CS303E: Elements of Computers and Programming

Tuples, Sets, Dictionaries

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Tuples

Another useful data type in Python is **tuples**. Tuples are like immutable lists of fixed size, but allow faster access than lists.

```
>>> tuple()                        # create an empty tuple
()
>>> t1 = ()                        # special syntax
>>> t1
()
>>> t2 = tuple( [1, 2, 3] ) # 3-tuple from list
>>> t2
(1, 2, 3)
>>> (1)                            # not considered a tuple
1
>>> t3 = tuple([1])                # force 1-tuple from list
>>> t3
(1,)                               # note odd syntax
>>> t4 = (2,)
>>> t4
(2,)
```

Sequence Operations for Tuples

Tuples, like strings and list, are sequences and inherit various functions from sequences. Like strings, but unlike lists, they are immutable.

Function	Description
`x in t`	x is in tuple t
`x not in t`	x is not in tuple t
`t1 + t2`	concatenates two tuples
`t * n`	repeat tuple t n times
`t[i]`	ith element of tuple (0-based)
`t[i:j]`	slice of tuple t from i to j-1
`len(t)`	number of elements in t
`min(t)`	minimum element of t
`max(t)`	maximum element of t
`sum(t)`	sum of elements in t
`for loop`	traverse elements of tuple
`<, <=, >, >=`	compares two tuples
`==, !=`	compares two tuples

Some Tuple Examples

```
>>> t1 = tuple([ 1, "red", 2.3 ])       # tuple from list
>>> 'red' in t1
True
>>> 'green' in t1
False
>>> t1 + ("green", 4.5 )                 # tuple concatenation
(1, 'red', 2.3, 'green', 4.5)
>>> t2 = t1 * 3                          # repeat tuple
>>> t2
(1, 'red', 2.3, 1, 'red', 2.3, 1, 'red', 2.3)
>>> t2[3]                                # indexing
1
>>> len(t2)                              # using len
9
>>> min(t2)                              # using min
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: '<' not supported between 'str' and 'int'
>>> t3 = tuple( [ x for x in range(11) ] )
>>> t3
(0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10)
```

Some Tuple Examples

If you want to manipulate (e.g., shuffle) a tuple, you can convert to a list first, and then back to a tuple.

```
>>> t3
(0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10)
>>> lst = list( t3 )
>>> lst
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
>>> import random
>>> lst2 = random.shuffle( lst )   # a common error!
>>> print(lst2)                    # what happened?
None
>>> random.shuffle( lst )          # shuffles in place
>>> lst
[1, 4, 7, 3, 5, 0, 6, 9, 8, 2, 10]
>>> tuple(lst)
(1, 4, 7, 3, 5, 0, 6, 9, 8, 2, 10)
```

Functions Returing Tuples

Functions can return tuples just as they can return other values. Specifically, if they return multiple values, they are really returning a tuple.

In file `Tuple.py`:

```
def MultiValues (x):
    return x + 4, x - 4, x ** 2  # 3-tuple
```

```
>>> from Tuple import *
>>> MultiValues( 9 )              # returns 3-tuple
(13, 5, 81)
>>> t1 = MultiValues( 9 )         # save as 3-tuple
>>> t1[0]
13
>>> x, y, z = MultiValues( 9 ) # save separately
>>> print( "x:", x, "y:", y, "z:", z )
x: 13 y: 5 z: 81
```

Sets

Sets are similar to lists except:

- sets don't store duplicate elements;
- sets are not ordered.

```
>>> s1 = set()                      # empty set
>>> s1
set()                               # notice odd syntax
>>> s1 is {}                        # {} is a dictionary,
False                               #   not a set
>>> type({})
<class 'dict'>
>>> type(set())
<class 'set'>
>>> s2 = set([1, 2, 2, 4, 3])       # set from list
>>> s2
{1, 2, 3, 4}                        # no duplicates
>>> set("abcda")                    # set from string
{'d', 'a', 'c', 'b'}
>>> {'d', 'a', 'c', 'b'} == {'a', 'c', 'b', 'd'}
True                                # order doesn't matter
>>> t = ("abc", 4, 2.3)
>>> set(t)                          # set from tuple
{2.3, 'abc', 4}
```

Some Functions on Sets

The following sequence functions are available on sets.

Function	Description
`x in s`	x is in set s
`x not in s`	x is not in set s
`len(s)`	number of elements in s
`min(s)`	minimum element of s
`max(s)`	maximum element of s
`sum(s)`	sum of elements in s
`for loop`	traverse elements of set

Set Examples

```
>>> s = {1, 2, "red", "green", 3.5 }
>>> s
{1, 2, 3.5, 'green', 'red'}     # order doesn't matter
>>> 2 in s
True
>>> 3 in s
False
>>> len( s )
5
>>> min( s )                    # items must be comparable
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: '<' not supported between 'str' and 'int'
>>> min( { -2, 17, 9, 4 } )
-2
>>> max( { -2, 17, 9, 4 } )
17
>>> sum( { -2, 17, 9, 4 } )
28
>>> for i in s: print( i, end = " " )
...
1 2 3.5 green red >>>
```

Additional Set Functions

Like lists, sets are mutable. These two methods alter the set.

Function	Description
s.add(e)	add e to set s
s.remove(e)	remove e from set s

```
>>> s = set()                       # create empty set
>>> s
set()
>>> s.add(2.5)                      # changes s
>>> s.add("red")                    # changes s
>>> s.add(1)                        # changes s
>>> s.add("red")                    # change?
>>> s
{1, 2.5, 'red'}
>>> s.remove("green")               # item must appear
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
KeyError: 'green'
>>> s.remove("red")                 # changes s
>>> s
{1, 2.5}
```

Subset and Superset

s1 is a *subset* of s2 if every element of s1 is also an element of s2. If s1 is a subset of s2, then s2 is a *superset* of s1.

Function	Description
s1.issubset(s2)	s1 is a subset of s2
s2.issuperset(s1)	s1 is a subset of s2

Notice that s is always a subset and superset of itself.

```
>>> s1 = { 2, 3, 5, 7 }
>>> s2 = { 2, 5, 7 }
>>> s2.issubset(s1)
True
>>> s1.issuperset(s2)
True
>>> s1.issubset(s1)
True
>>> s2.add(8)
>>> s2
{8, 2, 5, 7}
>>> s2.issubset(s1)
False
```

Subset: Alternate Syntax

Function	Description
`s1 <= s2`	s1 is a subset of s2
`s1 < s2`	s1 is a proper subset of s2
`s2 >= s1`	s2 is a superset of s1
`s2 > s1`	s2 is a proper superset of s1

s1 is a *proper* subset of s2 if s1 is a subset of s2, but not equal to s2.

```
>>> s1 = { 1, 2, 3 }
>>> s2 = { 0, 1, 2, 3, 4 }
>>> s1 < s2                     # is s1 a proper subset of s2
True
>>> s1 <= s2                    # is s1 a subset of s2
True
>>> s1 < s1                     # is s1 a proper subset of itself
False
>>> s1 <= s1                    # is s1 a subset of itself
True
>>> s2 > s1                     # is s2 a proper superset of s1
True
```

Set Operations

The following operations take two sets and return a new set.

Function	Alternate Syntax	Description
`s1.union(s2)`	`s1 | s2`	elements in s1 or s2
`s1.intersection(s2)`	`s1 & s2`	elements in both s1 and s2
`s1.difference(s2)`	`s1 - s2`	elements in s1 but not in s2
`s1.symmetric_difference(s2)`	`s1 ^ s2`	elements in s1 or s2, but not both

```
>>> s1 = { 1, 2, 3 }
>>> s2 = { 1, 3, 5, 7 }
>>> s1.union(s2)                  # new set
{1, 2, 3, 5, 7}
>>> s2.union(s1)                  # new set, commutes
{1, 2, 3, 5, 7}
>>> s1 | s2                       # alternate syntax
{1, 2, 3, 5, 7}
```

Set Operations

```
>>> s1 = { 1, 2, 3 }
>>> s2 = { 1, 3, 5, 7 }
>>> s1.intersection(s2)       # new set
{1, 3}
>>> s1 & s2                   # alternate syntax
{1, 3}
>>> s1.difference(s2)         # new set
{2}
>>> s2.difference(s1)         # not commutative
{5, 7}
>>> s1 - s2 == s2 - s1
False
>>> s1.symmetric_difference(s2) # new set
{2, 5, 7}
>>> s1 ^ s2                  # alternate syntax
{2, 5, 7}
>>> s2 ^ s1                  # commutes
{2, 5, 7}
```

Set Example: Count Keywords

In file `CountKeywords.py`:

```
import os.path

def CountKeywordsWithSet():
    """ Count the number of occurrence of keywords in a
        Python source code file specified by the user. """
    keywords = \
       { "and", "as", "assert", "break", "class",
         "continue", "def", "del", "elif", "else",
         "except", "False", "finally", "for", "from",
         "global", "if", "import", "in", "is", "lambda",
         "nonlocal", "None", "not", "or", "pass", "raise",
         "return", "True", "try", "while", "with", "yield" }

    # Accept a filename from the user.
    filename = input("Enter a filename: ").strip()
    # Check that the file exists.
    if not os.path.isfile( filename ):
        print( "File", filename, "does not exist.")
        return
    infile = open(filename, "r")
```

Code continues on next slide.

Set Example: Count Keywords

```
    # Read the file line by line, counting keywords.
    count = 0
    keywordsFound = set()
    line = infile.readline()
    while line:
        words = line.split()
        # Record keywords found in set keywordsFound.
        for word in words:
            if word in keywords:
                count += 1
                keywordsFound.add( word )
        line = infile.readline()
    # Print the results.
    print("Found", count, "keyword occurrences in file",
        filename)
    print("Keywords found:", keywordsFound )

CountKeywordsWithSet()
```

Set Example: Count Keywords

```
> python CountKeywords.py
Enter a filename: CountKeywords.py
Found 13 keyword occurrences in file CountKeywords.py
Keywords found: {'def', 'import', 'not', 'from', 'in', 'for'
    , 'if', 'return'}
```

This program could be improved. Can you see how?

Set Example: Count Keywords

```
> python CountKeywords.py
Enter a filename: CountKeywords.py
Found 13 keyword occurrences in file CountKeywords.py
Keywords found: {'def', 'import', 'not', 'from', 'in', 'for'
    , 'if', 'return'}
```

This program could be improved. Can you see how?

Since we split on whitespace, this will miss keywords that have adjacent punctuation like "True:"

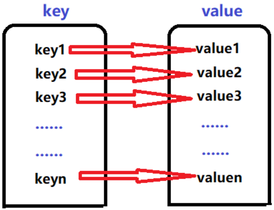
Let's Take a Break

A Python **dictionary** stores a set of key/value pairs. It enables very fast retrieval, deletion and updating of values using the keys.

```
squares = { 2 : 4, 3 : 9, 4 : 16, 5 : 25 }
```

Imagine a regular dictionary; associated with each word is a definition.

The word is the **key**, and the definition is the **value**.



The most fundamental operation is being able (quickly) to look up the value associated with the key.

Dictionary Manipulations

Use curly braces ({}) to denote a dictionary (and a set).

To add (or change) an item in a dictionary, use the syntax:

```
dictionaryName[key] = value
```

To retrieve the value associated with `key`, use:

```
dictionaryName[key]
```

To delete a key/value from the dictionary:

```
del dictionaryName[key]
```

```
>>> midterms = {}                # empty dictionary
>>> midterms['Susie'] = 80       # add 'Susie' : 80
>>> midterms['Frank'] = 87       # add 'Frank' : 87
>>> midterms['Albert'] = 56      # add 'Albert': 56
>>> midterms
{'Susie': 80, 'Frank': 87, 'Albert': 56}
>>> midterms['Susie'] = 82       # change Susie's grade
>>> midterms['Charles'] = 79     # add 'Charles': 79
```

Dictionary Manipulations

```
>>> midterms                          # show midterms
{'Susie': 82, 'Frank': 87, 'Albert': 56, 'Charles': 79}
>>> midterms['Frank']                 # what's Frank's grade
87
>>> midterms['Susie'] = 'dropped' # record Susie dropped
>>> midterms
{'Susie': 'dropped', 'Frank': 87, 'Albert': 56, 'Charles':
    79}
>>> midterms['Susie']                 # what's Susie's grade
'dropped'
>>> del midterms['Albert']            # delete Albert's record
>>> midterms
{'Susie': 'dropped', 'Frank': 87, 'Charles': 79}
>>> del midterms['Tony']              # delete Tony's record
Traceback (most recent call last):    # Tony's not in the
  File "<stdin>", line 1, in <module> # class
KeyError: 'Tony'
```

As of Python 3.7, dictionaries are kept in the order items were entered. However, it's a bad idea to rely on the order.

Looping Over a Dictionary

The most common way to iterate over a dictionary is to loop over the keys.

```
for key in dictionaryName:
    < body >
```

```
>>> midterms = {'Susie': 'dropped', 'Frank': 87, 'Charles':
    79}
>>> for key in midterms:
...     print( key, ":", midterms[key] )
...
Susie : dropped
Frank : 87
Charles : 79
```

Notice that dictionary keys (like sets) are not ordered. Two dictionaries are equal if they contain the same pairs:

```
>>> {'Susie':14, 'Frank':87} == {'Frank':87, 'Susie':14}
True
```

Dictionary Functions

The following sequence functions work for dictionaries:

Function	Description
`key in dict`	key is in the dict
`key not in dict`	key is not in dict
`len(dict)`	number of key/value pairs in dict
`min(dict)`	minimum key in dict, if comparable
`max(dict)`	maximum key in dict, if comparable
`sum(dict)`	sum of keys in dict, if summable
`for key in dict`	traverse dictionary
`==, !=`	compares two dictionaries

Dictionary Function Examples

```
>>> dict1 = {'Susie':87, 'Frank':78, 'Charles':90}
>>> 'Susie' in dict1
True
>>> 'susie' in dict1          # case matters
False
>>> 'frank' not in dict1
True
>>> len( dict1 )              # number of key/value pairs
3
>>> min( dict1 )              # minimum key
'Charles'
>>> max( dict1 )              # maximum key
'Susie'
>>> sum( dict1 )              # only if keys are summable
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: unsupported type(s) for +: 'int' and 'str'
>>> squares = {2:4, 3:9, 4:16, 5:25, 6:36}
>>> sum(squares)              # sums keys, not values
20
```

Other Dictionary Methods

These are methods from class `dict`. Dictionaries are mutable; the final three change `d`.

Function	Description
`d.keys()`	return the keys of d as a tuple*
`d.values()`	return the values of d as a tuple*
`d.items()`	return the key/value pairs from d as a tuple*
`d.get(key)`	return the value for the key, same as `d[key]`
`d.clear()`	delete all items in d
`d.pop(key)`	remove item with key and return the value
`d.popitem()`	remove a randomly selected item and return that key/value pair

Why wouldn't it make sense for `d.popitem()` to return the last item of d as in a list?

*It's not exactly a tuple. See the following slide on "Dictionary Views."

Other Dictionary Methods

```
>>> dict1 = {'Susie':87, 'Frank':78, 'Charles':90}
>>> dict1.keys()
dict_keys(['Susie', 'Frank', 'Charles'])
>>> dict1.values()
dict_values([87, 78, 90])
>>> dict1.items()
dict_items([('Susie', 87), ('Frank', 78), ('Charles', 90)])
>>> dict1.get('Frank')
78
>>> dict1.pop('Charles')
90
>>> dict1
{'Susie': 87, 'Frank': 78}
>>> dict1['Bernard'] = 92
>>> dict1
{'Susie': 87, 'Frank': 78, 'Bernard': 92}
>>> dict1.popitem()
('Bernard', 92)
>>> dict1.popitem()
('Frank', 78)
>>> dict1.clear()
>>> dict1
{}
```

Dictionary Views

```
>>> dict1.keys()
dict_keys(['Susie', 'Frank', 'Charles'])
>>> dict1.values()
dict_values([87, 78, 90])
>>> dict1.items()
dict_items([('Susie', 87), ('Frank', 78), ('Charles', 90)])
>>>
```

Those odd types `dict_keys`, `dict_values`, `dict_items` are *dictionary views*. They're tied to the dictionary; if you change the dictionary, the views change even if you try to save them into a variable.

```
>>> dict.items()
dict_items([('Susie', 50), ('Frank', 88)])
>>> x = dict.items()
>>> x
dict_items([('Susie', 50), ('Frank', 88)])
>>> dict['Susie'] = 25
>>> x
dict_items([('Susie', 25), ('Frank', 88)])
>>>
```

Dictionary Example: Count Keywords

In file CountKeywords.py:

```
def CountKeywordsWithDictionary():
    """ Count the number of occurrence of keywords in a
        Python source code file specified by the user,
        using a dictionary to record the counts."""
    keywords = \
       { "and", "as", "assert", "break", "class",
         "continue", "def", "del", "elif", "else",
         "except", "False", "finally", "for", "from",
         "global", "if", "import", "in", "is", "lambda",
         "nonlocal", "None", "not", "or", "pass", "raise",
         "return", "True", "try", "while", "with", "yield" }

    # Accept a filename from the user.
    filename = input("Enter a filename: ").strip()
    # Check that the file exists.
    if not os.path.isfile( filename ):
        print( "File", filename, "does not exist.")
        return
    infile = open(filename, "r")
```

Code continues on next slide:

```
keywordsFound = {}
line = infile.readline()
while line:
    words = line.split()
    for word in words:
        # Is word is a keyword?
        if word in keywords:
            # Is it already in the dictionary?
            if word in keywordsFound:
                # If so, increment the counter
                keywordsFound[word] += 1
            else:
                # Otherwise, start counter at 1.
                keywordsFound[word] = 1
    line = infile.readline()
# How many total keywords were found?
totalCount = sum( keywordsFound.values() )
# Print the results.
print("Found", totalCount, "keyword occurrences in", \
      filename)
print("Keywords found:")
for key in keywordsFound:
    print("   ", key + ":", keywordsFound[key] )
```

Running the Code

```
>>> CountKeywordsWithDictionary()
Enter a filename: CountKeywords.py
Found 33 keyword occurrences in CountKeywords.py
Keywords found:
   import: 1
   def: 2
   in: 10
   from: 2
   if: 5
   not: 4
   return: 2
   and: 2
   as: 2
   for: 3
```

By the way, the reason the counts don't match what we got with `CountKeywordsWithSet` *is because I added the code for* `CountKeywordsWithDictionary` *to the file.*

Next stop: Recursion.