

Ch08-1-Lists

August 7, 2020

1 8 Lists

- <http://openbookproject.net/thinkcs/python/english3e/lists.html>

1.1 Topics

- list data structure
- syntax to create lists
- methods or operations provided to list objects
- list operators
- list traversal
- list applications and problems

1.2 8.1 Lists

- a type of sequence or container
- ordered collection of values called elements or items
- lists are similar to strings (ordered collections of characters) except that elements of a list can be of any type

1.3 8.2 Creating lists

- several ways; the simplest is to enclose the elements in square brackets []

```
[15]: alist = [] # an empty list
```

```
[16]: blist = list() # an empty list
```

```
[17]: type(alist)
```

```
[17]: list
```

```
[18]: # creating lists with some elements of same type
list1 = [10, 20, 30, 40]
list2 = ['spam', 'bungee', 'swallow']
```

```
[6]: # lists with elements of different types
list3 = ["hello", 2.0, 10, [10, ('hi', 'world'), 3.5], (1, 'uno')]
```

```
[20]: # print list
      print(list3)
```

```
['hello', 2.0, 10, [10, ('hi', 'world'), 3.5], (1, 'uno')]
```

```
[21]: # quickly create a list of range of numbers between 1 and 19
      list4 = list(range(1, 20, 1))
```

```
[22]: print(list4)
```

```
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]
```

```
[23]: # print multiple lists
      print(alist, list1, list2, list3)
```

```
[] [10, 20, 30, 40] ['spam', 'bungee', 'swallow'] ['hello', 2.0, 10, [10, ('hi', 'world'), 3.5], (1, 'uno')]
```

```
[11]: # Exercise: create a list of even numbers between 1 and 20 inclusive
```

```
[12]: # Exercise: create a list of odd numbers between 1 and 20 inclusive
```

```
[13]: # Exercise: create a list of numbers from 20 to 1 inclusive
```

1.4 8.3 Accessing elements

- same syntax for accessing characters of a string, the index operator: ['index']

```
[14]: # let's see what elements are in list1
      list1
```

```
[14]: [10, 20, 30, 40]
```

```
[15]: # access an element, which one?
      list1[0]
```

```
[15]: 10
```

```
[16]: list3
```

```
[16]: ['hello', 2.0, 10, [10, ('hi', 'world'), 3.5], (1, 'uno')]
```

```
[17]: list3[2-2]
```

```
[17]: 'hello'
```

```
[18]: # list index can be variable as well
      index = 0
```

```
print(list3[index])
```

hello

```
[19]: # can you use float value as an index?
list3[1.0]
```

```

↳ -----

TypeError                                Traceback (most recent call↳
↳ last)

<ipython-input-19-1fc6b2fe2f36> in <module>()
    1 # can you use float value as an index?
----> 2 list3[1.0]

TypeError: list indices must be integers or slices, not float
```

```
[20]: # how many elements are there in list3?
len(list3)
```

```
[20]: 5
```

```
[21]: # what happens if you access an index equal to the size of the list
list3[5]
```

```

↳ -----

IndexError                                Traceback (most recent call↳
↳ last)

<ipython-input-21-207cd7e1c880> in <module>()
    1 # what happens if you access an index equal to the size of the list
----> 2 list3[5]

IndexError: list index out of range
```

```
[3]: list3
```

```
[3]: ['hello', 2.0, 10, [10, ('hi', 'world'), 3.5], (1, 'uno')]
```

```
[24]: # Exercise: access and print the last element of list3
```

```
[4]: # Can we use negative index?  
# Can you guess the output of the following code?  
print(list3[-1])
```

```
(1, 'uno')
```

```
[32]: # Exercise - access and print 'world' in list3
```

1.5 8.4 Membership

- checking if some data/object is a member/element in the given list
- **in** and **not in** boolean operators let's you check for membership

```
[1]: horsemen = ["war", "famine", "pestilence", ["death"]]  
     'death' in horsemen
```

```
[1]: False
```

```
[2]: 'War' not in horsemen
```

```
[2]: True
```

```
[3]: ["death"] in horsemen
```

```
[3]: True
```

1.6 8.5 Traversing lists

- for or while loop can be used to traverse through each element of a list

```
[29]: list3
```

```
[29]: ['hello', 2.0, 10, [10, ('hi', 'world'), 3.5], (1, 'uno')]
```

```
[5]: # common technique; use for loop  
for item in list3:  
    print(item)
```

```
hello  
2.0  
10  
[10, ('hi', 'world'), 3.5]  
(1, 'uno')
```

```
[6]: for item in list3:
      if isinstance(item, list) or isinstance(item, tuple):
          for l in item:
              print(l)
      else:
          print(item)
```

```
hello
2.0
10
10
('hi', 'world')
3.5
1
uno
```

```
[8]: horsemen = ["war", "famine", "pestilence", "death"]
      for i in [0, 1, 2, 3]:
          print(horsemen[i])
      # better way to do the same thing?
```

```
war
famine
pestilence
death
```

```
[10]: print("traversing using indices")
       for i in range(len(horsemen)):
           print(horsemen[i])
```

```
traversing using indices
war
famine
pestilence
death
```

```
[11]: print('traversing each element')
       for ele in horsemen:
           print(ele)
```

```
traversing each element
war
famine
pestilence
death
```

1.7 8.6 list operators

- + operator concatenates two lists and gives a bigger list
- * operator repeats a list elements a given number of times

```
[24]: list2
```

```
[24]: ['spam', 'bungee', 'swallow']
```

```
[26]: list3
```

```
[26]: ['hello', 2.0, 10, [10, ('hi', 'world'), 3.5], (1, 'uno')]
```

```
[27]: list4 = list2 + list3
```

```
[28]: list4
```

```
[28]: ['spam',  
      'bungee',  
      'swallow',  
      'hello',  
      2.0,  
      10,  
      [10, ('hi', 'world'), 3.5],  
      (1, 'uno')]
```

```
[29]: [0]*10
```

```
[29]: [0, 0, 0, 0, 0, 0, 0, 0, 0, 0]
```

```
[30]: a = [1, 2, 3]*4
```

```
[31]: a
```

```
[31]: [1, 2, 3, 1, 2, 3, 1, 2, 3, 1, 2, 3]
```

```
[32]: b = [a]*3
```

```
[33]: b
```

```
[33]: [[1, 2, 3, 1, 2, 3, 1, 2, 3, 1, 2, 3],  
      [1, 2, 3, 1, 2, 3, 1, 2, 3, 1, 2, 3],  
      [1, 2, 3, 1, 2, 3, 1, 2, 3, 1, 2, 3]]
```

```
[42]: # 2-D list or matrix  
matrix = [[1, 2], [3, 4], [5, 6]]
```

```
[43]: print(matrix)
```

```
[[1, 2], [3, 4], [5, 6]]
```

```
[44]: matrix
```

```
[44]: [[1, 2], [3, 4], [5, 6]]
```

```
[45]: # How do you replace 5 with 50 in matrix?  
matrix[2][0] = 50
```

```
[46]: matrix
```

```
[46]: [[1, 2], [3, 4], [50, 6]]
```

1.8 8.7 Slicing lists

- all the slice operations that work with strings also work with lists
- syntax: [startIndex : endIndex : step]
- startIndex is inclusive; endIndex is exclusive; step is optional by default 1

```
[36]: # create a list of lower-case alphabets  
alphas = ['a', 'b', 'c', 'd', 'e', 'f', 'g'] # add the rest...
```

```
[37]: alphas
```

```
[37]: ['a', 'b', 'c', 'd', 'e', 'f', 'g']
```

```
[38]: # there's better way to create lists of all lowercase ascii  
import string  
alphas = list(string.ascii_lowercase)
```

```
[39]: print(alphas[:])
```

```
['a', 'b', 'c', 'd', 'e', 'f', 'g', 'h', 'i', 'j', 'k', 'l', 'm', 'n', 'o', 'p',  
'q', 'r', 's', 't', 'u', 'v', 'w', 'x', 'y', 'z']
```

```
[40]: print(alphas[::3])
```

```
['a', 'd', 'g', 'j', 'm', 'p', 's', 'v', 'y']
```

```
[41]: print(alphas[1:3])
```

```
['b', 'c']
```

```
[42]: print(alphas[::-1])
```

```
['z', 'y', 'x', 'w', 'v', 'u', 't', 's', 'r', 'q', 'p', 'o', 'n', 'm', 'l', 'k',  
'j', 'i', 'h', 'g', 'f', 'e', 'd', 'c', 'b', 'a']
```

1.9 8.8 Lists and strings

- match made in heaven - work together really well :)

```
[44]: # convert string to list of characters  
alphaList = list(string.ascii_lowercase)
```

```
[45]: alphaList
```

```
[45]: ['a',  
      'b',  
      'c',  
      'd',  
      'e',  
      'f',  
      'g',  
      'h',  
      'i',  
      'j',  
      'k',  
      'l',  
      'm',  
      'n',  
      'o',  
      'p',  
      'q',  
      'r',  
      's',  
      't',  
      'u',  
      'v',  
      'w',  
      'x',  
      'y',  
      'z']
```

```
[46]: # convert list to string by joining pairs of chars with a delimiter  
alphaStr = '|'.join(alphaList)
```

```
[47]: alphaStr
```

```
[47]: 'a|b|c|d|e|f|g|h|i|j|k|l|m|n|o|p|q|r|s|t|u|v|w|x|y|z'
```

1.10 8.9 lists are mutable

- we can change/replace/update list elements in place


```
[48]: names = ["john", "David", "Alice"]
names[0] = "jake"
```

```
[49]: names
```

```
[49]: ['jake', 'David', 'Alice']
```

```
[50]: # How to correct spelling of jake?
names[0][0]
```

```
[50]: 'j'
```

```
[51]: names[0][0] = 'J'
```

```

      □
↳-----
      TypeError                                Traceback (most recent call↳
↳last)

    <ipython-input-51-0442e9474c4b> in <module>
----> 1 names[0][0] = 'J'

      TypeError: 'str' object does not support item assignment
```

```
[52]: names[0] = 'Jake'
```

```
[53]: names
```

```
[53]: ['Jake', 'David', 'Alice']
```

```
[54]: alphas
```

```
[54]: ['a',
      'b',
      'c',
      'd',
      'e',
      'f',
      'g',
      'h',
      'i',
      'j',
      'k',
```

```
'l',  
'm',  
'n',  
'o',  
'p',  
'q',  
'r',  
's',  
't',  
'u',  
'v',  
'w',  
'x',  
'y',  
'z']
```

```
[55]: alphas[:4] = ['A', 'B', 'C', 'D']
```

```
[56]: alphas
```

```
[56]: ['A',  
      'B',  
      'C',  
      'D',  
      'e',  
      'f',  
      'g',  
      'h',  
      'i',  
      'j',  
      'k',  
      'l',  
      'm',  
      'n',  
      'o',  
      'p',  
      'q',  
      'r',  
      's',  
      't',  
      'u',  
      'v',  
      'w',  
      'x',  
      'y',  
      'z']
```

```
[57]: alphas[:4] = []
```

```
[58]: alphas
```

```
[58]: ['e',  
      'f',  
      'g',  
      'h',  
      'i',  
      'j',  
      'k',  
      'l',  
      'm',  
      'n',  
      'o',  
      'p',  
      'q',  
      'r',  
      's',  
      't',  
      'u',  
      'v',  
      'w',  
      'x',  
      'y',  
      'z']
```

1.11 8.10 Deleting list elements

- del statement removes an element from a list given its index

```
[59]: alphas
```

```
[59]: ['e',  
      'f',  
      'g',  
      'h',  
      'i',  
      'j',  
      'k',  
      'l',  
      'm',  
      'n',  
      'o',  
      'p',  
      'q',  
      'r',
```

```
's',  
't',  
'u',  
'v',  
'w',  
'x',  
'y',  
'z']
```

```
[60]: del alphas[0]
```

```
[61]: alphas
```

```
[61]: ['f',  
      'g',  
      'h',  
      'i',  
      'j',  
      'k',  
      'l',  
      'm',  
      'n',  
      'o',  
      'p',  
      'q',  
      'r',  
      's',  
      't',  
      'u',  
      'v',  
      'w',  
      'x',  
      'y',  
      'z']
```

```
[62]: del alphas[26]
```

```
↳ -----  
IndexError                                Traceback (most recent call↳  
↳last)  
  
  <ipython-input-62-80e1a19bb44c> in <module>  
----> 1 del alphas[26]
```

IndexError: list assignment index out of range

```
[63]: alphas.index('z')
```

```
[63]: 20
```

```
[64]: alphas.index(alphas[-1])
```

```
[64]: 20
```

```
[65]: del alphas[1:3]
```

```
[66]: alphas
```

```
[66]: ['f',  
      'i',  
      'j',  
      'k',  
      'l',  
      'm',  
      'n',  
      'o',  
      'p',  
      'q',  
      'r',  
      's',  
      't',  
      'u',  
      'v',  
      'w',  
      'x',  
      'y',  
      'z']
```

```
[67]: indexOfZ = alphas.index('z')  
      del alphas[indexOfZ]
```

```
[68]: print(alphas)
```

```
['f', 'i', 'j', 'k', 'l', 'm', 'n', 'o', 'p', 'q', 'r', 's', 't', 'u', 'v', 'w',  
'x', 'y']
```

1.12 8.11 Objects and references

- **is** operator can be used to test if two objects are referencing the same memory location
 - meaning they're essentially the same object with the same values

```
[78]: # even though a and b are two separate objects is still evaluates to True
a = 'apple'
b = 'apple'
a is b
```

[78]: True

```
[69]: # even though c and d are two separate objects is still evaluates to True
c = 10
d = 10
c is d
```

[69]: True

```
[73]: # what about tuple?
e = (1, 2)
f = (1, 2)
print(e == f)
print(e is f)
```

True
False

```
[79]: # What about lists?
l1 = [1, 2, 3]
l2 = [1, 2, 3]
print(l1 == l2)
print(l1 is l2)
```

True
False

1.13 8.12 Copying lists (Shallow copy vs Deep copy)

- see [PythonTutor.com](https://www.python-tutor.com/aliasing) to visualize aliasing
- assignment = operator does shallow copy

```
[80]: a = [1, 2, 3]
b = a
print(a is b)
print(a == b)
```

True
True

```
[81]: b[0] = 10
print(a)
print(b)
```

```
[10, 2, 3]
[10, 2, 3]
```

```
[82]: # How do you actually clone lists - do a deep copy?
      c = a[:] # easy way shallow copy
      d = a.copy() # shallow copy
      import copy
      e = copy.deepcopy(b)
```

```
[83]: c is a
```

```
[83]: False
```

```
[84]: d is a
```

```
[84]: False
```

```
[85]: b is e
```

```
[85]: False
```

1.14 8.13 List methods

- list objects have a bunch methods that can be invoked to work with list
- run `help(list)`

```
[86]: help(list)
```

Help on class list in module builtins:

```
class list(object)
| list(iterable=(), /)
|
| Built-in mutable sequence.
|
| If no argument is given, the constructor creates a new empty list.
| The argument must be an iterable if specified.
|
| Methods defined here:
|
| __add__(self, value, /)
|     Return self+value.
|
| __contains__(self, key, /)
|     Return key in self.
|
| __delitem__(self, key, /)
|     Delete self[key].
```

```

|  __eq__(self, value, /)
|      Return self==value.
|
|  __ge__(self, value, /)
|      Return self>=value.
|
|  __getattr__(self, name, /)
|      Return getattr(self, name).
|
|  __getitem__(...)
|      x.__getitem__(y) <==> x[y]
|
|  __gt__(self, value, /)
|      Return self>value.
|
|  __iadd__(self, value, /)
|      Implement self+=value.
|
|  __imul__(self, value, /)
|      Implement self*=value.
|
|  __init__(self, /, *args, **kwargs)
|      Initialize self.  See help(type(self)) for accurate signature.
|
|  __iter__(self, /)
|      Implement iter(self).
|
|  __le__(self, value, /)
|      Return self<=value.
|
|  __len__(self, /)
|      Return len(self).
|
|  __lt__(self, value, /)
|      Return self<value.
|
|  __mul__(self, value, /)
|      Return self*value.
|
|  __ne__(self, value, /)
|      Return self!=value.
|
|  __repr__(self, /)
|      Return repr(self).
|
|  __reversed__(self, /)
|      Return a reverse iterator over the list.

```



```

|
|  __rmul__(self, value, /)
|      Return value*self.
|
|  __setitem__(self, key, value, /)
|      Set self[key] to value.
|
|  __sizeof__(self, /)
|      Return the size of the list in memory, in bytes.
|
|  append(self, object, /)
|      Append object to the end of the list.
|
|  clear(self, /)
|      Remove all items from list.
|
|  copy(self, /)
|      Return a shallow copy of the list.
|
|  count(self, value, /)
|      Return number of occurrences of value.
|
|  extend(self, iterable, /)
|      Extend list by appending elements from the iterable.
|
|  index(self, value, start=0, stop=9223372036854775807, /)
|      Return first index of value.
|
|      Raises ValueError if the value is not present.
|
|  insert(self, index, object, /)
|      Insert object before index.
|
|  pop(self, index=-1, /)
|      Remove and return item at index (default last).
|
|      Raises IndexError if list is empty or index is out of range.
|
|  remove(self, value, /)
|      Remove first occurrence of value.
|
|      Raises ValueError if the value is not present.
|
|  reverse(self, /)
|      Reverse *IN PLACE*.
|
|  sort(self, /, *, key=None, reverse=False)
|      Stable sort *IN PLACE*.

```

```

|
| -----
| Static methods defined here:
|
| __new__(*args, **kwargs) from builtins.type
|     Create and return a new object.  See help(type) for accurate signature.
|
| -----
| Data and other attributes defined here:
|
| __hash__ = None

```

```
[87]: a = []
      a.append(1)
      a.append(2)
      a.append([2, 3])
```

```
[88]: a
```

```
[88]: [1, 2, [2, 3]]
```

```
[89]: a.extend([3, 4])
```

```
[90]: a
```

```
[90]: [1, 2, [2, 3], 3, 4]
```

```
[91]: a.append([5, 6])
```

```
[92]: a
```

```
[92]: [1, 2, [2, 3], 3, 4, [5, 6]]
```

```
[93]: a.insert(0, 'hi')
```

```
[94]: a
```

```
[94]: ['hi', 1, 2, [2, 3], 3, 4, [5, 6]]
```

```
[95]: a.reverse()
```

```
[96]: a[0].reverse()
```

```
[97]: a
```

```
[97]: [[6, 5], 4, 3, [2, 3], 2, 1, 'hi']
```

```
a.sort()
```

TypeError

Traceback (most recent call last):

```
<ipython-input-98-2ed0d7de6146> in <module>()
----> 1 a.sort()
```

```
TypeError: '<' not supported between instances of 'int' and 'list'
```

```
blist = list(range(10, 0, -1))
```

```
blist
```

```
[100]: [10, 9, 8, 7, 6, 5, 4, 3, 2, 1]
```

```
blist.sort()
```

```
print(blist)
```

[1, 2, 3, 4, 5, 6, 7, 8, 9, 10]

```
blist.sort(reverse=True)
```

```
blist
```

```
[104]: [10, 9, 8, 7, 6, 5, 4, 3, 2, 1]
```

```
m = max(blist)
mI = blist.index(m)
```

```
print(mI)
```

0

```
min(blist)
```

[107]: 1

```
print(blist.count(100))
```

0

1.15 8.14 List applications

1.15.1 convert a string to list of integers

```
[4]: nums = input('Enter 5 numbers separated by space: ')
```

Enter 5 numbers separated by space: 1 2 100 5

```
[5]: nums
```

```
[5]: '1 2 100 5'
```

```
[76]: nums = nums.split(' ')
```

```
[77]: nums
```

```
[77]: ['1', '2', '100', '5']
```

```
[78]: intNums = []
      for n in nums:
          intN = int(n)
          intNums.append(intN)
```

```
[79]: intNums
```

```
[79]: [1, 2, 100, 5]
```

```
[80]: intNums.sort()
```

```
[81]: intNums
```

```
[81]: [1, 2, 5, 100]
```

1.15.2 convert list of integers to string

```
[94]: ' '.join(intNums)
```

```

↳
-----
TypeError                                Traceback (most recent call↳
↳last)

    <ipython-input-94-0dd63a44d5ec> in <module>
----> 1 ' '.join(intNums)
```

TypeError: sequence item 0: expected str instance, int found

```
[99]: strNum = []  
      for n in intNums:  
          strNum.append(str(n))
```

```
[100]: strNum
```

```
[100]: ['1', '2', '5', '100']
```

```
[101]: strNum = ' '.join(strNum)
```

```
[102]: strNum
```

```
[102]: '1 2 5 100'
```

1.16 8.15 Passing list to function - pass-by-reference

- mutable types such as list are passed-by-reference
- an alias or reference is passed instead of a copy of the data

```
[84]: def getData(someList):# someList is formal parameter  
      for i in range(5):  
          a = int(input('enter a number: '))  
          someList.append(a)
```

```
[85]: alist = []  
      getData(alist) # alist is actual argument
```

```
enter a number: 1  
enter a number: 10  
enter a number: 4  
enter a number: 6  
enter a number: 90
```

```
[86]: # when formal parameter is updated, actual parameter is also updated  
      alist
```

```
[1, 10, 4, 6, 90]
```

1.16.1 visualize - pass-by-reference with pythontutor.com

1.17 8.16 return list from functions

- lists can be returned from functions

```
[121]: def getMaxMin(alist):  
        m = max(alist)
```

```
minVal = min(alist)
return [m, minVal]
```

```
[122]: alist = list(range(-1000, 2000000))
print(getMaxMin(alist))
```

```
[1999999, -1000]
```

```
[123]: assert getMaxMin(alist) == [1999999, -1000]
```

1.18 8.17 Casting list into tuple and back

- since tuples are immutable it may be beneficial to cast them into lists and update
- can convert list back to tuple again

```
[88]: atuple = (1, 2, 3)
alist = list(atuple)
print(alist)
```

```
[1, 2, 3]
```

```
[89]: btuple = tuple(alist)
```

```
[90]: print(btuple)
```

```
(1, 2, 3)
```

```
[91]: atuple == btuple
```

```
[91]: True
```

```
[93]: # eventhough the elements are equal; the types of two objects are not
print(atuple, alist)
print(atuple == alist)
```

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

```
False
```

1.19 8.18 Exercises

1. Practice with the rest of the methods of list
2. Draw memory state snapshot for a and b after the following Python code is executed:

```
a = [1, 2, 3]
b = a[:]
b[0] = 5
```

3. Lists can be used to represent mathematical vectors. Write a function `add_vectors(u, v)` that takes two lists of numbers of the same length, and returns a new list containing the sums of the corresponding elements of each. The following test cases must pass once the `add_vectors` is complete.

```
[124]: def add_vectors(a, b):  
        pass
```

```
[125]: # test cases  
assert add_vectors([1, 1], [1, 1]) == [2, 2], 'vectors not added correctly'  
assert add_vectors([1, 2], [1, 4]) == [2, 6], 'vectors not added correctly'  
assert add_vectors([1, 2, 1], [1, 4, 3]) == [2, 6, 4], 'vectors not added_  
→correctly'
```

```
→  
-----  
AssertionError                                Traceback (most recent call_  
→last)  
  
  <ipython-input-125-f13d12d55331> in <module>()  
    1 # test cases  
----> 2 assert add_vectors([1, 1], [1, 1]) == [2, 2], 'vectors not added_  
→correctly'  
    3 assert add_vectors([1, 2], [1, 4]) == [2, 6], 'vectors not added_  
→correctly'  
    4 assert add_vectors([1, 2, 1], [1, 4, 3]) == [2, 6, 4], 'vectors not_  
→added correctly'
```

```
AssertionError: vectors not added correctly
```

1.20 Kattis problems

- the following Kattis problems can be solved using list
1. Dice Game - <https://open.kattis.com/problems/dicegame>
 - Height Ordering - <https://open.kattis.com/problems/height>
 - What does the fox say? - <https://open.kattis.com/problems/whatdoesthefoxsay>
 - Army Strength (Easy) - <https://open.kattis.com/problems/armystrengtheasy>
 - Army Strength (Hard) - <https://open.kattis.com/problems/armystrengthhard>
 - Black Friday - <https://open.kattis.com/problems/blackfriday>

1.20.1 List sorting with two keys

1. Roll Call - <https://open.kattis.com/problems/rollcall>

- Cooking Water - <https://open.kattis.com/problems/cookingwater>

[]: