7.2 CREATING AND ACCESSING LISTS

A list is a standard data type of Python that can store a sequence of values belonging to any type. The *Lists* are depicted through square brackets, *e.g.*, following are some lists in Python :

```
[]                          # list with no member, empty list
[1, 2, 3]                   # list of integers
[1, 2.5, 3.7, 9]            # list of numbers (integers and floating point)
['a', 'b', 'c']             # list of characters
['a', 1, 'b', 3.5, 'zero']  # list of mixed value types
['One', 'Two', 'Three']     # list of strings
```

Before we proceed and discuss how to create lists, one thing that must be clear is that **Lists are mutable** (*i.e.*, modifiable) *i.e.*, you can change elements of a list in place. In other words, the memory address of a list will not change even after you change its values. List is one of the two mutable types of *Python – Lists* and *Dictionaries* are mutable types ; all other data types of Python are immutable.

> **NOTE**
> Lists are **mutable sequences** of Python *i.e.*, you can change elements of a list in place.

7.2.1 Creating Lists

To create a list, put a number of expressions in square brackets. That is, use square brackets to indicate the *start* and *end* of the list, and separate the items by commas. *For example* :

```
[2, 4, 6]
['abc', 'def']
[1, 2.0, 3, 4.0]
[]
```

> **NOTE**
> Lists can contain values of mixed data types.

Thus to create a list you can write in the form given below :

```
L = []
L = [value, ...]
```

This construct is known as a **list display construct.**

Consider some more examples :

- **The empty list**

  The empty list is [ ]. It is the list equivalent of 0 or '' and like them it also has truth value as *false*. You can also create an empty list as :

  ```
  L = list()
  ```

  It will generate an empty list and name that list as L.

> **NOTE**
> Lists are formed by placing a comma-separated-list of expressions in square brackets.

- **Long lists**

  If a list contains many elements, then to enter such long lists, you can split it across several lines, like below :

  ```
  sqrs = [ 0, 1, 4, 9, 16, 25, 36, 49, 64, 81, 100, 121, 144, 169,
  196, 225, 256, 289, 324, 361, 400, 441, 484, 529, 576, 625 ]
  ```

  Notice the opening square bracket and closing square brackets appear just in the beginning and end of the list.

Nested lists

A list can have an element in it, which itself is a list. Such a list is called nested list, *e.g.*,

```
L1 = [3, 4, [5, 6], 7]
```

L1 is a nested list with four elements : 3, 4, [5, 6] and 7. **L1[2]** element is a list [5, 6]. Length of L1 is 4 as it counts [5, 6] as one element.

Creating Lists from Existing Sequences

You can also use the built-in list type object to create lists from sequences as per the syntax given below :

```
L = list(<sequence>)
```

where ***<sequence>*** can be any kind of sequence object including strings, tuples, and lists. Python creates the individual elements of the list from the individual elements of passed sequence. If you pass in another list, the list function makes a copy.

Consider following examples :

```
>>> l1 = list('hello')
>>> l1
['h', 'e', 'l', 'l', 'o']
```

List l1 is created from another sequence – a string "hello"
It generated individual elements from the individual letters of the string

```
>>> t = ('w', 'e' , 'r' , 't', 'y')
>>> l2 = list(t)
>>> l2
['w', 'e', 'r', 't', 'y']
```

List l2 is created from another sequence – a tuple t
It generated individual elements from the individual elements of the passed tuple t.

You can use this method of creating lists of single characters or single digits via keyboard input. Consider the code below :

```
l1 = list(input('Enter list elements: '))
enter list elements: 234567
>>> l1
['2', '3', '4', '5', '6', '7']
```

See, it created the elements of list t using each of the character input

Notice, this way the data type of all characters entered is ***string*** even though we entered digits. To enter a list of integers through keyboard, you can use the method given below.

Most commonly used method to input lists is **eval(input( ))** as shown below :

```
list = eval(input( "Enter list to be added:" ))
print ("list you entered :", list)
```

eval( ) tries to identify type by looking at the given expression (Read on next page)

when you execute it, it will work somewhat like :

```
Enter list to be added:[67, 78, 46, 23]
list you entered : [67, 78, 46, 23]
```

Please note, sometimes (not always) **eval( )** does not work in Python Shell. At that time, you can run it through a script or program too.

The eval( ) function of Python can be used to evaluate and return the result of an expression given as string. For example :

```
eval('5 + 8')
```

will give you result as 13

Similarly, following code fragment

```
y = eval("3*10")
print(y)
```

will print value as 30

Since eval( ) can interpret an expression given as string, you can use it with input( ) too :

```
var1 = eval(input("Enter Value:"))
print(var1, type(var1))
```

Executing this code will result as :

```
Enter Value: 15 + 3
18 <class 'int'>
```

See, the eval( ) has not only interpreted the string "15+3" as 18 but also stored the result as *int* value. Thus with eval( ), if you enter an integer or float value , it will interpret the values as the intended types :

```
var1 = eval(input("Enter Value:"))
print(var1, type(var1))
```

```
Enter Value: 75
75 <class 'int'>
```

```
var1 = eval(input("Enter Value: "))
print(var1, type(var1))
```

```
Enter Value: 89.9
89.9 <class 'float'>
```

You can use eval( ) to enter a list or tuple also. Use [ ] to enter lists' and ( ) to enter tuple values

```
var1 = eval(input("Enter Value: "))
print(var1, type(var1))
```

```
Enter Value: [1, 2, 3]
[1, 2, 3] <class 'list'>
```

```
var1 = eval(input("Enter Value: "))
print(var1, type(var1))
```

```
Enter Value: (2, 4, 6, 8)
(2, 4, 6, 8) <class 'tuple'>
```

However, use of eval( ) may lead to unforeseen problems, and thus, use of eval( ) is always discouraged.

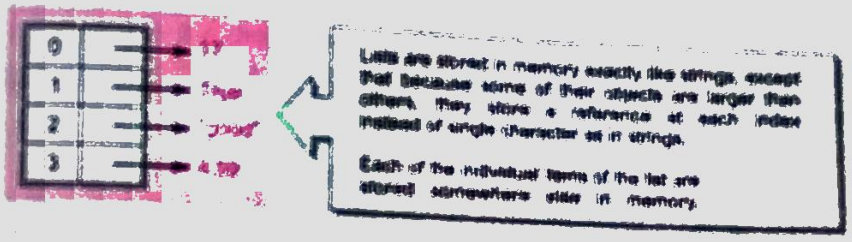
7.2.2 Accessing Lists

Lists are mutable (editable) sequences having a progression of elements. There must be a way to access its individual elements and certainly there is. But before we start accessing individual elements, let us discuss the similarity of Lists with strings that will make it very clear to you how individual elements are accessed in lists – the way you access string elements. Following subsection will make the things very clear to you, I bet !

...ility with Strings

Lists are sequences just like strings that you have read in previous chapter. They also index their individual elements, just like strings do. Recall figure 3.1 of chapter 3 that talks about indexing in strings. In the same manner, list elements are also indexed, i.e., forward indexing as 0, 1, 2, 3,... and backward indexing as –1, –2, –3, ... (See Fig 7.1(a)).

(a) List Elements' two way indexing



(b) How lists are internally organized

Figure 7.1

Thus, you can access the list elements just like you access a string's elements e.g., List[i] will give you the element at *i*th index of the list ; List[a:b] will give you elements between indexes *a* to *b* – 1 and so on.

Put in another words, Lists are similar to strings in following ways :

- **Length**

  Function **len(L)** returns the number of items (count) in the list *L*.

- **Indexing and slicing**

  L[i] returns the item at index *i* (the first item has index 0), and

  L[i : j] returns a new list, containing the objects at indexes between *i* and *j* (excluding index *j*).

- **Membership operators**

  Both 'in' and 'not in' operators work on *Lists* just like they work for other sequences. That is, in tells if an element is present in the list or not, and not in does the opposite.

- **Concatenation and replication operators + and ***

  The + operator adds one list to the end of another. The * operator repeats a list. We shall be talking about these two operations in a later section 7.3 – *List Operations*.

Accessing Individual Elements

As mentioned, the individual elements of a list are accessed through their indexes. Consider following examples :

```
>>> vowels = [ 'a', 'e', 'i', 'o', 'u' ]
>>> vowels[0]
'a'
>>> vowels[4]
'u'
>>> vowels[-1]
'u'
>>> vowels[-5]
'a'
```

NOTE

While accessing list elements, if you pass in a negative index, Python adds the length of the list to the index to get element's forward index. That is, for a 6-element list L, ***L[–5]*** will be internally computed as :
L [–5 + 6] = L [1], and so on.

Like strings, if you give index outside the legal indices (0 to *length* – 1 or – *length*, – *length* +1, ... , uptill –1) while accessing individual elements, Python will raise **Index Error** (see below)

```
>>> vowels = [ 'a', 'e', 'i', 'o', 'u' ]
>>> vowels[5]
Traceback (most recent call last):
  File "<pyshell#1>", line 1, in <module>
    vowels[5]
IndexError: list index out of range
```

*5 is not legal index for **vowels** list, thus cannot be used to access individual element*

Difference from Strings

Although lists are similar to strings in many ways, yet there is an important **difference in mutability of the two. Strings are not mutable, while lists are.** You cannot change individual elements of a string in place, but Lists allow you to do so. That is, following statement is fully valid for Lists (though not for strings) :

```
L[i] =<element>
```

For example, consider the same ***vowels*** list created above, that stores all vowels in lower case. Now, if you want to change some of these vowels, you may write something as shown below :

```
>>> vowels[0] = 'A'
>>> vowels
['A', 'e', 'i', 'o', 'u']
>>> vowels[-4] = 'E'
>>> vowels
['A', 'E', 'i', 'o', 'u']
```

*Notice, it changed the element in place; ('a' changed to 'A') no new list created – because **Lists** are **MUTABLE**.*

NOTE

Lists are similar to strings in many ways like indexing, slicing and accessing individual elements but they are different in the sense that ***Lists are mutable while strings are not.***

Traversing a List

Recall that traversal of a sequence means accessing and processing each element of it. Thus traversing a list also means the same and same is the tool for it, *i.e.*, the Python loops. That is why sometimes we call a traversal as looping over a sequence.

The **for loop** makes it easy to **traverse** or **loop over** the items in a list, as per following syntax :

```
for <item> in <List>:
    process each item here
```

For example, following loop shows each item of a list L in separate lines :

```
L = ['P', 'y', 't', 'h', 'o', 'n']
for a in L :
    print (a)
```

The above loop will produce result as :

```
P
y
t
h
o
n
```

How it works

The loop variable a in above loop will be assigned the List elements, one at a time. So, loop-variable a will be assigned **'P'** in *first* iteration and hence **'P'** will be printed ; in *second* iteration, a will get element 'y' and 'y' will be printed; and so on.

If you only need to use the indexes of elements to access them, you can use functions ***range( )*** and ***len( )*** as per following syntax :

```
for index in range(len(L)):
    process List[index] here
```

Consider program 7.1 that traverses through a list using above format and prints each item of a list L in separate lines along with its index.

Program 7.1 *Program to print elements of a list ['q', 'w', 'e', 'r', 't', 'y'] in separate lines along with element's both indexes (positive and negative).*

```
L = [ 'q', 'w', 'e', 'r', 't', 'y']
length = len(L)
for a in range(length) :
    print("At indexes", a, "and", (a - length), "element :", L[a])
```

Sample run of above program is :

```
At indexes 0 and -6 element : q
At indexes 1 and -5 element : w
At indexes 2 and -4 element : e
At indexes 3 and -3 element : r
At indexes 4 and -2 element : t
At indexes 5 and -1 element : y
```

Comparing Lists

You can compare two lists using standard comparison operators of Python, *i.e.*, <, >, ==, !=, etc. Python internally compares individual elements of lists (and tuples) in lexicographical order. This means that to compare equal, each corresponding element must compare equal and the two sequences must be of the same type *i.e.*, having comparable types of values.

Consider following examples :

```
>>> L1 , L2 = [1, 2, 3], [1, 2, 3]
>>> L3 = [1, [2, 3]]
>>> L1 == L2
True
>>> L1 == L3
False
```

For comparison operators >, <, >= , <=, the corresponding elements of two lists must be of comparable types , otherwise Python will give error.

Consider the following considering the above two lists :

```
>>> L1 < L2
False
>>> L1 < L3
Traceback (most recent call last):
    File "<ipython-input-180-84fdf598c3f1>", line 1, in <module>
        L1 < L3
    TypeError : '<' not supported between instances of 'int' and 'list'
```

For first comparison, Python did not give any error as both lists have values of same type.

For second comparison, as the values are not of comparable types, Python raised error

Python raised error above because the corresponding second elements of lists *i.e.,* L1[1] and L3[1] are not of comparable types. L1[1] is ***integer*** (2) and L3[1] is a ***list*** [2, 3] and list and numbers are not comparable types in Python.

Python gives the final result of non-equality comparisons as soon as it gets a result in terms of True/False from corresponding elements' comparison. If corresponding elements are equal, it goes on to the next element, and so on, until it finds elements that differ. Subsequent elements are not considered (even if they are really big). See below.

Table7.1 *Non-equality Comparison in List Sequences*

Comparison	Result	Reason
`[1, 2, 8, 9] < [9, 1]`	True	Gets the result with the comparison of corresponding first elements of two lists `1 < 9 is True`
`[1, 2, 8, 9] < [1, 2, 9, 1]`	True	Gets the result with the comparison of corresponding third elements of two lists `8 < 9 is True`
`[1, 2, 8, 9] < [1, 2, 9, 10]`	True	Gets the result with the comparison of corresponding third elements of two lists `8 < 9 is True`
`[1, 2, 8, 9] < [1, 2, 8, 4]`	False	Gets the result with the comparison of corresponding fourth elements of two lists `9 < 4 is False`

So, for comparison purposes, Python internally compares individual elements of two lists, applying all the comparison rules that you have read earlier. Consider following code :

```
>>> a = [2, 3]
>>> b = [2, 3]
>>> c = ['2', '3']
>>> d = [2.0, 3.0]
>>> e = [2, 3, 4]
>>> a == b
True
>>> a == c
False
>>> a > b
False
>>> d > a
False
>>> d == a
True
>>> a < e
True
```

Notice for comparison purposes, Python ignored the types of elements and compared values only

*Foe two lists to be equal, they must have same number of elements and matching values (recall **int** and **float** with matching values are considered equal)*

There is also a *cmp( )* function that can be used for sequences' comparisons but we are not covering it here.

7.3 LIST OPERATIONS

The most common operations that you perform with lists include *joining* lists, *replicating* lists and *slicing* lists. In this section, we are going to talk about the same.

7.3.1 Joining Lists

Joining two lists is very easy just like you perform addition, literally ;-) . The concatenation operator +, when used with two lists, joins two lists. Consider the example given below :

```
>>> lst1 = [ 1, 3, 5]
>>> lst2 = [6, 7, 8 ]
>>> lst1 + lst2
[1, 3, 5, 6, 7, 8]
```

The + operator concatenates two lists and creates a new list

As you can see that the resultant list has firstly elements of first list ***lst1*** and followed by elements of second list ***lst2***. You can also join two or more lists to form a new list, *e.g.*,

```
>>> lst1 = [10, 12, 14]
>>> lst2 = [20, 22, 24]
>>> lst3 = [30, 32, 34]
>>> lst = lst1 + lst2 + lst3
>>> lst
[10, 12, 14, 20, 22, 24, 30, 32, 34]
```

*The + operator is used to concatenate three individual lists to get a new combined list **lst**.*

The + operator when used with lists requires that both the operands must be of list types. You cannot add a number or any other value to a list. *For example*, following expression will result into error :

```
list + number
list + complex-number
list + string
```

Consider the following examples

```
>>> lst1 = [10, 12, 14]
>>> lst1 + 2

Traceback (most recent call last):
 File "<pyshell#42>", line 1, in <module>
    lst1+2
TypeError: can only concatenate list (not "int") to list
>>> lst1 + "abc"

Traceback (most recent call last):
 File "<pyshell#44>", line 1, in <module>
    lst1 + "abc"
TypeError: can only concatenate list (not "str") to list
```

See errors generated when anything other than a list is added to a list

7.3.2 Repeating or Replicating Lists

Like strings, you can use * operator to replicate a list specified number of times, *e.g.*, (considering the same list *lst1 = [1, 3, 5]*)

```
>>> lst1 * 3
[1, 3, 5, 1, 3, 5, 1, 3, 5]
```

*The * operator repeats a list specifies number of times and creates a new list*

Like strings, you can only use an integer with a * operator when trying to replicate a list.

NOTE

When used with lists, the + operator requires both the operands as list-types; and the * operator requires a list and an integer.

7.3.3 Slicing the Lists

List slices, like string slices are the sub part of a list extracted out. You can use indexes of list elements to create ***list slices*** as per following format :

```
seq = L[start:stop]
```

The above statement will create a *list slice* namely **seq** having elements of list L on indexes *start*, *start+1*, *start+2*,...., *stop–1*. Recall that index on last limit is not included in the *list slice*. The *list slice* is a list in itself, that is, you can perform all operations on it just like you perform on lists.

Consider the following example :

```
>>> lst =[10, 12, 14, 20, 22, 24, 30, 32, 34]
>>> seq = lst [ 3: -3]
>>> seq
[20, 22, 24]
>>> seq[1] = 28
>>> seq
[20, 28, 24]
```

Trying to modify an element of seq in place ; and it successfully does because the list slice seq is a list in itself.

NOTE

L[start:stop] creates a list slice out of list L with elements falling between indexes ***start*** and ***stop***, not including ***stop***.

For normal indexing, if the resulting index is outside the list, Python raises an **IndexError exception**. Slices are treated as boundaries instead, and the result will simply contain all items between the boundaries. For the ***start*** and ***stop*** given beyond list limits in a list slice (*i.e.*, out of bounds), Python simply returns the elements that fall between specified boundaries, if any, without raising any error.

For example, consider the following :

```
>>> lst =[10, 12, 14, 20, 22, 24, 30, 32, 34]
>>> lst [3:30]
[20, 22, 24, 30, 32, 34]
```

Giving upper limit way beyond the size of the list, but Python return elements from list falling in range 3 onwards <30

```
>>> lst [ -15 :7]
[10, 12, 14, 20, 22, 24, 30]
```

Giving lower limit much lower, but Python returns elements from list falling in range –15 onwards <7

```
>>> L1 [2, 3, 4, 5, 6, 7, 8]
>>> L1 [2 : 5]
[4, 5, 6]
```

*Legal index range is **0..6** and **–7 .. –1***

```
>>> L1 [ 6 : 10]
[8]
```

One limit is out of bounds

No error ! Python returns a sub-list as per given range

```
>>> L1 [10 : 20]
[ ]
```

Both limits are out of bounds

*Python gives no error and returns an empty sequence as no element of **L1** has index falling in range of 10 to 20.*

Lists also support ***slice steps***. That is, if you want to extract, not consecutive but every other element of the list, there is a way out – the ***slice steps***. The *slice steps* are used as per following format :

```
seq = L[start:stop:step]
```

NOTE

L[start : stop: step] creates a list slice out of list L with elements falling between indexes ***start*** and ***stop***, *not including stop*, skipping step-1 elements in between.

Consider some examples to understand this.

```
>>> lst
[10, 12, 14, 20, 22, 24, 30, 32, 34]
```

```
>>> lst[0 : 10 : 2 ]
[10, 14, 22, 30, 34]
```

*Include every 2nd element, i.e., **skip 1 element** in between. Check resulting list slice*

```
>>> lst[2 : 10 : 3 ]
[14, 24, 34]
```

*Include every 3rd element, i.e., **skip 2 elements** in between*

```
>>> lst[:: 3 ]
[10, 20, 30]
```

*No **start** and **stop** given. Only step is given as 3. That is, from the entire list, pick every 3rd element for the list slice.*

Consider some more examples :

```
seq = L[::2]     # get every other item, starting with the first
seq = L[5::2]    # get every other item, starting with the sixth element, i.e., index 5
```

Like strings, if you give <Listname> [:: –1], it will reverse the list *e.g.*, for a list say List = [5, 6, 8, 11, 3], following expression will reverse it :

```
>>> List [ :: -1]
[3, 11, 8, 6, 5]
```

See, List reversed

Program 7.2 *Extract two list-slices out of a given list of numbers. Display and print the sum of elements of first list-slice which contains every other element of the list between indexes 5 to 15. Program should also display the average of elements in second list slice that contains every fourth element of the list. The given list contains numbers from 1 to 20.*

```
lst = [ 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20]
slc1 = lst[5 : 15 :2]
slc2 = lst[::4]
sum = avg = 0
print ("Slice 1")
for a in slc1 :
    sum += a
    print (a, end = ' ')
print ()
print ("Sum of elements of slice 1:", sum)
print ("Slice 2")
sum = 0
for a in slc2 :
    sum += a
    print (a, end = ' ')
print ()
avg = sum /len(slc2)
print ("Average of elements of slice 2:", avg)
```

Sample run of above program is :

```
Slice 1
6 8 10 12 14
Sum of elements of slice 1: 50
Slice 2
1 5 9 13 17
Average of elements of slice 2: 9
```

Using Slices for List Modification

You can use slices to overwrite one or more list elements with one or more other elements. Following examples will make it clear to you :

```
>>> L = ["one", "two", "THREE"]
>>> L[0:2] = [ 0, 1 ]
>>> L
[0, 1, "THREE"]
>>> L =["one", "two", "THREE"]
>>> L[0:2] = "a"
>>> L
["a", "THREE"]
```

assigning new values to list slice

Notice, what the list changes to.

Notice, what the list changes to.

In all the above examples, we have assigned new values in the form of a sequence. **The values being assigned must be a sequence,** *i.e.*, a list or string or tuple etc.

For example, following assignment is also valid.

```
>>> L1 = [1, 2, 3]
>>> L1 [2 :] = "604"
>>> L1
[1, 2, 3, '6', '0', '4']
```

String is also a sequence

But if you try to assign a non-sequence value to a list slice such as a number, Python will give an error, *i.e.*,

```
>>> L1 [2 :] = 345
File "<.....>", line 1, in <module>
    L1 [2:] = 345
TypeError: can only assign an iterable
```

345 is a number, not a sequence

But here, you should also know something. If you give a list slice with range much outside the length of the list, it will simply add the values at the end *e.g.*,

```
>>> L1 = [1, 2, 3]
>>> L1 [ 10 : 20] = "abcd"
>>> L1
[1, 2, 3, 'a', 'b', 'c', 'd']
```

no error even though list slice limits are outside the length. Now Python will append the letters to the end of list L1.

7.4 WORKING WITH LISTS

Now that you have learnt to access the individual elements of a list, let us talk about how you can perform various operations on lists like : *appending, updating, deleting* etc.

Appending Elements to a List

You can also add items to an existing sequence. The **append( )** method **adds a single item to the end of the list.** It can be done as per following format :

```
L.append(item)
```

Consider some examples :

```
>>> lst1 = [10, 12, 14]
>>> lst1.append(16)
>>> lst1
[10, 12, 14, 16]
```

The element specified as argument to append() is added at the end of existing list

Updating Elements to a List

To update or change an element of the list in place, you just have to assign new value to the element's index in list as per syntax :

```
L[index] = <new value>
```

Consider following example :

```
>>> lst1 = [10, 12, 14, 16]
>>> lst1[2] = 24
>>> lst1
[10, 12, 24, 16]
```

Statement updating an element (3rd element – having index 2) in the list.

Display the list to see the ***updated list.***

Deleting Elements from a List

You can also remove items from lists. The **del** statement can be used to remove an individual item, or to remove all items identified by a slice. It is to be used as per syntax given below :

```
del <list>[<index>]          # to remove element at index
del <list>[<start>:<stop>]   # to remove elements in list slice
```

Consider following examples :

```
>>> lst=[2, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20]
>>> del lst[10]
>>> lst
[2, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20]
>>> del lst[10:15]
>>> lst
[2, 2, 3, 4, 5, 6, 7, 8, 9, 10, 17, 18, 19, 20]
```

Delete element at index 10 in list namely lst

See 11 got deleted. Compare with list above

Delete all elements between indexes 10 to 15 in list namely lst. Compare the result displayed below

If you use **del <listname>** only e.g., **del lst**, it will delete all the elements and the list object too. After this, no object by the name lst would be existing.

You can also use **pop( )** method to remove single element, not list slices. The *pop( ) method* removes an individual item and returns it. The **del statement** and the **pop method** do pretty much the same thing, except that pop method also returns the removed item along with deleting it from list. The *pop( ) method* is used as per following format :

```
<list>.pop(<index>)    # index optional; if skipped, last element is deleted
```

Consider examples below :

```
>>> lst=[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,
16, 17, 18, 19, 20]
>>> lst.pop()
20
>>> lst.pop(10)
11
```

NOTE

While **del** statement can remove a single element or a list-slice from a list, the **pop( )** can remove only single element, not list slices. Also pop( ) retruns the deleted element too.

The *pop( ) method* is useful only when you want to store the element being deleting for later use, e.g.,

```
item1=L.pop()          # last item
item2=L.pop(0)         # first item
item3=L.pop(5)         # sixth item
```

Now you can use item1, item2 and item3 in your program as per your requirement.

LISTS IN PYTHON – 1

Progress In Python 7.1

This PnP session works on the objective of practicing List Manipulation operators.

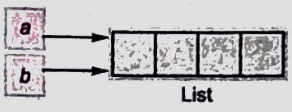
Making True Copy of a List

Sometimes you need to make a copy of a list and you generally tend to do it using assignment, *e.g.*,

```
a = [ 1, 2, 3]
b = a
```

Trying to make copy of ***list a*** *in* ***list b***

But it will not make **b** as a duplicate list of **a** ; rather just like Python does, it will make label **b** to point to where label **a** is pointing to, *i.e.*, as shown in adjacent figure.

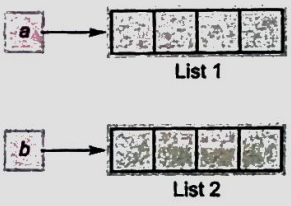


It will work fine as long as we do not modify lists. Now, if you make changes in any of the lists, it will be reflected in other because *a* and *b* are like aliases for the same list. See below :

```
>>> a = [1, 2, 3]
>>> b = a
>>> a[1] = 5
>>> a
[1, 5, 3]
>>> b
[1, 5, 3]
```

See, ***list b*** *is also reflecting the changed value of* ***list a.***

See, along with list *a*, list *b* also got modified. What if you want that the copy list *b* should remain unchanged while we make changes in *list a* ? That is, you want both lists to be independent of each other as shown in adjacent figure. For this, you should create copy of list as follows :




```
b = list(a)
```

Now *a* and *b* are separate lists. See below :

```
>>> a = [1, 2, 3]
>>> b = list(a)
>>> a[1] = 5
>>> a
[1, 5, 3]
>>> b
[1, 2, 3]
>>>
```

Now, ***list b*** *is not reflecting the changed value. List b is independent of* ***list a.***

Thus, true independent copy of a list is made via **list( )** method; assigning a list to another identifier just creates an alias for same list.

7.5 LIST FUNCTIONS AND METHODS

Python also offers many built-in functions and methods for list manipulation. You have already worked with one such method **len( )** in earlier chapters. In this chapter, you will learn about many other built-in powerful list methods of Python used for list manipulation.

Every list object that you create in Python is actually an instance of List class (you need not do anything specific for this; Python does it for you – you know *built-in*). The list manipulation methods that are being discussed below can be applied to list as per following syntax :

```
<listObject>.<method name>()
```

In the following examples, we are referring to <listObject> as *List* only (no angle brackets but the meaning is intact *i.e.*, you have to replace *List* with a legal list (*i.e.*, either a *list literal* or a *list object* that holds a list).

Let us now have a look at some useful built-in list manipulation methods.

1. The index method

This function returns the index of first matched item from the list. It is used as per following format :

```
List.index (<item>)
```

For example, for a list L1 = [13, 18, 11, 16, 18, 14],

```
>>> L1.index (18)
1
```

returns the index of first value 18, even if there is another value 18 at index 4.

However, if the given item is not in the list, it raises exception value Error (see below)

```
List.index(33)
Traceback (most recent call last):
  File "<ipython-input-60-038fc9bf9c5c>", line 1, in <module>
    list.index(33)
ValueError: 33 is not in list
```

2. The append method

As you have read earlier in section 7.4 that the *append( )* method **adds an item to the end of the list.** It works as per following syntax :

```
List.append(<item>)
```

– *Takes exactly one element and returns no value*

For example, to add a new item "yellow" to a list containing colours , you may write :

```
>>> colours = [ 'red', 'green', 'blue']
>>> colours.append('yellow')
>>> colours
['red', 'green', 'blue', 'yellow']
```

See the item got added at the end of the list

The ***append( ) does not return the new list***, just modifies the original. To understand this, consider the following example :

```
>>> lst = [1, 2, 3]
>>> lst2 = lst.append(12)
>>> lst2
>>> lst
[1, 2, 3, 12]
```

Trying to assign the result of ***lst.append()*** *to another list*

See, ***lst2*** *is empty as* ***append()*** *did not return any value*

But list ***lst****, on which* ***append()*** *was applied, has the newly added element*

3. The extend method

The *extend( )* method is also used for adding multiple elements (given in the form of a list) to a list. But it is different from *append( )*. First, let us understand the working of *extend( )* function then we'll talk about the difference between these *two* functions.

The *extend( )* function works as per following format :

```
List.extend(<list>)
```

– *Takes exactly one element (a list type) and returns no value*

That is *extend( )* takes a list as an argument and appends all of the elements of the argument list to the list object on which *extend( )* is applied.

Consider following example :

```
>>> t1 = ['a', 'b', 'c']
>>> t2 = ['d', 'e']
>>> t1.extend(t2)
>>> t1
['a', 'b', 'c', 'd', 'e']
>>> t2
['d', 'e']
```

*Extend the list **t1**, by adding all elements of **t2***

*See the elements of list **t2** are added at the end of list **t1***

*But list **t2** remains unchanged.*

The above example left list **t2** unmodified. Like *append(), extend()* also does not return any value.

Consider following example :

```
>>> t3 = t1.extend(t2)
>>> t3
```

*Trying to assign the result of **lst.extend()** to another list*

*See, **t3** is empty as **extend()** did not return any value. But list **t1** is extended with elements of list **t2**.*

Difference between append( ) and extend( )

While append( ) function adds one element to a list, *extend( )* can add multiple elements from a list supplied to it as argument. Consider the following example that will make it clear to you :

```
>>> t1 = [ 1, 3, 5 ]
>>> t2 = [ 7, 8 ]
>>> t1.append(10)
>>> t1
[1, 3, 5, 10]
>>> t1.append(12, 14)

Traceback (most recent call last):
  File "<pyshell#4>", line 1, in <module>
    t1.append(12, 14)
TypeError: append() takes exactly one argument (2 given)
```

append( ) can take single object – whether single item or single sequence

Notice when we try to give multiple arguments to append(). what happens?

Notice the error reported.

```
>>> t1.append([12,14])
>>> t1
[1, 3, 5, 10, [12, 14]]

>>> len(t1)
5

>>> t2.extend(10)

Traceback (most recent call last):
    File "<pyshell#7>", line 1, in <module>
        t2.extend(10)
TypeError: 'int' object is not iterable

>>> t2.extend([12, 14])
>>> t2
[7, 8, 12, 14]
>>> t3 = [20, 40]
>>> t2.extend(t3)
>>> t2
[7, 8, 12, 14, 20, 40]
>>> len (t2)
6
```

If you try to enter multiple elements in the form of a list (notice square brackets [ ])

Python will add the complete list as one element. Check the length of the list, it will show that now it has 5 elements, because newly added list [12, 14] is treated as single object.

The extend() cannot add a single element; it requires a list as argument.

Either provide list value or a list object

Notice, extend( ) added the individual elements of the list argument t3. t2, which earlier had 4 elements has now 6 elements – including 2 elements of list t3.

NOTE

The append( ) can add a single element to the end of a list while extend( ) can add argument-list's all elements to the end of the list.

After append( ), the length of the list will increase by 1 element only ; after extend( ), the length of the list will increase by the length of inserted list.

4. The insert method

The *insert( )* method is also an insertion method for lists, like append and extend methods. However, both *append( )* and *extend( )* insert the element(s) at the end of the list. If you want to insert an element somewhere in between or any position of your choice, both *append( )* and *extend( )* are of no use. For such a requirement *insert( )* is used.

The *insert( )* function inserts an item at a given position. It is used as per following syntax :

```
List.insert( <pos>, <item>)
```

– *Takes two arguments and returns no value.*

The first argument **<pos> is the index of the element before which the second argument <item> is to be added.**

Consider the following example:

```
>>> t1 = [ 'a', 'e', 'u']
>>> t1.insert(2, 'i')          # inset element 'i' at index 2.
>>> t1
['a', 'e', 'i', 'u']
```

See element 'i' inserted at index 2

For function insert( ), we can say that :

`list.insert(0, x)` will insert element **x** at the front of the list *i.e.*, at index 0 (zero)

`list.insert( len(a), x )` will insert element **x** at the end of the list – index equal to length of the list ; thus it is equivalent to **list.append(x)**.

If index is greater than *len(list)*, the object is simply appended.

If, however, index is less than zero and not equal to any of the valid negative indexes of the list (depends on the size of the list), the object is *prepended*, *i.e.*, added in the beginning of list *e.g.*, for a list **t1 = ['a', 'e', 'i', 'u']**, if we do :

```
>>> t1.insert(-9, 'k')
>>> t1
['k', 'a', 'e', 'i', 'u']
```
valid negative indexes are -1, -2, -3, -4

list prepended with element 'k'

5. The pop method

You have read about this method earlier. The *pop( )* is used to remove the item from the list. It is used as per following syntax :

```
List.pop(<index>)
```
<index is optional argument

– *Takes one optional argument and returns a value – the item being deleted*

Thus, pop( ) removes an element from the given position in the list, and return it. If no index is specified, pop( ) removes and returns the last item in the list. Consider some examples :

```
>>> t1
['k', 'a', 'e', 'i', 'p', 'q', 'u']
>>> ele1 = t1.pop(0)
>>> ele1
'k'
```
*Remove element at index 0 i.e., first element and store it in **ele1***

The removed element

```
>>> t1
['a', 'e', 'i', 'p', 'q', 'u']
>>> ele2 = t1.pop()
>>> ele2
'u'
```
List after removing first element

No index specified, it will remove the last element

```
>>> t1
['a', 'e', 'i', 'p', 'q']
```

The pop( ) method raises an exception(runtime error) if the list is already empty. Consider this :

```
>>> t2 = []
>>> t2.pop()
Traceback (most recent call last):
  File "<pyshell#31>", line 1, in <module>
    t2.pop()
IndexError: pop from empty list
```
empty list

Trying to delete from empty list raises exception

6. The remove method

While pop( ) removes an element whose position is given, what if you know the value of the element to be removed, but you do not know its index or position in the list ? Well, Python thought it in advance and made available the remove( ) method.

The **remove( )** method removes the first occurrence of given item from the list. It is used as per following format :

```
List.remove ( <value> )
```

– *Takes one essential argument and* ***does not return anything***

The remove( ) will report an error if there is no such item in the list. Consider some examples:

```
>>> t1 = ['a', 'e', 'i', 'p', 'q', 'a', 'q', 'p']
>>> t1.remove('a')
>>> t1
['e', 'i', 'p', 'q', 'a', 'q', 'p']
>>> t1.remove('p')
>>> t1
['e', 'i', 'q', 'a', 'q', 'p']
>>> t1.remove('k')
Traceback (most recent call last):
  File "<pyshell#45>", line 1, in <module>
    t1.remove('k')
ValueError: list.remove(x): x not in list
```

First occurrence of 'a' is removed from the list

First occurrence of 'p' is removed from the list

Trying to remove an element which is not present in the list, raises error.

NOTE

The **pop** method removes an individual item and returns it, while **remove** searches for an item, and removes the first matching item from the list.

7. The clear method

This method removes all the items from the list and the list becomes empty list after this function. This function returns nothing. It is used as per following format.

```
List.clear( )
```

For instance, if you have a list L1 as

```
>>> L1 = [2, 3, 4, 5]
>>> L1.clear( )
>>> L1
[ ]
```

it will remove all the items from list L1.

Now the L1 is an empty list.

Unlike **del <lstname>** statement, **clear( )** removes only the elements and not the list element. After **clear( )**, the list object still exists as an empty list.

8. The count method

This function returns the count of the item that you passed as argument. If the given item is not in the list, it returns zero. It is used as per following format :

```
List.count(<item> )
```

For instance, for a list L1 = [13, 18, 20, 10, 18, 23]

```
>>> L1.index [18]
2
>>> L1.index(28)
0
```

returns 2 as there are two items with value 18 in the list.

No item with value 28 in the list. hence it returned 0 (zero)

Check Point 7.1

1. Why are lists called mutable types ?
2. What are immutable counterparts of lists ?
3. What are different ways of creating lists ?
4. What values can we have in a list? Do they all have to be the same type ?
5. How are individual elements of lists are accessed and changed ?
6. How do you create the following lists ?
   (a) [4, 5, 6]
   (b) [-2, 1, 3]
   (c) [-9, -8, -7, -6, -5]
   (d) [-9, -10, -11, -12]
   (e) [0, 1, 2]
7. If a = [5, 4, 3, 2, 1, 0] evaluate the following expressions:
   (a) a[0]
   (b) a[-1]
   (c) a[a[0]]
   (d) a[a[-1]]
   (e) a[a [a [a [2] +1]]]
8. Can you change an element of a sequence? What if the sequence is a string? What if the sequence is a list?
9. What does a + b amounts to if a and b are lists ?
10. What does a * b amounts to if a and b are lists ?
11. What does a + b amounts to if a is a list and b = 5 ?
12. Is a string the same as a list of characters ?
13. Which functions can you use to add elements to a list ?
14. What is the difference between append( ) and insert( ) methods of list?
15. What is the difference between pop( ) and remove( ) methods of list?
16. What is the difference between append( ) and extend( ) methods of list?
17. How does the sort( ) work? Give example.
18. What does list.clear( )function do ?

9. The reverse method

The *reverse( )* reverses the items of the list. This is done **"in place"**, *i.e.*, it does not create a new list. The syntax to use reverse method is :

```
List.reverse()
```

– *Takes no argument, returns no list ; reverses the list 'in place' and does not return anything.*

For example,

```
>>>t1
['e', 'i', 'q', 'a', 'q', 'p']
>>> t1.reverse()
>>>t1                          <-- The reversed list
['p', 'q', 'a', 'q', 'i', 'e']

>>>t2 = [3, 4, 5]
>>>t3 = t2.reverse( )
>>>t3                          <-- t3 stores nothing as reverse( ) does not return anything.
>>>t2
[5, 4, 3]
```

10. The sort method

The *sort( )* function sorts the items of the list, by default in increasing order. This is done **"in place"**, *i.e.*, it does not create a new list. It is used as per following syntax :

```
List.sort()
```

For example,

```
>>> t1 = ['e', 'i', 'q', 'a', 'q', 'p']
>>> t1.sort()
>>>t1                          <-- Sorted list in default ascending order
['a', 'e', 'i', 'p', 'q', 'q']
```

Like reverse( ), sort( ) also performs its function and does not return anything.

To sort a list in decreasing order using sort( ), you can write :

```
>>>List.sort(reverse = True)
```

NOTE

Please note, *sort( )* won't be able to sort the values of a list if it contains a complex number as an element, because Python has *no ordering relation defined for complex numbers.*

Program 7.3 Program to find minimum element from a list of element along with its index in the list.

```
lst = eval(input("Enter list : "))
length = len(lst)
min_ele = lst[0]
min_index = 0
for i in range(1, length-1) :
    if lst[i] < min_ele :
        min_ele = lst[i]
        min_index = i
print("Given list is : ", lst)
print("The minimum element of the given list is :")
print(min_ele, "at index", min_index)
```

```
Enter list : [2, 3, 4, -2, 6, -7, 8, 11, -9, 11]
Given list is : [2, 3, 4, -2, 6, -7, 8, 11, -9, 11]
The minimum element of the given list is :
-9 at index 8
```

Program 7.4 Program to calculate mean of a given list of numbers.

```
lst = eval(input("Enter list : "))
length = len(lst)
mean = sum = 0
for i in range(0, length-1) :
    sum += lst[i]
mean = sum /length
print("Given list is : ", lst)
print("The mean of the given list is :", mean)
```

```
Enter list : [7, 23, -11, 55, 13.5, 20.05, -5.5]
Given list is : [7, 23, -11, 55, 13.5, 20.05, -5.5]
The mean of the given list is : 15.364285714285714
```

Program 7.5 Program to search for an element in a given list of numbers.

```
lst = eval(input("Enter list :"))
length = len(lst)
element = int(input("Enter element to be searched for :"))
for i in range(0, length-1) :
    if element == lst[i] :
        print(element, "found at index", i)
        break
else :                  # else of for loop
    print(element, "not found in given list")
```

Two sample runs of above program are being given below :

```
Enter list : [2, 8, 9, 11, -55, -11, 22, 78, 67]
Enter element to be searched for : -11
-11 found at index 5
```

```
Enter list : [2, 8, 9, 11, -55, -11, 22, 78, 67]
Enter element to be searched for : -22
-22 not found in given list
```

7.6 Program to count frequency of a given element in a list of numbers.

Program

```
lst = eval(input("Enter list :"))
length = len(lst)
element = int(input("Enter element :"))
count = 0
for i in range(0, length-1):
    if element == lst[i]:
        count += 1
if count == 0 :
    print(element, "not found in given list")
else :
    print(element,"has frequency as", count, "in given list")
```

Sample run of above program is given below :

```
Enter list : [1, 1, 1, 2, 2, 3, 4, 2, 2, 5, 5, 2, 2, 5]
Enter element : 2
2 has frequency as 6 in given list
```

GLOSSARY

List	A mutable sequence of Python that can store objects of any type.
Index	An integer variable that is used to identify the position of an element and access the element.
List Traversal	The sequential accessing of each of the elements in a list.
List slices	A list created from a list containing the requested elements.

Assignments

Type A : Short Answer Questions/Conceptual Questions

1. Discuss the utility and significance of Lists, briefly.
2. What do you understand by mutability ? What does "in place" memory updation mean ?
3. Start with the list [8, 9, 10]. Do the following using list functions :
   (*a*) Set the second entry (index 1) to 17
   (*b*) Add 4, 5 and 6 to the end of the list
   (*c*) Remove the first entry from the list
   (*d*) Sort the list
   (*e*) Double the list
   (*f*) Insert 25 at index 3
4. If a is [1, 2, 3]
   (*a*) what is the difference (if any) between a * 3 and [a, a, a] ?
   (*b*) is a * 3 equivalent to a + a + a ?
   (*c*) what is the meaning of a[1:1] = 9 ?
   (*d*) what's the difference between a[1:2] = 4 and a[1:1] = 4 ?
5. What's *a* [1 : 1] if a is a string of at least two characters ? And what if string is shorter ?
6. What's the purpose of the del operator and pop method ? Try deleting a slice.
7. What does each of the following expressions evaluate to ? Suppose that *L* is the list
   ["These", ["are", "a", "few", "words"], "that", "we", "will", "use"].
   (*a*) `L[1][0::2]`
   (*b*) `"a" in L[1][0]`
   (*c*) `L[:1] + L[1]`
   (*d*) `L[2::2]`
   (*e*) `L[2][2] in L[1]`
8. What are list slices ? What for can you use them ?
9. Does the slice operator always produce a new list ?
10. Compare lists with strings. How are they similar and how are they different ?
11. What do you understand by true copy of a list ? How is it different from shallow copy ?
12. An index out of bounds given with a list name causes error, but not with list slices. Why ?

Type B : Application Based Questions

1. What is the difference between following two expressions, if lst is given as [1, 3, 5]
   (*i*) `lst * 3`
   (*ii*) `lst *= 3`
2. Given two lists
   `L1 = ["this", 'is', 'a', 'List'], L2 = ["this", [ "is", "another"], "List"]`
   Which of the following expressions will cause an error and why ?
   (*a*) `L1 == L2` (*b*) `L1.upper( )` (*c*) `L1[3].upper( )`
   (*d*) `L2.upper( )` (*e*) `L2[1].upper( )` (*f*) `L2[1][1].upper( )`
3. From the previous question, give output of expressions that do not result in error.
4. Given a list L1 = [3, 4.5, 12, 25.7, [2, 1, 0, 5], 88]
   (*a*) Which list slice will return [12, 25.7, [2, 1, 0, 5]
   (*b*) Which expression will return [2, 1, 0, 5]
   (*c*) Which list slice will return [2, 1, 0, 5]
   (*d*) Which list slice will return [4.5, 25.7, 88]
5. Given a list L1 = [3, 4.5, 12, 25.7,]2, 1, 0, 5], 88], which function can change the list to :
   (*a*) [3, 4.5, 12, 25.7, 88]
   (*b*) [3, 4.5, 12, 25.7]
   (*c*) [[2, 1, 0, 5], 88]
6. What will the following code result in ?
```
L1 = [1, 3, 5, 7, 9]
print (L1 == L1.reverse( ) )
print (L1)
```
7. Predict the output
```
my_list = ['p', 'r', 'o', 'b', 'l', 'e', 'm']
my_list[2:3] = []
print(my_list)
my_list[2:5] = []
print(my_list)
```
8. Predict the output
```
List1 = [13, 18, 11, 16, 13, 18, 13]
print(List1.index(18))
print(List1.count(18))
List1.append(List1.count(13))
print(List1)
```
9. Predict the output
```
Odd = 1,3,5
print( (Odd +[2, 4, 6])[4] )
print( (Odd +[12, 14, 16])[4] – (Odd +[2, 4, 6])[4] )
```
10. Predict the output
```
a, b, c = [1,2], [1, 2], [1, 2]
print(a == b)
print (a is b)
```

11. Predict the output of following two parts. Are the outputs same? Are the outputs different? Why?

(a)
```
L1, L2 = [2, 4] , [2, 4]
L3 = L2
L2[1] = 5
print(L3)
```

(b)
```
L1, L2 = [2, 4] , [2, 4]
L3 = list(L2)
L2[1] = 5
print(L3)
```

12. Find the errors
```
L1 = [1, 11, 21, 31]
L2 = L1 + 2
L3 = L1 * 2
Idx = L1.index(45)
```

13. Find the errors

(a)
```
L1 = [1, 11, 21, 31]
An = L1.remove(41)
```

(b)
```
L1 = [1, 11, 21, 31]
An = L1.remove(31)
print(An + 2)
```

14. Find the errors

(a)
```
L1 = [3, 4, 5]
L2 = L1 * 3
print(L1 * 3.0)
print(L2)
```

(b)
```
L1 = [3, 3, 8, 1, 3, 0, '1', '0', '2', 'e', 'w', 'e', 'r']
print( L1[: : -1] )
print( L1 [-1: -2 : -3] )
print( L1 [-1 :-2 : -3 : -4] )
```

15. What will be the output of following code ?
```
x = ['3', '2', '5']
y = ''
while x :
   y = y + x [-1]
   x = x [: len(x) -1]
print (y)
print (x)
print (type(x), type(y))
```

Type C : Programming Practice/Knowledge based Questions

1. Write a program that reverses an array of integers (in place).
2. Write a program that inputs two lists and creates a third, that contains all elements of the first followed by all elements of the second.
3. Ask the user to enter a list containing numbers between 1 and 12. Then replace all of the entries in the list that are greater than 10 with 10.
4. Ask the user to enter a list of strings. Create a new list that consists of those strings with their first characters removed.
5. Create the following lists using a for loop :
   (a) A list consisting of the integers 0 through 49.
   (b) A list containing the squares of the integers 1 through 50.
   (c) The list ['a','bb','ccc','dddd', . . .] that ends with 26 copies of the letter z.
6. Write a program that takes any two lists L and M of the same size and adds their elements together to form a new list N whose elements are sums of the corresponding elements in L and M. For instance, if $L=[3,1,4]$ and $M=[1,5,9]$, then N should equal [4,6,13].

7. Write a program rotates the elements of a list so that the element at the first index moves to the second index, the element in the second index moves to the third index, etc., and the element in the last index moves to the first index.

8. Write a program that reads the *n* to display *nth* term of Fibonacci series.

   The Fibonacci sequence works as follows :

   - element 0 has the value 0
   - element 1 has the value 1
   - every element after that has the value of the sum of the two preceding elements

   The beginning of the sequence looks like :

   0, 1, 1, 2, 3, 5, 8, 13, 21, 34, ...

   The program prompts for an element and prints out the value of that element of the Fibonacci sequence. Thus :

   - input 7, produces 13
   - input 9, produces 34

   Hints.

   - Don't try to just type out the entire list. It gets big very fast. Element 25 is *75205*. Element 100 is *354224848179261915075*. So keep upper limit of *n* to 20.

9. Write programs as per following specifications

   (*a*)
   ```
   ''' Return the length of the longest
   string in the list of strings str_list.
   Precondition : the list will contain
   at least one element.'''
   ```

   (*b*)
   ```
   ''' L is a list of numbers. Return a new list where each element is the
   corresponding element of list L summed with number num.'''
   ```