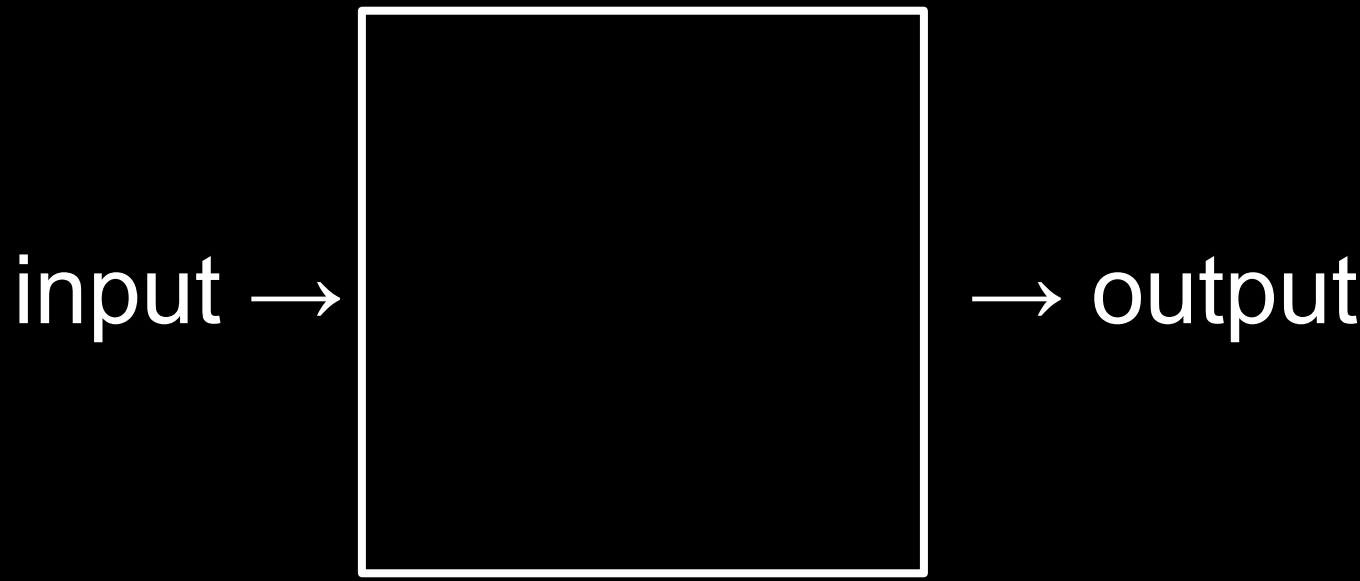
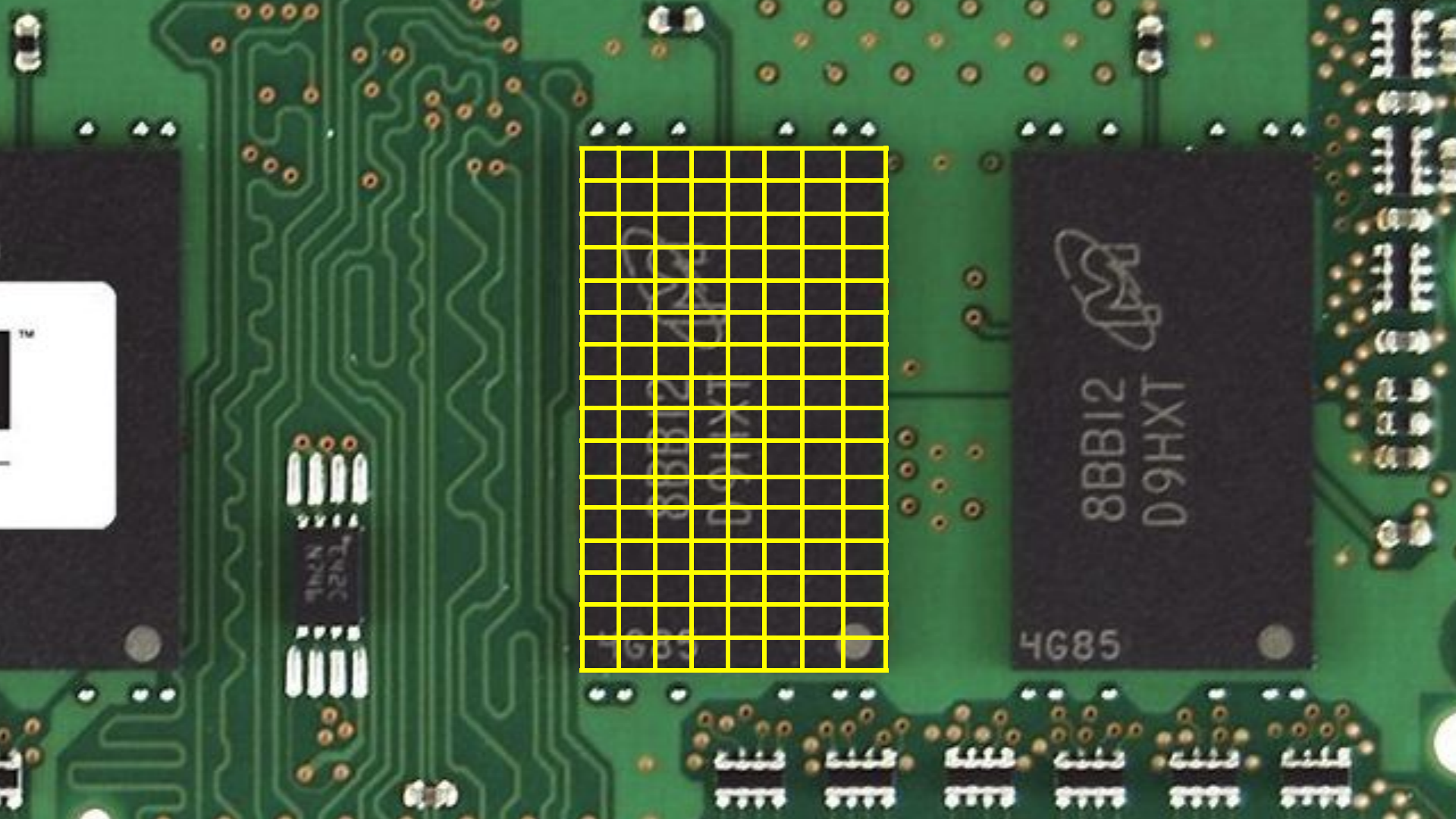
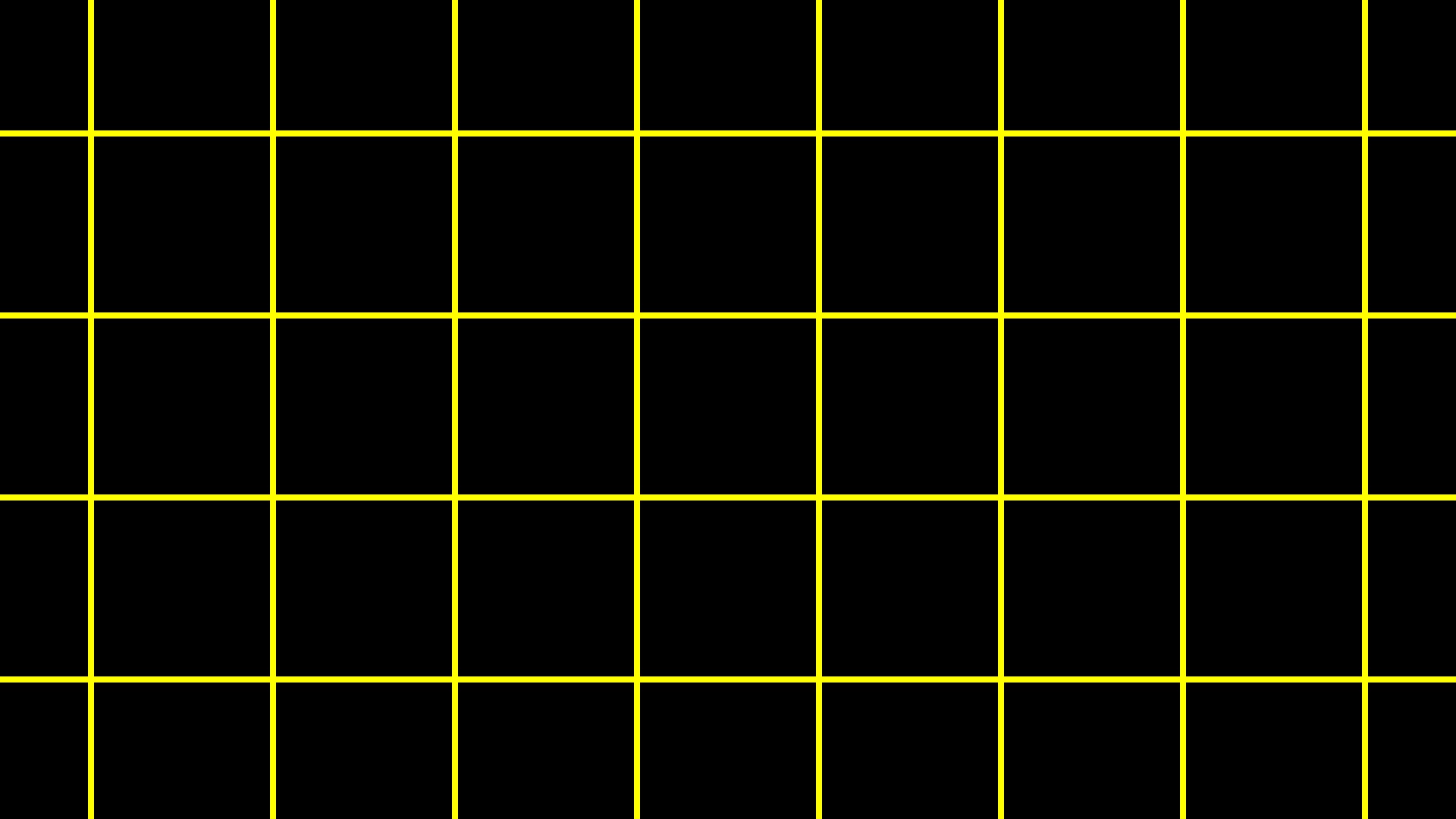
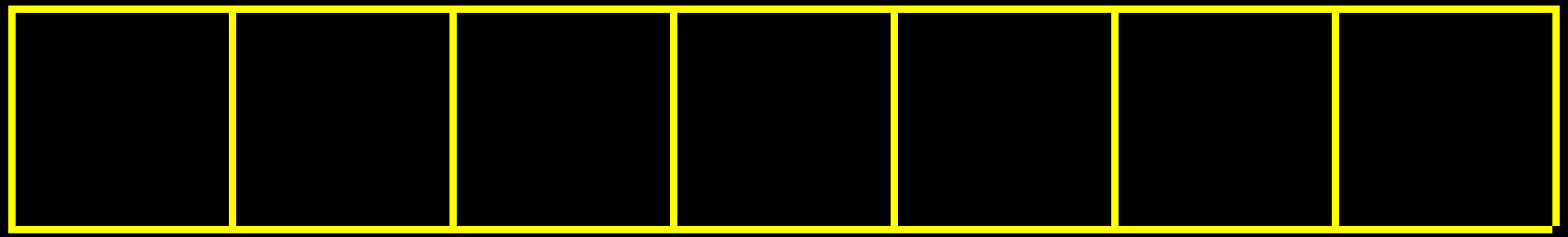
This is CS50

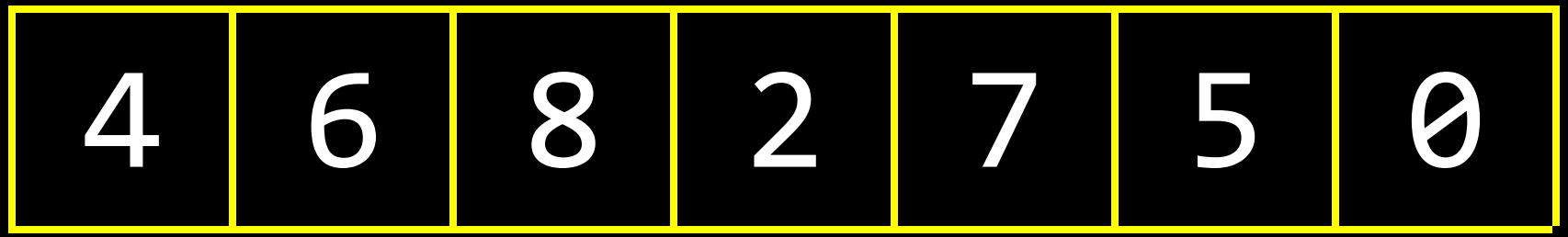

input →
→ output

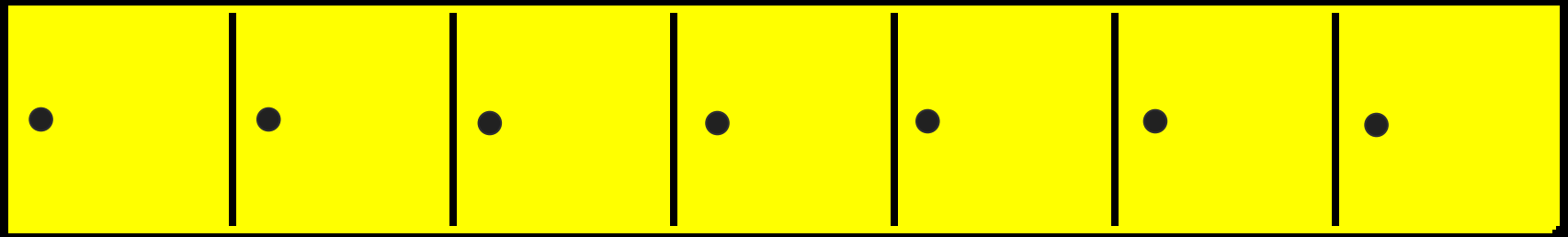
8BBI2
D9HXT
4G85
8BBI2
D9HXT
4G85

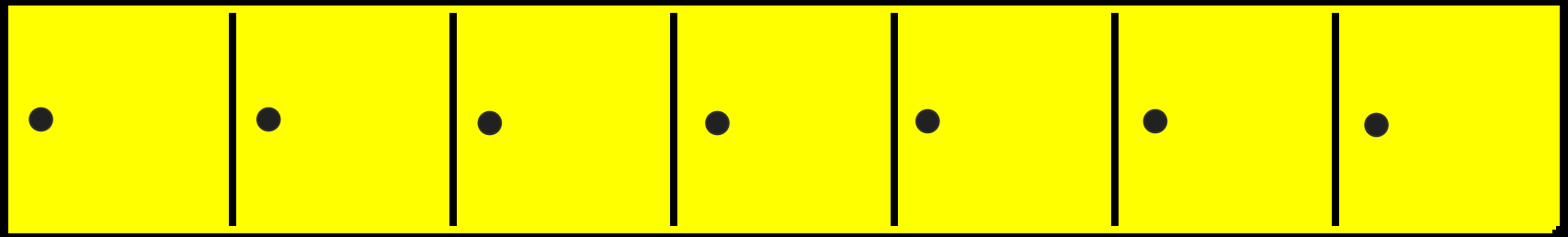

8BBI2
D9HXT
4G85



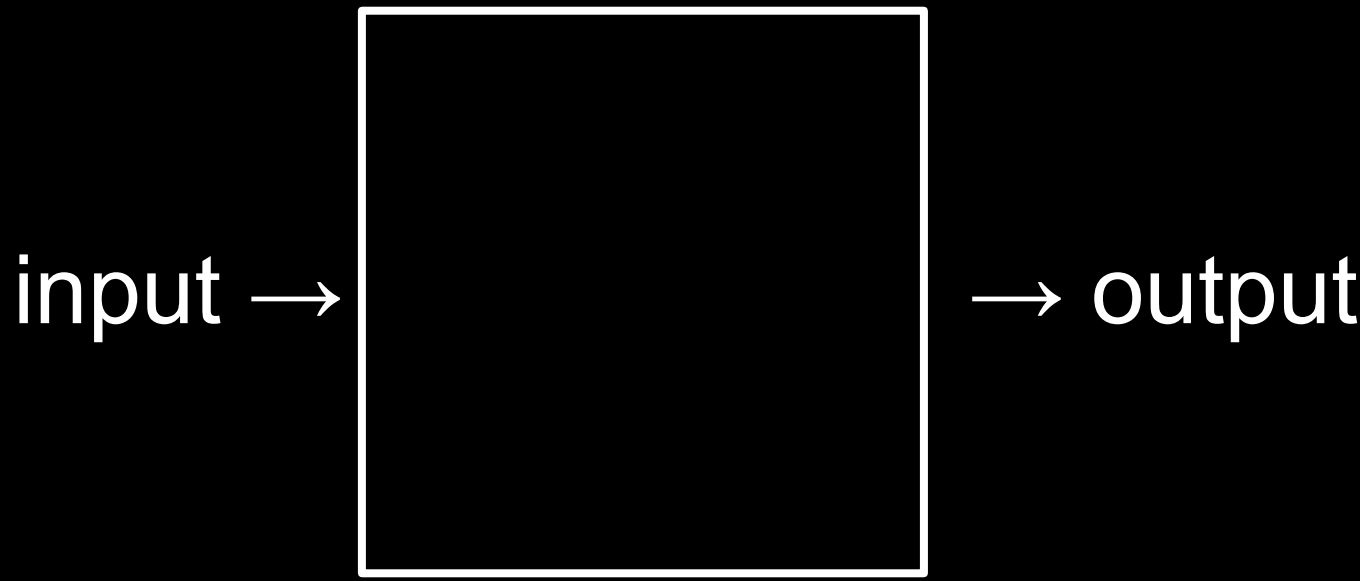


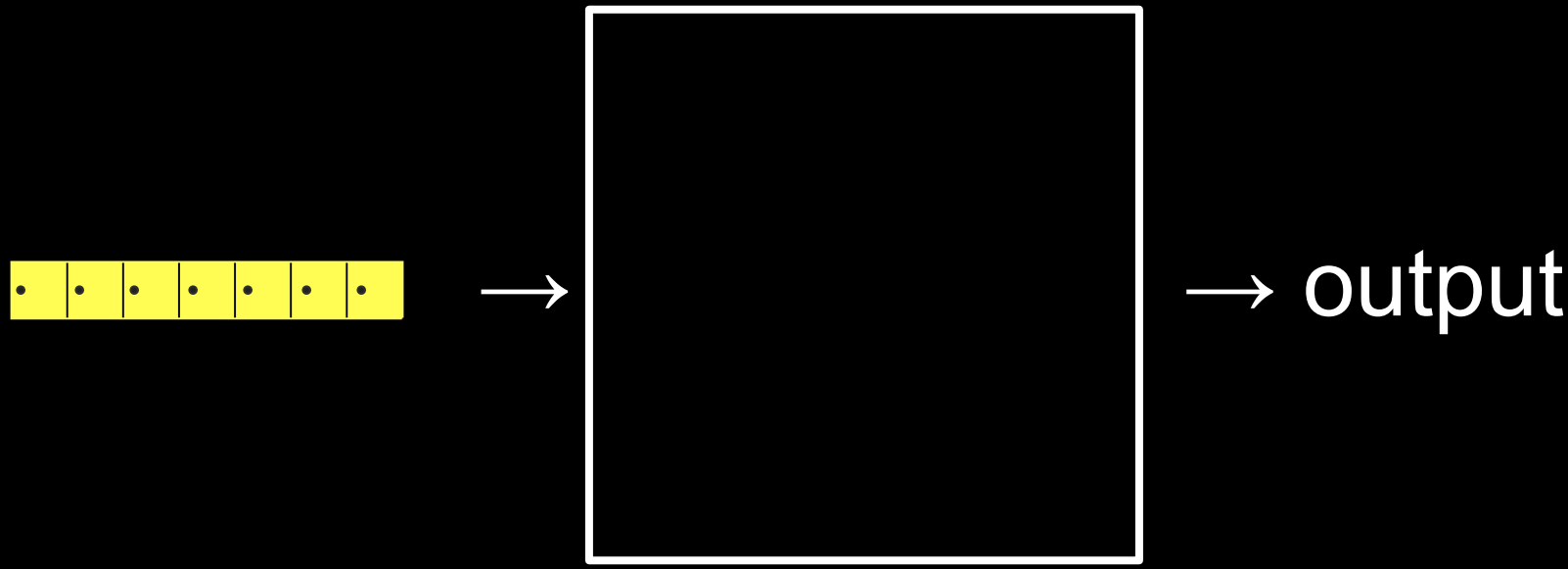

4
6
8
2
7
5
0

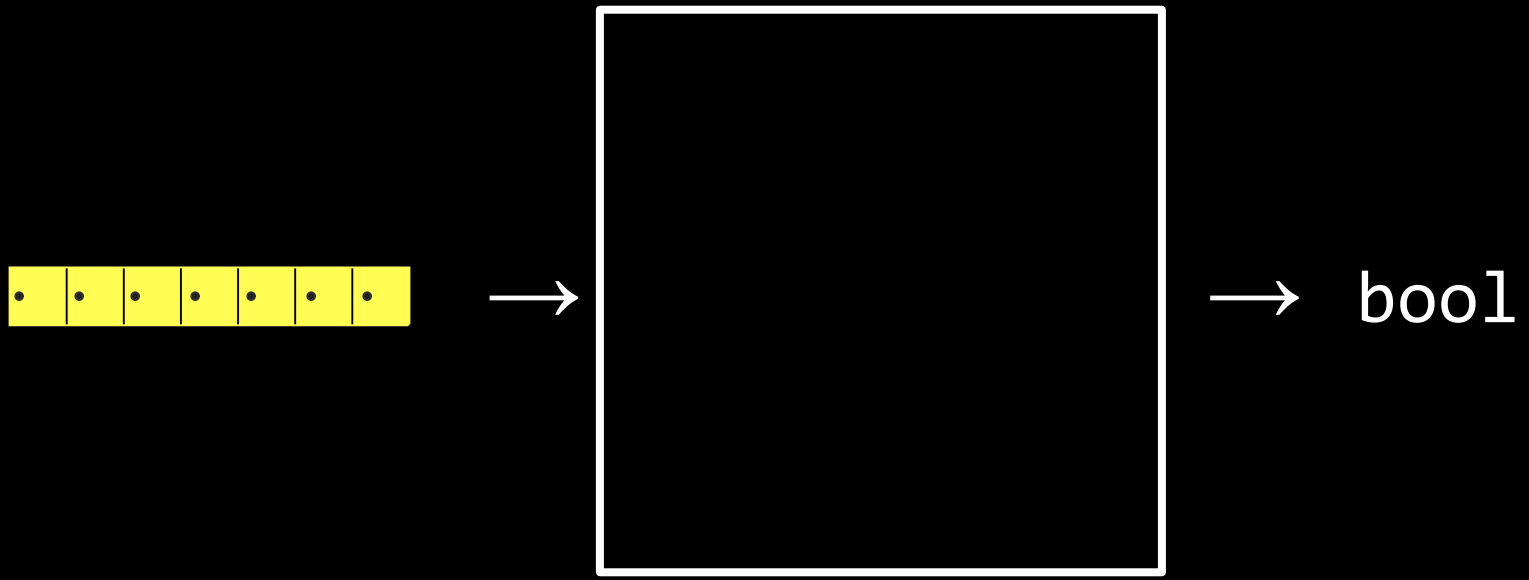


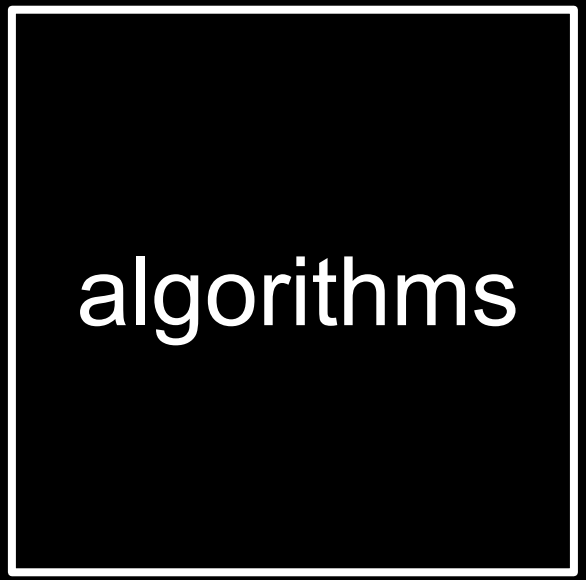

[0]
[1]
[2]
[3]
[4]
[5]
[6]

searching


input →
→ output

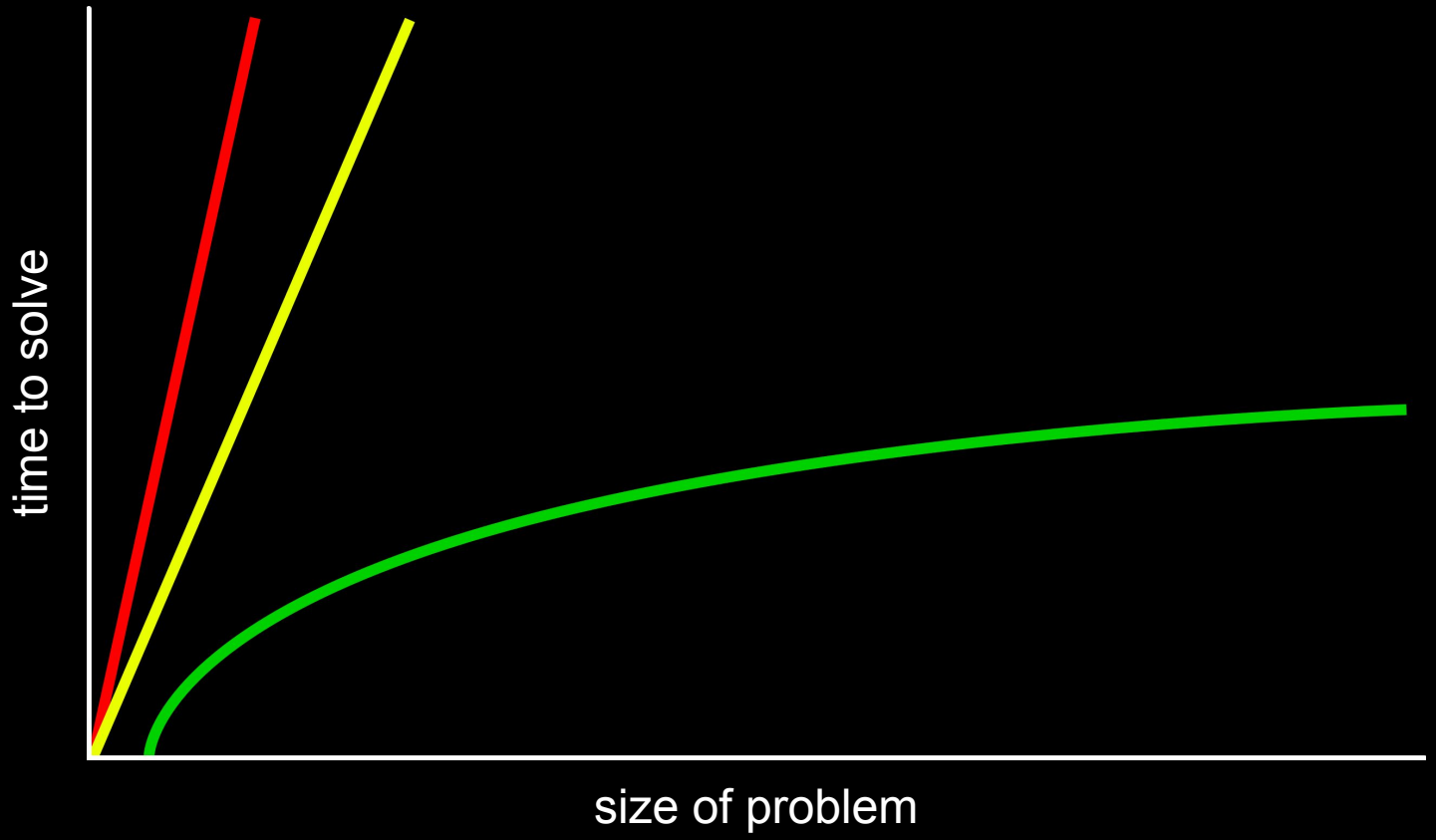

output

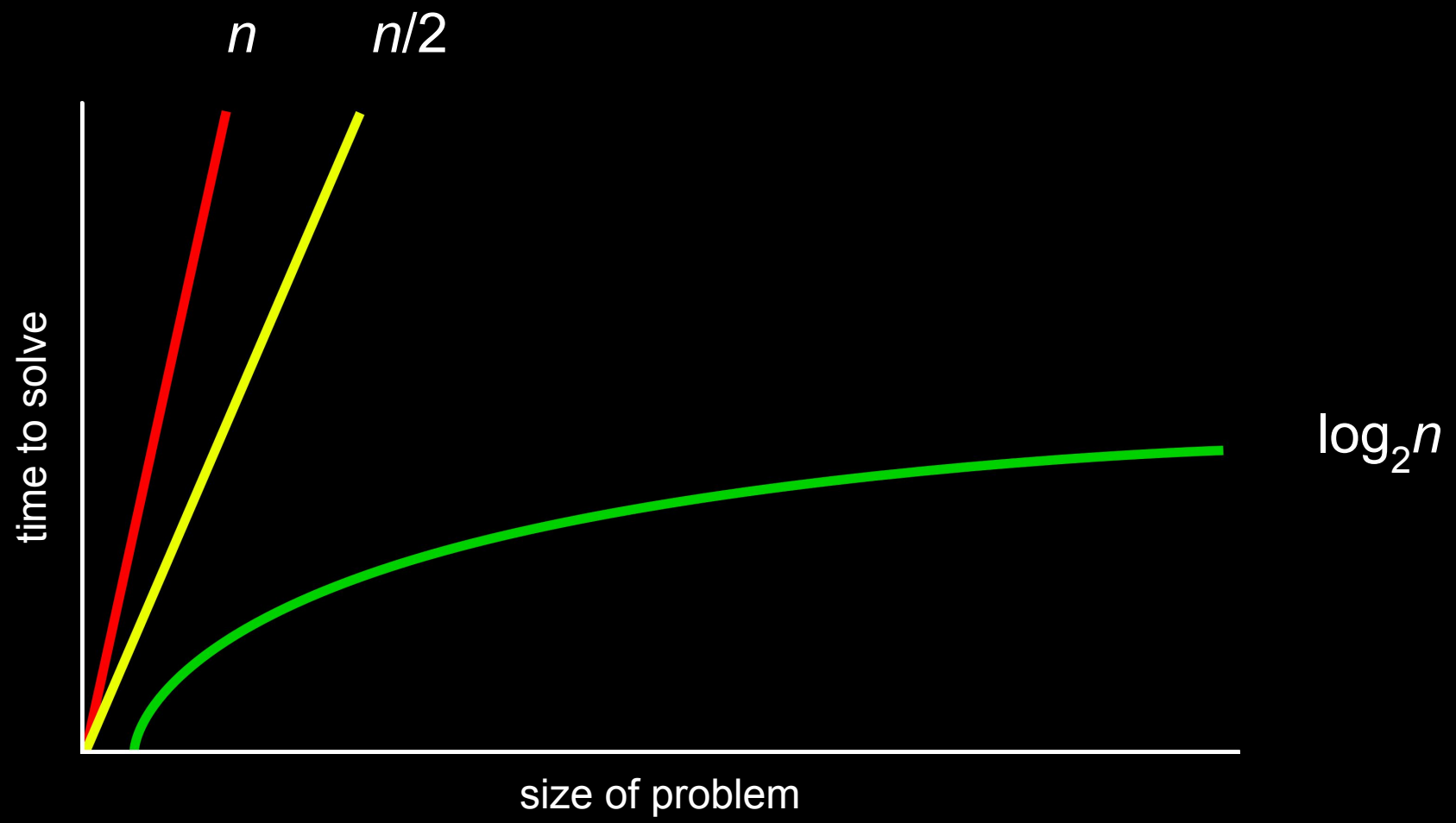

bool

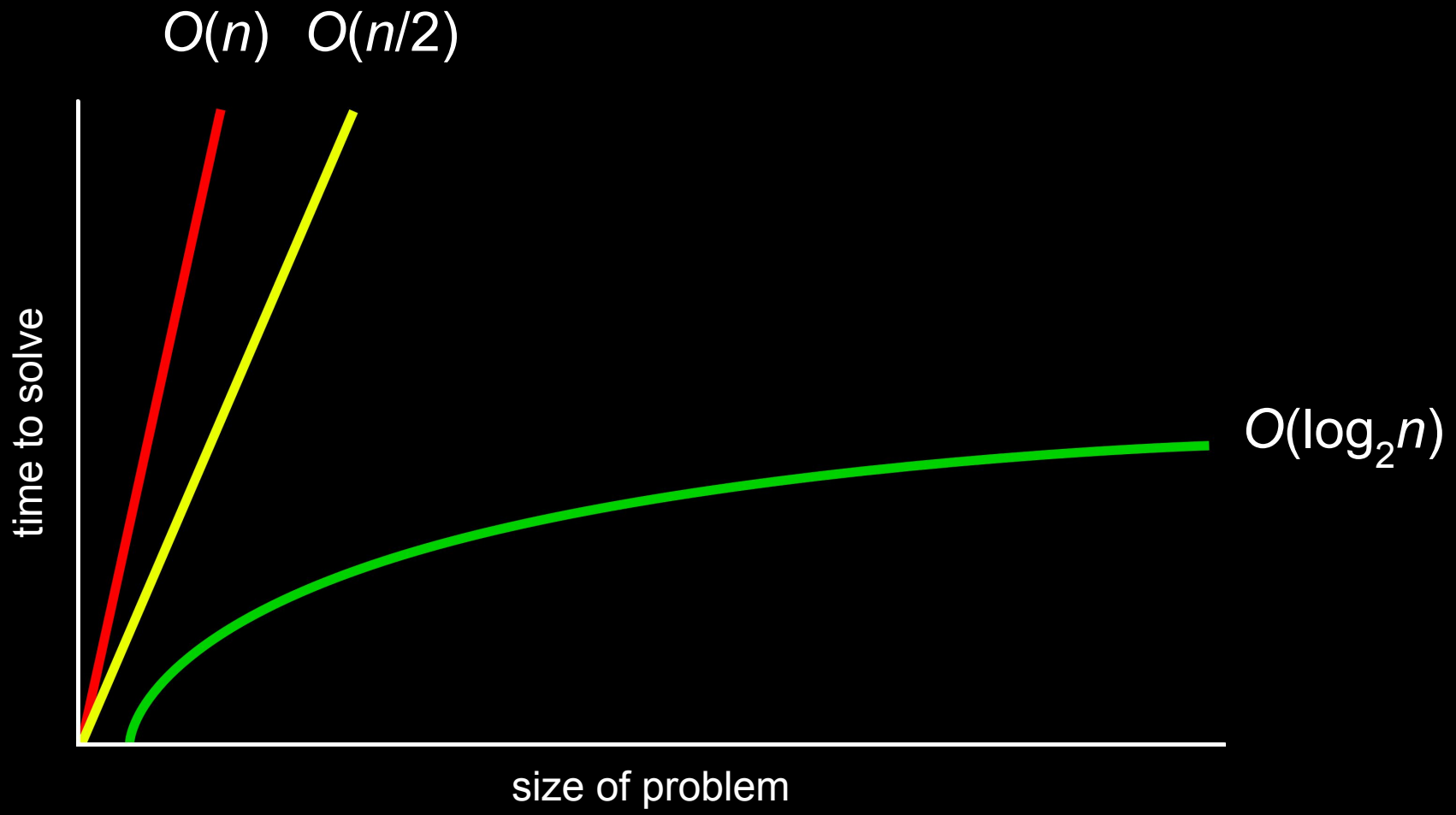

algorithms

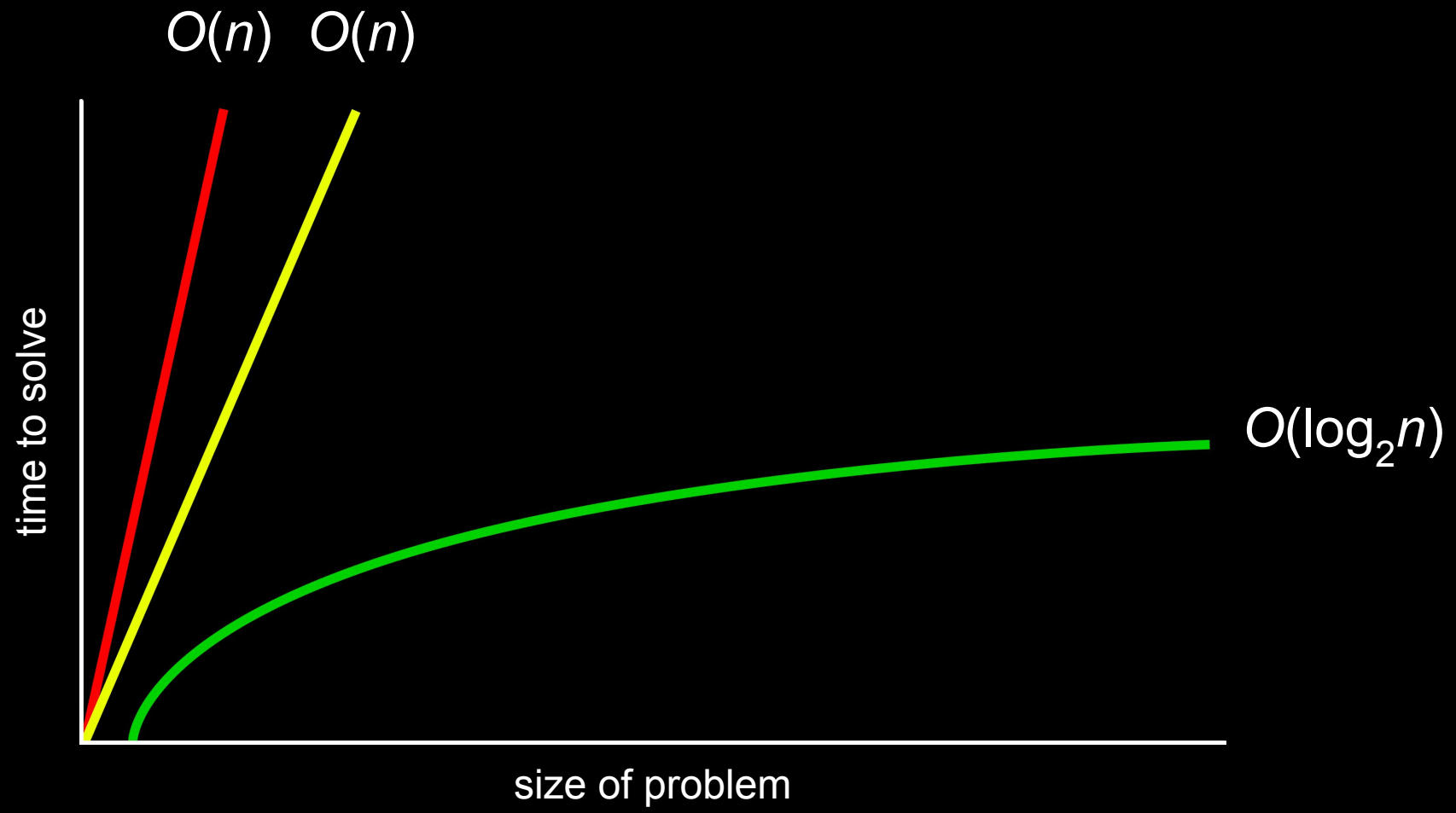
running times

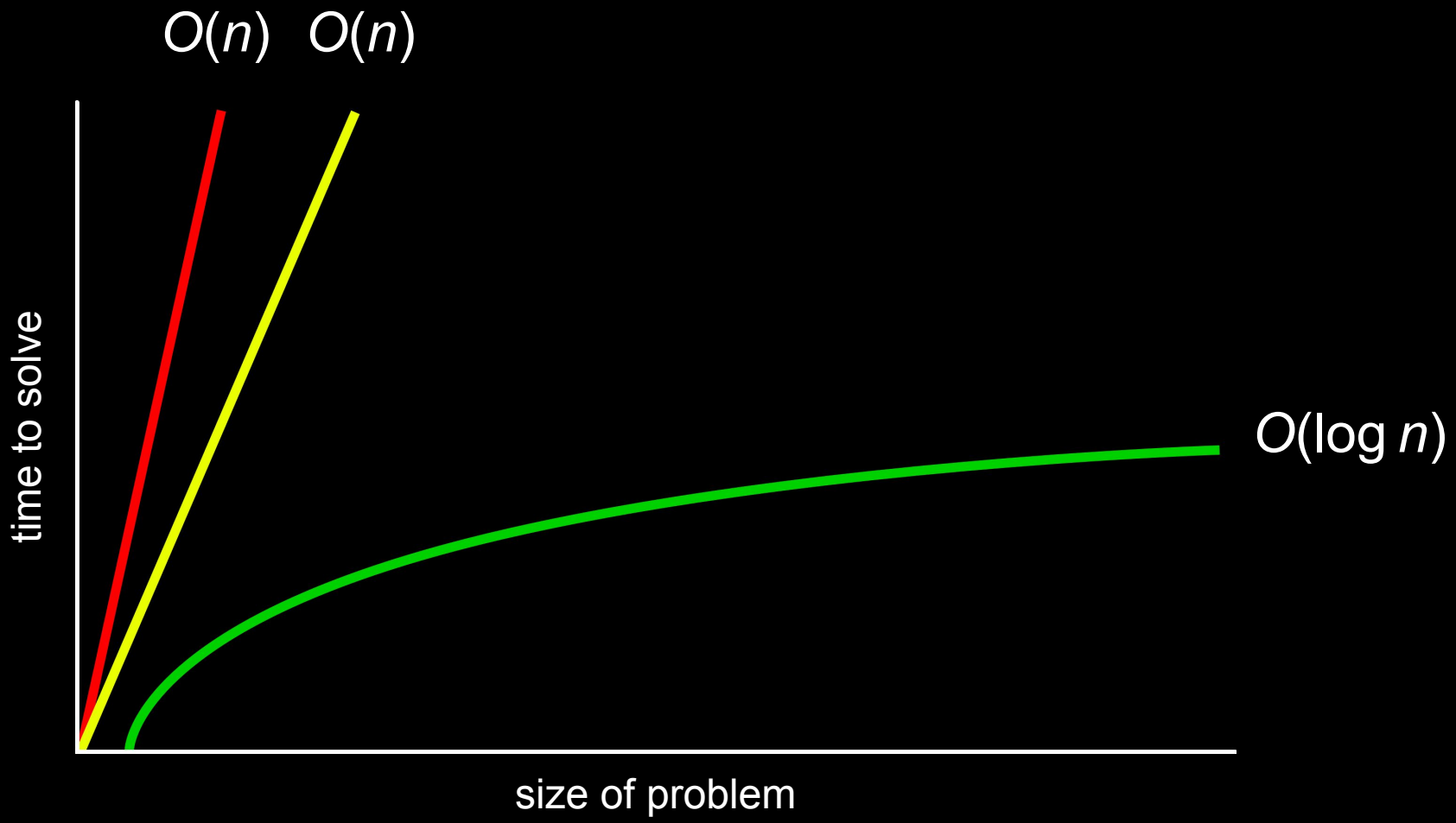
O

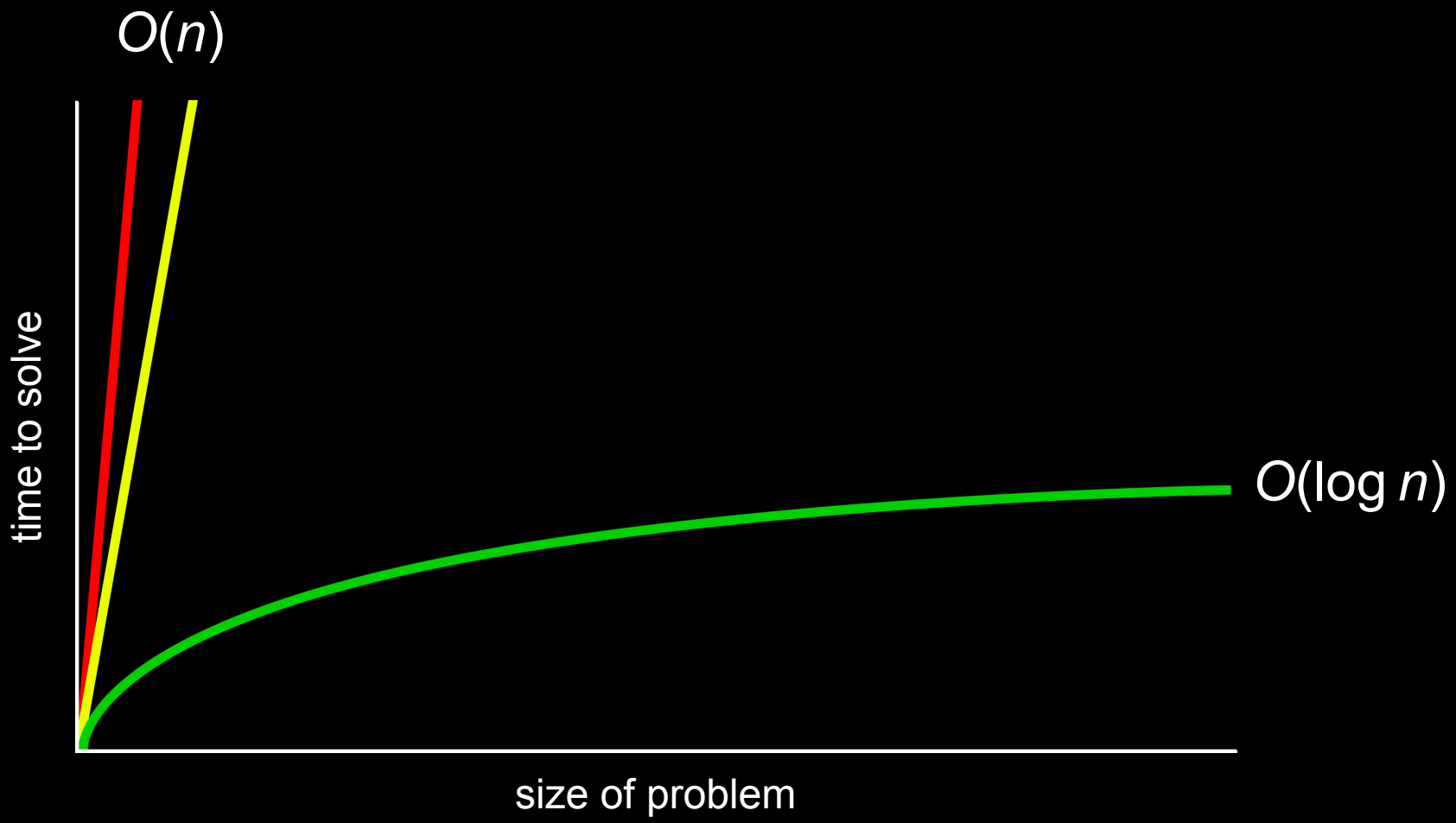

time to solve
size of problem


n
n/2
time to solve
log2n
size of problem


O(n)
O(n/2)
O(log2n)
time to solve
size of problem


O(n)
O(n)
time to solve
O(log2n)
size of problem


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


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

$O(n^2)$

$O(n \log n)$

$O(n)$

$O(\log n)$

$O(1)$

$\Omega(n^2)$

$\Omega(n \log n)$

$\Omega(n)$

$\Omega(\log n)$

$\Omega(1)$

$\Theta(n^2)$

$\Theta(n \log n)$

$\Theta(n)$

$\Theta(\log n)$

$\Theta(1)$

linear search

```
For each door from left to right
    If number is behind door
        Return true
Return false
```

```
For i from 0 to n-1
    If number behind doors[i]
        Return true
Return false
```

$O(n^2)$

$O(n \log n)$

$O(n)$

$O(\log n)$

$O(1)$

$O(n^2)$

$O(n \log n)$

$O(n)$ linear search

$O(\log n)$

$O(1)$

$\Omega(n^2)$

$\Omega(n \log n)$

$\Omega(n)$

$\Omega(\log n)$

$\Omega(1)$

$\Omega(n^2)$

$\Omega(n \log n)$

$\Omega(n)$

$\Omega(\log n)$

$\Omega(1)$ linear search

binary search

```
If number behind middle door
    Return true
Else if number < middle door
    Search left half
Else if number > middle door
    Search right half
```

```
If no doors

If number behind middle door
    Return true
Else if number < middle door
    Search left half
Else if number > middle door
    Search right half
```

```
If no doors
    Return false
If number behind middle door
    Return true
Else if number < middle door
    Search left half
Else if number > middle door
    Search right half
```

```
If no doors
    Return false
If number behind doors[middle]
    Return true
Else if number < doors[middle]
    Search doors[0] through doors[middle - 1]
Else if number > doors[middle]
    Search doors[middle + 1] through doors[n - 1]
```

$O(n^2)$

$O(n \log n)$

$O(n)$

$O(\log n)$

$O(1)$

$O(n^2)$

$O(n \log n)$

$O(n)$

$O(\log n)$ binary search

$O(1)$

$\Omega(n^2)$

$\Omega(n \log n)$

$\Omega(n)$

$\Omega(\log n)$

$\Omega(1)$

$\Omega(n^2)$

$\Omega(n \log n)$

$\Omega(n)$

$\Omega(\log n)$

$\Omega(1)$ binary search

```
int numbers[]
```

```
string names[]
```

```
string names[]
string numbers[]
```

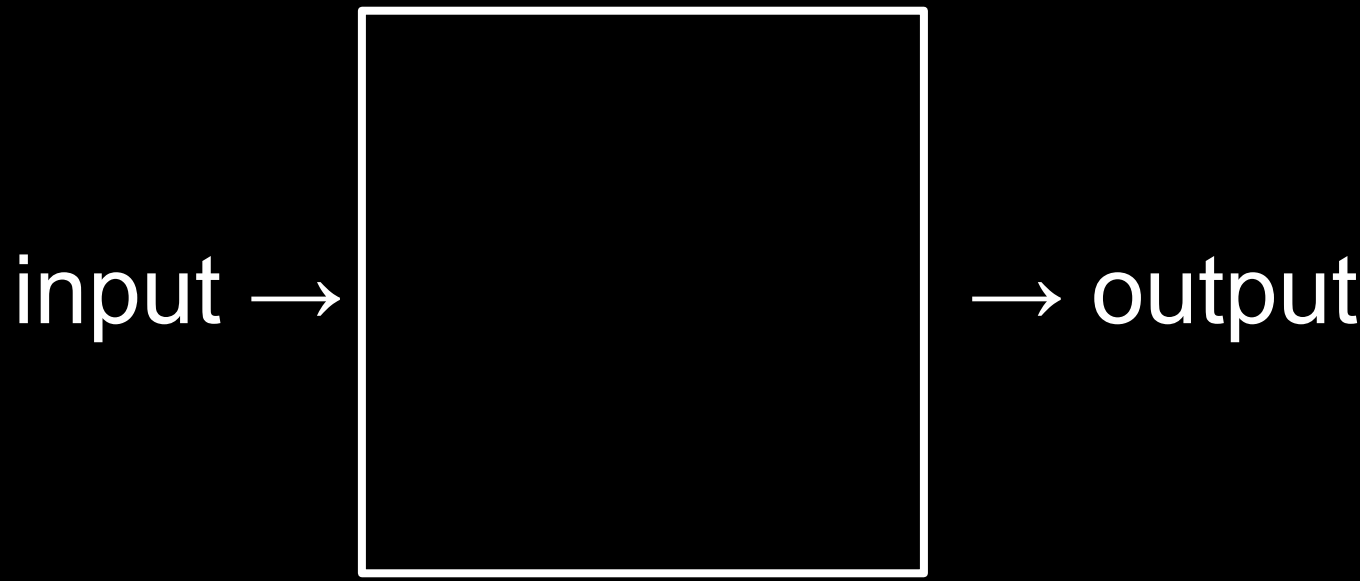
data structures

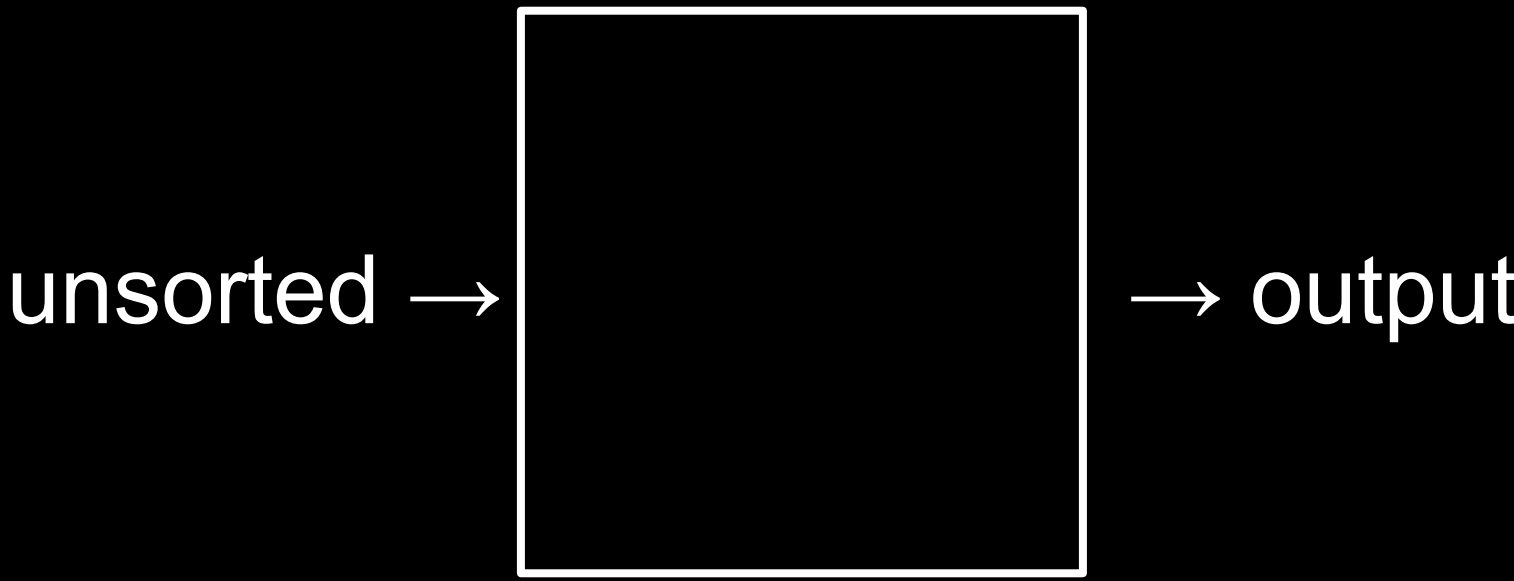
```
person people[]
```

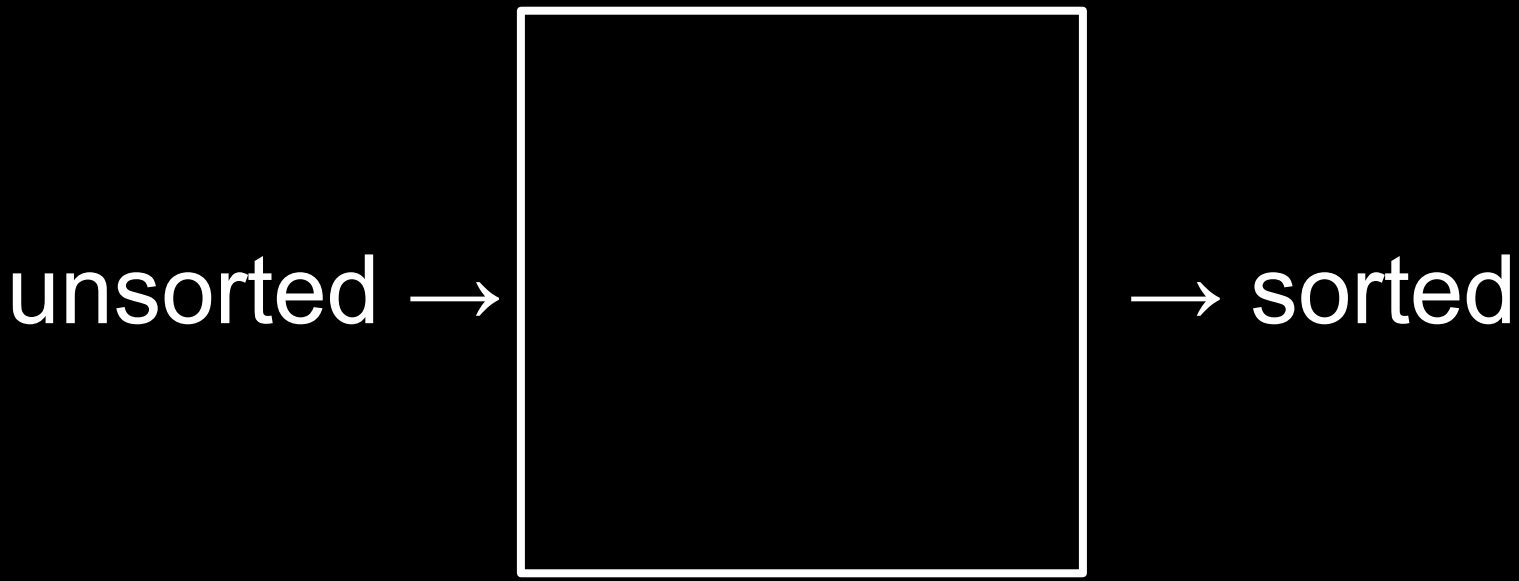
```
string name;
string number;
```

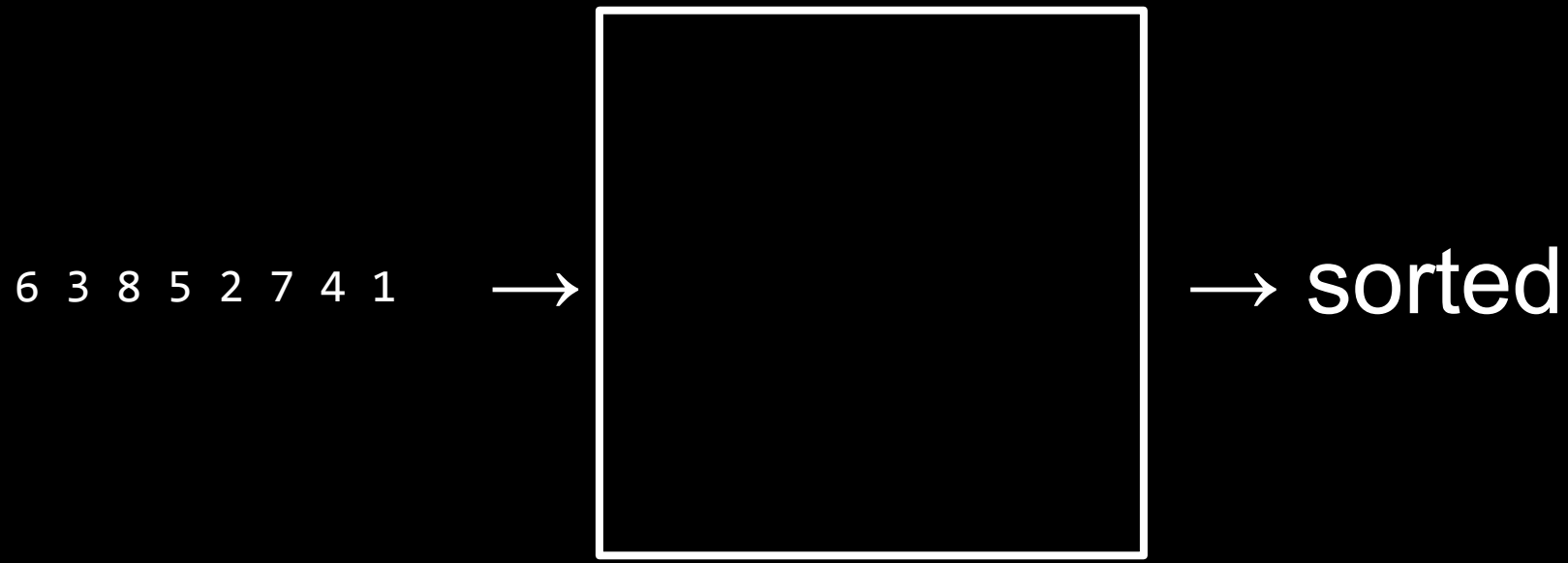
```
typedef struct
{
    string name;
    string number;
}
person;
```

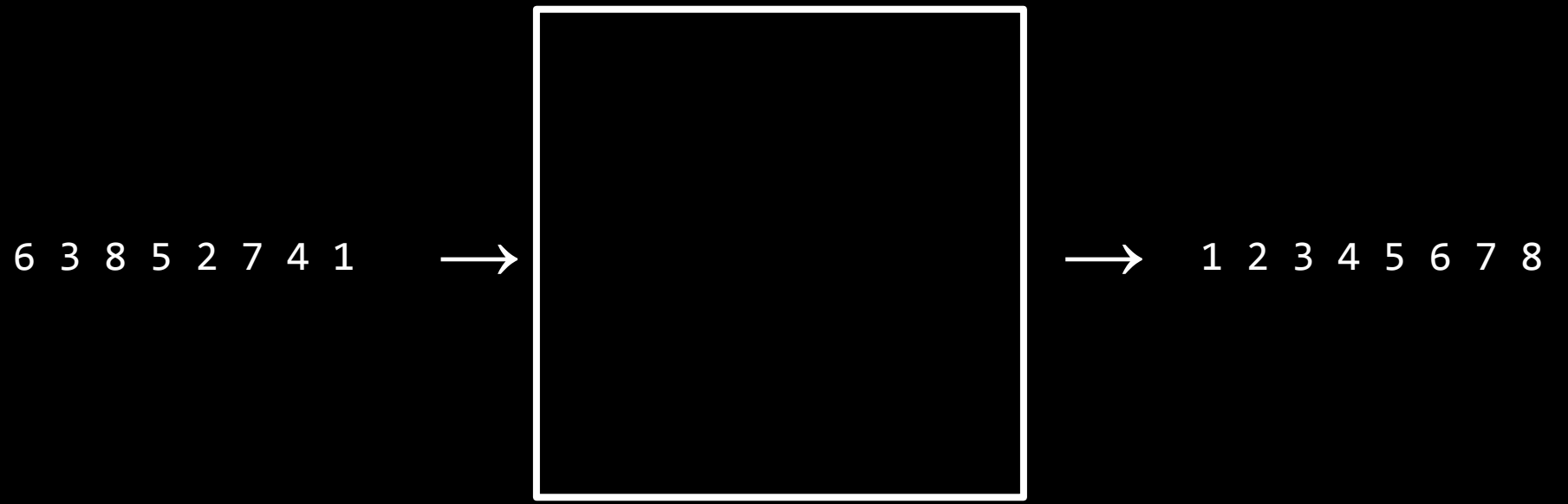
sorting


input →
→ output


unsorted →
→ output


unsorted →
→ sorted

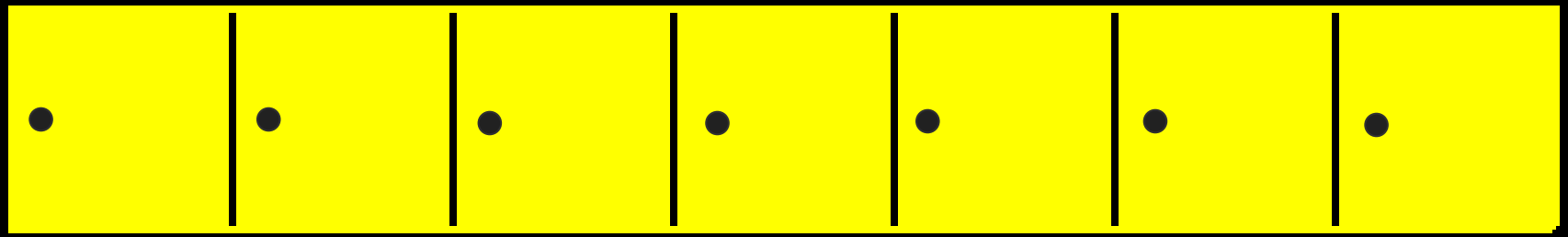

6 3 8 5 2 7 4 1
sorted


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

selection sort

5 2 7 4 1 6 3 0

```
For i from 0 to n-1
    Find smallest number between numbers[i] and numbers[n-1]
    Swap smallest number with numbers[i]
```


[0]
[1]
[2]
...
[n-3]
[n-2]
[n-1]

n

$n + (n - 1)$

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

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

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

$n(n + 1)/2$

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

$n(n + 1)/2$

$(n^2 + n)/2$

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

$n(n + 1)/2$

$(n^2 + n)/2$

$n^2/2 + n/2$

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

$n(n + 1)/2$

$(n^2 + n)/2$

$n^2/2 + n/2$

$O(n^2)$

$O(n^2)$

$O(n \log n)$

$O(n)$

$O(\log n)$

$O(1)$

$O(n^2)$ selection sort

$O(n \log n)$

$O(n)$

$O(\log n)$

$O(1)$

```
For i from 0 to n-1
    Find smallest number between numbers[i] and numbers[n-1]
    Swap smallest number with numbers[i]
```

$\Omega(n^2)$

$\Omega(n \log n)$

$\Omega(n)$

$\Omega(\log n)$

$\Omega(1)$

$\Omega(n^2)$ selection sort

$\Omega(n \log n)$

$\Omega(n)$

$\Omega(\log n)$

$\Omega(1)$

$\Theta(n^2)$

$\Theta(n \log n)$

$\Theta(n)$

$\Theta(\log n)$

$\Theta(1)$

$\Theta(n^2)$ selection sort

$\Theta(n \log n)$

$\Theta(n)$

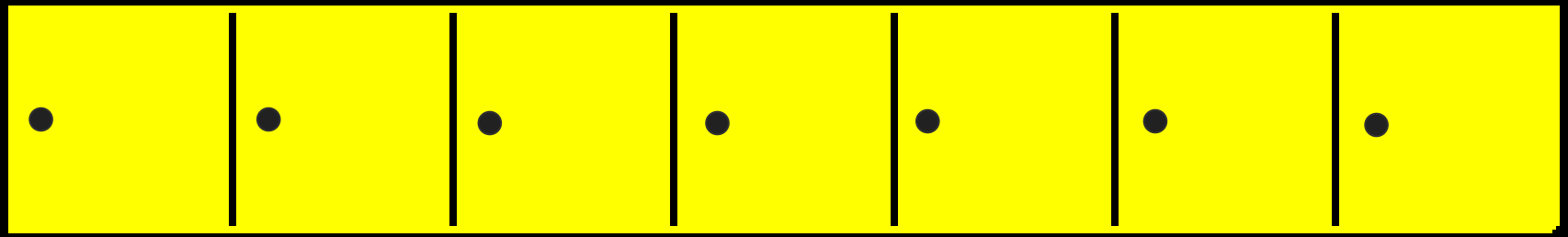
$\Theta(\log n)$

$\Theta(1)$

bubble sort

5 2 7 4 1 6 3 0

```
Repeat n-1 times
    For i from 0 to n-2
        If numbers[i] and numbers[i+1] out of order
            Swap them
```


[0]
[1]
[2]
...
[n-3]
[n-2]
[n-1]

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

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

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

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

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

$n^2 - 2n + 1$

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

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

$n^2 - 2n + 1$

$O(n^2)$

$O(n^2)$

$O(n \log n)$

$O(n)$

$O(\log n)$

$O(1)$

$O(n^2)$ bubble sort

$O(n \log n)$

$O(n)$

$O(\log n)$

$O(1)$

```
Repeat n-1 times
    For i from 0 to n-2
        If numbers[i] and numbers[i+1] out of order
            Swap them
    If no swaps
        Quit
```

$\Omega(n^2)$

$\Omega(n \log n)$

$\Omega(n)$

$\Omega(\log n)$

$\Omega(1)$

$\Omega(n^2)$

$\Omega(n \log n)$

$\Omega(n)$ bubble sort

$\Omega(\log n)$

$\Omega(1)$

recursion

```
If no doors
    Return false
If number behind middle door
    Return true
Else if number < middle door
    Search left half
Else if number > middle door
    Search right half
```

```
If no doors
    Return false
If number behind middle door
    Return true
Else if number < middle door
    Search left half
Else if number > middle door
    Search right half
```

```
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
2   Open to middle of phone book
3   Look at page
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6   Else if person is earlier in book
7       Open to middle of left half of book
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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
```

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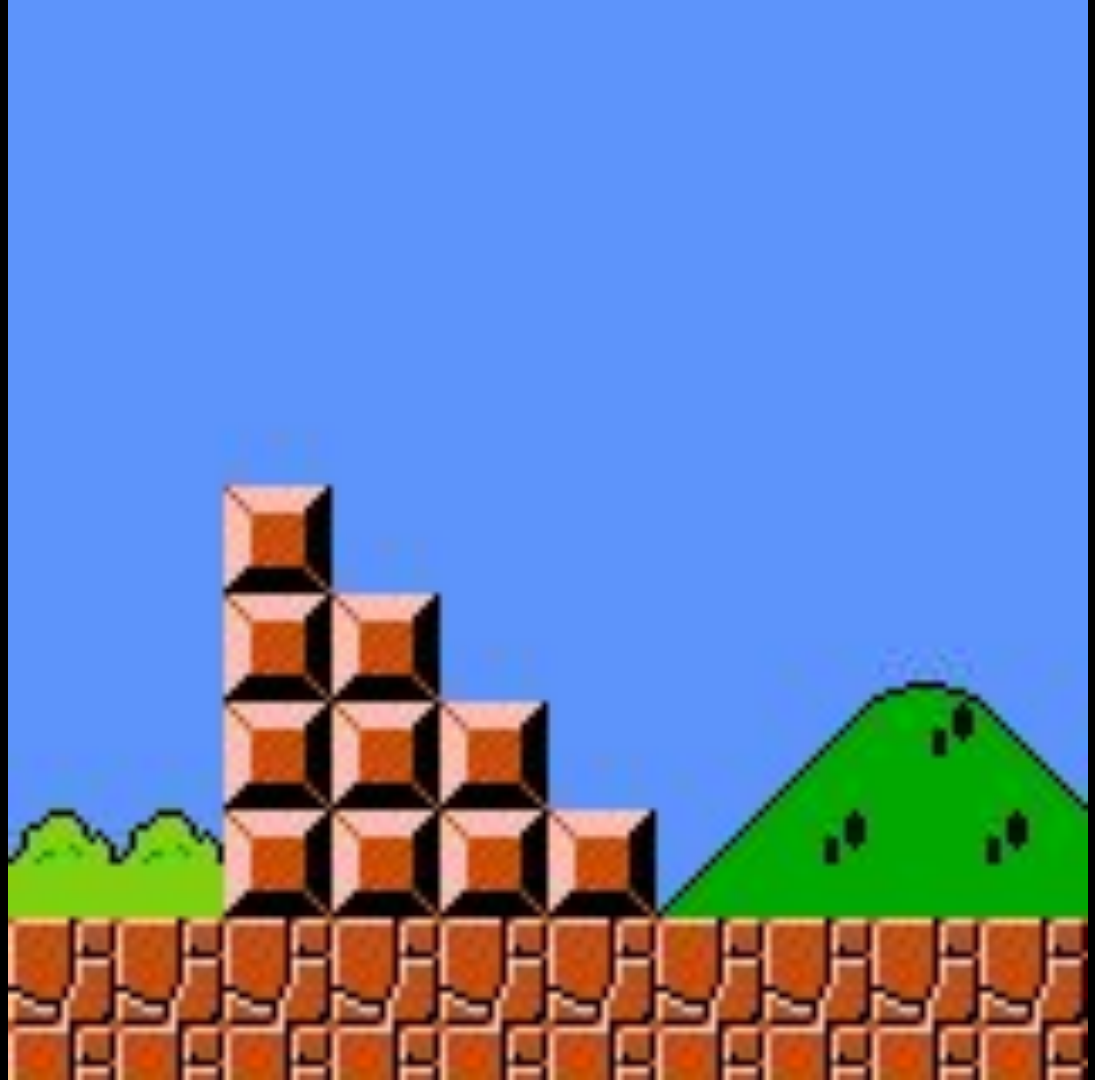
7       Open to middle of left half of book
8       Go back to line 3
9   Else if person is later in book
10      Open to middle of right half of book
11      Go back to line 3
12  Else
13      Quit
```

```
1   Pick up phone book
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
5       Call person
6   Else if person is earlier in book
7       Search left half of book
8   Else if person is later in book
9       Search right half of book
10  Else
11      Quit
```



merge sort

Sort left half of numbers
Sort right half of numbers
Merge sorted halves

```
If only one number
    Quit
Else
    Sort left half of numbers
    Sort right half of numbers
    Merge sorted halves
```

```
If only one number
    Quit
Else
    Sort left half of numbers
    Sort right half of numbers
    Merge sorted halves
```

2 4 5 7 0 1 3 6

```
If only one number
    Quit
Else
    Sort left half of numbers
    Sort right half of numbers
    Merge sorted halves
```

5 2 7 4 1 6 3 0

$O(n^2)$

$O(n \log n)$

$O(n)$

$O(\log n)$

$O(1)$

$O(n^2)$

$O(n \log n)$ merge sort

$O(n)$

$O(\log n)$

$O(1)$

$\Omega(n^2)$

$\Omega(n \log n)$

$\Omega(n)$

$\Omega(\log n)$

$\Omega(1)$

$\Omega(n^2)$

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

$\Omega(n)$

$\Omega(\log n)$

$\Omega(1)$

$\Theta(n^2)$

$\Theta(n \log n)$

$\Theta(n)$

$\Theta(\log n)$

$\Theta(1)$

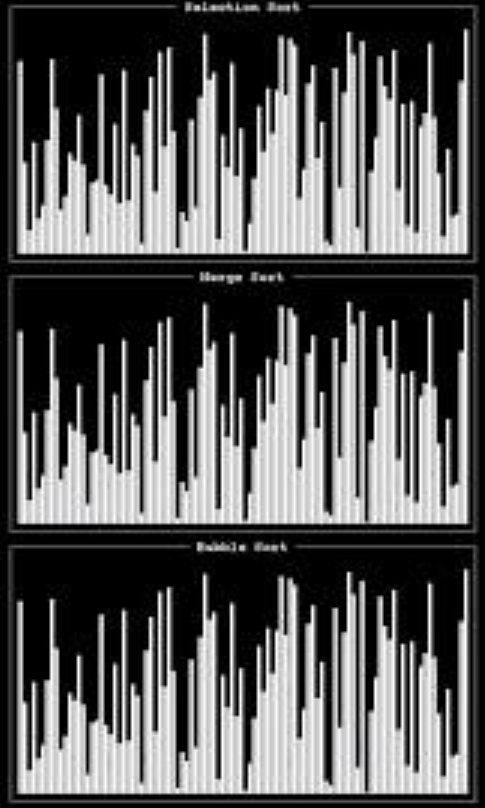
$\Theta(n^2)$

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

$\Theta(n)$

$\Theta(\log n)$

$\Theta(1)$



This is CS50