

# [220 / 319] Functions as Objects

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# Radical Claim:

# Functions are Objects

## **implications:**

- variables can reference functions
- lists/dicts can reference functions
- we can pass function references to other functions
- we can pass lists of function references to other functions
- ...

```
l1 = [1, 2, 3]
```

```
l2 = l1
```

```
def f(l):  
    return l[-1]
```

```
g = f
```

```
num = f(l2)
```

*which line of code is most novel for us?*

`l1 = [1, 2, 3]`

`l2 = l1`

**Explanation:** `l1` should reference a new list object

**Explanation:** `l2` should reference whatever `l1` references

```
def f(l):  
    return l[-1]
```

**Explanation:** `f` should reference a new function object

`g = f`

**Explanation:** `g` should reference whatever `f` references

➔ `num = f(l2)`

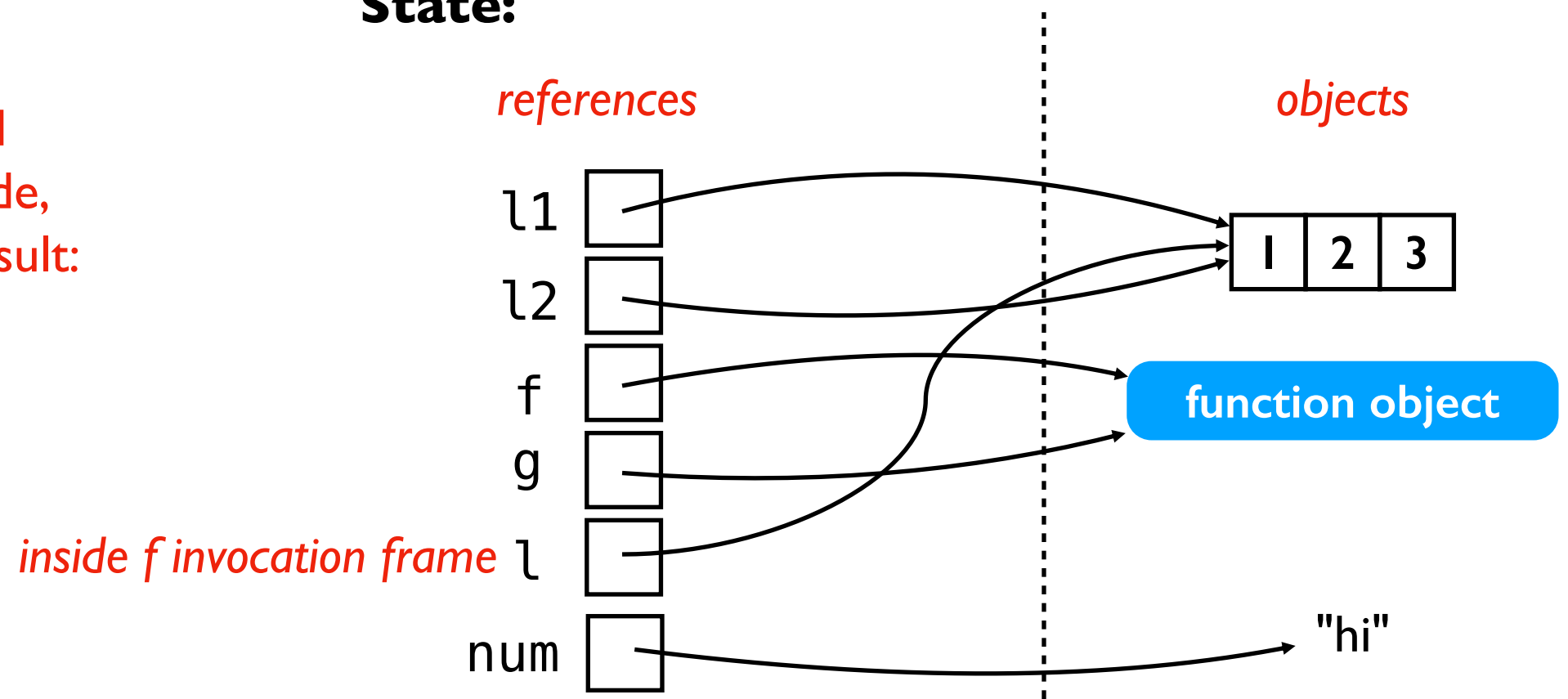
**Explanation:** `l` should reference whatever `l2` references

**Explanation:** `num` should reference whatever `f` returns

both these calls would  
have run the same code,  
returning the same result:

- `num = f(l1)`
- `num = g(l2)`

**State:**



l1 = [1, 2, 3]

l2 = l1

```
def f(l):  
    return l[-1]
```

g = f

num = f(l2)

**very similar** (reference new object)

**very similar** (reference existing object)

**very different** (invoke vs. reference)

# **CODING DEMOS**

## [Python Tutor]

# Function References (Part I)

## Outline

- functions as objects
- `sort`
- `lambda`

# Example: Sorting Names

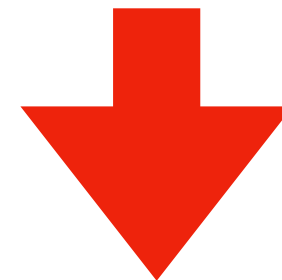
List of tuples:

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

```
names.sort()
```

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

Catherine	Baker
Bob	Adams
Alice	Clark



Alice	Clark
Bob	Adams
Catherine	Baker



# Example: Sorting Names

List of tuples:

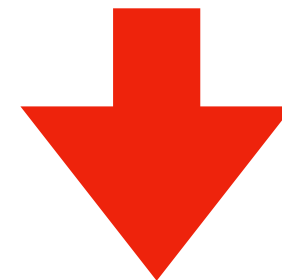
```
names = [  
    ("Catherine", "Baker"),  
    ("Alice", "Clark"),  
    ("Bob", "Adams"),  
]
```

```
names.sort()
```

**what if we want to  
sort by the last name?**

**or by the length of the name?**

Catherine	Baker
Bob	Adams
Alice	Clark



Alice	Clark
Bob	Adams
Catherine	Baker

# Example: Sorting Names

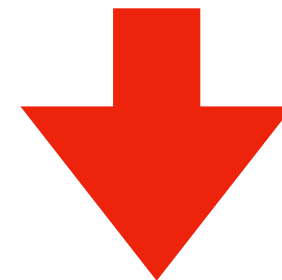
List of tuples:

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

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

```
names.sort(key=extract)
```

Catherine	Baker
Bob	Adams
Alice	Clark



# Example: Sorting Names

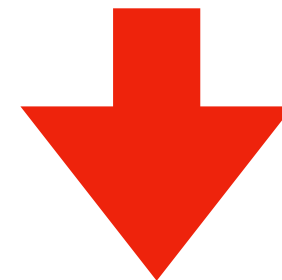
List of tuples:

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    ("Catherine", "Baker"),  
    ("Alice", "Clark"),  
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]
```

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

```
names.sort(key=extract)
```

Catherine	Baker
Bob	Adams
Alice	Clark



Bob	Adams
Catherine	Baker
Alice	Clark

# Example: Sorting Names

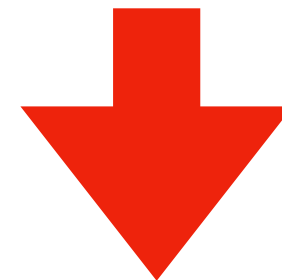
List of tuples:

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

```
def extract(name_tuple):  
    return len(name_tuple[0])
```

```
names.sort(key=extract)
```

Catherine	Baker
Bob	Adams
Alice	Clark



# Example: Sorting Names

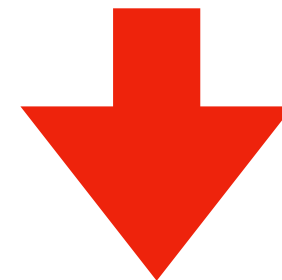
List of tuples:

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

```
def extract(name_tuple):  
    return len(name_tuple[0])
```

```
names.sort(key=extract)
```

Catherine	Baker
Bob	Adams
Alice	Clark



Bob	Adams
Alice	Clark
Catherine	Baker

# **CODING DEMOS**

## Jupyter notebook

# Function References (Part I)

## Outline

- functions as objects
- sort
- **lambda**

# Example: Sorting Dictionary by keys using lambdas

- lambda functions are a way to abstract a function reference
- multiple possible parameters and single expression as function body

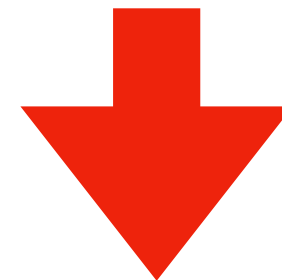
bob	20
alice	8
alex	9

***lambda* parameters:  
expression**

Dictionary:

```
players = {"bob": 20, "alice": 8,  
           "alex": 9}
```

```
dict(sorted(players.items(), key  
= lambda item: item[0]))
```



alex	9
alice	8
bob	20



# Example: Sorting Dictionary by values using lambdas

- lambda functions are a way to abstract a function reference
- multiple possible parameters and single expression as function body

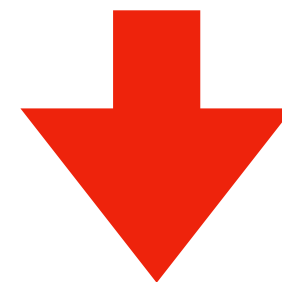
bob	20
alice	8
alex	9

***lambda* parameters:  
expression**

Dictionary:

```
players = {"bob": 20, "alice": 8,  
           "alex": 9}
```

```
dict(sorted(players.items(), key  
           = lambda item: item[1]))
```



alice	8
alex	9
bob	20