香港中文大學（深圳）
The Chinese University of Hong Kong, Shenzhen

Introduction to Computer Science: Programming Methodology

Lecture 5 List

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List

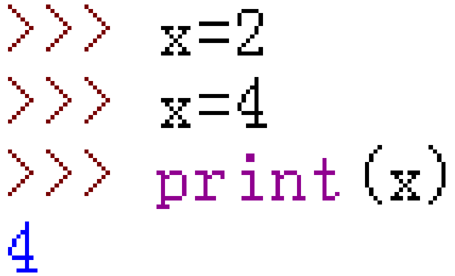
List is kind of a collection

- A collection allows us to put many values in a single “variable”

- A collection is nice because we can carry all many variables around in one convenient package

What is not a collection

- Most of our variables have only one value in them – when we put a new value in the variable, the old value will be over-written



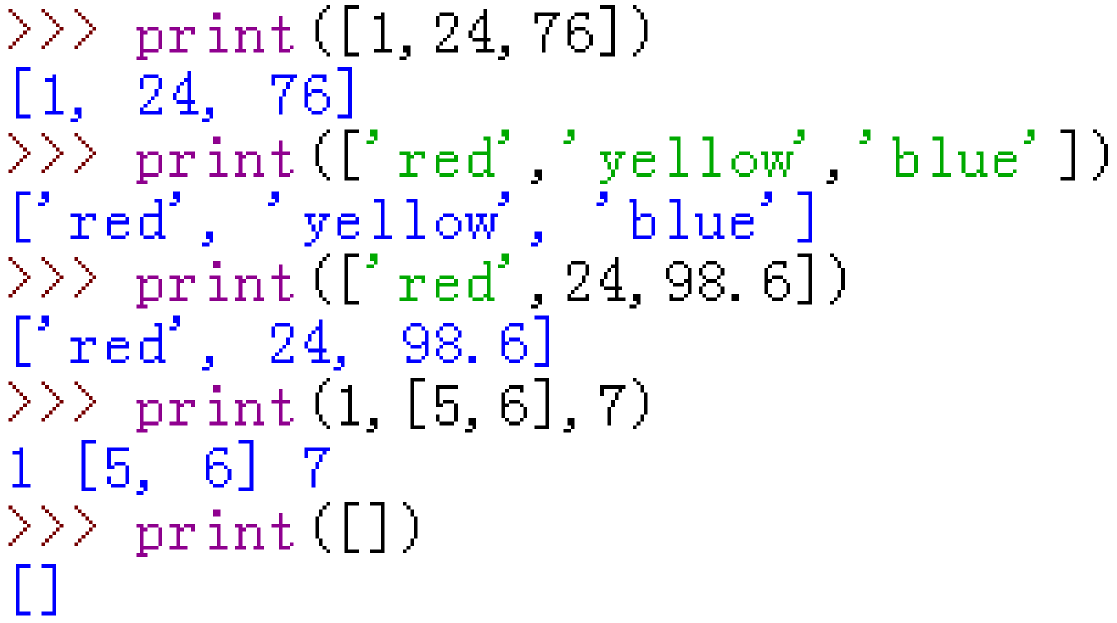
```
>>> x=2
>>> x=4
>>> print(x)
4
```

List constants

- List constants are surrounded by square brackets and the elements in the list are separated by commas

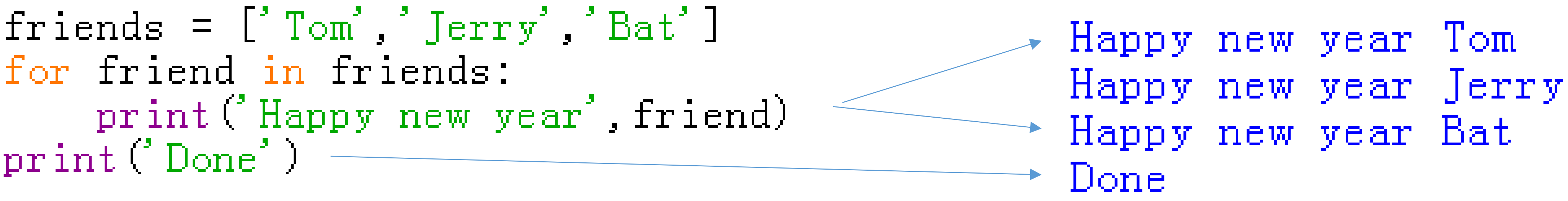
- A list element can be any Python object – even another list

- A list can be empty



```
>>> print([1,24,76])
[1, 24, 76]
>>> print([’red’,’yellow’,’blue’])
[’red’, ’yellow’, ’blue’]
>>> print([’red’,24,98.6])
[’red’, 24, 98.6]
>>> print(1,[5,6],7)
1 [5, 6] 7
>>> print([])
[]
```

List and definite loop - best pal

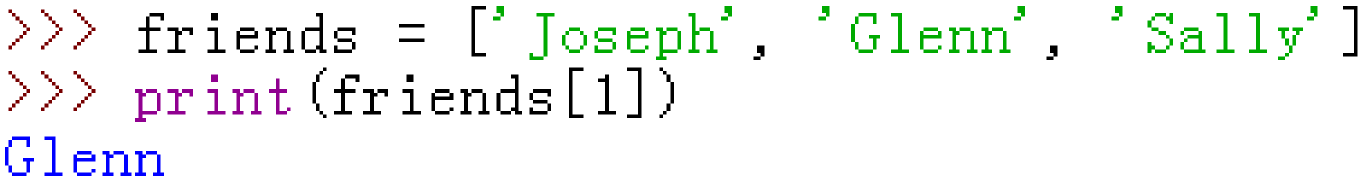


```
friends = [’Tom’,’Jerry’,’Bat’]
for friend in friends:
    print(’Happy new year’,friend)
print(’Done’)
```

```
Happy new year Tom
Happy new year Jerry
Happy new year Bat
Done
```

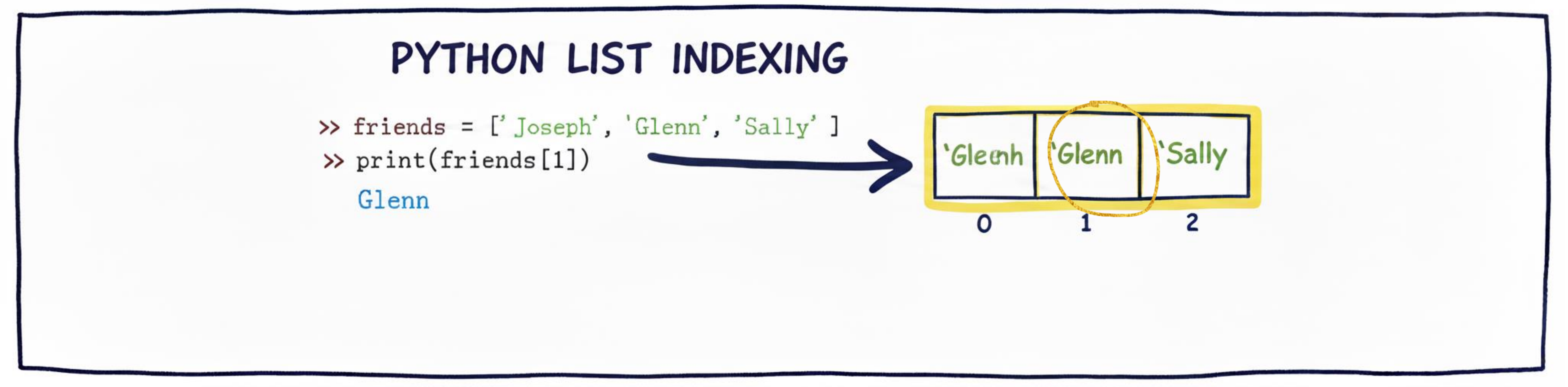
Looking inside lists

- Just like strings, we can access any single element in a list using an index specified in square bracket



```
>>> friends = ['Joseph', 'Glenn', 'Sally']
>>> print(friends[1])
Glenn
```

Looking inside lists

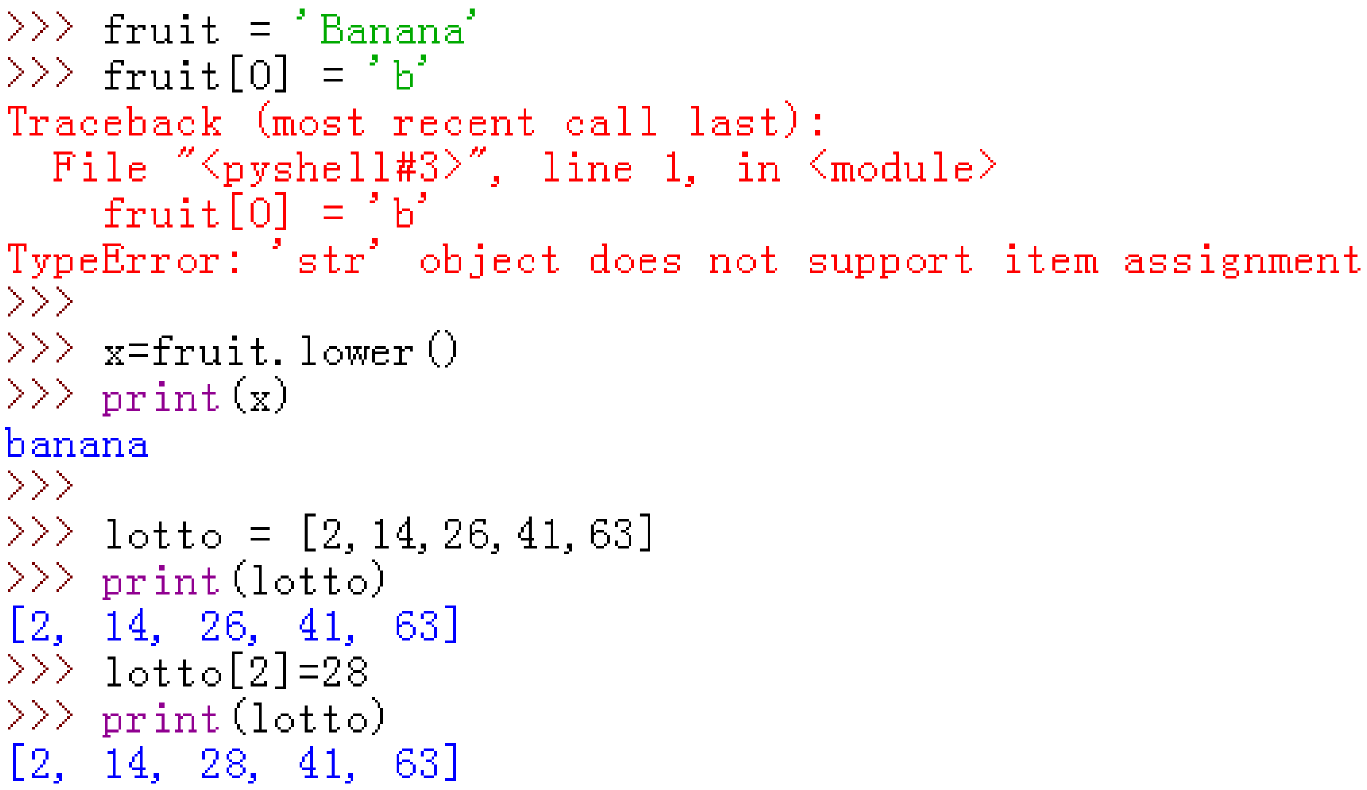


```
>> friends = [' Joseph', 'Glenn', 'Sally' ]
>> print(friends[1])
   Glenn
```

Lists are mutable

- Strings are “immutable” – we cannot change the contents of a string unless we make a new string

- Lists are “mutable” – we can change an element of a list using index operator

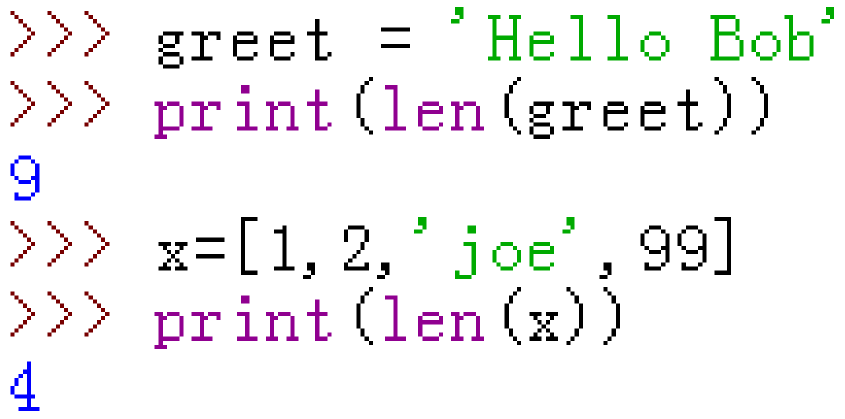


```
>>> fruit = 'Banana'
>>> fruit[0] = 'b'
Traceback (most recent call last):
  File "<pyshell#3>", line 1, in <module>
    fruit[0] = 'b'
TypeError: 'str' object does not support item assignment
>>>
>>> x=fruit.lower()
>>> print(x)
banana
>>>
>>> lotto = [2,14,26,41,63]
>>> print(lotto)
[2, 14, 26, 41, 63]
>>> lotto[2]=28
>>> print(lotto)
[2, 14, 28, 41, 63]
```

How long is a list?

- The len() function takes a list as input and returns the number of elements in that list

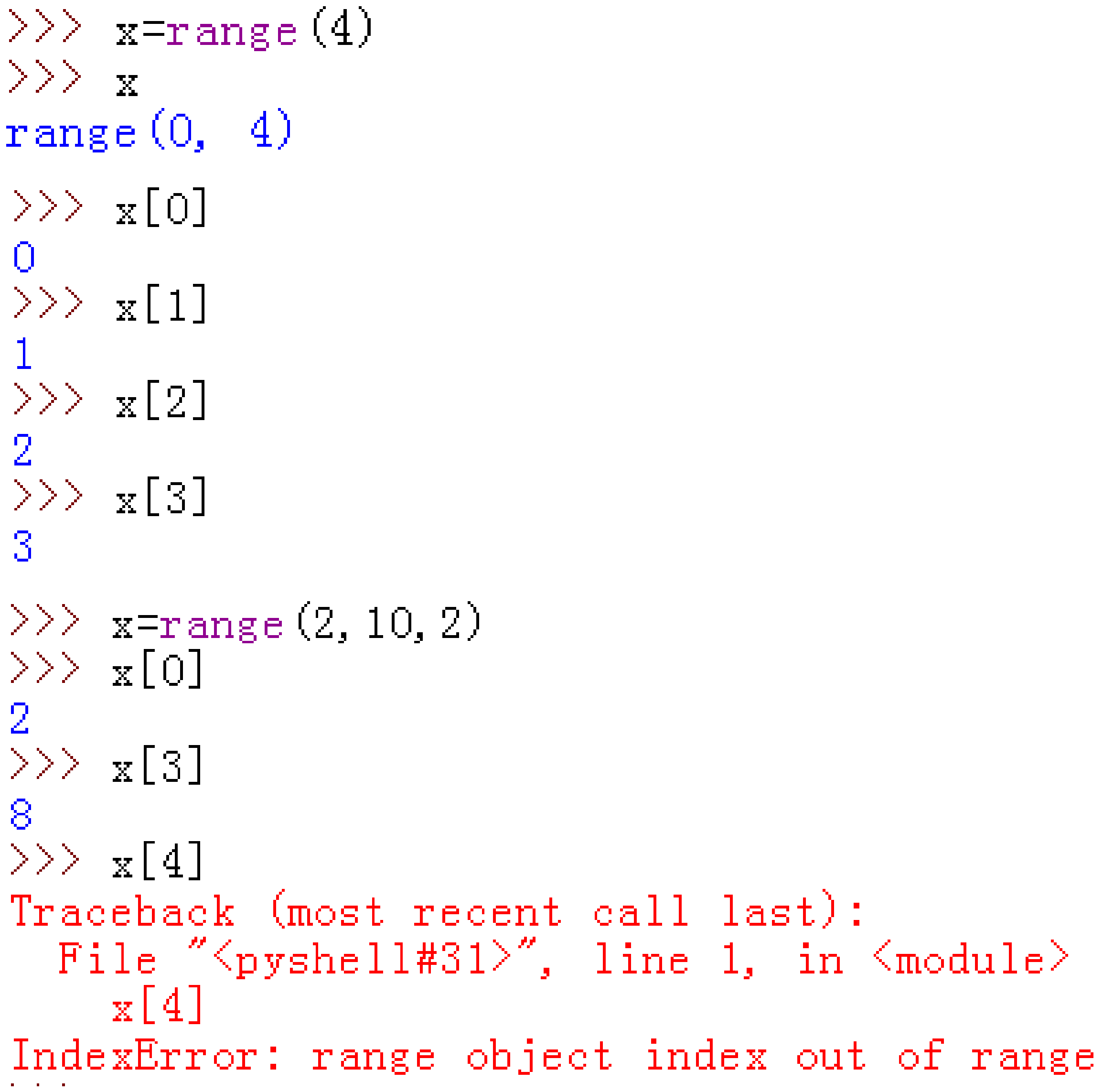
- Actually len() tells us the number of elements in any sequence (e.g. strings)



```
>>> greet = 'Hello Bob'
>>> print(len(greet))
9
>>> x=[1,2,'joe',99]
>>> print(len(x))
4
```

Range() function

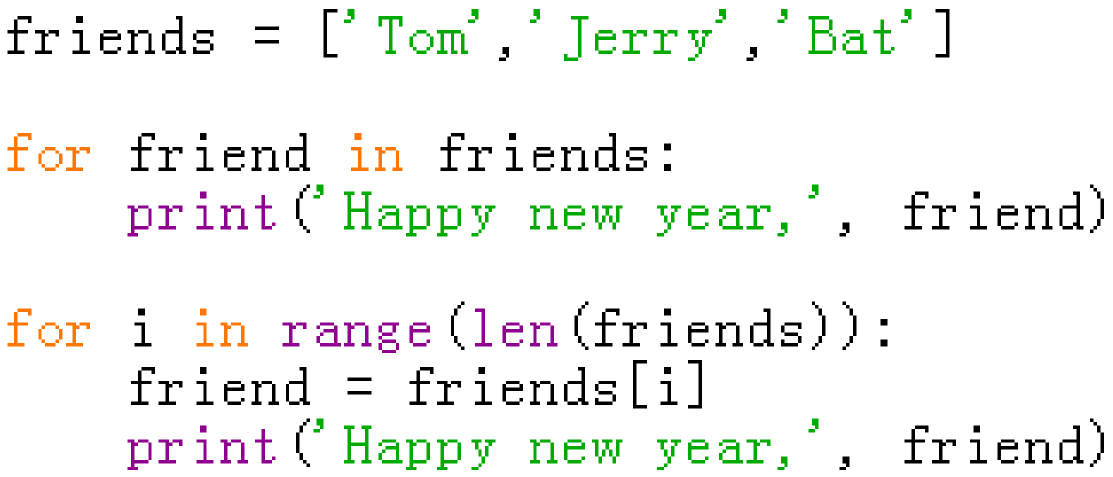
- The range() function returns a list of numbers
- We can construct an index loop using for and an integer iterator



```
>>> x=range(4)
>>> x
range(0, 4)
>>> x[0]
0
>>> x[1]
1
>>> x[2]
2
>>> x[3]
3
>>> x=range(2,10,2)
>>> x[0]
2
>>> x[3]
8
>>> x[4]
Traceback (most recent call last):
  File "<pyshell#31>", line 1, in <module>
    x[4]
IndexError: range object index out of range
```

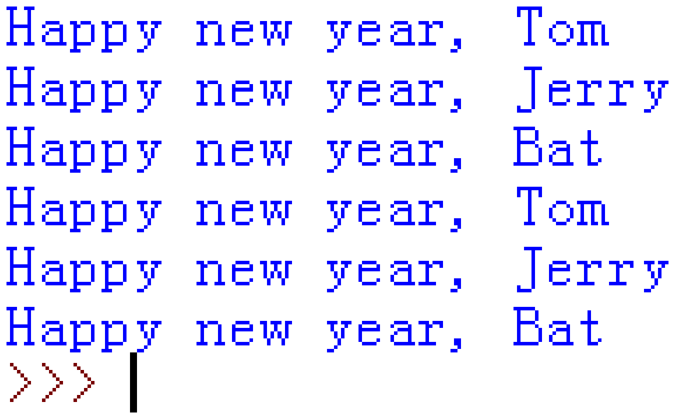
A table of two loops

Example



```
friends = [’Tom’,’Jerry’,’Bat’]

for friend in friends:
    print(’Happy new year,’, friend)

for i in range(len(friends)):
    friend = friends[i]
    print(’Happy new year,’, friend)
```

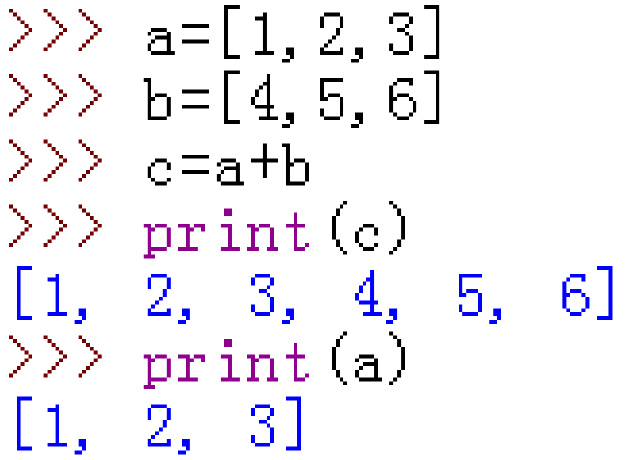
Output



```
Happy new year, Tom
Happy new year, Jerry
Happy new year, Bat
Happy new year, Tom
Happy new year, Jerry
Happy new year, Bat
>>> 
```

Concatenating lists using +

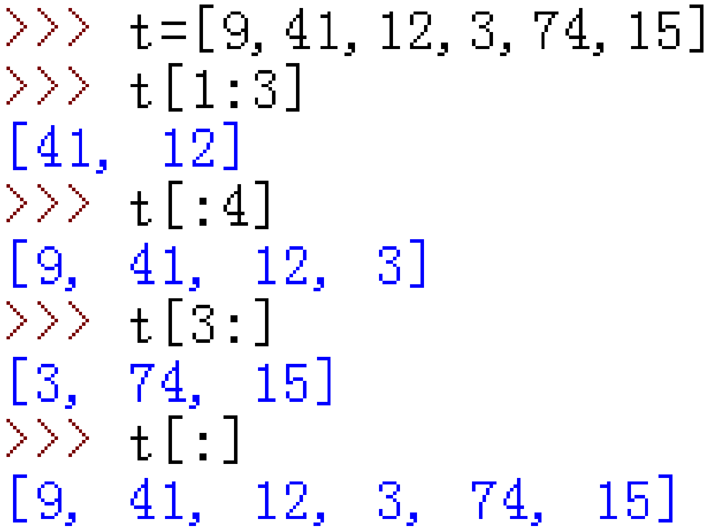
- Similar to strings, we can add two existing lists together to create a new list



```
>>> a=[1,2,3]
>>> b=[4,5,6]
>>> c=a+b
>>> print(c)
[1, 2, 3, 4, 5, 6]
>>> print(a)
[1, 2, 3]
```

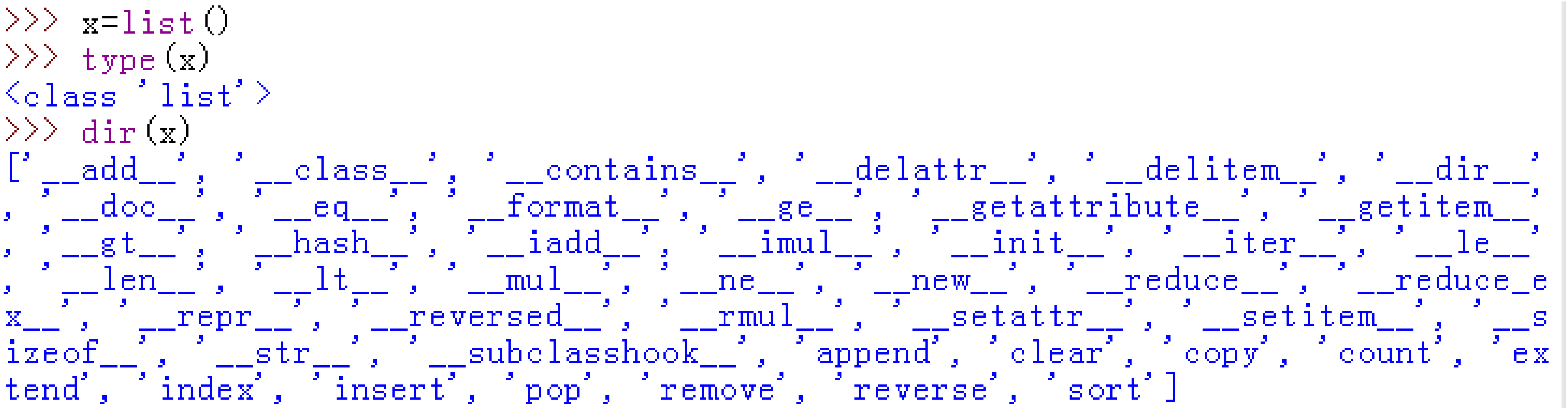
Lists can be sliced using :

- Remember: similar to strings, the second number is “up to but no including”



```
>>> t=[9,41,12,3,74,15]
>>> t[1:3]
[41, 12]
>>> t[:4]
[9, 41, 12, 3]
>>> t[3:]
[3, 74, 15]
>>> t[:]
[9, 41, 12, 3, 74, 15]
```

List methods

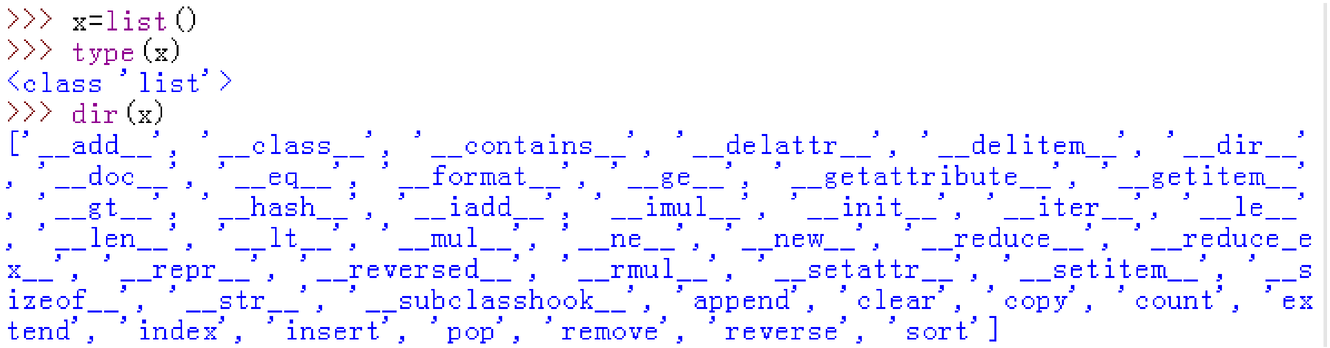


```
>>> x=list()
>>> type(x)
<class 'list'>
>>> dir(x)
['__add__', '__class__', '__contains__', '__delattr__', '__delitem__', '__dir__'
, '__doc__', '__eq__', '__format__', '__ge__', '__getattribute__', '__getitem__'
, '__gt__', '__hash__', '__iadd__', '__imul__', '__init__', '__iter__', '__le__'
, '__len__', '__lt__', '__mul__', '__ne__', '__new__', '__reduce__', '__reduce_e
x__', '__repr__', '__reversed__', '__rmul__', '__setattr__', '__setitem__', '__s
izeof__', '__str__', '__subclasshook__', 'append', 'clear', 'copy', 'count', 'ex
tend', 'index', 'insert', 'pop', 'remove', 'reverse', 'sort']
```

https://docs.python.org/3/tutorial/datastructures.html#more-on-lists

List methods

(Optional) **Naming convention**:



```
>>> x=list()
>>> type(x)
<class 'list'>
>>> dir(x)
['__add__', '__class__', '__contains__', '__delattr__', '__delitem__', '__dir__'
, '__doc__', '__eq__', '__format__', '__ge__', '__getattribute__', '__getitem__'
, '__gt__', '__hash__', '__iadd__', '__imul__', '__init__', '__iter__', '__le__'
, '__len__', '__lt__', '__mul__', '__ne__', '__new__', '__reduce__', '__reduce_e
x__', '__repr__', '__reversed__', '__rmul__', '__setattr__', '__setitem__', '__s
izeof__', '__str__', '__subclasshook__', 'append', 'clear', 'copy', 'count', 'ex
tend', 'index', 'insert', 'pop', 'remove', 'reverse', 'sort']
```

Regular Methods like append(), extend(), pop(), and copy() on lists are designed for straightforward, everyday operations that programmers need to perform on these data structures.

Special (Dunder) Methods are usually associated with enabling objects to implement and interact with Python's built-in functions and syntactic features

They are not usually called directly by the user, but are invoked **internally** by the interpreter to implement various language features. For example, when you use the len() function on a list, Python internally calls the list's __len__() method.

Building a list from scratch

- We can create an empty list using list(), and then add elements using append() method

- The list stays in order, and new elements are added at the end of the list

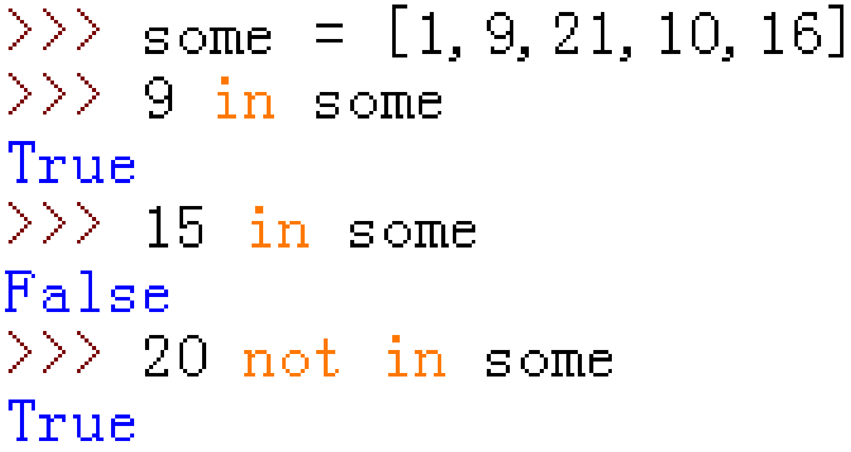
```
>>> stuff = list()
>>> stuff.append(’book’)
>>> stuff.append(99)
>>> print(stuff)
[’book’, 99]
>>> stuff.append(’cookie’)
>>> print(stuff)
[’book’, 99, ’cookie’]
```

Is something in a list

- Python provides two operators to check whether an item is in a list

- These are logical operators that return True or False

- They do not modify the list



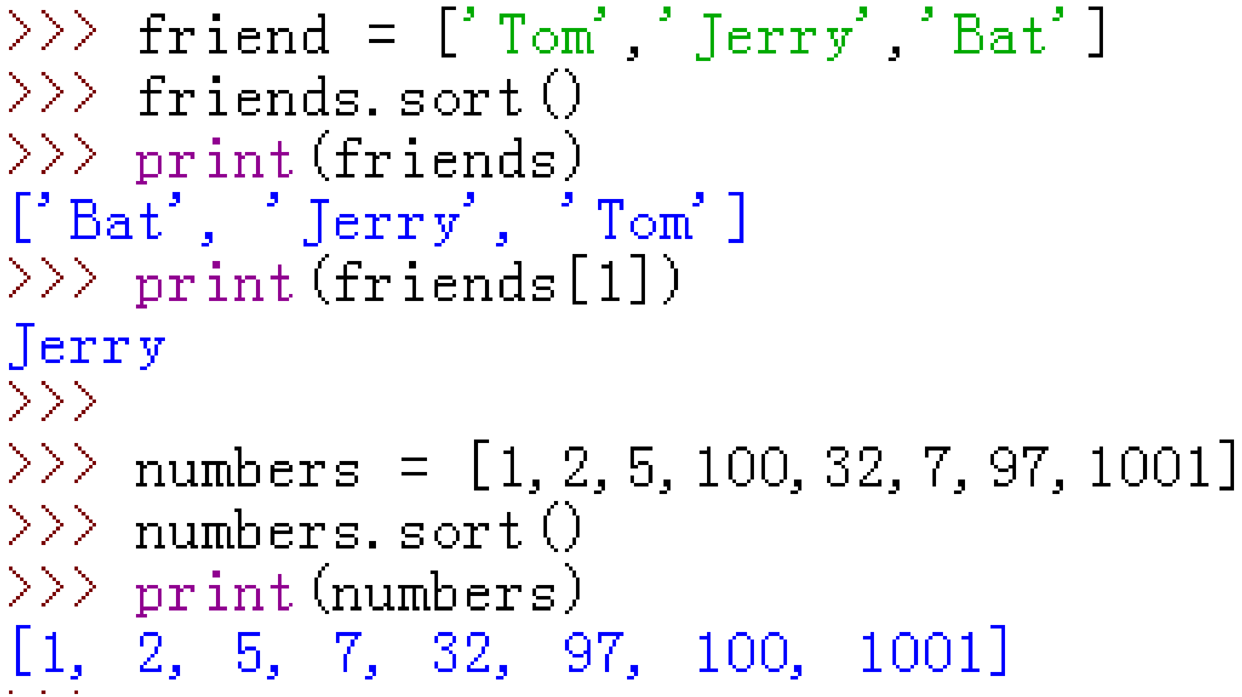
```
>>> some = [1, 9, 21, 10, 16]
>>> 9 in some
True
>>> 15 in some
False
>>> 20 not in some
True
```

A list is an ordered sequence

- A list can hold many items and keeps them in the order until we do something to change the order

- A list can be sorted (i.e. change the order)

- The sort() method means “sort yourself”

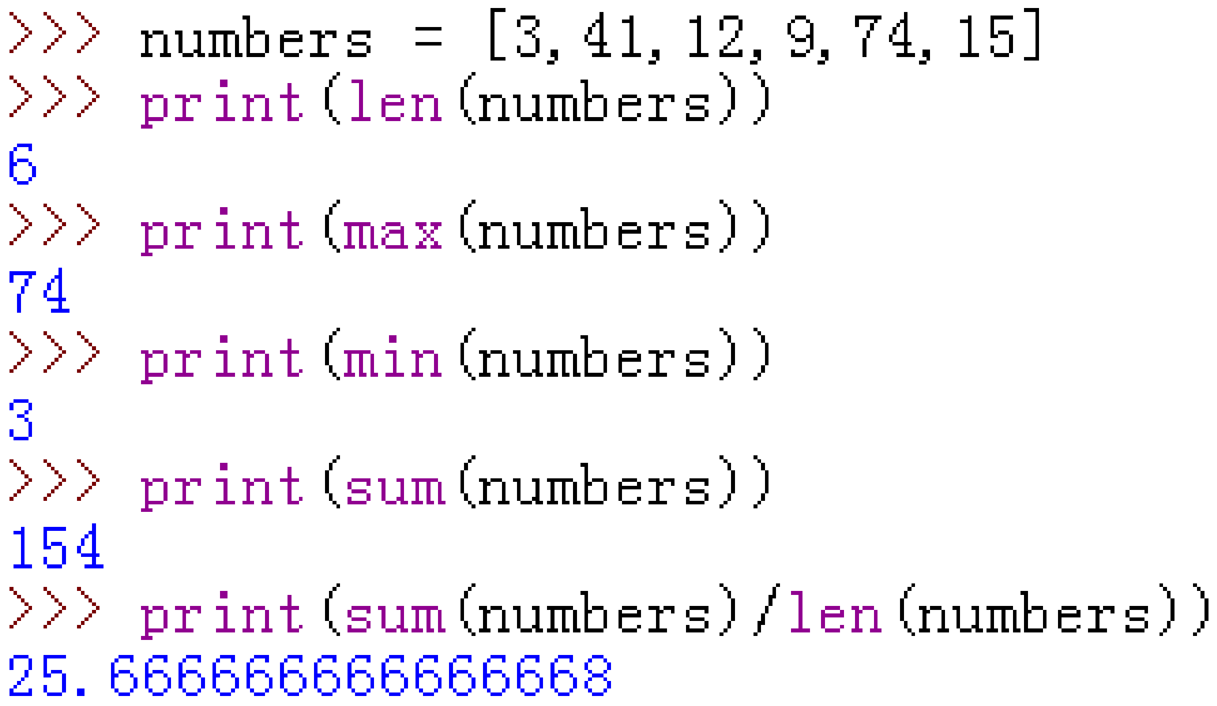


```
>>> friend = [’Tom’,’Jerry’,’Bat’]
>>> friends.sort()
>>> print(friends)
[’Bat’, ’Jerry’, ’Tom’]
>>> print(friends[1])
Jerry
>>>
>>> numbers = [1,2,5,100,32,7,97,1001]
>>> numbers.sort()
>>> print(numbers)
[1, 2, 5, 7, 32, 97, 100, 1001]
```

Built-in functions and lists

- There are a number of functions built into Python that take lists as inputs

- Remember the loops we built? These are much simpler



```
>>> numbers = [3, 41, 12, 9, 74, 15]
>>> print(len(numbers))
6
>>> print(max(numbers))
74
>>> print(min(numbers))
3
>>> print(sum(numbers))
154
>>> print(sum(numbers)/len(numbers))
25.666666666666668
```

Averaging with a list

```
total = 0
count = 0
while True:
    inp = input(’Enter a number:’)
    if inp == ’done’: break
    value = float(inp)
    total = total + value
    count = count + 1

average = total/count
print(’The average is:’, average)
```

Practice

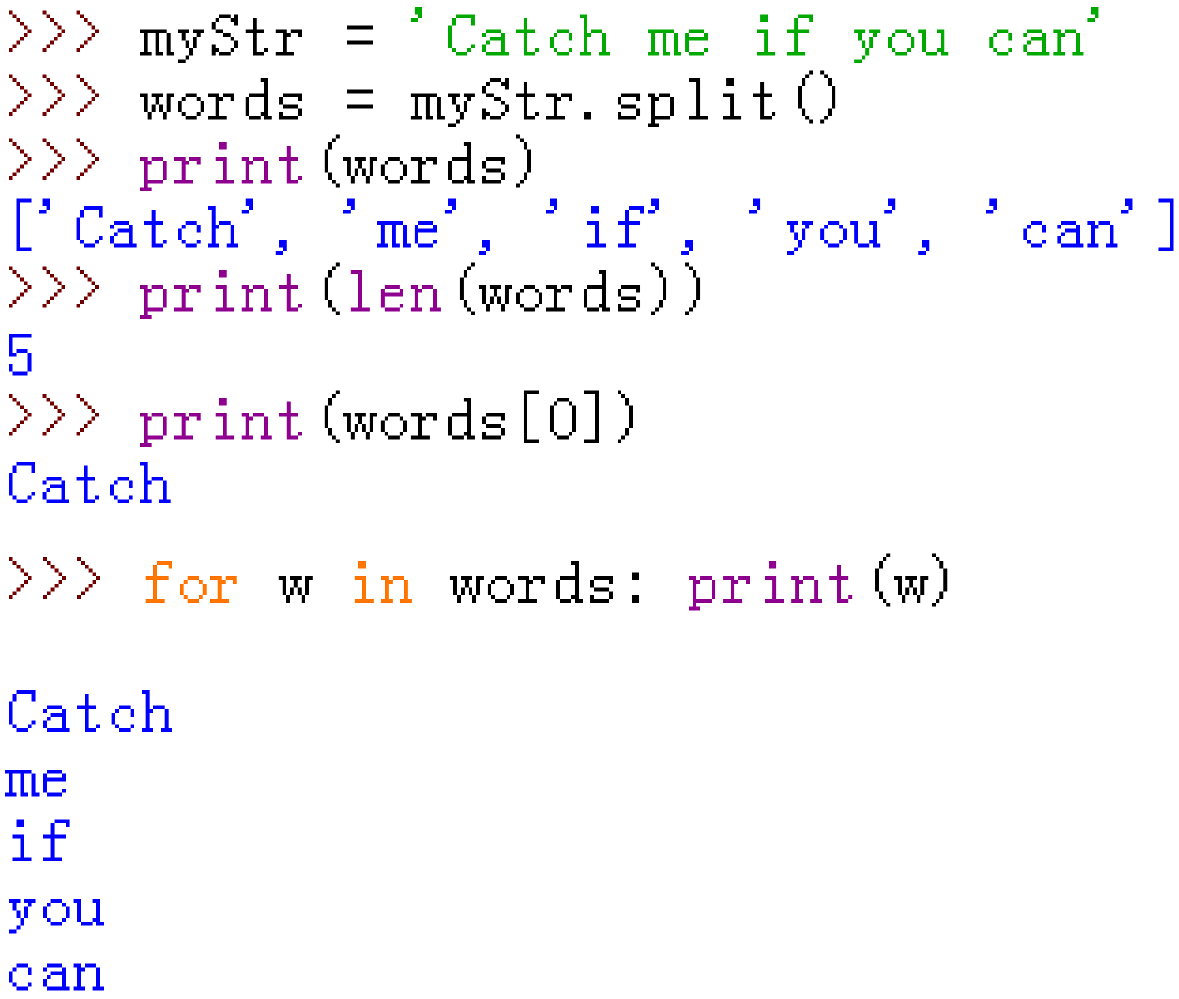
- Write a program to instruct the user to input several numbers and calculate their average using list methods

Best friends: strings and lists

- Use the split() method to break up a string into a list of strings

- We think of these as words

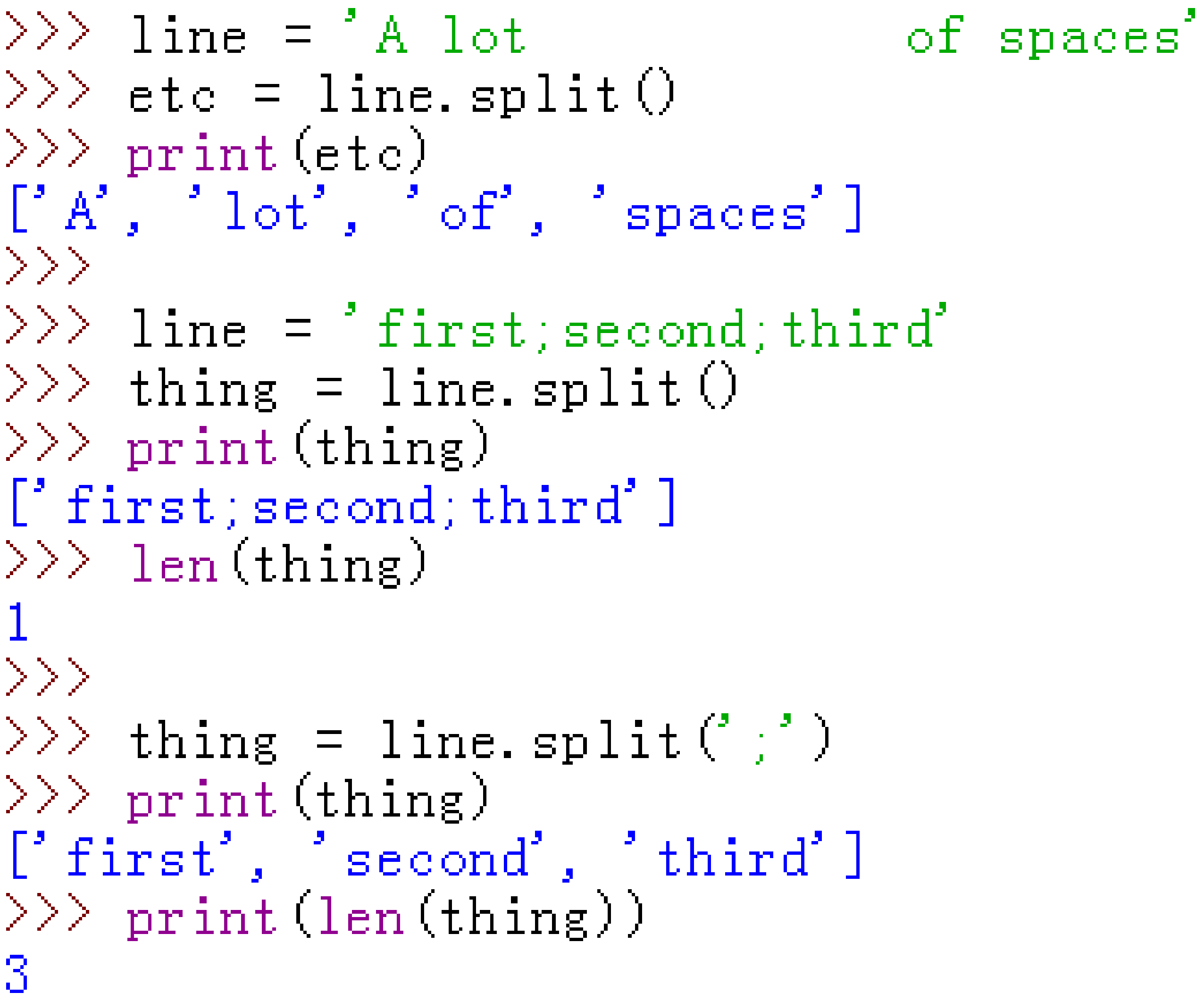
- We can access a particular word or loop through all the words



```
>>> myStr = ’Catch me if you can’
>>> words = myStr.split()
>>> print(words)
[’Catch’, ’me’, ’if’, ’you’, ’can’]
>>> print(len(words))
5
>>> print(words[0])
Catch

>>> for w in words: print(w)


Catch
me
if
you
can
```

- When you do not specify a delimiter, multiple spaces are treated like “one” delimiter

- You can specify what delimiter character to use in splitting



```
>>> line = 'A lot             of spaces'
>>> etc = line.split()
>>> print(etc)
['A', 'lot', 'of', 'spaces']
>>>
>>> line = 'first;second;third'
>>> thing = line.split()
>>> print(thing)
['first;second;third']
>>> len(thing)
1
>>>
>>> thing = line.split(';')
>>> print(thing)
['first', 'second', 'third']
>>> print(len(thing))
3
```

Practice

- The header of an email takes the following format:

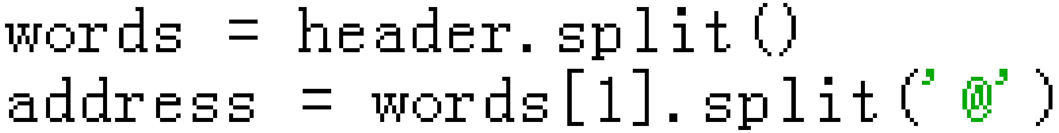
From professor.xman@uct.edu Sat Jan 5 09:14:16 2008

For a given email header, write a program to find out the domain of email address, and the month in which this email was sent

The double split pattern

- Sometimes we split a line one way, and then grab one piece of the line and split it again

From professor.xman@uct.edu Sat Jan 5 09:14:16 2008



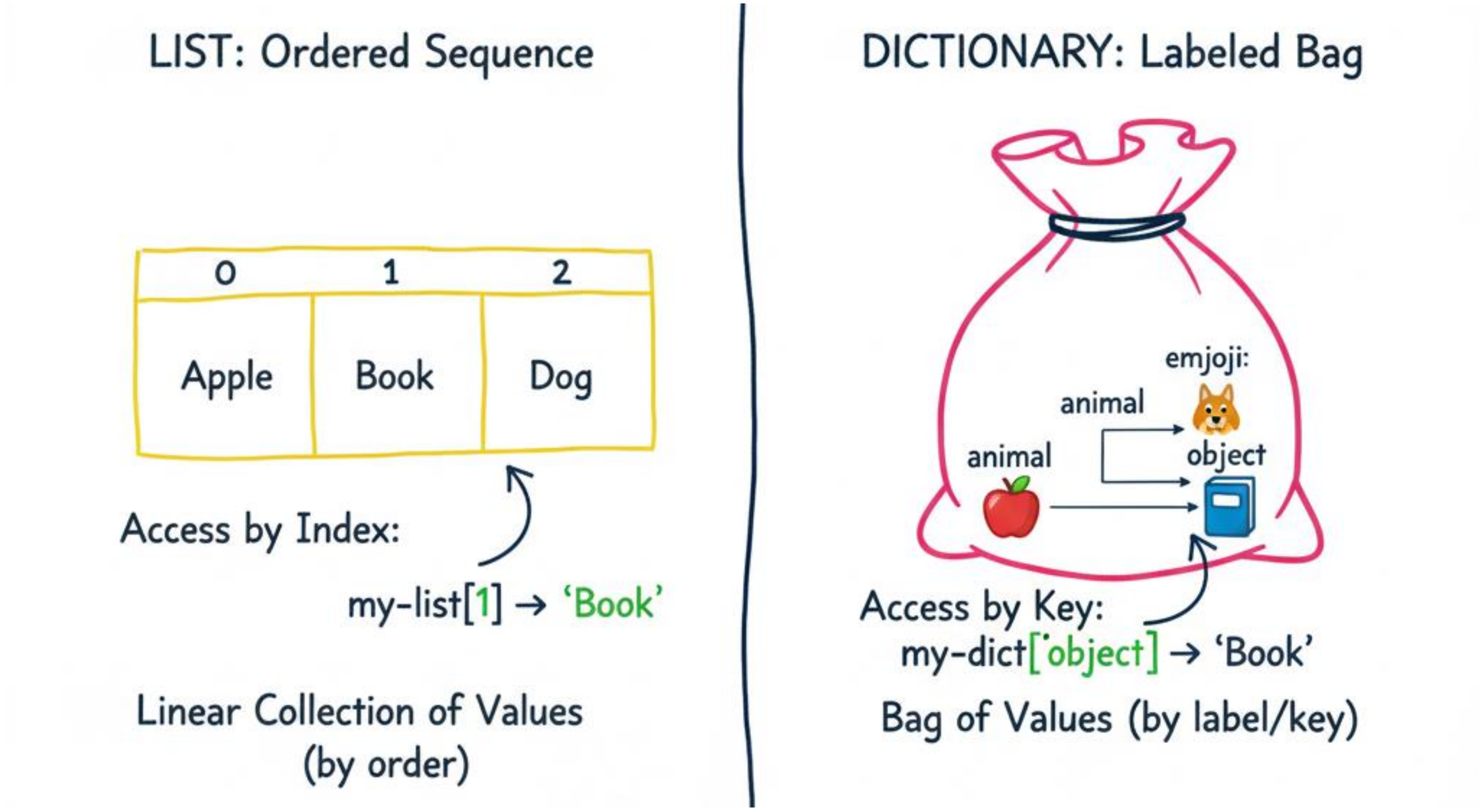
```
words = header.split()
address = words[1].split('@')
```

Dictionary

A story of two collections

- List: a linear collection of values that stay in order
- Dictionary: a “bag” of values, each with its own label

Dictionary


LIST: Ordered Sequence
0
1
2
Apple
Book
Dog
Access by Index:
my-list[1] → ‘Book’
Linear Collection of Values
(by order)
DICTIONARY: Labeled Bag
emjoji:
animal
animal
object
Access by Key:
my-dict['object] → ‘Book’
Bag of Values (by label/key)

Dictionary

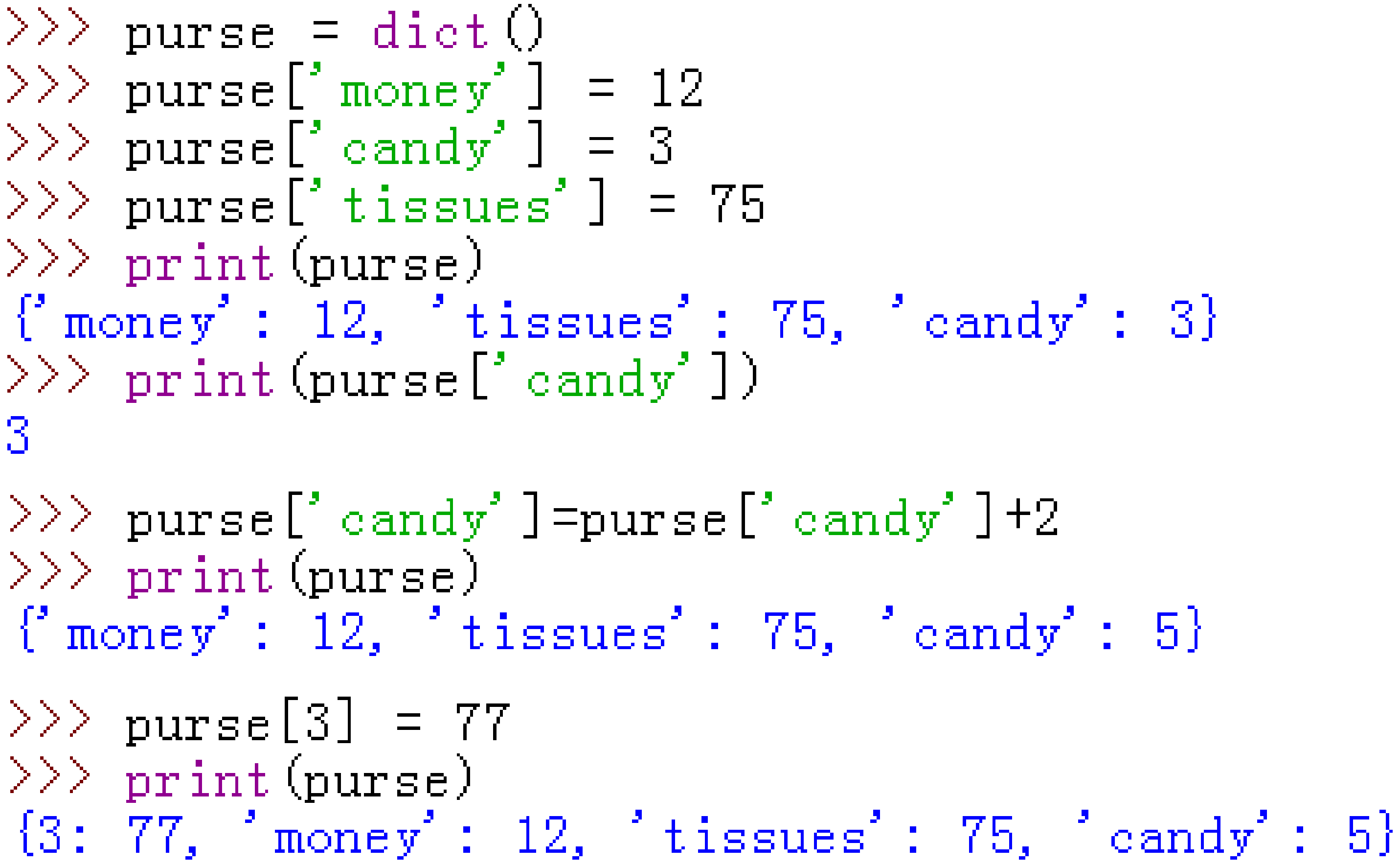
- Dictionaries are Python’s most powerful data collection
- Dictionaries allow us to do fast database-like operations in Python
- Dictionaries have different names in different languages
- Associative arrays – Perl/PHP
- Properties or Map or HashMap – Java
- Property Bag – C#/.Net

Dictionary

- Lists index their entries based on the position in the list

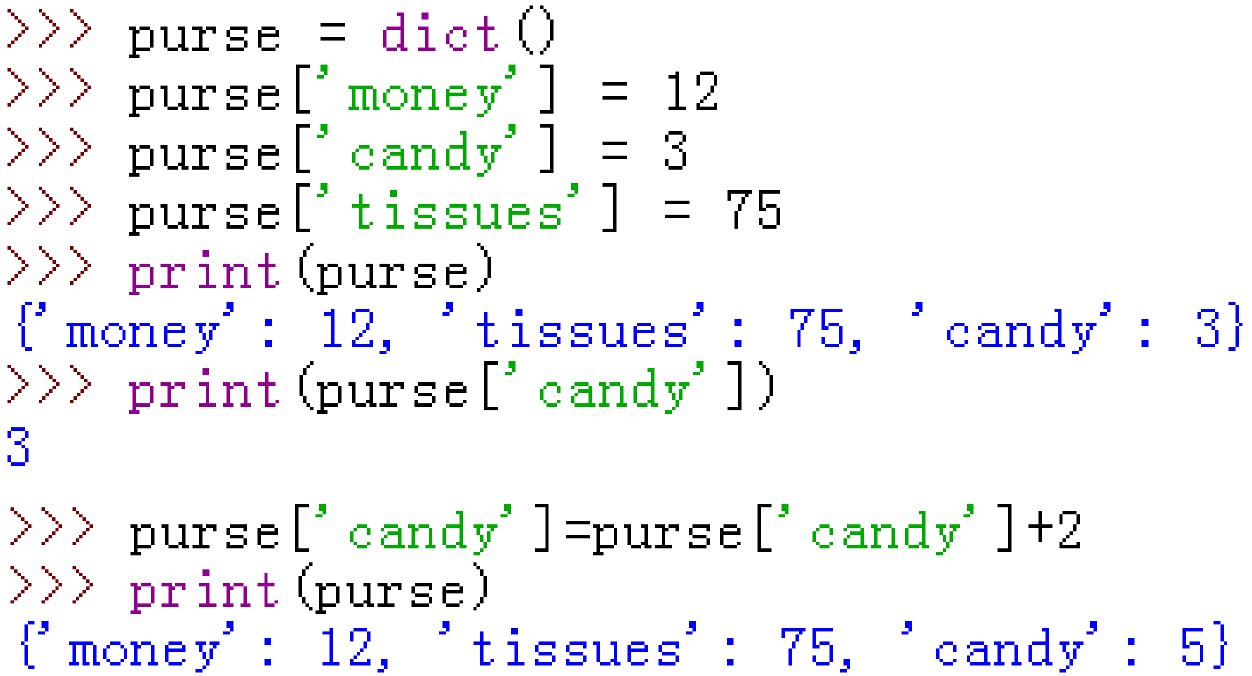
- Dictionaries are like bags – no order

- We index the elements we put in the dictionary with a “lookup tag”



```
>>> purse = dict()
>>> purse['money'] = 12
>>> purse['candy'] = 3
>>> purse['tissues'] = 75
>>> print(purse)
{'money': 12, 'tissues': 75, 'candy': 3}
>>> print(purse['candy'])
3

>>> purse['candy']=purse['candy']+2
>>> print(purse)
{'money': 12, 'tissues': 75, 'candy': 5}

>>> purse[3] = 77
>>> print(purse)
{3: 77, 'money': 12, 'tissues': 75, 'candy': 5}
```

Dictionary

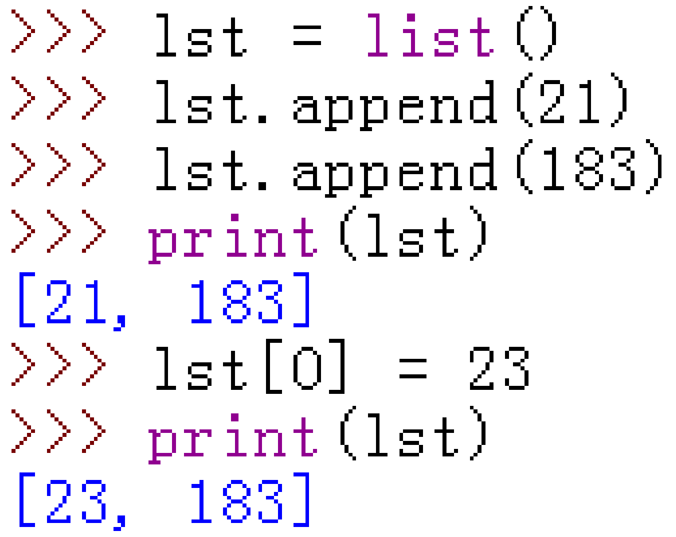


```
>>> purse = dict()
>>> purse[’money’] = 12
>>> purse[’candy’] = 3
>>> purse[’tissues’] = 75
>>> print(purse)
{’money’: 12, ’tissues’: 75, ’candy’: 3}
>>> print(purse[’candy’])
3

>>> purse[’candy’]=purse[’candy’]+2
>>> print(purse)
{’money’: 12, ’tissues’: 75, ’candy’: 5}
```

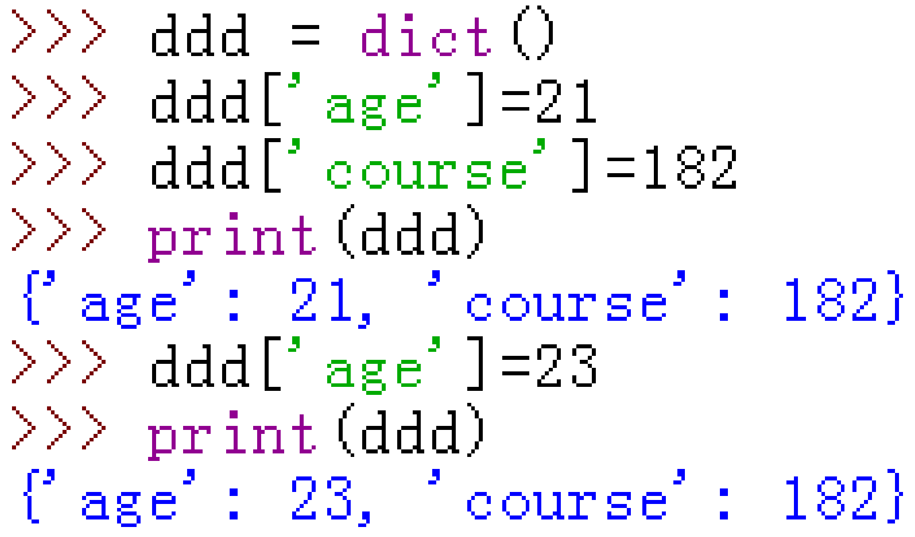
tissues 75
candy 3
money 12

List v.s. dictionary

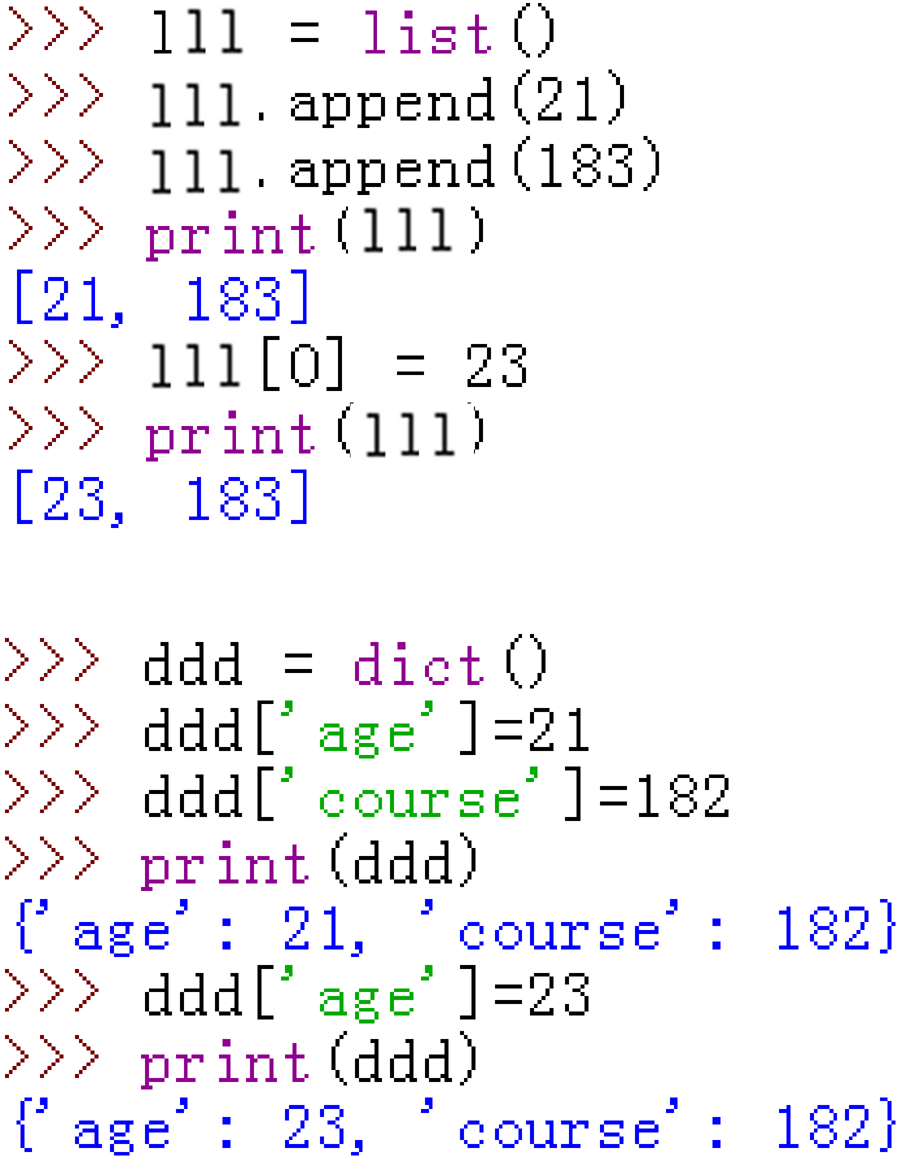
- Dictionaries are similar to lists, except that they use keys instead of numbers to look up values



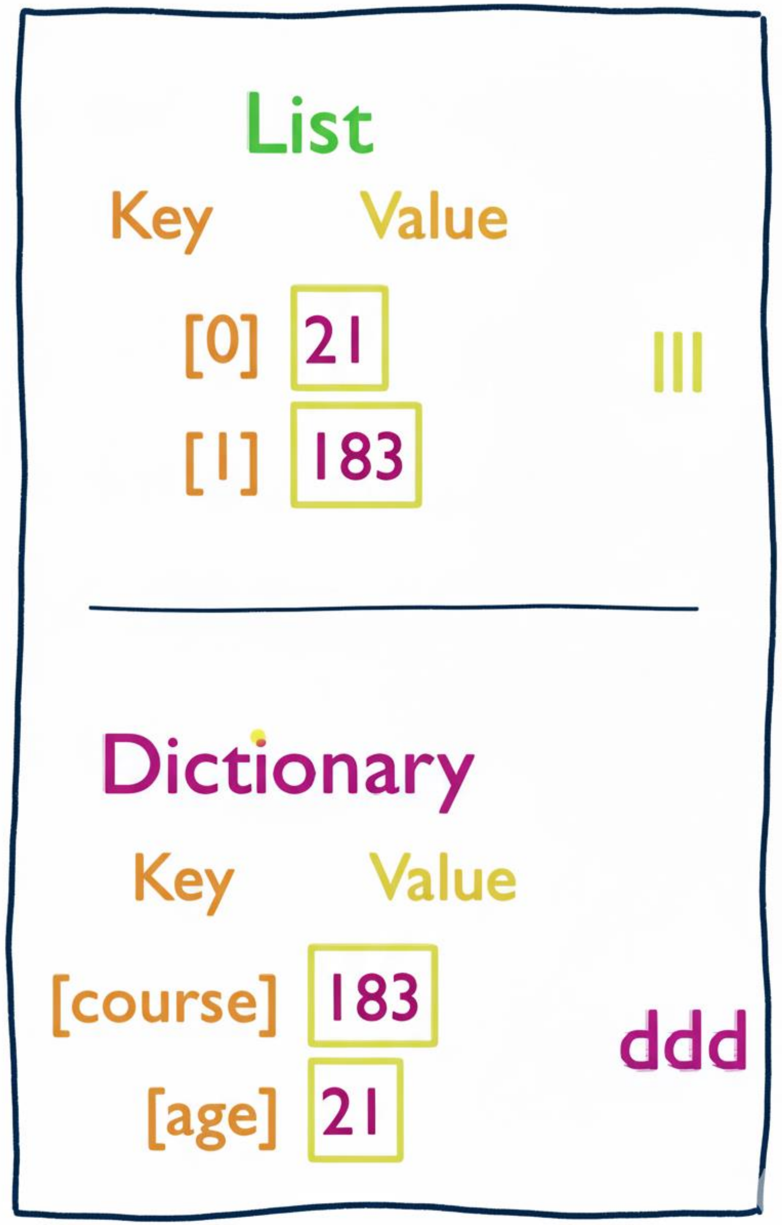
```
>>> lst = list()
>>> lst.append(21)
>>> lst.append(183)
>>> print(lst)
[21, 183]
>>> lst[0] = 23
>>> print(lst)
[23, 183]
```



```
>>> ddd = dict()
>>> ddd[’age’]=21
>>> ddd[’course’]=182
>>> print(ddd)
{’age’: 21, ’course’: 182}
>>> ddd[’age’]=23
>>> print(ddd)
{’age’: 23, ’course’: 182}
```

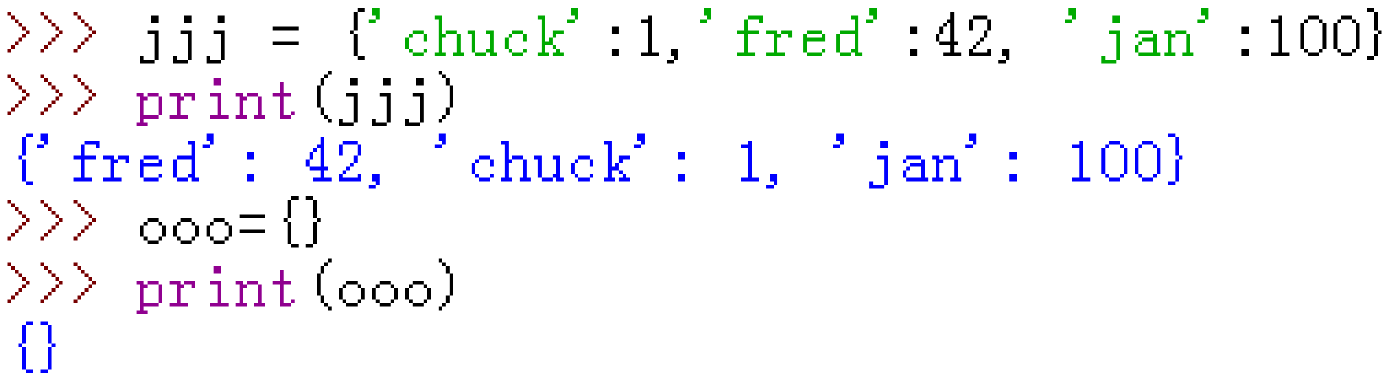


```
>>> lll = list()
>>> lll.append(21)
>>> lll.append(183)
>>> print(lll)
[21, 183]
>>> lll[0] = 23
>>> print(lll)
[23, 183]

>>> ddd = dict()
>>> ddd[’age’]=21
>>> ddd[’course’]=182
>>> print(ddd)
{’age’: 21, ’course’: 182}
>>> ddd[’age’]=23
>>> print(ddd)
{’age’: 23, ’course’: 182}
```



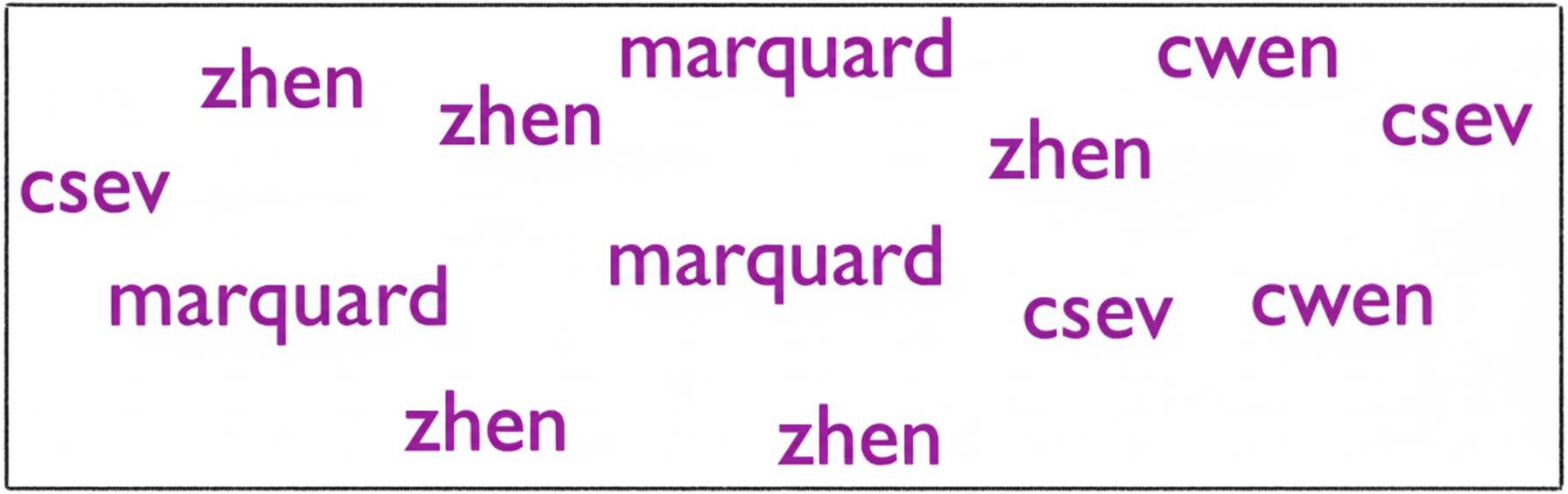
Dictionary literals (constants)

- Dictionary literals use curly braces and have list of key:value pairs
- You can make an empty dictionary using empty curly braces



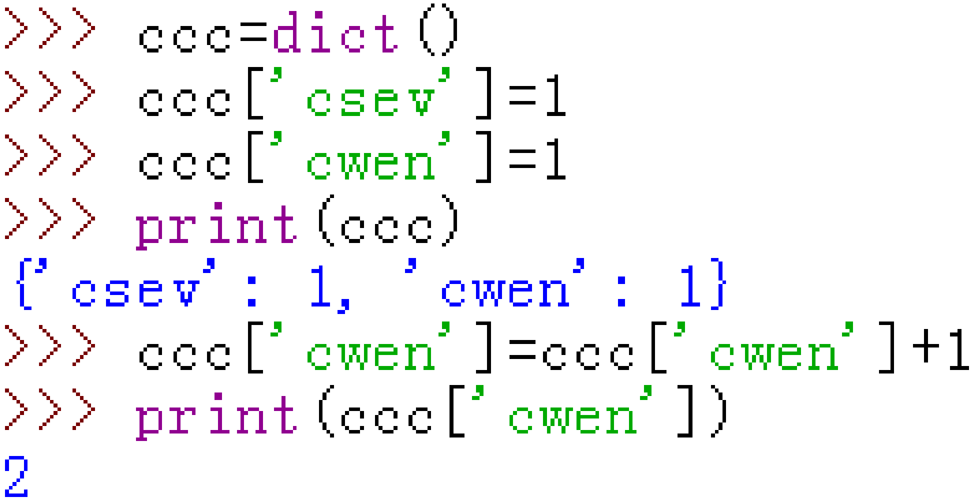
```
>>> jjj = {'chuck':1,'fred':42, 'jan':100}
>>> print(jjj)
{'fred': 42, 'chuck': 1, 'jan': 100}
>>> ooo={}
>>> print(ooo)
{}
```

Most common terms?



Counting with a dictionary

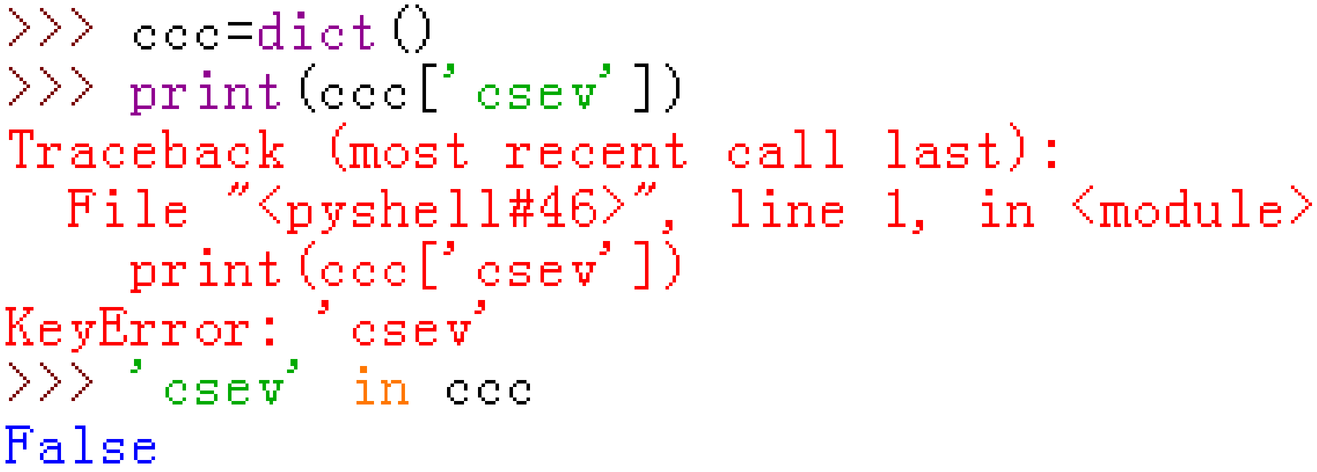
- A common use of dictionary is counting how often we “see” something



```
>>> ccc=dict()
>>> ccc['csev']=1
>>> ccc['cwen']=1
>>> print(ccc)
{'csev': 1, 'cwen': 1}
>>> ccc['cwen']=ccc['cwen']+1
>>> print(ccc['cwen'])
2
```

Dictionary tracebacks

- It is an error to reference a key which is not in the dictionary
- We can use the in operator to see if a key is in the dictionary



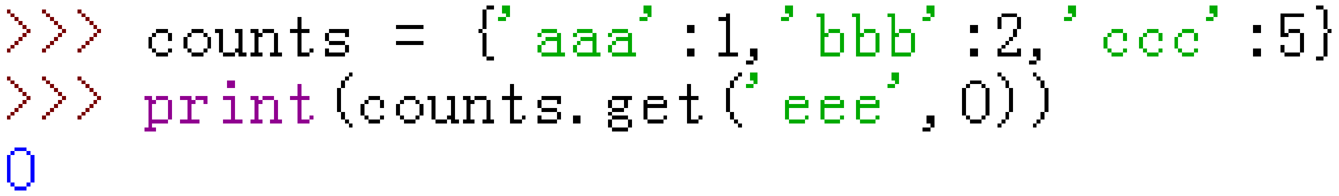
```
>>> ccc=dict()
>>> print(ccc['csev'])
Traceback (most recent call last):
  File "<pyshell#46>", line 1, in <module>
    print(ccc['csev'])
KeyError: 'csev'
>>> 'csev' in ccc
False
```

Practice

- Write a program to instruct the user to continuously input some words, and use dictionary to count how many times a word has been inputted before.

The get() method

- This pattern of checking if a key is already in a dictionary, and assuming a default value if the key is not there is so common, that there is a method called get() that does this for us



```
>>> counts = {'aaa':1,'bbb':2,'ccc':5}
>>> print(counts.get('eee',0))
0
```

Practice

- Write a program to instruct the user to input a line of texts, and use dictionary to count how many times a word has been seen in this line. You should use the get() method in this program.

Definite loops and dictionaries

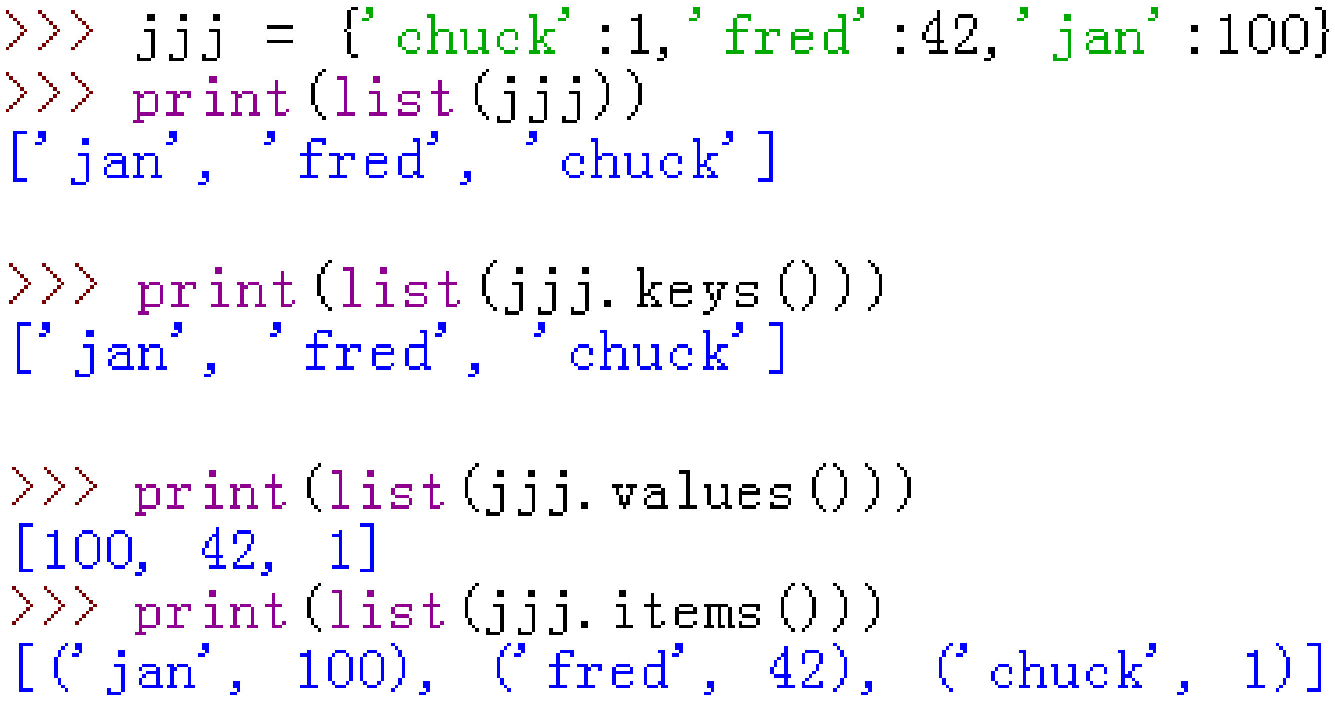
- Even though dictionaries are not stored in order, we can write a for loop that goes through all elements in a dictionary – actually it goes through all the keys in that dictionary and looks up the values

```
counts = {’chuck’:1,’fred’:42,’jan’:100}

for key in counts:
    print(key,counts[key])
```

```
jan 100
fred 42
chuck 1
```

Retrieving lists of keys and values

- You can get a list of keys, values or items (both) from a dictionary

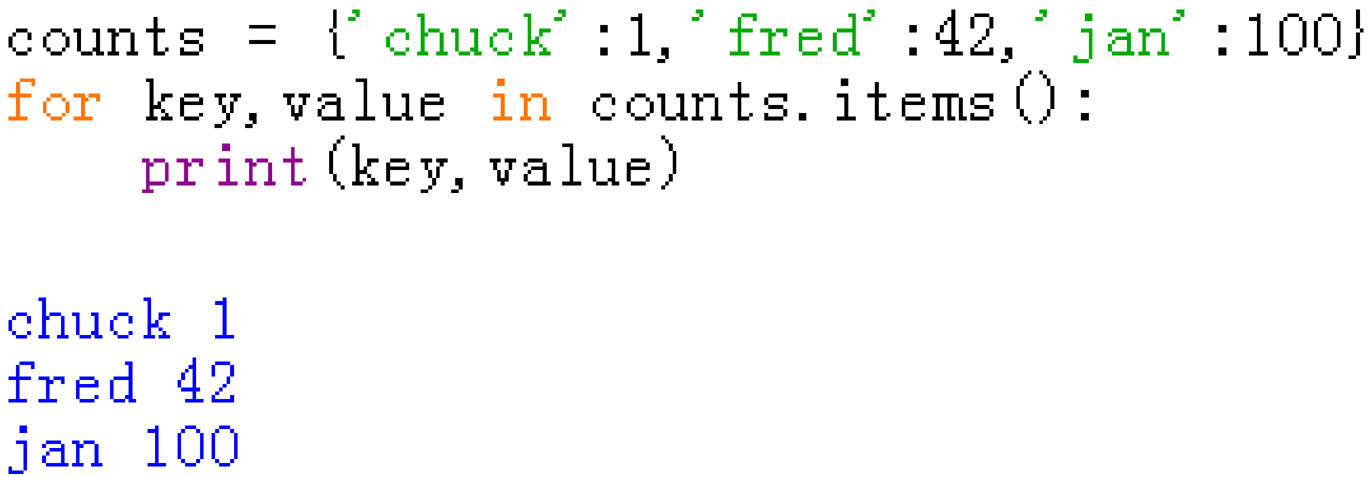


```
>>> jjj = {'chuck':1,'fred':42,'jan':100}
>>> print(list(jjj))
['jan', 'fred', 'chuck']

>>> print(list(jjj.keys()))
['jan', 'fred', 'chuck']

>>> print(list(jjj.values()))
[100, 42, 1]
>>> print(list(jjj.items()))
[('jan', 100), ('fred', 42), ('chuck', 1)]
```

Bonus: two iteration variables

- We loop through the key-value pairs in a dictionary using two iteration variables

- Each iteration, the first variable is the key, and the second variable is the corresponding value for the key



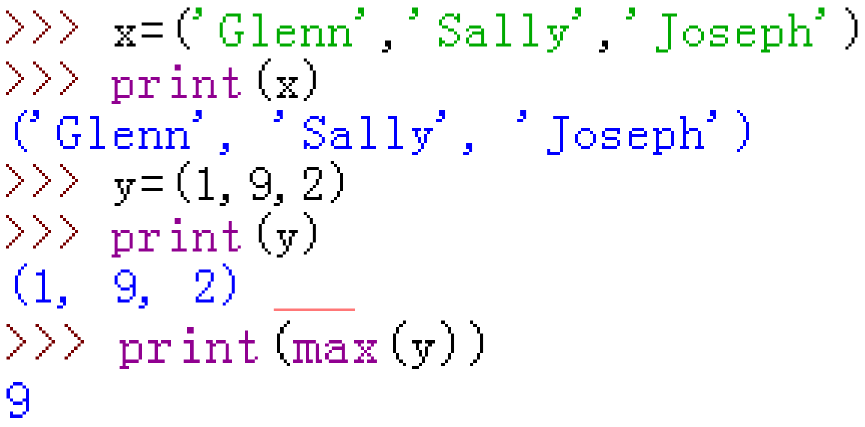
```
counts = {'chuck':1,'fred':42,'jan':100}
for key,value in counts.items():
    print(key,value)
```

```
chuck 1
fred 42
jan 100
```

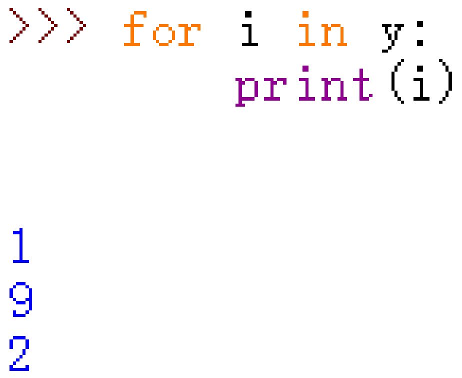
Tuple

Tuples

- Tuples are another type of sequence that function more like a list – they have elements which are indexed starting from 0



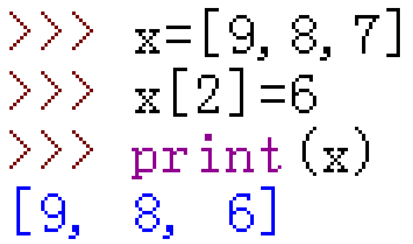
```
>>> x=('Glenn','Sally','Joseph')
>>> print(x)
('Glenn', 'Sally', 'Joseph')
>>> y=(1,9,2)
>>> print(y)
(1, 9, 2)
>>> print(max(y))
9
```



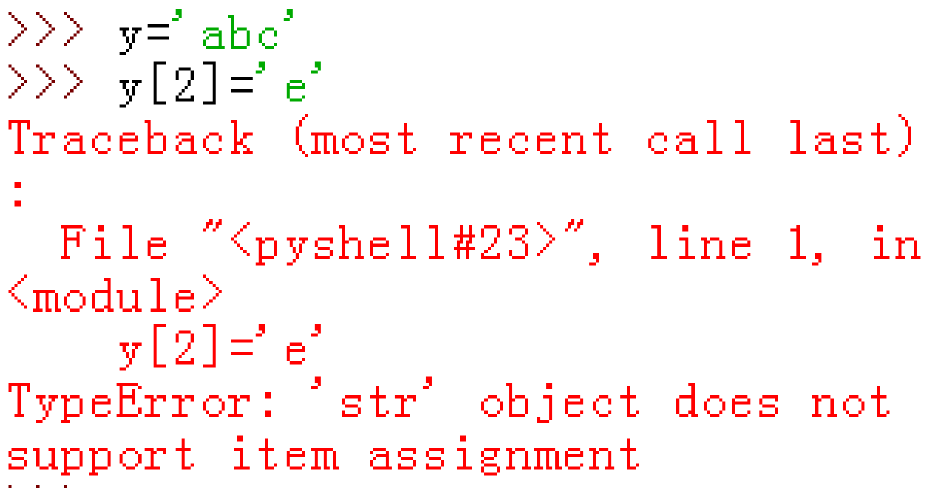
```
>>> for i in y:
        print(i)



1
9
2
```

But, tuples are “immutable”

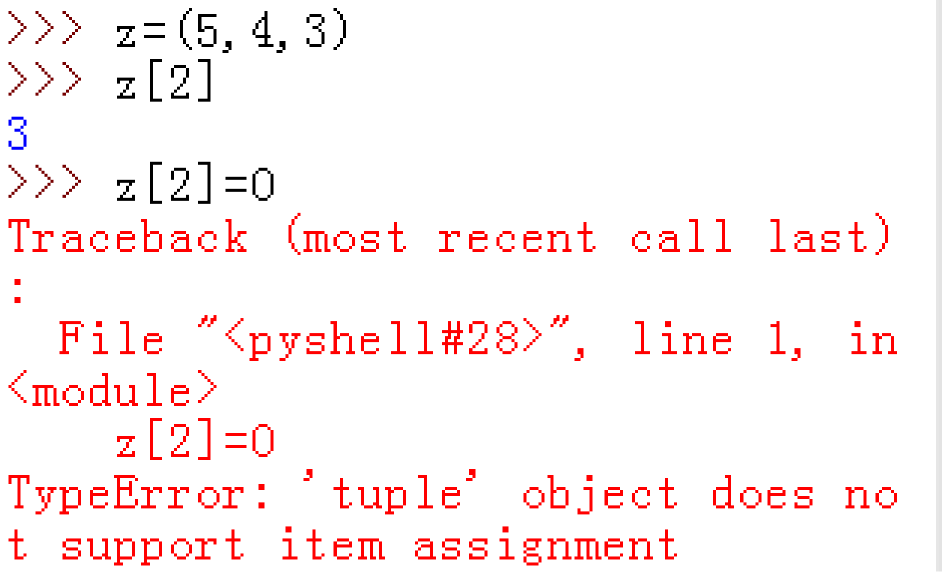
- Unlike a list, once you create a tuple, you cannot change its contents – similar to a string



```
>>> x=[9,8,7]
>>> x[2]=6
>>> print(x)
[9, 8, 6]
```

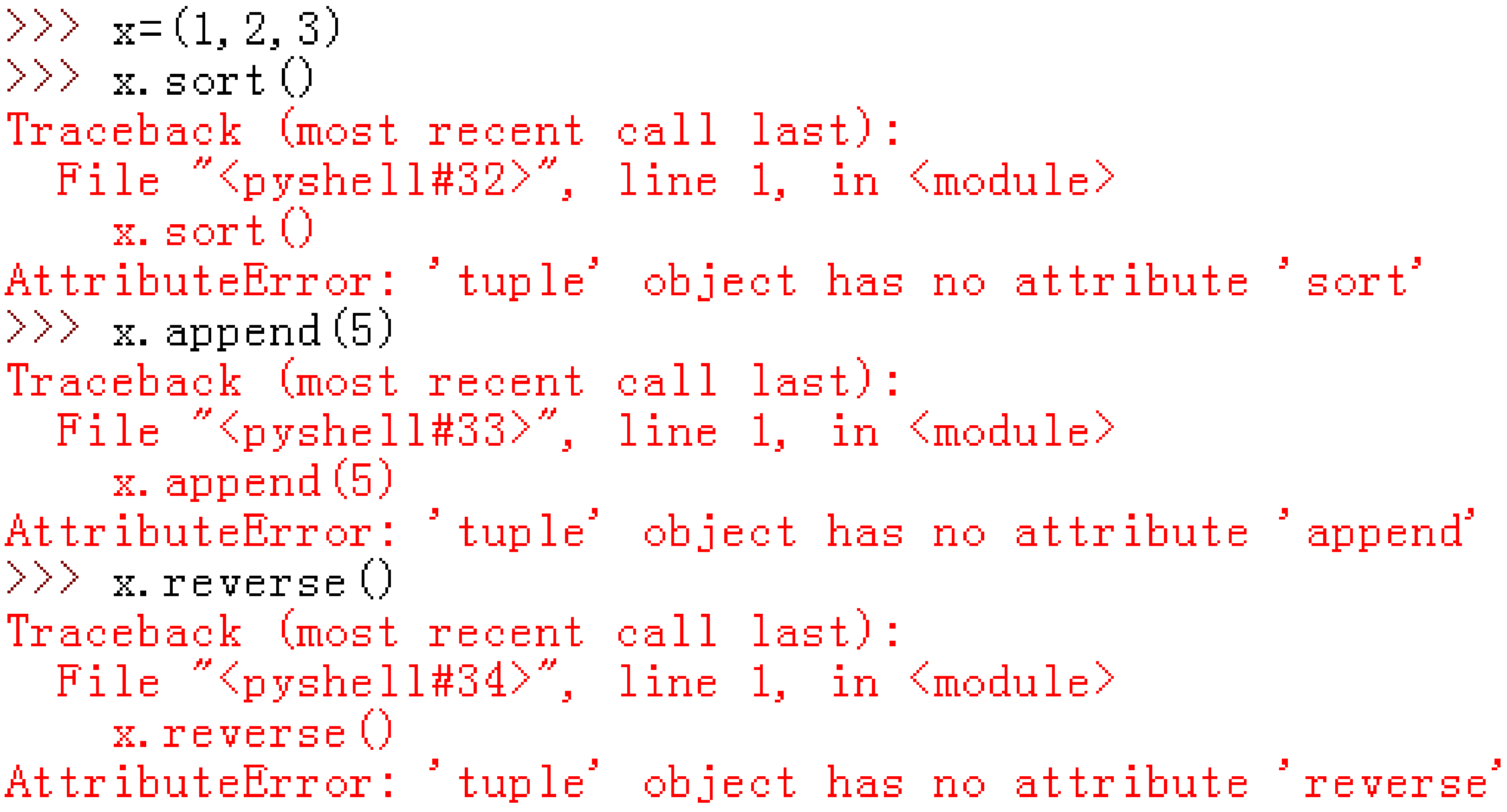


```
>>> y='abc'
>>> y[2]='e'
Traceback (most recent call last)
:
  File "<pyshell#23>", line 1, in
<module>
    y[2]='e'
TypeError: 'str' object does not
support item assignment
```



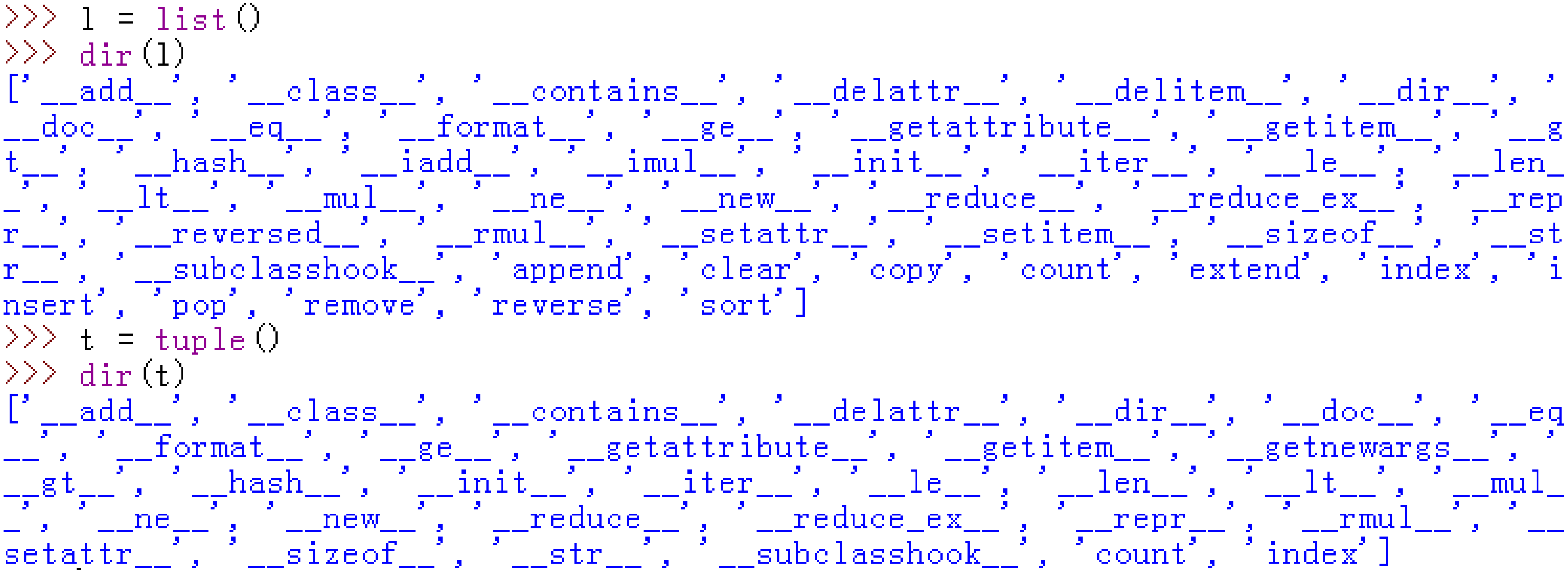
```
>>> z=(5,4,3)
>>> z[2]
3
>>> z[2]=0
Traceback (most recent call last)
:
  File "<pyshell#28>", line 1, in
<module>
    z[2]=0
TypeError: 'tuple' object does no
t support item assignment
```

Some things that you cannot do with tuples



```
>>> x=(1,2,3)
>>> x.sort()
Traceback (most recent call last):
  File "<pyshell#32>", line 1, in <module>
    x.sort()
AttributeError: 'tuple' object has no attribute 'sort'
>>> x.append(5)
Traceback (most recent call last):
  File "<pyshell#33>", line 1, in <module>
    x.append(5)
AttributeError: 'tuple' object has no attribute 'append'
>>> x.reverse()
Traceback (most recent call last):
  File "<pyshell#34>", line 1, in <module>
    x.reverse()
AttributeError: 'tuple' object has no attribute 'reverse'
```

A tale of two sequences



```
>>> l = list()
>>> dir(l)
['__add__', '__class__', '__contains__', '__delattr__', '__delitem__', '__dir__', '
__doc__', '__eq__', '__format__', '__ge__', '__getattribute__', '__getitem__', '__g
t__', '__hash__', '__iadd__', '__imul__', '__init__', '__iter__', '__le__', '__len_
_', '__lt__', '__mul__', '__ne__', '__new__', '__reduce__', '__reduce_ex__', '__rep
r__', '__reversed__', '__rmul__', '__setattr__', '__setitem__', '__sizeof__', '__st
r__', '__subclasshook__', 'append', 'clear', 'copy', 'count', 'extend', 'index', 'i
nsert', 'pop', 'remove', 'reverse', 'sort']
>>> t = tuple()
>>> dir(t)
['__add__', '__class__', '__contains__', '__delattr__', '__dir__', '__doc__', '__eq
__', '__format__', '__ge__', '__getattribute__', '__getitem__', '__getnewargs__', '
__gt__', '__hash__', '__init__', '__iter__', '__le__', '__len__', '__lt__', '__mul_
_', '__ne__', '__new__', '__reduce__', '__reduce_ex__', '__repr__', '__rmul__', '__
setattr__', '__sizeof__', '__str__', '__subclasshook__', 'count', 'index']
```

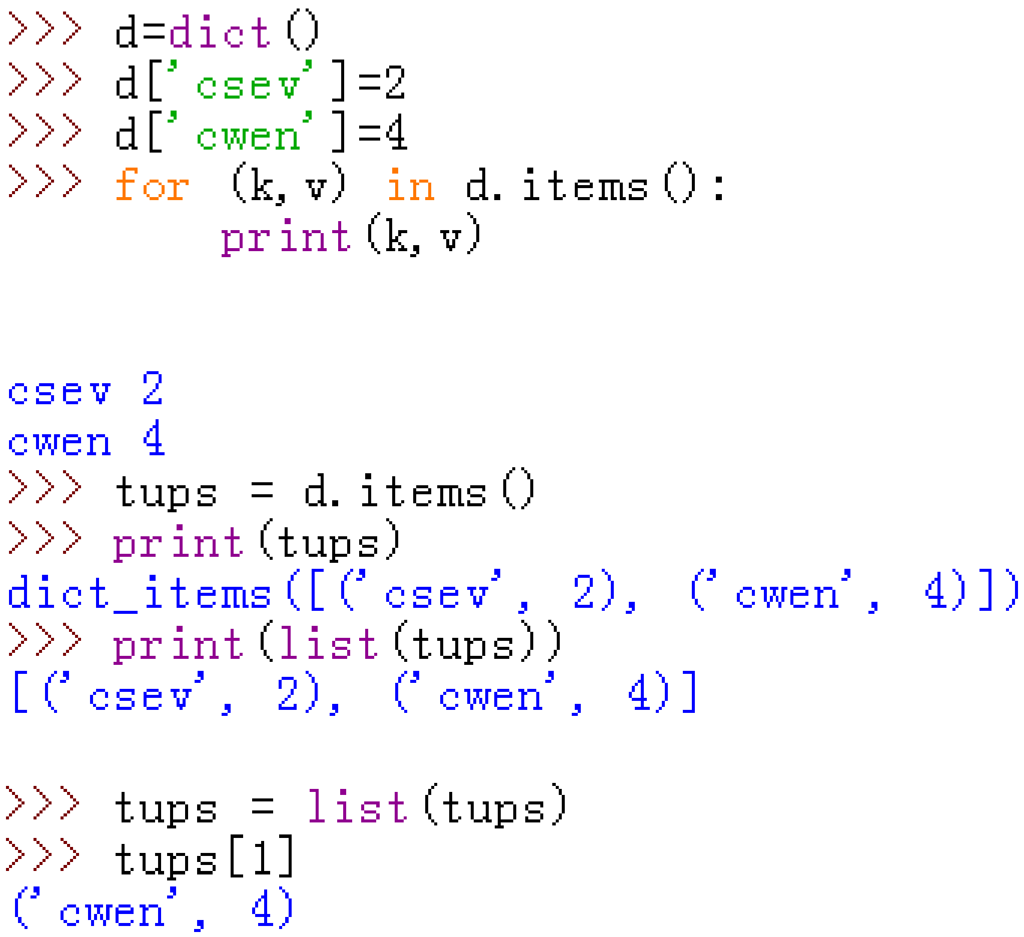
Tuples are more efficient

- Since Python does not have to build tuple structures to be modifiable, they are simpler and more efficient in terms of memory use and performance than lists

- In our program when we are making “temporary variables” we prefer tuples over lists

Tuples and dictionaries

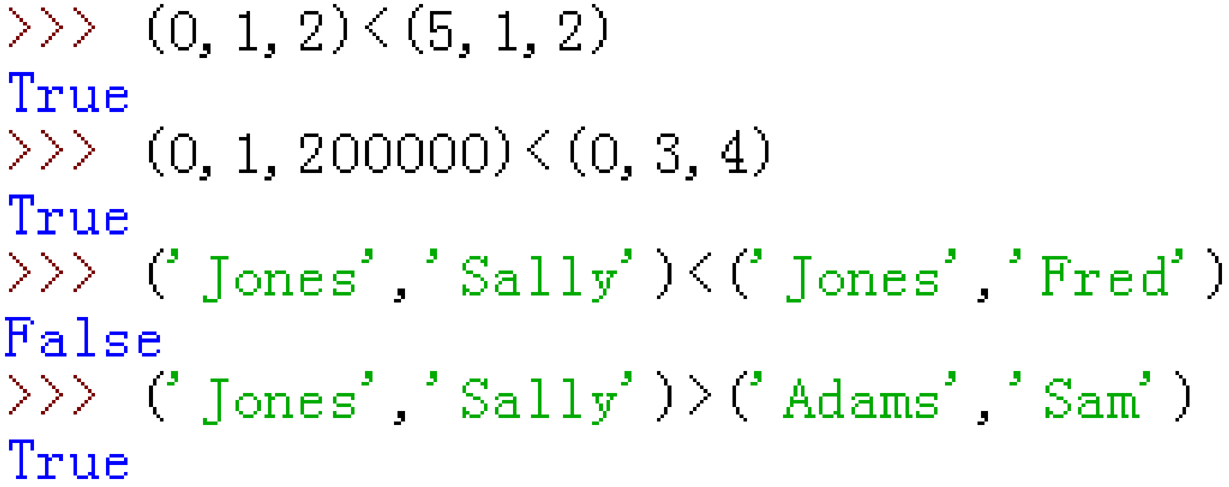
- The item() method in dictionaries returns a list of (key, value) tuples



```
>>> d=dict()
>>> d[’csev’]=2
>>> d[’cwen’]=4
>>> for (k,v) in d.items():
        print(k,v)


csev 2
cwen 4
>>> tups = d.items()
>>> print(tups)
dict_items([(’csev’, 2), (’cwen’, 4)])
>>> print(list(tups))
[(’csev’, 2), (’cwen’, 4)]

>>> tups = list(tups)
>>> tups[1]
(’cwen’, 4)
```

Tuples are comparable

- The comparison operators work with tuples and other sequences if the first item is equal. Python goes on to the next element, until it finds the elements which are different

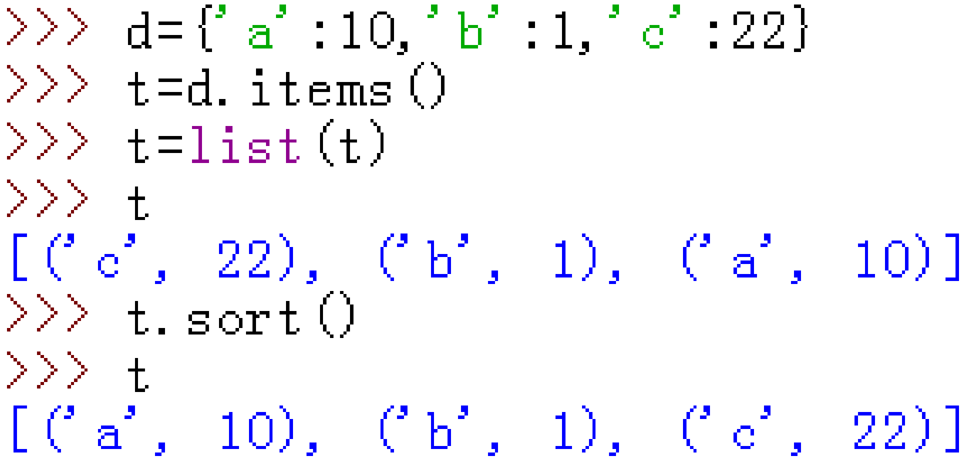


```
>>> (0, 1, 2)<(5, 1, 2)
True
>>> (0, 1, 200000)<(0, 3, 4)
True
>>> (’Jones’,’Sally’)<(’Jones’,’Fred’)
False
>>> (’Jones’,’Sally’)>(’Adams’,’Sam’)
True
```

Sorting lists of tuples

- We can take advantage of the ability to sort a list of tuples to get a sorted version of a dictionary

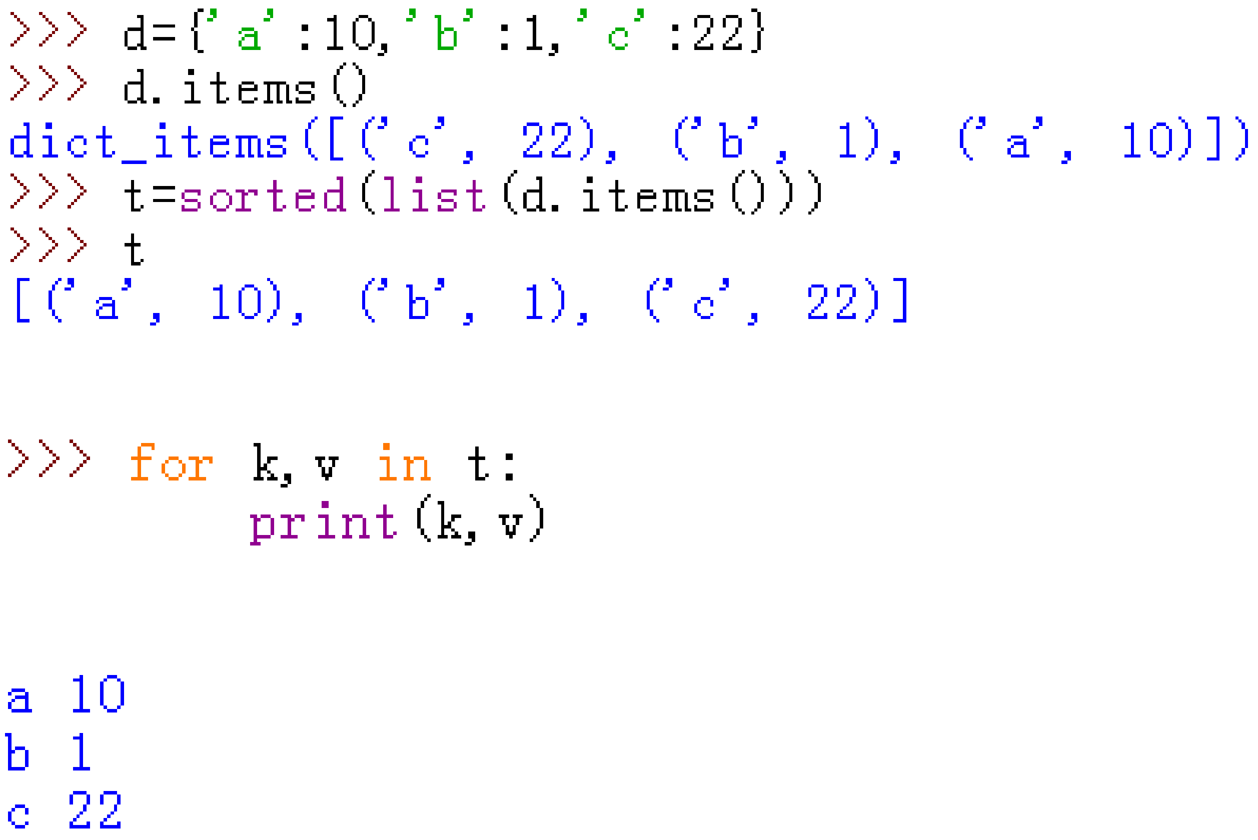
- First we sort the dictionary by the key using the items() method



```
>>> d={‘a’:10,‘b’:1,‘c’:22}
>>> t=d.items()
>>> t=list(t)
>>> t
[(‘c’, 22), (‘b’, 1), (‘a’, 10)]
>>> t.sort()
>>> t
[(‘a’, 10), (‘b’, 1), (‘c’, 22)]
```

Using sorted()

- We can do this even more efficiently using a built-in function sorted() which takes a sequence as a parameter and returns a sorted sequence



```
>>> d={’a’:10,’b’:1,’c’:22}
>>> d.items()
dict_items([(’c’, 22), (’b’, 1), (’a’, 10)])
>>> t=sorted(list(d.items()))
>>> t
[(’a’, 10), (’b’, 1), (’c’, 22)]


>>> for k,v in t:
        print(k,v)


a 10
b 1
c 22
```

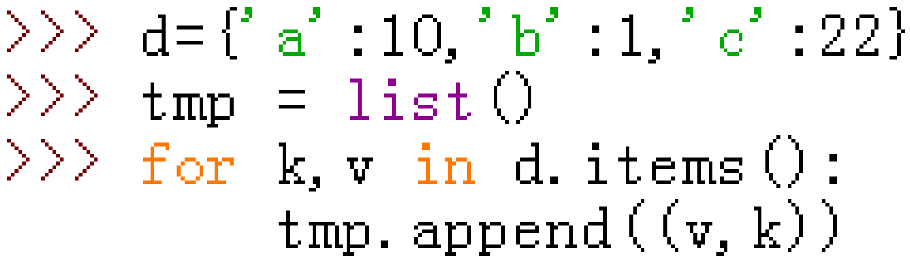
Practice

- Write a program, which sorts the elements of a dictionary by the value of each element

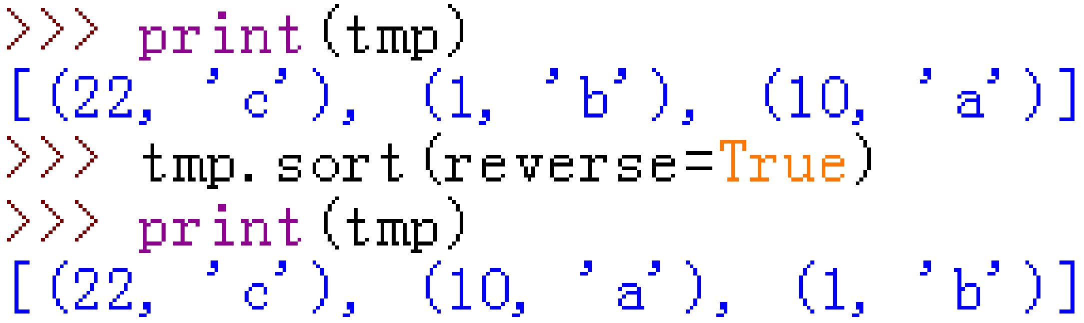
Sort by values instead of key

- If we could construct a list of tuples of the form (key, value) we could sort by value

- We do this with a for loop that creates a list of tuples

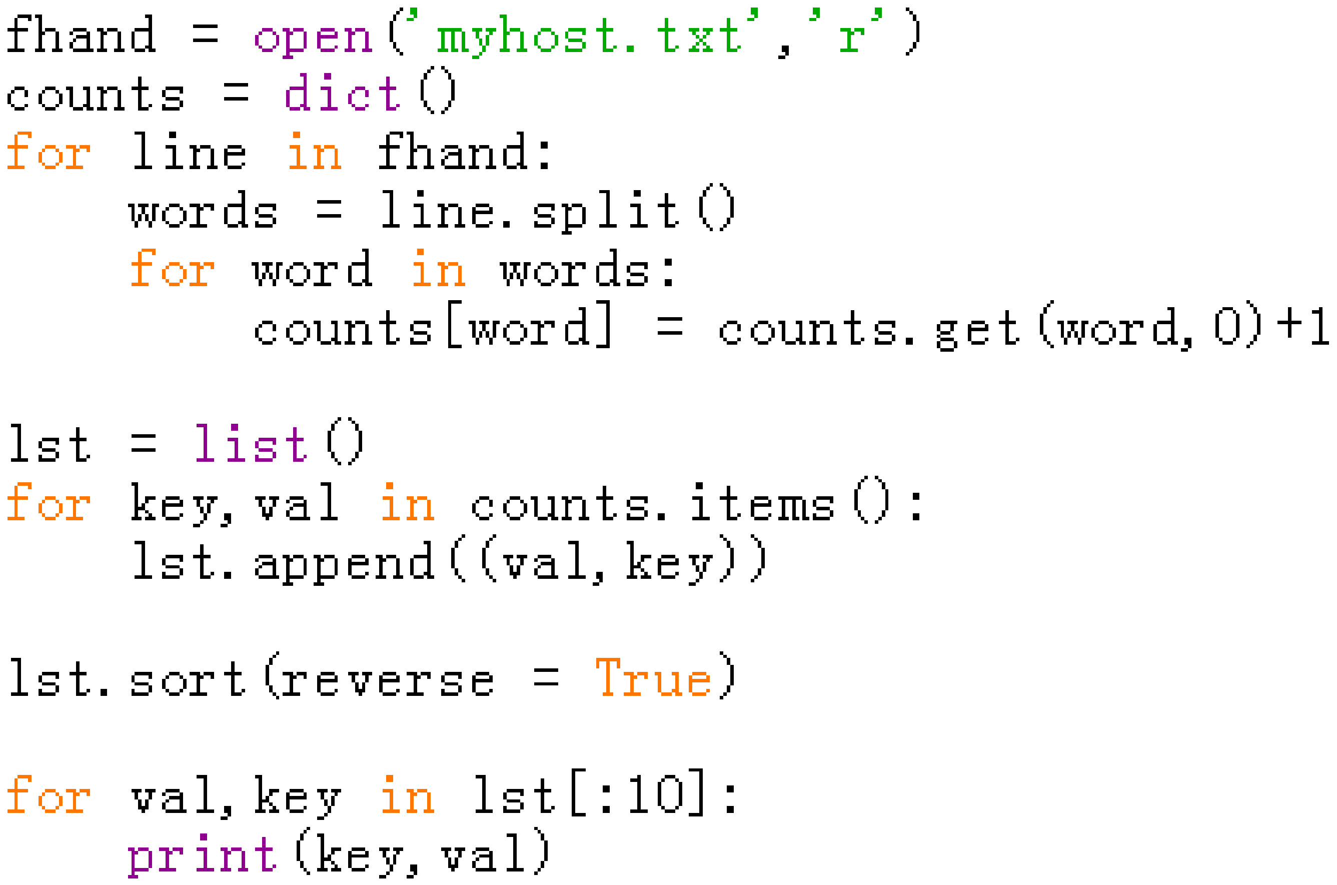


```
>>> d={'a':10,'b':1,'c':22}
>>> tmp = list()
>>> for k, v in d.items():
        tmp.append((v, k))
```



```
>>> print(tmp)
[(22, 'c'), (1, 'b'), (10, 'a')]
>>> tmp.sort(reverse=True)
>>> print(tmp)
[(22, 'c'), (10, 'a'), (1, 'b')]
```

Example: Finding the 10 most common words in a file



```
fhand = open(’myhost.txt’,’r’)
counts = dict()
for line in fhand:
    words = line.split()
    for word in words:
        counts[word] = counts.get(word,0)+1

lst = list()
for key,val in counts.items():
    lst.append((val,key))

lst.sort(reverse = True)

for val,key in lst[:10]:
    print(key,val)
```