

Introduction to Python

Built-In Sequences: Lists

Topics

- 1) Lists
 - a) Indexing and Slicing
 - b) List Methods
- 3) List comprehensions
- 4) Iterables
- 5) Membership and Operations

Containers

Python includes several built-in sequences: *lists*, *tuples*, *strings*.

We discussed strings in the previous lecture. String is a flat sequence which holds item of one type. Flat sequences physically store the value of each item within its own memory space.

Lists and *tuples* are *container sequences*, which can hold items of different type. They hold references to objects they contain (more on this later).

Another way of grouping sequence types is by *mutability*. Lists are *mutable* (can be modified) sequences while strings and tuples are *immutable* sequences. We discuss lists in this lecture and tuples in the next.

Lists

Lists are the basic *ordered* and *mutable* data collection type in Python. They can be defined with comma-separated values between square brackets.

```
In[1]: L = [2, 3, 5, 7]
```

```
In [2]: len(L) # len also worked with strings
```

```
Out [2]: 4
```

```
In [3]: L.append(11) # append to the end of the list
```

```
In [4]: L
```

```
Out [4]: [2, 3, 5, 7, 11]
```

Indexing

Indexing is a means the fetching of a single value from the list. This is a 0-based indexing scheme. This is similar to strings from the previous lecture.

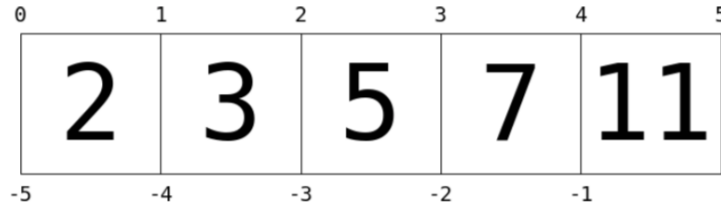
```
In[1]: L = [2, 3, 5, 7, 11]
```

```
In [2]: L[0]
```

```
Out [2]: 2
```

```
In [3]: L[1]
```

```
Out [3]: 3
```



```
In [4]: L[5] # index out of bounds error.
```

Indexing

Negative index wraps around the end.

```
In[1]:L = [2, 3, 5, 7, 11]
```

```
In [2]: L[-1]
```

```
Out [2]: 11
```

```
In [3]: L[-2]
```

```
Out [3]: 7
```

Lists can contain different types of objects

List can contain different types and even other lists.

```
In [1]: L = [1, 'two', 3.14, [0, 3, 5]]
```

```
In [2]: L[0]
```

```
Out [2]: 1
```

```
In [3]: L[1]
```

```
Out [3]: 'two'
```

```
In [4]: L[3]
```

```
Out [4]: [0, 3, 5]
```

```
In [5]: L[3][2]
```

```
Out [5]: 5
```

List of lists(2D lists)

A list of lists in Python is a list object where each list element is a list by itself.

```
In [1]: L = [[1, -5, 9], [0, 3, 4]]
```

```
In [2]: L[0]
```

```
Out [2]: [1, -5, 9]
```

```
In [3]: L[1]
```

```
Out [3]: [0, 3, 4]
```

```
In [4]: L[0][0]
```

```
Out [4]: 1
```

```
In [4]: L[0][1]
```

```
Out [4]: -5
```

```
In [4]: L[1][2]
```

```
Out [4]: 4
```


List of Lists(2D lists)

Compute the sum of a 2D list using nested loops.

```
In[1]: lst = [[1, 2, 3],  
              [4, 5, 6],  
              [7, 8, 9]]
```

```
In[2]: sum = 0  
       for row in lst:  
           for item in row:  
               sum += item  
       print(sum)
```

Slicing

Similar to strings, lists also support slicing. *Slicing* is accessing multiple values from the list. It uses a colon to indicate the start point (inclusive) and end point (non-inclusive) of the subarray.

```
In[1]: L = [1, 2, 3, 4, 5]
```

```
In [2]: L[0:3]
```

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

```
In [3]: L[:3]
```

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

Leaving out the first
index defaults to 0.

```
In [4]: L[-3:]
```

```
Out [4]: [3, 4, 5]
```

Leaving out the last index
defaults to length of list.

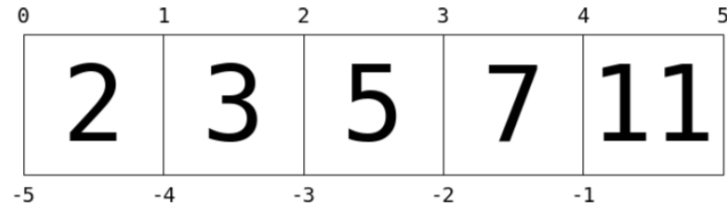
Slicing

Finally, it is possible to specify a third integer that represents the step size.

```
In[1]:L = [2, 3, 5, 7, 11]
```

```
In [2]: L[::2] # equivalent to L[0:len(L):2]
```

```
Out [2]: [2, 5, 11]
```



Slicing

A particularly useful version of this is to specify a negative step, which will reverse the list. In this case, the default start index is at the end of the list and the default stop index is at the beginning(inclusive).

```
In [1]: L = [1, 2, 3, 4, 5]
```

```
In [2]: L[::-1]
```

```
Out [2]: [5, 4, 3, 2, 1] # defaults end of array to beginning
```

```
In [3]: L[1::-1] # first two items reversed
```

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

```
In [4]: L[:-3:-1] # last two items reversed
```

```
Out [4]: [5, 4]
```

```
In [5]: L[-3::-1] # everything except last two items reversed
```

```
Out [5]: [3, 2, 1]
```

Modifying a List

Both indexing and slicing can be used to set elements as well as access them.

```
In [1]: L[0] = 100
```

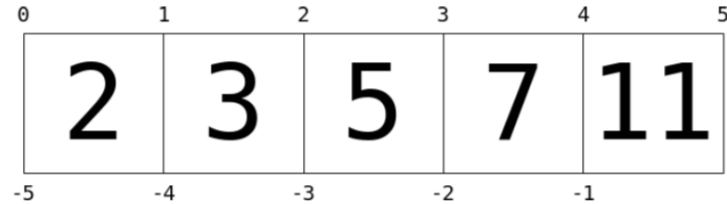
```
In [2]: print(L)
```

```
[100, 3, 5, 7, 11]
```

```
In[3]: L[1:3] = [99, 99]
```

```
In [4]: print(L)
```

```
[100, 99, 99, 7, 11]
```



Lists: Concatenation

List Concatenation: + operator will concatenate two lists.

```
In[1]: L = [2, 3, 5, 7, 11]
```

```
In [2]: L + [13, 17, 19]
```

```
Out [1]: [2, 3, 5, 7, 11, 13, 17, 19]
```

List Methods

The following is a short list of useful list methods. (memorize the method highlighted in red)

<code>append(value)</code>	appends value to the end of the list
<code>insert(index, value)</code>	inserts value at position given by index, shifts elements to the right.
<code>pop(index)</code>	removes object at index from list, shifts elements left and returns removed object. Returns last element if index is omitted. The index parameter is optional (default = -1)
<code>remove(value)</code>	removes object from list by value . Remove only the first one if there are multiple occurrences.
<code>index(value)</code>	returns index of first occurrence of value if exists, otherwise throws a <code>ValueError</code> .
<code>count(value)</code>	returns the number times value appear in list.

List Methods

```
In [1]: L = [3, "hi", -4, 6]
```

```
In [2]: L.append(2) # [3, "hi", -4, 6, 2]
```

```
In [3]: L.insert(1, "hello") # [3, "hello", "hi", -4, 6, 2]
```

```
In [4]: a = L.pop(3) # [3, "hello", "hi", 6, 2]
```

```
In [5]: print(a)
```

-4

```
In [6]: L.pop() # [3, "hello", "hi", 6]
```

```
In [7]: L.remove("hi") # [3, "hello", 6]
```

```
In [8]: ind = L.index(6) # 2
```

```
In [9]: L.count("hello") # 1
```


Remove Duplicate Zeroes

Write code that remove all zeroes from a list.

```
In [1]: lst = [1, 0, 0, 5, 0]
```

```
In [2]: for x in lst:
        if x == 0:
            lst.remove(x)
        print(lst)
```

```
[1,0,5]
```

This code doesn't work! Once a zero is removed, the elements get shifted to the left and causes the next zero element to be skipped!

Remove Duplicate Zeroes

Traverse the list backwards!

```
In [1]: lst = [1, 0, 0, 5, 0]
```

```
In [2]: for i in range(len(lst)-1, -1, -1):  
        if lst[i] == 0:  
            lst.pop(i)  
        print(lst)
```

```
[1,5]
```

This works! Do you see why?

Insert Error

Insert zeroes into a list. Be careful of the following error!

```
In [1]: lst = [1, 2, 3, 4, 5]
In [2]: index = 0
        for x in lst:
            if x % 2 == 0:
                lst.insert(index, 0)
            index += 1
        print(lst)
```

This is an infinite loop!! Do you see why?

list()

A useful operation is to use list() with range() to create new lists easily.

```
In [1]: lst = list(range(1,7))
```

```
In [2]: lst
```

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

```
In [3]: lst2 = list(range(1,1000))
```

List Comprehensions

List comprehension(or listcomp) is a concise and readable way of creating a new list from another iterable(list, tuple, string).

Suppose we want to square all numbers from a list.

```
In [1]: lst = [2, 3, 5, 7]
        new_lst = []
        for x in lst:
            new_lst.append(x ** 2)
        print(new_lst)
```

4 9 25 49

We can use list comprehension to do this much simpler and more Pythonic.

List Comprehensions

We can use list comprehension to do the previous problem much simpler and more Pythonic.

```
In[2]: lst = [2, 3, 5, 7]
        new_lst = [x**2 for x in lst]
        print(new_lst)
```

```
4 9 25 49
```

For loops are used to do many things: scan through a list, pick out items, compute sums, counts and averages, etc... Listcomp is a one trick pony: create new lists.

List Comprehensions

List comprehension can also contain conditions.

```
In[3]: lst = [x**2 for x in range(7) if x % 2 == 0]  
        print(lst)
```

```
0 4 16 36
```

List Comprehensions

List comprehension can also contain nested loops. A **list of lists** can be created in this way.

```
In[1]: colors = ["red", "black"]
```

```
In[2]: sizes = ["S", "M", "L"]
```

```
In[3]: shirts = [[color, size] for color in colors  
                  for size in sizes]
```

```
In[4]: shirts
```

```
Out[4]:
```

```
[['red', 'S'], ['red', 'M'], ['red', 'L'], ['black', 'S'],  
 ['black', 'M'], ['black', 'L']]
```


Iterables

An **iterable** is an object from which we can loop over. Lists and strings are iterables.

```
In[1]: lst = [2, 3, 5, 7]
        for x in lst:
            print(x, end=' ')
```

2 3 5 7

```
In[2]: message = "python"
        for x in message:
            print(x, end=' ')
```

p y t h o n

split()

split() method splits a string into a list. A separator can be specified. The default separator is any whitespace.

```
In [1]: fruits = "apple mango banana grape"  
        fruits.split()
```

```
Out [1]: ['apple', 'mango', 'banana', 'grape']
```

```
In [2]: list = "hi, I am Mike, I just graduate."  
        list.split(", ")
```

```
Out [2]: ['hi', 'I am Mike', 'I just graduate.']
```

split()

When using `split()` to split a string of integers into a list of integers, remember to use the `int()` constructor to convert the list elements into integers.

```
s = input("Enter a list of integers separated by spaces: ")  
list_nums = [int(x) for x in s.split()]  
print(list_nums) # list of integers instead of strings
```

Membership and Operations

Operator	Description
<code>a is b</code>	True if a and b are identical objects
<code>a is not b</code>	True if a and b are not identical objects
<code>a in b</code>	True if a is a member of b
<code>a not in b</code>	True if a is not a member of b

Identity Operations

The comparison operator `==` checks for *object equality*. It checks to see if two objects have the same content.

```
In [1]: a = [1,2,3]
```

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

```
In[2]: a == b # a and b are different lists, same content
```

```
Out [2]: True
```

Identity Operations

The identity operators, `is` and `is not`, check for *object identity*. They check whether two variable **references** the same object.

```
In[3]: a is b
```

```
Out [3]: False
```

```
In[4]: a is not b
```

```
Out [4]: True
```

```
In [5]: a = [1,2,3]
```

```
        b = a
```

```
        a is b
```

```
Out [5]: True
```

Membership Operations

Membership operators check for membership within compound objects like lists.

```
In [1]: 1 in [1, 2, 3]
```

```
Out [1]: True
```

```
In [2]: 2 not in [1, 2, 3]
```

```
Out [2]: False
```

```
In [3]: 'a' in "python"
```

```
Out [3]: False
```

list() + make copies of a list

Converting between a string and a list can be done using the `list()` constructor.

```
In [1]: message = "python"  
        list(message)
```

```
Out [1]: ['p', 'y', 't', 'h', 'o', 'n']
```

Calling a list constructor on another list will make a **copy** of that list.

```
In [1]: a = [1,2,3]
```

```
In [2]: b = list(a)
```

```
In [2]: a is b
```

```
Out [1]: False
```

```
In [2]: a == b
```

```
Out [1]: True
```


Variables Are Pointers

Variables are pointers, that is, they don't store the actual object just the **address** or **reference** to the object.

```
In [1]: x = 3  
        y = x
```

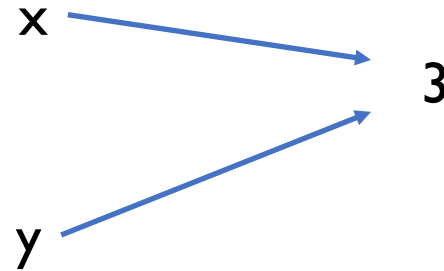
```
In [2]: x is y
```

```
Out [2]: True
```

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

```
In [4]: a is b
```

```
Out [4]: True
```



Mutable vs Immutable

The class `int`, `float`, `bool` and `str` are all immutable. This means that these objects cannot be modified or changed.

```
In [1]: x = 3
```

```
        y = x
```

```
In [2]: x is y
```

```
Out [2]: True
```

```
In [3]: y = 4
```

```
In [4]: print(x, y)
```

```
3 4
```

```
In [5]: x is y
```

```
Out [5]: False
```

Since `y` can't modify the immutable integer 3, this creates a new integer object 4 and `y` now points to it.

Thus `x` and `y` are now different objects.

Mutable vs Immutable

The list class is mutable. Compare and contrast this example to the previous slide.

```
In [1]: x = [1, 2, 3]
```

```
        y = x
```

```
In [2]: x is y
```

```
Out [2]: True
```

```
In [3]: y[0] = 4
```

```
In [4]: print(y)
```

```
[4, 2, 3]
```

```
In [5]: print(x)
```

```
[4, 2, 3]
```

Since `y` can modify the mutable list, changing `y` will also change `x` since they both point to the same object!

List items hold references

Items in lists and tuples hold references or addresses to objects they contain.

```
In [1]: x = [1, 2, [3, 4, 5]]
```

```
In [2]: y = x[2] # y and x[2] both references [3,4,5]
```

```
In [3]: y[1] = 44 # modifying y will modify x[2] also!
```

```
In [3]: y
```

```
[3, 44, 5]
```

```
In [5]: x
```

```
[1, 2, [3, 44, 5]]
```

Both `x[2]` and `y` reference (points to the address) to the same list object. Modifying one will affect the other!

Lab I

Create a new repl on repl.it Use list comprehensions to create the following lists.

- 1) Create this list and assign it to a variable `[3,41,62,87,101, 88]`. Use a for loop to compute the sum. Print out the sum.
- 2) Use a for loop to compute the sum of odd numbers from the list above.
- 3) Use a for loop to compute the sum of values located at even indices.(Use the `len()` function).

Lab 2

Create a new repl on repl.it Use list comprehensions to create the following lists.

- 1) `[2,4,6,8,10,...,20]`
- 2) `[1,8,27,64,125]`
- 3) `[0.5,1.0,1.5,2.0,2.5,3.0]`
- 4) `['1','2','3','4','5']`
- 5) `[1,3,5,7,9,...,99]`. Must use condition in the list comprehension.
- 6) The nested 2D list: `[1,2,3,4,5]` repeated 10 times.
- 7) The nested 2D list: `[0,0,0,0,0]` repeated 20 times.

References

- 1) Vanderplas, Jake, A Whirlwind Tour of Python, O'reilly Media.
- 2) Luciano, Ramalho, Fluent Python, O'reilly Media.