[320] Welcome + First Lecture

[reproducibility]

Yiyin Shen

Who am I?

Yiyin Shen

- CS PhD student
- Email: yshen82@wisc.edu

Research Interest

- CS Education
- Large Language Models

Teaching Experience

- CS320 TA => Head TA => Instructor
- CS220, CS402 Guest Lectures

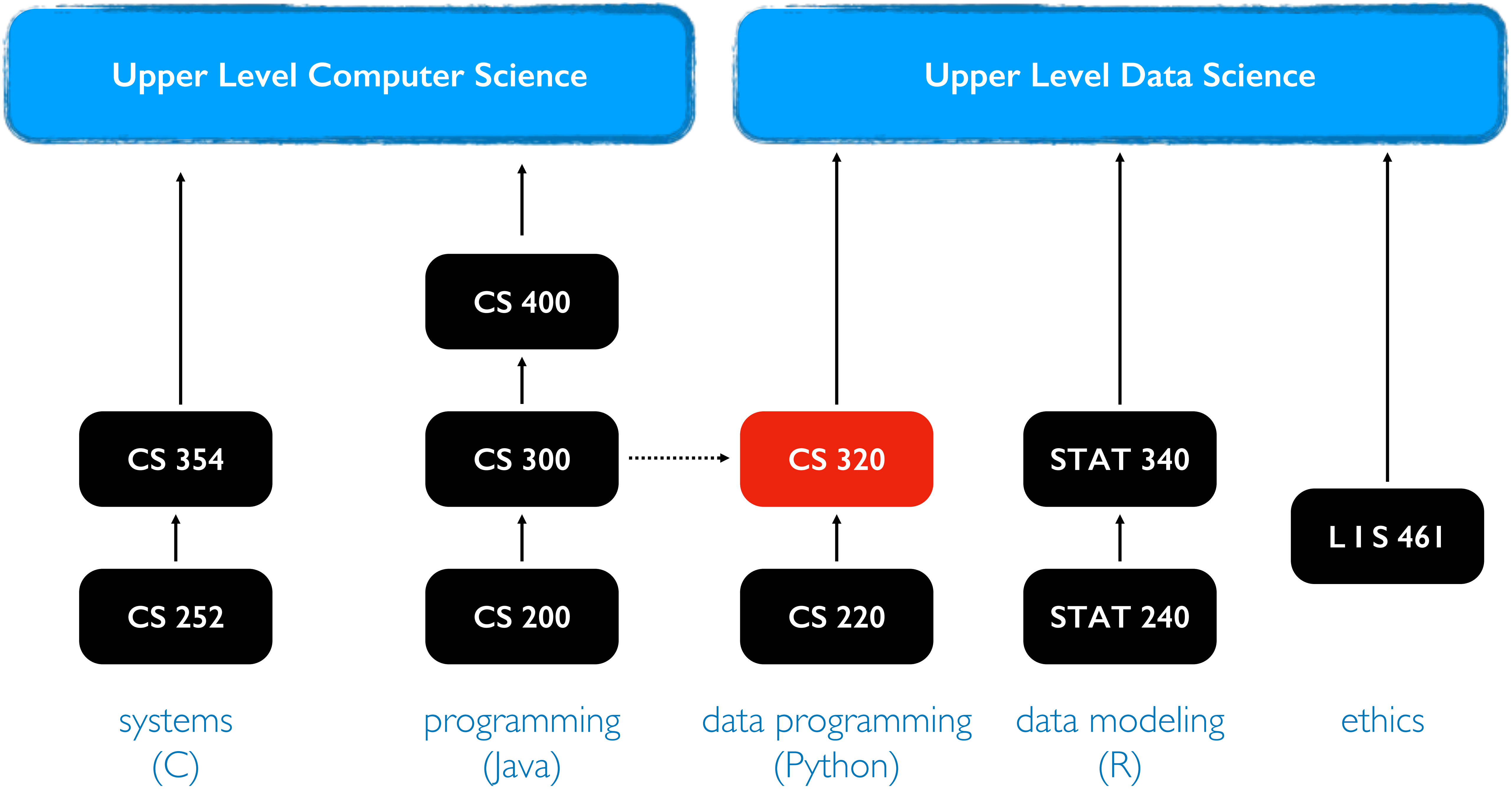
Who are You?

Year in school?
Major?

Please fill out the Student Information form:
(due Wed, June 7th):
https://forms.gle/bSGCkxBW7MPGGeHQ6
Why?

- Help me get to know you
- Get survey credit
- Group formation

Related courses



Upper Level Computer Science

Upper Level Data Science

CS 400

CS 354

CS 300

CS 320

STAT 340

L I S 461

CS 252

CS 200

CS 220

STAT 240

systems (C)

programming (Java)

data programming (Python)

data modeling (R)

ethics

P1 (Project 1) will help 300-to-320 students pickup Python.

Welcome to Data Science Programming II!

Builds on CS220. https://stat.wisc.edu/undergraduate-data-science-studies/

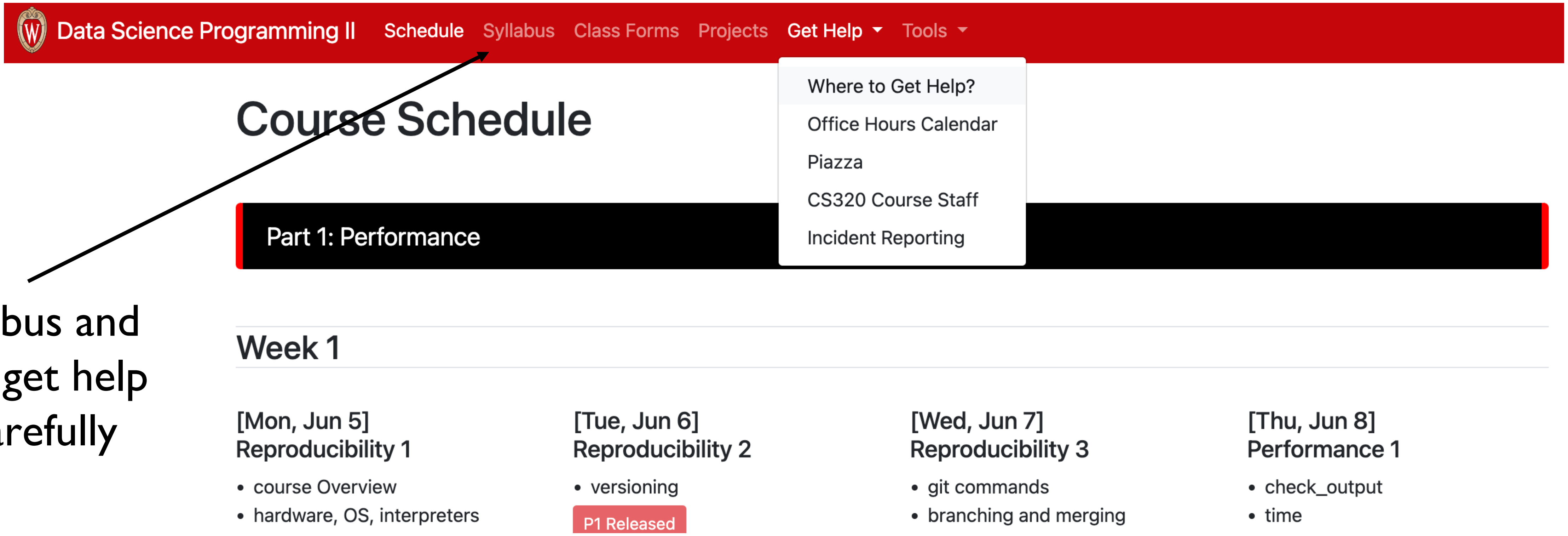
CS220	CS320
getting results	getting **reproducible** results
writing correct code	writing **efficient** code
using objects	designing **new types** of objects
functions: `f(obj)`	**methods**: `obj.f()`
lists + dicts	graphs + trees
analyzing datasets	**collecting** + analyzing datasets
plots	visualizations
tabular analysis	**simple machine learning**

CS220 content (for review): https://cs220.cs.wisc.edu/f22/schedule.html

Course Logistics

Course Website

https://tyler.caraza-harter.com/yiyin/su23/schedule.html



Course Schedule

Part 1: Performance

Week 1

[Mon, Jun 5]
Reproducibility 1

- course Overview
- hardware, OS, interpreters

[Tue, Jun 6]
Reproducibility 2

- versioning

P1 Released

[Wed, Jun 7]
Reproducibility 3

- git commands
- branching and merging

[Thu, Jun 8]
Performance 1

- check_output
- time

read syllabus and where to get help pages carefully

I'll also use Canvas for:

- Announcements
- Quizzes/exams
- Zoom: lectures, labs, office hours
- Late day summaries
- Grades

Class Organization: People

Groups

- you'll be assigned to a group of 4-7 students
- groups will last the whole semester
- collaboration with group members are allowed (not required) on labs, quizzes, and group part of the projects
- collaboration with non-group members is not allowed

Communication

Drop-in Office Hours:

- Course website – Get Help – Office Hour Calendar
- Queue: https://ohwl.herokuapp.com/

Piazza

- Don't post >5 lines of project-related code (considered cheating)
- Private posts disabled

Forms

- https://tyler.caraza-harter.com/yiyin/su23/surveys.html
- Student Information Survey, Exam Conflicts Forms, Project/Lab Grading Issue Form, Feedback Form, Thank You Form

Email (least preferred)

- me: yshen82@wisc.edu
- TA: Victor vsuciu@wisc.edu
- Course staff: https://canvas.wisc.edu/courses/355770/pages/course-staff

Scheduled Activities

Lectures (MTWR 10:00 – 10:50 AM) (2% overall)

- Recommendation: use your laptop to take notes on the provided template notebook and another screen to follow along the lecture
- Attendance is required. Attendance recorded through Google forms
- 14 drops out of 38 lectures

Labs (TR 11:00 – 11:50 AM) (4% overall)

- Work through lab activities with group mates
- 320 staff will circulate around breakout rooms to answer questions
- Attendance is required. 6 drops out of 18 labs
- 5 attendance points per lab:
- 2 for arriving no later than 5 mins after the lab starts
- 3 for showing sufficient working progress (submit code and/or running results to Canvas at the end of the lab)

Graded Work: Quizzes & Exams

Eight Online Quizzes - 1% each (1 drop, 7% overall)

- cumulative, no time limit
- on Canvas, open book/notes
- can take together AT THE SAME TIME with group members (no help from other human is allowed)

Midterms - 11% each (22% overall)

- cumulative, individual, multi-choice, 50 minutes
- one-page two-sided note sheet
- Friday, June 30th, 7:00PM - 8:30PM
- Friday, July 21st, 7:00PM - 8:30PM

Final - 15%

- cumulative, individual, multi-choice, 2 hours
- two-page two-sided note sheet
- Thursday, August 10th, 10:00AM - 12:30PM

Graded Work: Projects & Surveys

7 Projects - 7% each (49% overall)

- format: python notebook or module
- group part: you can optionally collaborate with group
- individual part: must be done individually (only receive help from 320 staff)
- regular deadlines on course website
- late days: overall 8 late days
- hard deadline: 4 days after the regular deadline – maximum 2 late days; 10% score penalty per day after day 2
- `tester.py` with TA evaluation
- clearing auto-grader on the submission portal (course website) is mandatory

Surveys (1% overall)

Letter Grades

- Your final grade is based on sum of all points earned
- Your grade does not depend on other students' grade
- Scores will NOT be rounded up at the end of the semester
- No major score changes at the end of the semester
- No extra credits

Grade cut-offs

93% - 100%:	A
88% - 92.99%:	AB
80% - 87.99%:	B
75% - 79.99%:	BC
70% - 74.99%:	C
60% - 69.99%:	D

Time Commitment & Academic Conduct

Project commitment

- 10-12 hours per project is typical (2-4 hours can be done in labs)
- 20% of students sometimes spend 20+ hours on some projects
- recommendation: start early and be proactive

Typical Weekly Expectations

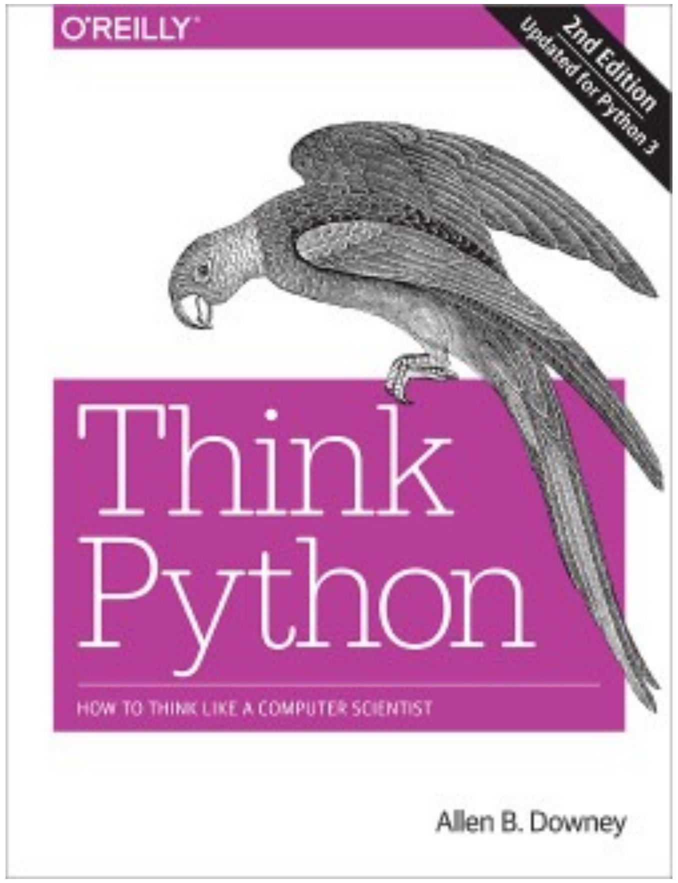
- 6 hours - lecture/lab
- 8 hours - project coding
- 2 hours - reading/quizzes/etc

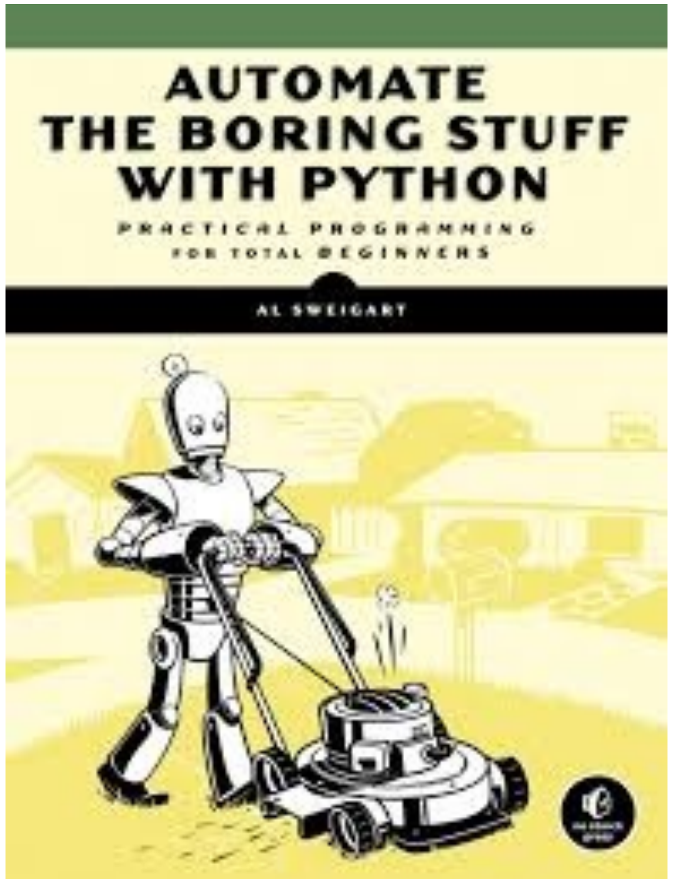
Please talk to me if you're feeling overwhelmed with 320 or your semester in general.

Academic Conduct

- Read syllabus to make sure you know what is and isn't acceptable.
- We will run plagiarism detector on project submissions.

Reading: same as 220/301 and some others...




AUTOMATE THE BORING STUFF WITH PYTHON
PRACTICAL PROGRAMMING FOR TOTAL BEGINNERS
AL SWEIGART

I'll post links to other online articles and notes

Lectures don't assume any reading prior to class

Tips for 320 Success

1. Just show up
   Get 100% on attendance, don't miss quizzes, submit group work

2. Use office hours

3. Do labs before projects

4. Take the lead on group collaboration

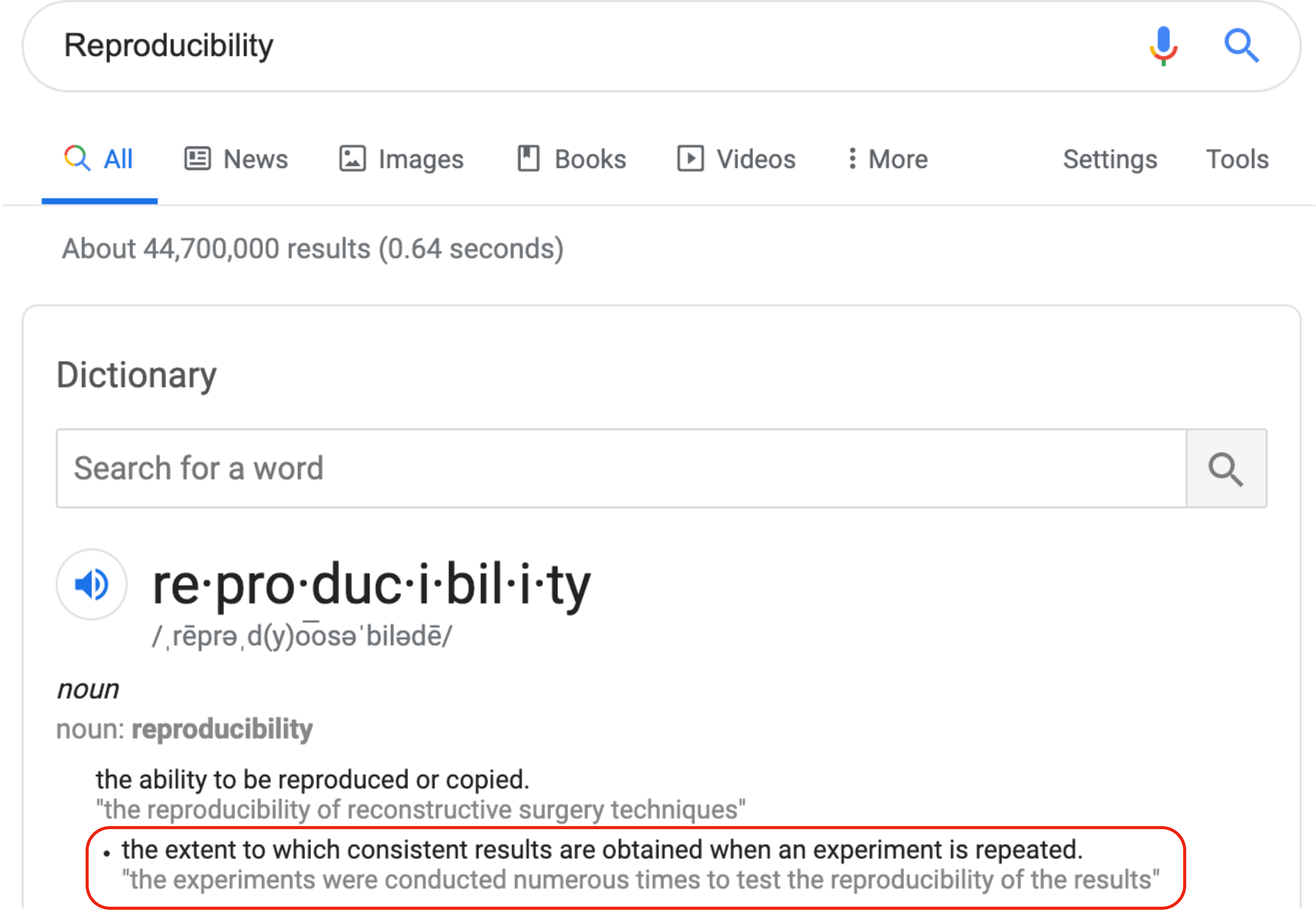
5. Learn debugging

6. Run the tester often

7. If you're struggling, reach out -- the sooner, the better

Today's Lecture:

Reproducibility



Reproducibility

About 44,700,000 results (0.64 seconds)

Dictionary

re·pro·duc·i·bil·i·ty

/ˌrēprəˌd(y)o͞osəˈbilədē/

noun

noun: **reproducibility**

the ability to be reproduced or copied.

"the reproducibility of reconstructive surgery techniques"

- the extent to which consistent results are obtained when an experiment is repeated.
  "the experiments were conducted numerous times to test the reproducibility of the results"

Discuss: *how might we define "reproducibility" for a data scientist?*

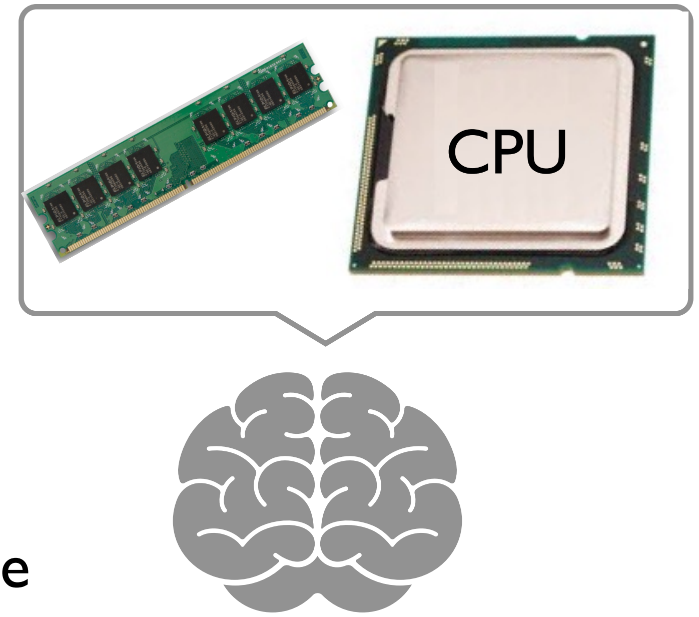
Big question: *will my program run on someone else's computer?*
(not necessarily written in Python)

Things to match:

1 Hardware

2 Operating System ← next lecture

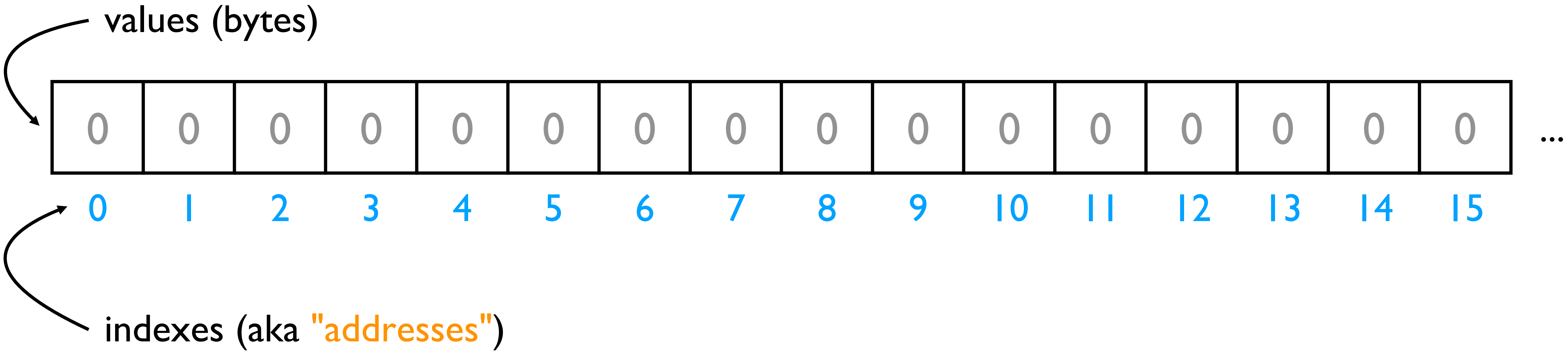
3 Dependencies ← next lecture



Hardware: Mental Model of Process Memory

Imagine...

- one huge list, **per each** ~~running program~~ **process**, called **"address space"**
- every entry in the list is an integer between 0 and 255 (aka a "byte")



values (bytes)

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	...
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	

indexes (aka "addresses")

How can we use one giant list to handle the following?

- multiple lists
- variables and other references
- strings
- code

data

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	...
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	

Is this really all we have for state?

How can we use one giant list to handle the following?

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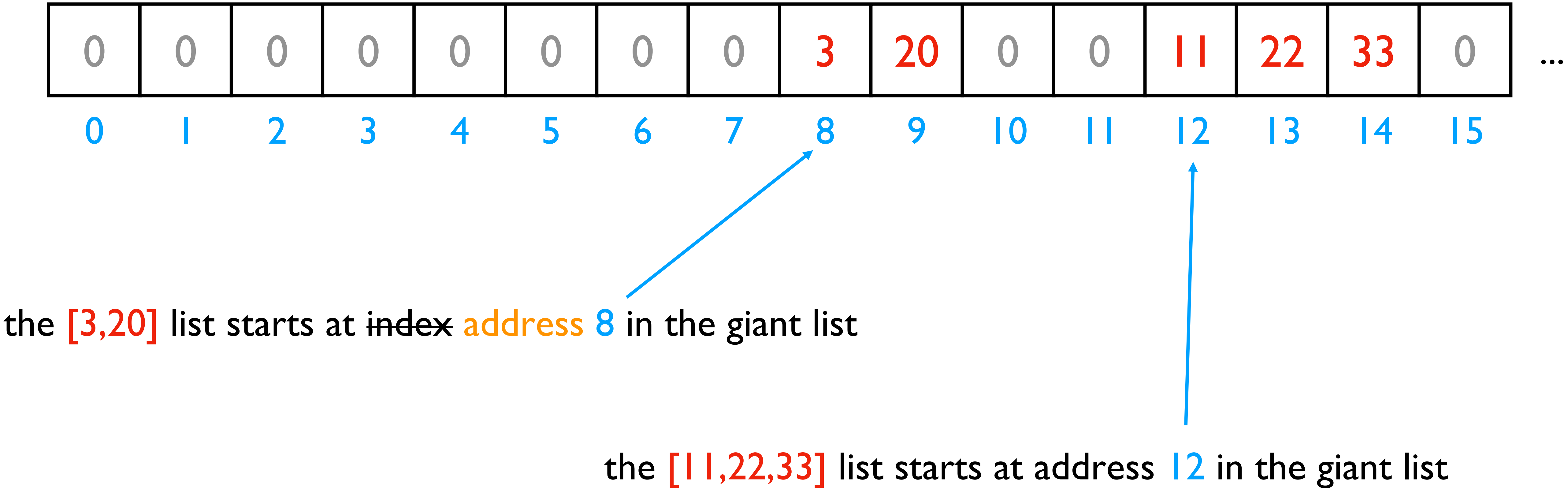

0	0	0	0	0	0	0	0	3	20	0	0	11	22	33	0	...
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	

the [3,20] list starts at ~~index~~ address 8 in the giant list

the [11,22,33] list starts at address 12 in the giant list

How can we use one giant list to handle the following?

- multiple lists
- variables and other references
- strings
- code

0	0	0	0	0	0	0	0	3	20	0	0	11	22	33	0	...
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	

```
# fast
L2.append(44)
```

implications for performance...

How can we use one giant list to handle the following?

- multiple lists
- variables and other references
- strings
- code

0	0	0	0	0	0	0	0	3	20	0	0	11	22	33	44	…
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	

```
# fast
L2.append(44)
```

implications for performance...

How can we use one giant list to handle the following?

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0	0	0	0	0	0	0	0	3	20	0	0	11	22	33	44	...
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	

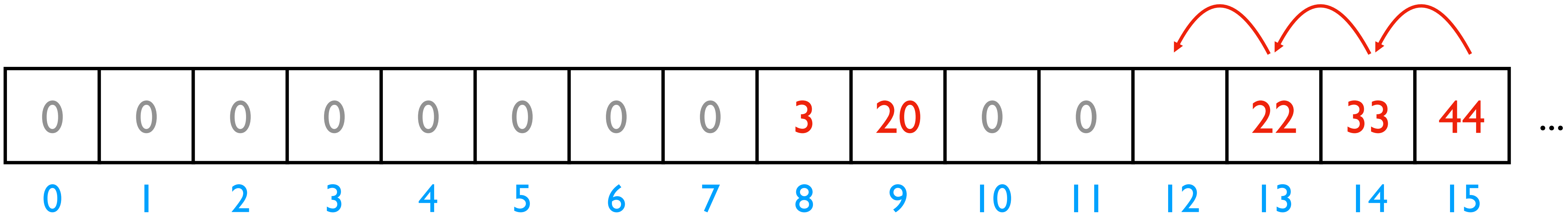
implications for performance...

```
# fast
L2.append(44)

# slow
L2.pop(0)
```

How can we use one giant list to handle the following?

- multiple lists
- variables and other references
- strings
- code



0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
0	0	0	0	0	0	0	0	3	20	0	0		22	33	44	...

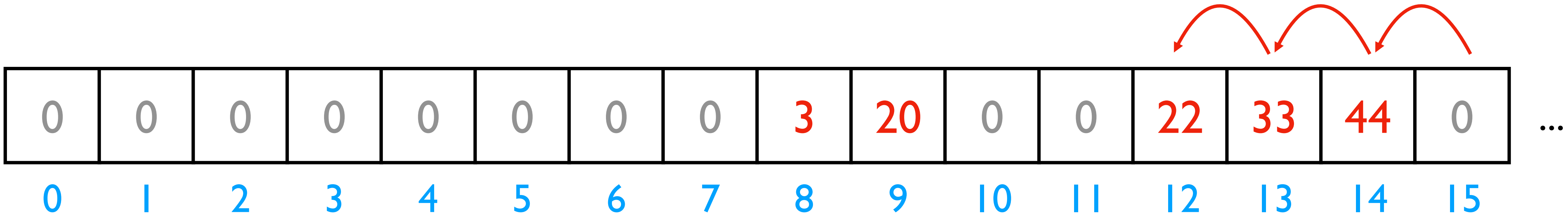
implications for performance...

```
# fast
L2.append(44)

# slow
L2.pop(0)
```

How can we use one giant list to handle the following?

- multiple lists
- variables and other references
- strings
- code



0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
0	0	0	0	0	0	0	0	3	20	0	0	22	33	44	0	...

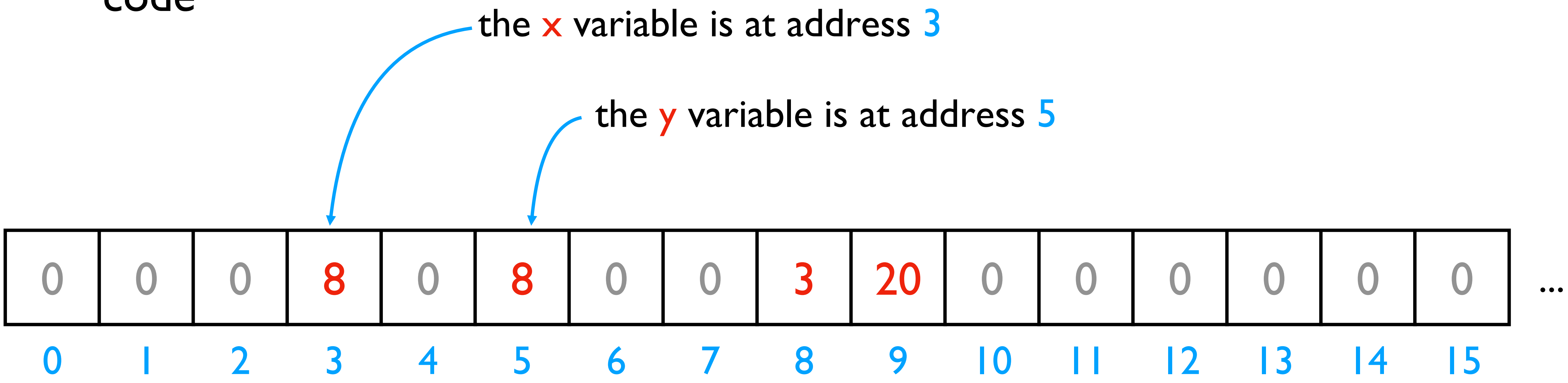
We'll think more rigorously about performance in CS 320 (big-O notation)

```
# fast
L2.append(44)

# slow
L2.pop(0)
```

How can we use one giant list to handle the following?

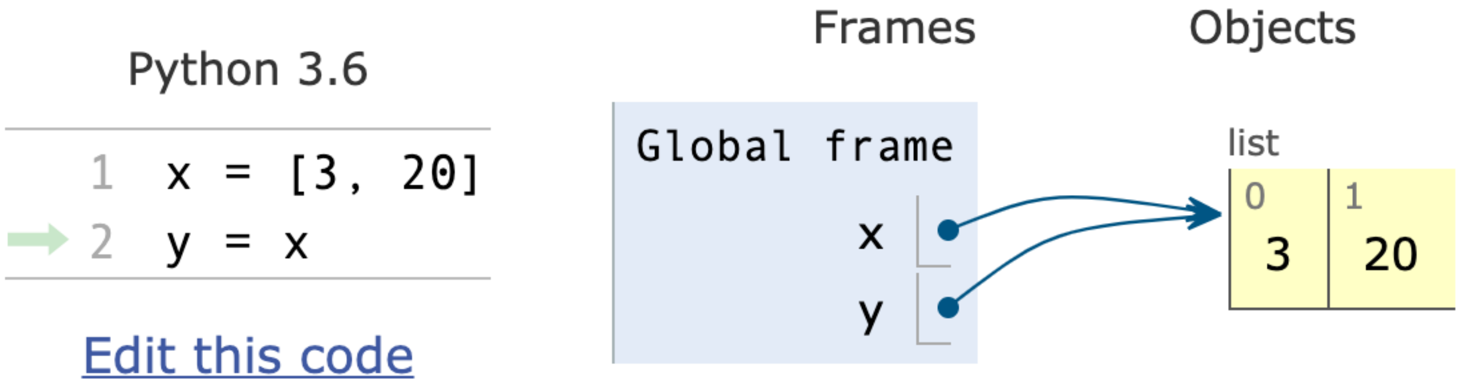
- multiple lists
- variables and other references
- strings
- code



the x variable is at address 3

the y variable is at address 5

0	0	0	8	0	8	0	0	3	20	0	0	0	0	0	0	...
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	



Python 3.6

```
x = [3, 20]
y = x
```

PythonTutor's visualization

How can we use one giant list to handle the following?

- multiple lists
- variables and other references
- strings
- code

discuss: how?

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	...
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	

Is this really all we have for state?

How can we use one giant list to handle the following?

- multiple lists
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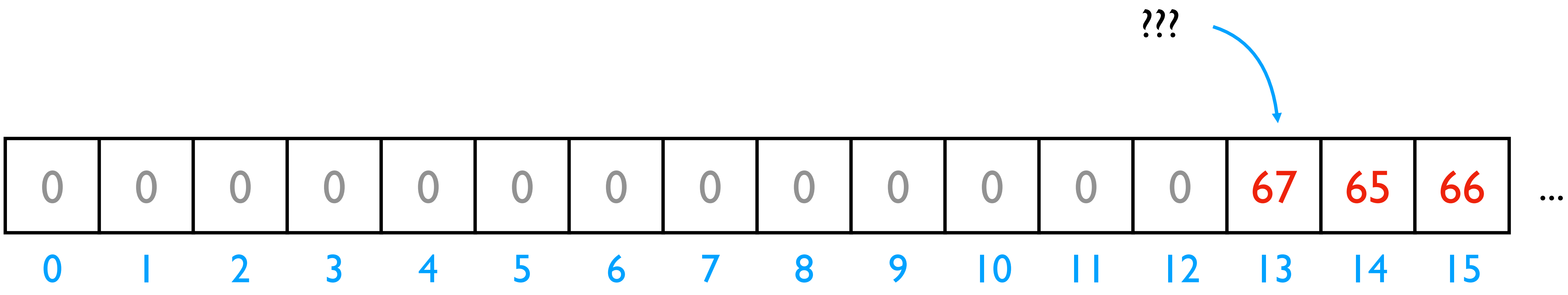
- code



0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
0	0	0	0	0	0	0	0	0	0	0	0	0	67	65	66	...

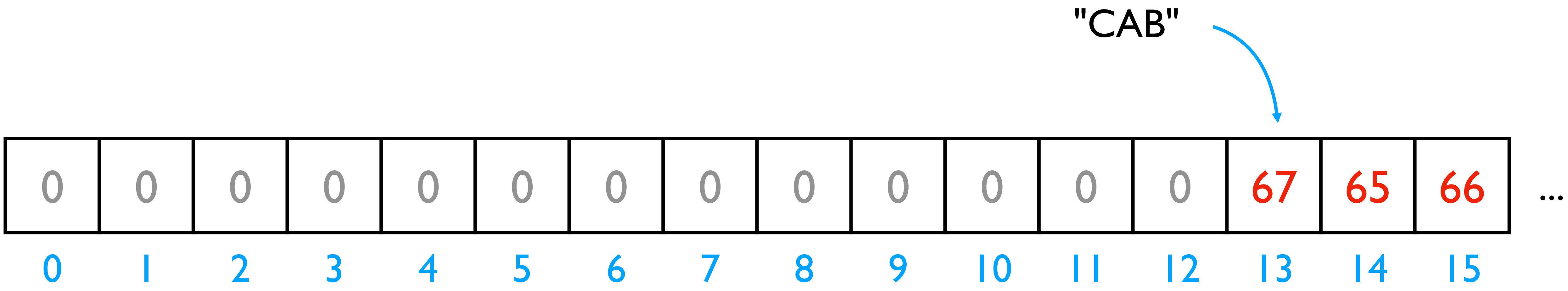
encoding:

code	letter
65	A
66	B
67	C
68	D
...	...

```
f = open("file.txt", encoding="utf-8")
```

How can we use one giant list to handle the following?

- multiple lists
- variables and other references
- strings
- code



"CAB"

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
0	0	0	0	0	0	0	0	0	0	0	0	0	67	65	66	...

encoding:

code	letter
65	A
66	B
67	C
68	D
...	...

```
f = open("file.txt", encoding="utf-8")
```

How can we use one giant list to handle the following?

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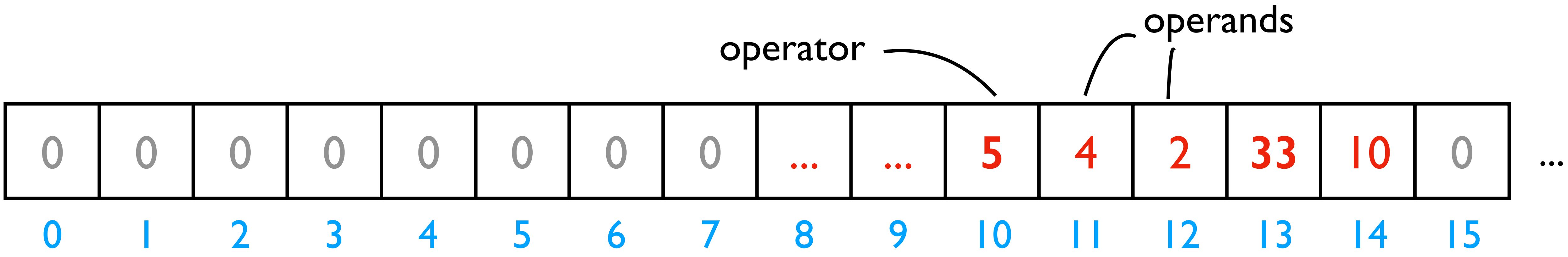
- strings
- code

```
i = 0
while ????:
   i += 2
   # what line next?
```



operator

operands

0	0	0	0	0	0	0	0	...	...	5	4	2	33	10	0	...
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	

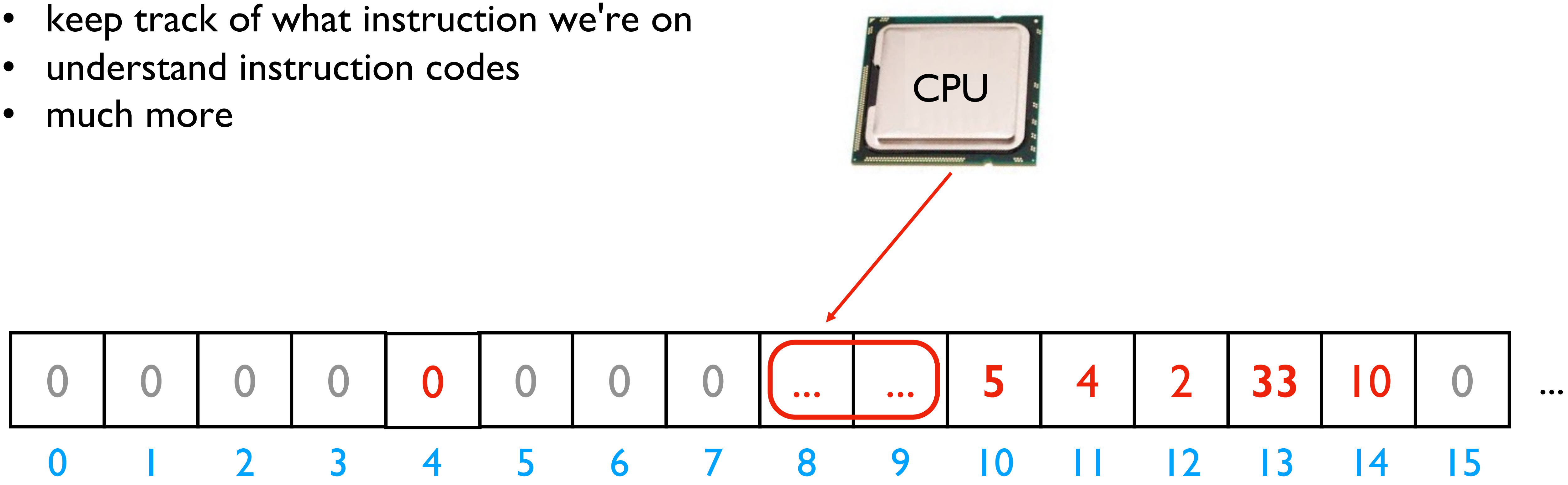
Instruction Set

code	operation
5	ADD
8	SUB
33	JUMP
...	...

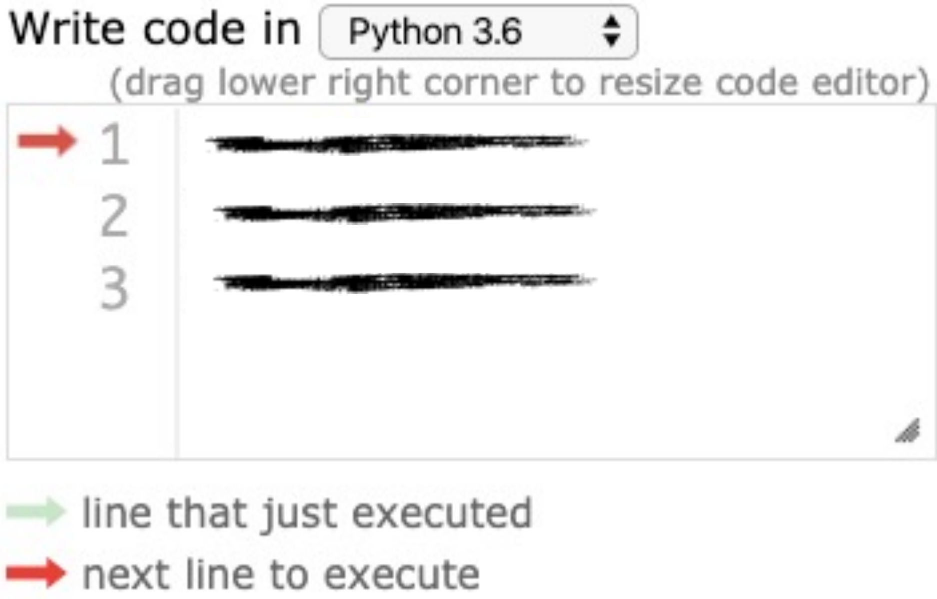
Hardware: Mental Model of CPU

CPUs interact with memory:

- keep track of what instruction we're on
- understand instruction codes
- much more



0	0	0	0	0	0	0	0	...	...	5	4	2	33	10	0	...
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	



Write code in Python 3.6

(drag lower right corner to resize code editor)

```
[redacted]
```

→ line that just executed

→ next line to execute

Instruction Set

code	operation
5	ADD
8	SUB
33	JUMP
...	...

Hardware: Mental Model of CPU

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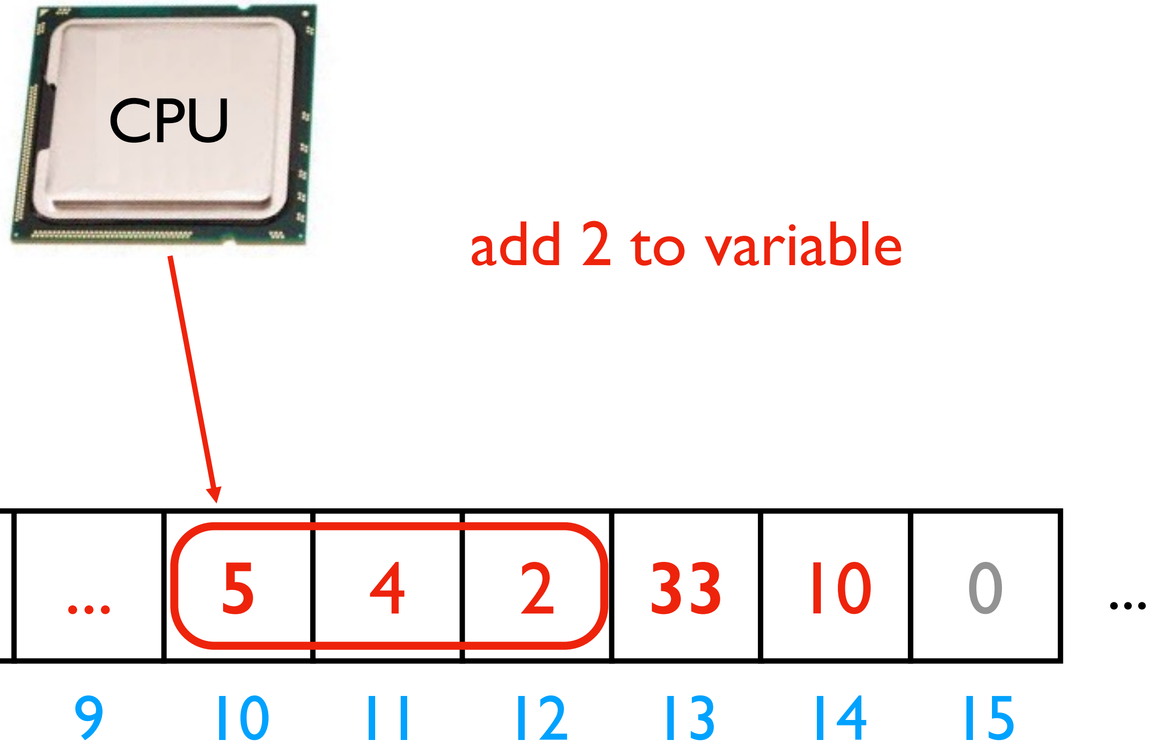

add 2 to variable

0	0	0	0	2	0	0	0	...	...	5	4	2	33	10	0	...
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	

Instruction Set

code	operation
5	ADD
8	SUB
33	JUMP
...	...

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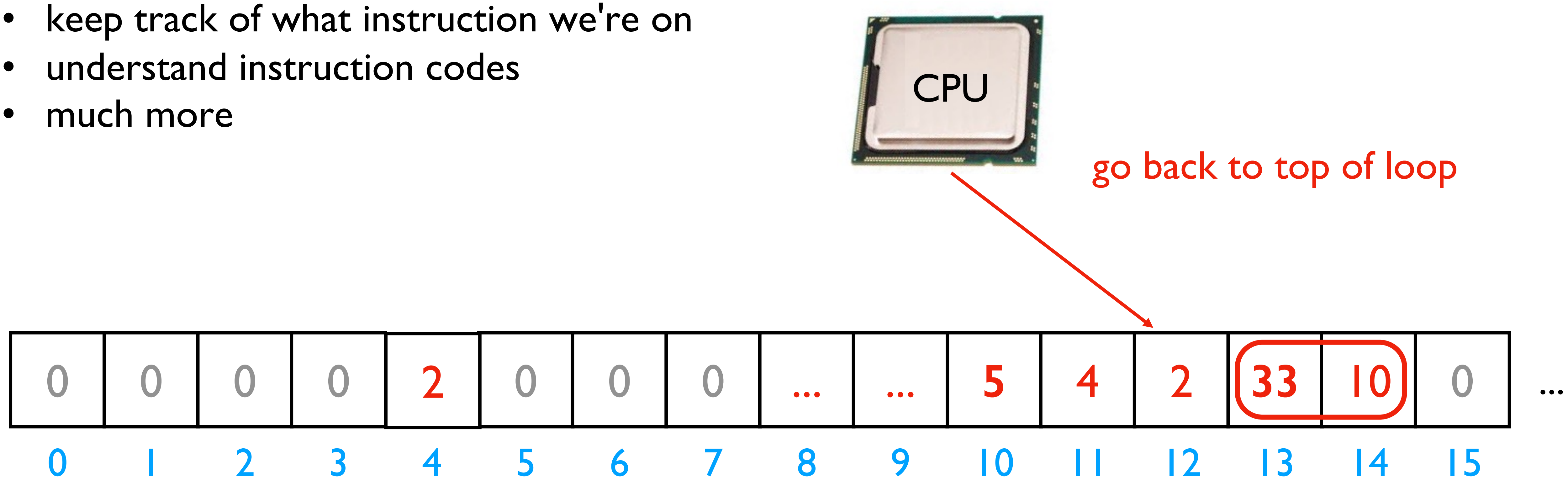

go back to top of loop

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
0	0	0	0	2	0	0	0	...	...	5	4	2	33	10	0	...

Instruction Set

code	operation
5	ADD
8	SUB
33	JUMP
...	...

Hardware: Mental Model of CPU

CPUs interact with memory:

- keep track of what instruction we're on
- understand instruction codes
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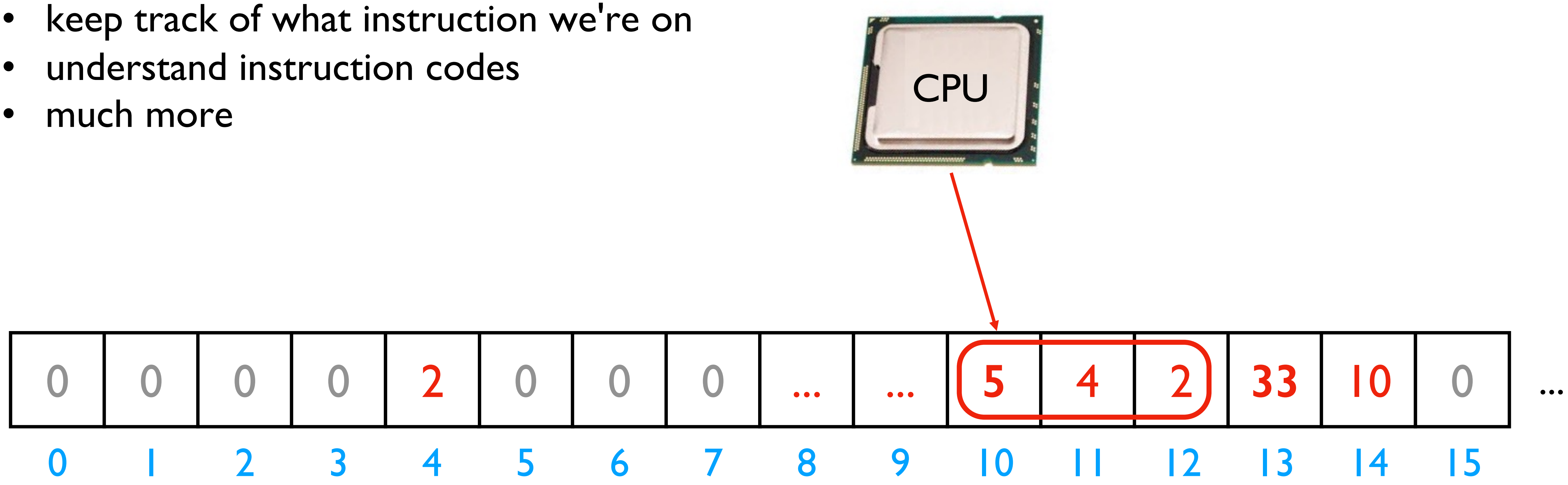


0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
0	0	0	0	2	0	0	0	...	...	5	4	2	33	10	0	...

Instruction Set

code	operation
5	ADD
8	SUB
33	JUMP
...	...

Hardware: Mental Model of CPU

discuss: what would happen if a CPU tried to execute an instruction for a different CPU?

0	0	0	0	0	0	0	0	...	...	5	4	2	33	10	0	...
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	

Instruction Set for CPU X

code	operation
5	ADD
8	SUB
33	JUMP
...	...

Instruction Set for CPU Y

code	operation
5	SUB
8	ADD
33	undefined
...	...

Hardware: Mental Model of CPU

a CPU can only run programs that
use instructions it understands!

0	0	0	0	0	0	0	0	...	...	5	4	2	33	10	0	...
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	

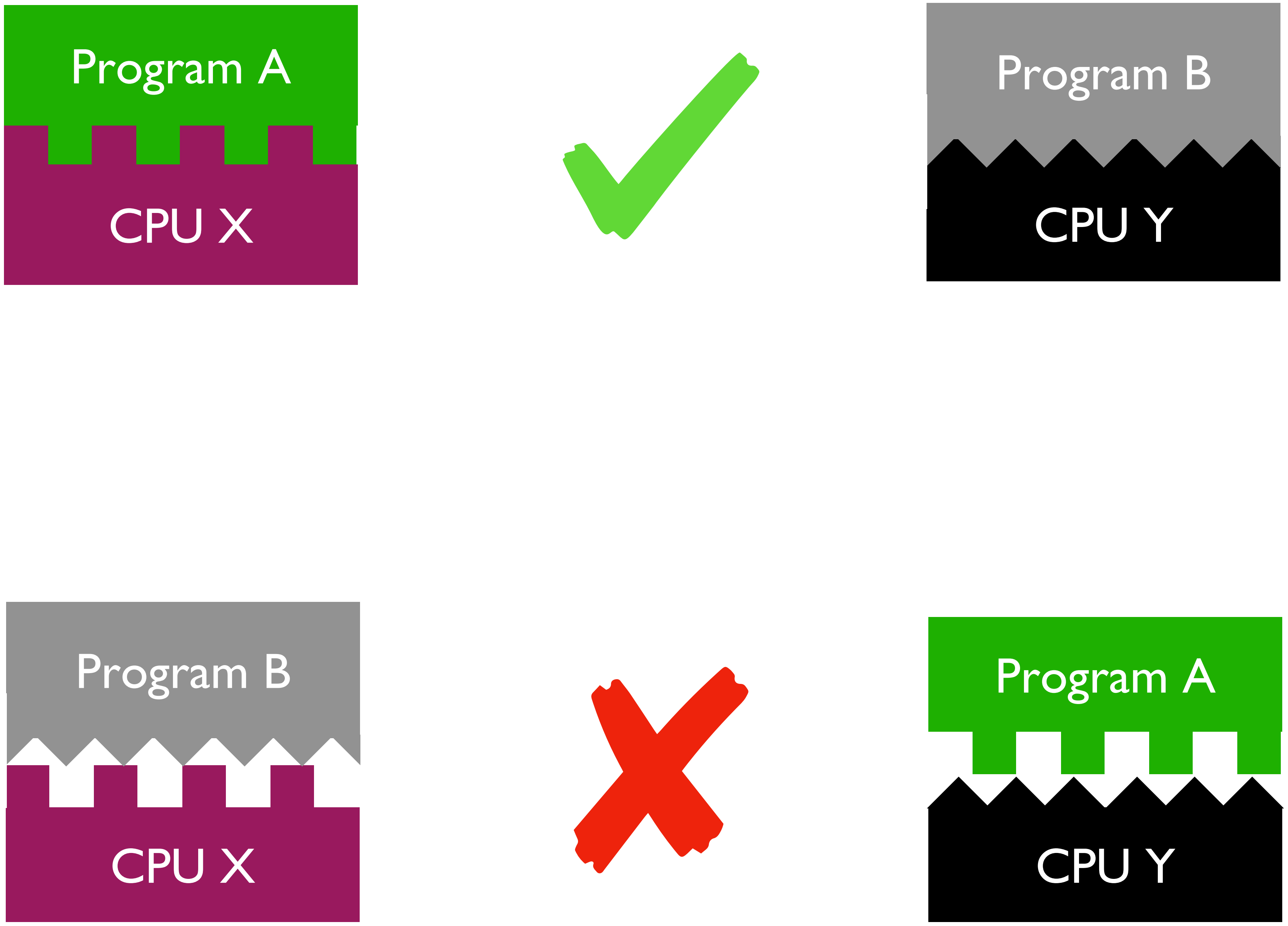
Instruction Set
for CPU X

code	operation
5	ADD
8	SUB
33	JUMP
...	...

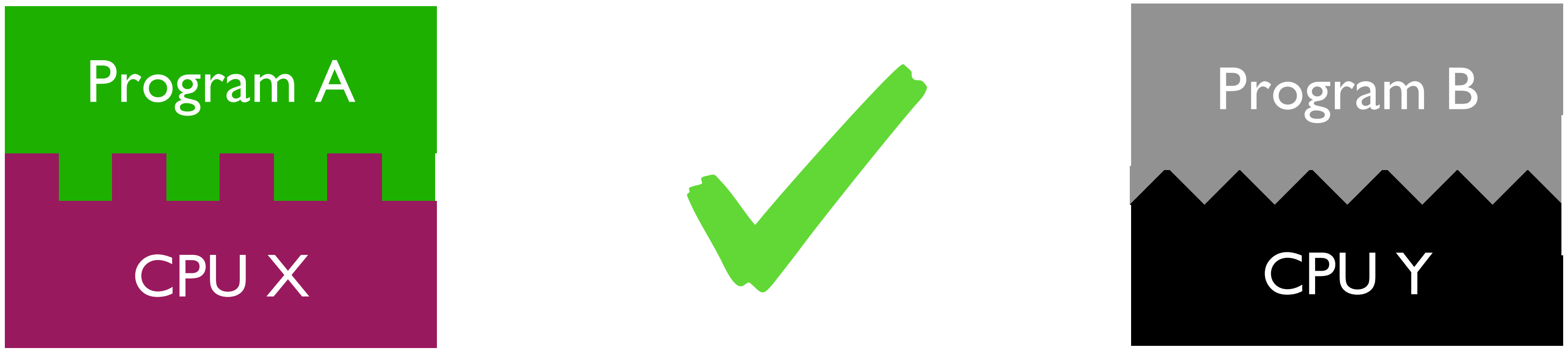
Instruction Set
for CPU Y

code	operation
5	SUB
8	ADD
33	undefined
...	...

A Program and CPU need to "fit"

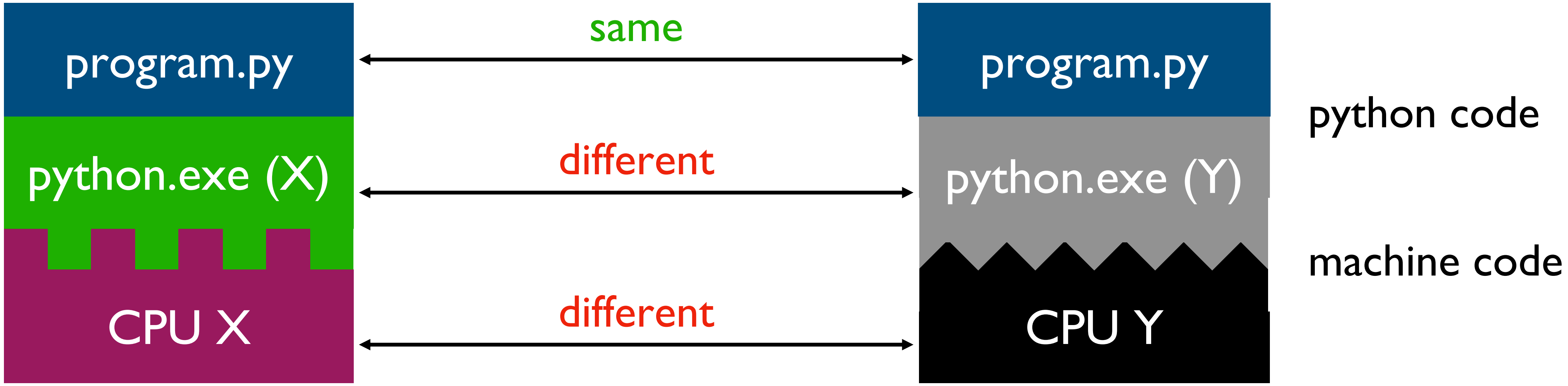


A Program and CPU need to "fit"



why haven't we noticed this yet
for our Python programs?

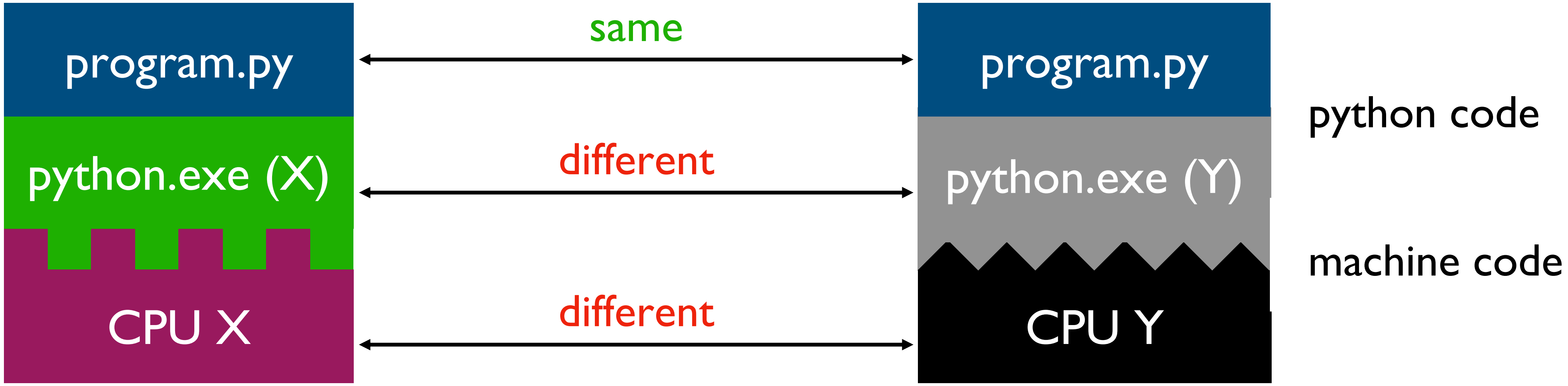
Interpreters



Interpreters (such as python.exe) make it easier to run the same code on different machines

A compiler is another tool for running the same code on different CPUs

Interpreters



Interpreters (such as python.exe) make it easier to run the same code on different machines

Discuss: *if all CPUs had the instruction set, would we still need a Python interpreter?*