[301] Advanced Functions

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Learning Objectives Today

Iterators

- what is an iteratable?
- how to read files, with sequences or iterators
- advantages of laziness
- writing your own generators

References to functions

- ways to get a reference
- map
- sort

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Revisiting the For Loop

for loops can iterate over **sequences**

- list values
- string characters
- other sequences

```
for letter in “hello”:
    print(letter)
```

```
for num in [1,2,3]:
    print(num)
```

Revisiting the For Loop

for loops can iterate over **sequences**

- list values
- string characters
- other sequences

More precisely…

```
for letter in “hello”:
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```
for num in [1,2,3]:
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Revisiting the For Loop

for loops can iterate over **sequences**

- list values
- string characters
- other sequences

More precisely…

for loops can iterate over **iterables**

- **sequences** are **iterable**
- **other things** (like dict values) are also **iterable**

Example: Dictionary Values

```
d = {1:"one", 2:"two", 3:"three"}
d.values() # type is <class 'dict_values'>
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```
vals = list(d.values())

for v in vals:
    print(v)
```

Prints (or other order):
two
one
three

Example: Dictionary Values

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d = {1:"one", 2:"two", 3:"three"}
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```
vals = list(d.values())
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```
it = iter(d.values())
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for v in vals:
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vals = list(d.values())

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it = iter(d.values())
```

if you can call **iter(x)**,
then **x** is *iterable*,
by definition

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vals = list(d.values())

for v in vals:
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```

```
it = iter(d.values())
```

d.values() is iterable, and **it** is an iterator

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vals = list(d.values())
for v in vals:
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it = iter(d.values())
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Both print the same:

two
one
three

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for v in it:
    print(v)
```

Both print the same:
two
one
three

NOTE: the for loop automatically calls iter if necessary, so we could have written this instead:

```
for v in d.values():
    print(v)
```

Example: Dictionary Values

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d = {1:"one", 2:"two", 3:"three"}
d.values() # type is <class 'dict_values'>
```

```
vals = list(d.values())

for v in vals:
    print(v)

print(vals[2])
```

```
it = iter(d.values())

for v in it:
    print(v)
```

We can index over a sequence.
Example prints:
three

Example: Dictionary Values

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d.values() # type is <class 'dict_values'>
```

```
vals = list(d.values())

for v in vals:
    print(v)

print(vals[2])
```

```
it = iter(d.values())

for v in it:
    print(v)

print(it[2]) # BAD!
```

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d = {1:"one", 2:"two", 3:"three"}
d.values() # type is <class 'dict_values'>
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```
vals = list(d.values())

for v in vals:
    print(v)

print(vals[2])
```

```
it = iter(d.values())

for v in it:
    print(v)

print(it[2]) # BAD!
```

```
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: 'dict_valueiterator' object is not subscriptable
```

You can only loop over iterators, not index with them

Comparison

	sequence	**iterator**
can use for loop	✓	✓
can do indexing	✓	✗

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why ever use the less-capable iterator?

Comparison

	sequence	iterator
can use for loop	✓	✓
can do indexing	✓	✗

why ever use the less-capable iterator?

it's often faster (as we'll see later)

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Reading Files

```
path = “file.txt”
f = open(path)
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open(…) function is built in

Reading Files

```
path = “file.txt”
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```

it takes a string argument,
which contains path to a file

file.txt

```
This is a test!
3
2
1
Go!
```

c:\users\tyler\my-doc.txt

/var/log/events.log

../data/input.csv

Reading Files

```
path = “file.txt”
f = open(path)
```

it returns a file object

file.txt

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This is a test!
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Reading Files

```
path = “file.txt”
f = open(path)
```

it returns a file object

file objects are iterable!

file.txt

```
This is a test!
3
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Reading Files

```
path = “file.txt”
f = open(path)

for line in f:
    print(line)
```

file.txt

```
This is a test!
3
2
1
Go!
```

Output

```
This is a test!

3

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Go!
```

Reading Files

```
path = “file.txt”
f = open(path)

for line in f:
    print(line.strip())
```

file.txt

```
This is a test!
3
2
1
Go!
```

Output

```
This is a test!
3
2
1
Go!
```

Reading Files

```
path = “file.txt”
f = open(path)

for line in f:
    print(line.strip())
```

file.txt

```
This is a test!
3
2
1
Go!
```

Another option: use the iterable file object to create a list

Reading Files

```
path = “file.txt”
f = open(path)
lines = list(f) # create list from iterable

for line in f:
    print(line.strip())
```

file.txt

```
This is a test!
3
2
1
Go!
```

Another option: use the iterable file object to create a list

Reading Files

```
path = “file.txt”
f = open(path)
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for line in f:
    print(line.strip())
```

file.txt

```
This is a test!
3
2
1
Go!
```

Another option: use the iterable file object to create a list

lines is a list:

```
[“This is a test\n”, “3\n”, “2\n”, “1\n”, “Go!\n”]
```

Reading Files

```
path = “file.txt”
f = open(path)
lines = list(f) # create list from iterable

for line in £ lines:
    print(line.strip())
```

file.txt

```
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Demo 1: Add numbers in a file

Goal: read all lines from a file as integers and add them

Input:

- file containing **50 million numbers** between 0 and 100

Output:

- The sum of the numbers

Example:

```
prompt> python sum.py
2499463617
```

Demo 1: Add numbers in a file

Goal: read all lines from a file as integers and add them

Input:

- file containing **50 million numbers** between 0 and 100

Output:

- The sum of the numbers

Example:

```
prompt> python sum.py
2499463617
```

Two ways:

- Put all lines in a list first
- Directly use iterable file

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Reviewing Return

```
def f():
  return “A”
  return “B”
  return “C”

print(“Got”, f())
```

What is printed?

Reviewing Return

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def f():
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Got A

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What is printed?

Got A

Let’s say we want to return 3 values

Reviewing Return

```
def f():
  items = []
  items.append(“A”)
  items.append(“B”)
  items.append(“C”)
  return items

for item in f():
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What is printed?

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```

What is printed?

Got A
Got B
Got C

Reviewing Return

```
def f():
  items = []
  print("Produce A")
  items.append("A")
  print("Produce B")
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for item in f():
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What is printed?

Produce A
Produce B
Produce C
Got A
Got B
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everything is produced…

Reviewing Return

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everything is produced…

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…before anything is used

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What is printed?

Produce A
Produce B
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everything is produced…

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…before anything is used

Sometimes we want to be "lazy" and only produce values right before they're needed

Introducing Yield

```
def f():
  print(“Produce A”)
  yield “A”
  print(“Produce B”)
  yield “B”
  print(“Produce C”)
  yield “C”

items = f()
```

Introducing Yield

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type of items is:
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weird, no?
we don't return anything

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- functions with yield automatically return a *generator*, a type of iterator

observations

- we bounce in and out of a generator function
- the function starts producing values even before it finishes

What is printed?

Produce A
A
Produce B
B
Produce C
C

Demo 2: Squares

Goal: generate sequence of squares

Input:

- none

Output:

- Squares

Example:

```
prompt> python squares.py
1
4
9
16
25
...
```

Iterator/Generator Vocabulary Recap

Sequence: object we can loop over (with for) **AND** index into

Iterator: object we can loop over (with for)

Iterable: object **x** that can give us an iterator if we call **iter(x)**

Generator: simple iterator returned by a function that **yields**

Generator function: function that returns a generator

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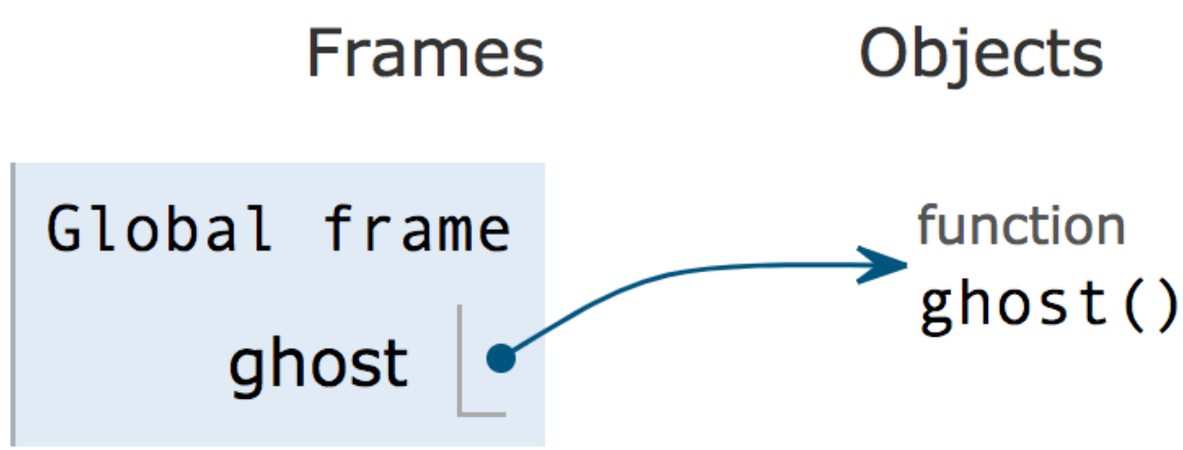
Python Tutor

Write code in Python 3.6

(drag lower right corner to resize code editor)

```
1  def ghost():
2      print('boo')
3
4
```



why does Python Tutor visualize functions this way?

Functions are objects

Functions are just a special type of object!

- function name is reference
- function code is the object

```
def ghost():
    print('boo')

ghost()
```

State:

references *objects*

Functions are objects

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- function name is reference
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```
def ghost():
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```

```
ghost()
```

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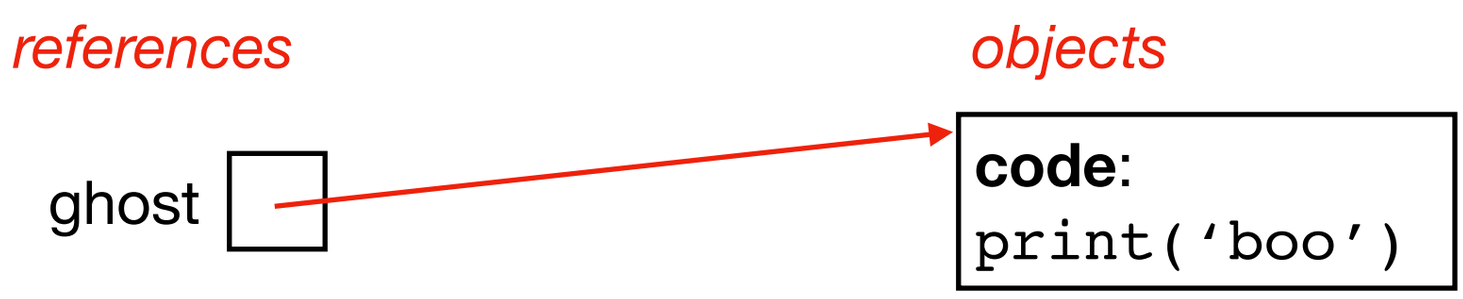

Functions are objects

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def ghost():
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```
ghost()
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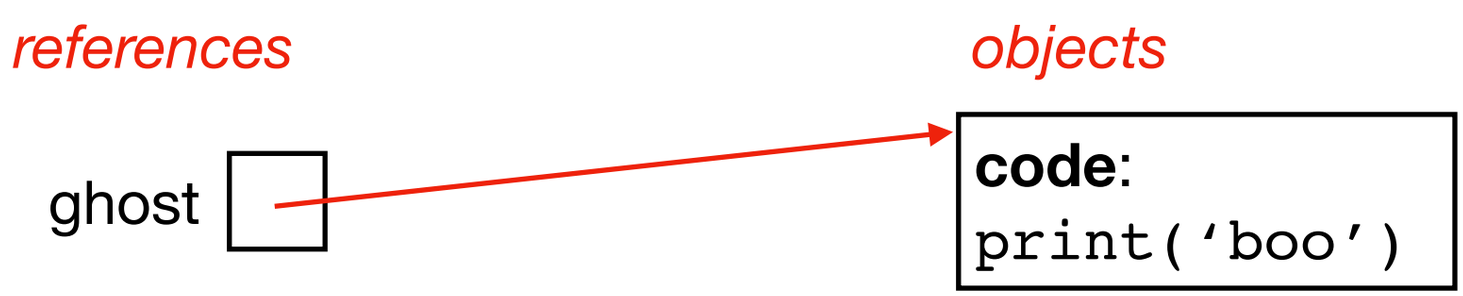
when we say f()

- look for a variable named f
- follow the reference to some code
- run that code

State:



Functions are objects

Functions are just a special type of object!

- function name is reference
- function code is the object

```
def ghost():
    print('boo')
```

```
ghost()
```

when we say f()

- **look for a variable named f**
- follow the reference to some code
- run that code

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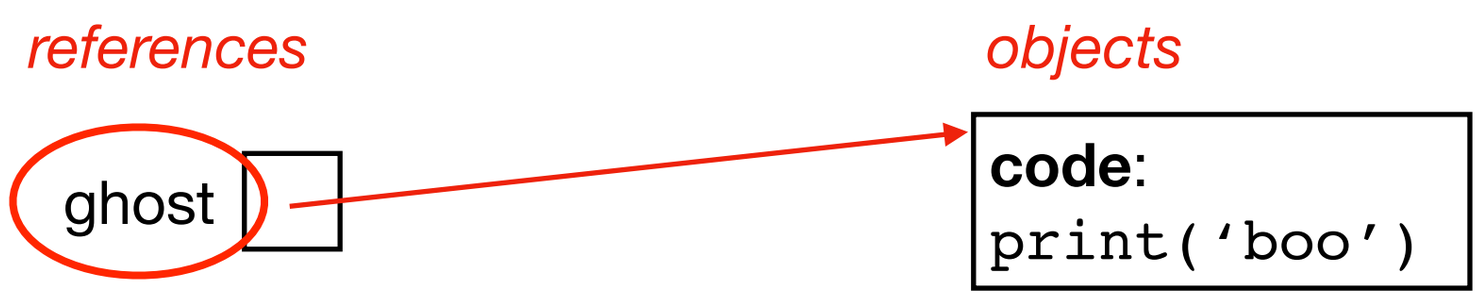

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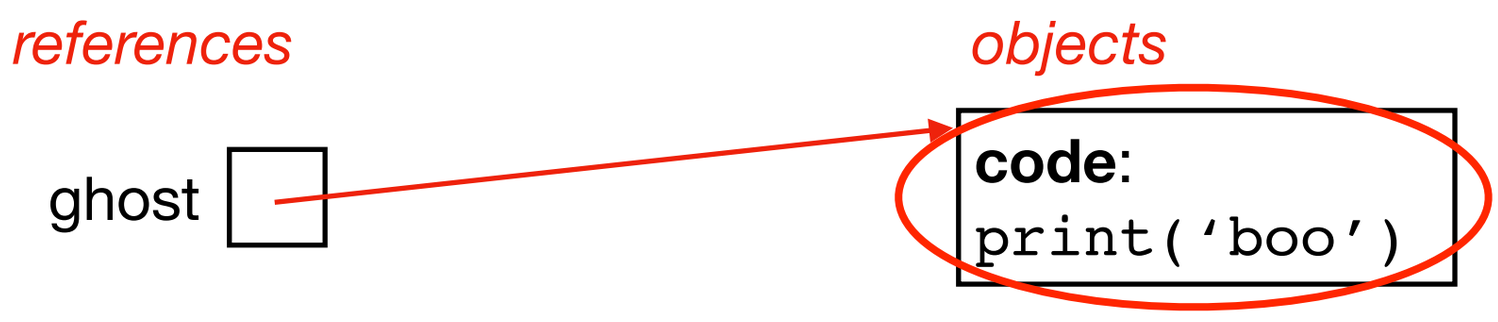

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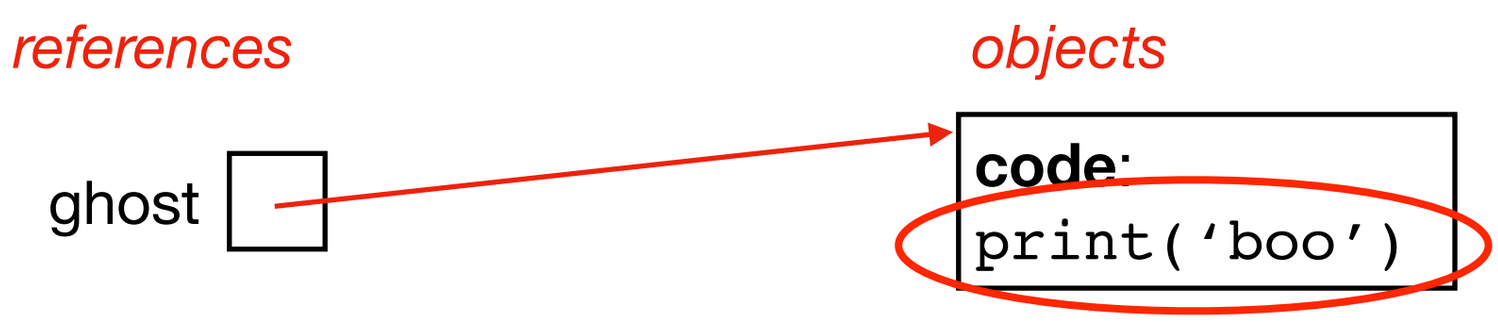

Python Tutor: Example 1

```
x = ["A", "B", "C"]
y = x

def f(items):
    print(len(items))

f(x)

g = f
g(x)
```

Python Tutor: Example 2

```
def call_it(my_function):
    print("calling", my_function)
    my_function()

def test():
    print("inside test function")

call_it(test)
```

Python Tutor: Example 2

```
def call_it(my_function):
    print("calling", my_function)
    my_function()

def test():
    print("inside test function")

call_it(test)
```

functions like test are sometimes called “callbacks” because we’re asking somebody else’s function to call back to our own code

Ways to get a reference

refs to normal objects

```
def f(z):
    # way 3: param
    print(z)

x = [1,2,3] # way 1: new object
y = x       # way 2: copy ref
f(x)
```

refs to function objects

```
# way 1: def
def f():
    print('hi')

def call_me(h):
    # way 3: param
    h()

g = f # way 2: copy ref
call_me(f)
```

Ways to get a reference

refs to normal objects

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Learning Objectives Today

Iterators

- what is an iteratable?
- how to read files, with sequences or iterators
- advantages of laziness
- writing your own generators

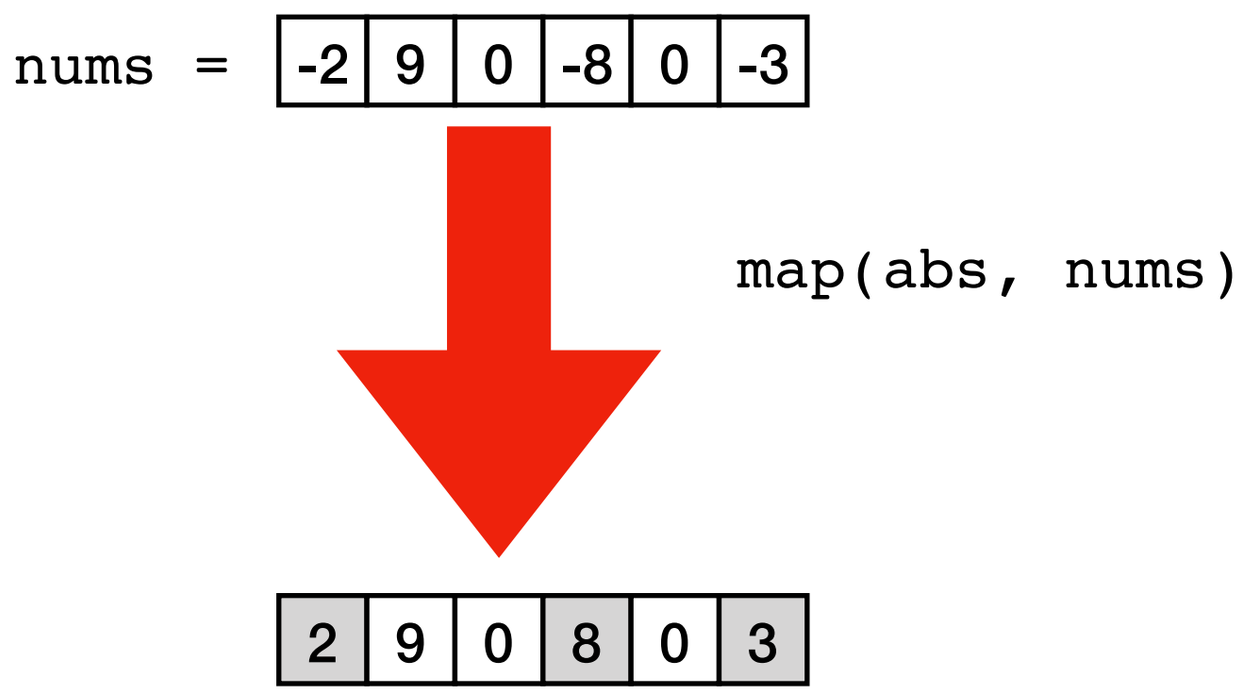
References to functions

- ways to get a reference
- map
- sort

map function

We often will want to run a function on every item in a list

- input 1: a function
- input 2: a list
- output: list produced by running function on items in input list



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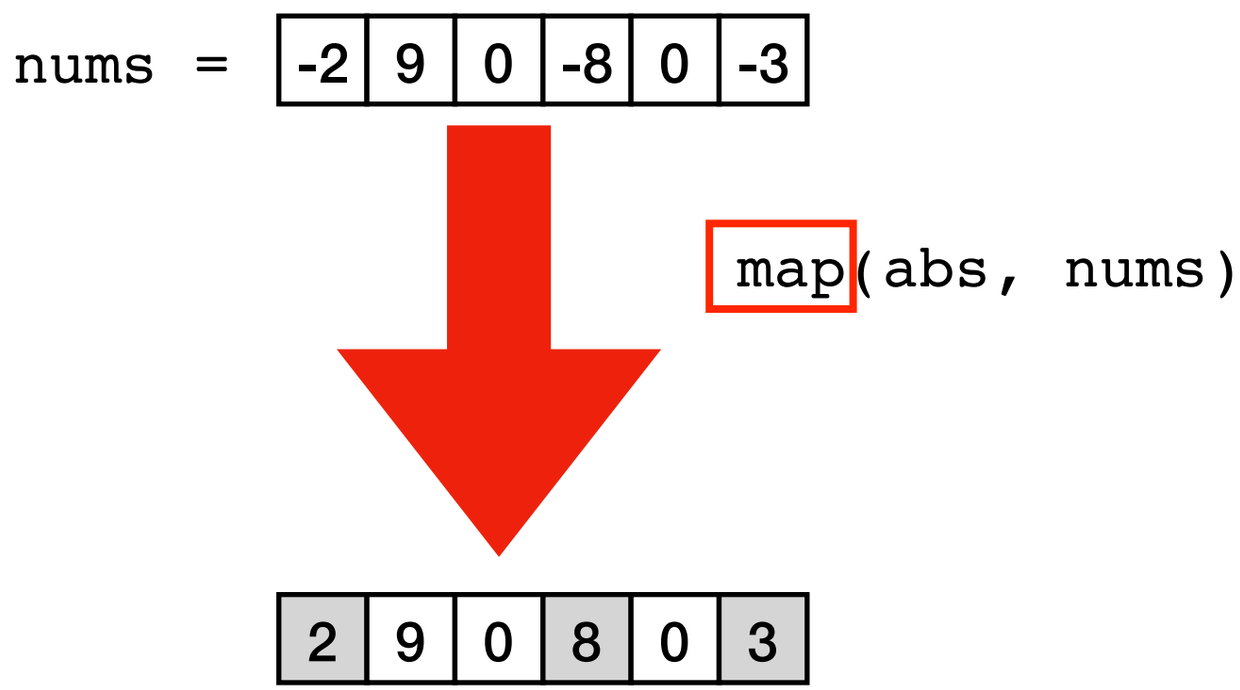

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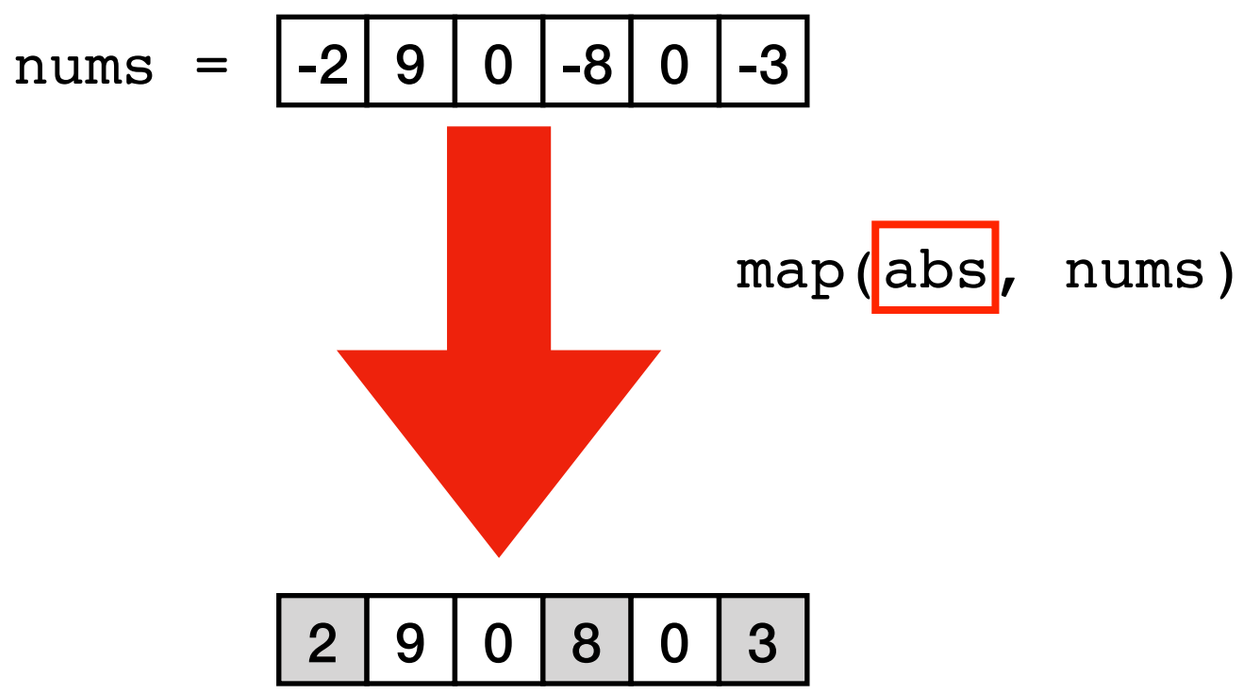

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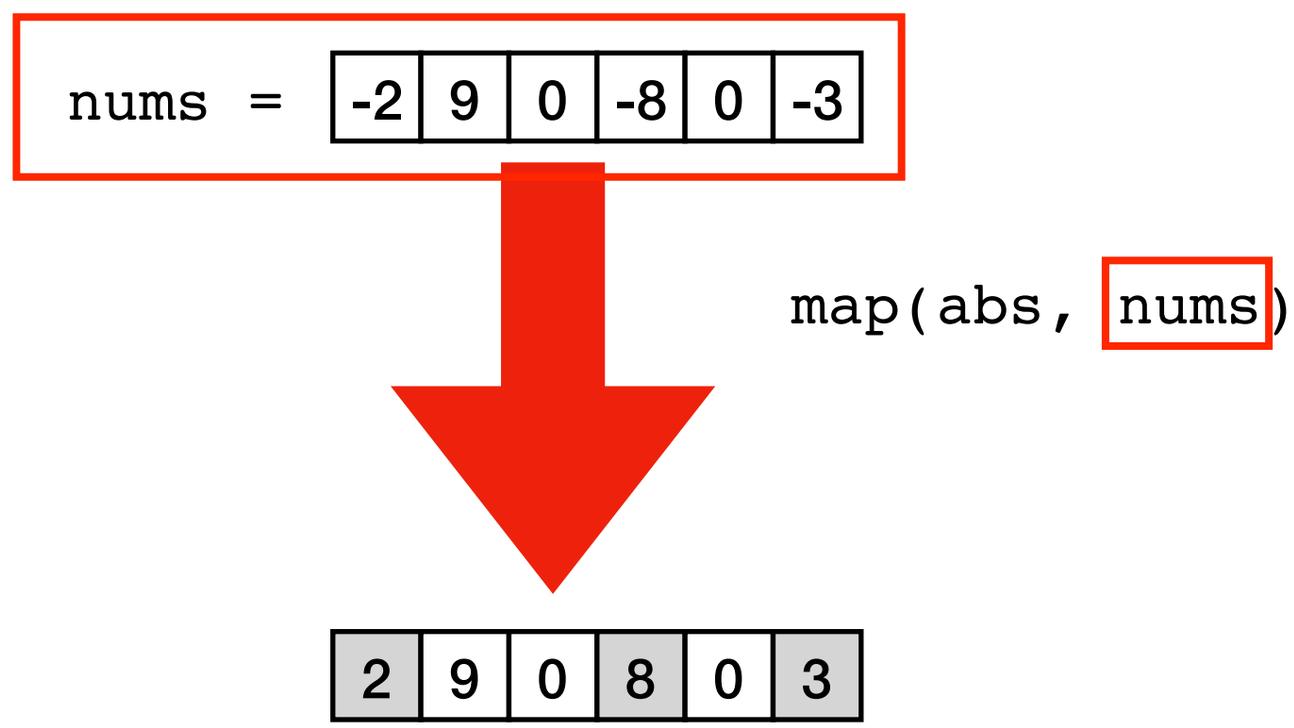

map function

We often will want to run a function on every item in a list

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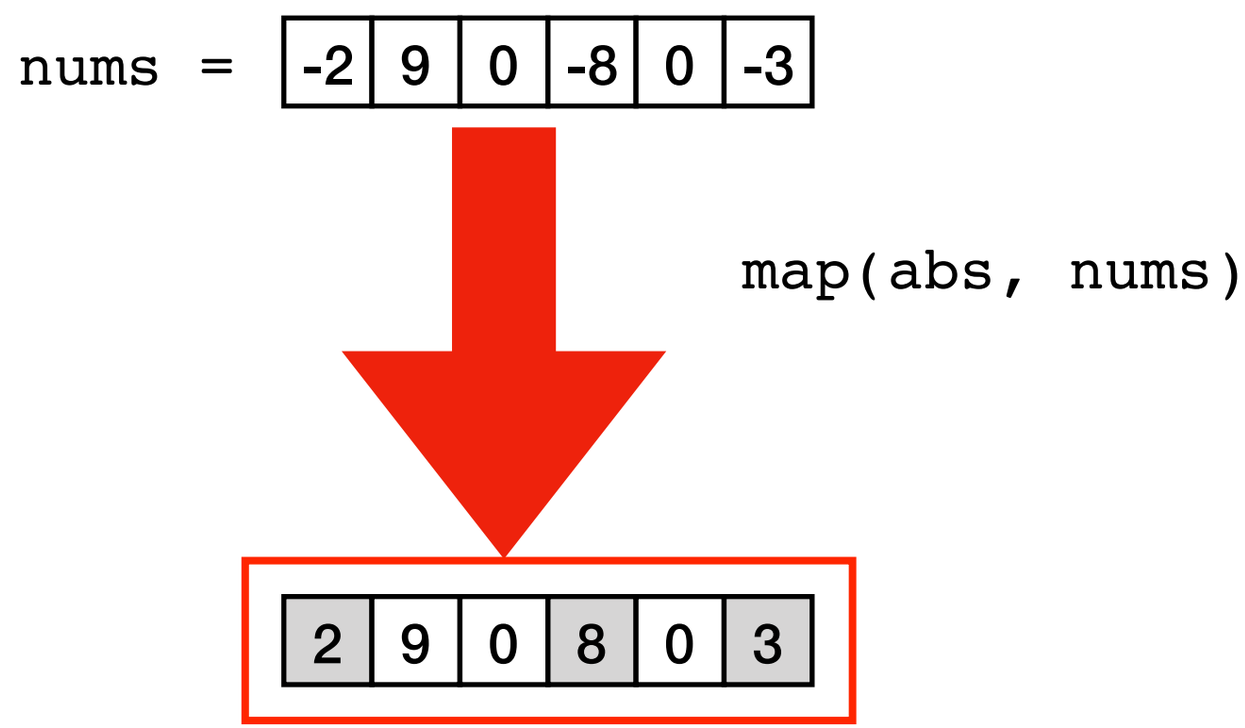
- input 2: a list
- output: list produced by running function on items in input list



map code

```
def map(f, items):
  result = []
  for item in items:
    new_item = f(item)
    result.append(new_item)
  return result
```

map code

```
def map(f, items):
  result = []
  for item in items:
    new_item = f(item)
    result.append(new_item)
  return result
```

```
>>> map(abs, [1, -1])
[1, 1]
>>> map(abs, [0, 8, -9, -5, 10])
[0, 8, 9, 5, 10]
```

Note: Python has a built-in map function.
Like this, but returns a generator instead of list.

Learning Objectives Today

Iterators

- what is an iteratable?
- how to read files, with sequences or iterators
- advantages of laziness
- writing your own generators

References to functions

- ways to get a reference
- map
- sort

Learning Objectives Today

List of tuples:

```
names = [
    ("Cindy", "Baker"),
    ("Alice", "Clark"),
    ("Bob", "Adams"),
]
```

Cindy	Baker
Bob	Adams
Alice	Clark

Learning Objectives Today

List of tuples:

```
names = [
     ("Cindy", "Baker"),
     ("Alice", "Clark"),
     ("Bob", "Adams"),
]
```

Cindy	Baker
Bob	Adams
Alice	Clark

```
names.sort()
```

sorting tuples is done on first element
(ties go to 2nd element)

Alice	Clark
Bob	Adams
Cindy	Baker

Learning Objectives Today

List of tuples:

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names = [
    ("Cindy", "Baker"),
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]
```

Cindy	Baker
Bob	Adams
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```
names.sort()
```

what if we want to sort by the last name?

Alice	Clark
Bob	Adams
Cindy	Baker

Learning Objectives Today

List of tuples:

```
names = [
    ("Cindy", "Baker"),
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    ("Bob", "Adams"),
]
```

Cindy	Baker
Bob	Adams
Alice	Clark

```
names.sort()
```

Alice	Clark
Bob	Adams
Cindy	Baker

what if we want to sort by the last name?

or by the length of the name?

or by something else?

Learning Objectives Today

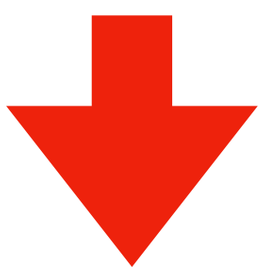
List of tuples:

```
names = [
    ("Cindy", "Baker"),
    ("Alice", "Clark"),
    ("Bob", "Adams"),
]
```

Cindy	Baker
Bob	Adams
Alice	Clark

```
def extract(name_tuple):
    return name_tuple[1]

list(map(extract, names))
```



```
["Baker", "Clark", "Adams"]
```

Learning Objectives Today

this is what we want to sort on

List of tuples:

```
names = [
    ("Cindy", "Baker"),
    ("Alice", "Clark"),
    ("Bob", "Adams"),
]
```

Cindy	Baker
Bob	Adams
Alice	Clark

```
def extract(name_tuple):
    return name_tuple[1]

list(map(extract, names))
```

```
["Baker", "Clark", "Adams"]
```

Learning Objectives Today

List of tuples:

```
names = [
    ("Cindy", "Baker"),
    ("Alice", "Clark"),
    ("Bob", "Adams"),
]

def extract(name_tuple):
    return name_tuple[1]

names.sort(key=extract)
```

Cindy	Baker
Bob	Adams
Alice	Clark

Bob	Adams
Cindy	Baker
Alice	Clark

Conclusion

Iterators

- like sequences, with for loops, without indexing
- a function with yields automatically returns a generator
- a generator is a kind of iterator

Function references

- three ways to get them: (1) def, (2) assignment, (3) arg passing
- passing a function to a function: callback
- useful for map and sort