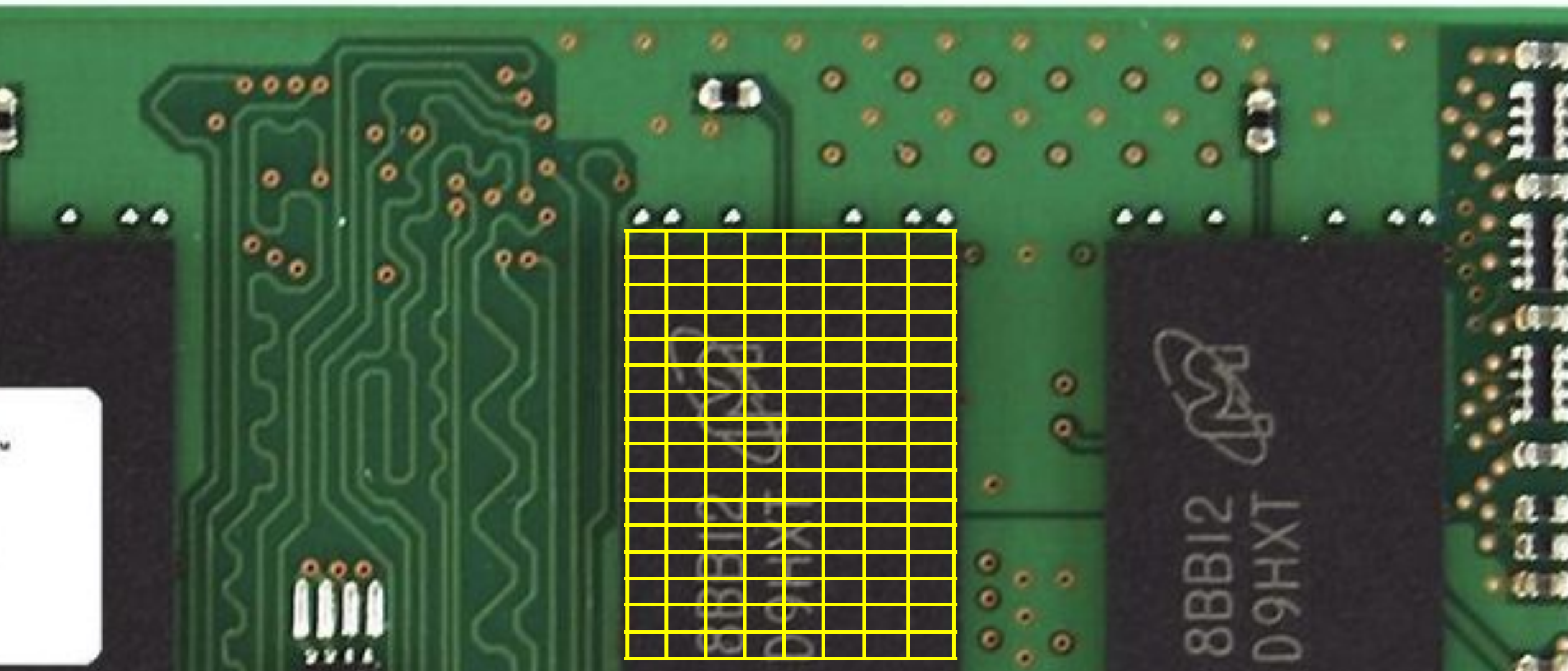
CS50 for JDs

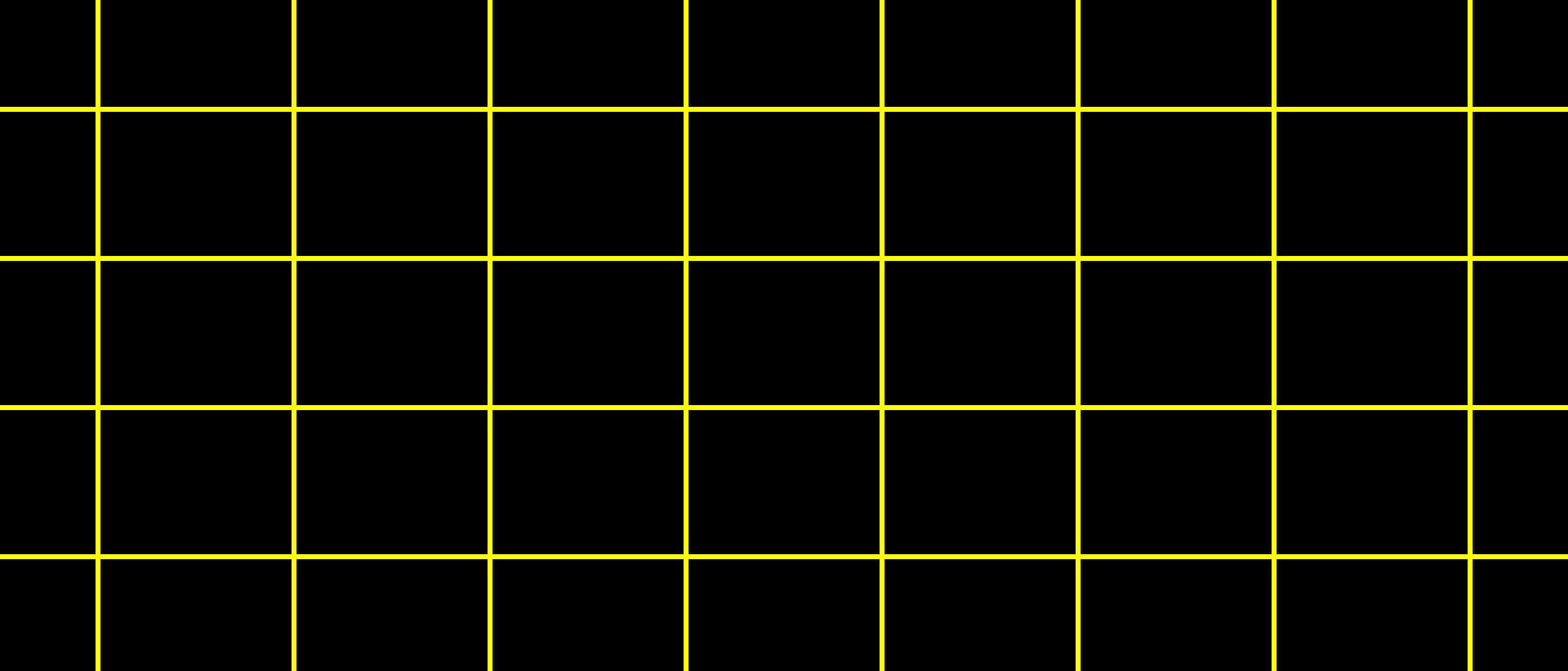
cs50.harvard.edu/hls

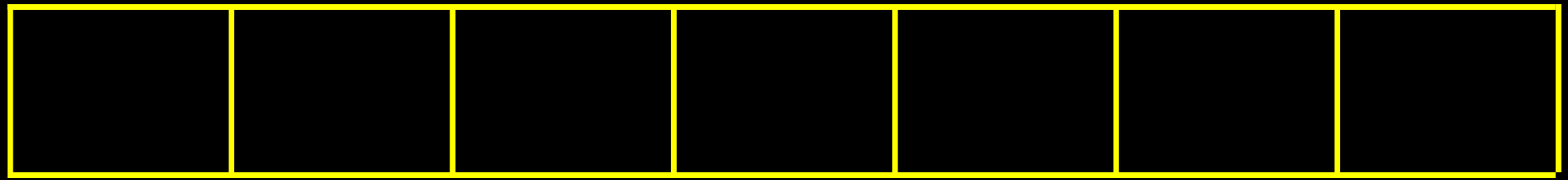
Algorithms, Data Structures

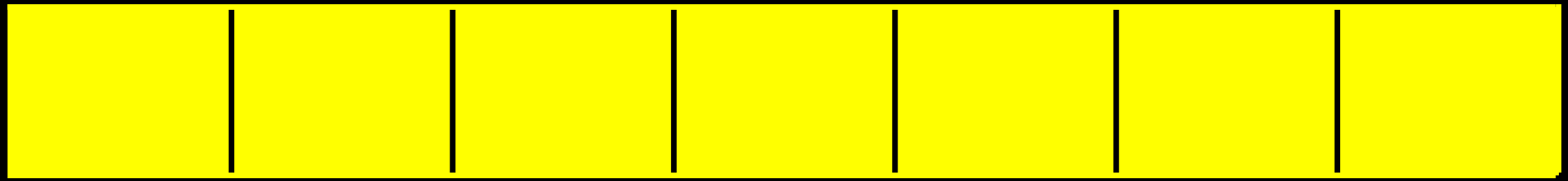

crucial
by Micron
8BBI2
D9HXT
8BBI2
D9HXT
4G85
4G85
4G85
47J6


8BB12
D9HXT
8BB12
D9HXT

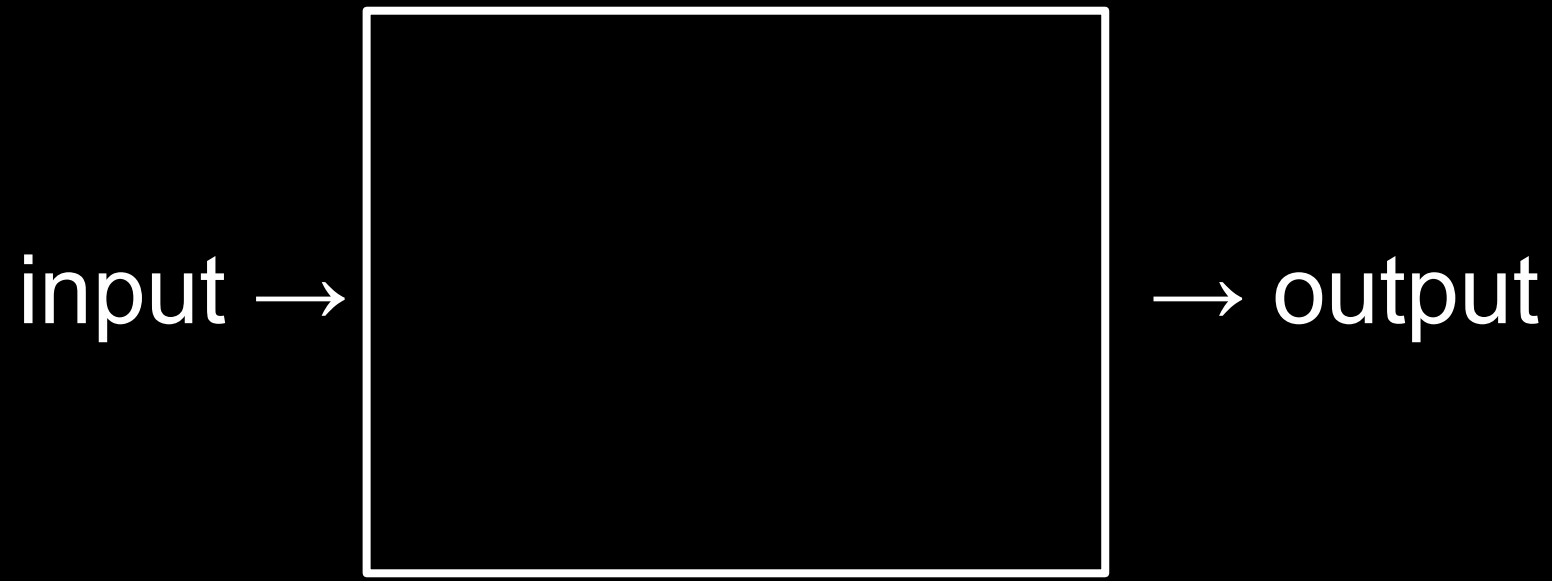

8BBI2
D9HXT

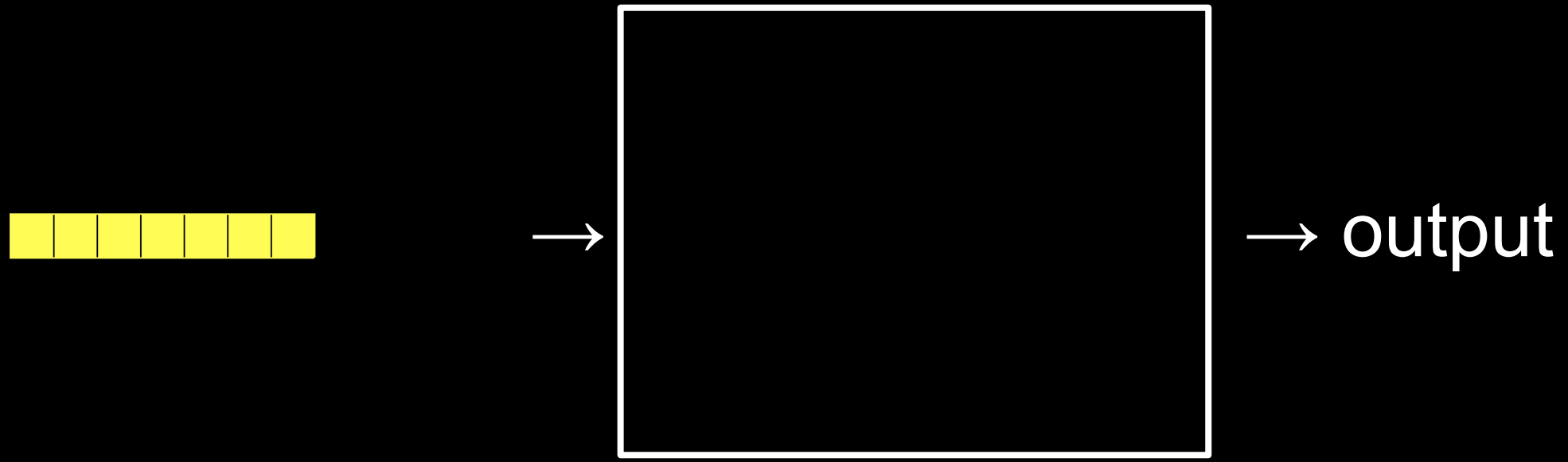


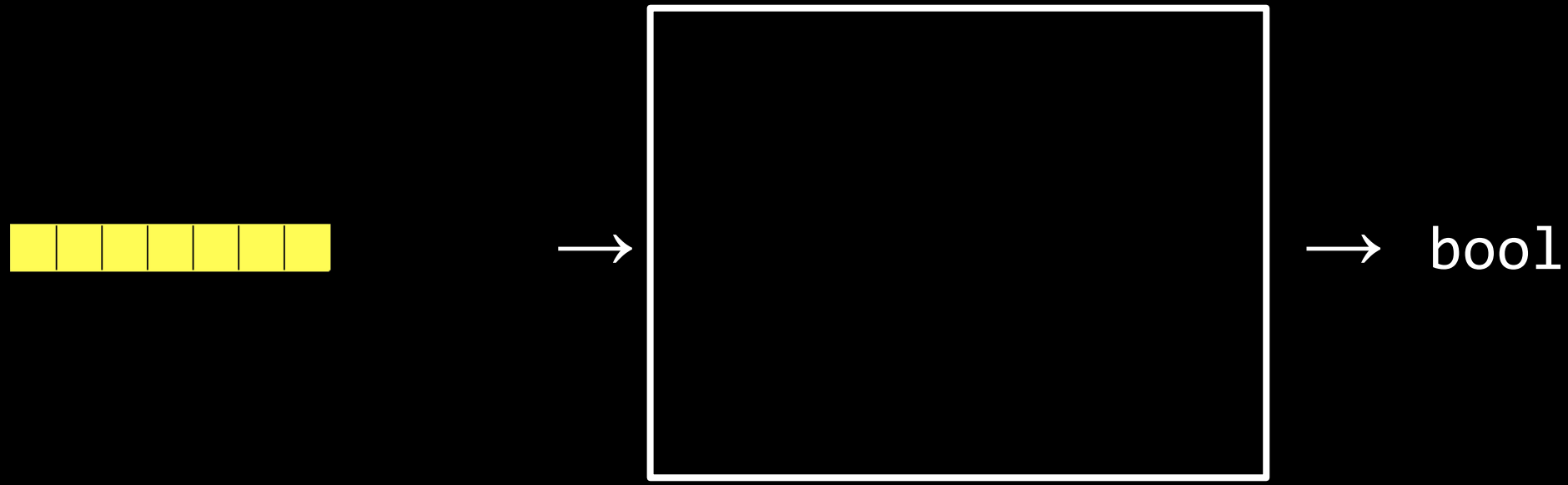


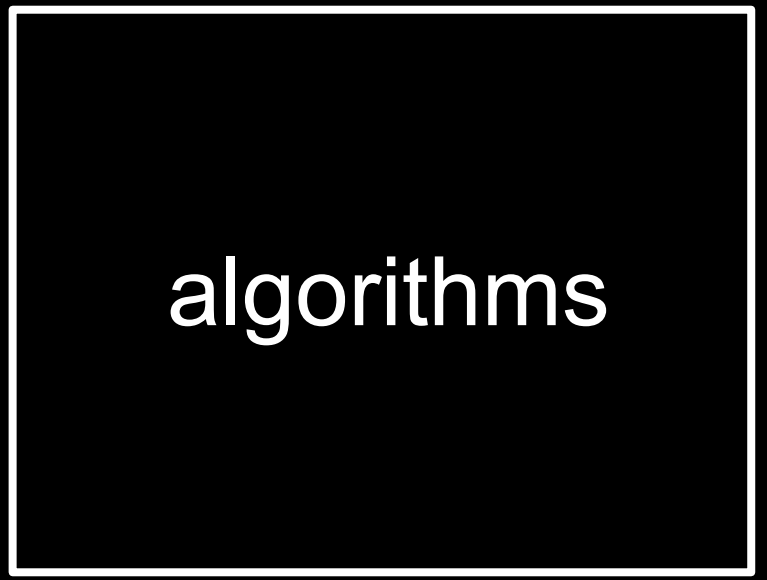


arrays


input →
→ output


output


bool


algorithms

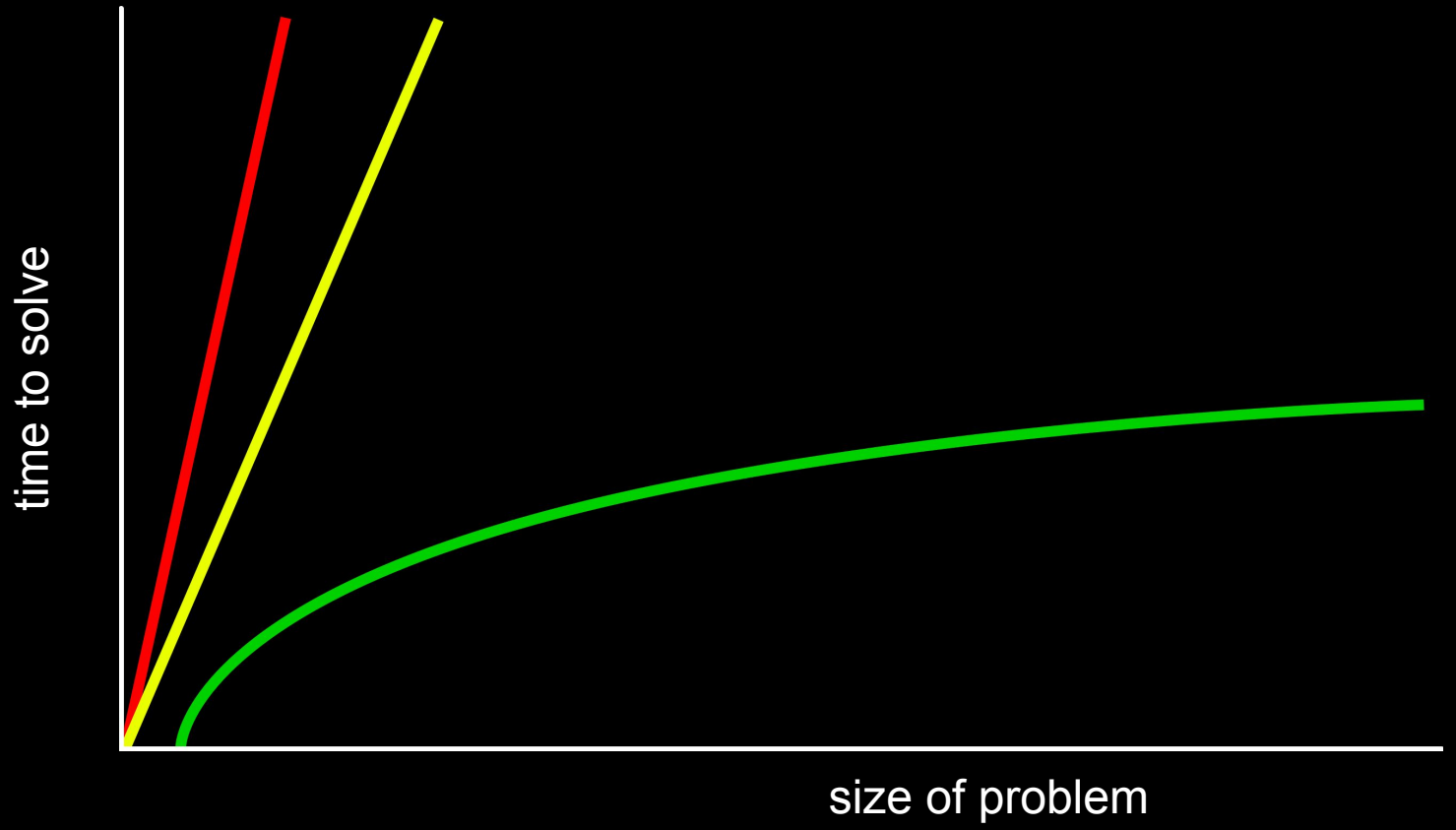
linear search

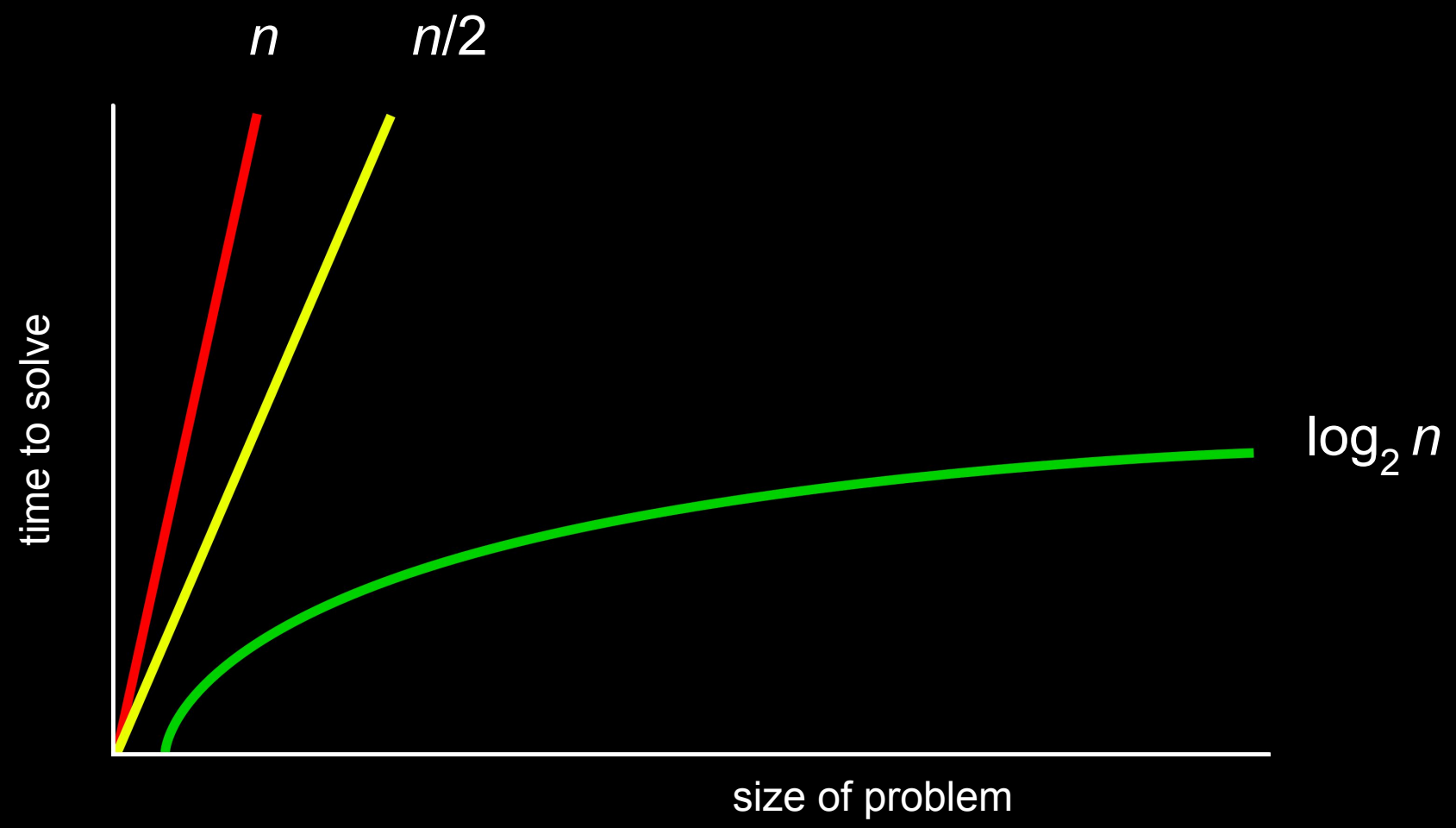
```
For i from 0 to n-1
    If i'th element is 50
        Return true
Return false
```

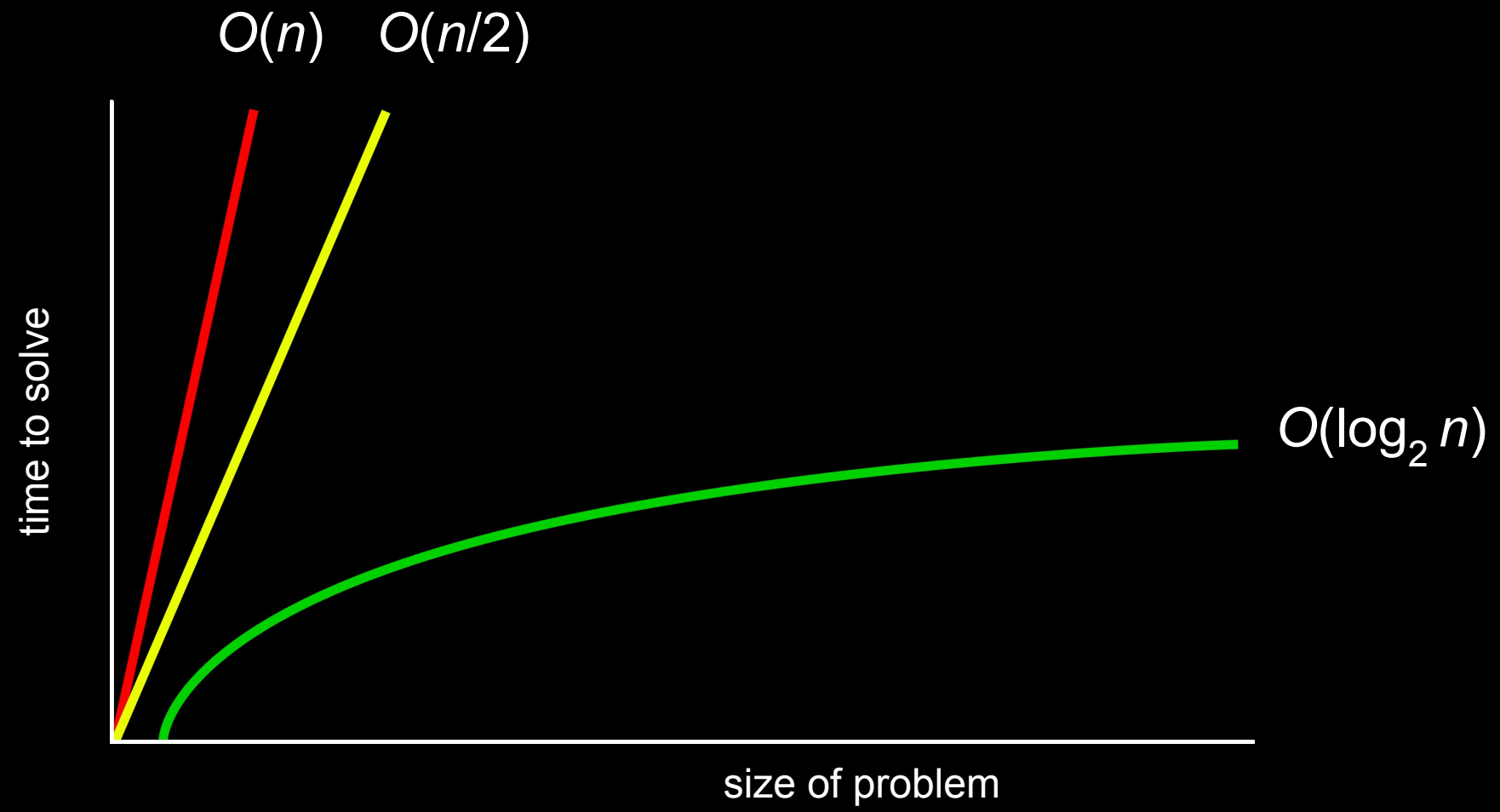
binary search

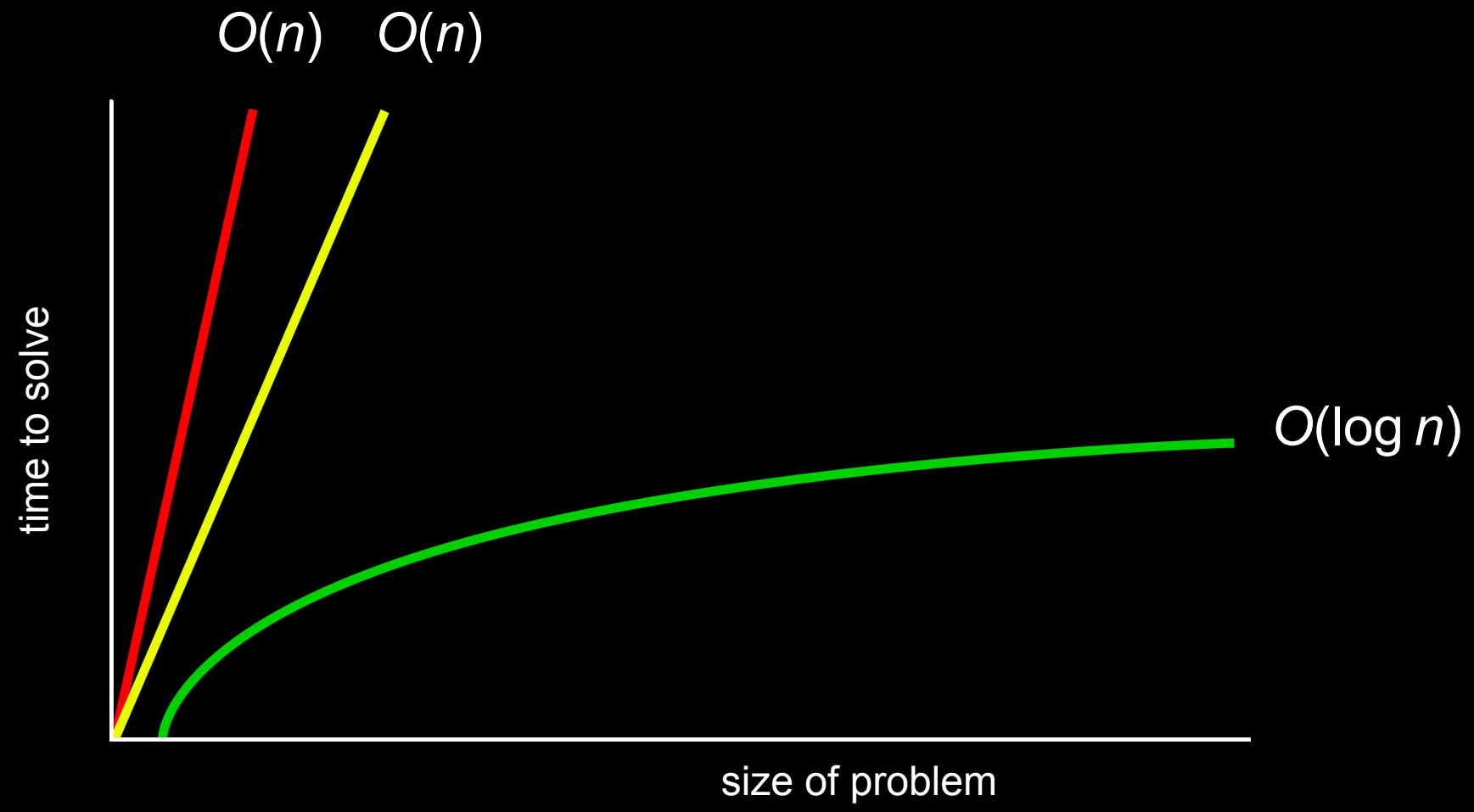
```
If middle item is 50
    Return true
Else if 50 < middle item
    Search left half
Else if 50 > middle item
    Search right half
```

```
If no items
    Return false
If middle item is 50
    Return true
Else if 50 < middle item
    Search left half
Else if 50 > middle item
    Search right half
```


time to solve
size of problem


n
n/2
log2 n
time to solve
size of problem


O(n)
O(n/2)
O(log2 n)
time to solve
size of problem


O(n)
O(n)
time to solve
O(log n)
size of problem

$O(n^2)$

$O(n \log n)$

$O(n)$

$O(\log n)$

$O(1)$

$O(n^2)$

$O(n \log n)$

$O(n)$ linear search

$O(\log n)$ binary search

$O(1)$

$\Omega(n^2)$

$\Omega(n \log n)$

$\Omega(n)$

$\Omega(\log n)$

$\Omega(1)$

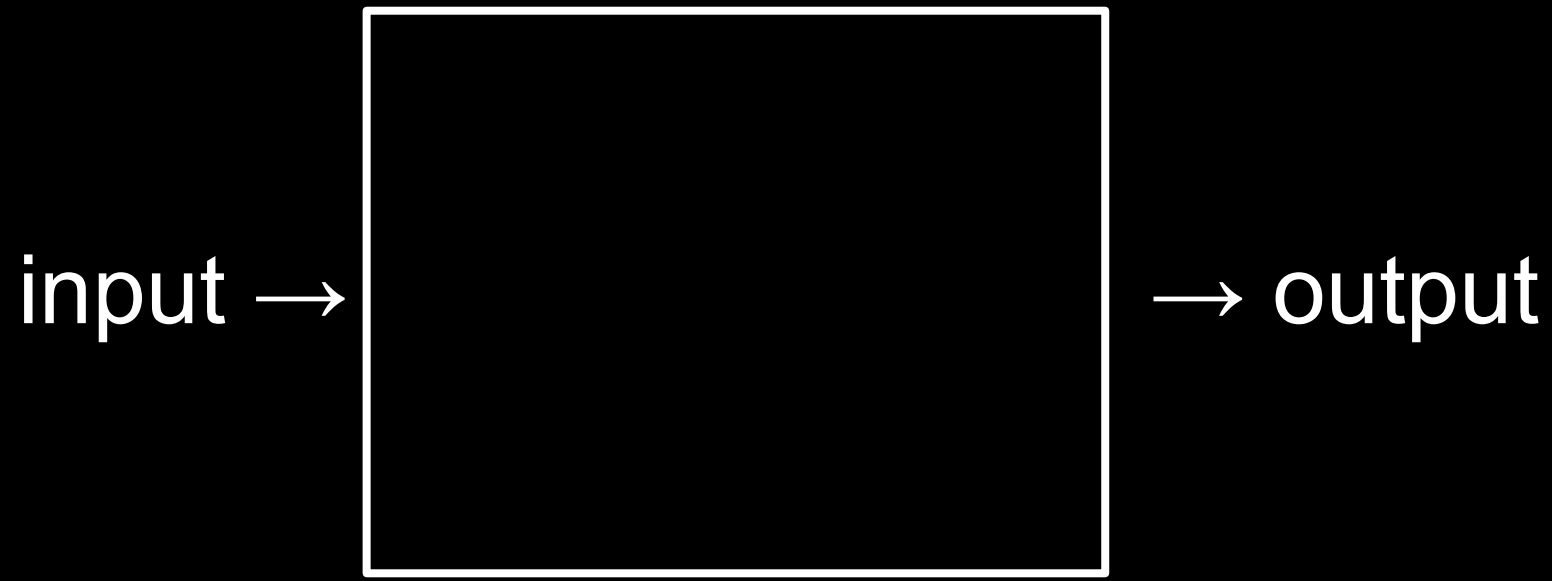
$\Omega(n^2)$

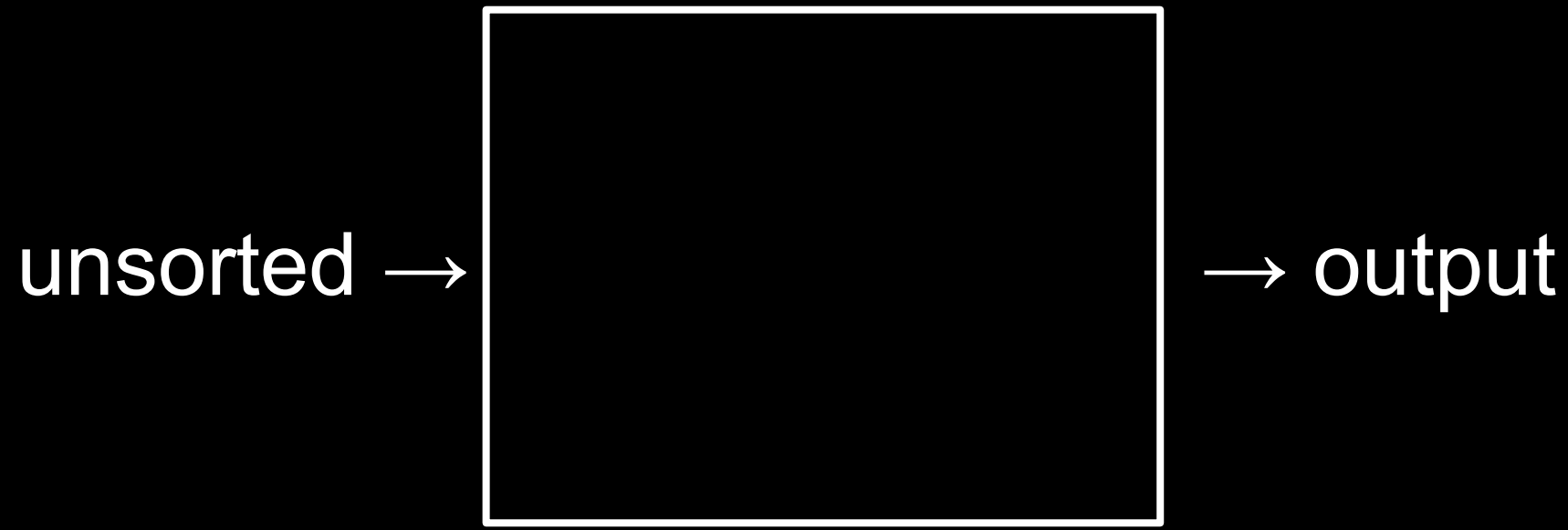
$\Omega(n \log n)$

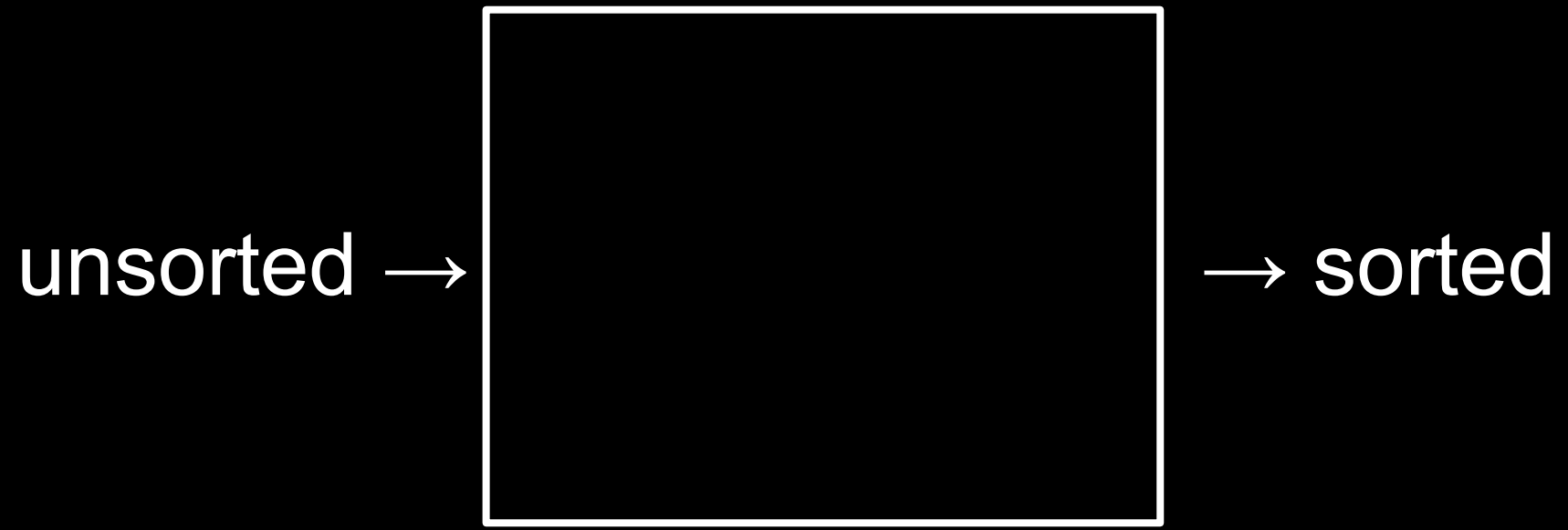
$\Omega(n)$

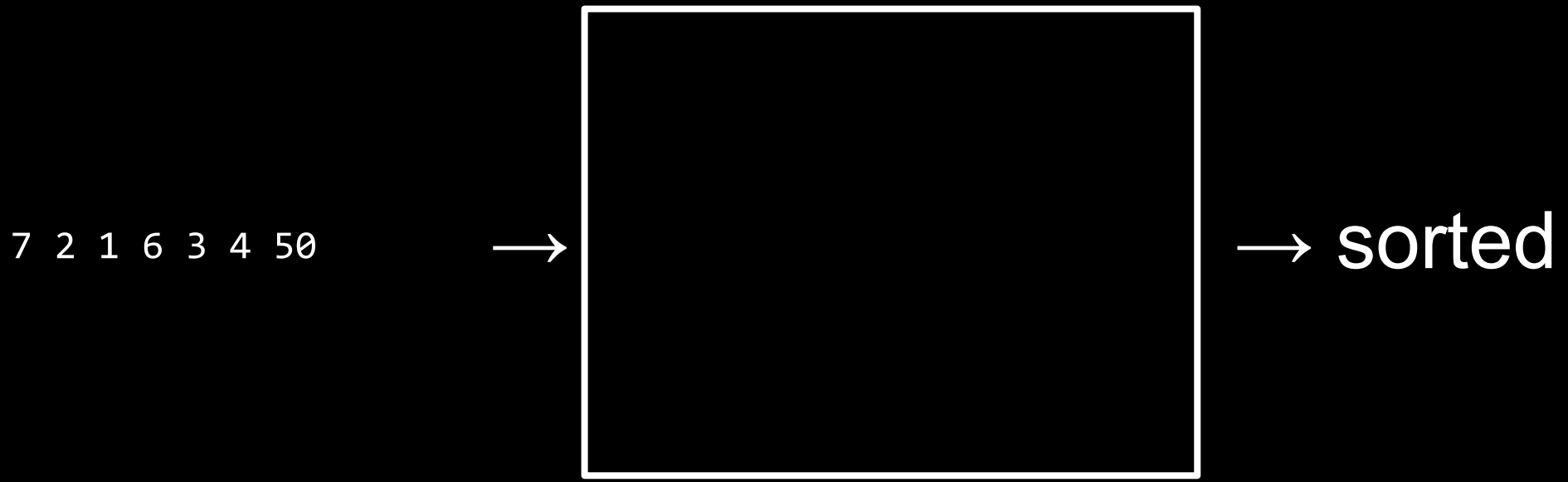
$\Omega(\log n)$

$\Omega(1)$ linear search, binary search


input →
→ output


unsorted →
→ output


unsorted →
→ sorted


7 2 1 6 3 4 50
sorted

6 3 8 5 2 7 4 1

bubble sort

```
Repeat n-1 times
    For i from 0 to n-2
        If i'th and i+1'th elements out of order
            Swap them
```

$(n - 1) \times (n - 1)$

$(n - 1) \times (n - 1)$

$n^2 - 1n - 1n + 1$

$(n - 1) \times (n - 1)$

$n^2 - 1n - 1n + 1$

$n^2 - 2n + 1$

$(n - 1) \times (n - 1)$

$n^2 - 1n - 1n + 1$

$n^2 - 2n + 1$

$O(n^2)$

$O(n^2)$ bubble sort

$O(n \log n)$

$O(n)$

$O(\log n)$

$O(1)$

$\Omega(n^2)$

$\Omega(n \log n)$

$\Omega(n)$ bubble sort

$\Omega(\log n)$

$\Omega(1)$

selection sort

```
For i from 0 to n-1
    Find smallest item between i'th item and last item
    Swap smallest item with i'th item
```

n

$n + (n - 1)$

$n + (n - 1) + (n - 2)$

$n + (n - 1) + (n - 2) + \ldots + 1$

$n + (n - 1) + (n - 2) + \ldots + 1$

$n(n + 1)/2$

$n + (n - 1) + (n - 2) + \ldots + 1$

$n(n + 1)/2$

$(n^2 + n)/2$

$n + (n - 1) + (n - 2) + \ldots + 1$

$n(n + 1)/2$

$(n^2 + n)/2$

$n^2/2 + n/2$

$n + (n - 1) + (n - 2) + \ldots + 1$

$n(n + 1)/2$

$(n^2 + n)/2$

$n^2/2 + n/2$

$O(n^2)$

$O(n^2)$ selection sort

$O(n \log n)$

$O(n)$

$O(\log n)$

$O(1)$

$\Omega(n^2)$ selection sort

$\Omega(n \log n)$

$\Omega(n)$

$\Omega(\log n)$

$\Omega(1)$

bubble sort

```
Repeat n-1 times
    For i from 0 to n-2
        If i'th and i+1'th elements out of order
            Swap them
```

```
Repeat until no swaps
    For i from 0 to n-2
        If i'th and i+1'th elements out of order
            Swap them
```

$\Omega(n^2)$	bubble sort, selection sort
$\Omega(n \log n)$	
$\Omega(n)$	
$\Omega(\log n)$	
$\Omega(1)$	linear search, binary search

$\Omega(n^2)$

$\Omega(n \log n)$

$\Omega(n)$ bubble sort

$\Omega(\log n)$

$\Omega(1)$


Google

recursion

```
1   Pick up phone book
2   Open to middle of phone book
3   Look at page
4   If person is on page
5       Call person
6   Else if person is earlier in book
7       Open to middle of left half of book
8       Go back to line 3
9   Else if person is later in book
10      Open to middle of right half of book
11      Go back to line 3
12  Else
13      Quit
```

```
1   Pick up phone book
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13      Quit
```

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10      Open to middle of right half of book
11      Go back to line 3
12  Else
13      Quit
```

```
1   Pick up phone book
2   Open to middle of phone book
3   Look at page
4   If person is on page
5       Call person
6   Else if person is earlier in book
7       Search left half of book
8
9   Else if person is later in book
10      Search right half of book
11
12  Else
13      Quit
```

```
1   Pick up phone book
2   Open to middle of phone book
3   Look at page
4   If person is on page
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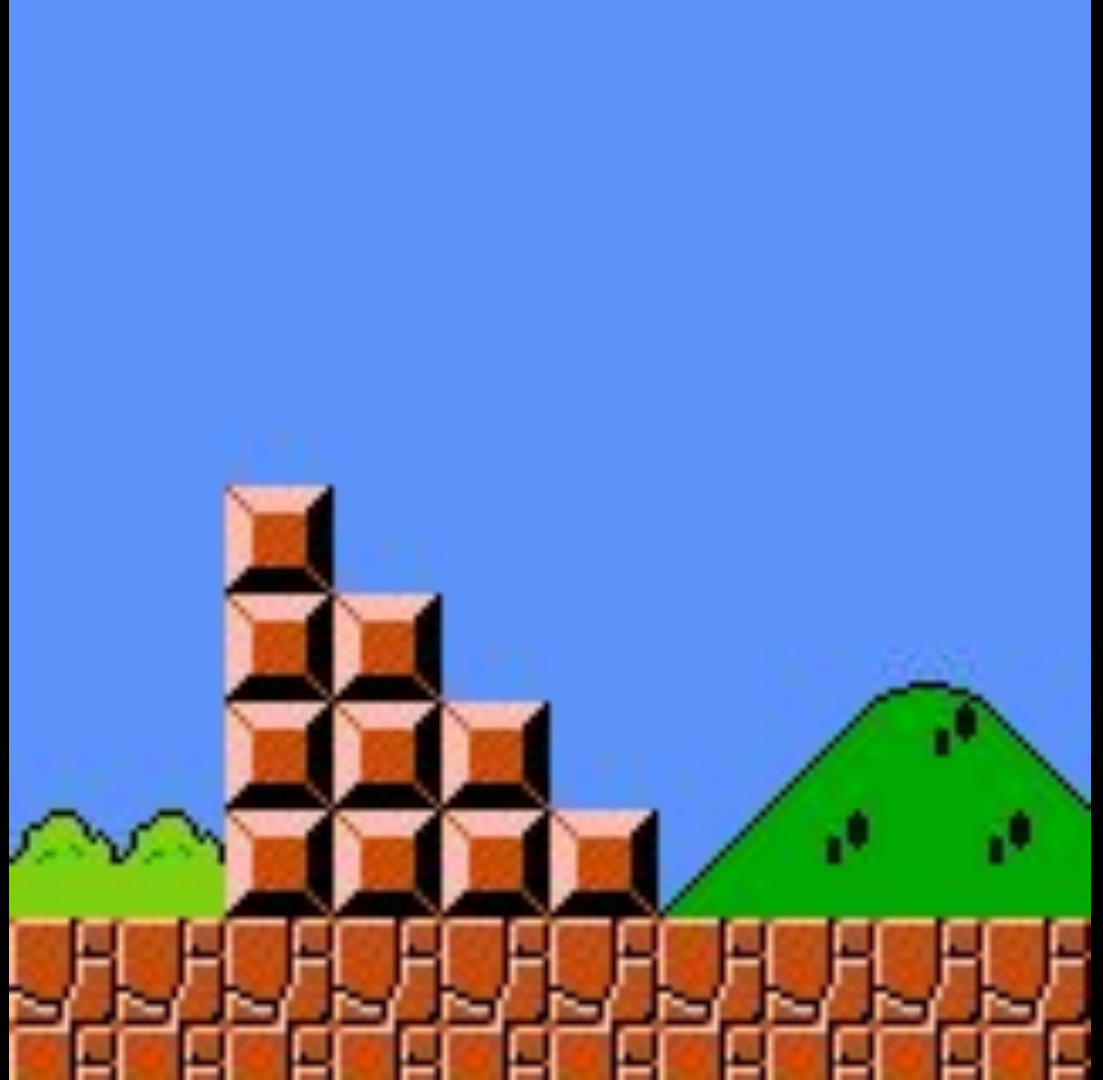
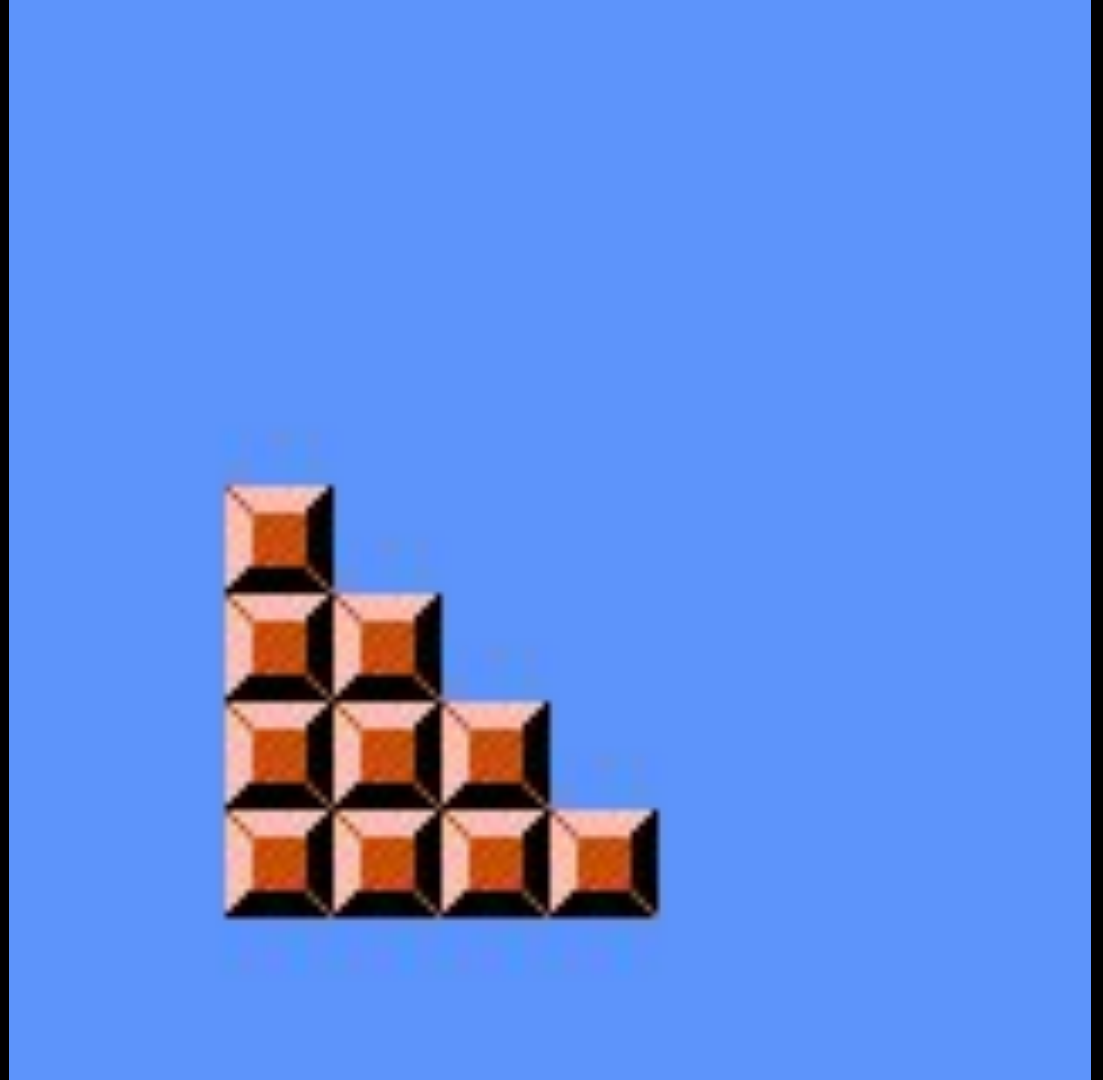
10  Else
11      Quit
```





merge sort

```
If only one item
    Return
Else
    Sort left half of items
    Sort right half of items
    Merge sorted halves
```

```
If only one item
    Return
Else
    Sort left half of items
    Sort right half of items
    Merge sorted halves
```

7 4 5 2 6 3 8 1


7 4 5 2 6 3 8 1

7 4 5 2 6 3 8 1

7 4 5 2 6 3 8 1

7 4 5 2 6 3 8 1


7
4
5
2
6
3
8
1

7

5 2 6 3 8 1

4

5 2 6 3 8 1

4 7

5 2 6 3 8 1

4 7

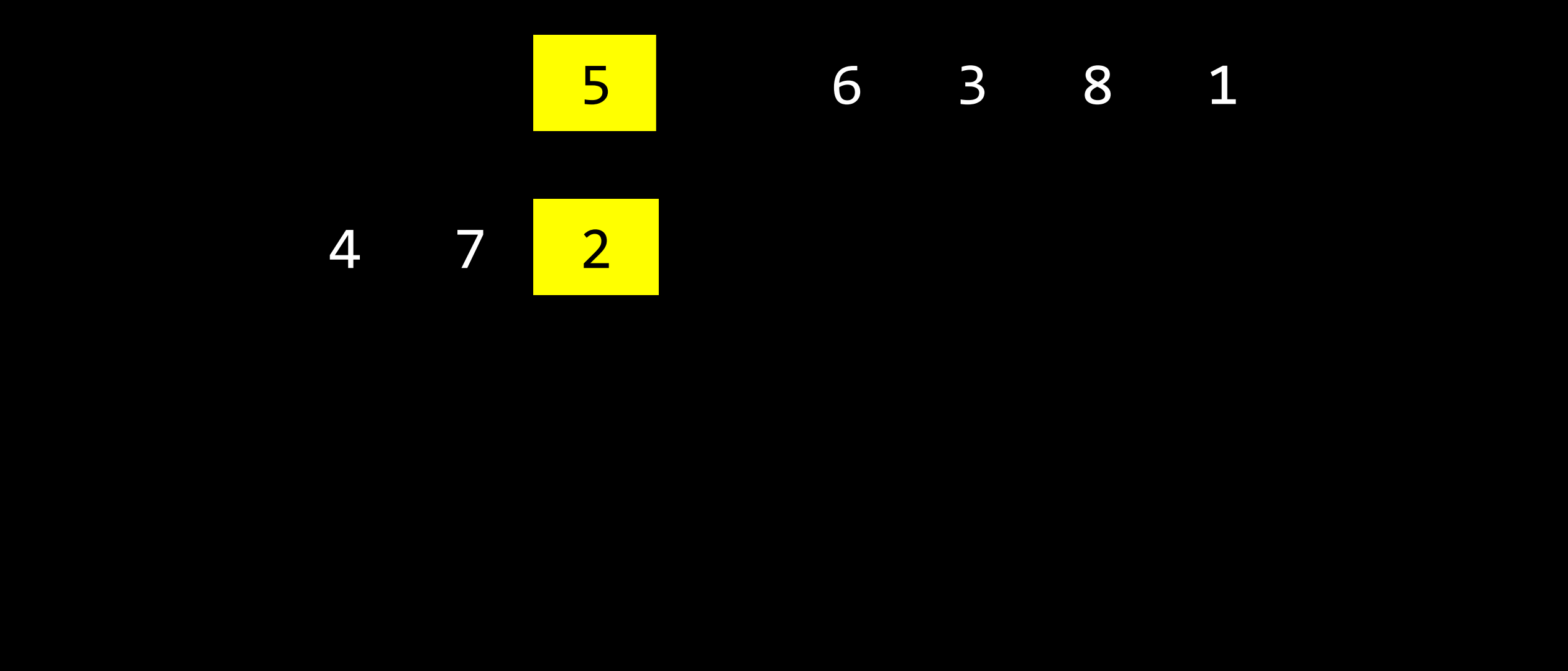
5 2 6 3 8 1

4 7

5 2 6 3 8 1

4 7

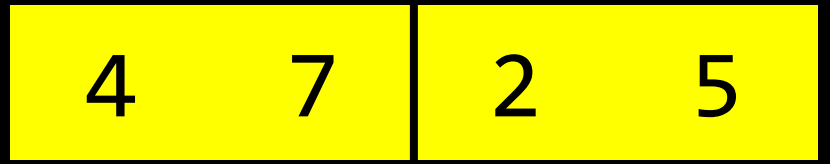
4 7


5
6
3
8
1
4
7
2

6 3 8 1

4 7 2 5

6 3 8 1



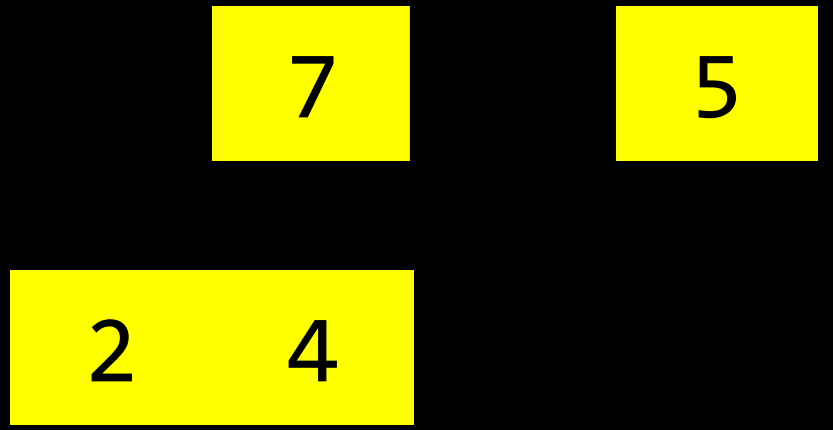
6 3 8 1

4 7

5

2

6 3 8 1



6 3 8 1

7

2 4 5

6 3 8 1

2 4 5 7

6 3 8 1

2 4 5 7

6 3 8 1

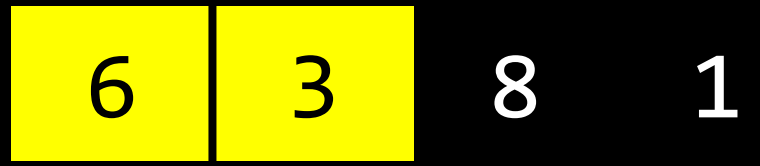
2 4 5 7

6 3 8 1

2 4 5 7

6 3 8 1

2 4 5 7



2 4 5 7

6 8 1

3

2 4 5 7

8 1

3 6

2 4 5 7

8 1

3 6

2 4 5 7

8 1

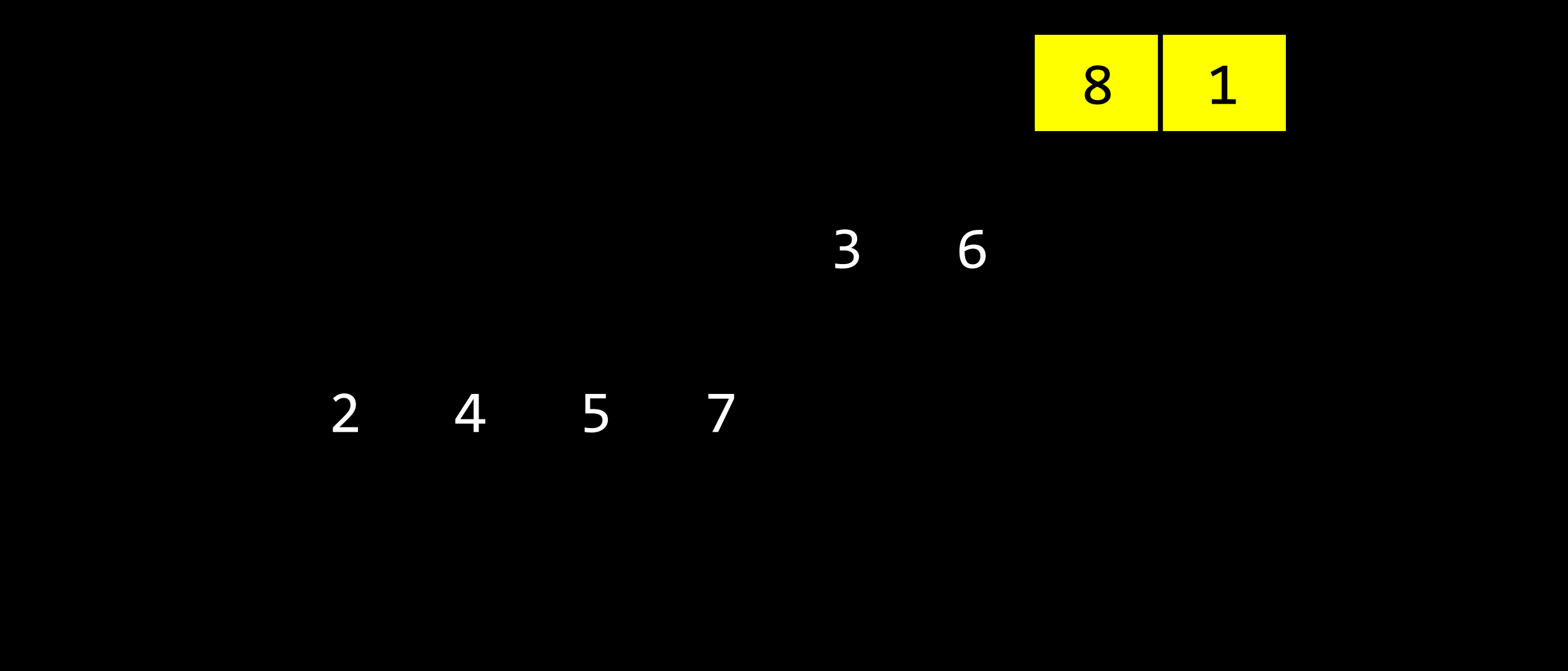
3 6

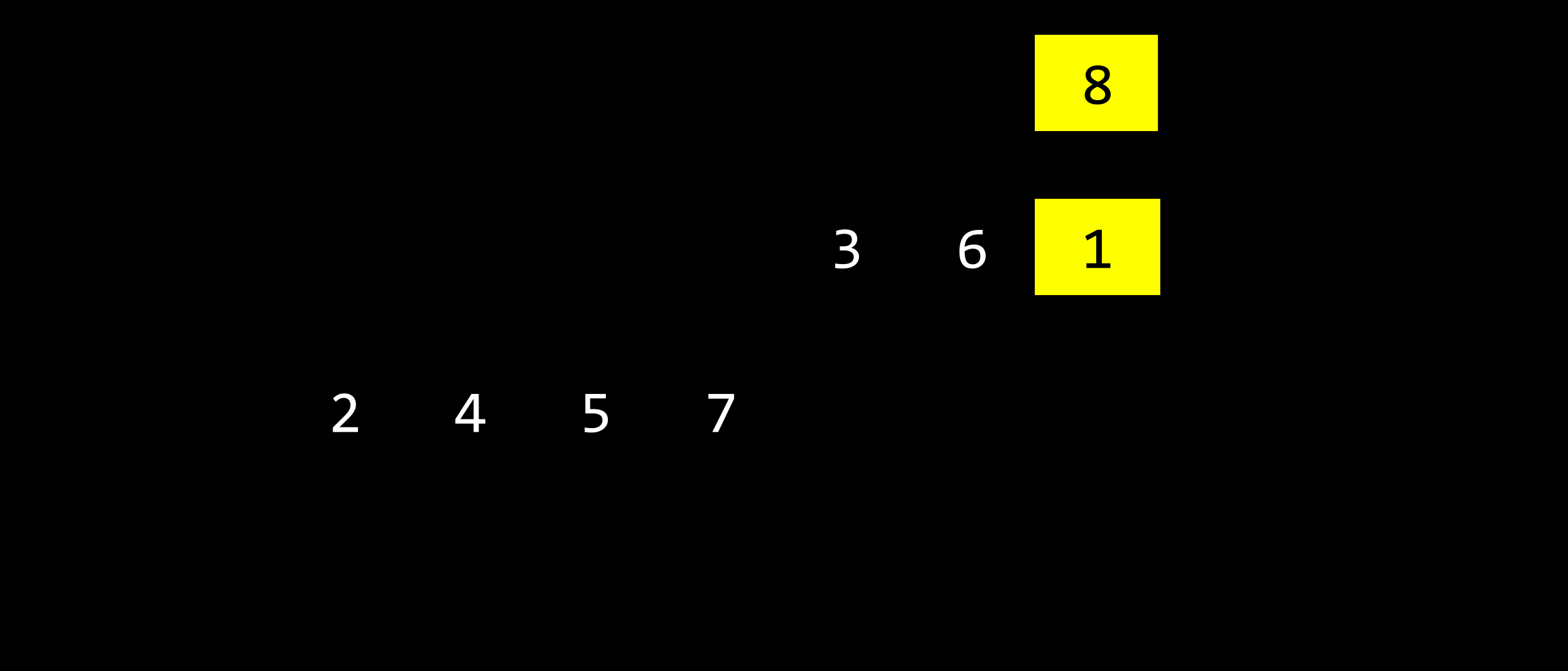
2 4 5 7

8 1

3 6

2 4 5 7


8
1
3
6
2
4
5
7


8
3
6
1
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4
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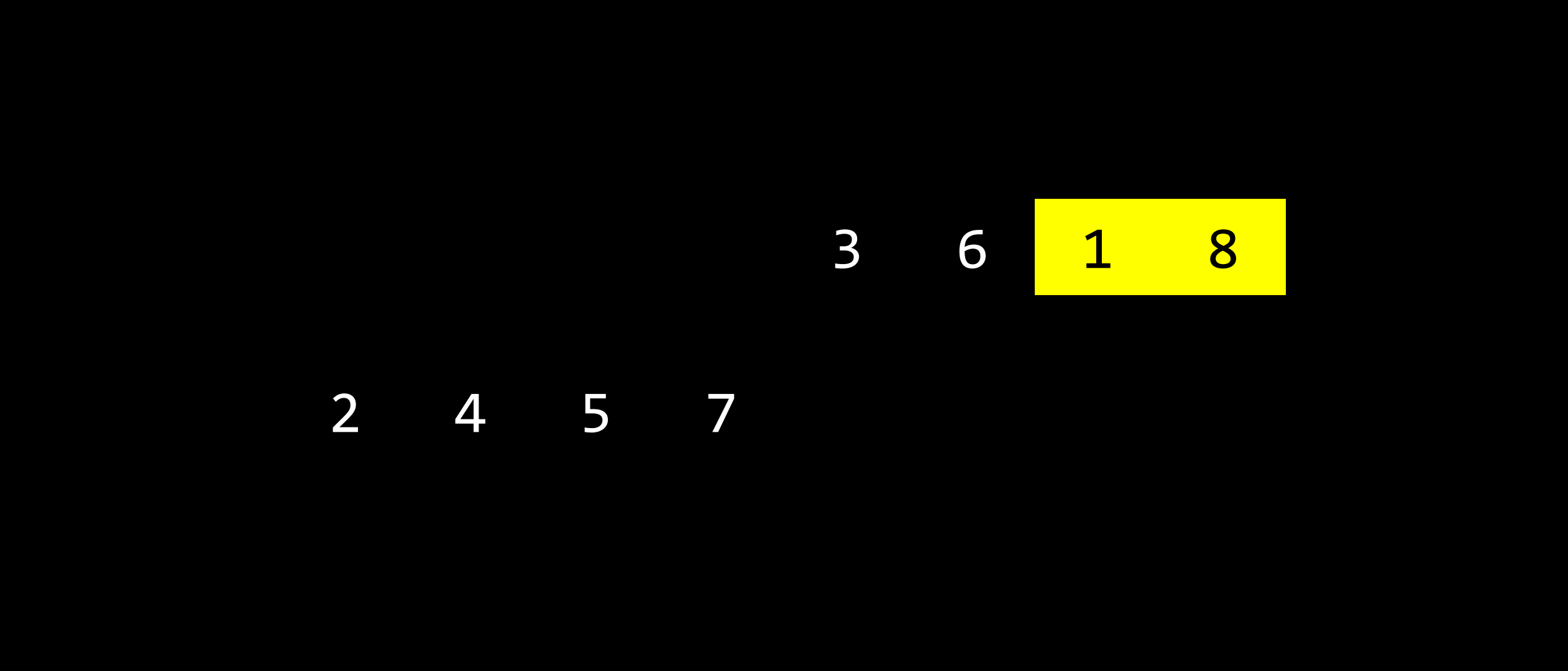
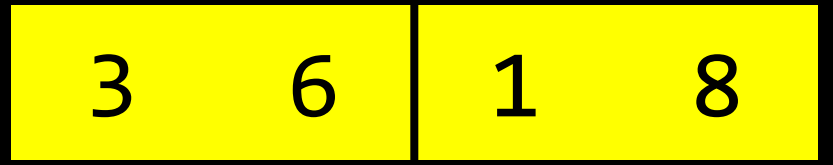
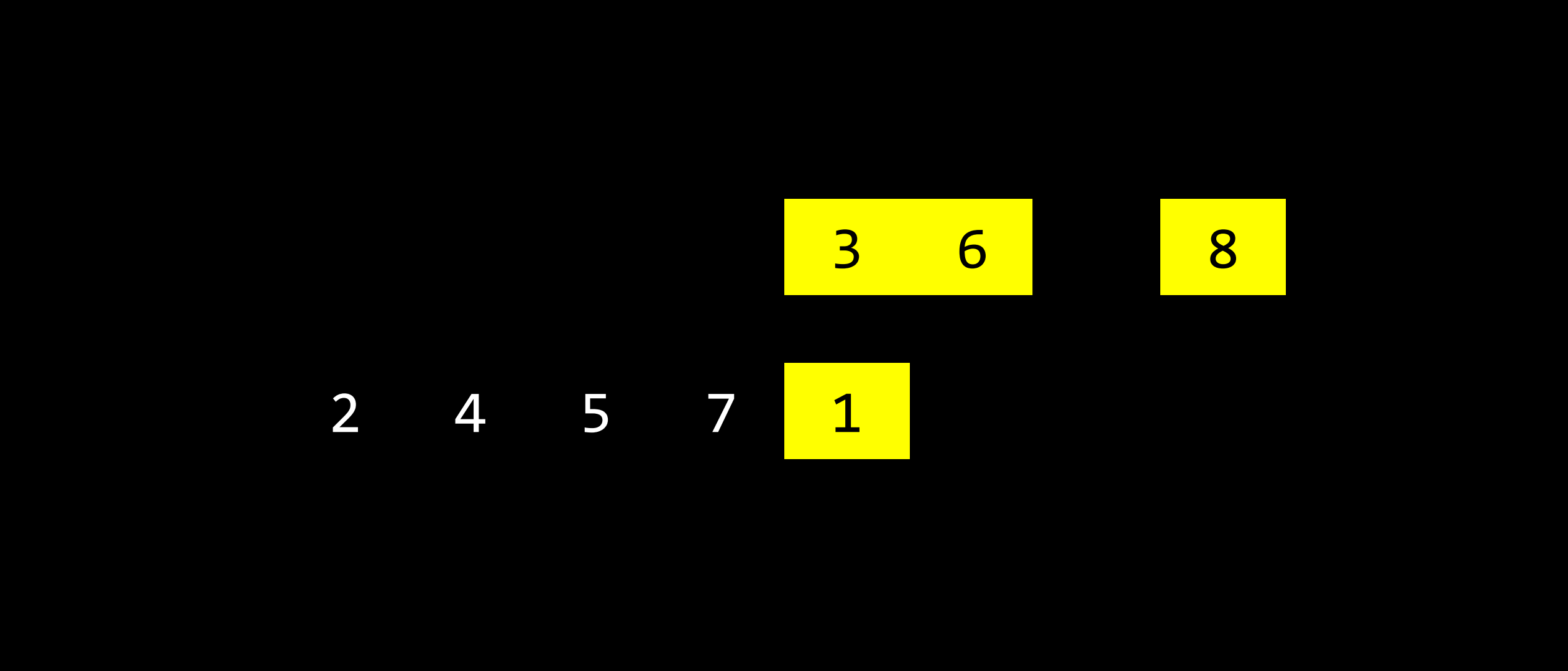
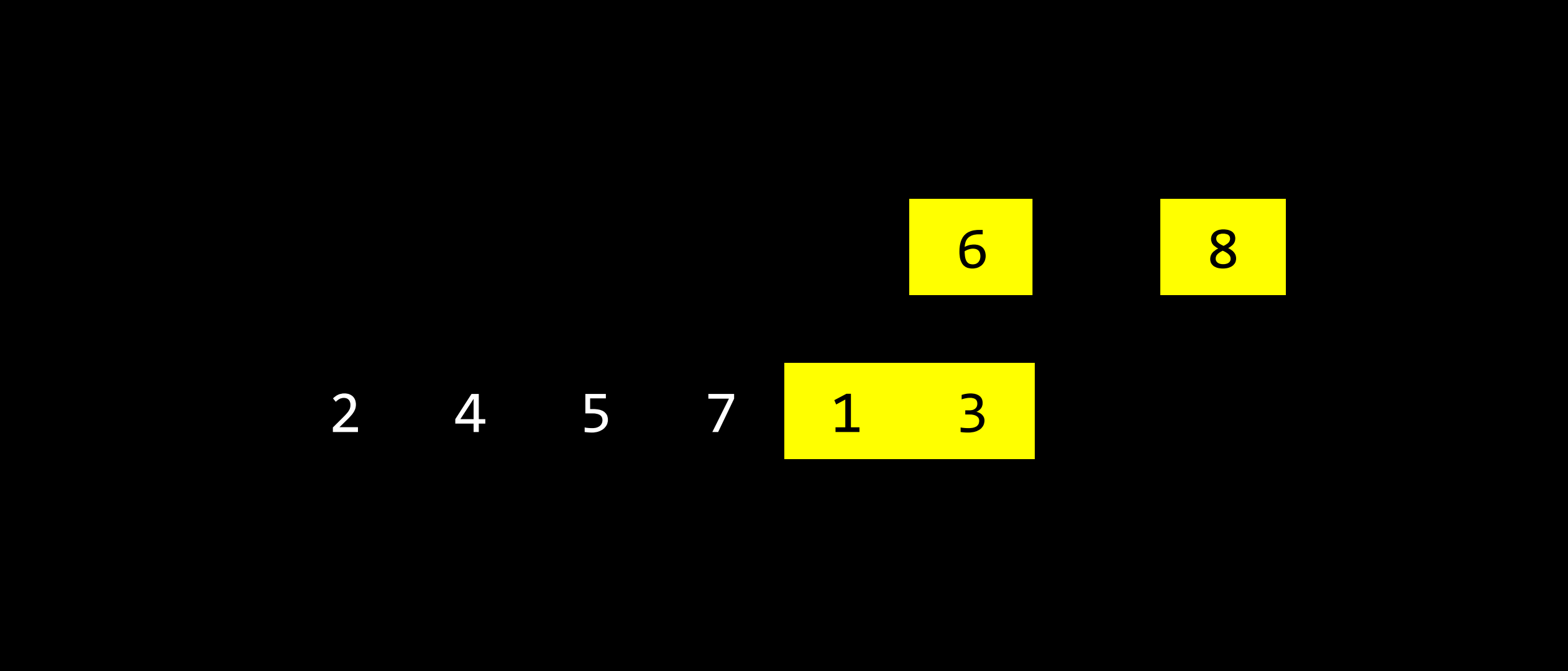
7


3 6 1 8
2 4 5 7



2 4 5 7


3 6
8
2 4 5 7
1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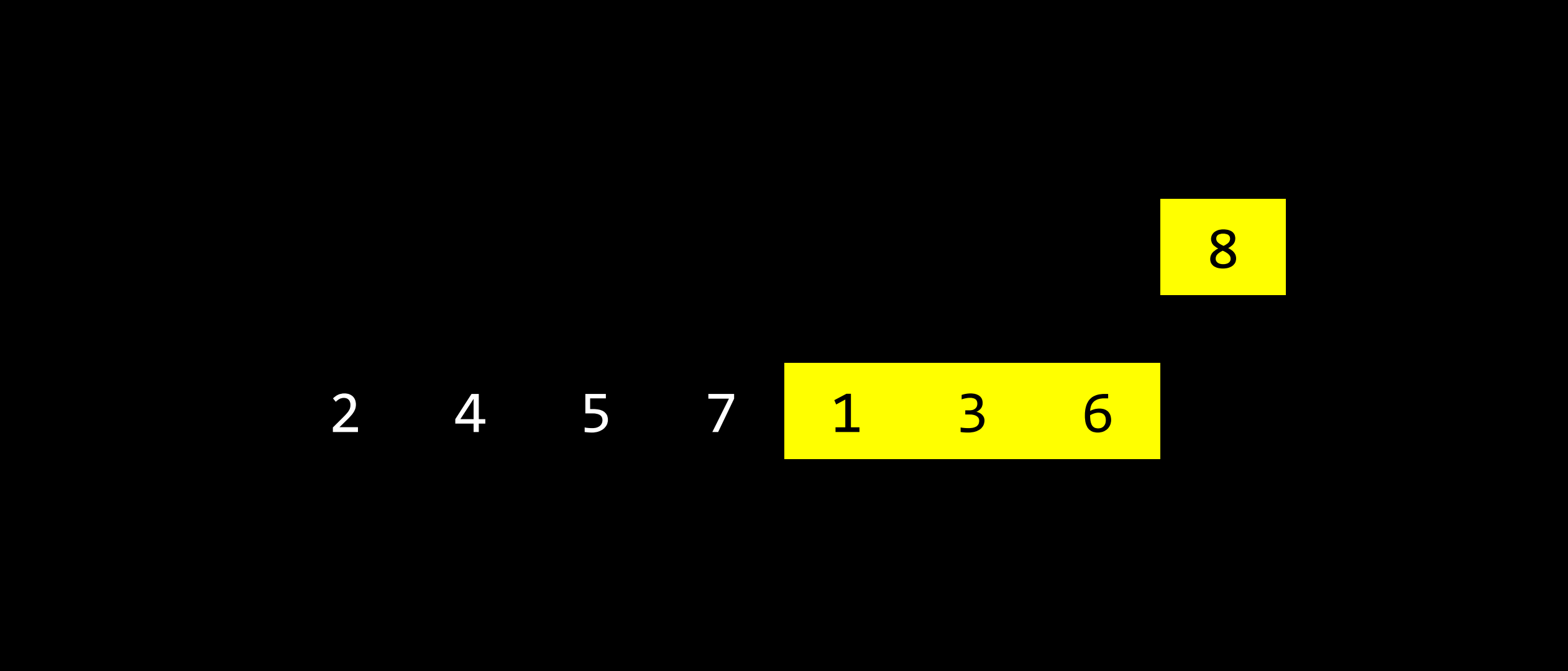
5
7
1
3


8
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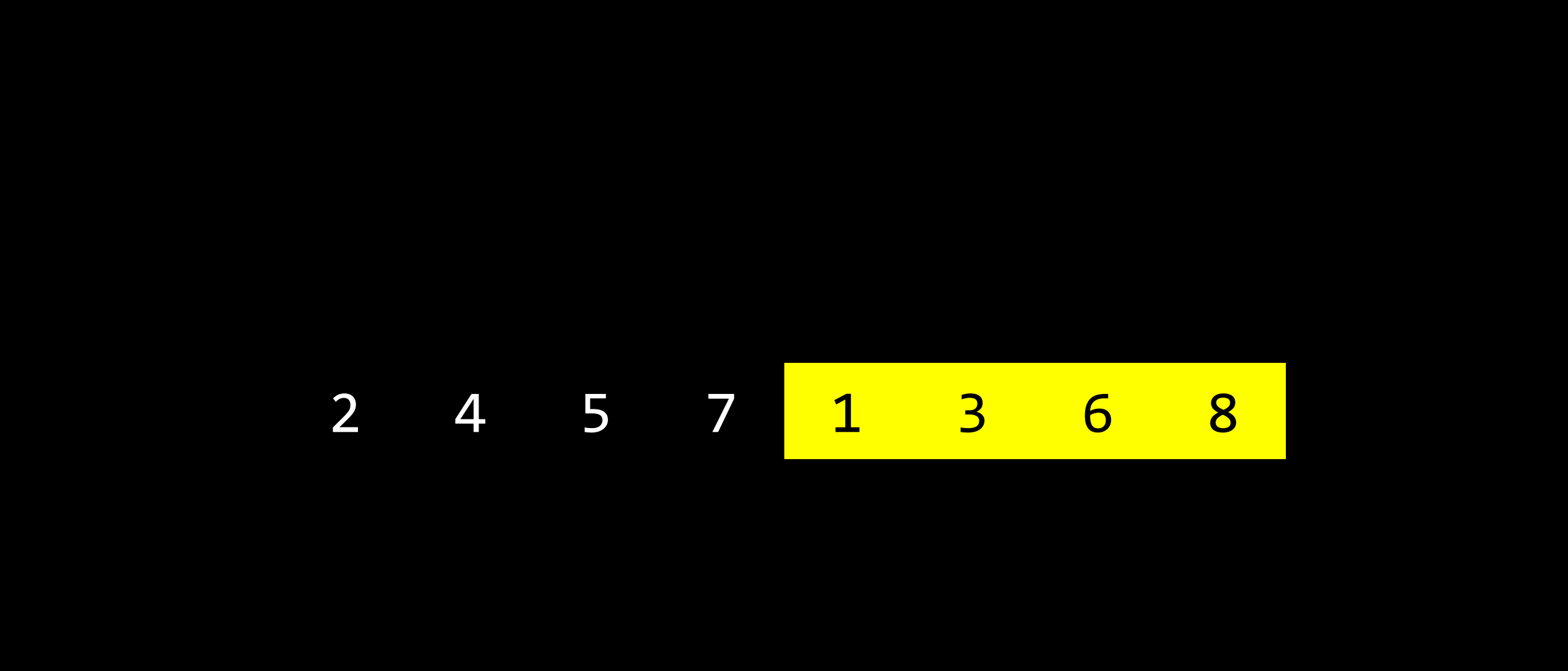
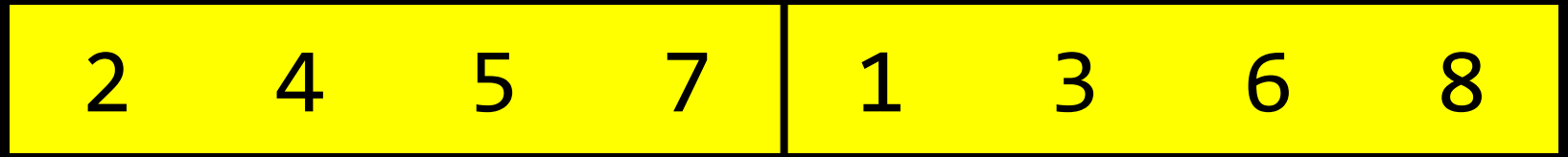

2 4 5 7 1 3 6 8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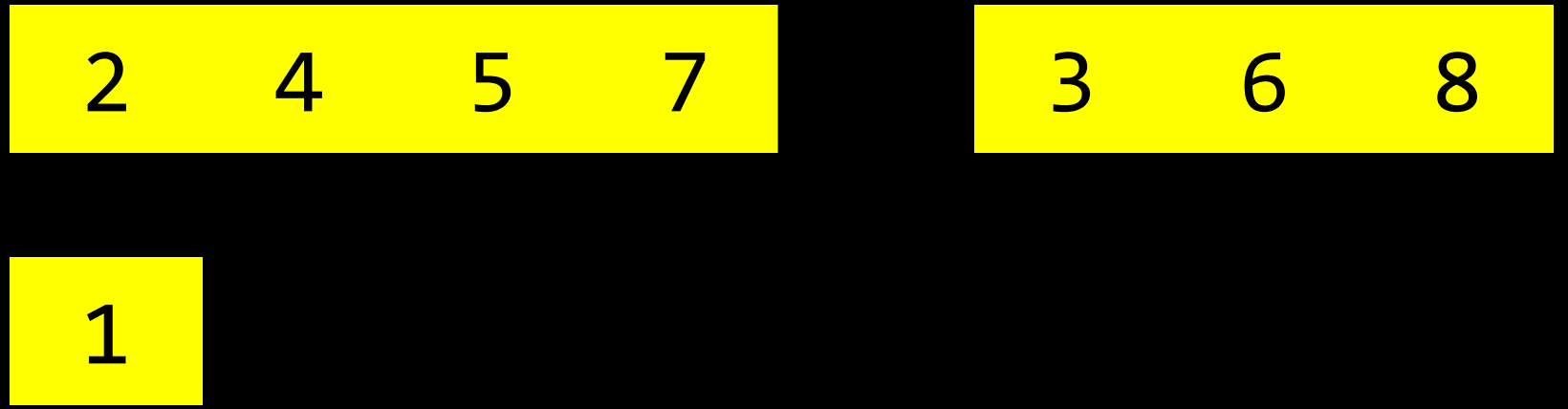
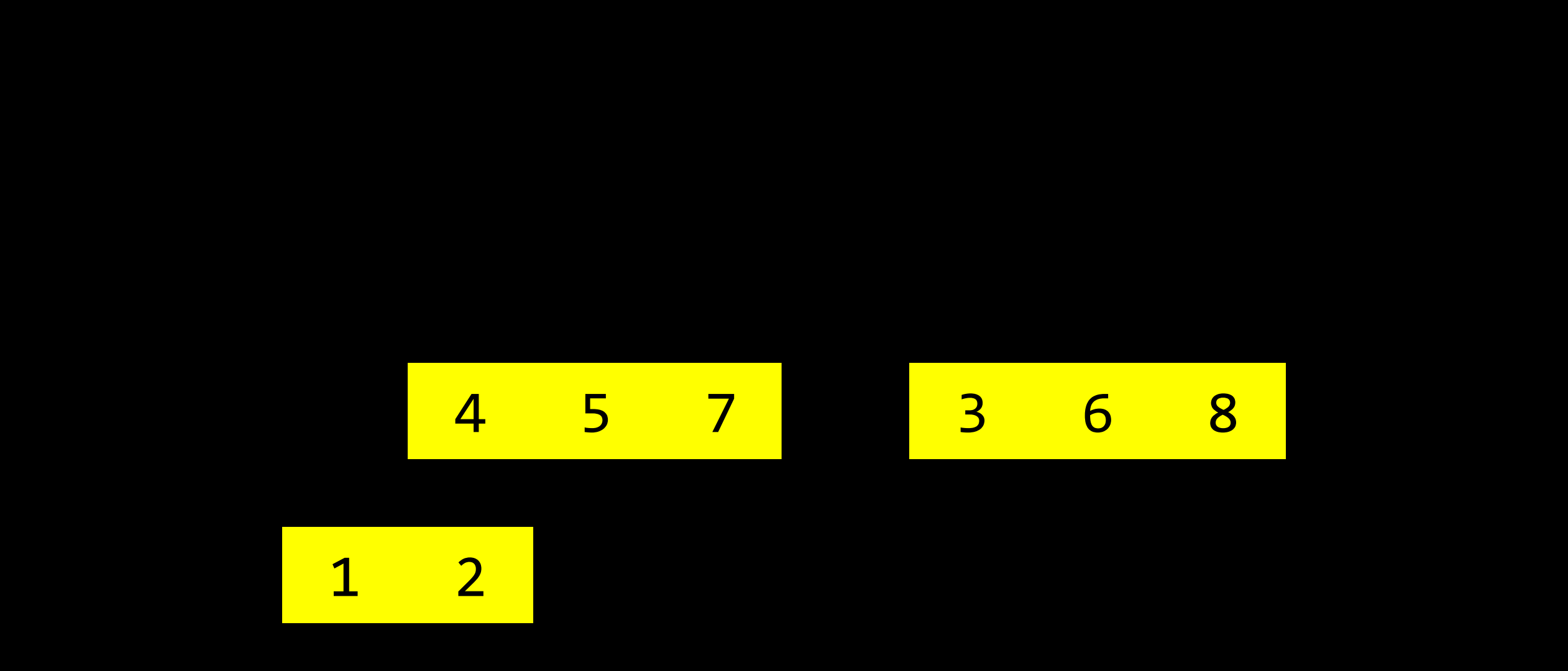
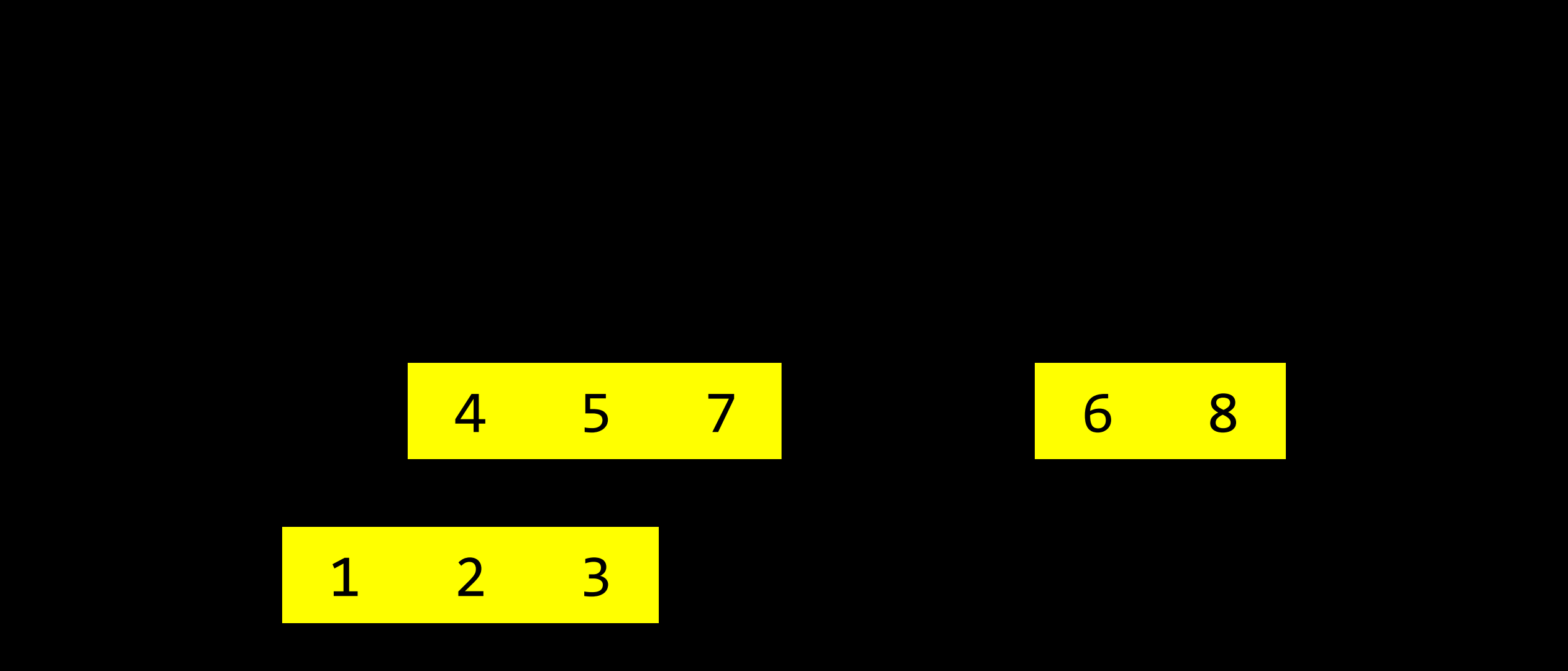
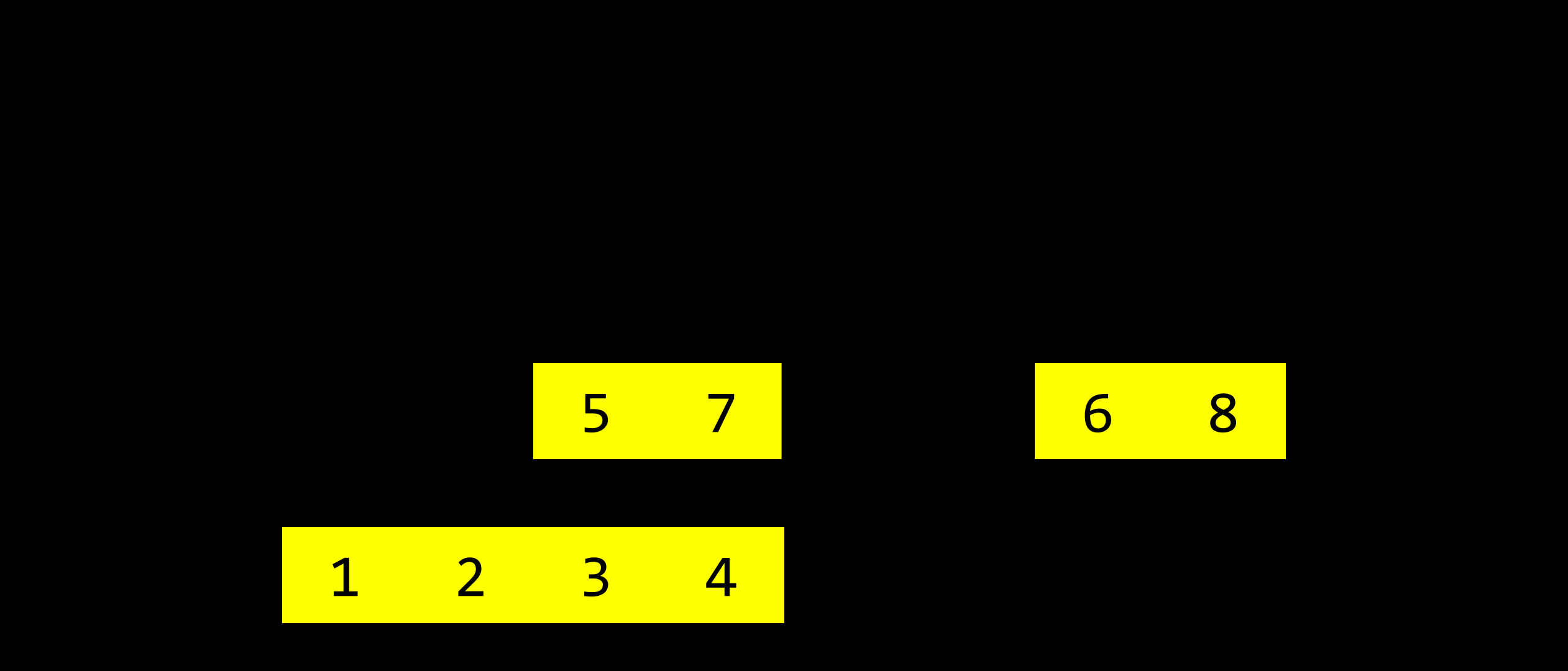
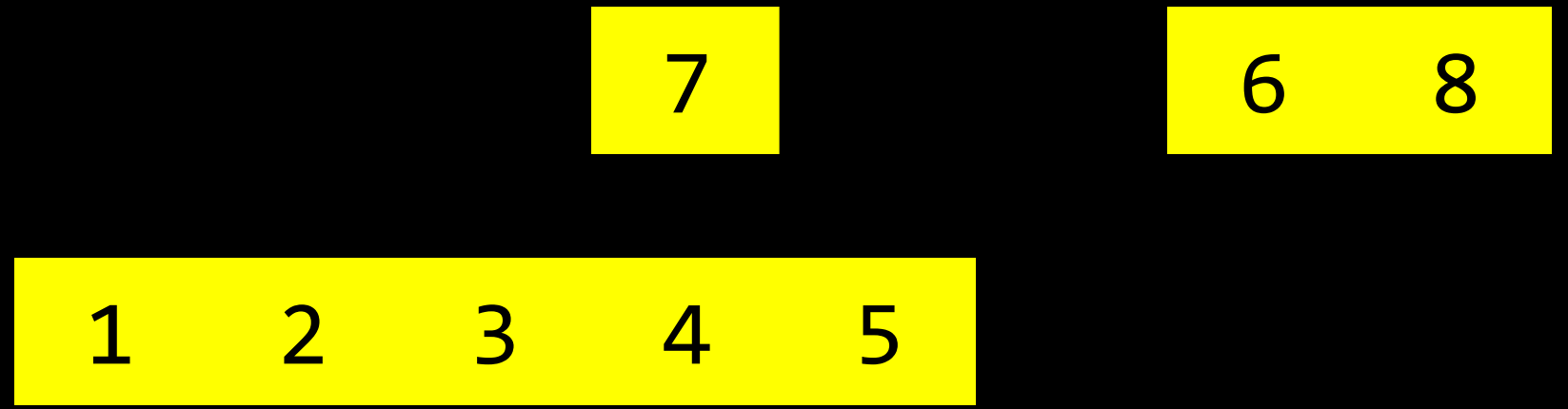
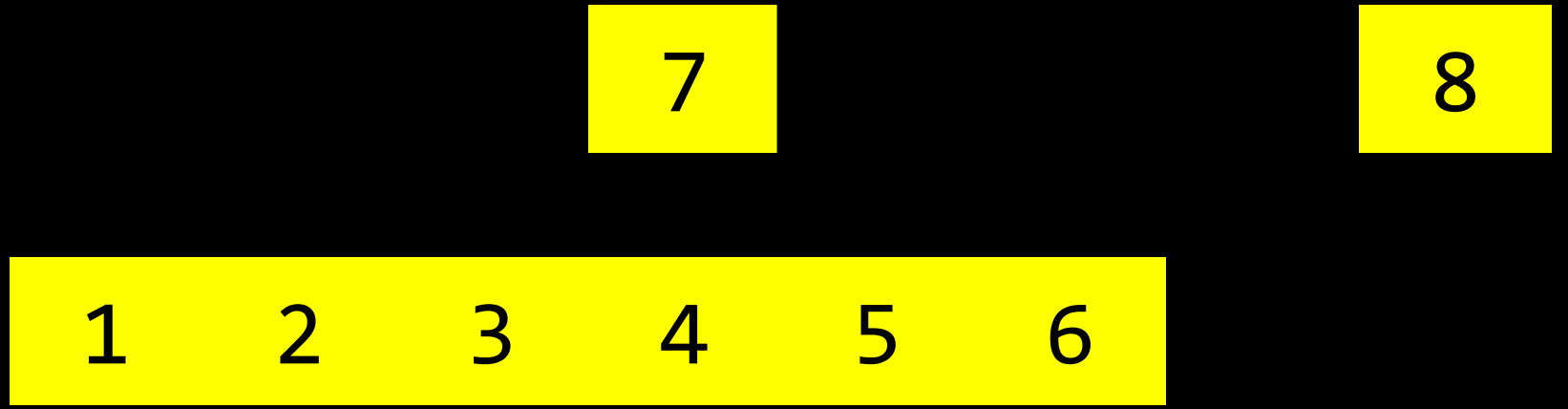

2 4 5 7
3 6 8
1

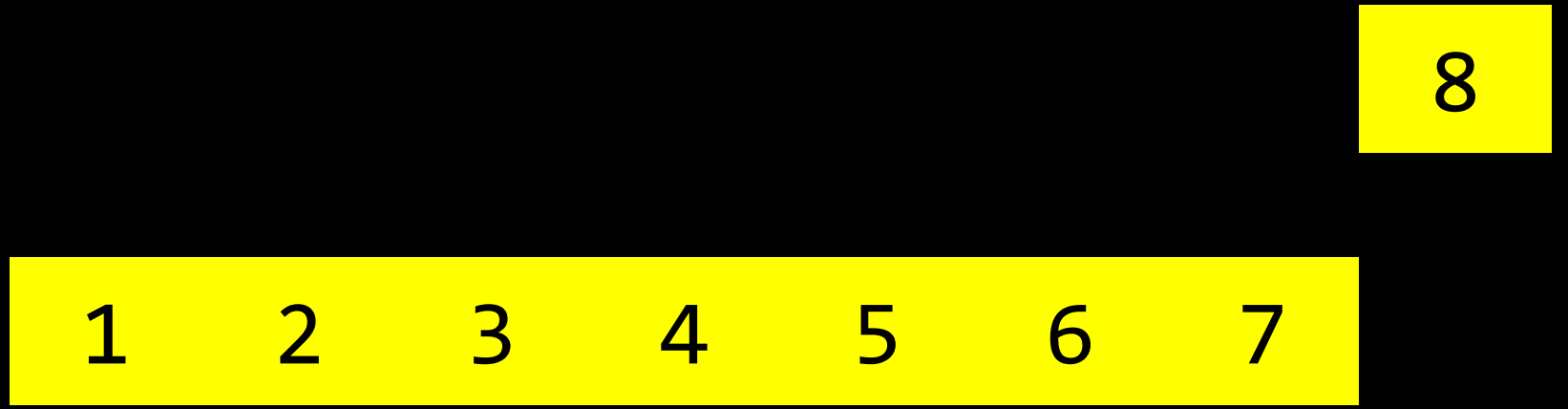

4 5 7
3 6 8
1 2

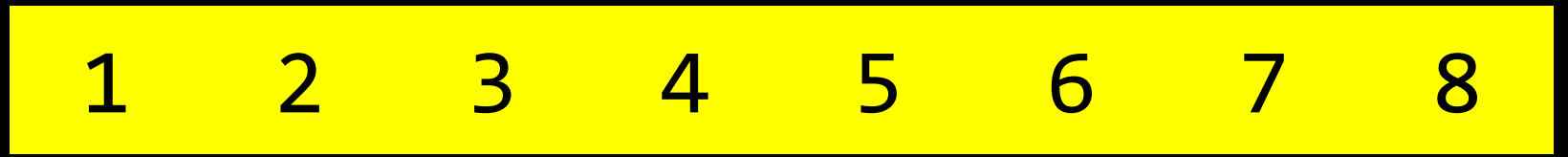

4 5 7
6 8
1 2 3

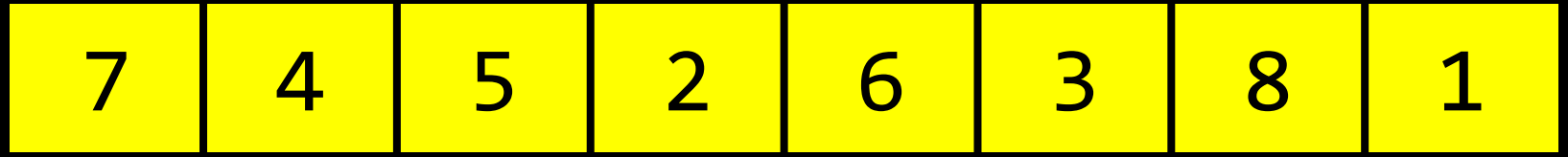

5 7
6 8
1 2 3 4


7
6 8
1 2 3 4 5


7
8
1 2 3 4 5 6


8
1 2 3 4 5 6 7


1 2 3 4 5 6 7 8


7
4
5
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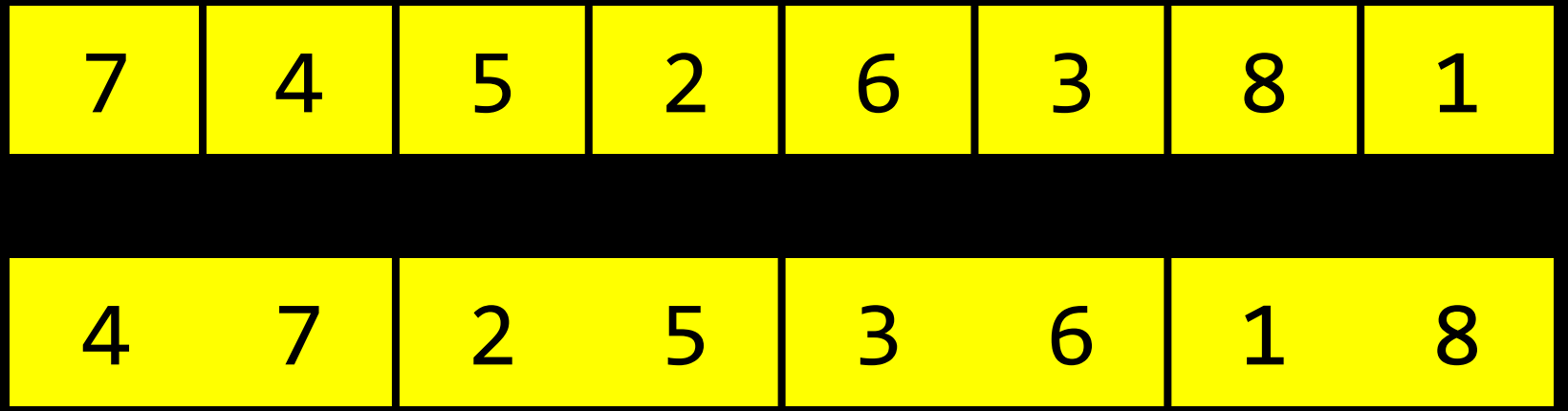
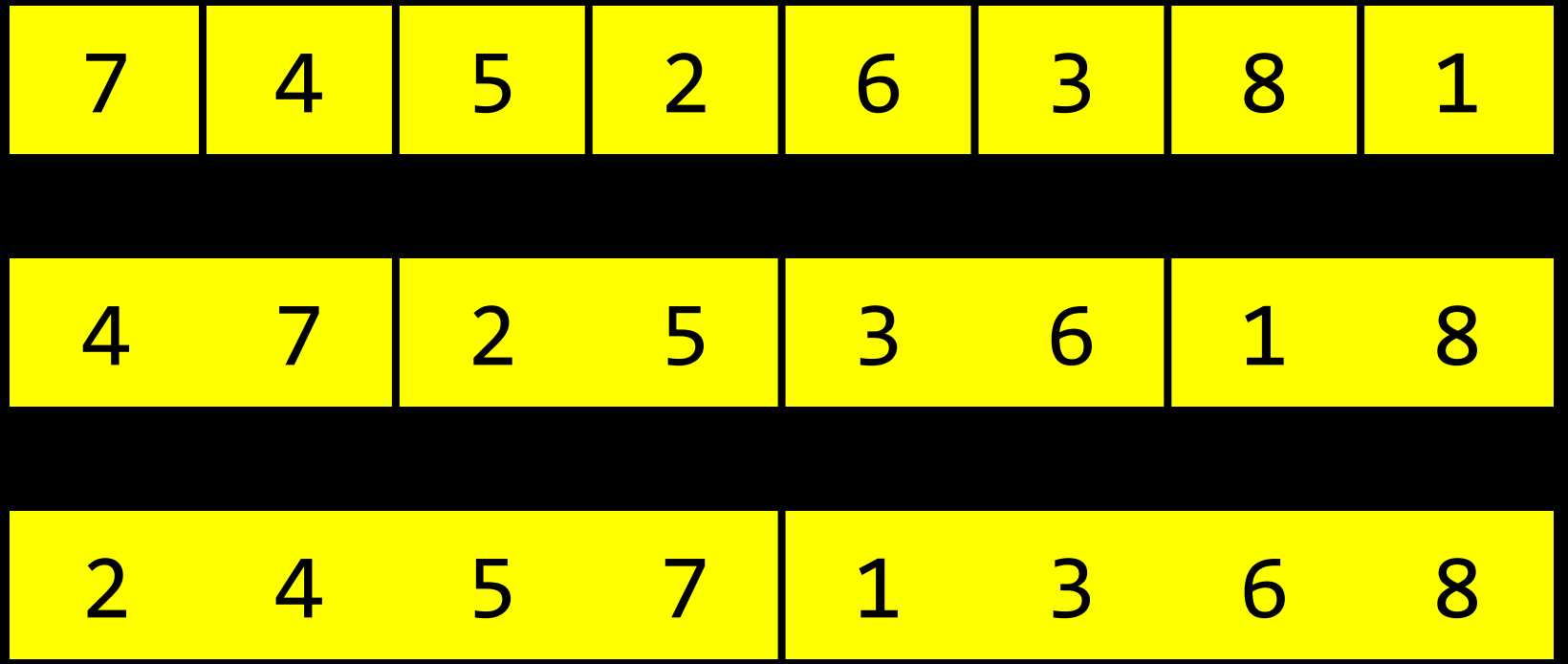
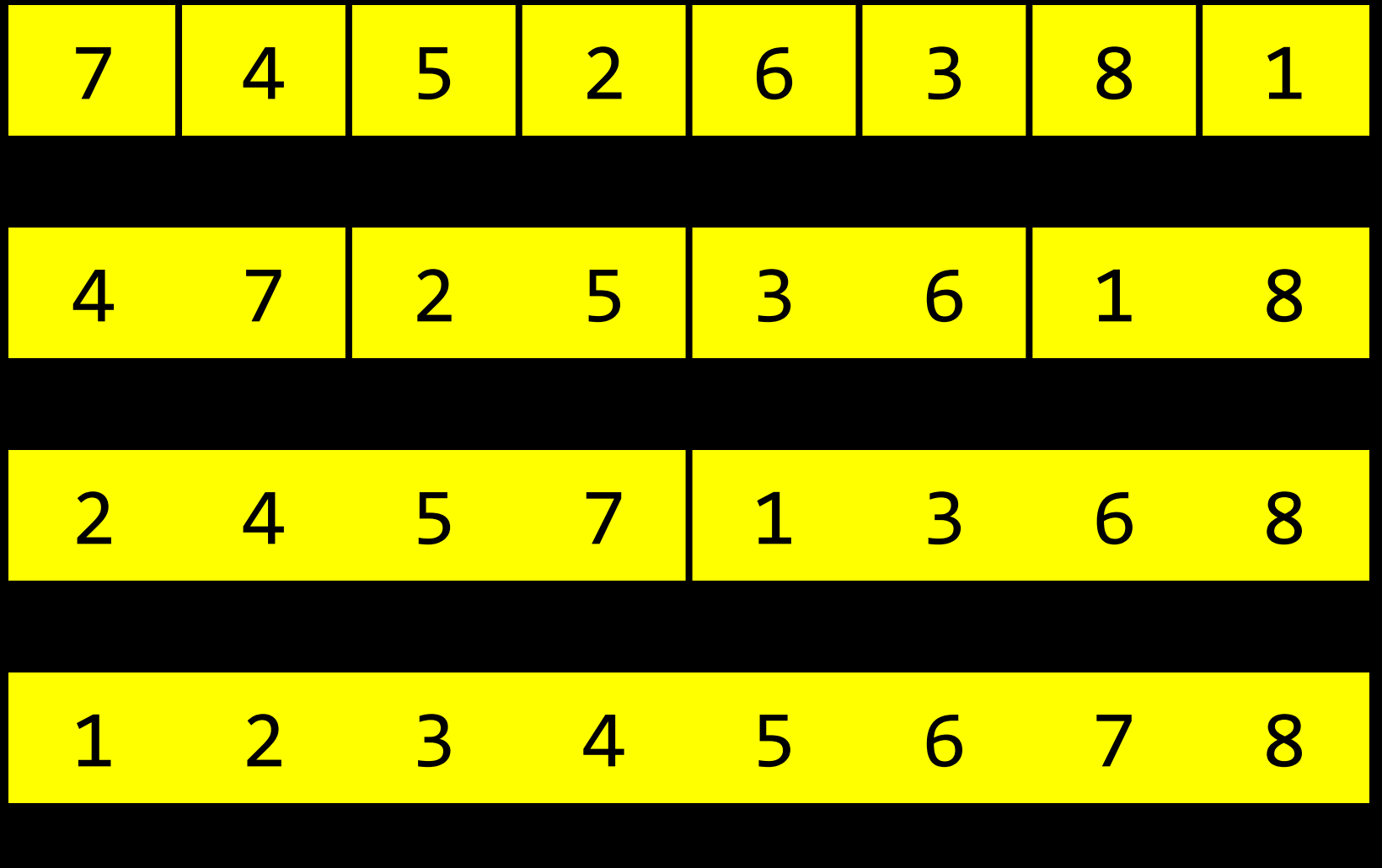
6
3
8
1


7 4 5 2 6 3 8 1
4 7 2 5 3 6 1 8


7 4 5 2 6 3 8 1
4 7 2 5 3 6 1 8
2 4 5 7 1 3 6 8


7 4 5 2 6 3 8 1
4 7 2 5 3 6 1 8
2 4 5 7 1 3 6 8
1 2 3 4 5 6 7 8

$O(n^2)$

$O(n \log n)$ merge sort

$O(n)$

$O(\log n)$

$O(1)$

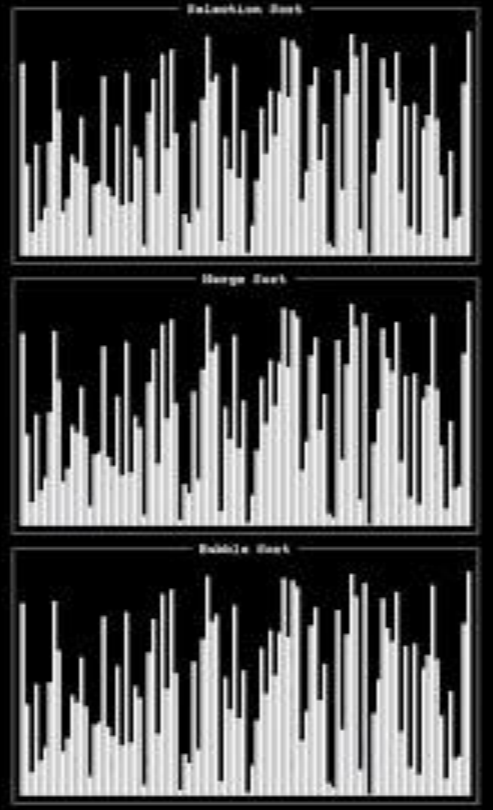
$\Omega(n^2)$

$\Omega(n \log n)$ merge sort

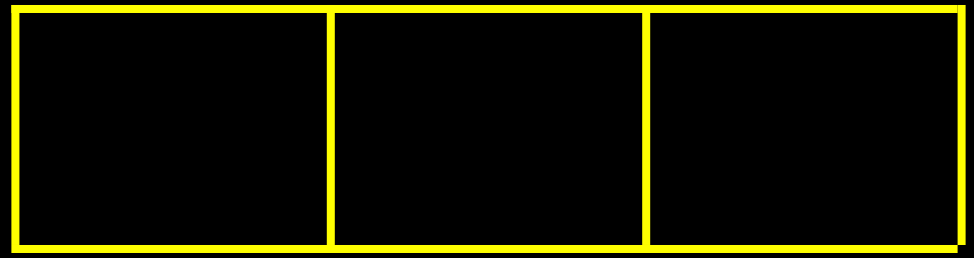
$\Omega(n)$

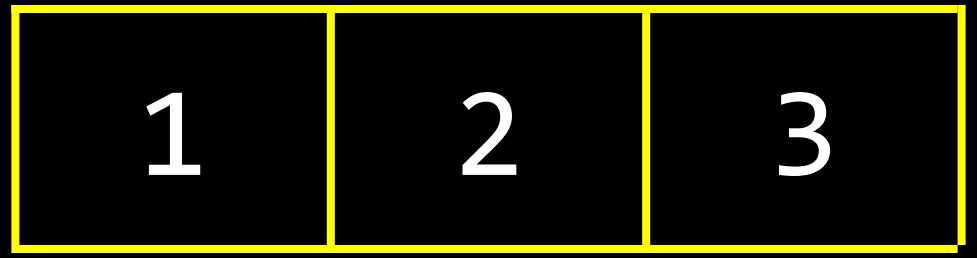
$\Omega(\log n)$

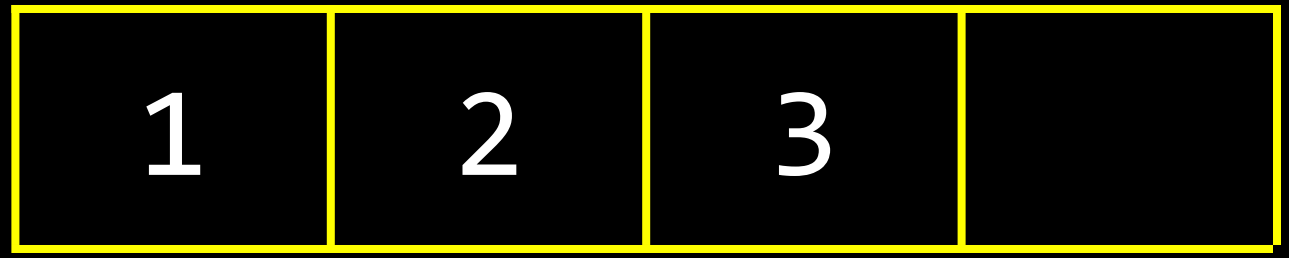
$\Omega(1)$


Selection Sort
Merge Sort
Bubble Sort

arrays




1
2
3


1
2
3

1 2 3

?	?	?	?	?	?	?	?
?	1	2	3	?	?	?	?
?	?	?	?	?	?	?	?
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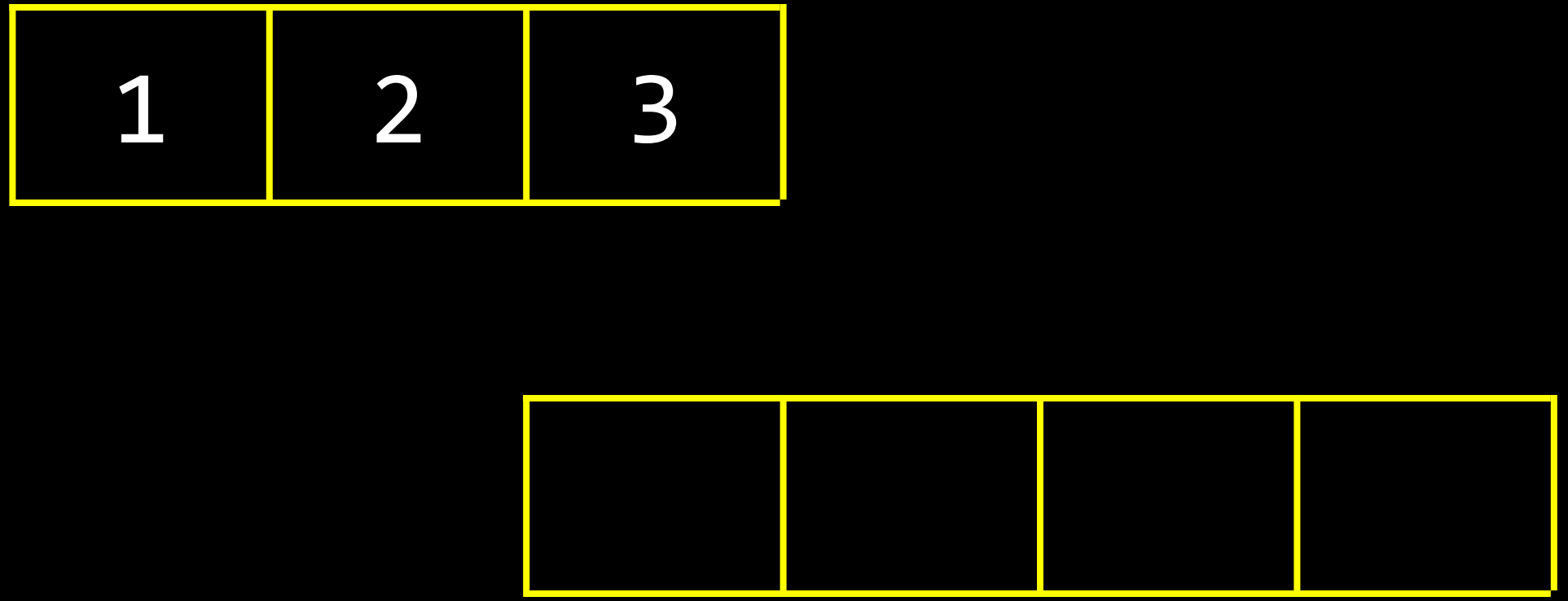
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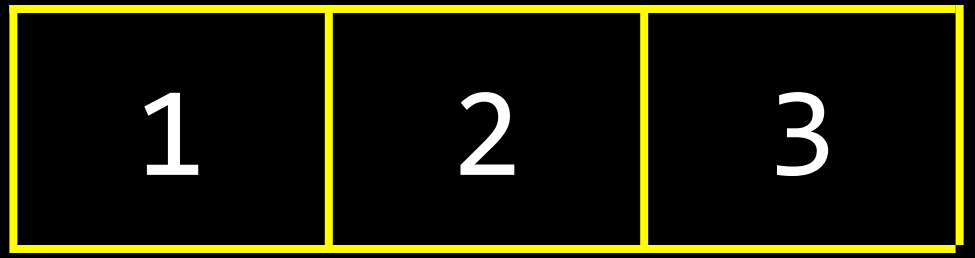
3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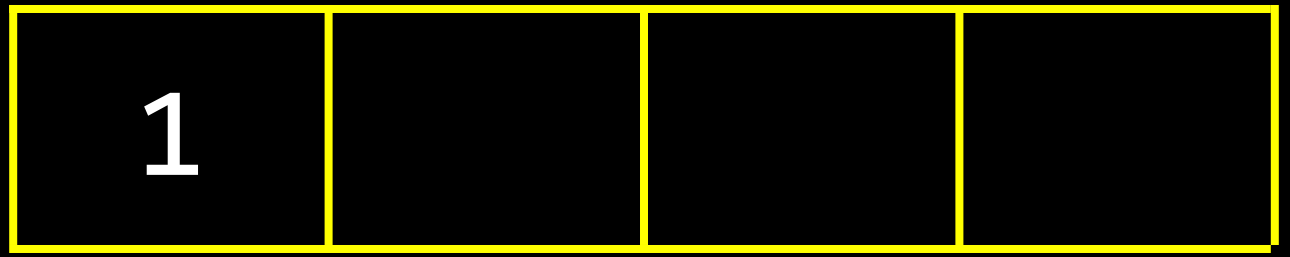
3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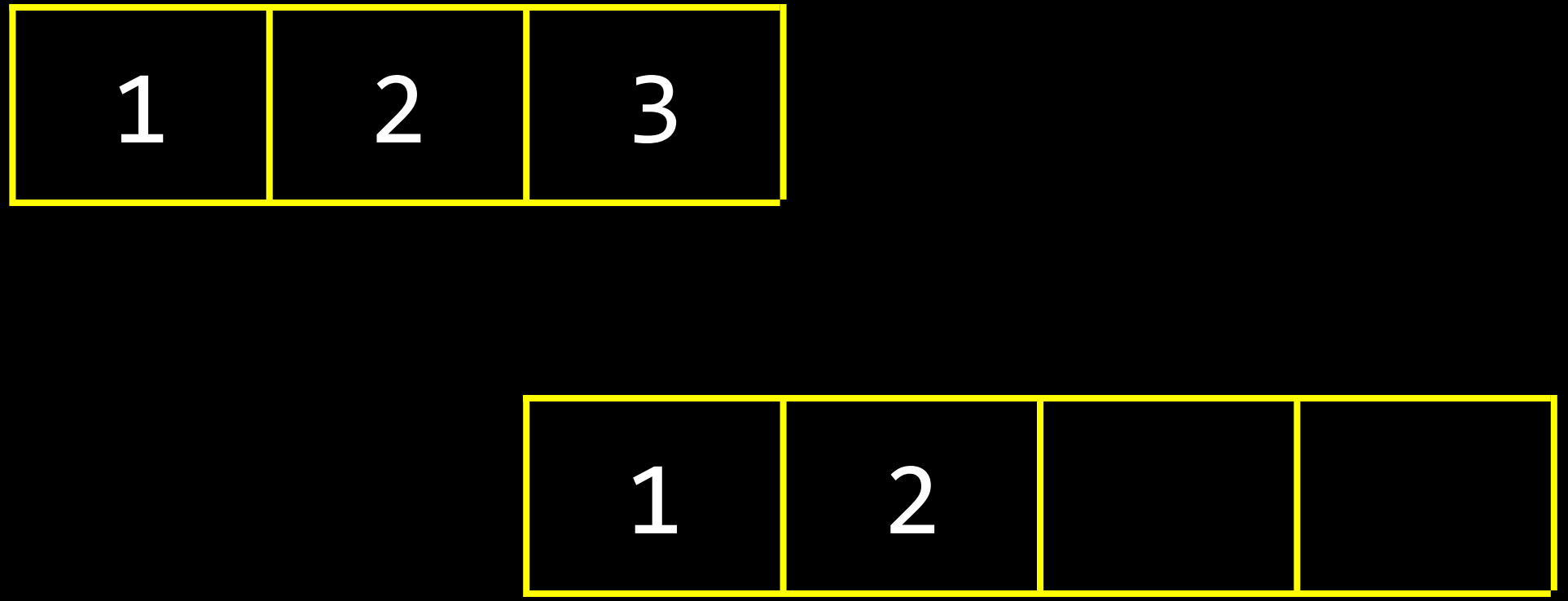
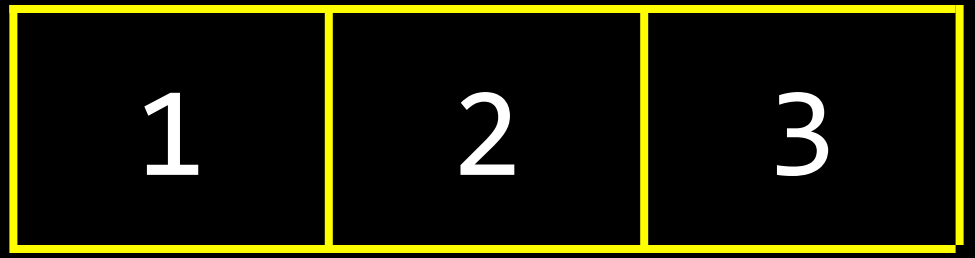

1
2
3
1
2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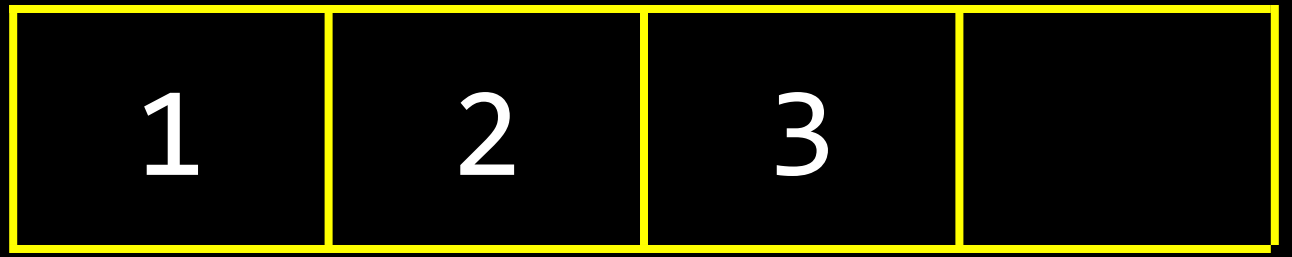
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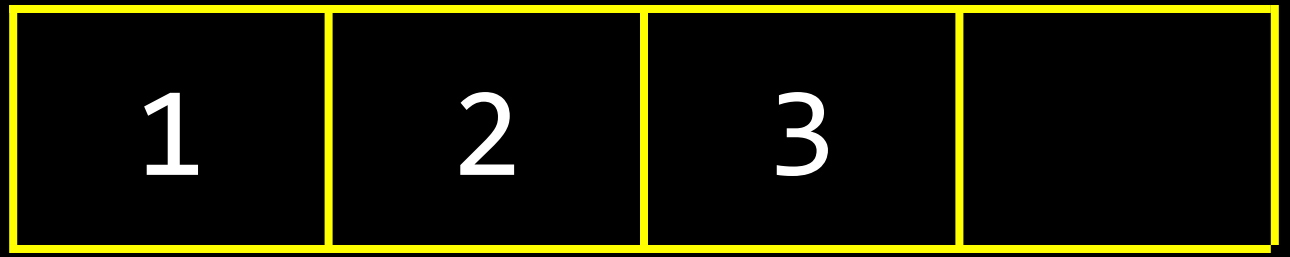
1
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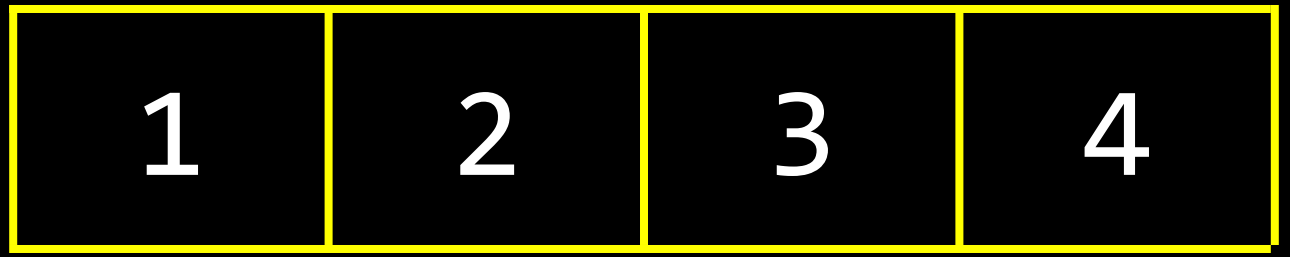

1
2
3
4

$O(n^2)$

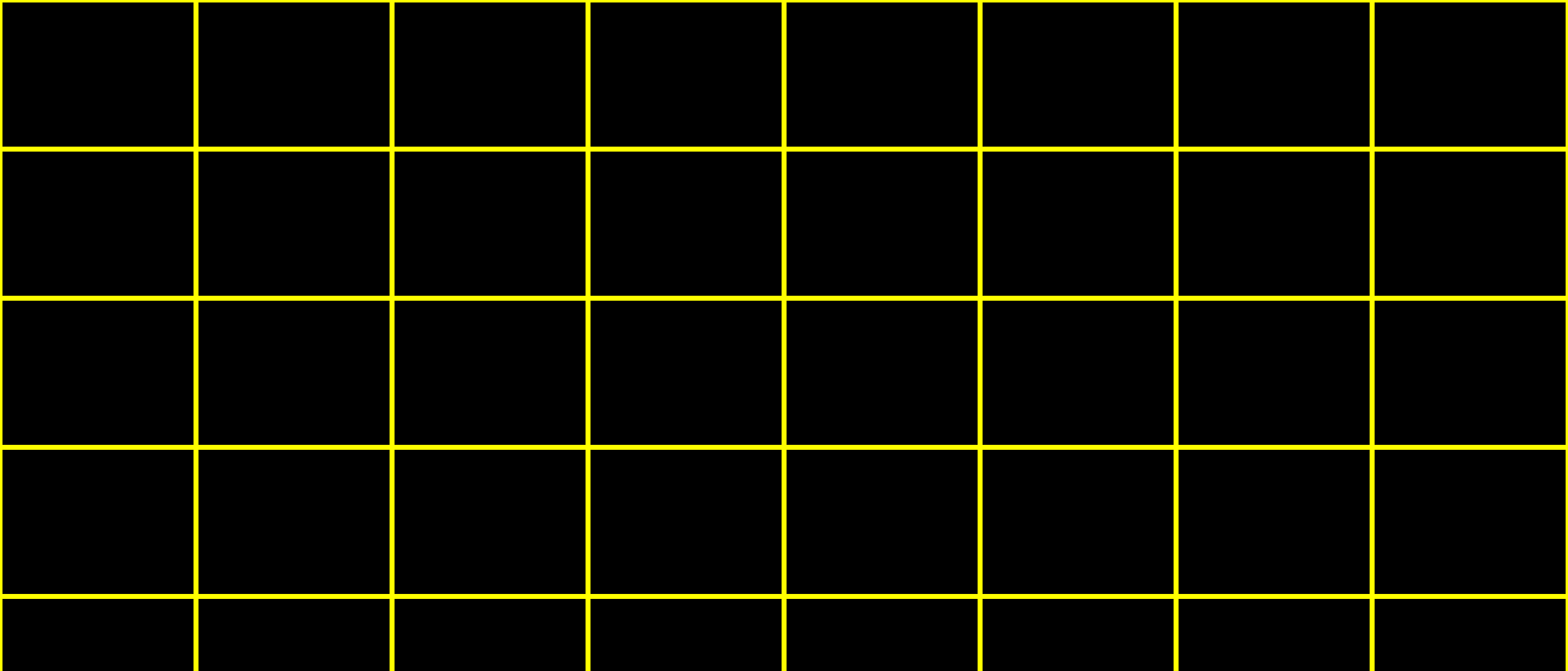
$O(n \log n)$

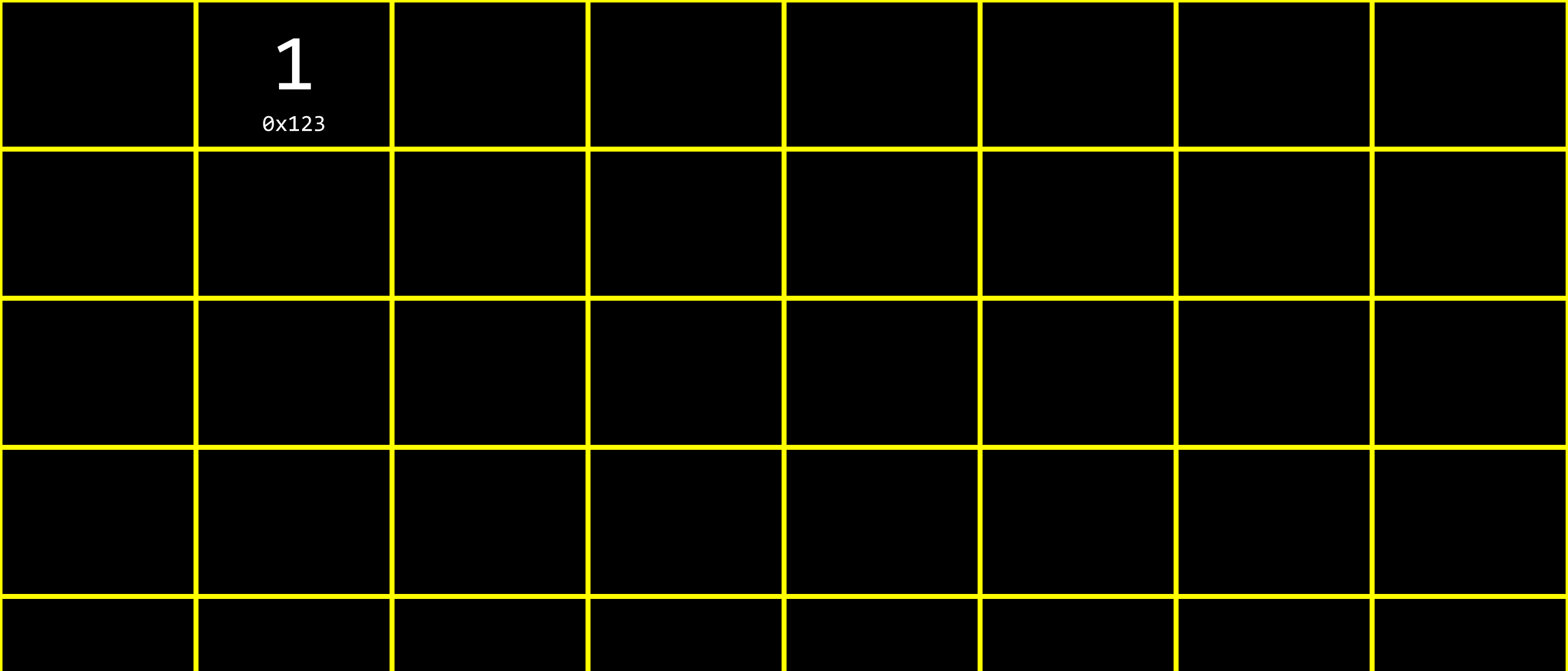
$O(n)$

$O(\log n)$

$O(1)$

linked lists

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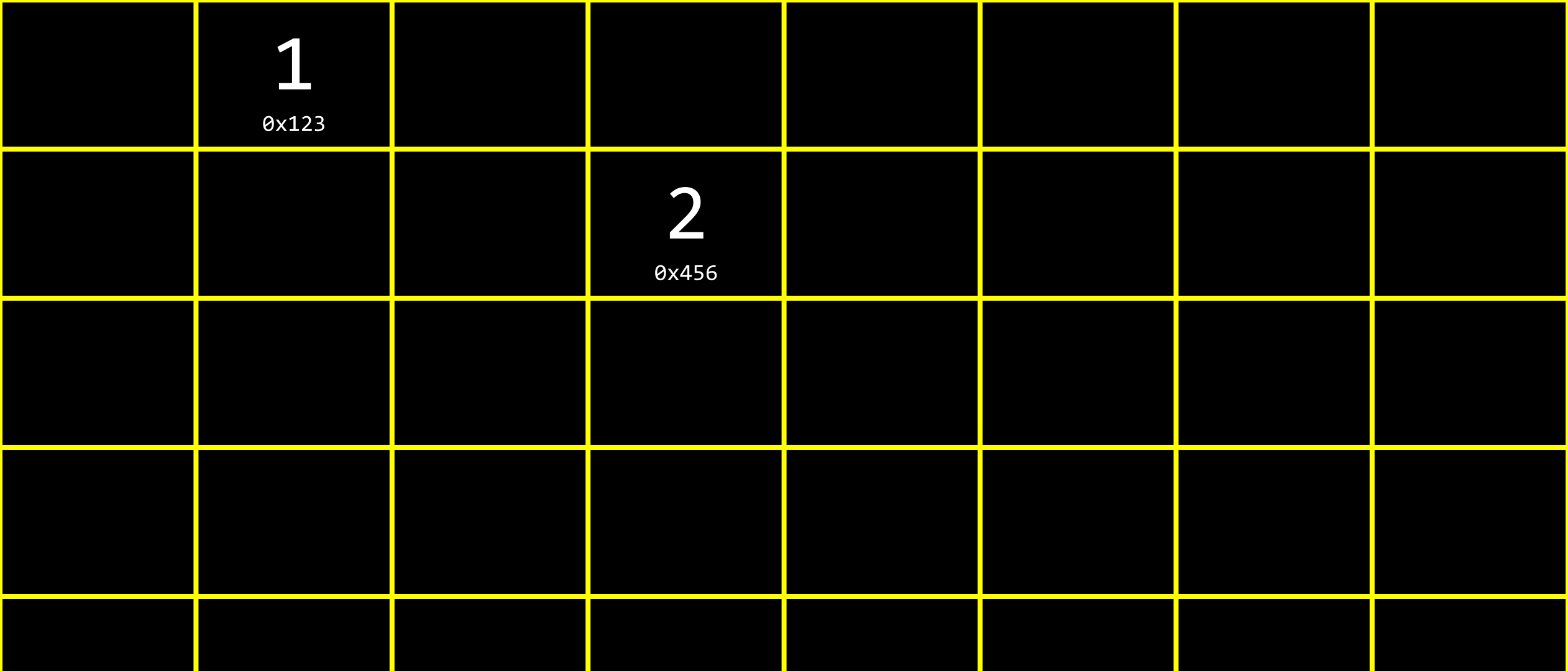
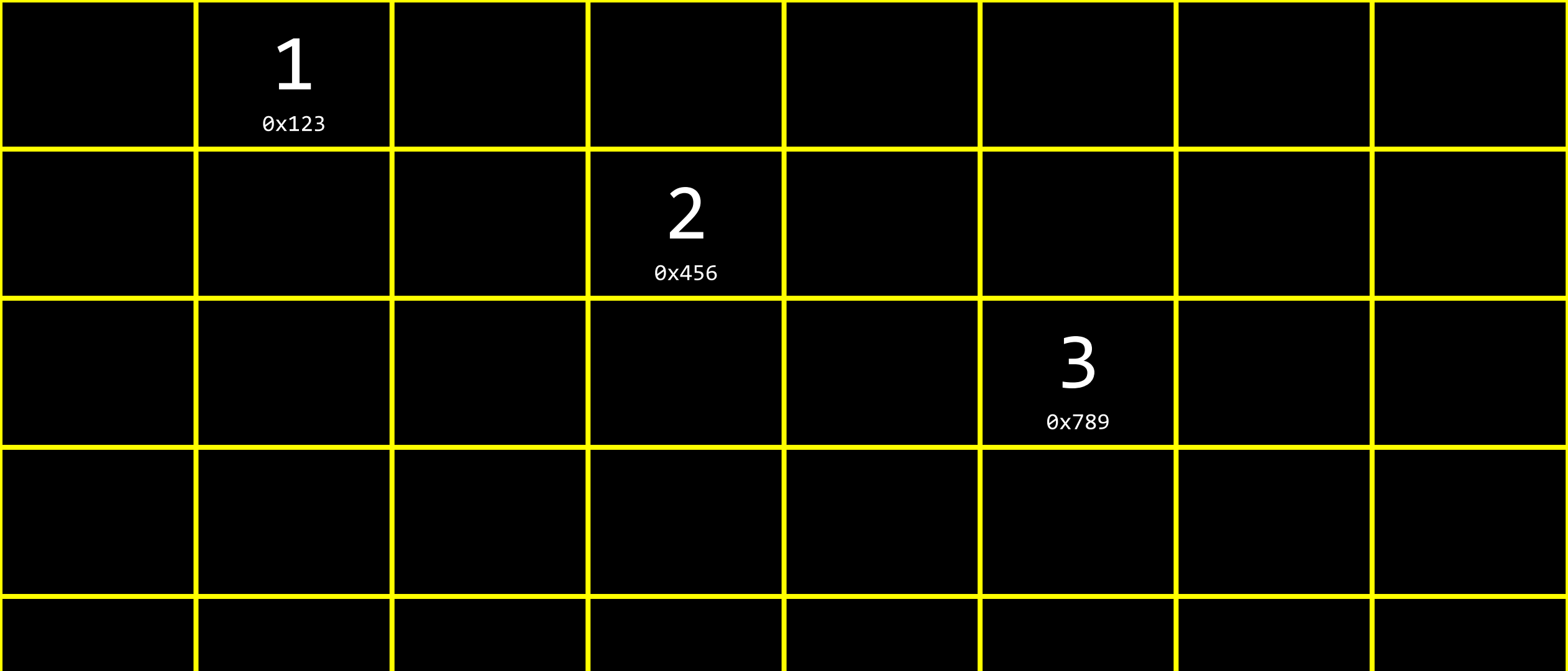
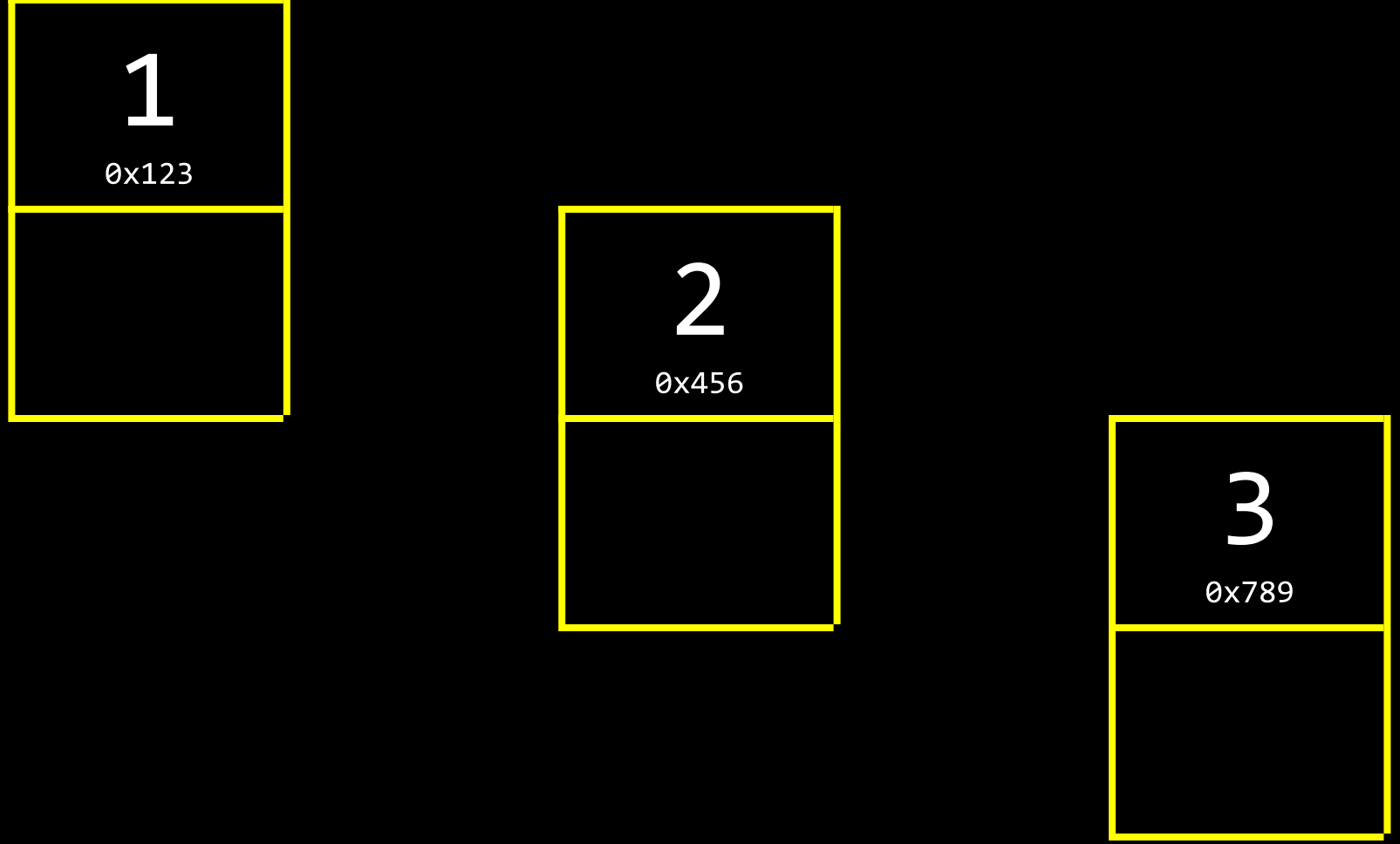
0x123


1
0x123
2
0x456


1
0x123
2
0x456
3
0x789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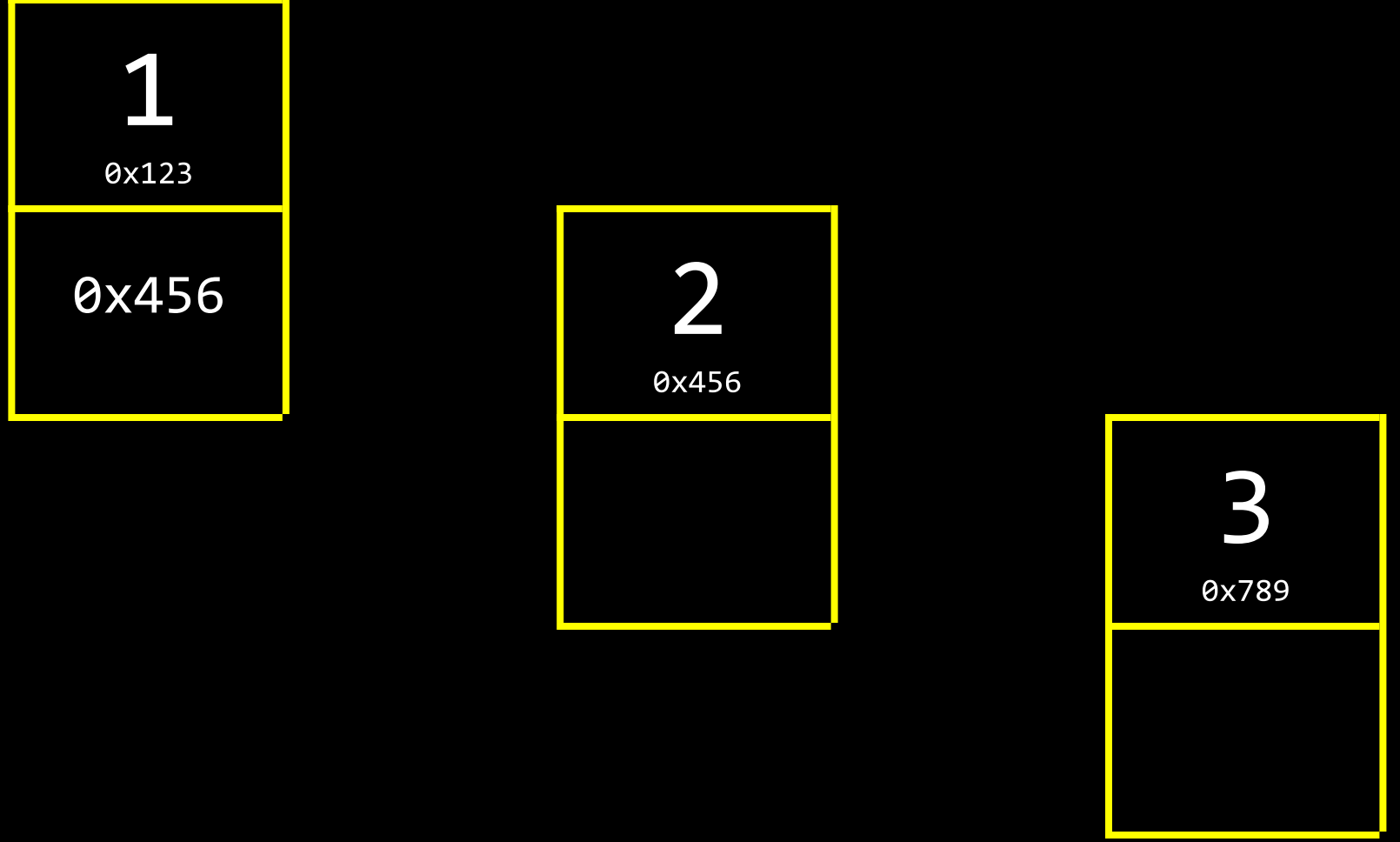
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0x456
2
0x456
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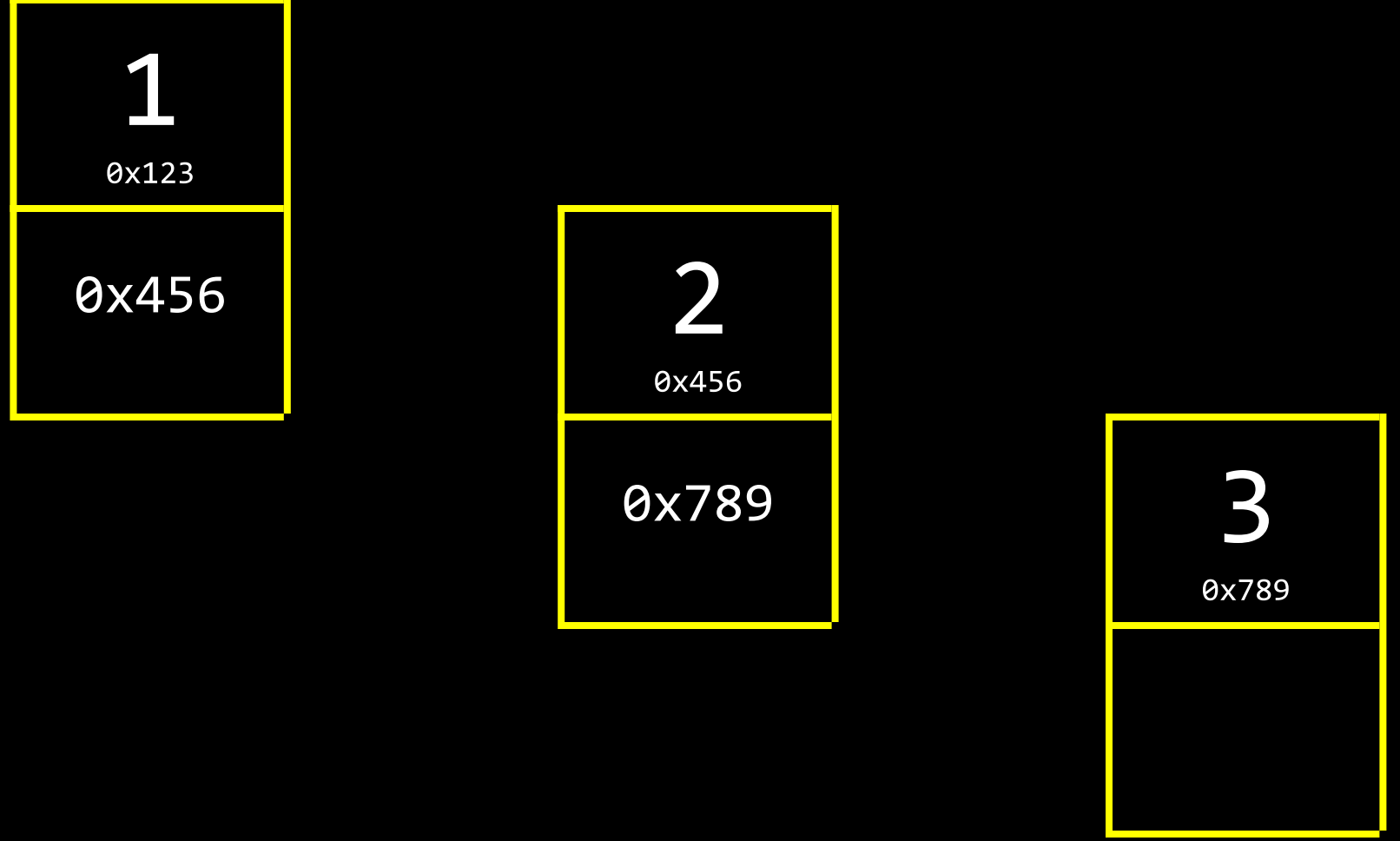
0x789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0x456
2
0x456
0x789
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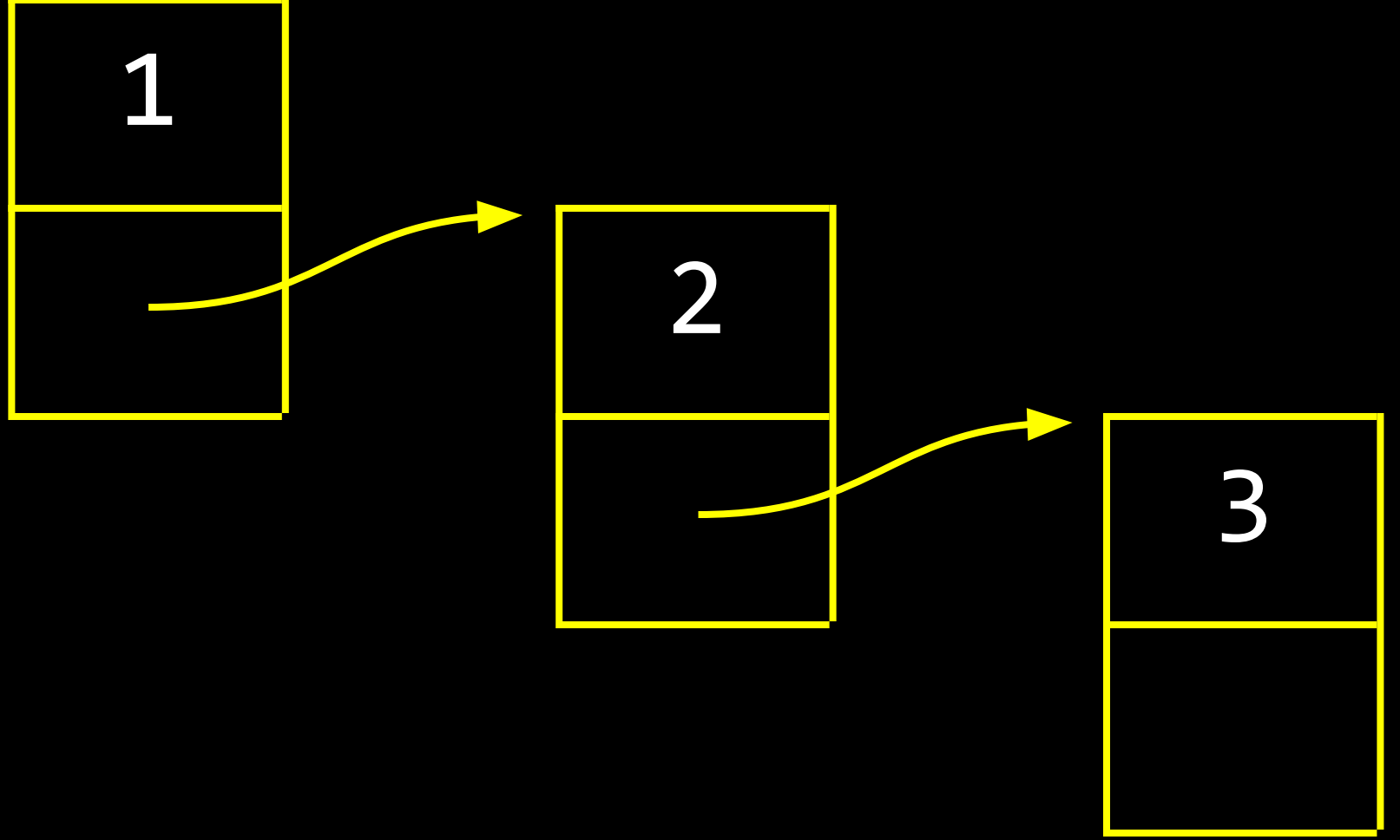
1
2
3

```
dict
list
range
set
tuple
...
```

trees

binary search trees


1
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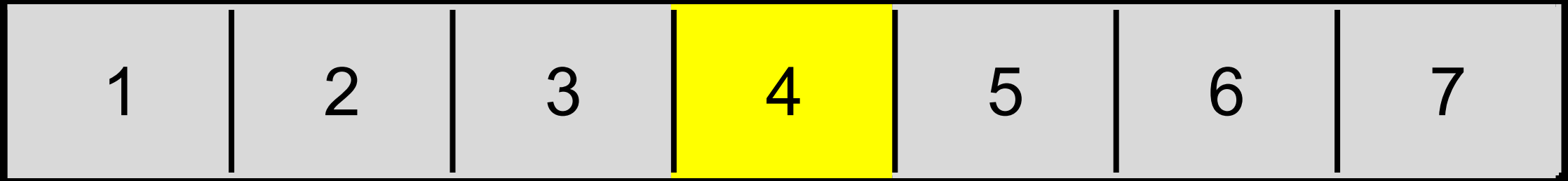
6
7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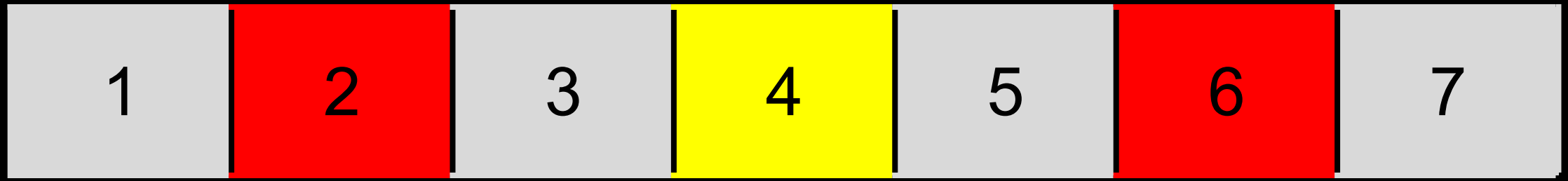
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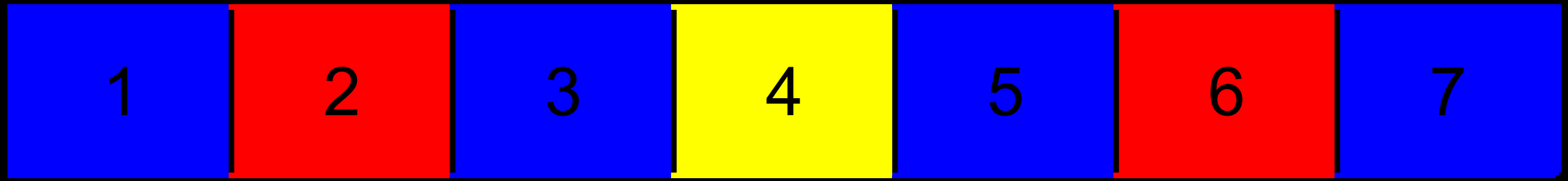
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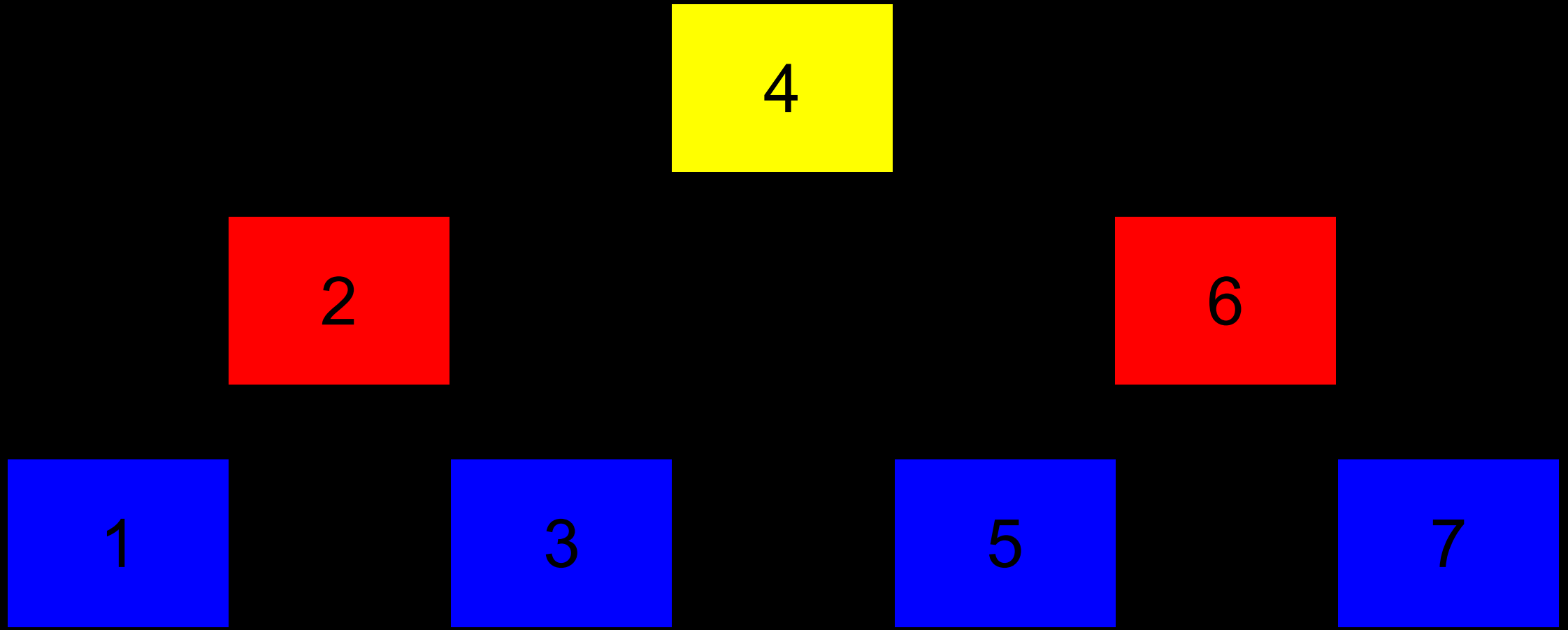
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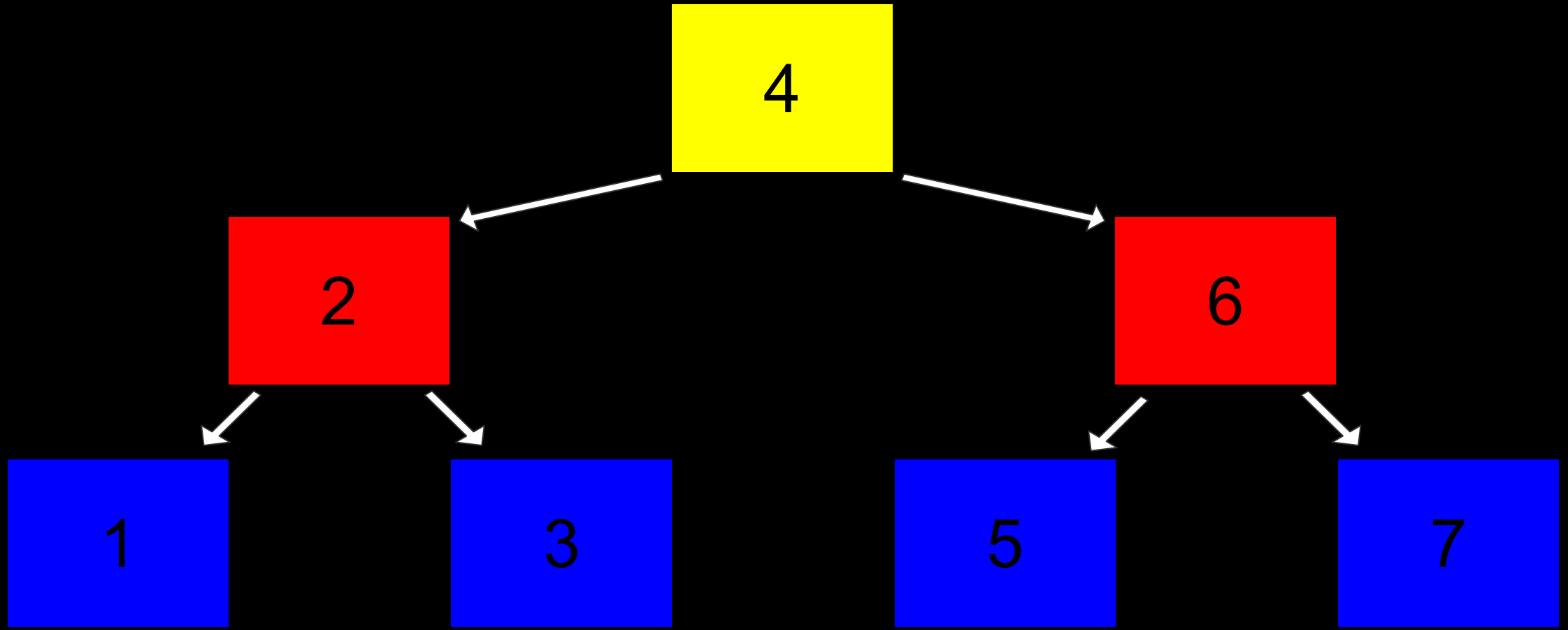
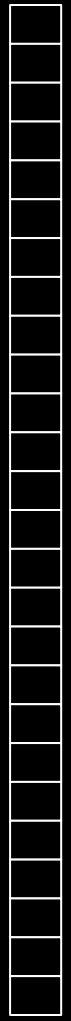

4
2
6
1
3
5
7

hash tables

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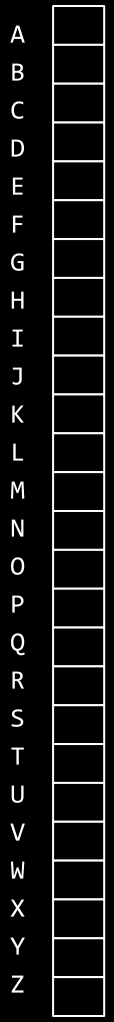
A
B
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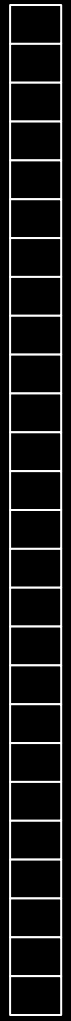
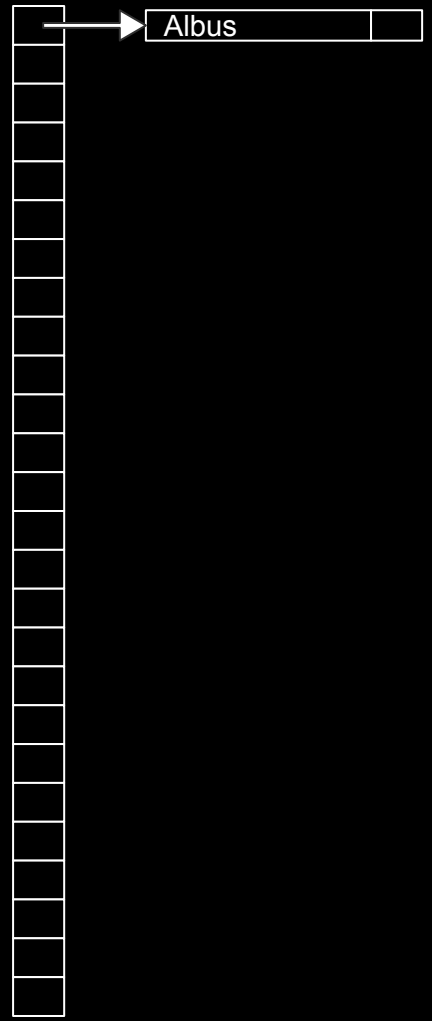
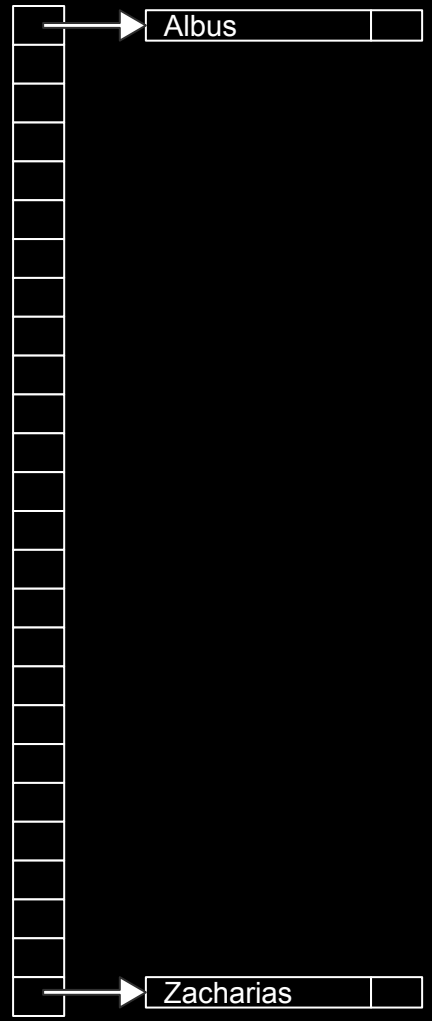
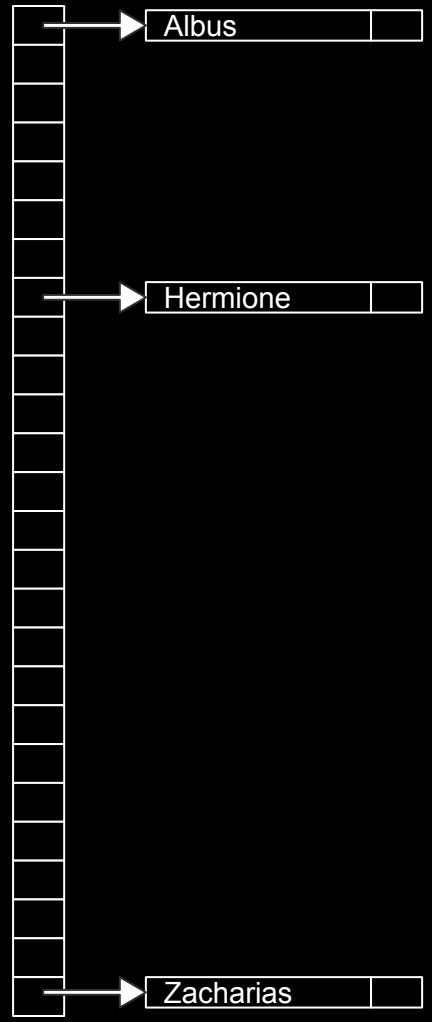
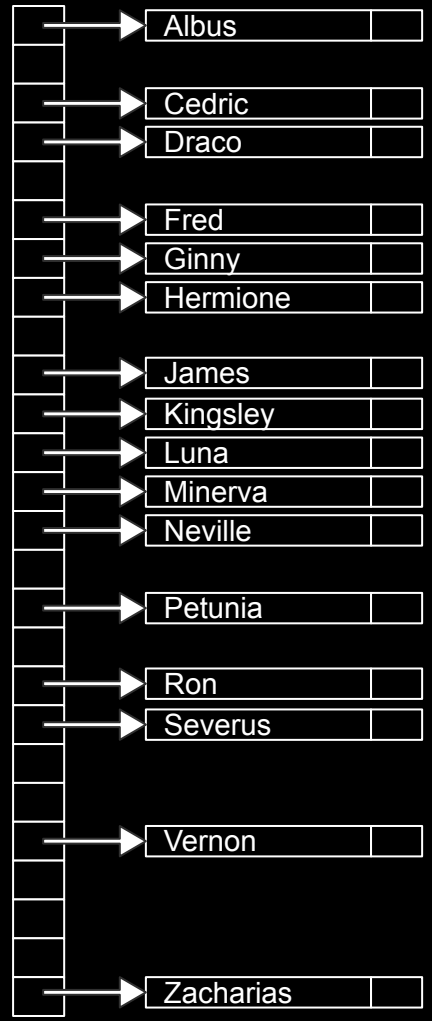
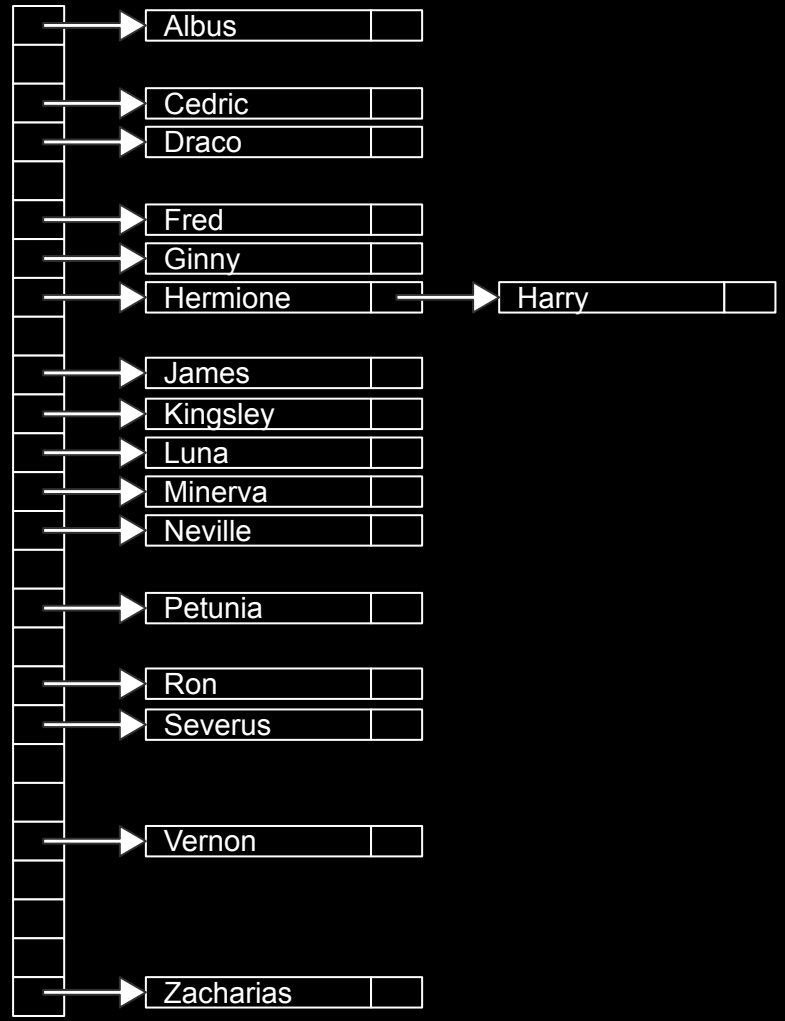


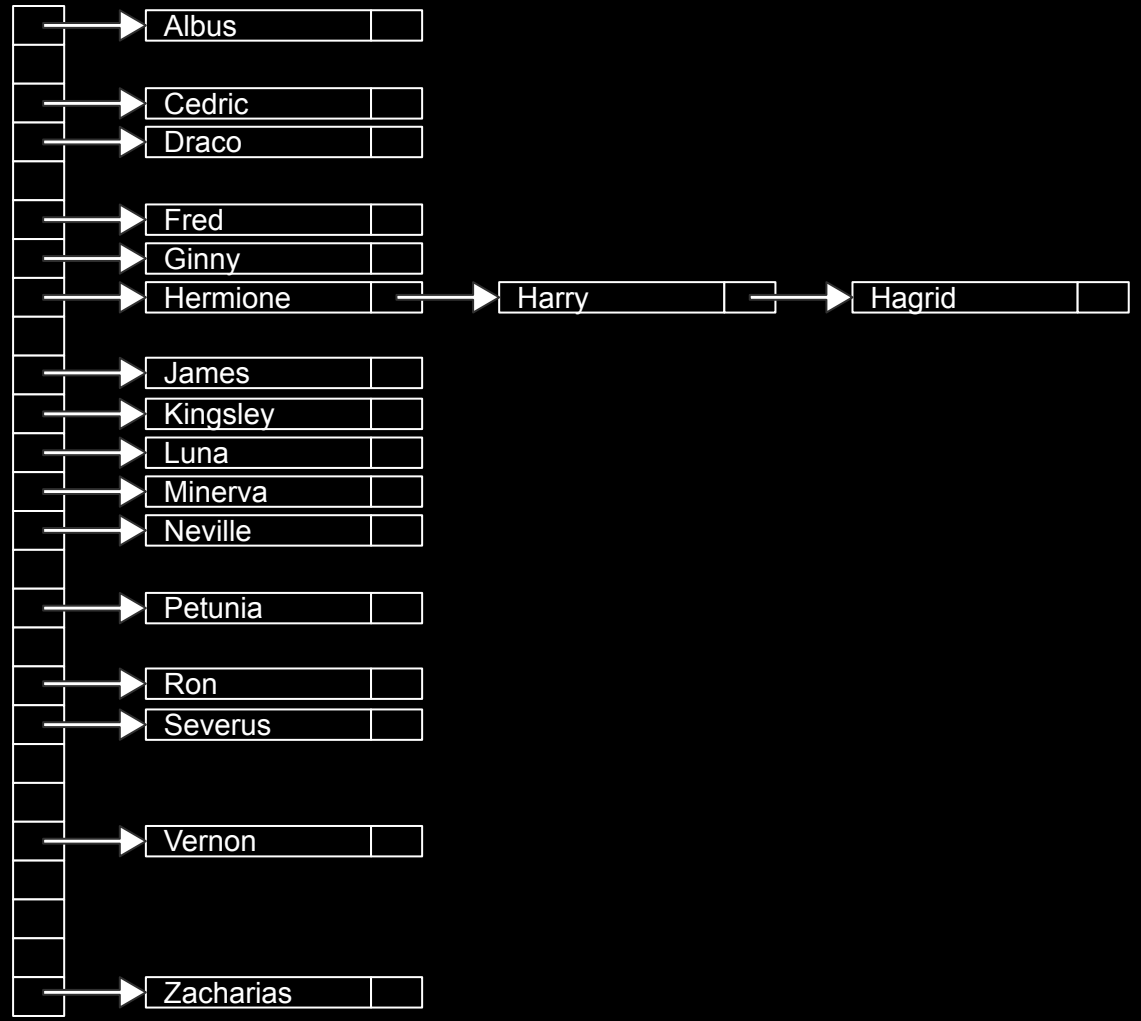

Albus

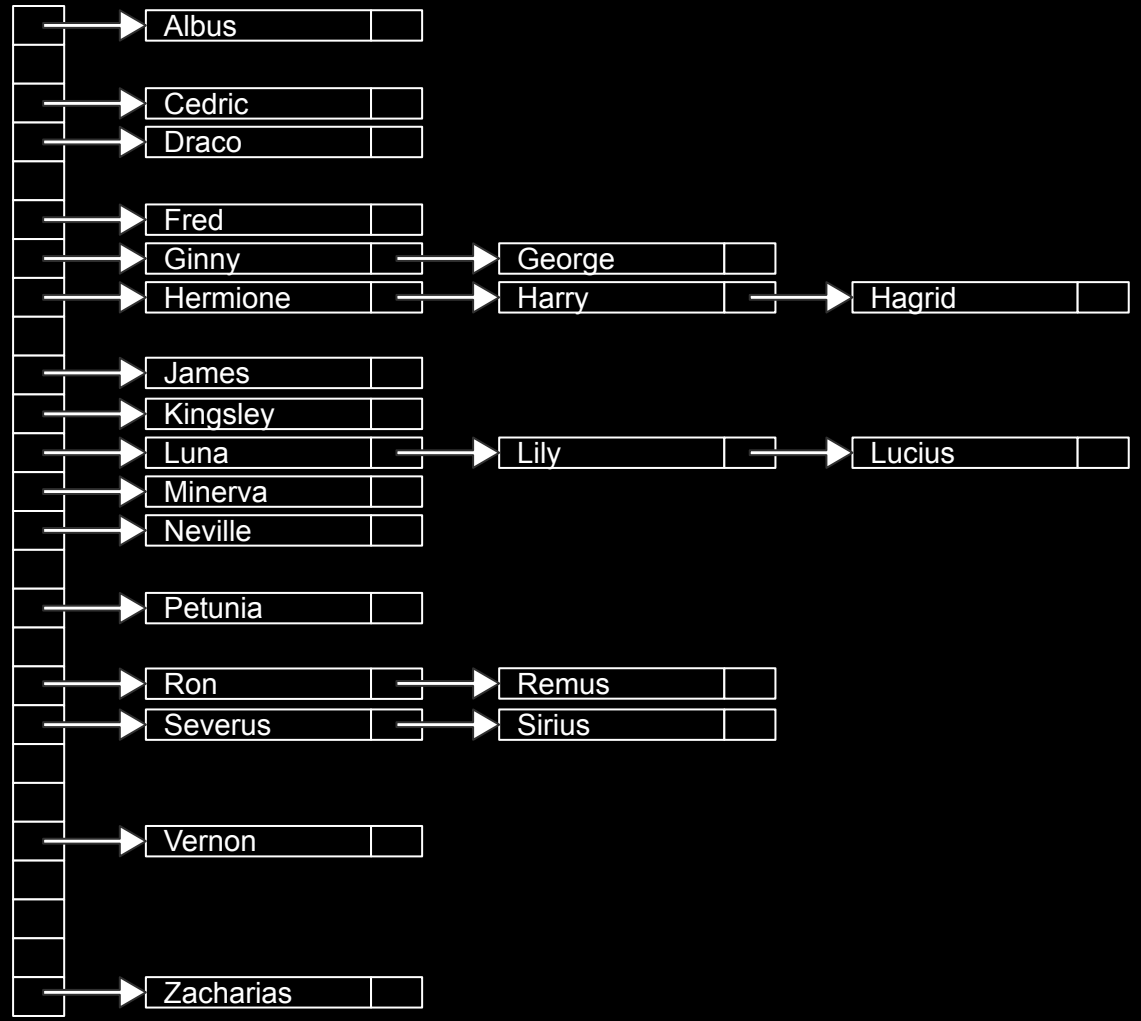

Albus
Zacharias

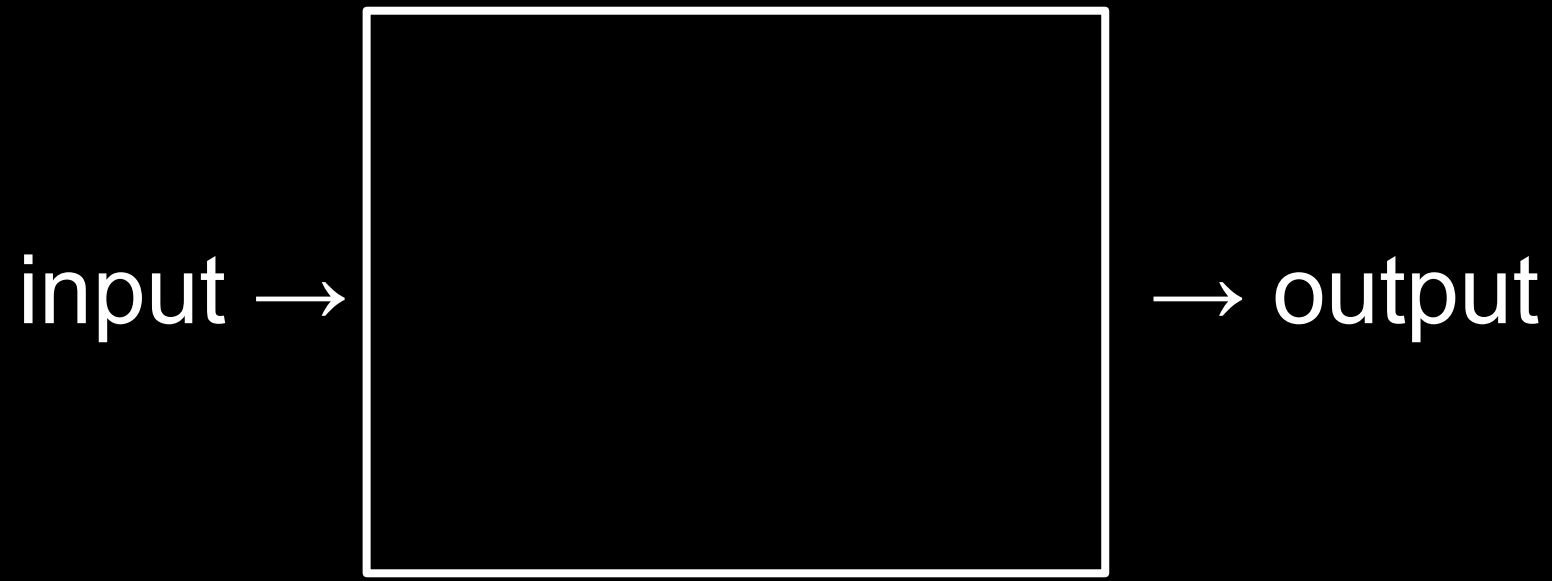

Albus
Hermione
Zacharias

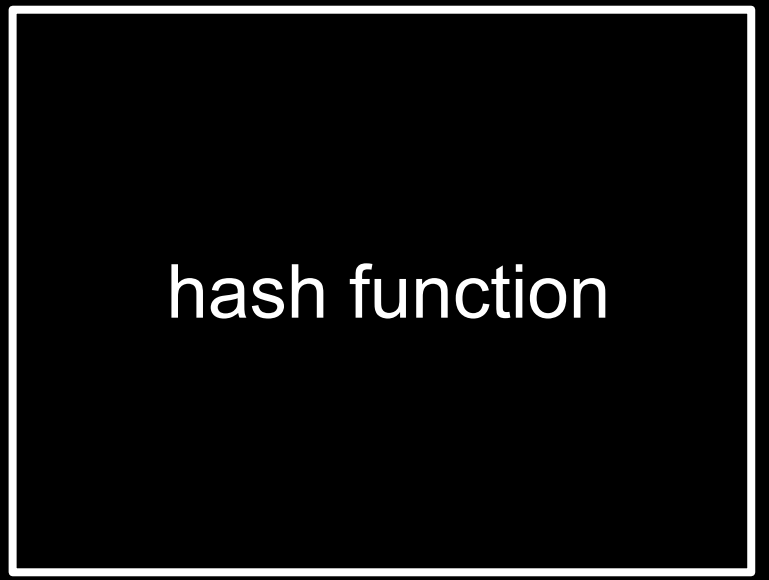

Albus
Cedric
Draco
Fred
Ginny
Hermione
James
Kingsley
Luna
Minerva
Neville
Petunia
Ron
Severus
Vernon
Zacharias

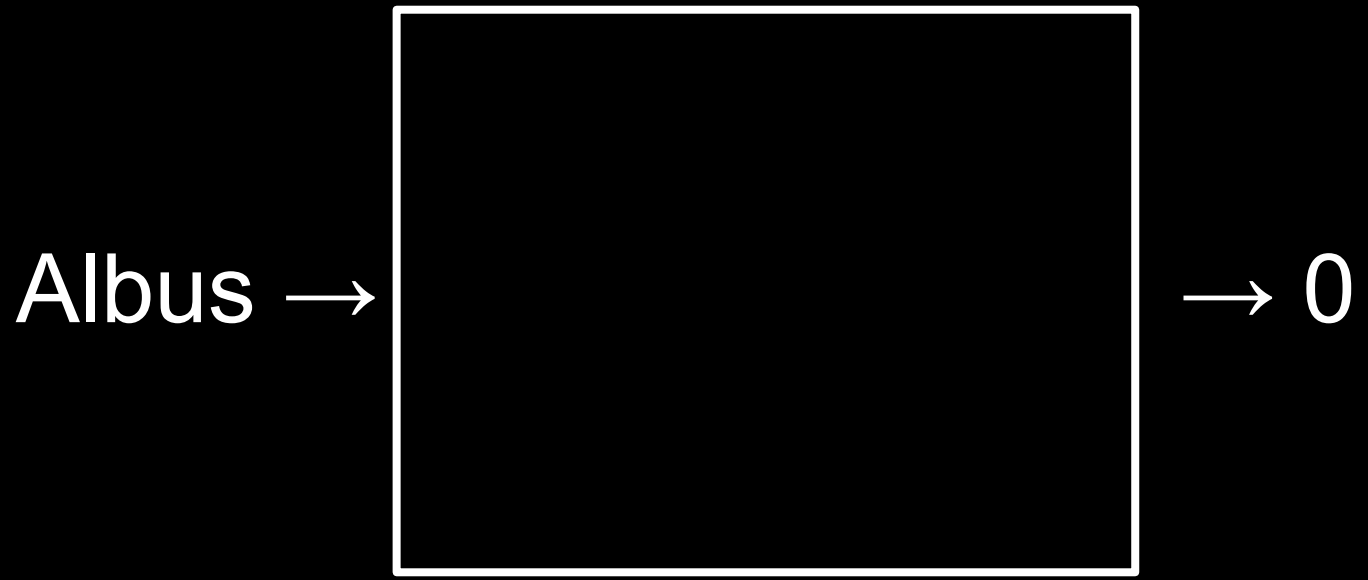

Albus
Cedric
Draco
Fred
Ginny
Hermione
Harry
James
Kingsley
Luna
Minerva
Neville
Petunia
Ron
Severus
Vernon
Zacharias

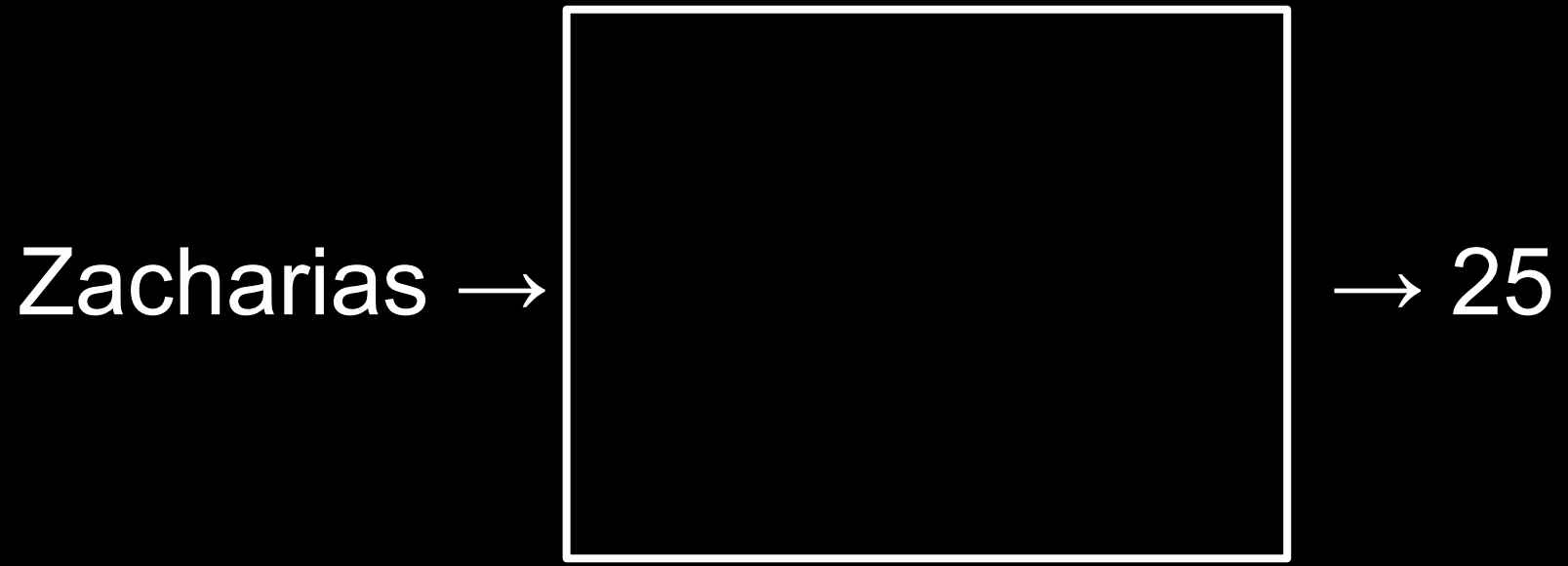

Albus
Cedric
Draco
Fred
Ginny
Hermione
Harry
Hagrid
James
Kingsley
Luna
Minerva
Neville
Petunia
Ron
Severus
Vernon
Zacharias

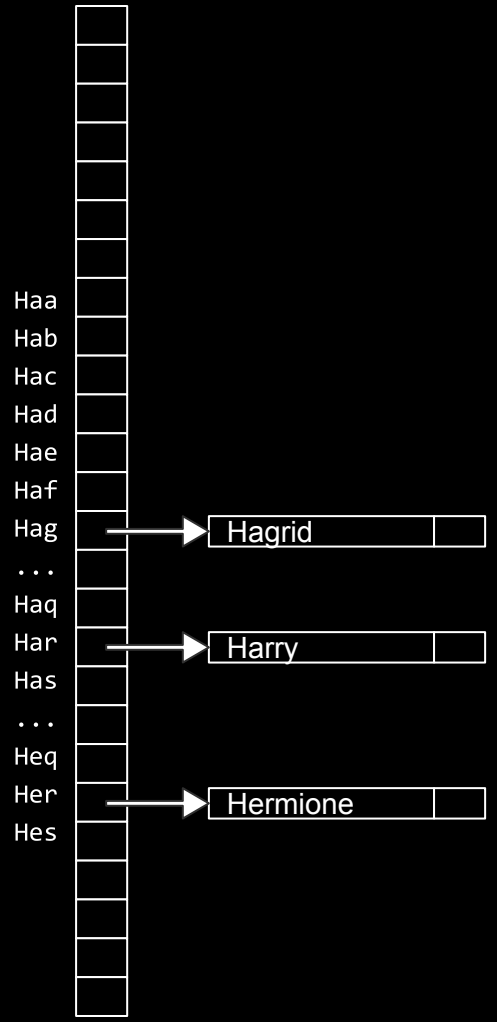

Albus
Cedric
Draco
Fred
Ginny
George
Hermione
Harry
Hagrid
James
Kingsley
Luna
Lily
Lucius
Minerva
Neville
Petunia
Ron
Remus
Severus
Sirius
Vernon
Zacharias


input →
→ output


hash function


Albus →
→ 0


Zacharias →
→ 25


Haa
Hab
Hac
Had
Hae
Haf
Hag
...
Haq
Har
Has
...
Heq
Her
Hes
Hagrid
Harry
Hermione

$O(n^2)$

$O(n \log n)$

$O(n)$

$O(\log n)$

$O(1)$

$O(n^2)$

$O(n \log n)$

$O(n)$ search

$O(\log n)$

$O(1)$

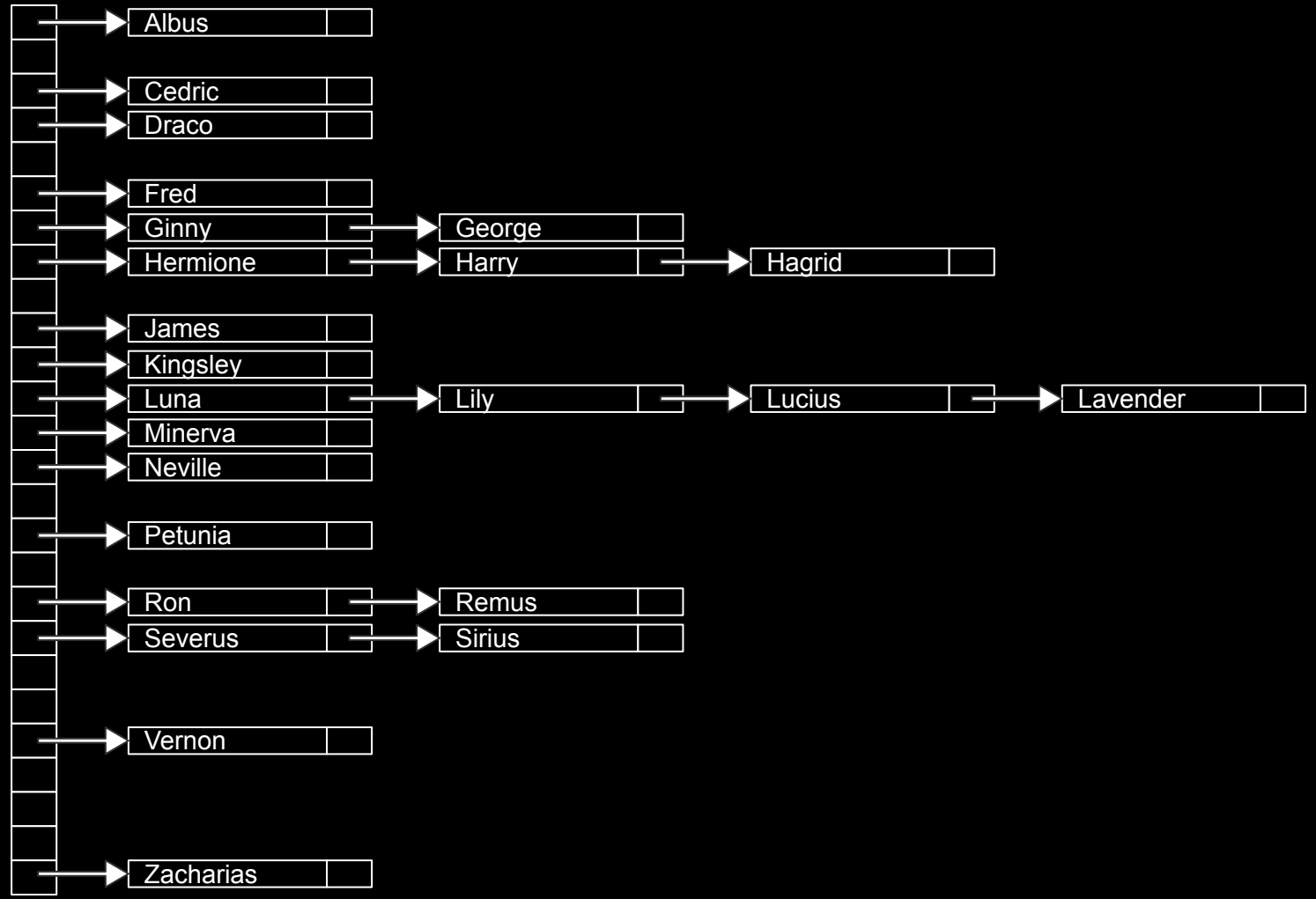
$O(n^2)$

$O(n \log n)$

$O(n)$ search

$O(\log n)$

$O(1)$ insert


Albus
Cedric
Draco
Fred
Ginny
George
Hermione
Harry
Hagrid
James
Kingsley
Luna
Lily
Lucius
Lavender
Minerva
Neville
Petunia
Ron
Remus
Severus
Sirius
Vernon
Zacharias

dictionaries

```
dict
list
range
set
tuple
...
```


ICK ME UP
B C D E F G H I
K L M N O P Q R
T U V W X Y Z

queues

stacks

Lab

Python

Assignment 2

cs50.harvard.edu/hls/2021/winter/assignments/2

Office Hours

cs50.harvard.edu/hls/2021/winter/hours

CS50 for JDs

cs50.harvard.edu/hls