

Containers

Announcements

Iteration and Recursion

Replacing Iteration with Recursion

You can convert while/for statements to recursion without inventing new logic:

- Each pass through the body of a while/for statement is replaced by a recursive call.
- Instead of using assignment statements, assign names to values using a call expression.
- If needed, introduce a new function with an argument for every value that must be tracked.

(Demo)

Box-and-Pointer Notation

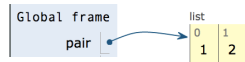
The Closure Property of Data Types

- A method for combining data values satisfies the *closure property* if:
 - The result of combination can itself be combined using the same method
- Closure is powerful because it permits us to create hierarchical structures
- Hierarchical structures are made up of parts, which themselves are made up of parts, and so on

Lists can contain lists as elements (in addition to anything else)

Box-and-Pointer Notation in Environment Diagrams

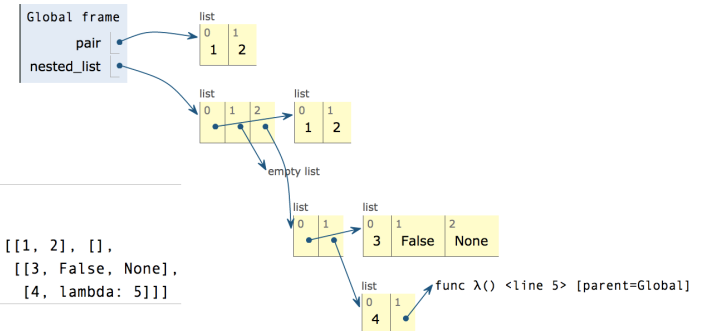
Lists are represented as a row of index-labeled adjacent boxes, one per element
Each box either contains a primitive value or points to a compound value



```
pair = [1, 2]
```

Box-and-Pointer Notation in Environment Diagrams

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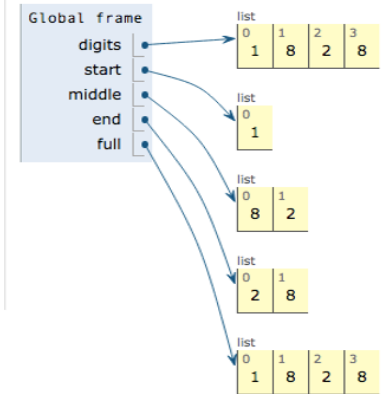


```
1 pair = [1, 2]
2
3 nested_list = [[1, 2], [],
4                [3, False, None],
5                [4, lambda: 5]]
```

Slicing Creates Lists

Slicing Creates New Values

```
1 digits = [1, 8, 2, 8]
2 start = digits[:1]
3 middle = digits[1:3]
4 end = digits[2:]
5 full = digits[:]
```



Processing Container Values

(Demo)

Aggregation

Several built-in functions take iterable arguments and aggregate them into a value

- **sum(iterable[, start])** -> value

Return the sum of an iterable (not of strings) plus the value of parameter 'start' (which defaults to 0). When the iterable is empty, return start.

- **max(iterable[, key=func])** -> value
- **max(a, b, c, ..., key=func)** -> value

With a single iterable argument, return its largest item. With two or more arguments, return the largest argument.

- **all(iterable)** -> bool

Return True if bool(x) is True for all values x in the iterable. If the iterable is empty, return True.

Discussion Question

Find the power of 2 that is closest to 1,000 using one line:

(You can assume that it's smaller than 2^{100} .)

```
min( [ 2 ** n for n in range(100) ], key= lambda x: abs(1000 - x) )
```

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Strings

Strings are an Abstraction

Representing data:

```
'200'      '1.2e-5'      'False'      '[1, 2]'
```

Representing language:

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

Representing programs:

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

(Demo)

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String Literals Have Three Forms

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

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

Single-quoted and double-quoted strings are equivalent

```
>>> '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.'
```

A backslash "escapes" the following character

"Line feed" character represents a new line

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Dictionarys

```
{'Dem': 0}
```

Limitations on Dictionarys

Dictionarys are 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 dictionarys

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

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Dictionary Comprehensions

```
{<key exp>: <value exp> for <name> in <iter exp> if <filter exp>}
```

Short version: {<key exp>: <value exp> for <name> in <iter exp>}

An expression that evaluates to a dictionary using this evaluation procedure:

1. Add a new frame with the current frame as its parent
 2. Create an empty *result dictionary* 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 to the result dictionary an entry that pairs the value of *<key exp>* to the value of *<value exp>*
- {x * x: x for x in [1, 2, 3, 4, 5] if x > 2} evaluates to {9: 3, 16: 4, 25: 5}

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Example: Indexing

Implement `index`, which takes a sequence of `keys`, a sequence of `values`, and a two-argument `match` function. It returns a dictionary from `keys` to lists in which the list for a key `k` contains all `values` `v` for which `match(k, v)` is a true value.

```
def index(keys, values, match):  
    """Return a dictionary from keys k to a list of values v for which  
    match(k, v) is a true value.  
  
    >>> index([7, 9, 11], range(30, 50), lambda k, v: v % k == 0)  
    {7: [35, 42, 49], 9: [36, 45], 11: [33, 44]}  
    """  
    return {k: [v for v in values if match(k, v)] for k in keys}
```

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