Sharing, mutability, and immutability

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Copying and mutation

```python
list1 = ['e1', 'e2', 'e3', 'e4']
list2 = list1
list3 = list(list1)  # make a copy; also "list1[:]"

print(list1, list2, list3)
list1.append('e5')
list2.append('e6')
list3.append('e7')

print(list1, list2, list3)
list1 = list3
list1.append('e8')
print(list1, list2, list3)
```

Variable reassignment vs. Object mutation

• Reassigning a **variable** changes a **binding**, it does not change (mutate) any **object**

  Reassigning is **always** done via the syntax:

  ```
  myvar = expr
  size = 6
  list2 = list1
  ```

  Changes what the variables `size` and `list2` are bound to

  ```
  Changes something about the object that `mylist` refers to
  ```

  ```
  Examples:
  ```
  mylist[3] = myvalue
  ```

• Mutating (changing) an **object** does not change any **variable** binding

  Two syntaxes:

  ```
  left_expr = right_expr
  ```

  ```
  expr.method(args...)
  ```

  ```
  Examples:
  ```
  mylist.append(myvalue)
Example: Variable reassignment or Object mutation?

def no_change(lst):
    """does NOT modify what lst refers to, instead re-binds lst""
    lst = lst + [99]
def change_val(lst):
    """modifies object lst refers to""
    lst[0] = 13
def append_val(lst):
    """modifies object lst refers to""
    lst.append(99)

lst2 = [1, 2]
no_change(lst2)
change_val(lst2)
append_val(lst2)

See in python tutor
New and old values

• Every **expression** evaluates to a value
  – It might be a new value
  – It might be a value that already exists

• A **constructor** evaluates to a **new** value:
  \[ [3, 1, 4, 1, 5, 9] \]
  \[ [3, 1, 4] + [1, 5, 9] \]
  \[ mylist = [[[3, 1], [4, 1]]] \]

• An **access** expression evaluates to an **existing** value:
  \[ mylist[1] \]

• What does a function call evaluate to?
Example: Lists of lists

```python
def make_new_grid(grid):
    new_grid = []
    for row in grid:
        new_grid.append(row)
    new_grid[0][0] = 99
    return new_grid

grid1 = [[1, 2, 3], [4, 5, 6]]
grid2 = make_new_grid(grid1)
grid2[0][1] = 88

Be careful you do not unintentionally change parts of an input parameter!
```
An aside: List notation

• Possibly misleading notation:

```
list
“four” | “score” | “and” | “seven” | “years”
```

• More accurate, but more verbose, notation:

```
list
↓     ↓     ↓     ↓     ↓
“four” “score” “and” “seven” “years”
```
Aside: Object identity

- An object’s **identity** never changes
- Can think of it as its **address in memory**
- Its value of the object (the thing it represents) may change

```python
mylist = [1, 2, 3]
otherlist = mylist
mylist.append(4)

mylist is otherlist  ⇒  True
                      mylist and otherlist  refer to the **exact same object**

mylist == [1, 2, 3, 4]  ⇒  True
                      The object mylist  refers to is **equal to** the object [1,2,3,4]
                      (but they are two different objects)

mylist is [1, 2, 3, 4]  ⇒  False
                      The object mylist  refers to is **not the exact same object**
                      as the object [1,2,3,4]

**Use == to check for equality, NOT is**
```

Aside: Using is with **None** is o.k:  if x is is None:
Object type and variable type

- An object’s type never changes
- A variable can get rebound to a value of a different type

Example: The variable `a` can be bound to an int or a list

```
a = 5
```
5 is always an int

```
a = [1, 2, 3, 4]
```
[1, 2, 3, 4] is always a list

- A type indicates:
  - what operations are allowed
  - the set of representable values
  - `type(object)` returns the type of an object
New datatype: tuple

• Like lists, tuples represent an ordered sequence of values
• Like strings, tuples are immutable
• The elements of a tuple can be anything (including mutable types)

Examples:
()  
(4, 7, 9)  
("hi", [1, 2], 5)
Tuple operations

Constructors

- Literals: Use parentheses
  
  ("four", "score", "and", "seven", "years")
  
  (3, 1) + (4, 1)  =>  (3, 1, 4, 1)  # creates a new tuple!

Queries

- Can index just like lists:

  ```
  tup = ("four", "score", "and", "seven", "years")
  print(tup[0])  =>  "four"
  print(tup[-1])  =>  "years"
  ```

Mutators

- Like strings, tuples are immutable, so have no mutators
Immutable datatype

• An immutable datatype is one that doesn’t have any functions in the third category:
  – Constructors
  – Queries
  – Mutators: Does not have any!

• Immutable datatypes:
  – int, float, boolean, string, tuple, frozenset

• Mutable datatypes:
  – list, dictionary, set
Remember:
Not every value may be placed in a set

• Set *elements* must be *immutable* values
  – int, float, bool, string, *tuple*
  – *not*: list, set, dictionary

• The set itself is *mutable* (e.g. we can add and remove elements)

  • *Aside*: *frozenset* must contain immutable values and is itself immutable (cannot add and remove elements)
Remember: Not every value is allowed to be a key in a dictionary

- Remember: Dictionaries hold key:value pairs
- **Keys** must be immutable
  - int, float, bool, string, *tuple of immutable types*
  - *not*: list, set, dictionary
- **Values** in a dictionary can be mutable
- The dictionary itself is mutable (e.g. we can add and remove elements)
Python’s *Data Model*

- All data is represented by **objects**
- Each object has:
  - an *identity*
    - Never changes
    - Think of this as address in memory
    - Test with *is* (but you rarely need to do so)
  - a *type*
    - Never changes
  - a *value*
    - Can change for *mutable* objects
    - Cannot change for *immutable* objects
    - Test with **==**
Mutable and Immutable Types

• **Immutable** datatypes:
  – int, float, boolean, string, function, tuple, frozenset

• **Mutable** datatypes:
  – list, dictionary, set

Note: a set is mutable, but a frozenset is immutable
Tuples are immutable
Lists are mutable

def update_record(record, position, value):
    """Change the value at the given position""
    record[position] = value

mylist = [1, 2, 3]
mytuple = (1, 2, 3)
update_record(mylist, 1, 10)
print(mylist)
update_record(mytuple, 1, 10)
print(mytuple)
Increment Example

def increment(words_dict, word):
    """increment the count for word""
    if word in words_dict:
        words_dict[word] = words_dict[word] + 1
    else:
        words_dict[word] = 1
my_words = dict()
increment(my_words, "school")
print(my_words)
def increment(value):
    """increment the value""
    value = value + 1
my_val = 5
increment(my_val)
print(my_val)
Increment Example (cont.)

```python
>>> def increment(words_dict, word):
...     """increment the count for word""
...     if word in words_dict:
...         words_dict[word] = words_dict[word] + 1
...     else:
...         words_dict[word] = 1

>>> my_words = dict()
>>> increment(my_words, "school")
>>> print(my_words)
{'school': 1}

>>> def increment(value):
...     """increment the value???'""
...     value = value + 1

>>> my_val = 5
>>> increment(my_val)
>>> print(my_val)
5
```