Happy Halloween!

Image: https://www.cmu.edu/piper/news/archives/2020/october/october-29-briefs.html

15-112 Lecture 2

Week 8 Thu Efficiency & Object-Oriented Programming

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Previous Poll 1

Which of these needs to visit all N elements in the list `data`, assuming N = len(data)?

Select ALL that apply.

A.
```
for x in data:
    print(x)
```

B.
```
for i in range(len(data)):
    print(x)
```

C.
```
if x in data:
    print("Found it")
```

D.
```
x = data[i]
```

E.
```
x = max(data)
```

F. None of the above

Previous Poll 2

Which of these needs to visit all N elements in the set `data`, assuming N = len(data)?

Select ALL that apply.

A.
```
for x in data:
    print(x)
```

B.
```
for i in range(len(data)):
    print(x)
```

C.
```
if x in data:
    print("Found it")
```

D.
```
x = data[i]
```

E.
```
x = max(data)
```

F. None of the above

Dictionaries

Dictionaries

Map keys to values

Keys are stored like sets

Efficiency

Counting operations

Worksheet

Counting operations

N is the size of the input data

- e.g. the length of an input list

The function f(N) is a measurement or count of resources used based on N

- Often based on computation time needed, but can be related to other resources like space (memory) needed
- Measured in number of operations rather than time
  - Lots of reasons, e.g. easier to compare algorithms despite changes in computer speed
- Small details either ignored or estimated (because of big-O)

Big O

Describes asymptotic behavior of a function

Informally (for 15112):

- Ignore all lower-order terms and constants

A few examples:

- $3N^2 - 2N + 25$ is in $O(N^2)$
- $30000N^2 + 2N - 25$ is in $O(N^2)$
- $0.000001N^2 + 123456N$ is in $O(N^2)$
- $10N \log_{17} N + 25N - 17$ is in $O(N \log N)$

Common Function Families

Constant: $O(1)$

Logarithmic: $O(\log N)$

Linear: $O(N)$

Loglinear: $O(N \log N)$

Quadratic: $O(N^2)$

Exponential: $O(2^N)$

Poll 3

Which of these is O(N) for the dictionary `d`, assuming N = len(d)?
Note: all of these are either O(1) or O(N)

Select ALL that apply.

A.
```
for key in d:
    print(d[key])
```
B.
```
for i in range(len(d)):
    print(d[i])
```
C.
```
if key in d:
    print("Found it")
```
D.
```
x = d[key]
```
E.
```
d[key] = x
```
F. None of the above

Poll 4

I'm thinking of a number between 1 and 64. After each guess, I'll tell you if you're correct or if my number is higher or lower.

$100 if you win. $0 if you lose.

How many guesses do you want to buy, $1 each?

A: 6

B: 7

C: 32

D: 64

Guess a Number: Binary Search

I'm thinking of a number between 1 and N. After each guess, I'll tell you if you're correct or if my number is higher or lower.

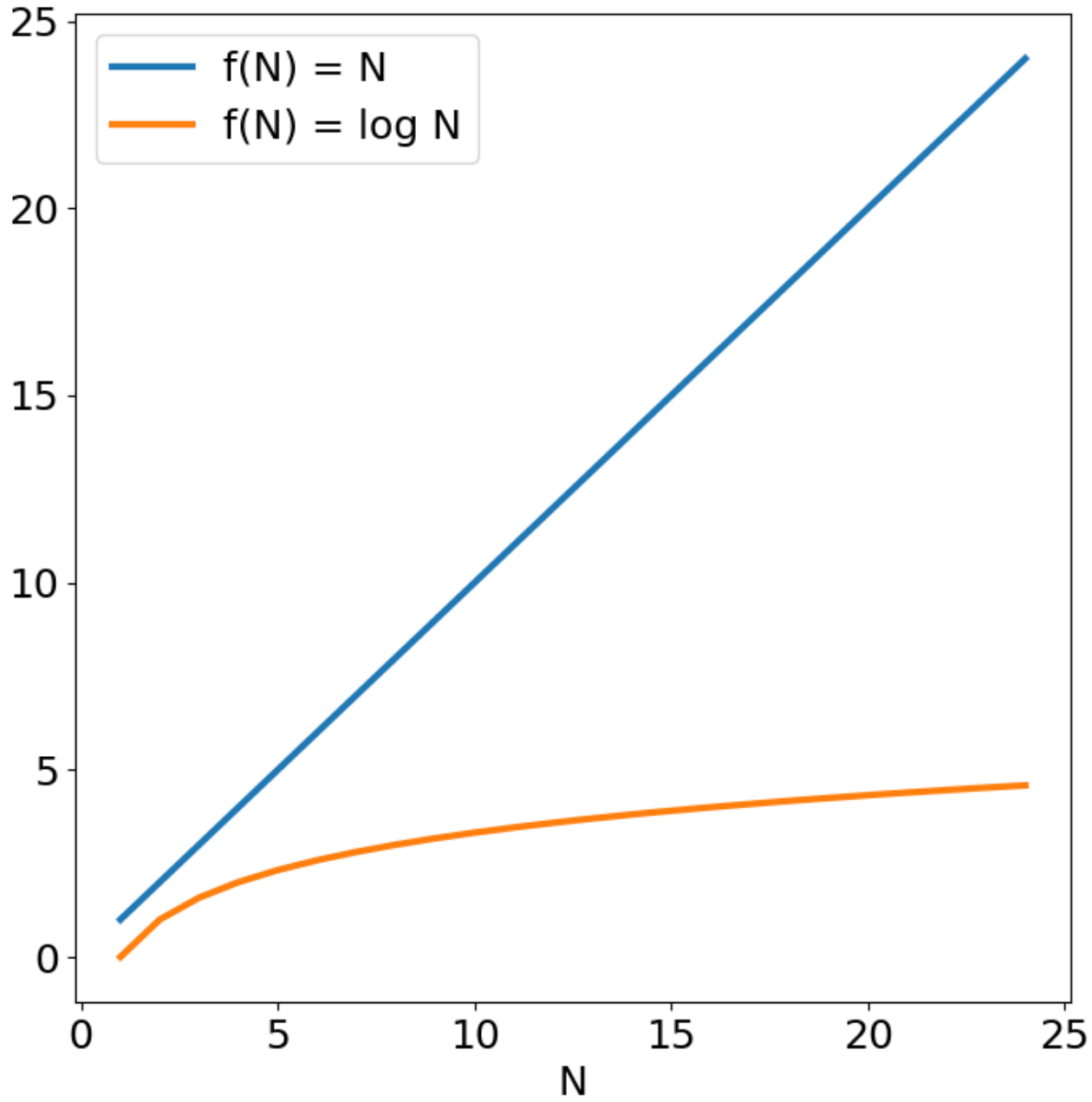
What is the maximum number of guesses you'll need to play this game?

N	10	100	1,000	10,000	100,000	1,000,000	10,000,000
$\log_2 N$	3.3	6.6	10.0	13.3	16.6	19.9	23.3
$\lfloor \log_2 N \rfloor + 1$	4.0	7.0	11.0	14.0	17.0	20.0	24.0

Linear vs Binary Search

Linear search: $O(N)$

Binary search: $O(\log N)$



Linear vs Binary Search

Linear search: $O(N)$

N = 40

Binary search: $O(\log N)$

Common Function Families

Constant: $O(1)$

Logarithmic: $O(\log N)$

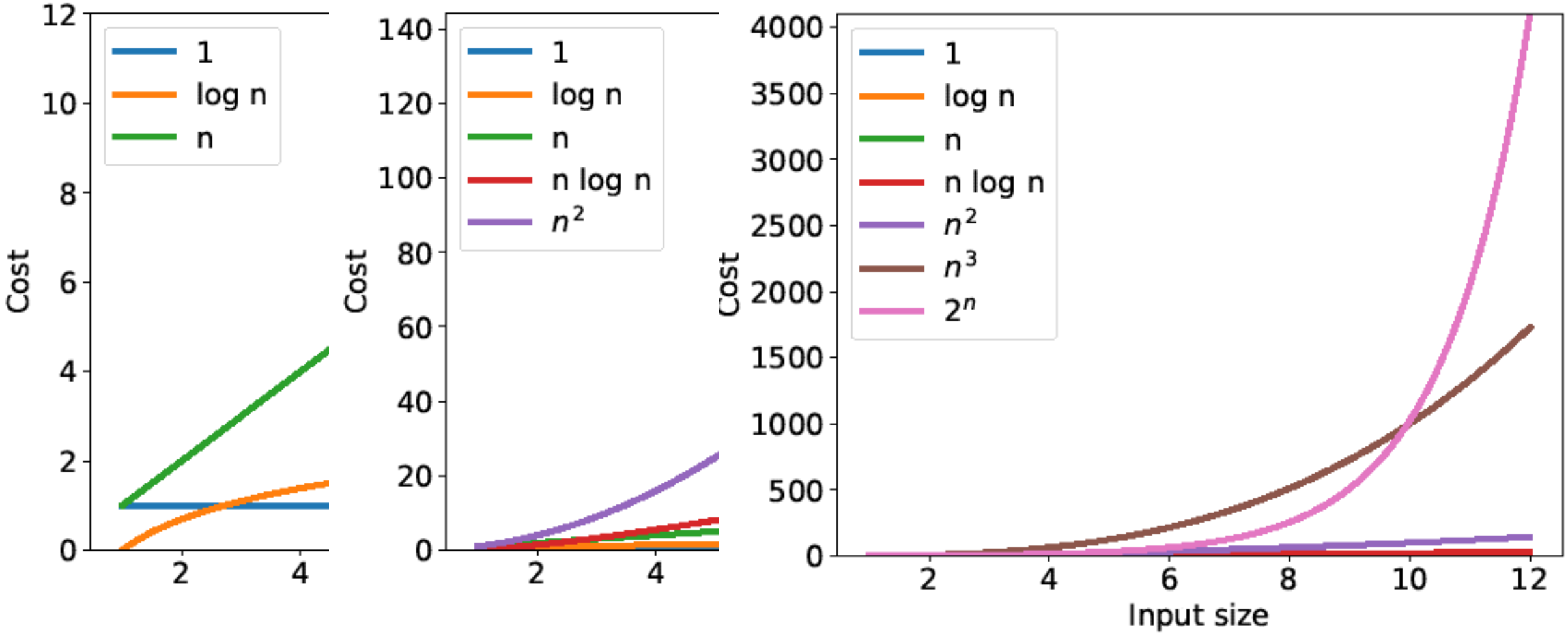
Linear: $O(N)$

Loglinear: $O(N \log N)$

Quadratic: $O(N^2)$

Exponential: $O(2^N)$

Complexity Classes



Efficiency of Sorting Algorithms

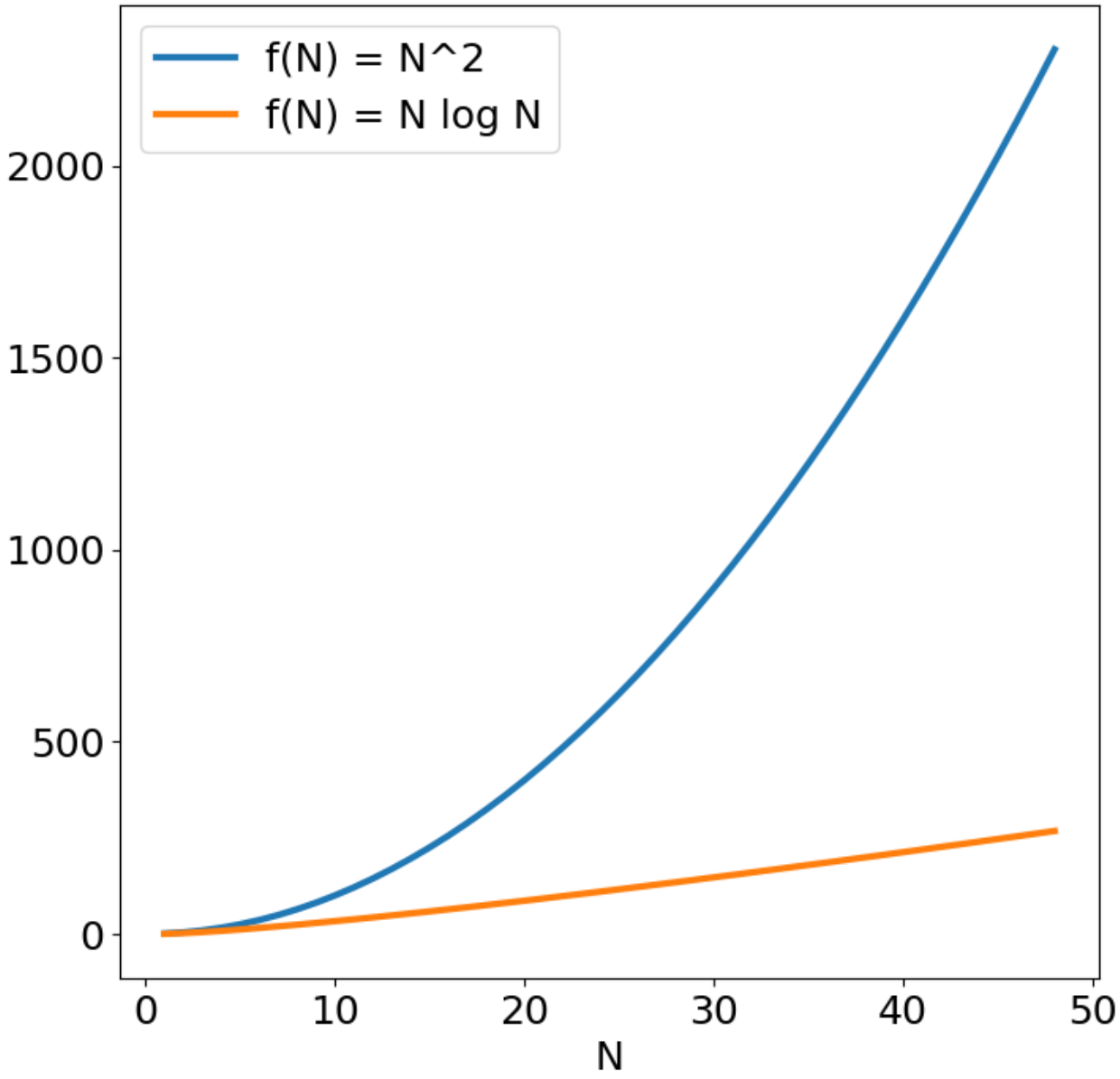
Sorting algorithms

xSortLab

http://math.hws.edu/eck/js/sorting/xSortLab.html

Selection sort: $O(N^2)$

Merge sort: $O(N \log N)$



Sorting algorithms

Selection sort: $O(N^2)$

Loop

- Find max in unsorted region
- Swap max with value at the end of the unsorted region
- Shrink unsorted region by 1

Merge sort: $O(N \log N)$

Sorting algorithms

Merge sort: $O(N \log N)$

Merge concept:

Assume you had two piles that were already independently sorted.

Could you shuffle them together into one sorted pile in O(N)?

Obejct-oriented Programming

Term Project Preview