Today: better/shorter code invariant, more string functions, unicode

Midterm Tuesday

See course page for timing, logistics, lots of practice problems. Finish Crypto program, first, take a day off, then worry about the exam. You might plan on spending, say, Sun evening practicing.

Topics on the exam: simple Bit (hw1), images/pixels/nested-loops (hw2), 2-d grids (hw3), strings, loops, simple lists (hw4)

Topics not on exam: bit decomposition problems, bluescreen algorithm, writing main(), file reading, int div //

CS Coding Exam

The bad news / good news of it

- High School; 90% = A
  That's not how Stanford Engineering works
  We will have a range of challenging problems
  We want to scare you a bit now, so you practice
  Compute a curve
- Closed note, closed computer
  Makes more normal looking problems
- Writing on paper
- Not grading on syntax, we award partial credit
- The exam topics are predictable
  Important code patterns .. these are in lecture and hw problems
  Exam is made of these same, familiar looking patterns
  Therefore: studying for this exam pays off
- Exam = 60 minutes
  Enough time to solve

Not enough time to learn it
Ideal: "Oh, I've solved something like this before"

- No HW5 going out until after the exam .. clearing out time for you to practice

How To Practice

- Get a problem
- Don't just look at the solution
- Get a blank sheet of paper
- Try to solve it like on the exam
- Then you can compare your solution to ours
- Repeat!

Practice Problems - Reps

- Exam practice problems - on course page
- Last year's exam
- Lecture problems
- Homework problems
- Section problems
- Also: practice mode on experimental server

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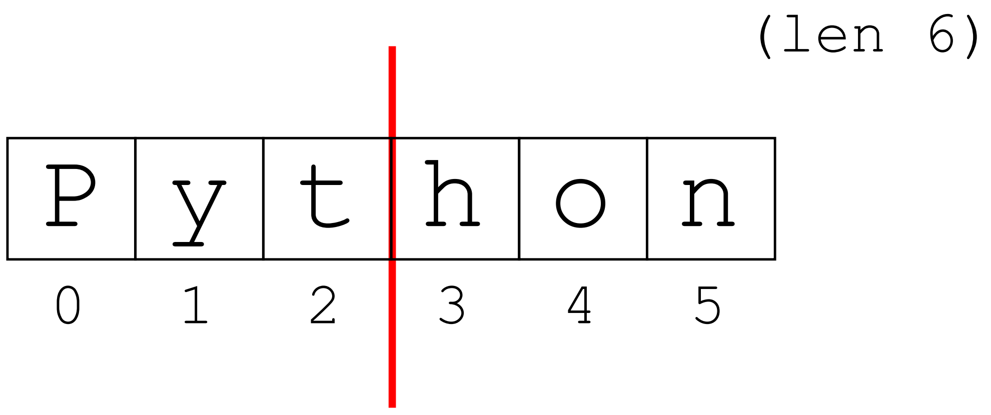
int div // - For Indexing

Midpoint of a String

Suppose I want to extract the right half of a string.

```
>>> s = 'Python'
```

The right half begins at index 3. The length is 6, so an obvious approach is to divide the length by 2. This actually does not work, and leads to a whole story.



Question: At what index does the right half begin?

Answer-maybe: `mid = len(s) / 2`

```
>>> s = 'Python'
>>> mid = len(s) / 3
>>> mid
3.0
>>> s[mid:]
TypeError: slice indices must be integers
...
>>>
```

What is going on here?

Recall: int vs. float

Recall: int and float, two separate types. Indexing, such as into a string or list, always uses ints. There is no char at `i = 3.2`. It's at 3 or it's at 4.

1. Division / always produces float, even with int inputs

```
>>> 7 / 2
3.5
>>> 8 / 2
4.0
```

2. Cannot use float for indexing or range()

```
>>> s = 'Python'
>>> s[6 / 2]
TypeError: string indices must be integers
>>> range(6 / 2)
TypeError: 'float' object cannot be
interpreted as an integer
```

Solution: int div `//`

Python has a separate "int division" operator `//`. It does division and discards any remainder, rounding the result down to the next integer.

```
>>> 7 // 2
3
>>> 8 // 2
4
>>> 59 // 10
5
>>> 60 // 10
6
>>> 100 // 25
4
```

```
>>> 102 // 25
4
```

Right Half of String

```
>>> s = 'Python'
>>> mid = len(s) // 2
>>> mid
3
>>>
>>> s[mid:]     # int + indexing
'hon'
>>>
```

Int-Div and Images

Suppose the width of an image is in a variable `width`, with a value like 100 or 125. What is the for-loop to generate the x values for the left half of the image?

```
# NO .. int/float issue
for x in range(width / 2):
    # use x in here



# YES
for x in range(width // 2):
    # use x in here

# e.g. width = 100: range is 0..49, since:
width // 2 -> 50
```

(optional) Example: right_left()

> right_left()

```
'aabb' -> 'bbbbaaaa'
```

right_left(s): We'll say the midpoint of a string is the len divided by 2, dividing the string into a left half before the midpoint and a right half starting at the midpoint. Given string s, return a new string made of 2 copies of right followed by 2 copies of left. So 'aabb' returns 'bbbbaaaa'.

String - More Functions

See guide for details: Strings

Thus far we have done String 1.0: len, index numbers, upper, lower, isalpha, isdigit, slices, .find().

There are more functions. You should at least have an idea that these exist, so you can look them up if needed. The important strategy is: don't write code manually to do something a built-in function in Python will do for you. The most important functions you should have memorized, and the more rare ones you can look up.

s.startswith() s.endswith()

These are very convenient True/False tests for the specific case of checking if a substring appears at the start or end of a string. Also a pretty nice example of function naming.

```
>>> 'Python'.startswith('Py')
True
>>> 'Python'.startswith('Px')
False
>>> 'resume.html'.endswith('.html')
True
```

String - replace()

- `str.replace(old, new)`
- Returns a new string with replacements done (immutable)
- Does not respect word boundaries, just dumb replacement
- Aside: Anti-Pattern
  Trying to compute something about s
  e.g. count the digits in s
  Do not use replace() to modify s as a shortcut to computing about s
  Not a good strategy

```
>>> s ='this is it'
>>> s.replace('is', 'xxx')  # returns
changed version
'thxxx xxx it'
>>>
>>> s.replace('is', '')
'th  it'
>>>
>>> s          # s not changed
'this is it'
```

Recall: s.foo() Does Not Change s

Recall how calling a string function does not change it. Need to **use** the return value...

```
# NO: Call without using result:
s.replace('is', 'xxx')
# s is the same as it was
# YES: this works
s = s.replace('is', 'xxx')
```

String - strip()

- Removes whitespace chars from either end
- Use inside `for line in f` to trim off `'\n'

```
>>> s = '    this and that\n'
>>> s.strip()
'this and that'
```

String - split()

- Nice feature to parse a line of text
  e.g. from a file line `11,45,19.2,N`
- `str.split()` -> array of strings
- `str.split(',')` - split on `','` substring
- `str.split()` - with zero parameters
  a special form of split()
  splits on 1 or more whitespace chars
  combines multiple whitespace chars
  handy primitive "word" from line feature

```
>>> s = '11,45,19.2,N'
>>> s.split(',')
['11', '45', '19.2', 'N']
>>> 'apple:banana:donut'.split(':')
['apple', 'banana', 'donut']
>>>
>>> 'this    is     it\n'.split()   #
```

```
special whitespace form
['this', 'is', 'it']
```

String - join()

- Reverse of split()
- Given list of strings, puts them together to make a big string
- Mnemonic: str.split() and str.join()
  The string is the noun in noun.verb form

```
>>> foods = ['apple', 'banana', 'donut']
>>> ':'.join(foods)
'apple:banana:donut'
```

String - + and str()

- You have a string and want to paste values into it
- Simple way: use +, call str() function

```
>>> name = 'Alice'
>>> score = 12
>>> 'Alice' + ' got score:' + str(score)
'Alice got score:12'
>>>
```

Format String - New

Put a lowercase 'f' to the left of the string literal. For each { } in the string, pastes values into string there - super handy!

```
>>> name = 'Alice'
>>>
>>> f'this is {name}'
'this is Alice'
>>>
>>> score = 12
>>> f'{name} got {score}'
Alice got 12
>>>
```

Optional: Limit Digits `{x:.4}`

Add ":.4" within the curly braces to limit decimal digits. There are many other format options.

```
>>> x = 2/3
>>> f'value: {x}'
'value: 0.6666666666666666'
>>> f'value: {x:.4}'
'value: 0.6667'
```

String Unicode

In the early days of computers, the ASCII character encoding was very common, encoding the roman a-z alphabet. ASCII is simple, and requires just 1 byte to store 1 character, but it has no ability to represent characters of other languages.

Each character in a Python string is a unicode character, so characters for all languages are supported. Also, many emoji have been added to unicode as a sort of character.

Every unicode character is defined by a unicode "code point" which is basically a big int value that uniquely identifies that character. Unicode characters can be written using the "hex" version of their code point, e.g. "03A3" is the "Sigma" char Σ, and "2665" is the heart emoji char ♥.

Hexadecimal aside: hexadecimal is a way of writing an int in base-16 using the digits 0-9 plus the letters A-F, like this: **7F9A** or **7f9a**. Two hex digits together like 9A or FF represent the value stored in one byte, so hex is a traditional easy way to write out the value of a byte. When you look up an emoji on the web, typically you will see the code point written out in hex, like 1F644, the eye-roll emoji 🙄.

You can write a unicode char out in a Python string with a `\u` followed by the 4 hex digits of its code point. Notice how each unicode char is just one more character in the string:

```
>>> s = 'hi \u03A3'
>>> s
'hi Σ'
>>> len(s)
4
>>> s[0]
'h'
>>> s[3]
'Σ'
>>>
>>> s = '\u03A9'   # upper case omega
>>> s
'Ω'
>>> s.lower()      # compute lowercase
'ω'
>>> s.isalpha()    # isalpha() knows about unicode
True
>>>
>>> 'I \u2665'
'I ♥'
```

For a code point with more than 4-hex-digits, use `\U` (uppercase U) followed by 8 digits with leading 0's as needed, like the fire emoji 1F525, and the inevitable 1F4A9.

```
>>> 'the place is on \U0001F525'
'the place is on 🔥'
>>> s = 'oh \U0001F4A9'
>>> len(s)
4
```

Ethics of Generosity and Unicode

Generosity is Good

- Your life goal is not to consume everything just for yourself
- Part of your life is contributing to others
  Most closely, your family
  But the circle of people to contribute to extends outwards
  Including people around the world you don't know
- You do not need to live a vow of poverty
  But there should be generosity to others in your life
- Happiness research:
  Being generous is a source of personal happiness

History of Unicode and Python

The history of ASCII and Unicode is an example of ethics.

ASCII

In the early days of computing in the US, computers were designed with the ASCII character set, supporting only the roman a-z alphabet. This hurt the rest of the planet, which mostly doesn't write in English. There is a well known pattern where technology comes first in the developed world, is scaled up and becomes inexpensive, and then proliferates to the developing world. Computers in the US using ASCII hurt that technology pipeline. Choosing a US-only solution was the cheapest choice for the US in the moment, but made the technology hard to access for most of the world. This choice is somewhere between ungenerous and unethical.

Unicode Technology

Unicode takes 2-4 bytes per char, so it is more costly than ASCII. Cost per byte aside, Unicode is a good solution - a freely available standard. If a system uses Unicode, it and its data can interoperate with the other Unicode compliant systems.

Unicode vs. RAM Costs vs. Moore's Law

The cost of supporting non-ASCII data can be related to the cost of the RAM to store the unicode characters. In the 1950's every byte was literally expensive. An IBM model 360 could be leased for $5,000 per month, non inflation adjusted, and had about 32 kilobytes of RAM (not megabytes or gigabytes .. kilobytes!). So doing very approximate math, figuring RAM is half the cost of the computer, we get a cost of about $1 per byte per year.

```
>>> 5000 * 12 / (2 * 32000)
0.9375
```

So in 1950, Unicode is a non-starter. RAM is expensive.

RAM Costs Today

What does the RAM in your phone cost today? Say your phone costs $500 and has 8GB of RAM (conservative). Say the RAM is all the cost and the rest of the phone is free. What is the cost per byte?

The figure 8 GB is 8 billion bytes. In Python, you can write that as `8e9` - like on your scientific calculator.

```
>>> 500 / 8e9   # 8 GB
6.25e-08
>>>
>>> 500 / 8e9 * 100  # in pennies
6.2499999999999995e-06
```

RAM costs nothing today - 6 millionths of a cent per byte. This is the result of Moore's law. Exponential growth is incredible.

Unicode Makes Sense in 1990s

Sometime in the 1990s, RAM was cheap enough that spending 2-4 bytes per char was not so bad, and around then is when Unicode was created. Unicode is a standard way of encoding chars in bytes, so that all the Unicode systems can transparently exchange data with each other.

With Unicode, the tech leaders were showing a little generosity to all the non-ASCII computer users out there in the world.

Generosity and Python Story

- Python created by Guido van Rossum
- From the Netherlands
- Where they speak Dutch
- What language encoding was used for Python?
- Unicode, of course
- Therefore, Python works with data in Palo Alto, Tokyo, Stockholm .. everywhere

With Unicode, there is just one Python that works in every country. A world of programmers contribute to Python as free, open source software. We **all** benefit from that community, vs. each country maintaining their own in-country programming language, which would be a crazy waste of duplicated effort.

Ethic: Generosity

So being generous is the right thing to do. But the story also shows, that when you are generous to the world, that generosity may well come around and help you as well.