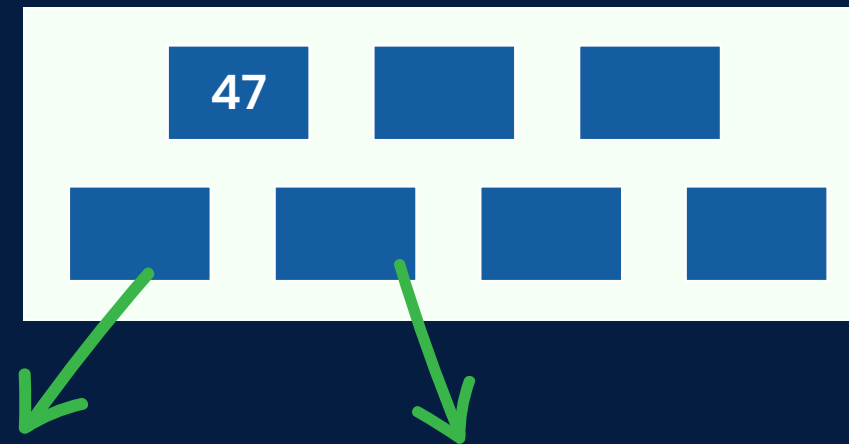
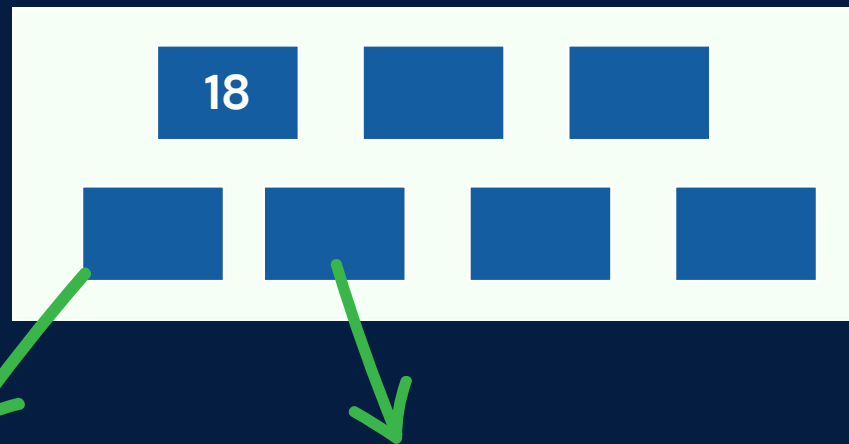
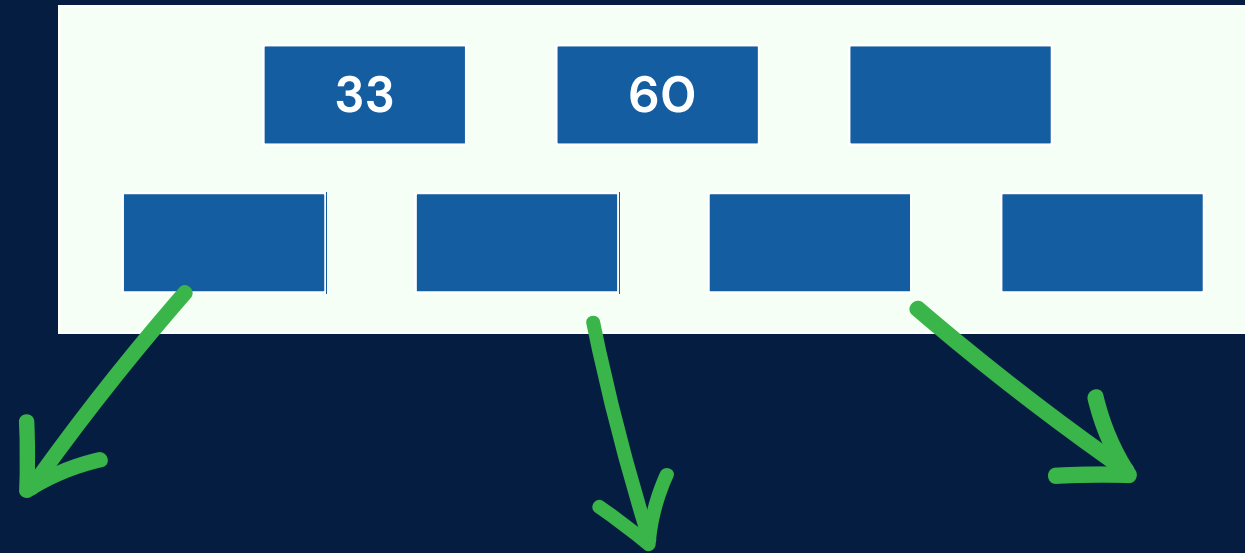
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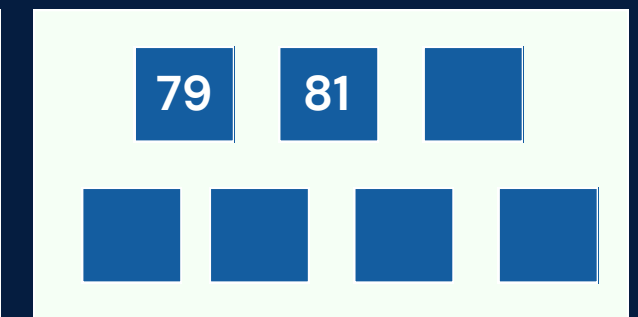
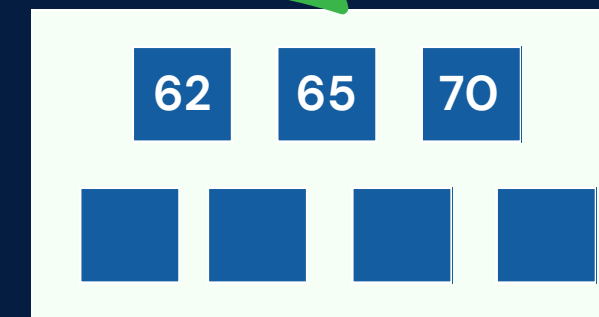
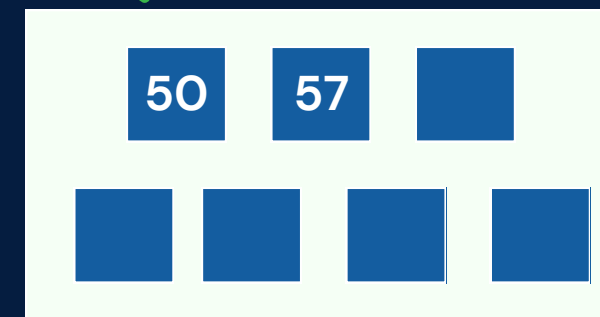
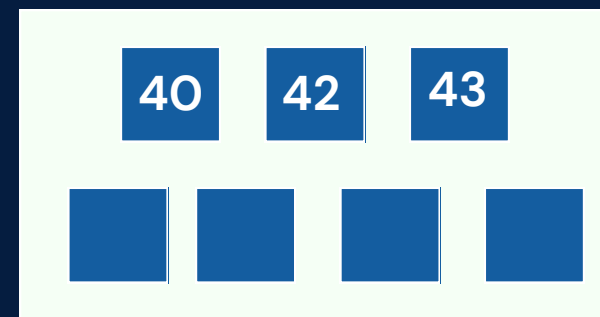
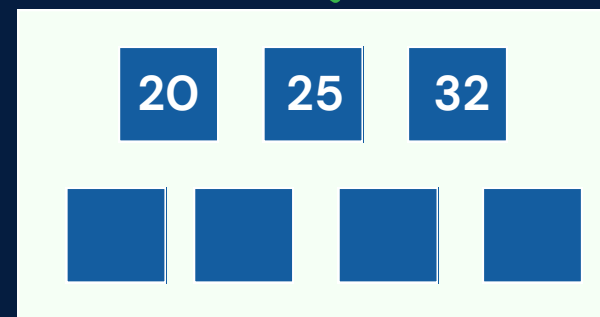
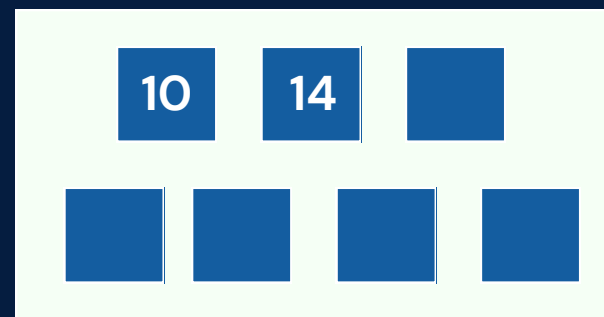
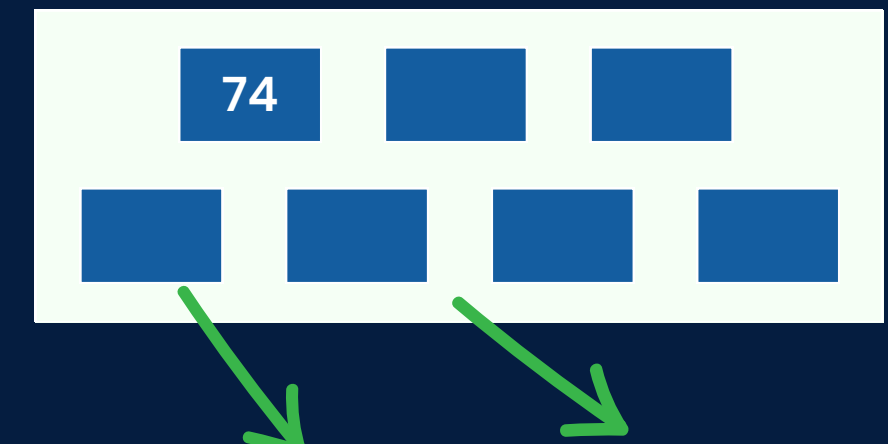
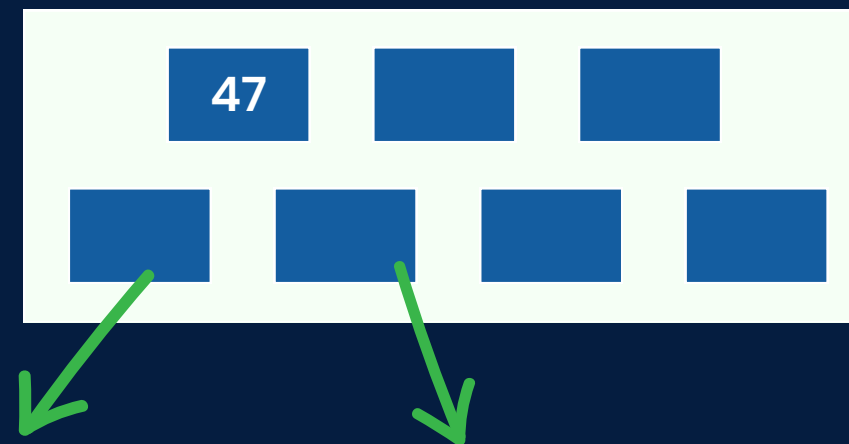
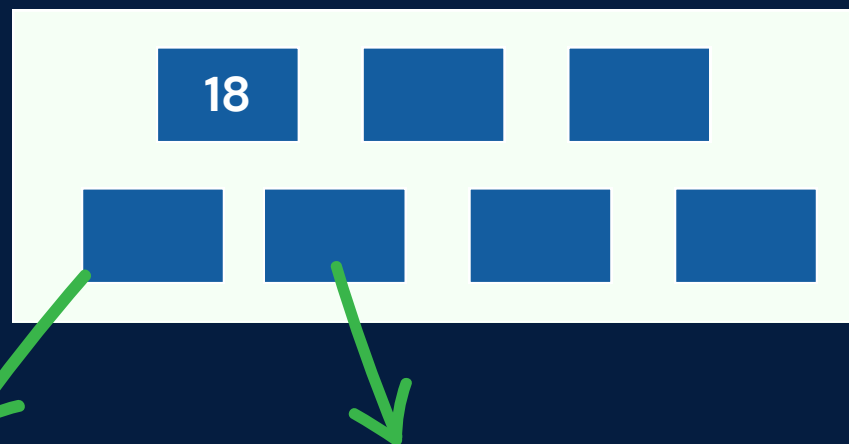
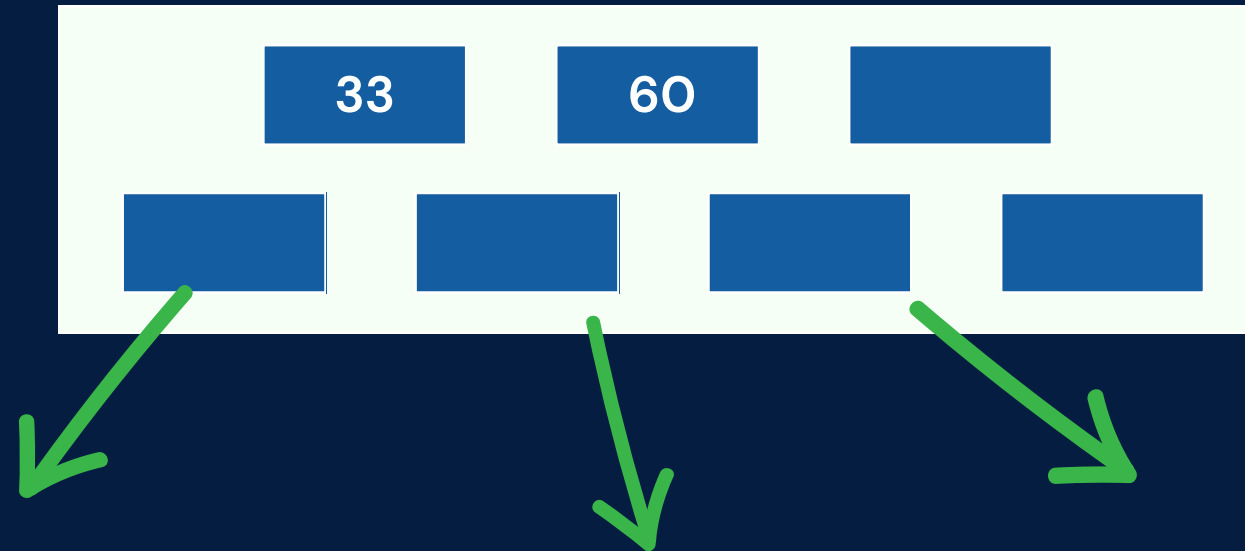
BUSCA

18,25,100,70



REMOÇÃO

60,10,25,43,65,81,14,74,18,32,40,57,70,50,42,47,62,79



REMOÇÃO

60,10,25,43,65,81,14,74,18,32,40,57,70,50,42,47,62,79

Caso 1

Remover uma chave em um nó intermediário. Buscar o maior dos menores ou o menor dos maiores e troca com a chave a ser removida. O maior ou o menor sempre estarão em uma folha.

Remover uma chave em um nó intermediário quando o maior dos menores e o menor dos maiores está sozinho no nó folha. Remove o elemento e faz uma junção com os filhos.

Caso 2

Caso 3

Remoção em nó folha com mais de uma chave. Remove a chave e verifica a ordenação.

Remoção em nó folha com apenas uma chave e raiz da árvore. Remove e libera a memória do nó.

Caso 4

Caso 5

Remoção em nó folha com apenas uma chave, não é raiz e irmão adjacente tem mais de 1 chave. Pai desce para o nó onde foi removido a chave e sobe uma chave do irmão adjacente.

Remoção em nó folha com apenas uma chave e não é raiz. Pai e irmão com apenas 1 chave. Remove o nó e faz uma junção.

Caso 6

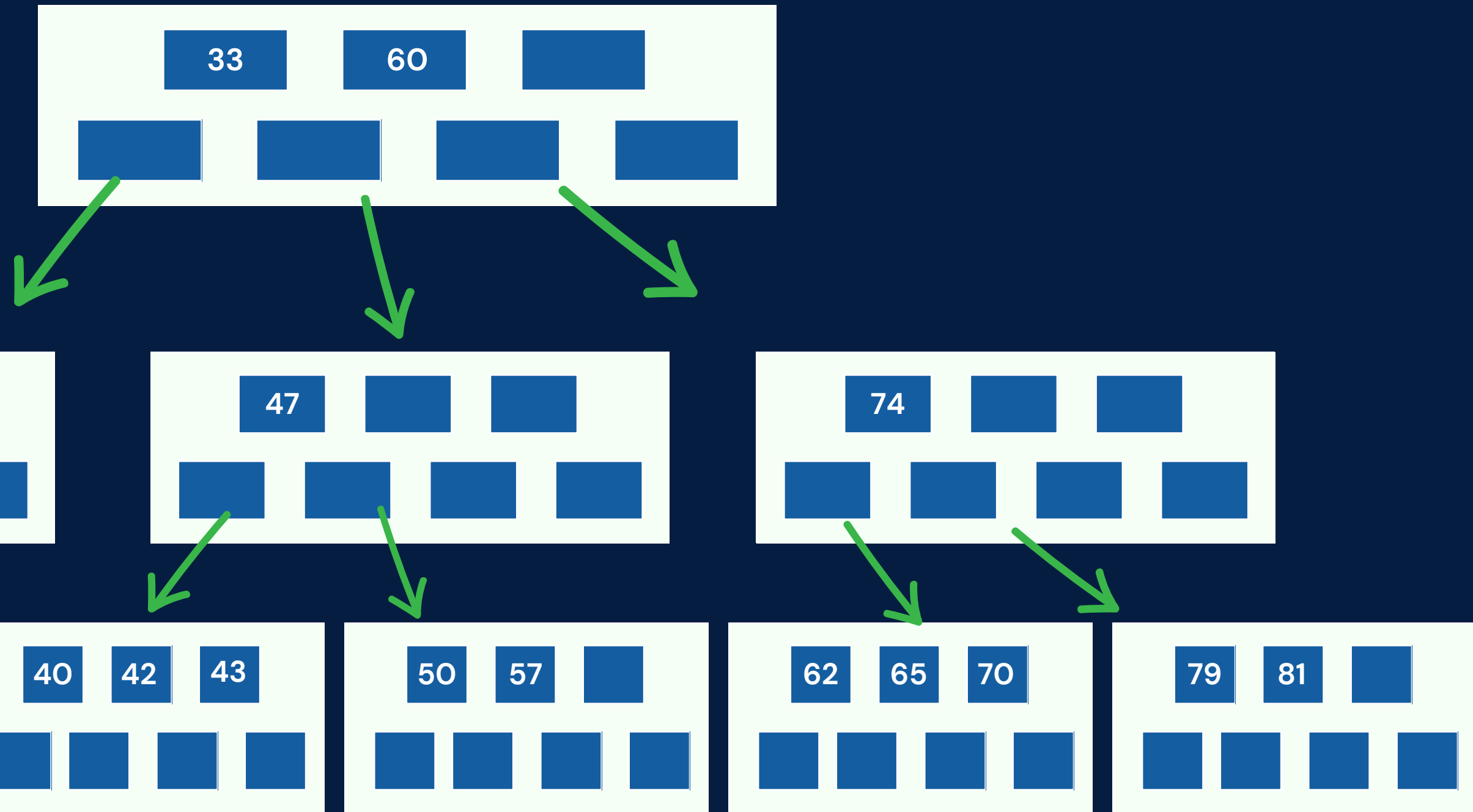
Caso 7

Remoção em nó folha. Nó pai tem mais de 1 chave e os irmãos têm apenas 1 chave. Junção e rotação. Uma chave do pai desce para um dos filhos e este filho ocupa a posição do nó removido.

REMOÇÃO

60,10,25,43,65,81,14,74,18,32,40,57,70,50,42,47,62,79

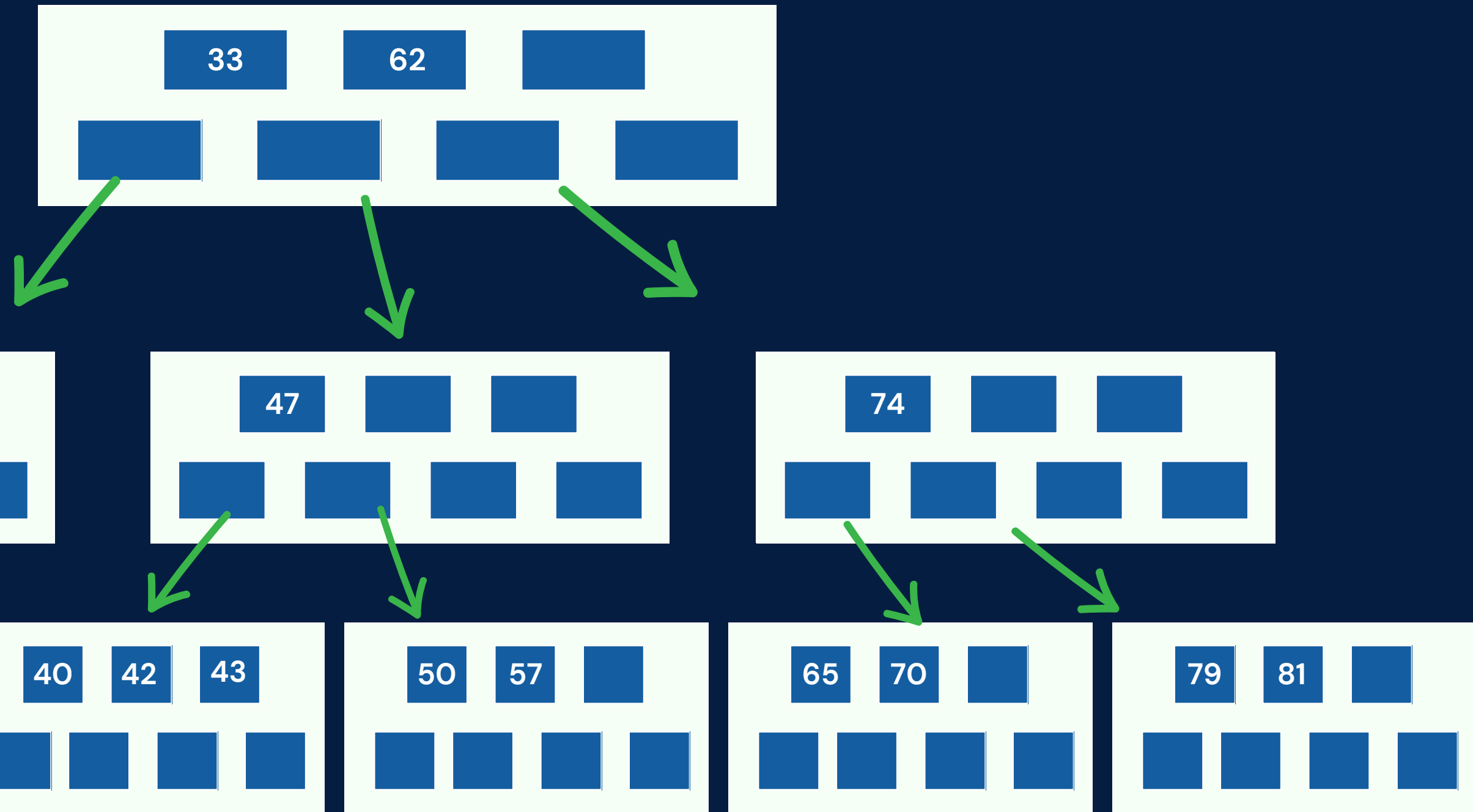
CASO 1: BUSCAR O MAIOR DOS MENORES
OU O MENOR DOS MAIORES E TROCA
COM A CHAVE A SER REMOVIDA. O
MAIOR OU O MENOR SEMPRE ESTARÃO
EM UMA FOLHA. PODE FAZER POIS A
FOLHA POSSUI MAIS DE UMA CHAVE



REMOÇÃO

60,10,25,43,65,81,14,74,18,32,40,57,70,50,42,47,62,79

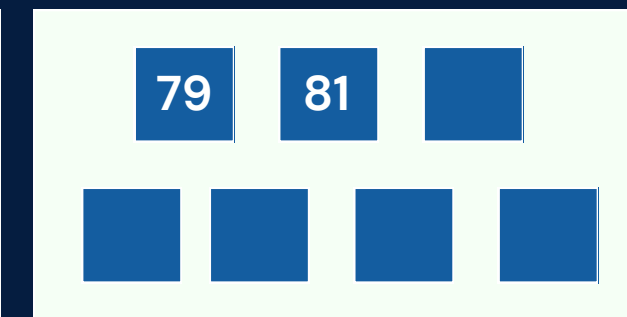
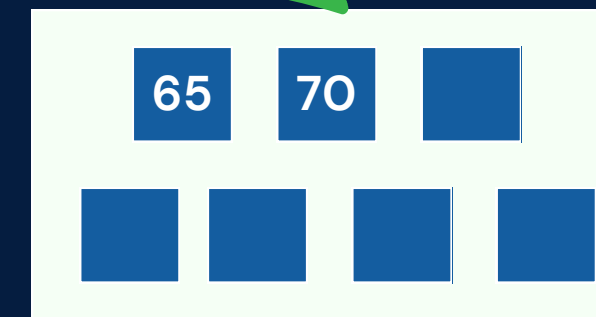
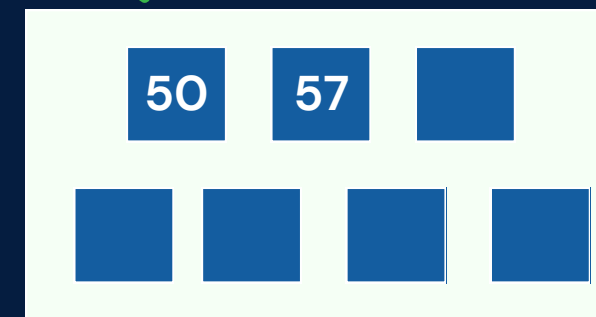
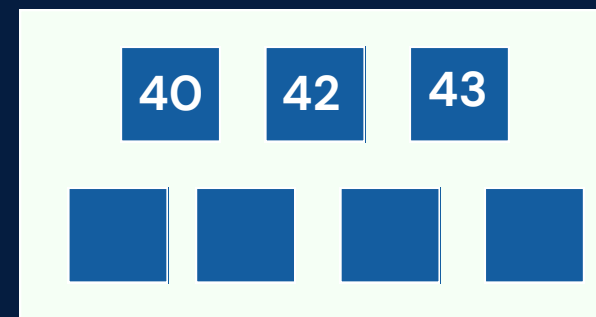
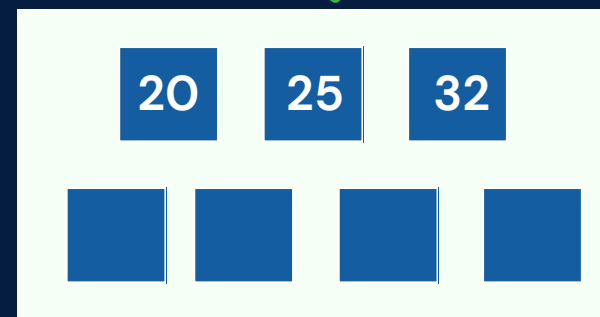
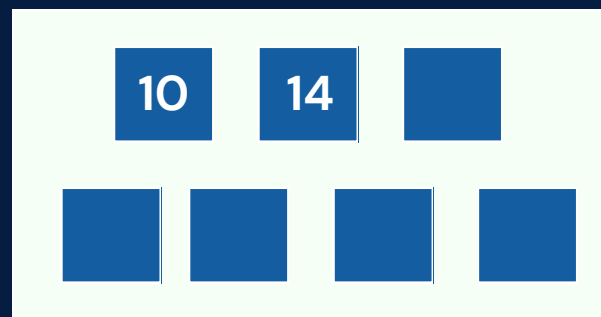
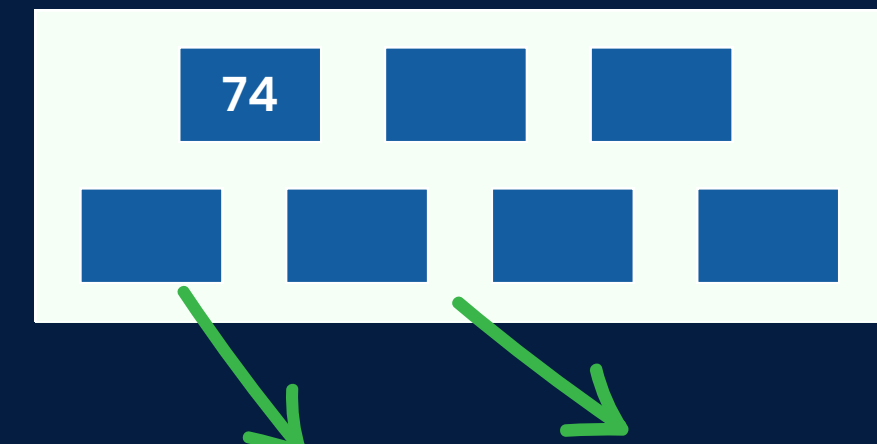
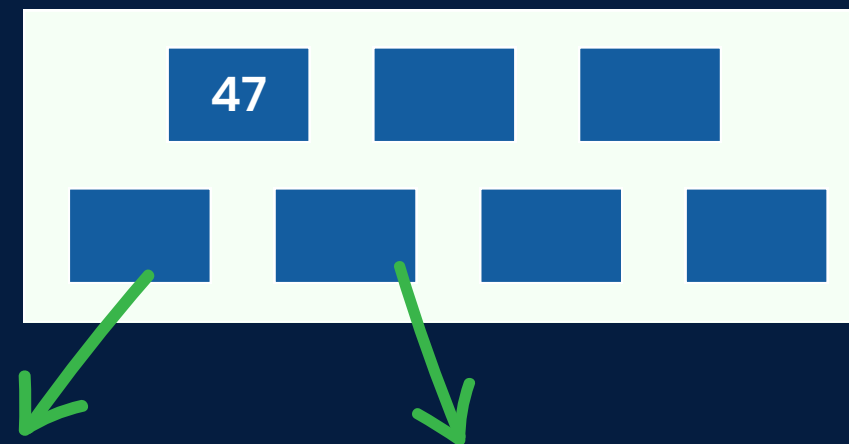
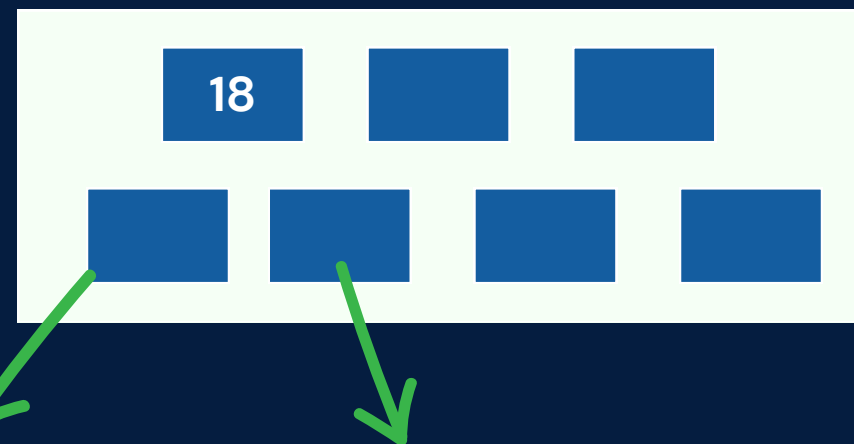
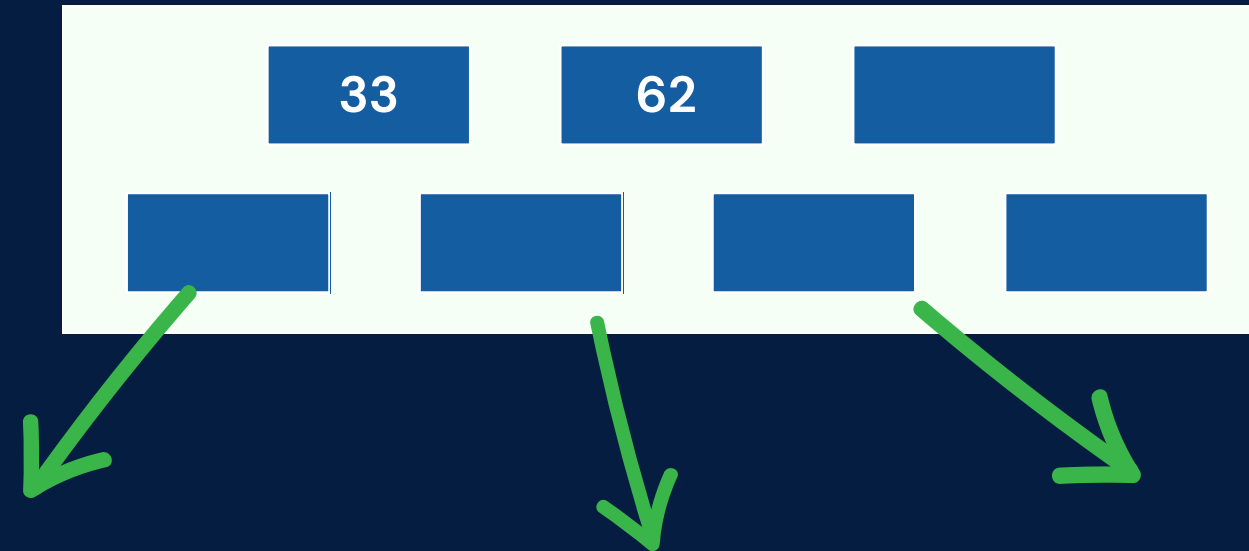
CASO 1: BUSCAR O MAIOR DOS MENORES
OU O MENOR DOS MAIORES E TROCA
COM A CHAVE A SER REMOVIDA. O
MAIOR OU O MENOR SEMPRE ESTARÃO
EM UMA FOLHA. PODE FAZER POIS A
FOLHA POSSUI MAIS DE UMA CHAVE



REMOÇÃO

10,25,43,65,81,14,74,18,32,40,57,70,50,42,47,62,79

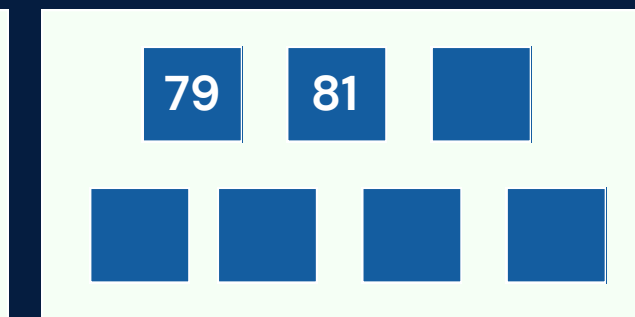
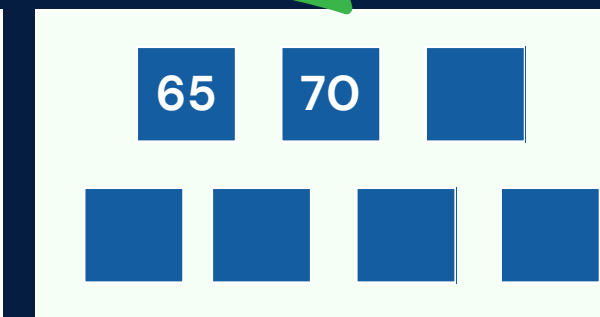
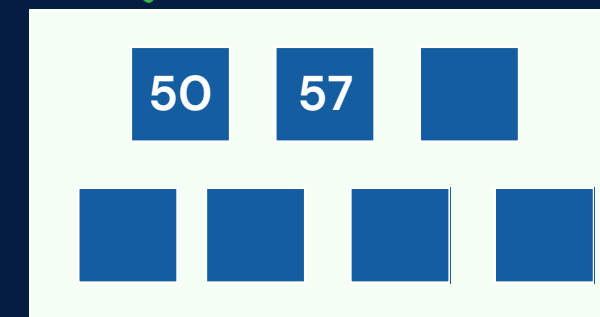
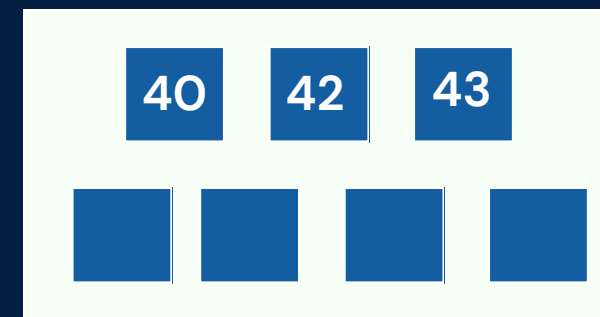
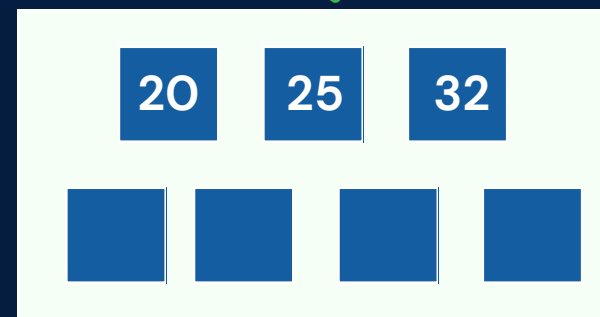
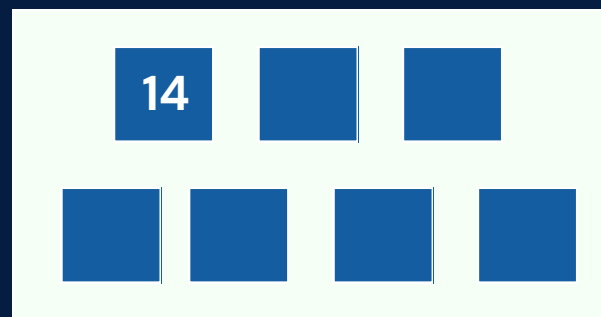
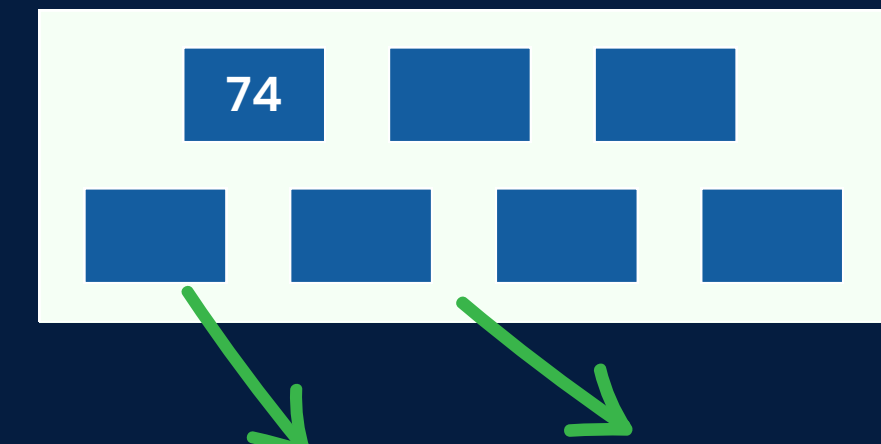
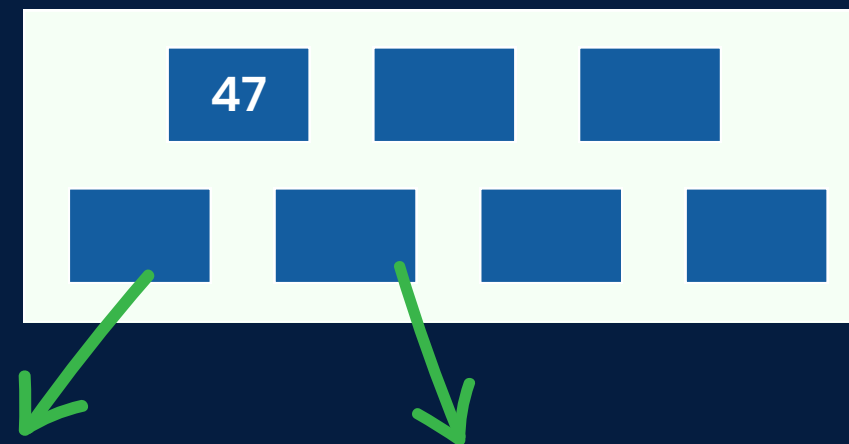
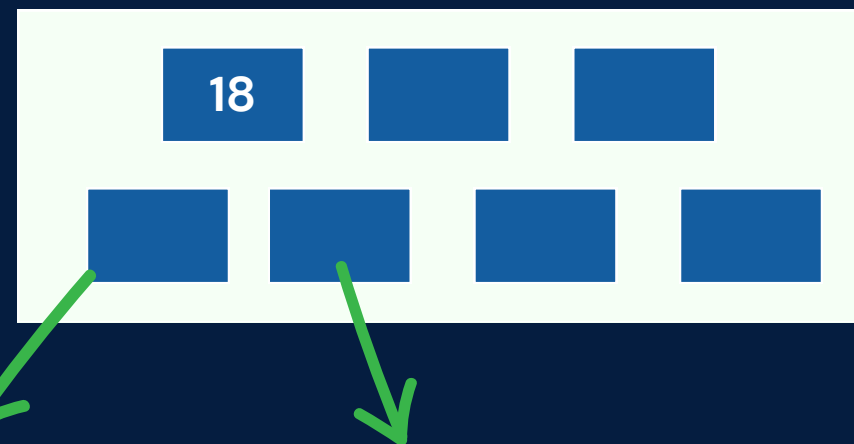
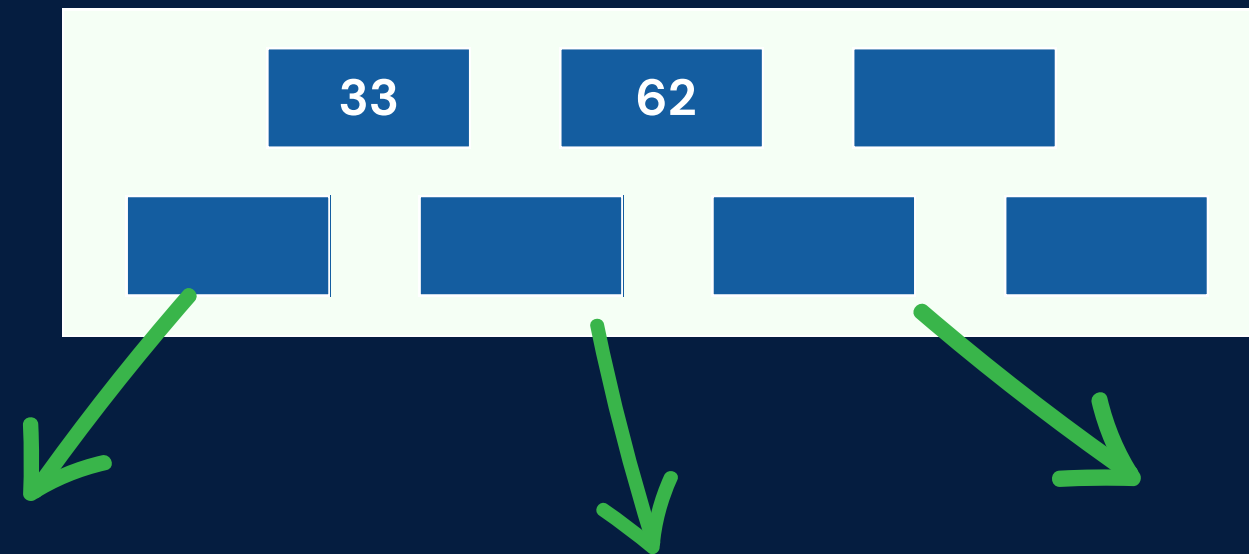
CASO 3: REMOÇÃO EM NÓ FOLHA COM MAIS DE UMA CHAVE. REMOVE A CHAVE E VERIFICA A ORDENAÇÃO.



REMOÇÃO

25,43,65,81,14,74,18,32,40,57,70,50,42,47,62,79

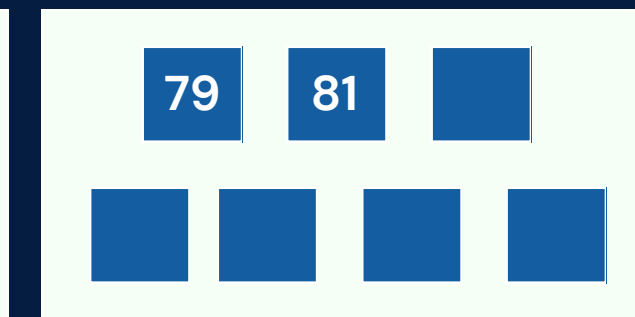
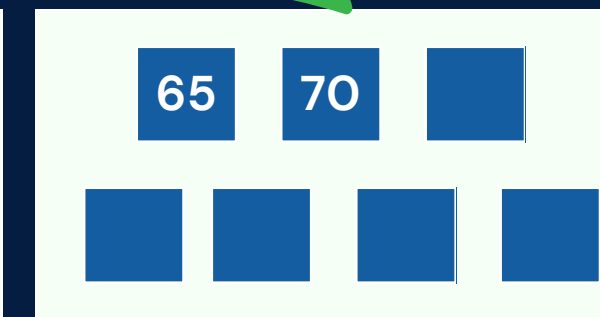
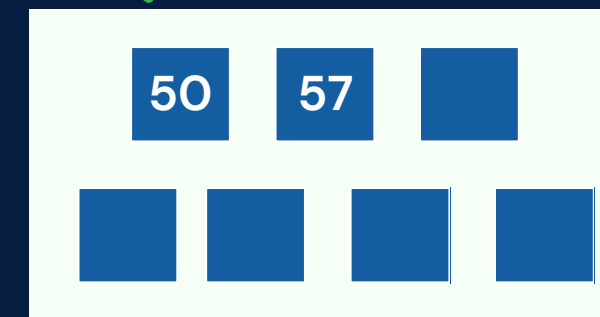
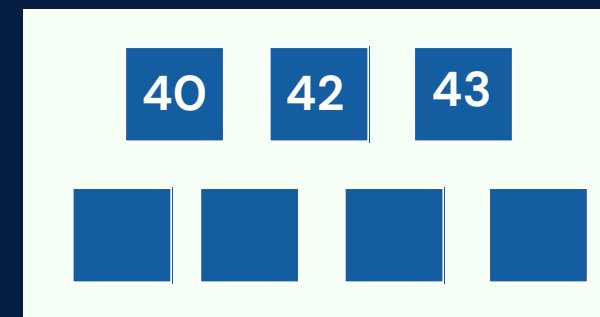
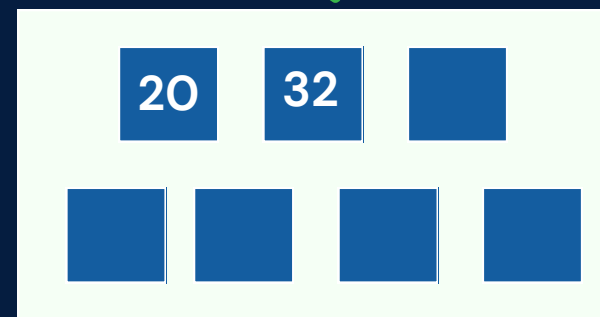
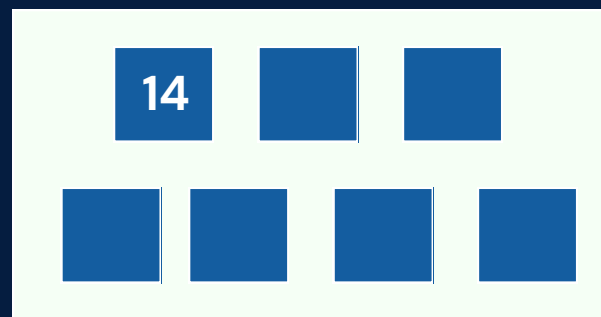
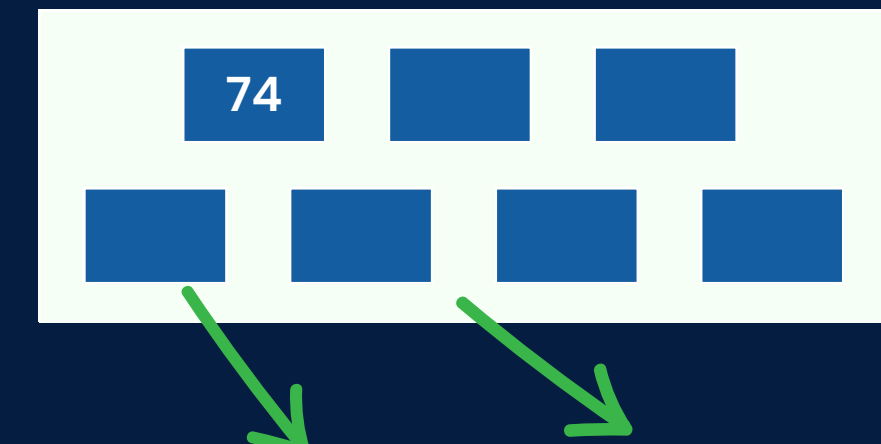
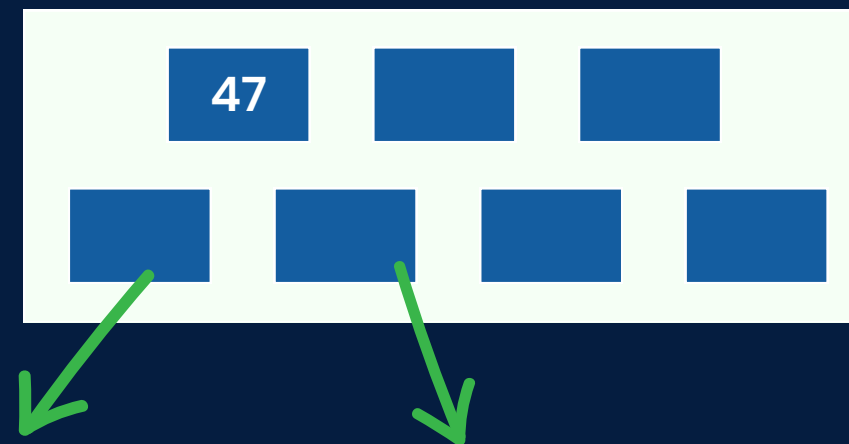
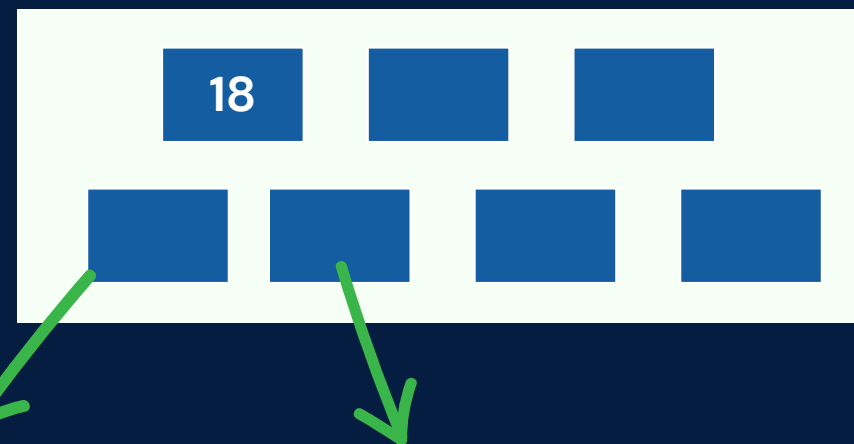
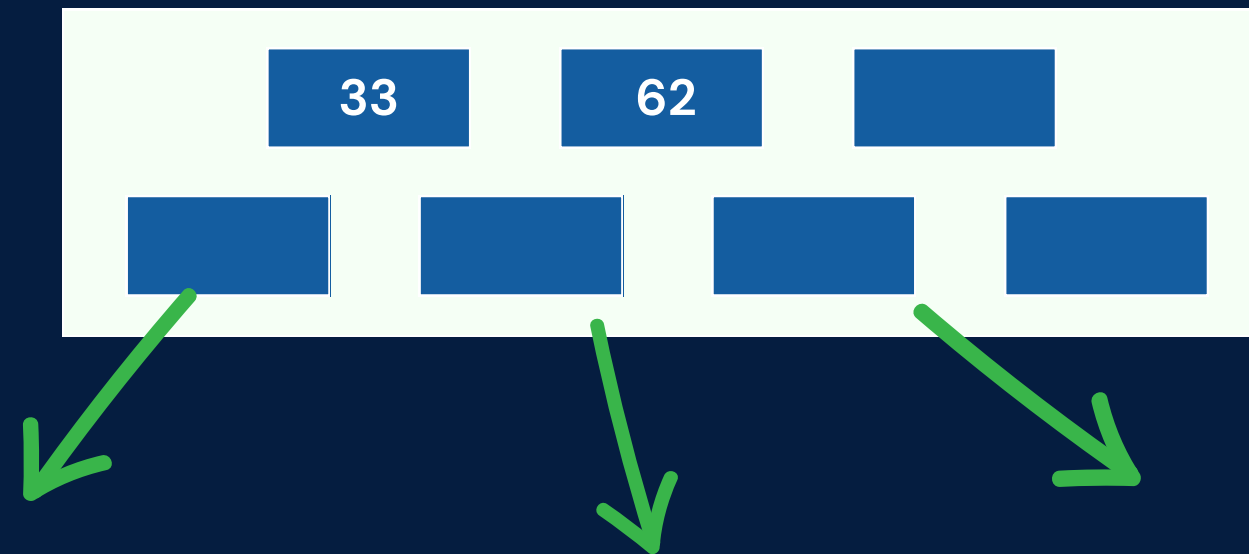
CASO 3: REMOÇÃO EM NÓ FOLHA COM MAIS DE UMA CHAVE. REMOVE A CHAVE E VERIFICA A ORDENAÇÃO.



REMOÇÃO

43,65,81,14,74,18,32,40,57,70,50,42,47,62,79

CASO 3: REMOÇÃO EM NÓ FOLHA COM MAIS DE UMA CHAVE. REMOVE A CHAVE E VERIFICA A ORDENAÇÃO.



REMOÇÃO

14,74,18,32,40,57,70,50,42,47,62,79

CASO 5: REMOÇÃO EM NÓ FOLHA COM APENAS UMA CHAVE, NÃO É RAIZ E IRMÃO ADJACENTE TEM MAIS DE 1 CHAVE. PAI DESCE PARA O NÓ ONDE FOI REMOVIDO A CHAVE E SOBE UMA CHAVE DO IRMÃO ADJACENTE.



REMOÇÃO

14,74,18,32,40,57,70,50,42,47,62,79

CASO 5: REMOÇÃO EM NÓ FOLHA COM APENAS UMA CHAVE, NÃO É RAIZ E IRMÃO ADJACENTE TEM MAIS DE 1 CHAVE. PAI DESCE PARA O NÓ ONDE FOI REMOVIDO A CHAVE E SOBE UMA CHAVE DO IRMÃO ADJACENTE.



REMOÇÃO

14,74,18,32,40,57,70,50,42,47,62,79

CASO 5: REMOÇÃO EM NÓ FOLHA COM APENAS UMA CHAVE, NÃO É RAIZ E IRMÃO ADJACENTE TEM MAIS DE 1 CHAVE. PAI DESCE PARA O NÓ ONDE FOI REMOVIDO A CHAVE E SOBE UMA CHAVE DO IRMÃO ADJACENTE.

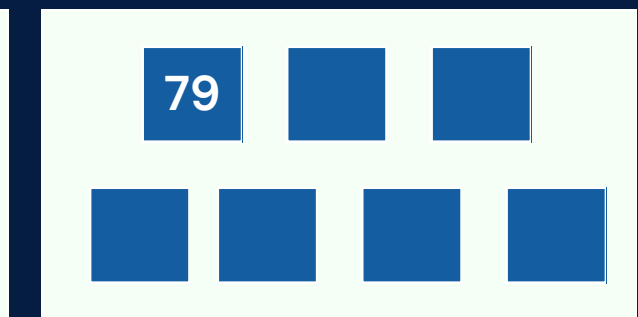
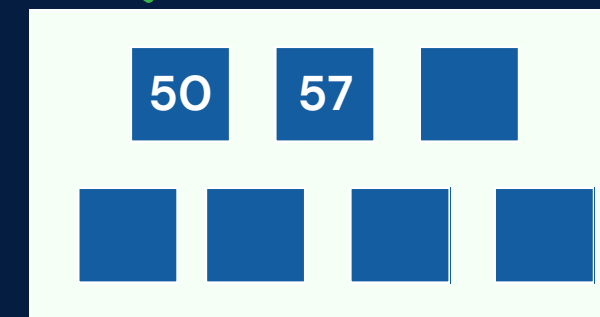
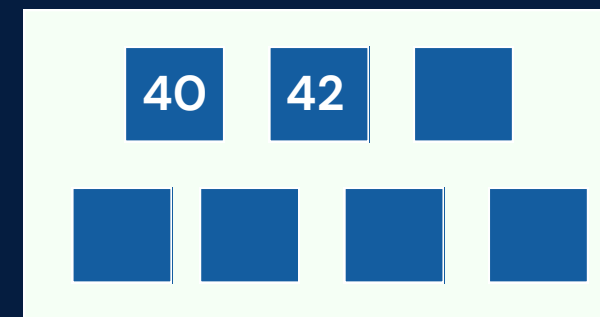
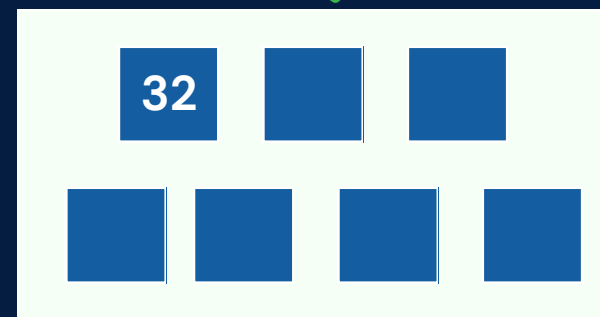
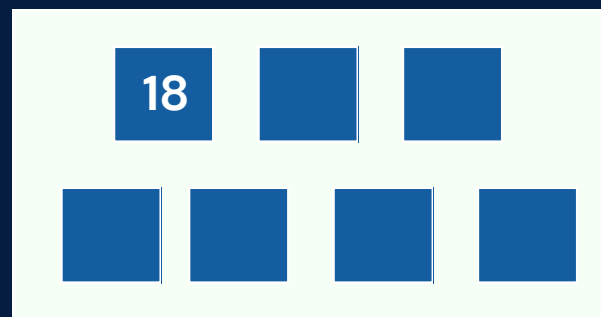
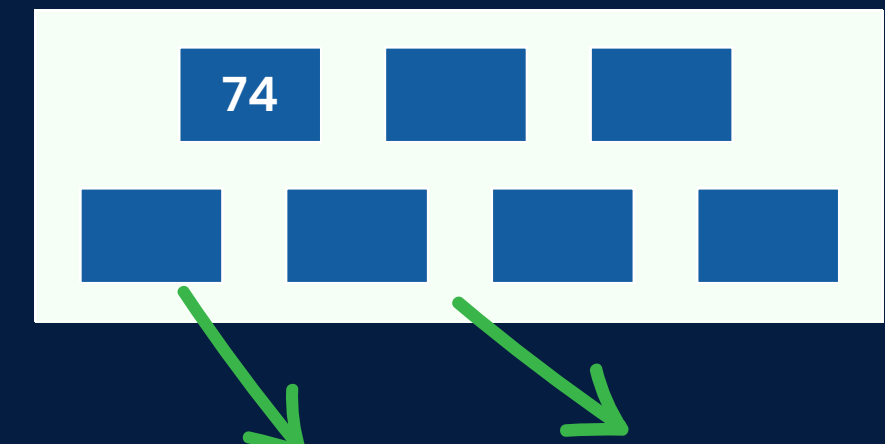
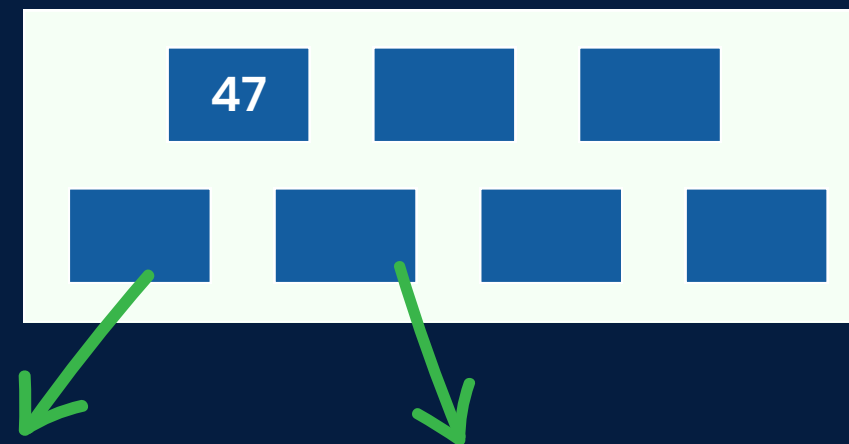
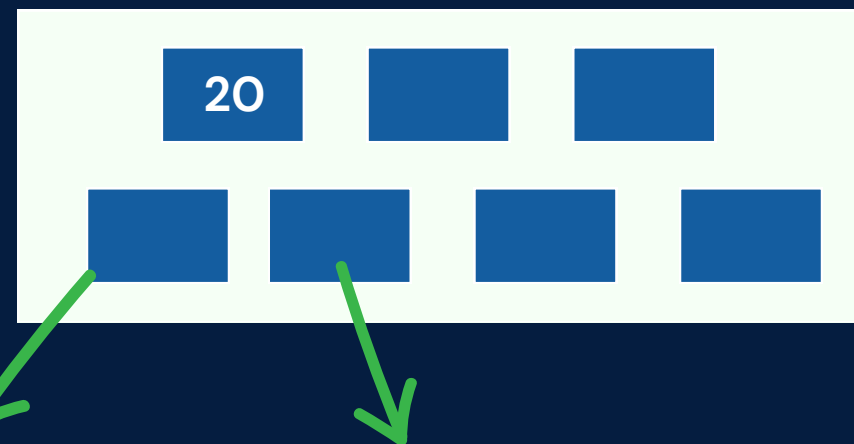
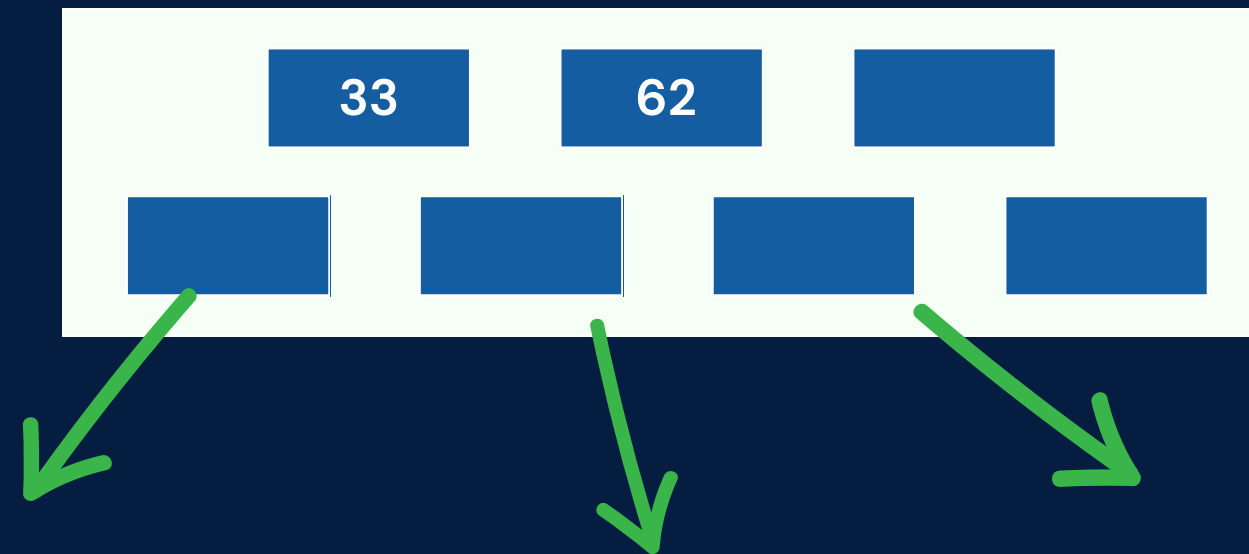


REMOÇÃO

74,18,32,40,57,70,50,42,62,79

CASO 2: REMOVER UMA CHAVE EM UM NÓ INTERMEDIÁRIO QUANDO O MAIOR DOS MENORES E O MENOR DOS MAIORES ESTÁ SOZINHO NO NÓ FOLHA. REMOVE O ELEMENTO E FAZ UMA JUNÇÃO COM OS FILHOS.

- JUNTA OS FILHOS
- UMA CHAVE DO PAI DESCE

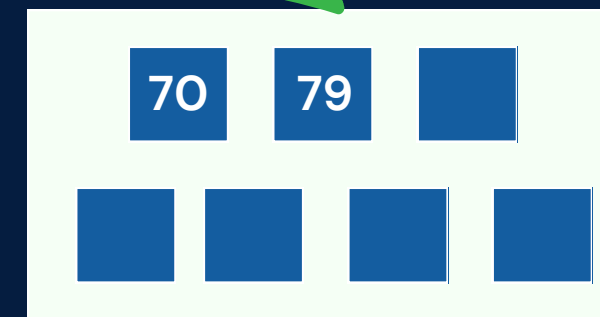
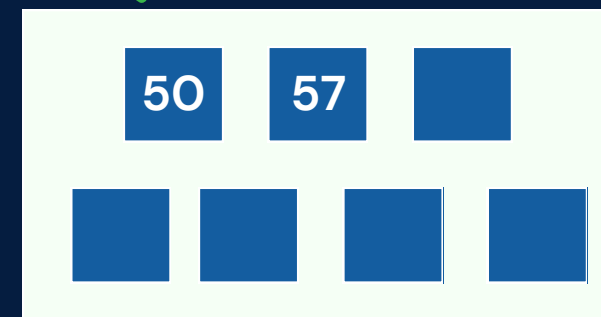
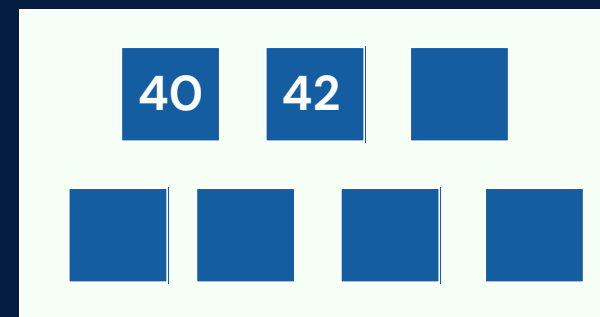
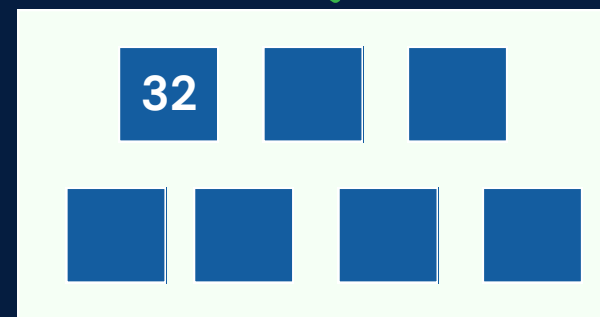
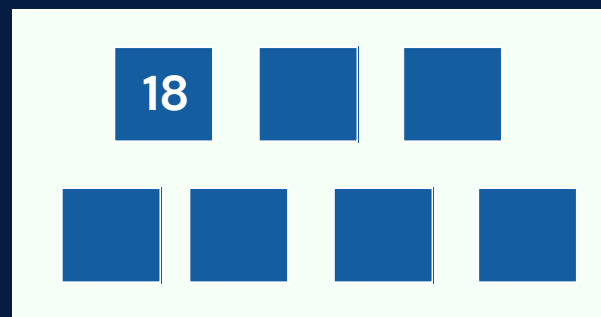
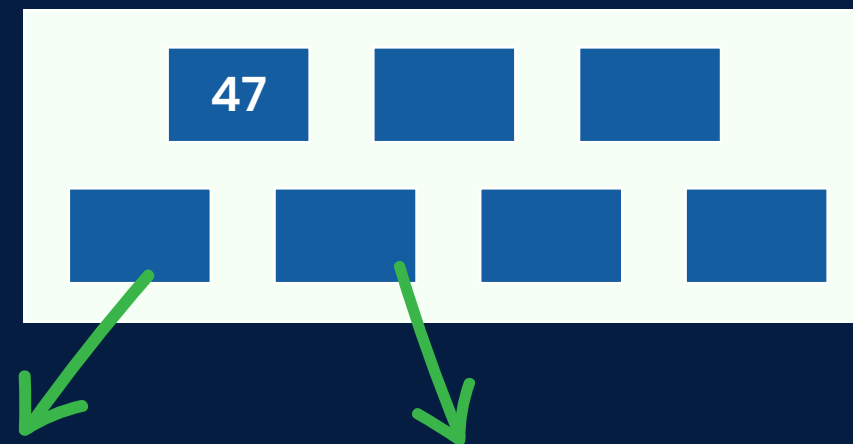
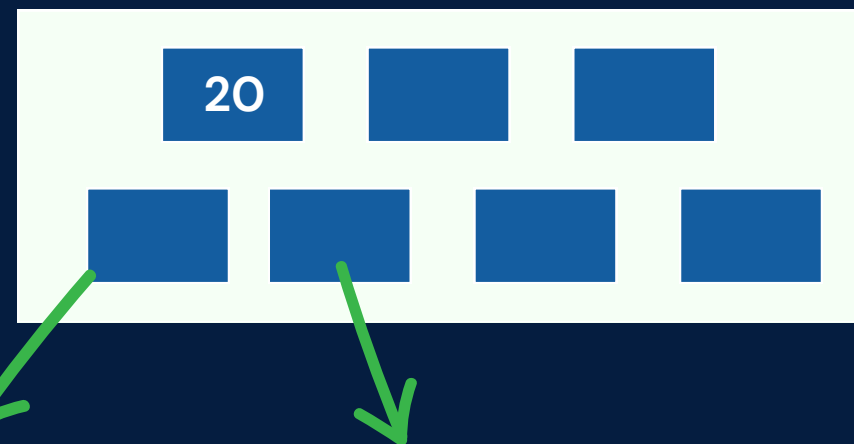
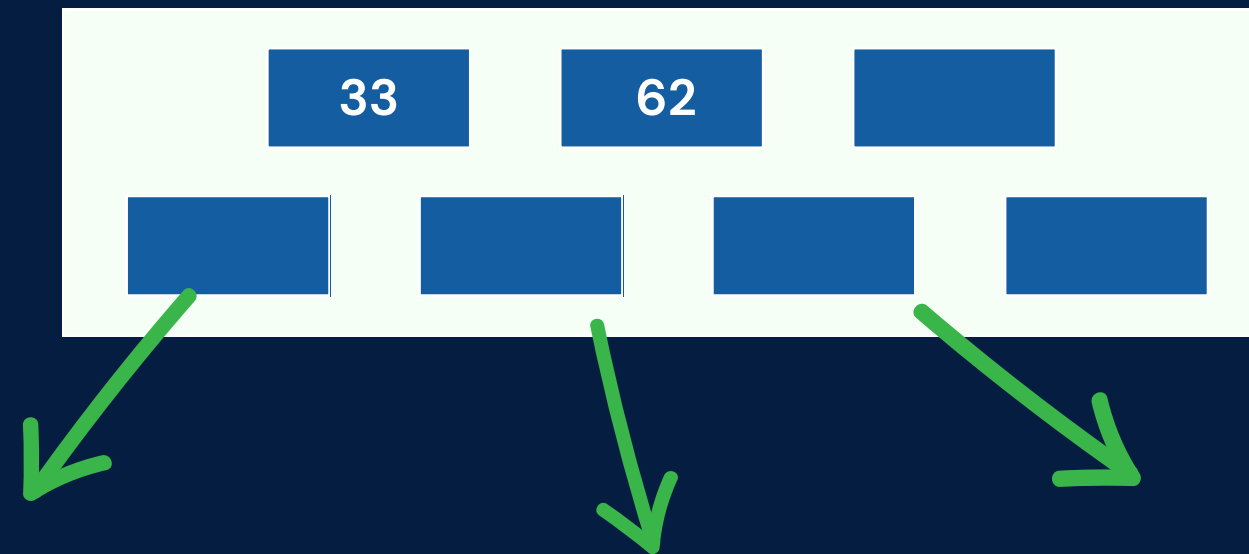


REMOÇÃO

74,18,32,40,57,70,50,42,62,79

CASO 2: REMOVER UMA CHAVE EM UM NÓ INTERMEDIÁRIO QUANDO O MAIOR DOS MENORES E O MENOR DOS MAIORES ESTÁ SOZINHO NO NÓ FOLHA. REMOVE O ELEMENTO E FAZ UMA JUNÇÃO COM OS FILHOS.

- JUNTA OS FILHOS
- UMA CHAVE DO PAI DESCE



REMOÇÃO

74,18,32,40,57,70,50,42,47,62,79

CASO 2: REMOVER UMA CHAVE EM UM NÓ INTERMEDIÁRIO QUANDO O MAIOR DOS MENORES E O MENOR DOS MAIORES ESTÁ SOZINHO NO NÓ FOLHA. REMOVE O ELEMENTO E FAZ UMA JUNÇÃO COM OS FILHOS.

- JUNTA OS FILHOS
- UMA CHAVE DO PAI DESCE

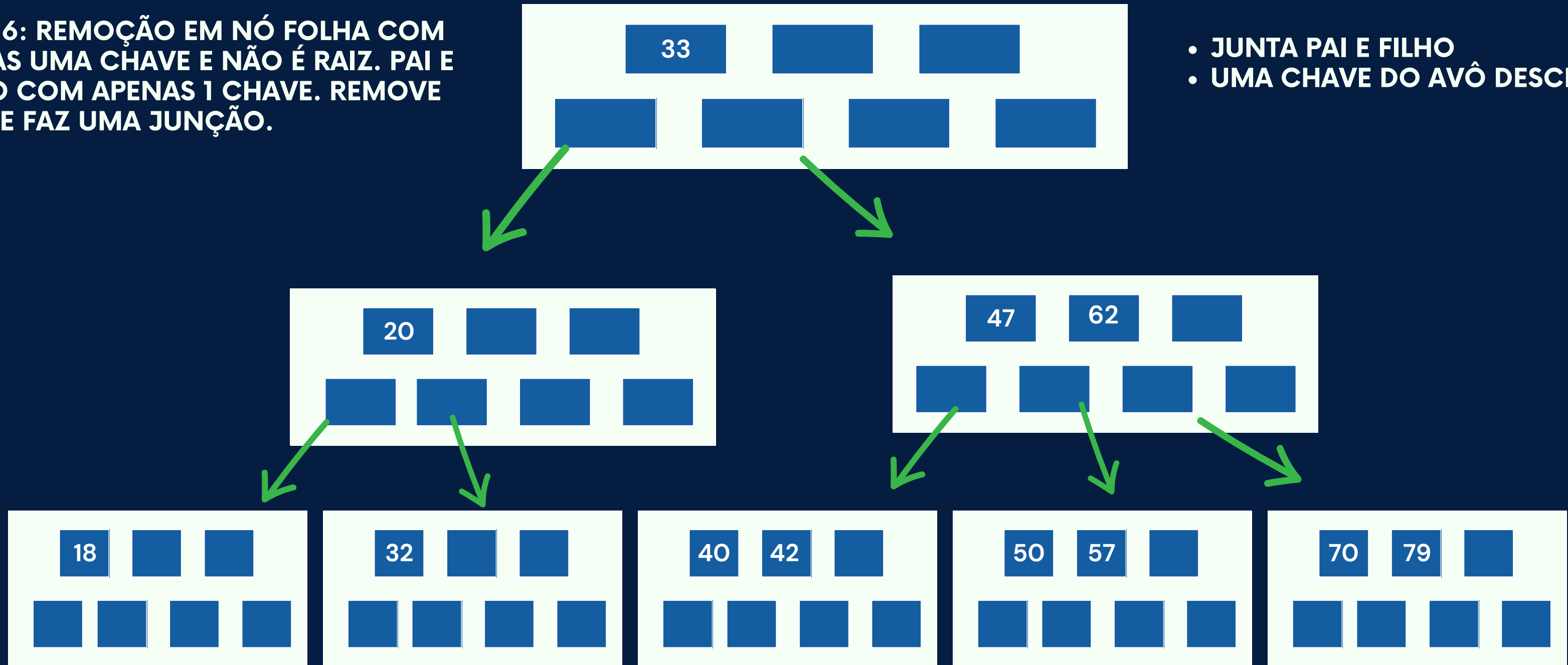


REMOÇÃO

18,32,40,57,70,50,42,47,62,79

CASO 6: REMOÇÃO EM NÓ FOLHA COM APENAS UMA CHAVE E NÃO É RAIZ. PAI E IRMÃO COM APENAS 1 CHAVE. REMOVE O NÓ E FAZ UMA JUNÇÃO.

- JUNTA PAI E FILHO
- UMA CHAVE DO AVÔ DESCE

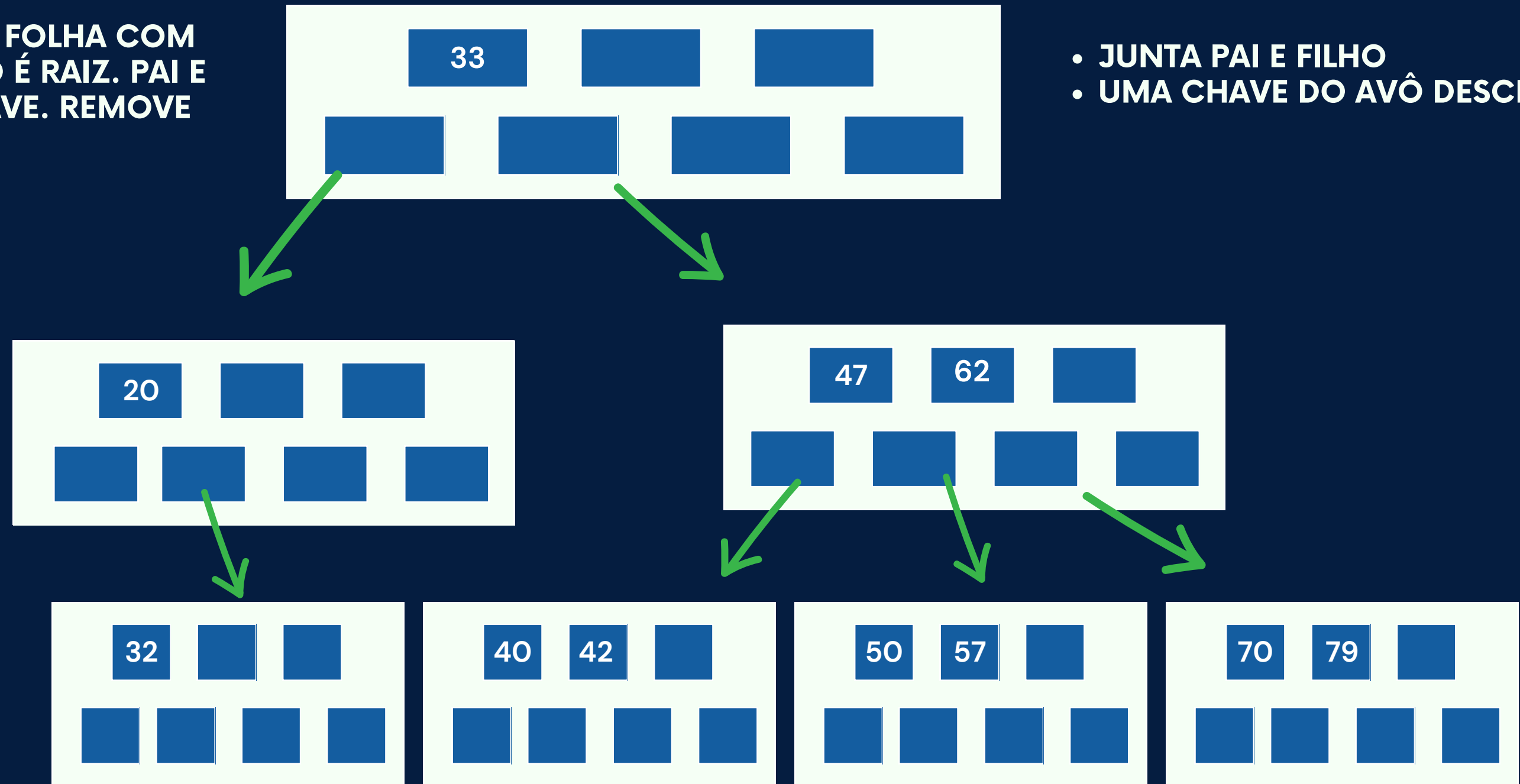


REMOÇÃO

18,32,40,57,70,50,42,47,62,79

CASO 6: REMOÇÃO EM NÓ FOLHA COM APENAS UMA CHAVE E NÃO É RAIZ. PAI E IRMÃO COM APENAS 1 CHAVE. REMOVE O NÓ E FAZ UMA JUNÇÃO.

- JUNTA PAI E FILHO
- UMA CHAVE DO AVÔ DESCE

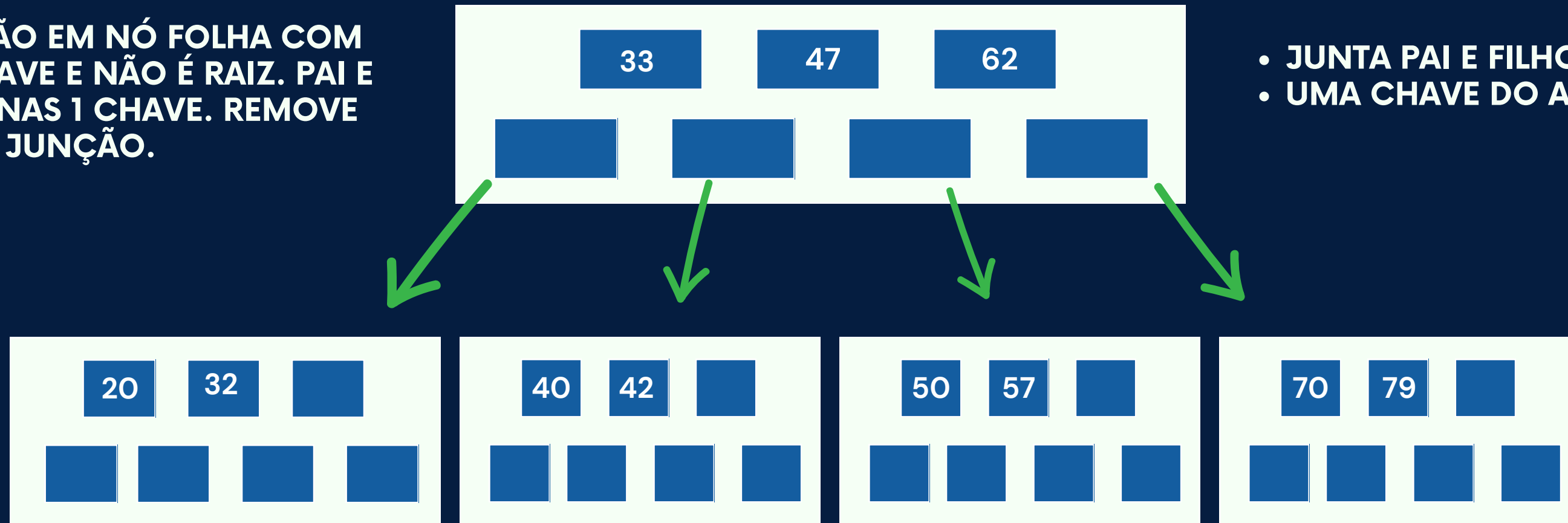


REMOÇÃO

18,32,40,57,70,50,42,47,62,79

CASO 6: REMOÇÃO EM NÓ FOLHA COM APENAS UMA CHAVE E NÃO É RAIZ. PAI E IRMÃO COM APENAS 1 CHAVE. REMOVE O NÓ E FAZ UMA JUNÇÃO.

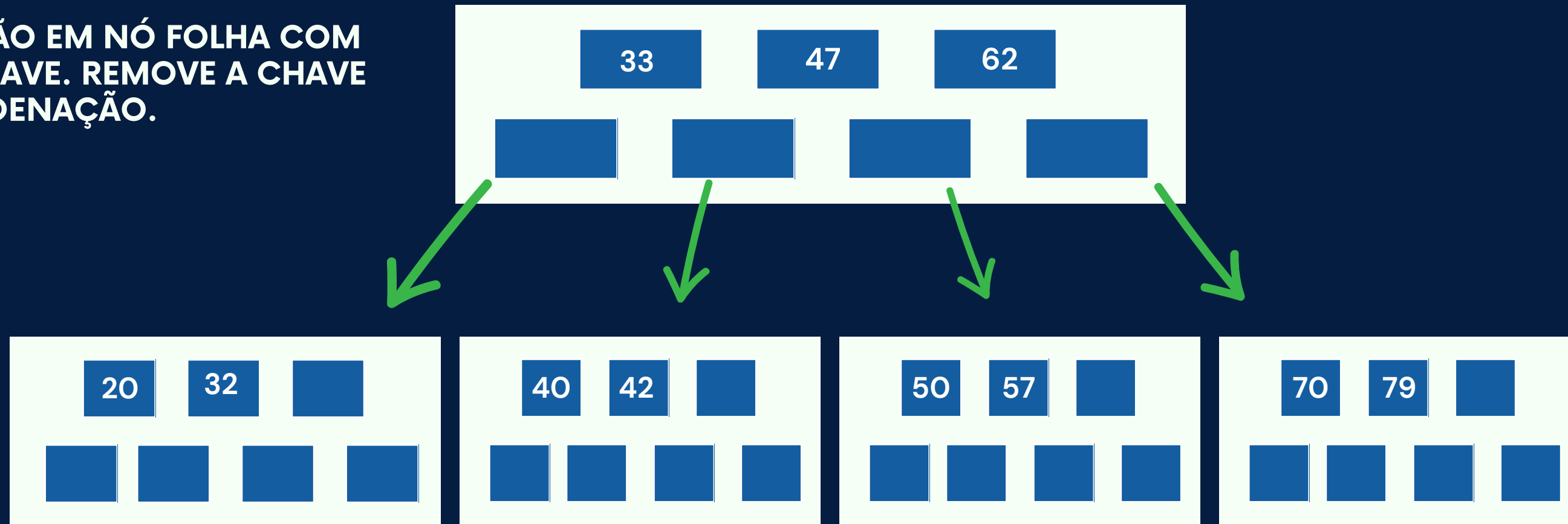
- JUNTA PAI E FILHO
- UMA CHAVE DO AVÔ DESCE



REMOÇÃO

32,40,57,70,50,42,47,62,79

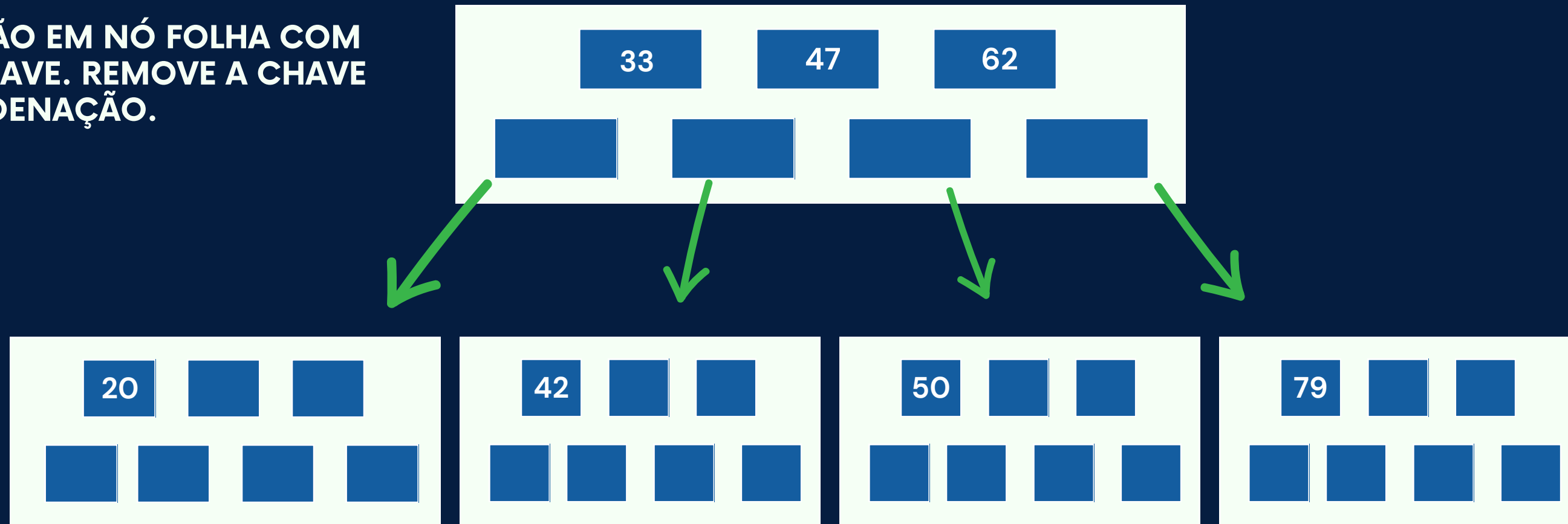
CASO 3: REMOÇÃO EM NÓ FOLHA COM MAIS DE UMA CHAVE. REMOVE A CHAVE E VERIFICA A ORDENAÇÃO.



REMOÇÃO

32,40,57,70,50,42,47,62,79

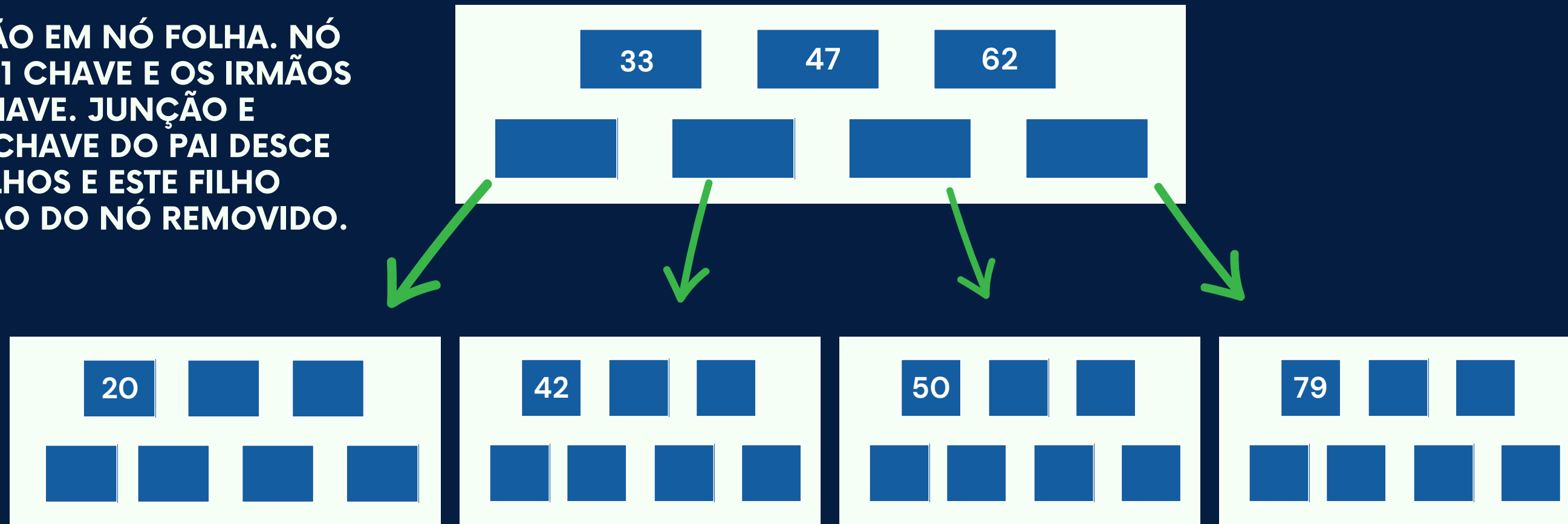
CASO 3: REMOÇÃO EM NÓ FOLHA COM MAIS DE UMA CHAVE. REMOVE A CHAVE E VERIFICA A ORDENAÇÃO.



REMOÇÃO

50,42,47,62,79

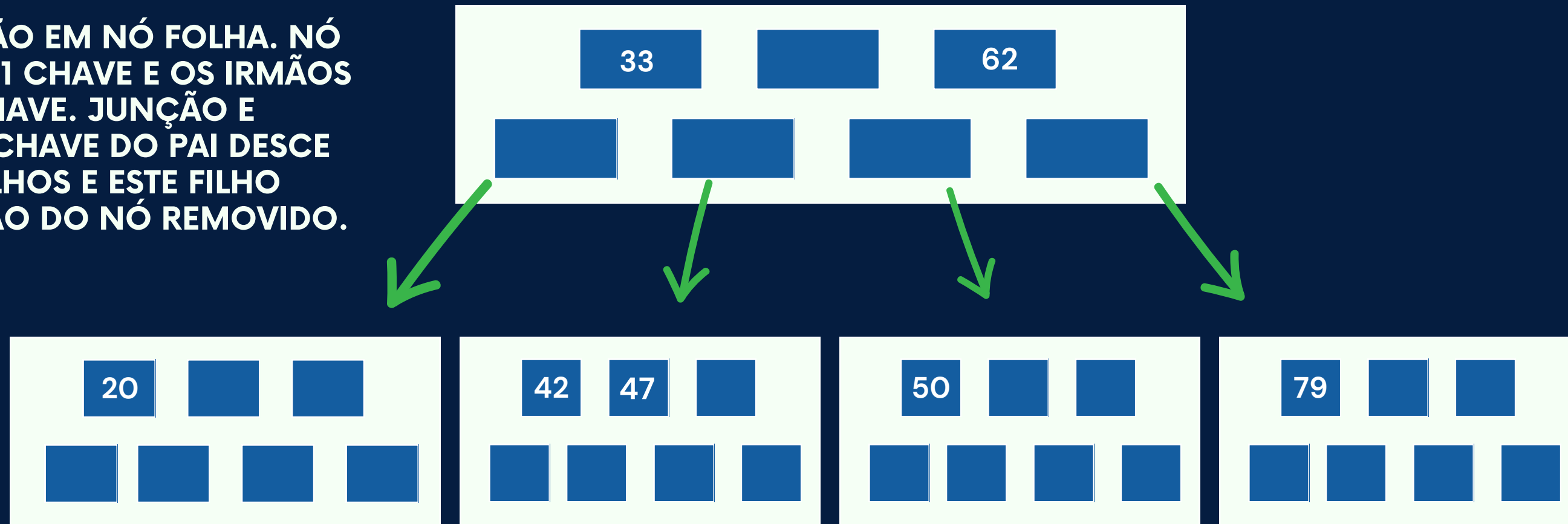
CASO 7: REMOÇÃO EM NÓ FOLHA. NÓ PAI TEM MAIS DE 1 CHAVE E OS IRMÃOS TÊM APENAS 1 CHAVE. JUNÇÃO E ROTAÇÃO. UMA CHAVE DO PAI DESCE PARA UM DOS FILHOS E ESTE FILHO OCUPA A POSIÇÃO DO NÓ REMOVIDO.



REMOÇÃO

50,42,47,62,79

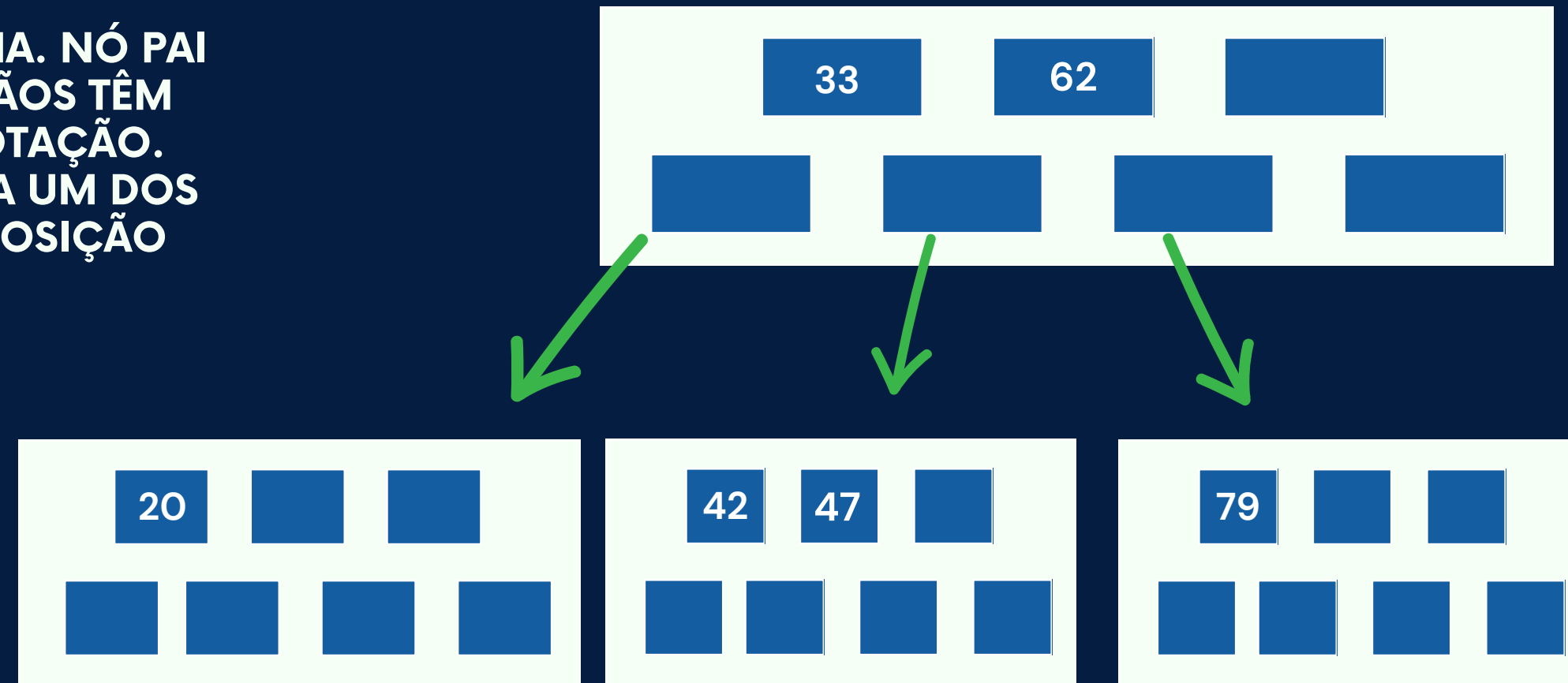
CASO 7: REMOÇÃO EM NÓ FOLHA. NÓ PAI TEM MAIS DE 1 CHAVE E OS IRMÃOS TÊM APENAS 1 CHAVE. JUNÇÃO E ROTAÇÃO. UMA CHAVE DO PAI DESCE PARA UM DOS FILHOS E ESTE FILHO OCUPA A POSIÇÃO DO NÓ REMOVIDO.



REMOÇÃO

50,42,47,62,79

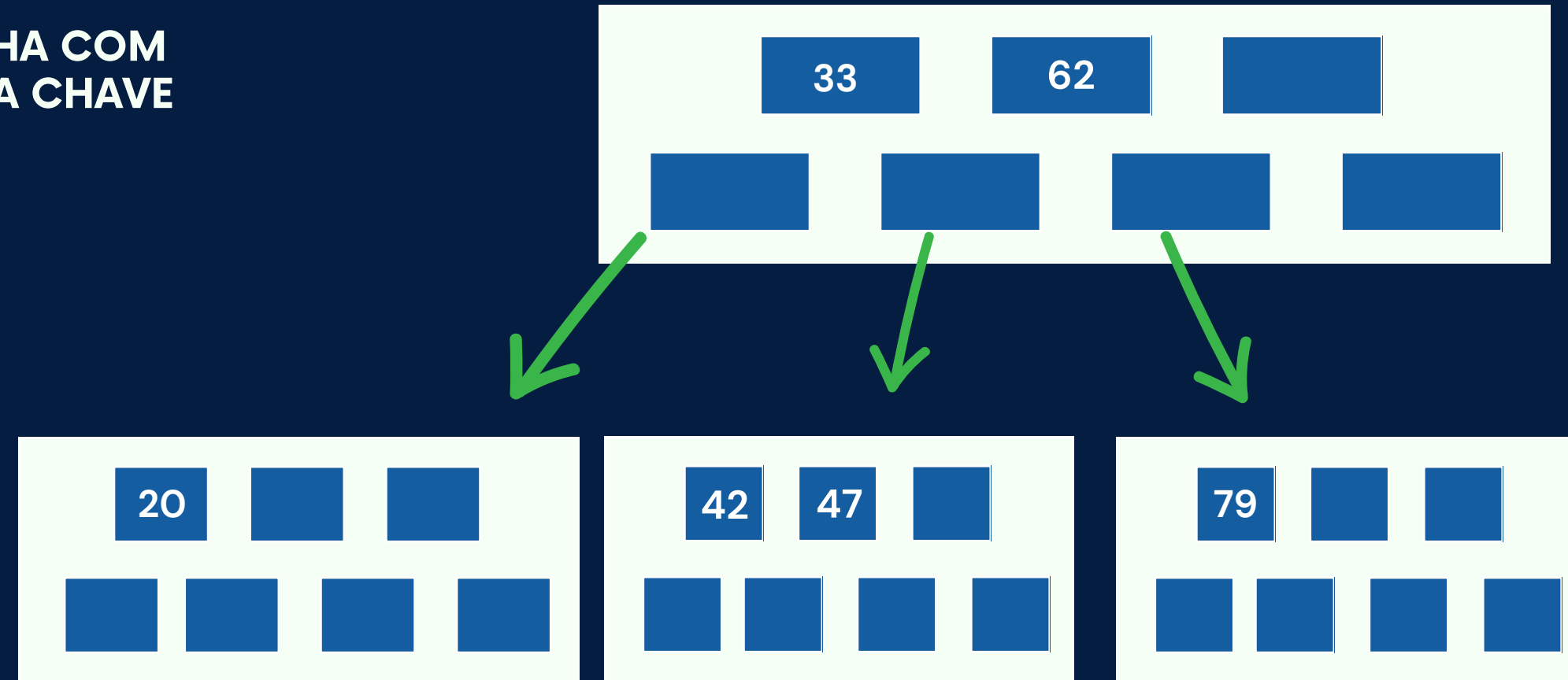
CASO 7:REMOÇÃO EM NÓ FOLHA. NÓ PAI TEM MAIS DE 1 CHAVE E OS IRMÃOS TÊM APENAS 1 CHAVE. JUNÇÃO E ROTAÇÃO. UMA CHAVE DO PAI DESCE PARA UM DOS FILHOS E ESTE FILHO OCUPA A POSIÇÃO DO NÓ REMOVIDO.



REMOÇÃO

42,47,62,79

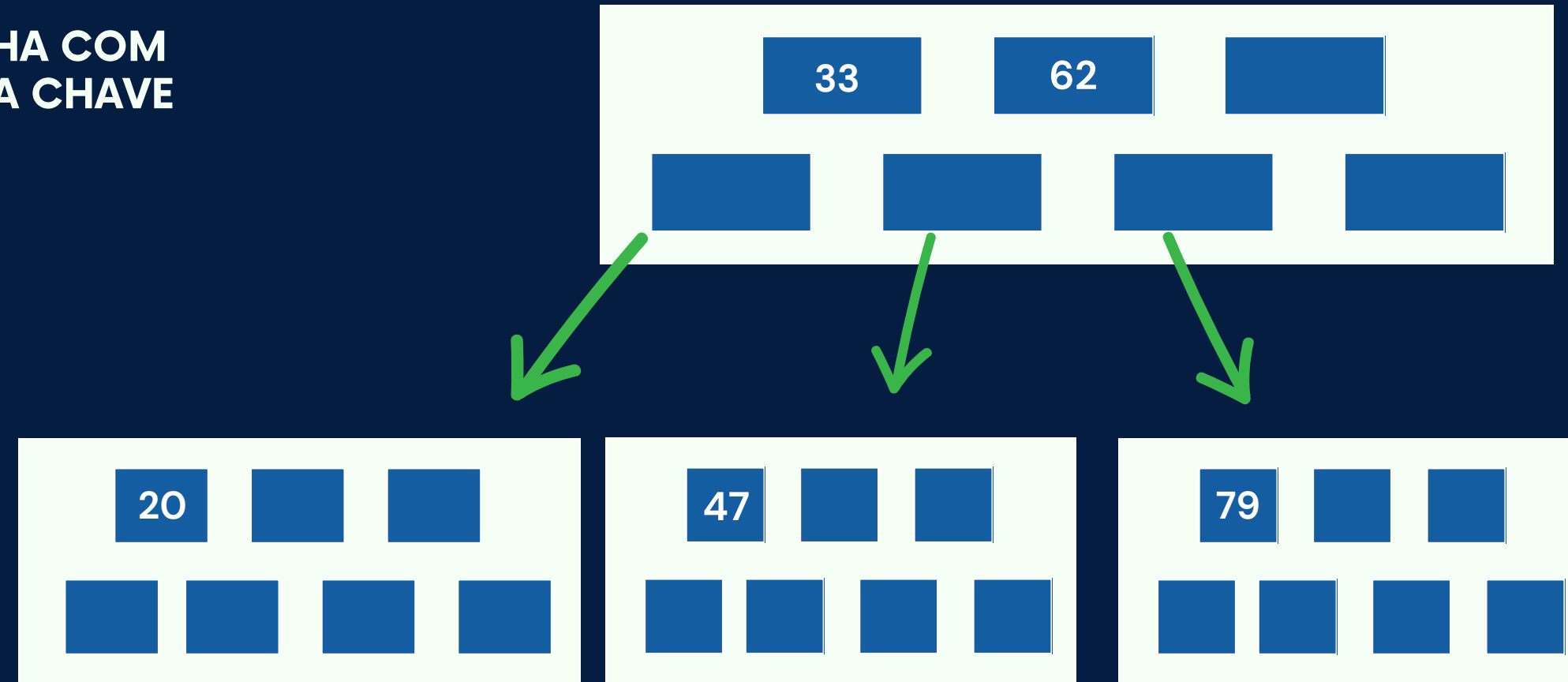
CASO 3: REMOÇÃO EM NÓ FOLHA COM MAIS DE UMA CHAVE. REMOVE A CHAVE E VERIFICA A ORDENAÇÃO.

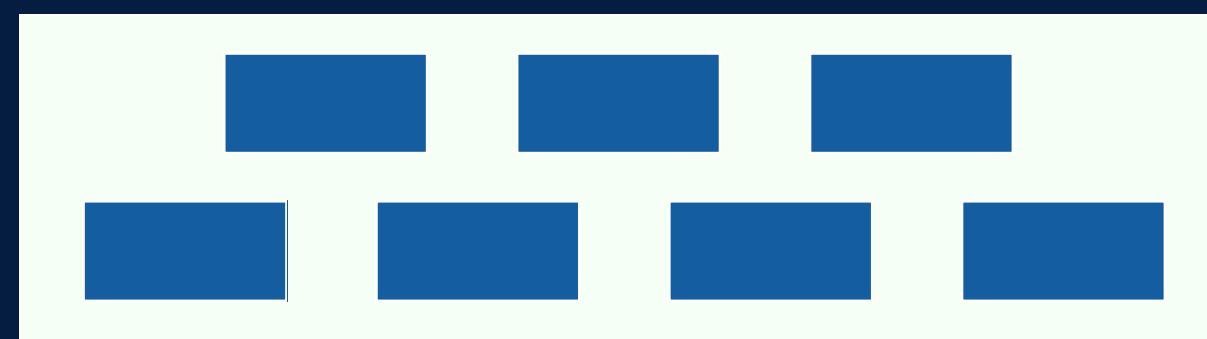
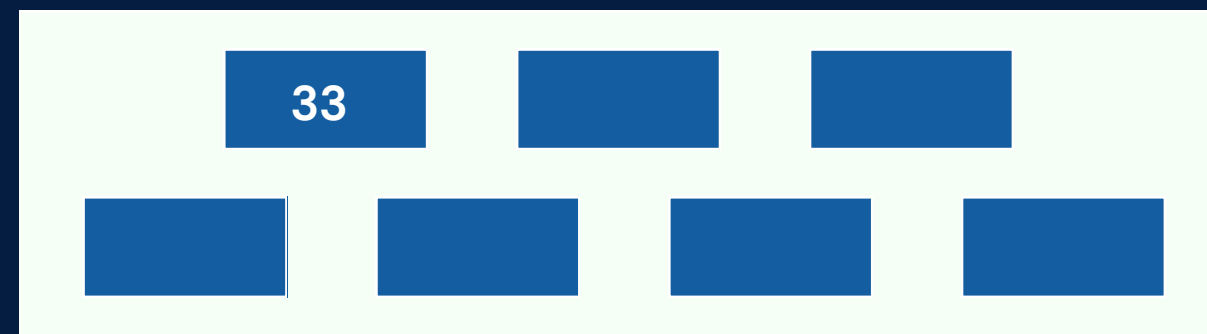


REMOÇÃO

42,47,62,79

CASO 3: REMOÇÃO EM NÓ FOLHA COM MAIS DE UMA CHAVE. REMOVE A CHAVE E VERIFICA A ORDENAÇÃO.





BASTA REMOVER E DAR UM FREE NA MEMÓRIA





VANTAGENS

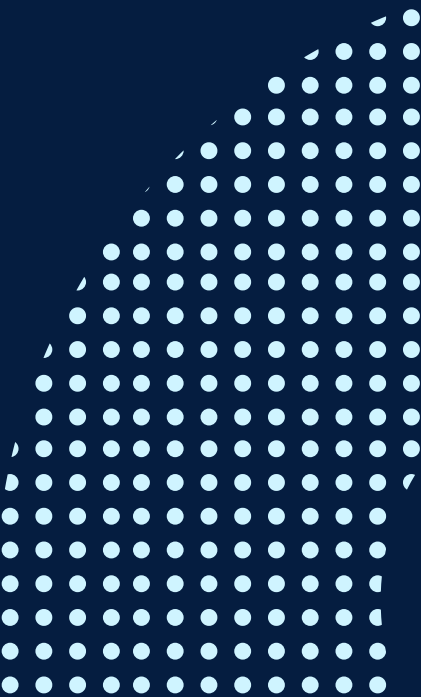
01 Balanceamento Automático



02 Eficiência em Busca, Inserção e Remoção

03 Compacta

04 Complexidade





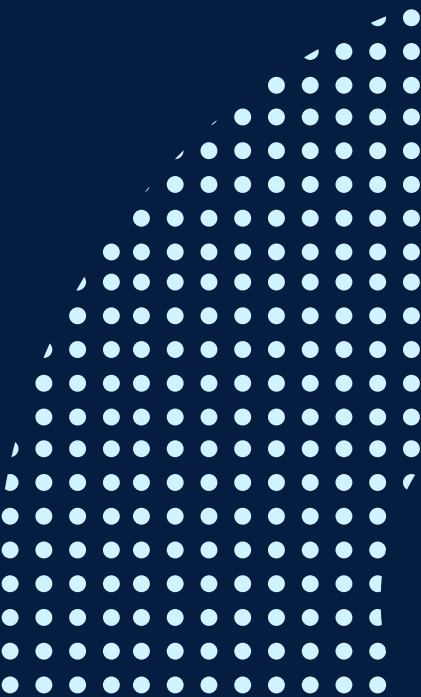
DESVANTAGENS

01 Implementação complexa



02 Não é adequada para dados pequenos

03 Sobrecarga da memória



ÁVORE 2 3 4 X ÁVORE RUBRO-NEGRO

	2,3,4	RUBRO-NEGRO
ESTRUTURA	NÓS COM 1-3 CHAVES E 2-4 FILHOS	NÓS BINÁRIOS
BALANCEAMENTO	SPLIT	ROTAÇÃO E RECOLORAÇÃO
COMPLEXIDADE	COMPLEXIDADE MAIOR	COMPLEXIDADE MENOR

```
#include <stdio.h>
#include <stdlib.h>
#include "arvore2-3-4.h"
```

```
int main() {
    Arvore2_3_4 arv;
    arv.raiz = NULL;
    int opcao;
```

```
do {
    printf("Digite ");
    scanf("%d", &opcao);
    if (opcao != 0)
        inserir(&arv, opcao);
    printf("\n\tARVORE:");
    imprimir(arv.raiz);
    printf("\n");
} while (opcao != 0);
```

```
imprimir(arv.raiz, 0);
printf("Quantidade de ");
```

```
do {
```

ONDE SE APLICA ÁRVORE 2, 3, 4



Bancos de Dados



Dicionários

Obrigada!