Lecture 7

Abstract data types
Mutable Values

Some slides were borrowed from CS88, Berkeley

Abstract Data Types

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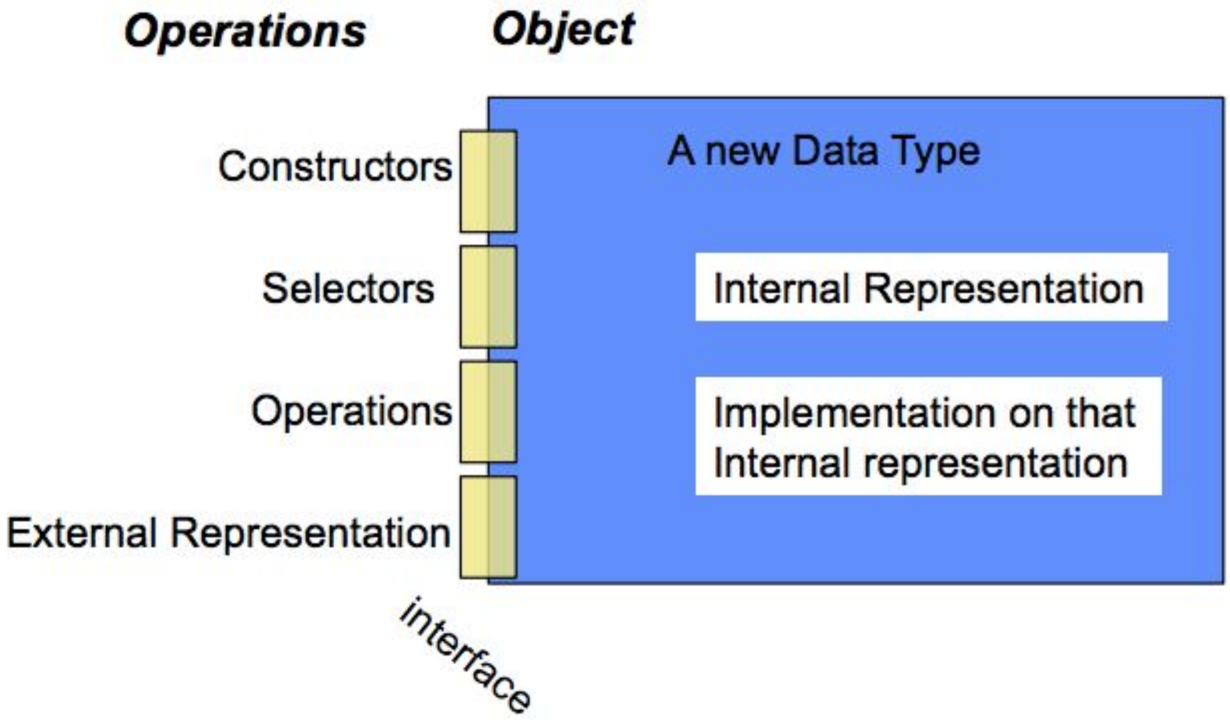
Data abstraction

- Compound values combine other values together
  - A date: a year, a month, and a day
  - A geographic position: latitude and longitude
- Data abstraction lets us manipulate compound values as *units*
- Isolate two parts of any program that uses data:
  - How data are represented (as parts)
  - How data are manipulated (as units)
- **Data abstraction**: A methodology by which functions enforce an abstraction barrier between representation and use

Abstract Data Type



Operations

Object

Constructors

Selectors

Operations

External Representation

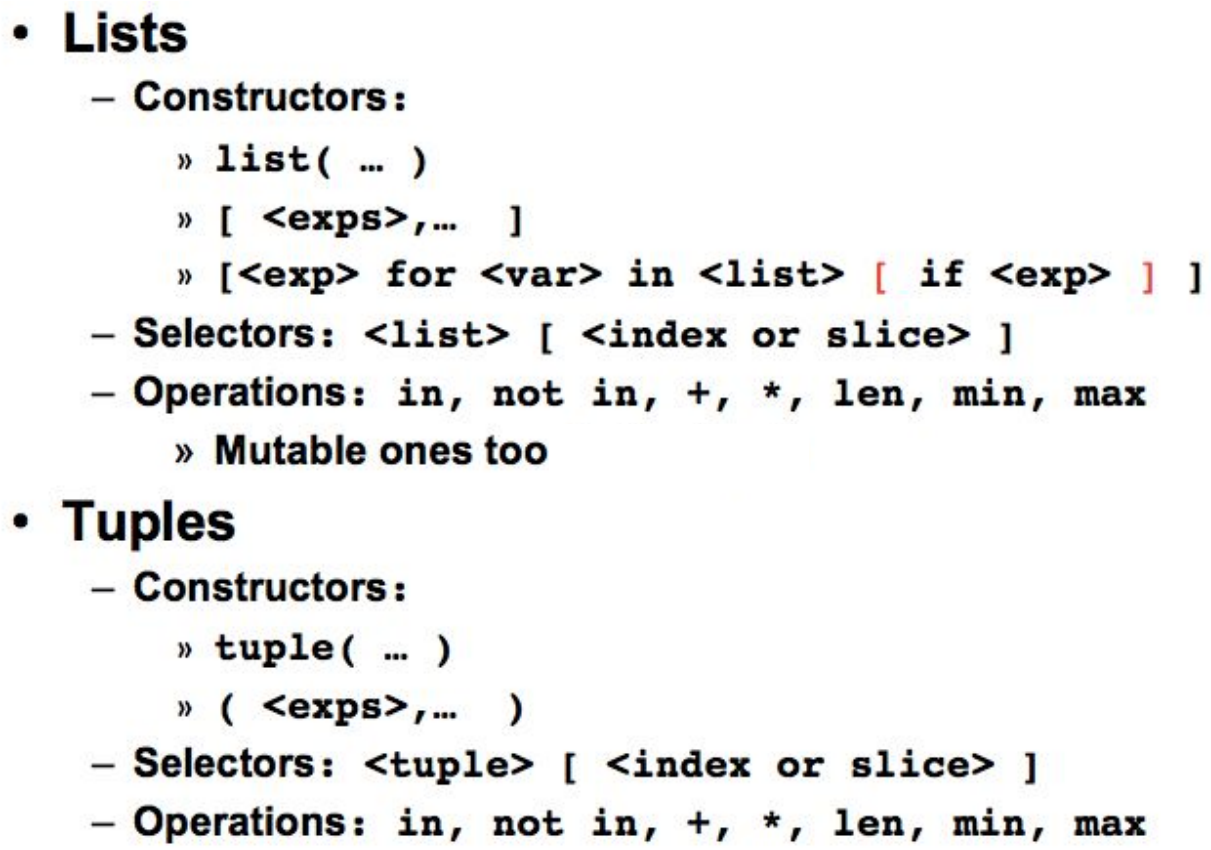
interface

A new Data Type

Internal Representation

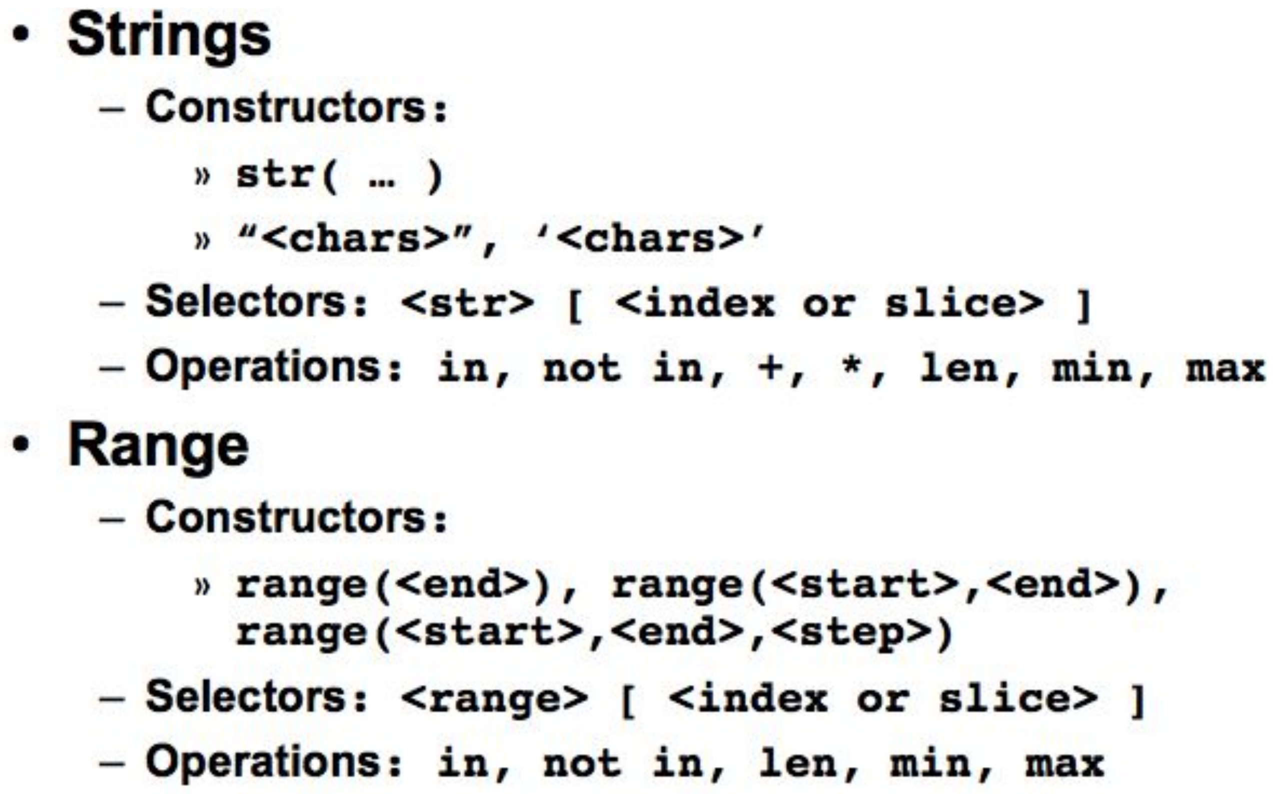
Implementation on that Internal representation

Data Types You have seen



- **Lists**
  - Constructors:
    - » `list( … )`
    - » `[ <exps>,…  ]`
    - » `[<exp> for <var> in <list> [ if <exp> ] ]`
  - Selectors: `<list> [ <index or slice> ]`
  - Operations: `in, not in, +, *, len, min, max`
    - » Mutable ones too
- **Tuples**
  - Constructors:
    - » `tuple( … )`
    - » `( <exps>,…  )`
  - Selectors: `<tuple> [ <index or slice> ]`
  - Operations: `in, not in, +, *, len, min, max`

More “Built-in” Examples



- **Strings**
  - Constructors:
    - » `str( … )`
    - » `“<chars>”, ‘<chars>’`
  - Selectors: `<str> [ <index or slice> ]`
  - Operations: `in, not in, +, *, len, min, max`
- **Range**
  - Constructors:
    - » `range(<end>), range(<start>,<end>), range(<start>,<end>,<step>)`
  - Selectors: `<range> [ <index or slice> ]`
  - Operations: `in, not in, len, min, max`

(Demo)

Abstraction Barriers

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Parts of the program that…	Treat city as	Using ...

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Implementation of lists

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Implementation of lists

Violating Abstraction Barriers

```
closer_city(34, 67,[‘Moscow’, 45, 43], [‘Paris’,65, 78])
```

```
def distance(x, y):
    return sqrt((x[1] - y[1])** 2 + (x[2] - y[2])**2))
```

How many violations can you spot?

A: 0 B: 1 C: 2 D: 3 E: 4

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```
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def distance(x
    return sqrt
y[2])**2))
```

No selectors!

How many violation

A: 0 B: 1

Violating Abstraction Barriers

```
(Thank you, John. It was fun :))
```

Time for fun!

Check point

```
lst = [1, -2, -3, 4, 5]
def func1(x):
    return x < 2

it = filter(func1, lst)
print(list(it))
```

What is the output of the code shown?

A: [1, 4, 5]

B: Error

C: [-2, -3]

D: [1, -2, -3, None, None]

E: None of the above

Check point

```
lst = [1, -2, -3, 4, 5]

def func1(x):
    return x < -1

it = map(func1, lst)
print(list(it))
```

What is the output of the code shown?

A: [False, False, False, False, False]

B: [False, True, True, False, False]

C: [True, False, False, True, True]

D: [True, True, True, True, True]

E: None of the above

Questions from last week video lecture

```
d = { (1,2):1, (2,3):2 }

print(d[1,2])
```

What Will Be The Output

A: KeyError

B: 1

C: {(2,3):2}

D: {(1,2):1}

E: None of the above

Question based on last week video lecture

```python
basket = {}

def addone(index):
    if index in basket:
        basket[index] += 1
    else:
        basket[index] = 1

addone('Apple')
addone('Banana')
addone('apple')
addone('Apple')
print (len(basket))
```

What Will Be The Output

A: 1

B: 2

C: 3

D: 4

E: None of the above

Question based on last week video lecture

```
def problem(lst, index):
    try:
        average = sum(lst)/len(lst)
        last_elem = lst[index]
    except IndexError as e:
        print('Index is wrong')
    except ZeroDivisionError as e:
        print("Can't divide by a 0")

    print("I'm safe")

problem( [1, 2, 3], 3)
```

A: Index is wrong

B: Can't divide by a 0

C: Can't divide by a 0
I’m safe

D: Index is wrong
I’m safe

E: None of the above

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problem ( [], 17)
```

A: Index is wrong

B: Can't divide by a 0

C: Can't divide by a 0
I’m safe

D: Index is wrong
I’m safe

E: None of the above

Question

- Is there a way in Python to call filter on a list where the filtering function has a *number of formal parameters* **bound** during the call ?

```
def func (a, b, c):
    return a + b < c
```

```
lst = [10, 20, 30, 40]
filter(func(a=10, c=35), lst) #Want to happen
```

```
def make_filter(a, c):
   def my_filter(b):
       return a + b < c
   return my_filter

filt = make_filter(10, 35)
lst = [10, 20, 30 , 40]

list(filter(filt, lst))
```

```
def func (a, b, c):
    return a + b < c

lst = [10, 20, 30, 40]

list(filter(lambda x: func(10, x, 35), lst))
```

Mutable Data

Mutability

- Immutable – the value of the object cannot be changed:
  - integers, floats, booleans
  - strings, tuples
- Mutable – the value of the object can be changed:
  - Lists
  - Dictionaries

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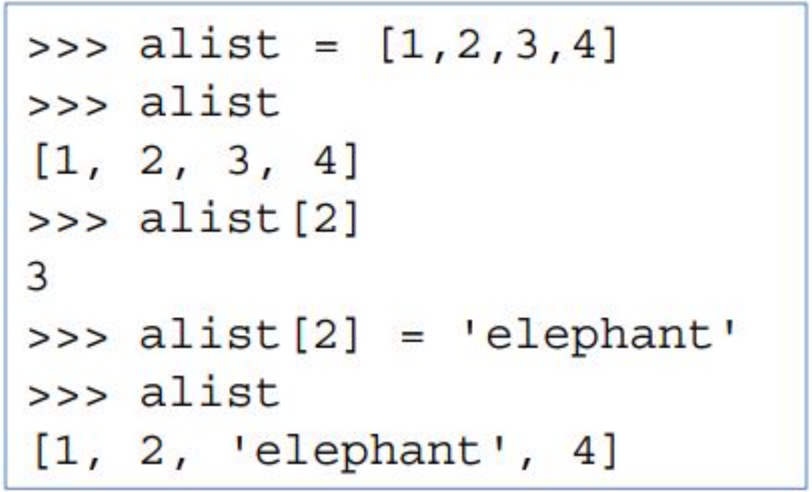

```
>>> alist = [1,2,3,4]
>>> alist
[1, 2, 3, 4]
>>> alist[2]
3
>>> alist[2] = 'elephant'
>>> alist
[1, 2, 'elephant', 4]
```

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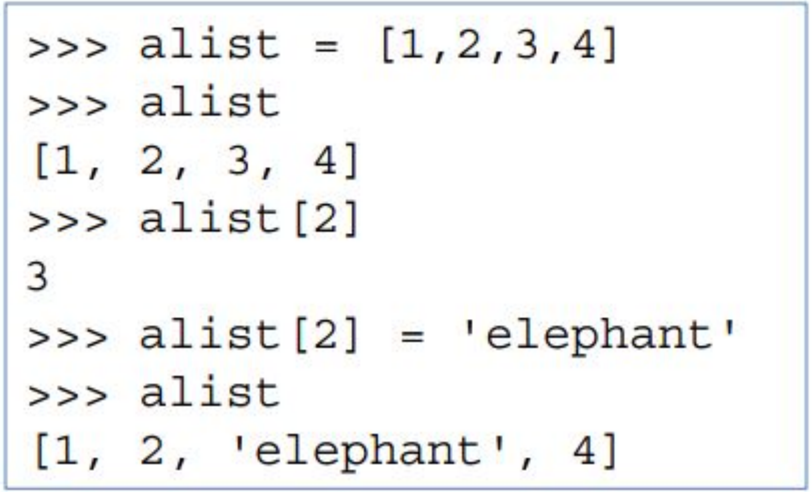

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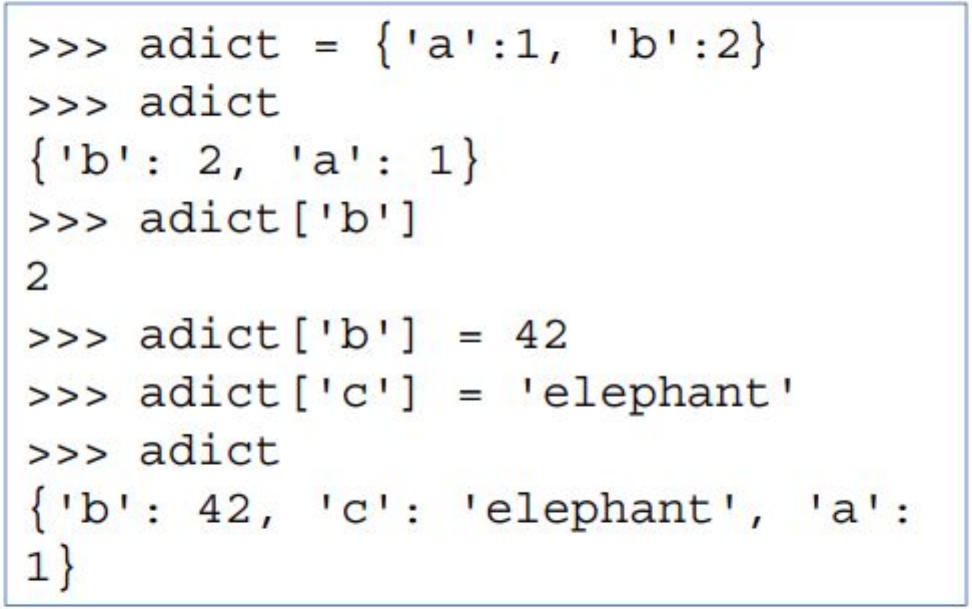

```
>>> adict = {'a':1, 'b':2}
>>> adict
{'b': 2, 'a': 1}
>>> adict['b']
2
>>> adict['b'] = 42
>>> adict['c'] = 'elephant'
>>> adict
{'b': 42, 'c': 'elephant', 'a':
1}
```

From value to storage …

- A variable assigned a compound value (object) is a **reference** to that object.
- Mutable object can be *changed* but the variable(s) still refer to it

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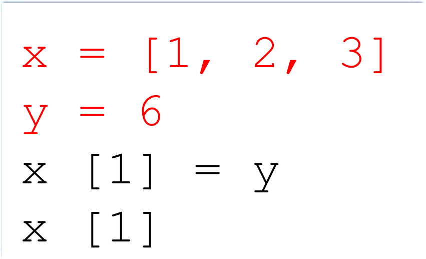
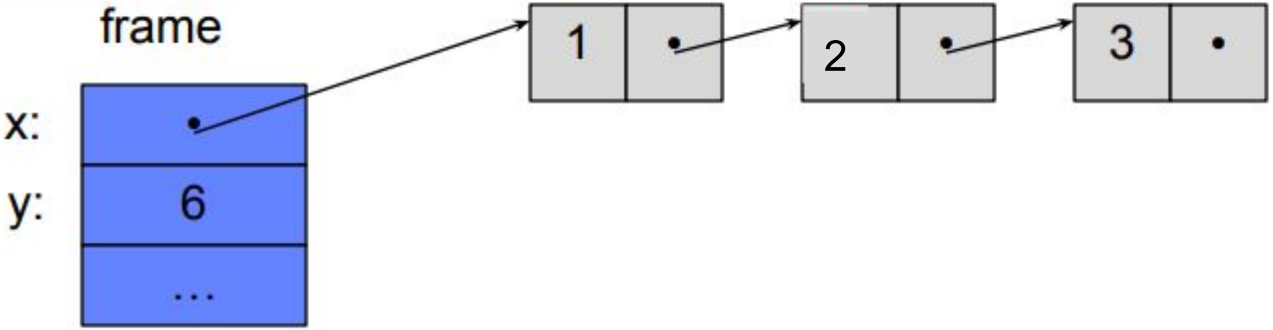


```
x = [1, 2, 3]
y = 6
x [1] = y
x [1]
```



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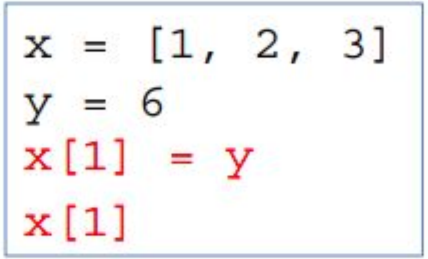

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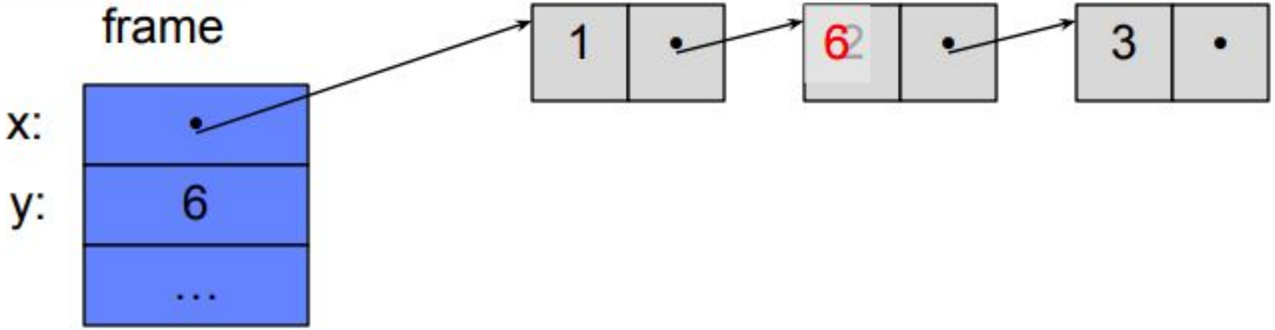


Examples

```
x = [1, 2 , 3]
y = x
print (y)
x[1] = 11
print (y)
```

```
x = [1, 2]
y = [x, x, x]
print (y)
x[1] = 3
print (y)
y[2] = [1, 3]
print (y[0] == y[2])
print (y[0] is y[2])
```

Copies, ‘is’ and ‘==‘

```
 >>> alist = [1, 2, 3, 4]
 >>> alist == [1, 2, 3, 4]  # Equal values?

 True

 >>> alist is [1, 2, 3, 4] # same object?

  False
>>> blist = alist          # assignment refers
>>> alist is blist         # to same object. Shallow copy

 True

 >>> blist = list(alist)   # type constructors copy
 >>> blist is alist         # Deep copy

 False
```

Copies, ‘is’ and ‘==‘

```
>>> alist = [1, 2, 3, 4]
>>> alist == [1, 2, 3, 4]  # Equal values?

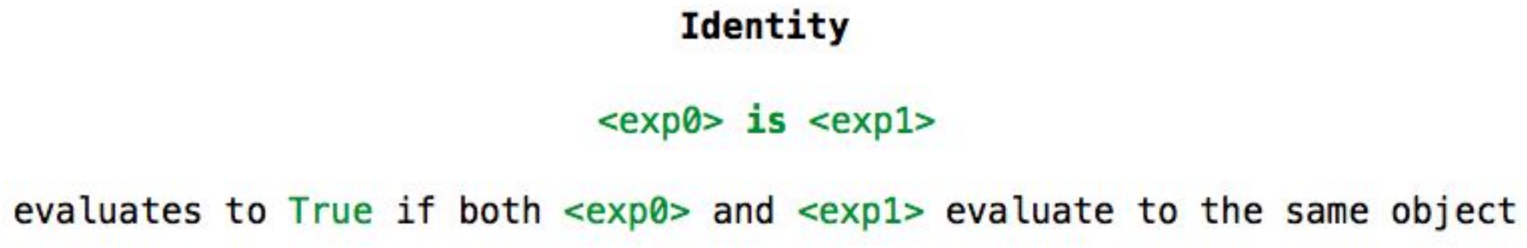
True

>>> blist = alist[ : ]     # so does slicing
>>> blist is alist

False

>>> blist
[1, 2, 3, 4]
>>>
```

Identity Operators: is is not

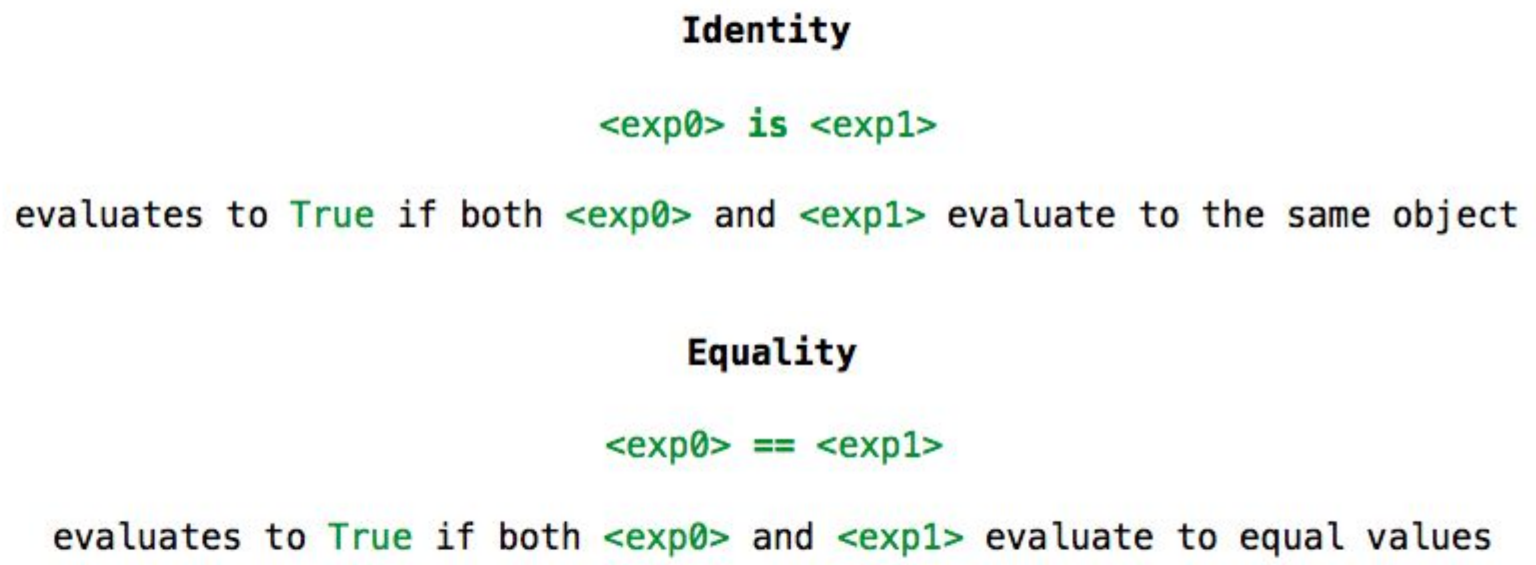


Identity

```
<exp0> is <exp1>
```

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

Identity Operators



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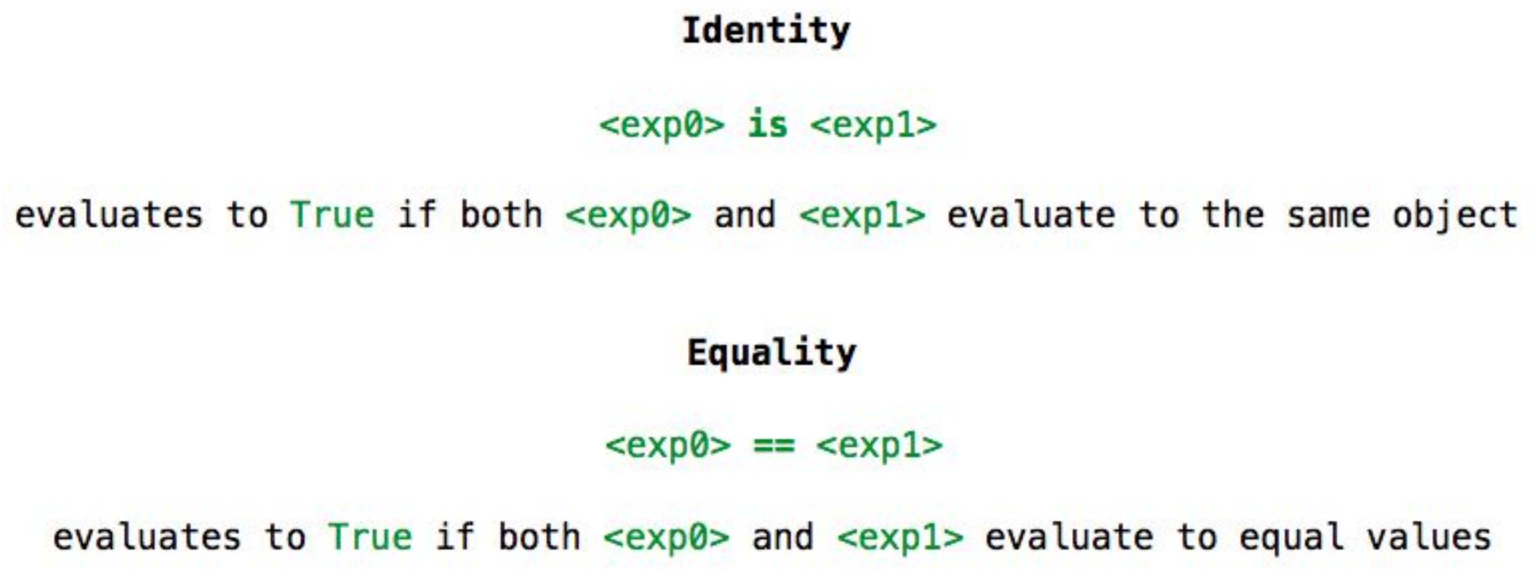

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Equality

`<exp0> == <exp1>`

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

Identical objects are always equal values

Parameter passing: Output?

```
def test (x):
    x = x + 1
y = 10
test(y)
print(y)
```

A: 10

B: 11

C: None

D: Error

E: I do not know

Parameter passing: Output?

```
def test (x):
    x[0] = x[0] + 1
y = [1, 2, 3]
test(y)
print(y)
```

A: [1, 2, 3]

B: [2, 2, 3]

C: None

D: Error

E: I do not know