Announcements

- Guerrilla Section 2 is on Monday 2/16
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  ▸ RSVP on Piazza if you want to come!
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• Homework 3 due Thursday 2/19 @ 11:59pm (extended)
Announcements

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  ▪ RSVP on Piazza if you want to come!

• Homework 3 due Thursday 2/19 @ 11:59pm (extended)
  ▪ Homework Party on Tuesday 2/17 5pm–6:30pm in 2050 VLSB
Announcements

• Guerrilla Section 2 is on Monday 2/16
  ▪ RSVP on Piazza if you want to come!

• Homework 3 due Thursday 2/19 @ 11:59pm (extended)
  ▪ Homework Party on Tuesday 2/17 5pm–6:30pm in 2050 VLSB

• Optional Hog Contest due Wednesday 2/18 @ 11:59pm
Sequences
The Sequence Abstraction
The Sequence Abstraction

red, orange, yellow, green, blue, indigo, violet.
The Sequence Abstraction

red, orange, yellow, green, blue, indigo, violet.

There isn't just one sequence class or data abstraction (in Python or in general).
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The sequence abstraction is a collection of behaviors:
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The sequence abstraction is a collection of behaviors:

- **Length.** A sequence has a finite length.
- **Element selection.** A sequence has an element corresponding to any non-negative integer index less than its length, starting at 0.
The Sequence Abstraction

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0, 1, 2, 3, 4, 5, 6.

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There is built-in syntax associated with this behavior, or we can use functions.
The Sequence Abstraction

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- **Length.** A sequence has a finite length.

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There is built-in syntax associated with this behavior, or we can use functions.

A list is a kind of built-in sequence.
Lists

['Demo']
Lists are Sequences
Lists are Sequences

```python
>>> digits = [1, 8, 2, 8]
```
Lists are Sequences

```python
>>> digits = [1, 8, 2, 8]
>>> len(digits)
4
```
Lists are Sequences

```python
>>> digits = [1, 8, 2, 8]
>>> len(digits)
4
>>> digits[3]
8
```
Lists are Sequences

>>> digits = [1, 8, 2, 8]
>>> len(digits)
4
>>> digits[3]
8

**Length.** A sequence has a finite length.

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Lists are Sequences

```python
>>> digits = [1, 8, 2, 8]
>>> len(digits)
4
>>> digits[3]
8
```

**Length.** A sequence has a finite length.

**Element selection.** A sequence has an element corresponding to any non-negative integer index less than its length, starting at 0.

```python
>>> [2, 7] + digits * 2
[2, 7, 1, 8, 2, 8, 1, 8, 2, 8]
```
Lists are Sequences

```python
>>> digits = [1, 8, 2, 8]
>>> len(digits)
4
>>> digits[3]
8
```

**Length.** A sequence has a finite length.

**Element selection.** A sequence has an element corresponding to any non-negative integer index less than its length, starting at 0.

```python
>>> [2, 7] + digits * 2
[2, 7, 1, 8, 2, 8, 1, 8, 2, 8]

>>> pairs = [[10, 20], [30, 40]]
```
Lists are Sequences

>>> digits = [1, 8, 2, 8]
>>> len(digits)
4
>>> digits[3]
8

**Length.** A sequence has a finite length.

**Element selection.** A sequence has an element corresponding to any non-negative integer index less than its length, starting at 0.

>>> [2, 7] + digits * 2
[2, 7, 1, 8, 2, 8, 1, 8, 2, 8]

>>> pairs = [[10, 20], [30, 40]]
>>> pairs[1]
[30, 40]
Lists are Sequences

>>> digits = [1, 8, 2, 8]
>>> len(digits)
4
>>> digits[3]
8

Length. A sequence has a finite length.

Element selection. A sequence has an element corresponding to any non-negative integer index less than its length, starting at 0.

>>> [2, 7] + digits * 2
[2, 7, 1, 8, 2, 8, 1, 8, 2, 8]

>>> pairs = [[10, 20], [30, 40]]
>>> pairs[1]
[30, 40]
>>> pairs[1][0]
30
For Statements

(Demo)
Sequence Iteration
def count(s, value):
    total = 0
    for element in s:
        if element == value:
            total = total + 1
    return total
def count(s, value):
    total = 0
    for element in s:
        if element == value:
            total += 1
    return total
For Statement Execution Procedure
For Statement Execution Procedure

for <name> in <expression>:
    <suite>
For Statement Execution Procedure

```python
for <name> in <expression>:
    <suite>
```

1. Evaluate the header `<expression>`, which must yield an iterable value (a sequence)
For Statement Execution Procedure

for <name> in <expression>:
    <suite>

1. Evaluate the header <expression>, which must yield an iterable value (a sequence)

2. For each element in that sequence, in order:
For Statement Execution Procedure

```python
for <name> in <expression>:
    <suite>
```

1. Evaluate the header `<expression>`, which must yield an iterable value (a sequence)

2. For each element in that sequence, in order:
   
   A. Bind `<name>` to that element in the current frame
For Statement Execution Procedure

for <name> in <expression>:
    <suite>

1. Evaluate the header <expression>, which must yield an iterable value (a sequence)

2. For each element in that sequence, in order:
   A. Bind <name> to that element in the current frame
   B. Execute the <suite>
Sequence Unpacking in For Statements
Sequence Unpacking in For Statements

```python
>>> pairs = [[1, 2], [2, 2], [3, 2], [4, 4]]

>>> same_count = 0
```
Sequence Unpacking in For Statements

A sequence of fixed-length sequences

```python
>>> pairs = [[1, 2], [2, 2], [3, 2], [4, 4]]

>>> same_count = 0
```
Sequence Unpacking in For Statements

A sequence of fixed-length sequences

```python
>>> pairs = [[1, 2], [2, 2], [3, 2], [4, 4]]
>>> same_count = 0

>>> for x, y in pairs:
...    if x == y:
...        same_count = same_count + 1

>>> same_count
2
```
Sequence Unpacking in For Statements

>>> pairs = [[1, 2], [2, 2], [3, 2], [4, 4]]

>>> same_count = 0

>>> for x, y in pairs:
...    if x == y:
...        same_count = same_count + 1

>>> same_count
2
Sequence Unpacking in For Statements

A sequence of fixed-length sequences

```python
>>> pairs = [[1, 2], [2, 2], [3, 2], [4, 4]]
>>> same_count = 0
```

A name for each element in a fixed-length sequence

Each name is bound to a value, as in multiple assignment

```python
>>> for x, y in pairs:
...     if x == y:
...         same_count = same_count + 1

>>> same_count
2
```
Ranges
The Range Type

A range is a sequence of consecutive integers.*
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* Ranges can actually represent more general integer sequences.
The Range Type

A range is a sequence of consecutive integers.*

..., −5, −4, −3, −2, −1, 0, 1, 2, 3, 4, 5, ...

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The Range Type

A range is a sequence of consecutive integers.*

\[\ldots, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, \ldots\]

\texttt{range}(-2, 2)

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..., −5, −4, −3, −2, −1, 0, 1, 2, 3, 4, 5, ...

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The Range Type

A range is a sequence of consecutive integers.*

\[ ...,-5,-4,-3,-2,-1,0,1,2,3,4,5,... \]

\[ \text{range}(-2,2) \]

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..., -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, ...

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Length: ending value - starting value
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..., -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, ...

Length: ending value - starting value

Element selection: starting value + index

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... -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, ...

Length: ending value - starting value

Element selection: starting value + index

```python
>>> list(range(-2, 2))
[-2, -1, 0, 1]
```

```python
>>> list(range(4))
[0, 1, 2, 3]
```

*Ranges can actually represent more general integer sequences.*
The Range Type

A range is a sequence of consecutive integers.*

\[ \ldots, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, \ldots \]

Length: ending value - starting value

Element selection: starting value + index

\[
>>> \text{list(range(-2, 2))} \rightarrow \text{List constructor}
\]

\[
\{ [-2, -1, 0, 1] \}
\]

\[
>>> \text{list(range(4))} \rightarrow \text{List constructor}
\]

\[
\{ [0, 1, 2, 3] \}
\]

* Ranges can actually represent more general integer sequences.
The Range Type

A range is a sequence of consecutive integers.*

\[ ..., -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, ... \]

Length: ending value − starting value

Element selection: starting value + index

\[
\text{>>=} \text{ list(range(-2, 2))} \\
[-2, -1, 0, 1]
\]

\[
\text{>>=} \text{ list(range(4))} \\
[0, 1, 2, 3]
\]

* Ranges can actually represent more general integer sequences.
The Range Type

A range is a sequence of consecutive integers.*

\[ \ldots, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, \ldots \]

Length: ending value \(-\) starting value

Element selection: starting value + index

```python
>>> list(range(-2, 2))
[-2, -1, 0, 1]
```

```python
>>> list(range(4))
[0, 1, 2, 3]
```

*Ranges can actually represent more general integer sequences.*
List Comprehensions
List Comprehensions

```python
>>> letters = ['a', 'b', 'c', 'd', 'e', 'f', 'm', 'n', 'o', 'p']
>>> [letters[i] for i in [3, 4, 6, 8]]
```
List Comprehensions

```python
>>> letters = ['a', 'b', 'c', 'd', 'e', 'f', 'm', 'n', 'o', 'p']
>>> [letters[i] for i in [3, 4, 6, 8]]
['d', 'e', 'm', 'o']
```
List Comprehensions
List Comprehensions

\[
[\text{\textit{map exp}} \ for \ \textit{name} \ in \ \textit{iter exp} \ if \ \textit{filter exp}]
\]
List Comprehensions

\[
[\text{map exp} \ for \ \text{name} \ in \ \text{iter exp} \ if \ \text{filter exp}]
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Short version: \[
[\text{map exp} \ for \ \text{name} \ in \ \text{iter exp}]
\]
List Comprehensions

[<map exp> for <name> in <iter exp> if <filter exp>]

Short version: [<map exp> for <name> in <iter exp>]

A combined expression that evaluates to a list using this evaluation procedure:
List Comprehensions

\[
[\text{map exp} \ for \ <\text{name}> \ in \ <\text{iter exp}> \ if \ <\text{filter exp}>]
\]

Short version: \[<\text{map exp} \ for \ <\text{name}> \ in \ <\text{iter exp}>]\n
A combined expression that evaluates to a list using this evaluation procedure:
1. Add a new frame with the current frame as its parent
List Comprehensions

[<map exp> for <name> in <iter exp> if <filter exp>]

Short version: [<map exp> for <name> in <iter exp>]

A combined expression that evaluates to a list using this evaluation procedure:

1. Add a new frame with the current frame as its parent
2. Create an empty result list that is the value of the expression
List Comprehensions

\[\langle\text{map exp}\rangle \text{ for } \langle\text{name}\rangle \text{ in } \langle\text{iter exp}\rangle \text{ if } \langle\text{filter exp}\rangle\]

Short version: \[\langle\text{map exp}\rangle \text{ for } \langle\text{name}\rangle \text{ in } \langle\text{iter exp}\rangle\]

A combined expression that evaluates to a list using this evaluation procedure:

1. Add a new frame with the current frame as its parent
2. Create an empty result list that is the value of the expression
3. For each element in the iterable value of \langle\text{iter exp}\rangle:
List Comprehensions

\[
\{\text{map exp} \ for \ <name> \ in \ <iter \ exp> \ if \ <filter \ exp>\}
\]

Short version: \[
\{\text{map exp} \ for \ <name> \ in \ <iter \ exp>\}
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A combined expression that evaluates to a list using this evaluation procedure:

1. Add a new frame with the current frame as its parent
2. Create an empty result list that is the value of the expression
3. For each element in the iterable value of \(<iter \ exp>\):
   A. Bind \(<name>\) to that element in the new frame from step 1
List Comprehensions

\[
[\text{map exp} \ for \ <name> \ in \ <iter \ exp> \ if \ <filter \ exp>]
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Short version: \[
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A combined expression that evaluates to a list using this evaluation procedure:

1. Add a new frame with the current frame as its parent
2. Create an empty result list that is the value of the expression
3. For each element in the iterable value of \(<iter \ exp>\):
   A. Bind \(<name>\) to that element in the new frame from step 1
   B. If \(<filter \ exp>\) evaluates to a true value, then add the value of \(<map \ exp>\) to the result list
Strings
Strings are an Abstraction
Strings are an Abstraction

Representing data:

'200'   '1.2e-5'   'False'   '(1, 2)'
Strings are an Abstraction

**Representing data:**

'200'  '1.2e-5'  'False'  '(1, 2)'

**Representing language:**

"""And, as imagination bodies forth
The forms of things to unknown, and the poet's pen
Turns them to shapes, and gives to airy nothing
A local habitation and a name."""
**Strings are an Abstraction**

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**Representing programs:**

'curry = lambda f: lambda x: lambda y: f(x, y)'
Strings are an Abstraction

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Representing programs:

'curry = lambda f: lambda x: lambda y: f(x, y)'

(Demo)
String Literals Have Three Forms

```python
>>> 'I am string!'
'I am string!'

>>> "I've got an apostrophe"
"I've got an apostrophe"

>>> '您好'
'您好'
```
String Literals Have Three Forms

>>> 'I am string!'
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"I've got an apostrophe"

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'您好'

Single-quoted and double-quoted strings are equivalent
String Literals Have Three Forms

>>> 'I am string!'  
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>>> "I've got an apostrophe"  
"I've got an apostrophe"

>>> '您好'  
'您好'

>>> """The Zen of Python  
claims, Readability counts.  
Read more: import this."""  
'The Zen of Python\nclaims, Readability counts.\nRead more: import this.'
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```

- Single-quoted and double-quoted strings are equivalent.
- A backslash "escapes" the following character.
String Literals Have Three Forms

>>> 'I am string!'
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"I've got an apostrophe"

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'The Zen of Python
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Single-quoted and double-quoted strings are equivalent

A backslash "escapes" the following character

"Line feed" character represents a new line
Strings are Sequences
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Length and element selection are similar to all sequences
Strings are Sequences

Length and element selection are similar to all sequences

```python
>>> city = 'Berkeley'
>>> len(city)
8
>>> city[3]
'k'
```
Strings are Sequences

Length and element selection are similar to all sequences

```python
>>> city = 'Berkeley'
>>> len(city)
8
>>> city[3]
'k'
```

Careful: An element of a string is itself a string, but with only one element!
Strings are Sequences

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>>> city = 'Berkeley'
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However, the "in" and "not in" operators match substrings

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8
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'k'
```

Careful: An element of a string is itself a string, but with only one element!

However, the "in" and "not in" operators match substrings

```python
>>> 'here' in "Where's Waldo?"
True
>>> 234 in [1, 2, 3, 4, 5]
False
>>> [2, 3, 4] in [1, 2, 3, 4, 5]
False
```
Strings are Sequences

Length and element selection are similar to all sequences

```python
>>> city = 'Berkeley'
>>> len(city)
8
>>> city[3]
'k'
```

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>>> 'here' in "Where's Waldo?"
True
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False
>>> [2, 3, 4] in [1, 2, 3, 4, 5]
False
```

When working with strings, we usually care about whole words more than letters
Dictionaries

{"Dem": 0}
Limitations on Dictionaries
Limitations on Dictionaries

Dictionaries are *unordered* collections of key-value pairs
Limitations on Dictionaries

Dictionaries are unordered collections of key-value pairs

Dictionary keys do have two restrictions:
Limitations on Dictionaries

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- A key of a dictionary cannot be a list or a dictionary (or any mutable type)
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- Two keys cannot be equal; There can be at most one value for a given key
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This first restriction is tied to Python's underlying implementation of dictionaries
Limitations on Dictionaries

Dictionaries are unordered collections of key-value pairs.

Dictionary keys do have two restrictions:

- A key of a dictionary cannot be a list or a dictionary (or any mutable type).
- Two keys cannot be equal; There can be at most one value for a given key.

This first restriction is tied to Python's underlying implementation of dictionaries.

The second restriction is part of the dictionary abstraction.
Limitations on Dictionaries

Dictionaries are *unordered* collections of key–value pairs

Dictionary keys do have two restrictions:

- A key of a dictionary *cannot be* a list or a dictionary (or any *mutable type*)

- Two *keys cannot be equal*; There can be at most one value for a given key

This first restriction is tied to Python's underlying implementation of dictionaries

The second restriction is part of the dictionary abstraction

If you want to associate multiple values with a key, store them all in a sequence value