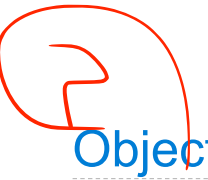
Mutability

Announcements

Objects

(Demo)



Objects

```
from datetime import date
today = date(2023, 2, 24)
today.strftime('%A %b %d')
>> 'Friday Feb 24'
today.year
>> 2023
today.month
>> 2
freedom = date(2023, 5, 9)
print(freedom - today)
>> 74 days, 0:00:00
```

- 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

a = type(1)
a
>> <class ‘int’>
‘hello’
>> ‘hello’

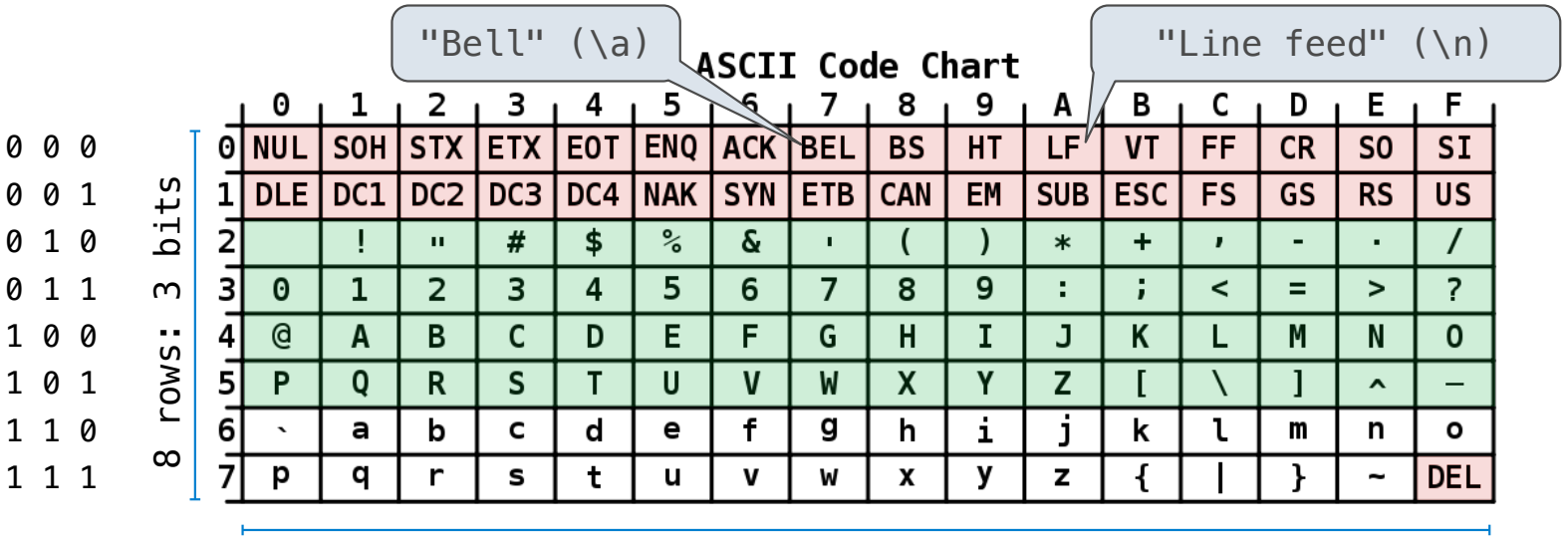
Example: Strings

(Demo)

before oop,
just list of numbers

Representing Strings: the ASCII Standard

American Standard Code for Information Interchange



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

- 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)

lookpup('EIGHTH NOTE')
>>'(음표모양)'
lookup('SNOWMAN')
>> '(

string is not a list of primitive anymore
abstraction. you can build

Representing Strings: the Unicode Standard

- 137,994 characters in Unicode 12.1
- 150 scripts (organized)
- Enumeration of character properties, such as case
- Supports bidirectional display order
- A canonical name for every character

http://ian-albert.com/unicode_chart/unichart-chinese.jpg

LATIN CAPITAL LETTER A

DIE FACE-6

EIGHTH NOTE

(Demo)

Mutation Operations

changing object itself

Some Objects Can Change

dictionary에 같은 key에 다른 값 각각 넣으면,
마지막에 넣은 값으로 저장.

```
>> s = [‘a’, ‘b’, ‘c’, ‘d’]
>> s
[‘a’, ‘b’, ‘c’, ‘d’]
>> originally = s
>> s.pop()
‘d’
>> s.pop(0)
‘a’
>> s
[‘b’, ‘c’]
>> s.remove(‘b’)
>> s
[‘c’]
>> s[0]
‘c’
>> s.extend([‘y’, ‘z’])
[‘c’, ‘d’, ‘y’, ‘z’]
>> s[1:2] = [‘v’, ‘w’, ‘x’]
>> s
[‘c’, ‘v’, ‘w’, ‘x’, ‘y’, ‘z’]
>>
```

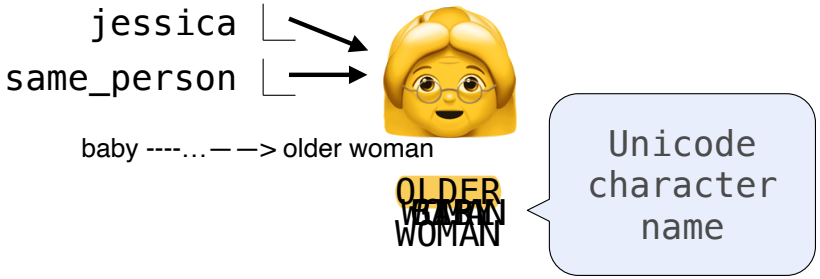
remove VS. pop
returnX. returnO.

[Demo]

First example in the course of an object changing state

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

```
>> s = [1, 2]
>> s.append([3])
>> s.extend([4, [5]])
>> s
[1, 2, [3], 4, [5]]
>> s[2].append(6)
>> s
[1, 2, [3, 6], 4, [5]
```



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

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

{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()
```

or

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

global에 있어서 부르는게 가능

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

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


pythontutor.com/composingprograms.html#code=def%20mystery%28s%29%3A%0A%20%20%20%20s.pop%28%29%0A%20%20%20%20s.pop%28%29%0A%0Afour%20%3D%20[1,%202,%203,%204]%0Amystery%28four%29&mode=display&origin=composingprograms.js&cumulative=true&py=3&rawInputLstJSON=[]&curInstr=0

Tuples

(Demo)

Tuples are Immutable Sequences

변경 불가
ex) .pop()이나 s[0] = 5

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!']
```

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

Name change:

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

Object mutation:

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

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)
```

Mutation

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
[10, 20]
>>> b
[10, 20]
>>> a == b
True
```

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

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

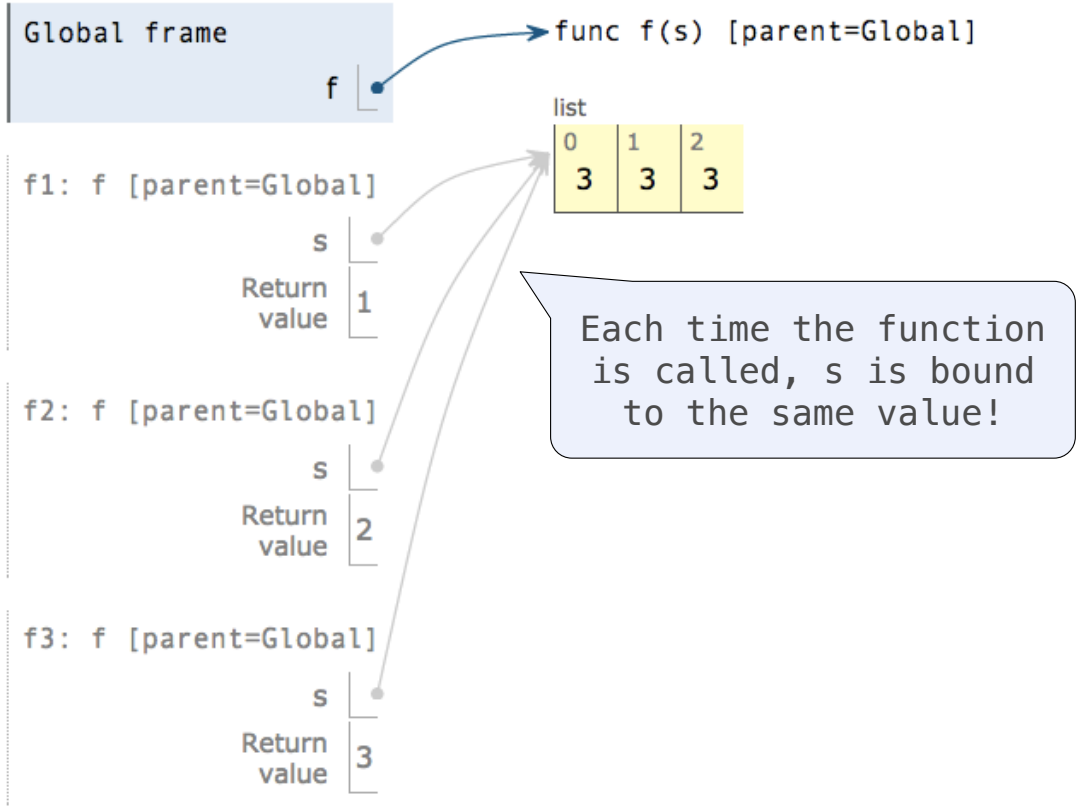
Identical objects are always equal values

(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
```



pythontutor.com/composingprograms.html#code=def%20f%28s%3D[]%29%3A%0A%20%20%20%20s.append%283%29%0A%20%20%20%20return%20len%28s%29%0A%20%20%20%20%0Af%28%29%0Af%28%29%0Af%28%29&mode=display&origin=composingprograms.js&cumulative=true&py=3&rawInputLstJSON=[]&curInstr=0

Mutable Functions

A Function with Behavior That Varies Over Time

Let's model a bank account that has a balance of $100

```
>>> withdraw = make_withdraw_list(100)

>>> withdraw(25)
75

>>> withdraw(25)
50

>>> withdraw(60)
'Insufficient funds'

>>> withdraw(15)
35
```

In a (mutable) list referenced in the parent frame of the function

Argument: amount to withdraw

Return value: remaining balance

Second withdrawal of the same amount

Different return value!

Where's this balance stored?

Mutable Values & Persistent Local State