

Objects

(Demo)

Objects

- Objects represent information
- They consist of data and behavior, bundled together to create abstractions
- Objects can represent things, but also properties, interactions, & processes
- A type of object is called a class; **classes** are first-class values in Python
- Object-oriented programming:
 - A metaphor for organizing large programs
 - Special syntax that can improve the composition of programs
- In Python, every value is an object
 - All **objects** have **attributes**
 - A lot of data manipulation happens through object **methods**
 - Functions do one thing; objects do many related things

Example: Strings

(Demo)

Representing Strings: the ASCII Standard

American Standard Code for Information Interchange

| | | ASCII Code Chart | | | | | | | | | | | | | | | |
|----------------|---|------------------|-----|-----|-----|-----|-----|-----|-----|------------------|----|-----|-----|----|----|----|-----|
| | | "Bell" (\a) | | | | | | | | "Line feed" (\n) | | | | | | | |
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
| 8 rows: 8 bits | 0 | NUL | SOH | STX | ETX | EOT | ENO | ACK | BEL | BS | HT | LF | VT | FF | CR | SO | SI |
| | 1 | DLE | DC1 | DC2 | DC3 | DC4 | NAK | SYN | ETB | CAN | EM | SUB | ESC | FS | GS | RS | US |
| | 2 | ! | " | # | \$ | % | & | ' | (|) | * | + | , | - | . | / | |
| | 3 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | : | < | = | > | | |
| | 4 | @ | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
| | 5 | P | Q | R | S | T | U | V | W | X | Y | Z | [| \ |] | ^ | _ |
| | 6 | - | a | b | c | d | e | f | g | h | i | j | k | l | m | n | o |
| | 7 | p | q | r | s | t | u | v | w | x | y | z | { | | } | - | DEL |

16 columns: 4 bits

- Layout was chosen to support sorting by character code
 - Rows indexed 2-5 are a useful 6-bit (64 element) subset
 - Control characters were designed for transmission
- (Demo)

Representing Strings: the Unicode Standard

- 109,000 characters
- 93 scripts (organized)
- Enumeration of character properties, such as case
- Supports bidirectional display order
- A canonical name for every character

聃 聃 聃 聃 聃 聃 聃 聃
 聃 聃 聃 聃 聃 聃 聃 聃
 聃 聃 聃 聃 聃 聃 聃 聃
 聃 聃 聃 聃 聃 聃 聃 聃
 聃 聃 聃 聃 聃 聃 聃 聃

Mutation Operations

- U+0058 LATIN CAPITAL LETTER X
- U+263a WHITE SMILING FACE
- U+2639 WHITE FROWNING FACE



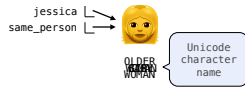
(Demo)

Some Objects Can Change

[Demo]

First example in the course of an object changing state

The same object can change in value throughout the course of computation



All names that refer to the same object are affected by a mutation

Only objects of *mutable* types can change: Lists & dictionaries

{Demo}

Tuples

(Demo)

Mutation Can Happen Within a Function Call

A function can change the value of any object in its scope

```
>>> four = [1, 2, 3, 4]
>>> len(four)
4
>>> mystery(four)
>>> len(four)
2
```

```
def mystery(s):
    s.pop()
    s.pop()
    s[2] = []
```

```
>>> four = [1, 2, 3, 4]
>>> len(four)
4
>>> another_mystery() # No arguments!
>>> len(four)
2
```

```
def another_mystery():
    four.pop()
    four.pop()
```

Interactive Diagram

Tuples are Immutable Sequences

Immutable values are protected from mutation

```
>>> turtle = (1, 2, 3)
>>> ooze()
>>> turtle
(1, 2, 3)
```

```
>>> turtle = [1, 2, 3]
>>> ooze()
>>> turtle
['Anything could be inside!']
```

Next lecture: ooze can change turtle's binding

The value of an expression can change because of changes in names or objects

```
>>> x = 2
>>> x + x
4
>>> x = 3
>>> x + x
6
```

```
>>> x = [1, 2]
>>> x + x
[1, 2, 1, 2]
>>> x.append(3)
>>> x + x
[1, 2, 3, 1, 2, 3]
```

Name change: **Object mutation:**

An immutable sequence may still change if it contains a mutable value as an element

```
>>> s = ([1, 2], 3)
>>> s[0] = 4
ERROR
```

```
>>> s = ([1, 2], 3)
>>> s[0][0] = 4
>>> s
([4, 2], 3)
```

Sameness and Change

- As long as we never modify objects, a compound object is just the totality of its pieces
- A rational number is just its numerator and denominator
- This view is no longer valid in the presence of change
- A compound data object has an "identity" in addition to the pieces of which it is composed
- A list is still "the same" list even if we change its contents
- Conversely, we could have two lists that happen to have the same contents, but are different

```
>>> a = [10]
>>> b = a
>>> a == b
True
>>> a.append(20)
>>> a == b
True
>>> a
[10, 20]
>>> b
[10, 20]
```

```
>>> a = [10]
>>> b = [10]
>>> a == b
True
>>> b.append(20)
>>> a
[10]
>>> b
[10, 20]
>>> a == b
False
```

Mutation

Identity Operators

Identity

`<exp0> is <exp1>`

evaluates to **True** if both `<exp0>` and `<exp1>` evaluate to the same object

Equality

`<exp0> == <exp1>`

evaluates to **True** if both `<exp0>` and `<exp1>` evaluate to equal values

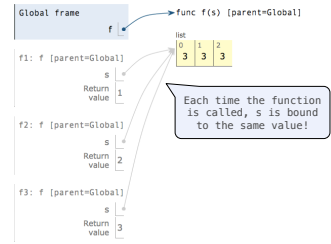
Identical objects are always equal values

(Demo)

Mutable Default Arguments are Dangerous

A default argument value is part of a function value, not generated by a call

```
>>> def f(s=[]):
...     s.append(3)
...     return len(s)
>>> f()
1
>>> f()
2
>>> f()
3
```



Interactive Diagram