[320] Complexity

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Review

The situation where git cannot auto-merge is called a ________________

What is the missing step?

1. nano file.txt
2. ????
3. git commit -m "I changed file.txt"
4. git push

What type does check_output return?

How can you use time.time() to measure an operation that is much faster than calling time.time()?

Today's Reading

Required: Think Python, Appendix B

http://www.greenteapress.com/thinkpython/html/thinkpython022.html (skip B.4)

Optional [math heavy]:

http://web.mit.edu/16.070/www/lecture/big_o.pdf

Complexity

Performance vs. Complexity

Things that affect performance (total time to run):

- speed of the computer (CPU, etc)
- speed of Python (quality+efficiency of interpretation)
- **algorithm**: strategy for solving the problem
- **input size:** how much data do we have?

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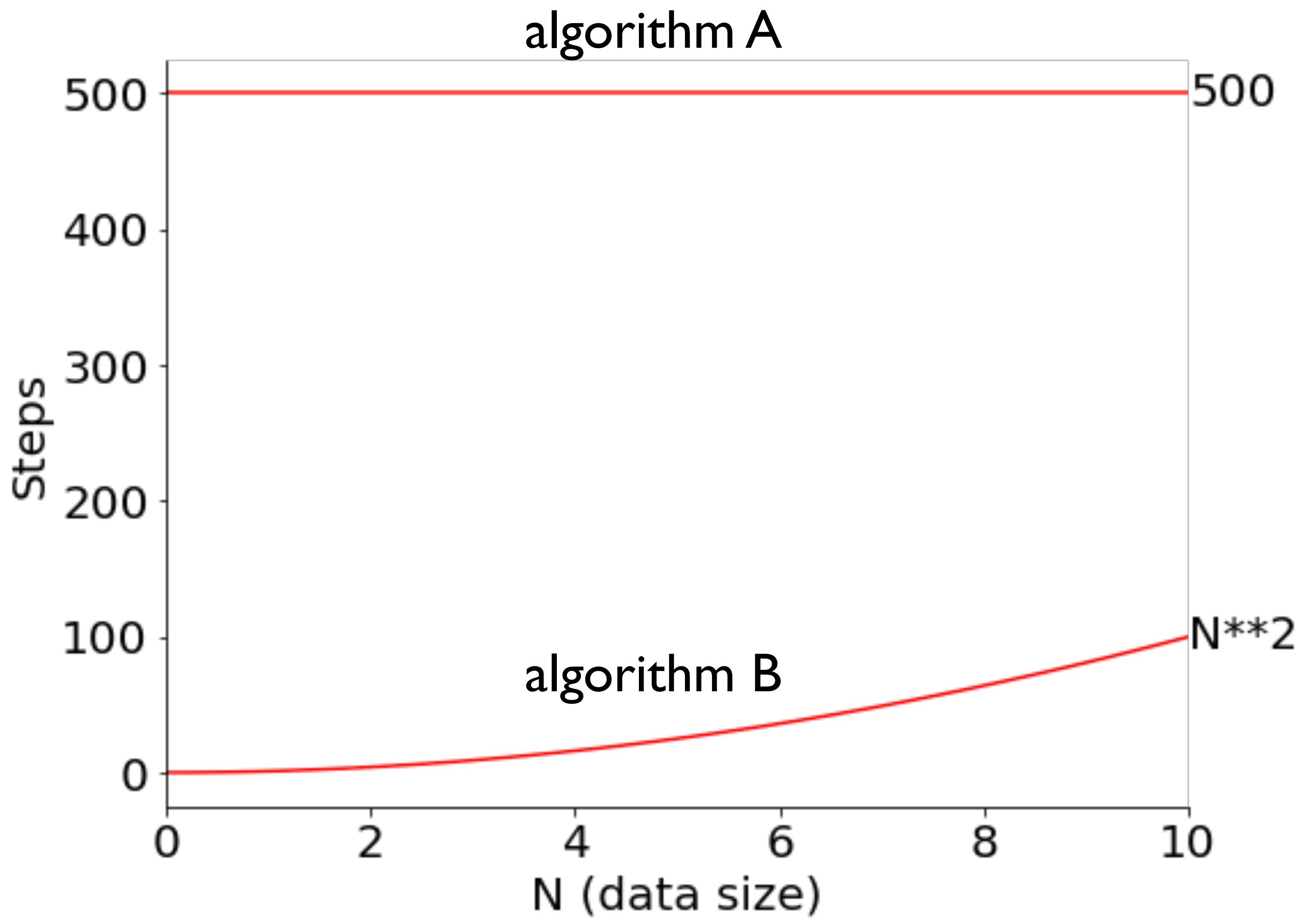
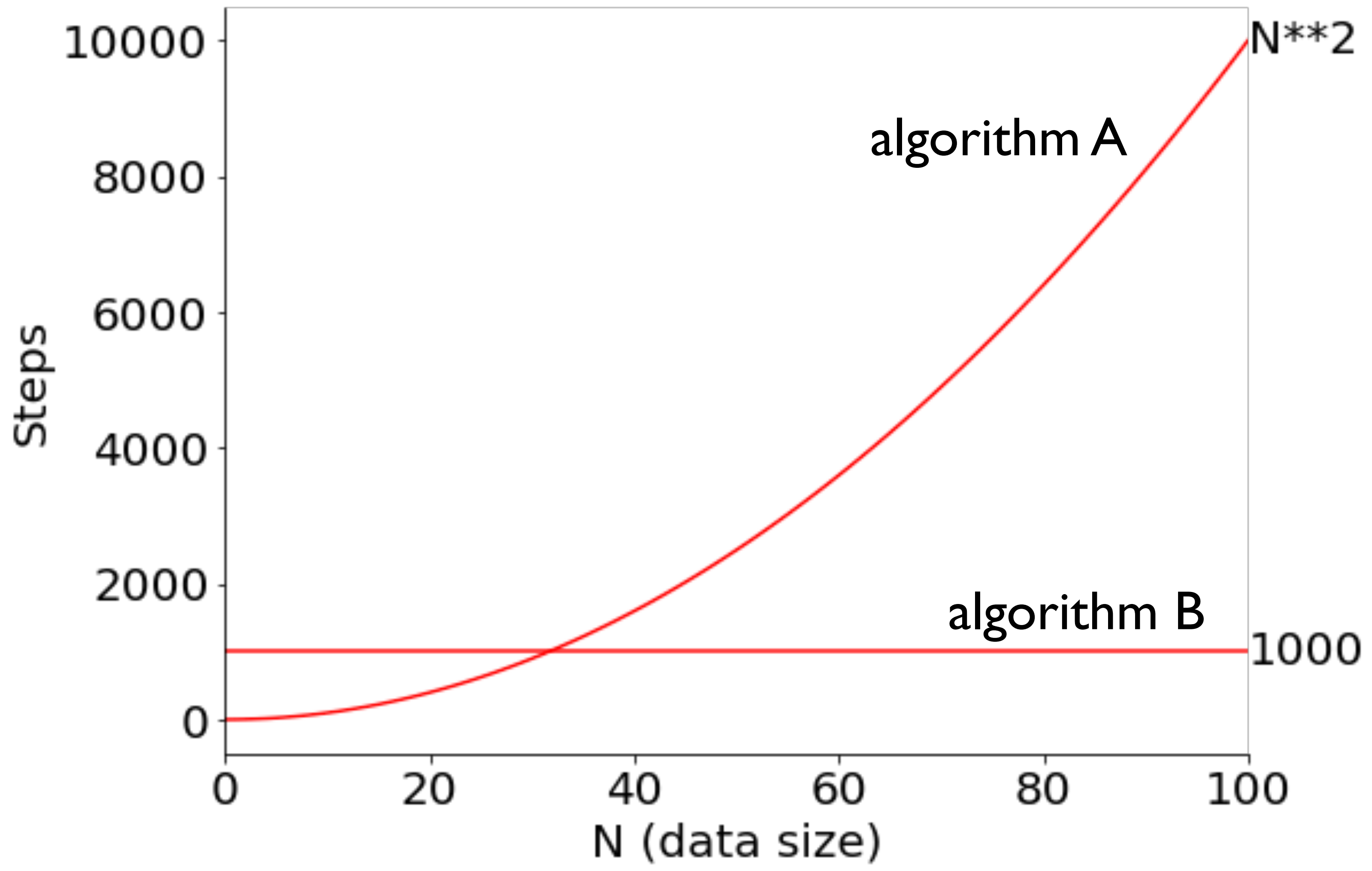
complexity analysis: how many steps must the algorithm perform, as a function of input size?

Which algorithm is better?



Do you prefer A or B?

Which algorithm is better?



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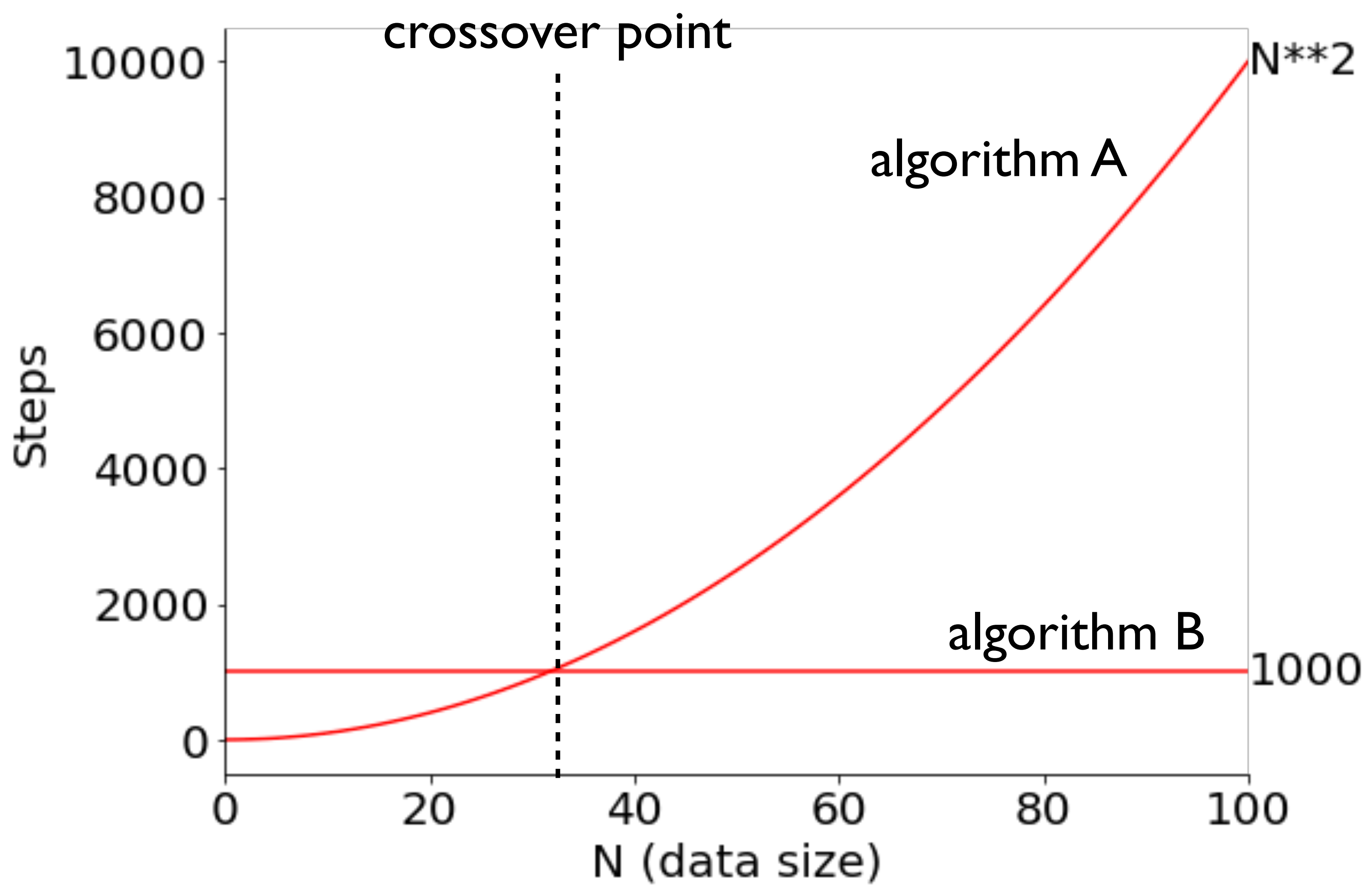
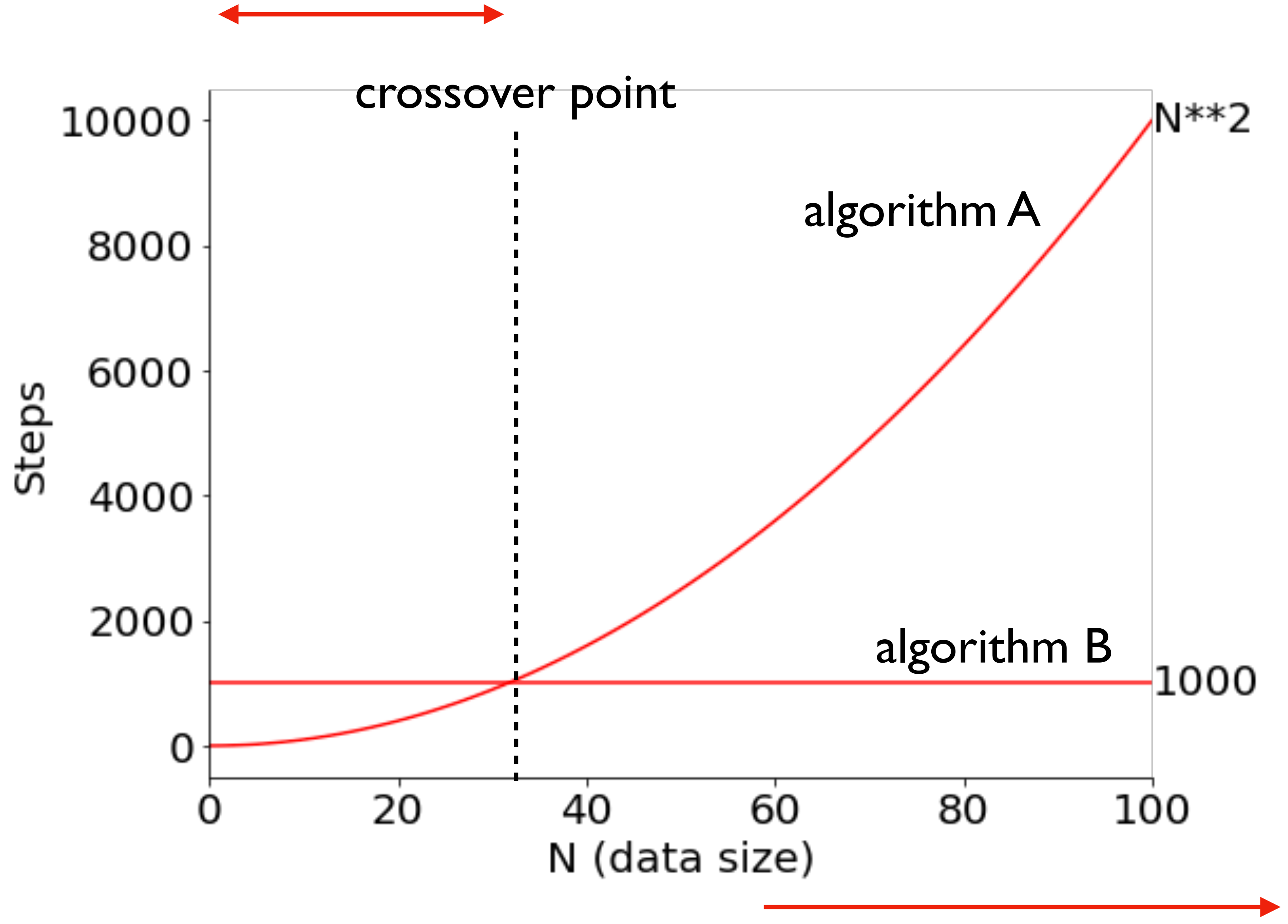


Which algorithm is better?

you might still reasonably care about this portion!



complexity analysis only cares about "big" inputs

What is the asymptotic behavior of the function?

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what is this?

complexity analysis: how many **steps** must the algorithm perform, as a function of input size?

What is a "step"?

What is a step?

A **step** is any unit of work that has a time to execute that **does not** depend on the input size

input size is length of this list

```
           input_nums = [2, 3, ...]

STEP       odd_count = 0
STEP       odd_sum = 0
STEP       for num in input_nums:
STEP           if num % 2 == 1:
STEP               odd_count += 1
STEP               odd_sum += num
STEP       odd_avg = odd_sum
STEP       odd_avg /= odd_count
```

✓

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```

✓

One line can do a lot, so no reason to have lines and steps be equivalent

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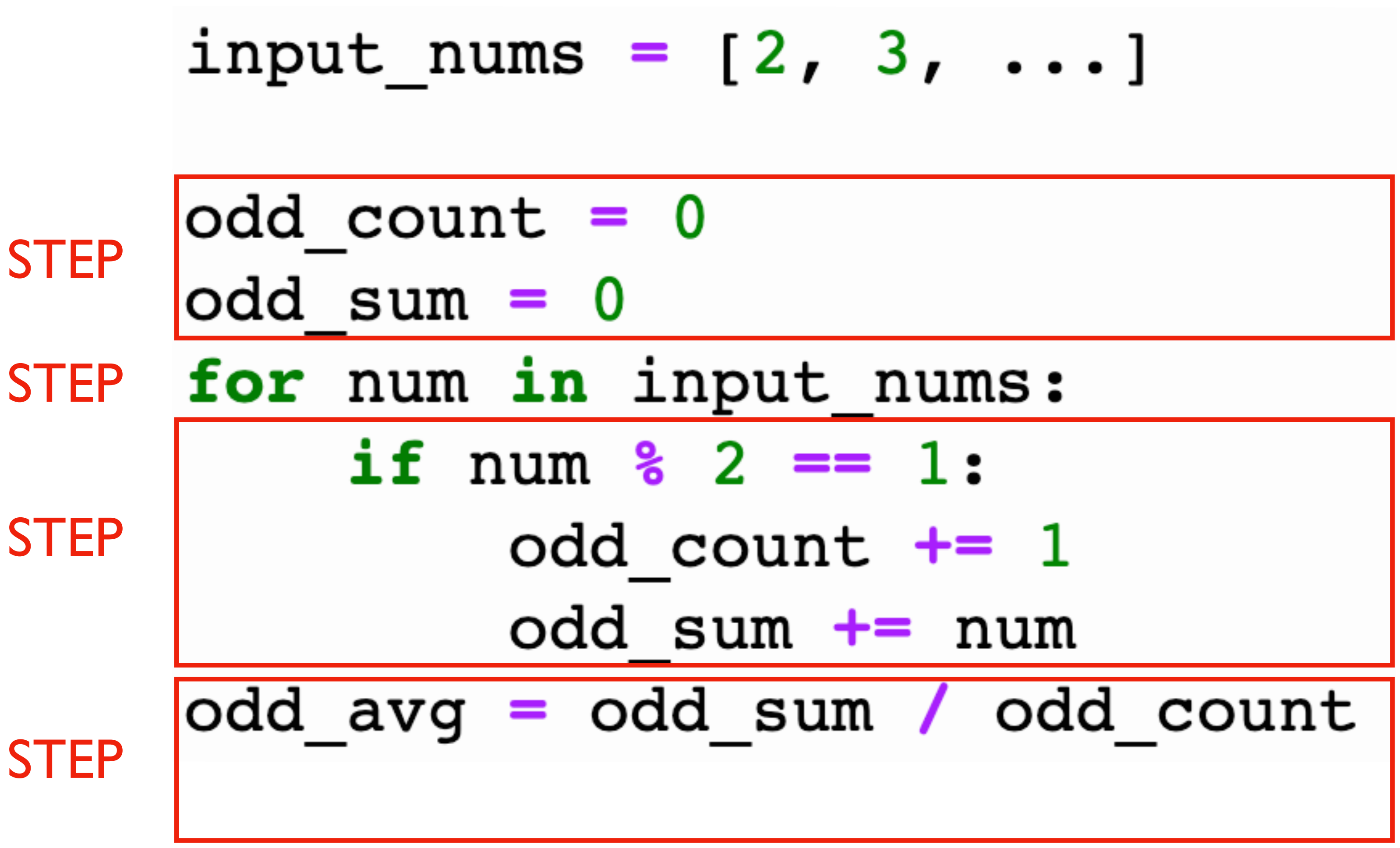

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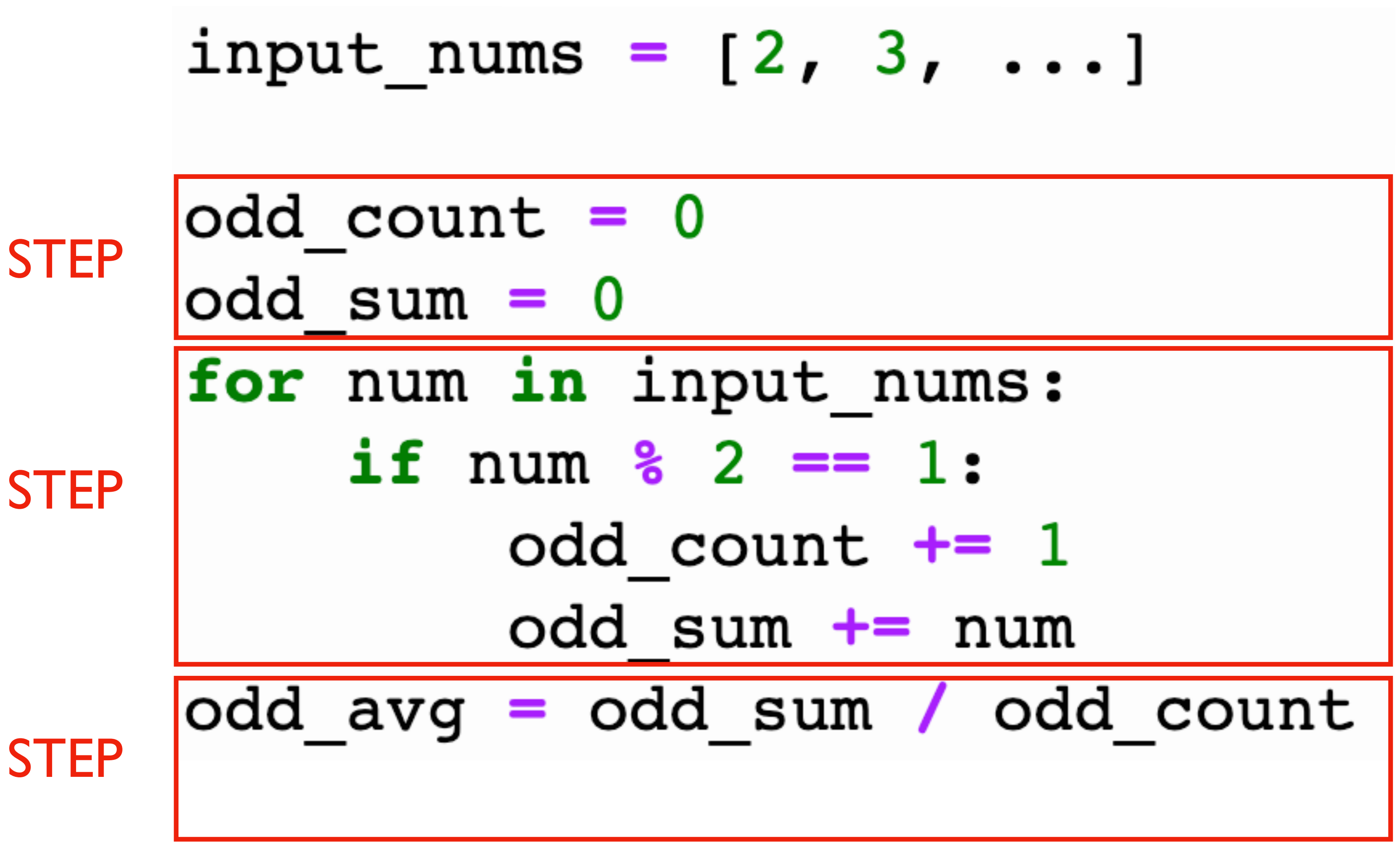

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???

is this a valid way to identify steps?

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```

STEP

STEP

not a "step", because exec time depends on input size

STEP

✗

Counting Executed Steps

A **step** is any unit of work that has a time to execute that **does not** depend on the input size

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How many total steps will **execute** if `len(input_nums) == 10`?

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```

1 STEP

+ 11 STEP

+ 10 STEP

+ 1 STEP

= 23 steps

For **N** elements, there will be **2*N+3** steps

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                       input_nums = [2, 3, ...]

       1      STEP     odd_count = 0
     + 1      STEP     odd_sum = 0
     + 11     STEP     for num in input_nums:
     + 10     STEP         if num % 2 == 1:
+ 0 to 10     STEP             odd_count += 1
+ 0 to 10     STEP             odd_sum += num
     + 1      STEP     odd_avg = odd_sum
     + 1      STEP     odd_avg /= odd_count
```

For **N** elements, there will be between
2*N+5 and **4*N+5** steps

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```

Important: we might not identify steps the same, but our execution counts can at most differ by a constant factor!

can we broadly (but rigorously) categorize based on this?

Big O Notation ("O" is for "order of growth")

If $f(N) < C * g(N)$ *for large x values and some fixed <u>constant</u> C*

Then $f(N) \in O(g(N))$

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which ones are true?

$2N \in O(N)$

$100N \in O(N^2)$

$N^2 \in O(1000000N)$

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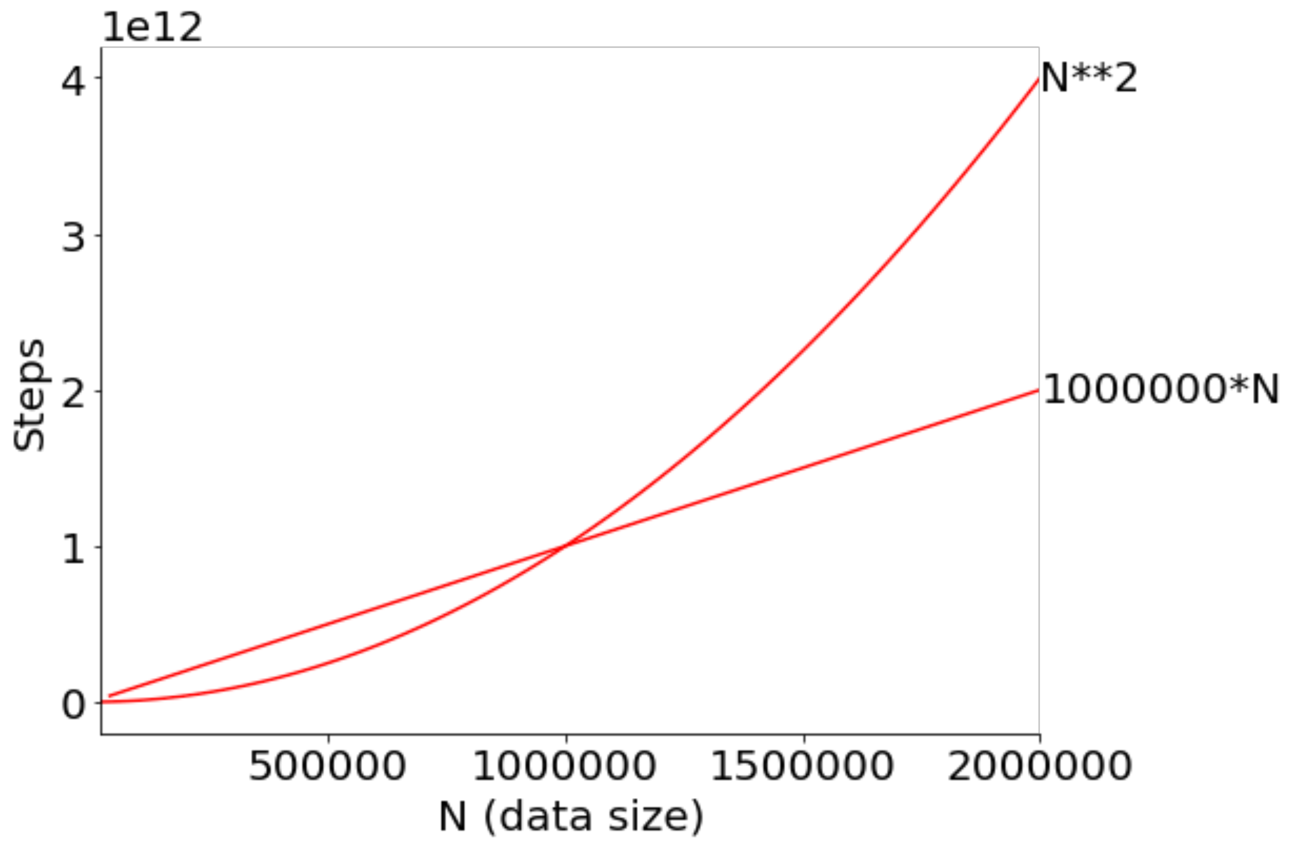

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$N^2 \in O(N^2+N+1)$

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$N^5 \in O(N^4 + N^3 + N^2 + N)$

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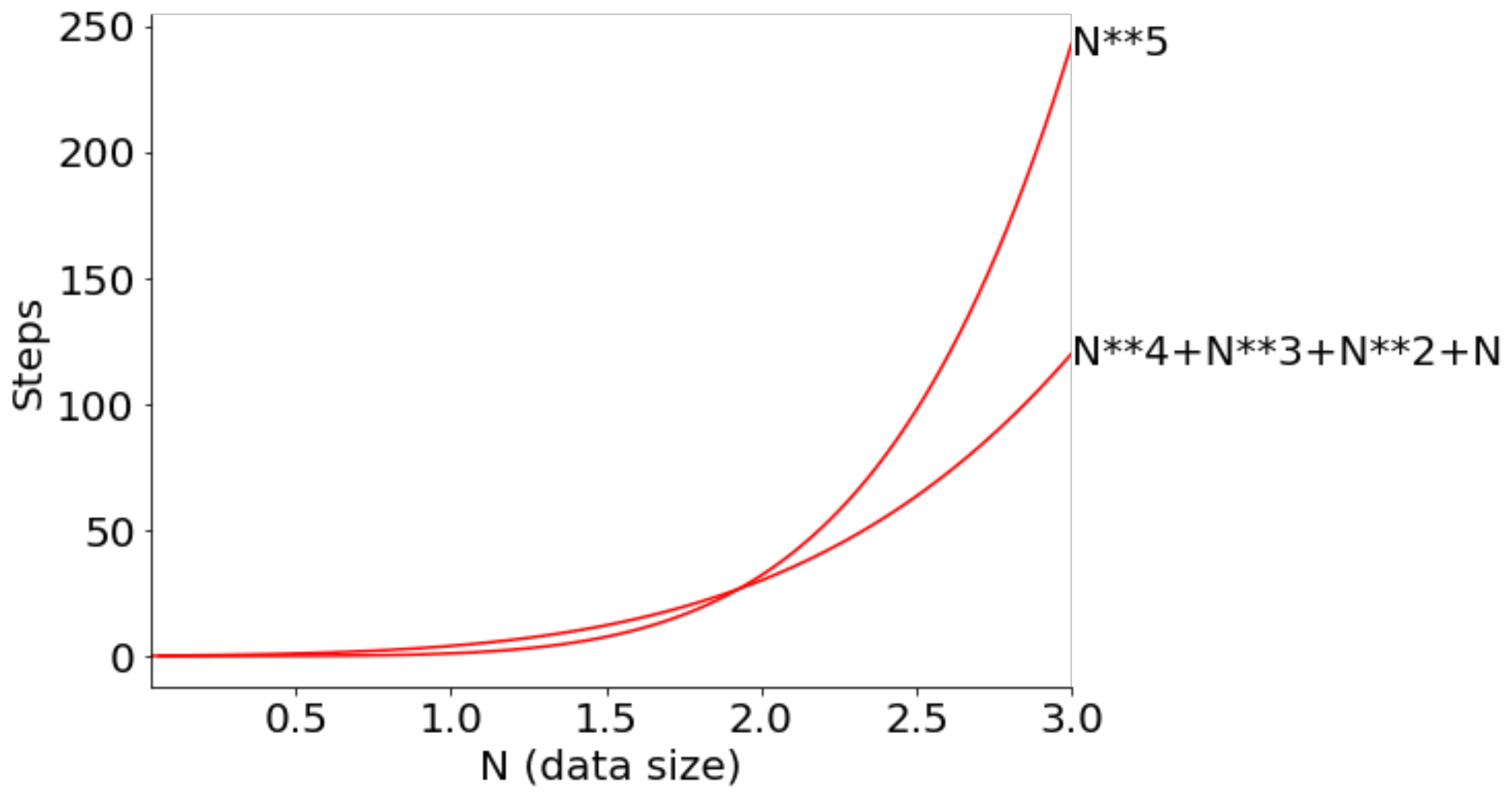

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$N^2+N+1 \in O(N^2)$

~~$N^5 \in O(N^4 + N^3 + N^2 + N)$~~

TODO: find example: beginning vs. end. Worst case.

TODO: the "in" operator is not a step (or sum, sort, etc)

Summary of Terms

commit:	a snapshot of files at a point in time
HEAD:	a convenient label for the current commit
tag:	a label attached to a commit
branch:	a label attached to a commit that re-attaches to new commits
merge:	to combine changes on another branch into the current branch
conflict:	differences that cannot automatically be merged