CSIT110

Fundamental Programming with Python

Collections 1 – List

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Previously

Numbers

- integer
- float
- complex number

Boolean

Str

Collections of Data

- List
- Tuples
- Dictionary
- Sets

In this lecture

- List
- Splicing
- List methods
- "".join(<List>)
- Tuple
- Multi-dimensional list
- Problem solving with List

List

This is how we define a list:

```
list_variable = [object1, object2, …, objectN]
```

List

A list/array is used to hold a list of items:

```
animal_list = ["dog", "cat", "frog"]

fibo_numbers = [0, 1, 1, 2, 3, 5, 8, 13]

prime_numbers = [2, 3, 5, 7, 11, 13, 17]

subject_list = ["MATH101", "CS222", "PHY102", "ACCY203"]

correct_answer_list = [True, False, True, True, False]

random_list = ["Production Info", 342, False]

selected_products = [] # this is an empty list
```

List – adding and multiplying

```
list1 = [1, 4, 4, 10, -1]
list2 = [10, 7, 5]
```

adding two lists

```
list12 = list1 + list2  # now list12 = [1, 4, 4, 10, -1, 10, 7, 5]

list21 = list2 + list1  # now list21 = [10, 7, 5, 1, 4, 4, 10, -1]
```

multiply a list

```
list3 = [9, 8]

list4 = list3 * 3       # now list4 = [9, 8, 9, 8, 9, 8]
```

List

List is zero-indexed
List items can be accessed via **index/indices**:

```
animal_list = ["dog", "cat", "frog"]

print(animal_list[0])   → "dog"
print(animal_list[1])   → "cat"
print(animal_list[2])   → "frog"

fibo_numbers = [0, 1, 1, 2, 3, 5, 8, 13]

print(fibo_numbers[0])
print(fibo_numbers[1])
print(fibo_numbers[2])
print(fibo_numbers[3])
print(fibo_numbers[4])
print(fibo_numbers[5])
print(fibo_numbers[6])
print(fibo_numbers[7])
```

```
0
1
1
2
3
5
8
13
```

List - Splicing

Multiple list items can be accessed via **indices**:

```
animal_list = ["dog", "cat", "frog"]

print(animal_list[0:2])   → ["dog", "cat"]
print(animal_list[1:2])   → ["cat"]
print(animal_list[1:1])   → []
print(animal_list[1:])    → ["cat", "frog"]
```

List - Splicing

Sub-lists can be retrieved via **indices**:

```
a[start:stop] # elements from start to stop-1
a[start:]     # elements from start to the rest of the array
a[:stop]      # elements from the beginning to stop-1
a[:]          # a copy of the whole array
a[-1]         # the last element
```

Just like str data type!

List – check if element is in the list

```
<item> in <list>

if 3 in [1,3,2,4]:
     print('There is a three!')

if "3" in [1,3,2,4]:
     print('There is a three!')
else:
     print('There isn\'t a three!')
```

```
There is a three!
```

```
There isn't a three!
```

List – Length of list

using `len()` to find out how many items are in the list:

```
animal_list = ["dog", "cat", "frog"]

animal_count = len(animal_list)
```

```
3
```

Note that `len(animal_list)` is 3, but the **last index** is 2 because the index starts from 0.

```
print(animal_list[0])
print(animal_list[1])
print(animal_list[2])
```

```
"dog"
"cat"
"frog"
```

List – Add a list element

```
animal_list = ["dog", "cat", "frog"]

animal_list[0] = "wombat"
animal_list[1] = "echidna"
animal_list[2] = "koala"

animal_list[3] = "kangaroo"
```

```
ERROR: index out of range
```

List – Add a list element

```
animal_list = ["dog", "cat", "frog"]

animal_list[0] = "wombat"
animal_list[1] = "echidna"
animal_list[2] = "koala"

animal_list[3] = "kangaroo"

# we have to do this instead
animal_list.append("kangaroo")
animal_list.append("emu")

print(animal_list)
```

```
['wombat', 'echidna', 'koala', 'kangaroo', 'emu']
```

List

items **appended** are added to the end of the list:

```
fibo_numbers = [0, 1, 1, 2, 3, 5, 8, 13]
fibo_numbers.append(21)
fibo_numbers.append(34)
fibo_numbers.append(55)
fibo_numbers.append(89)
print(fibo_numbers)
```

```
[0, 1, 1, 2, 3, 5, 8, 13 , 21 , 34 , 55 , 89]
```

List – extending the list

```
list1 = [1, 4, 4, 10, -1]
list2 = [10, 7, 5]
```

Using .append()

```
list1.append(list2)
# list1 is now [1, 4, 4, 10, -1, [10, 7, 5]]
```

List – extending the list

```
list1 = [1, 4, 4, 10, -1]
list2 = [10, 7, 5]
```

Using .append()

```
list1.append(list2)
# list1 is now [1, 4, 4, 10, -1, [10, 7, 5]]
```

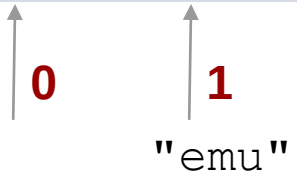
Using .extend() instead

```
list1.extend(list2)
# list1 is then [1, 4, 4, 10, -1, 10, 7, 5]
```

List – insert an element

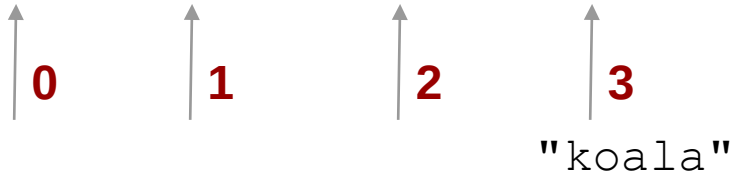
items can be **inserted** into the list:

```
animal_list = ["dog", "cat", "frog"]
```




```
animal_list.insert(1, "emu")
```

```
["dog", "emu", "cat", "frog"]
```




```
animal_list.insert(3, "koala")
```

```
["dog", "emu", "cat", "koala", "frog"]
```

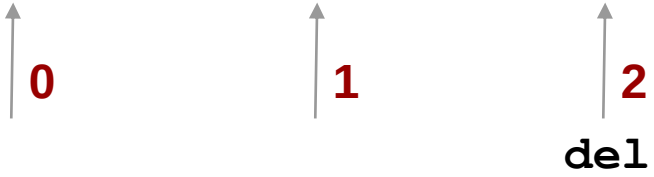
List – Remove an element by its index

items can be **deleted** from the list via **index**:

```
subject_list = ["MATH101", "CS222", "PHY102", "ACCY203"]
```


```
# deleting the item at index 1
del subject_list[1]
```

```
["MATH101", "PHY102", "ACCY203"]
```




```
# deleting the item at index 2
del subject_list[2]
```

```
["MATH101", "PHY102"]
```

List – Remove by value

items can be removed from the list via value, only the **FIRST occurrence** get removed.

```
random_numbers = [3, 12, 4, 5, 4, 3, 2, 6, 12]

# remove the first appearance of 4
random_numbers.remove(4)
#  → [3, 12, 5, 4, 3, 2, 6, 12]

# remove the first appearance of 12
random_numbers.remove(12)
#  → [3, 5, 4, 3, 2, 6, 12]

# remove the first appearance of 7
random_numbers.remove(7)
  ValueError: list.remove(x): x not in list
```

List – Count elements

```
random_numbers = [1, 4, 4, 10, -1]
```

count how many an item appears in the list

```
four_count = random_numbers.count(4)   → 2

ten_count = random_numbers.count(10)   → 1

five_count = random_numbers.count(5)   → 0
```

List – Search element, getting index of the first

```
random_numbers = [1, 4, 4, 10, -1]
```

find the smallest **index** of an item in the list

```
four_index = random_numbers.index(4)
```
→ 1

```
ten_index = random_numbers.index(10)
```
→ 3

```
five_index = random_numbers.index(5)
```

```
ValueError: 5 is not in the list
```

List – Find smallest and largest numeric element

```
random_numbers = [1, 4, 4, 10, -1]

# finding min item
number_min = min(random_numbers) → -1

# finding max item
number_max = max(random_numbers) → 10
```

List – Sorting

```
random_numbers = [1, 4, 4, 10, -1]
```

Sorting a list and return a new list, **original list is unchanged**

```
sorted_numbers = sorted(random_numbers)
```

sorted() is a built-in function that returns a new list

Now `sorted_numbers` is `[-1, 1, 4, 4, 10]`
but `random_numbers` is unchanged:
`random_numbers` is still `[1, 4, 4, 10, -1]`

List – Sorting

```
random_numbers = [1, 4, 4, 10, -1]
```

Sorting a list and **modify the original list**

```
random_numbers.sort()
```

list.sort() is a method of the list object which modifies said list

```
now random_numbers is changed,
random_numbers is now [-1, 1, 4, 4, 10]
```

List – **reverse order** and **clear**

```
random_numbers = [1, 4, 4, 10, -1]
```

items can be reversed

```
random_numbers.reverse()     # now [-1, 10, 4, 4, 1]
```

remove all items

```
random_numbers.clear()       # now []
```

Thus far

methods:

```
<List>.copy()
<List>.append(<obj>)
<List>.extend(<List>)
<List>.insert(int, <obj>)
<List>.remove(<obj>)
<List>.count(<obj>)
<List>.index(<obj>)
<List>.reverse()
<List>.clear()
<List>.sort()
```

Built-in functions:

```
id(<obj>)
del
min(<List>)
max(List[int])
sorted(<List>)
```

List

```
animal_list = ["dog", "cat", "frog"]

print(animal_list[0])   → "dog"
print(animal_list[1])   → "cat"
print(animal_list[2])   → "frog"
```

```
"dog"
"cat"
"frog"
```

We can go through the list using for loop via **index**:

```
for i in range(0, len(animal_list)):
    print(animal_list[i])
```

Or:

```
for i in range(0, len(animal_list)):
    animal = animal_list[i]
    print(animal)
```

List

Example – increase each item by 10

```
random_numbers = [1, 4, 4, 10, -1]
```

Using for-loop, increase each item by 10:

```
for i in range(0, len(random_numbers)):
    random_numbers[i] = random_numbers[i] + 10

print(random_numbers)
```

```
[11, 14, 14, 20, 9]
```

List – An iterable Object

```
animal_list = ["dog", "cat", "frog"]

print(animal_list[0])   → "dog"
print(animal_list[1])   → "cat"
print(animal_list[2])   → "frog"
```

```
"dog"
"cat"
"frog"
```

Alternative way: go through the list using for loop:

```
for animal in animal_list:
    print(animal)
```

Are there iterators that returns two values at the same time?

Yes.

List

my_list = [1, 2, "b", "c", []]

for idx, val in enumerate(my_list):

idx = 0 , val = 1
idx = start + 1 , val = 2
idx = start + 2 , val = "b"
idx = start + 3 , val= "c"
…
idx = len(my_text) -1 , val = []

Example – Square sequence 0, 1, 4, 9, …

Create a list and put the first 10 squares into the list

```
# initially, create an empty list
square_list = []
for i in range(0, 10):
    # adding square numbers to the list
    square_number = i * i
    square_list.append(square_number)
print("First 10 square numbers:")
print(square_list)
```

```
First 10 square numbers:
[0, 1, 4, 9, 16, 25, 36, 49, 64, 81]
```

Example – Fibonacci 0, 1, 1, 2, 3, 5, 8, …

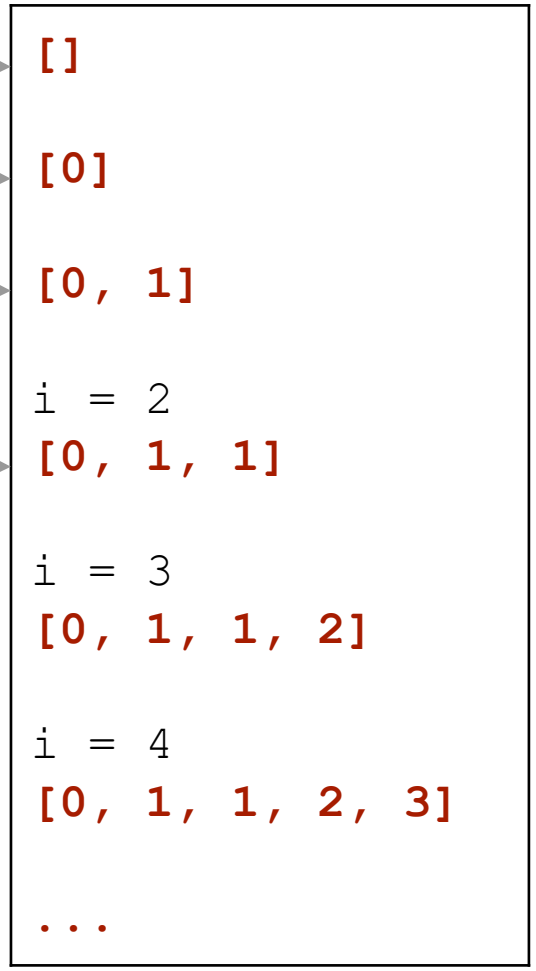
Create a list and put the first 10 fibonacci numbers into the list

```
fibo_list = []

fibo_list.append(0)

fibo_list.append(1)

for i in range(2, 10):
    fibo = fibo_list[i-1] + fibo_list[i-2]
    fibo_list.append(fibo)
```



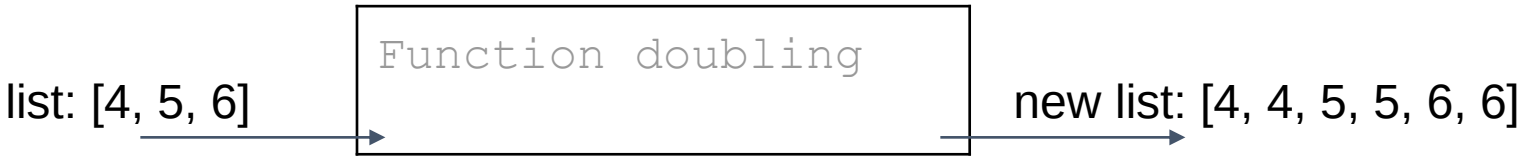

```
i=2
    fibo = fibo_list[1] + fibo_list[0] = 1 + 0 = 1
    fibo_list.append(fibo)
i=3
    fibo = fibo_list[2] + fibo_list[1] = 1 + 1 = 2
    fibo_list.append(fibo)
i=4
    fibo = fibo_list[3] + fibo_list[2] = 2 + 1 = 3
    fibo_list.append(fibo)
i=5
    fibo = fibo_list[4] + fibo_list[3] = 3 + 2 = 5
    fibo_list.append(fibo)
...
```

Example – Doubling

Write a function doubling

- 1 parameter – `list`
- 1 return value – `new_list`
- Create a new list where each element of the original list gets repeated twice.

For example, if the list is [4, 5, 6], then the program creates a new list [4, 4, 5, 5, 6, 6].



Example – Doubling

```
def doubling(mylist):
    # create an empty list first
    new_list = []

    for i in range(0, len(mylist)):
        # go through each list element
        element = mylist[i]

        # add the element to the new list TWICE
        new_list.append(element)
        new_list.append(element)

    # return the new list
    return new_list
```

```
# main program
# testing
list1 = [4,5,6]
print(list1)

list2 = doubling(list1)
print(list2)
```

```
[4, 5, 6]
[4, 4, 5, 5, 6, 6]
```

Example – manual element-wise multiplication

Write a function named `list_multiply` that
- Takes in 2 input arguments
- Assumes the input `list1` and `list2` of the function are 2 lists of integers **containing the same number of elements**
- Multiplies the two list elements of the same index one by one
- returns the result as a new list.

`list_multiply(list1, list2)` returns `new_list`

For example, if
list1 is [4, 5, 6]; and
list2 is [10, 0, 1]; then
the function returns the list: [40, 0, 6].

Example – manual element-wise multiplication

```
def list_multiply(list1, list2):
    # create an empty list first
    new_list = []

    for i in range(0, len(list1)):
        # go through each list element
        list1_element = list1[i]
        list2_element = list2[i]

        # multiply them
        result = list1_element * list2_element

        # add the product to the new list
        new_list.append(result)

    # return the new list
    return new_list
```

```
# main program
# testing
list1 = [4,5,6]
list2 = [10, 0, 1]
list3 =
list_multiply(list1, list2)
print(list1)
print(list2)
print(list3)
```

```
Output:

[4, 5, 6]
[10, 0, 1]
[40, 0, 6]
```

Example – manual element-wise multiplication

```
def list_multiply(list1, list2):
    # create an empty list first
    new_list = []

    for i in range(0, len(list1)):
        # go through each list element
        list1_element = list1[i]
        list2_element = list2[i]

        # multiply them
        result = list1[i] * list2[i]

        # add the product to the new list
        new_list.append(result)

    # return the new list
    return new_list
```

```
# main program
# testing
list1 = [4,5,6]
list2 = [10, 0, 1]
list3 =
list_multiply(list1, list2)
print(list1)
print(list2)
print(list3)
```

```
Output:

[4, 5, 6]
[10, 0, 1]
[40, 0, 6]
```

Example

During winter break, each student can choose exactly one intensive subject to study. Write a program to

- ***Step 1:*** *let a student select a number of preferred subjects;*
- ***Step 2:*** *then among the preferred subjects the student selected, choose a random subject for student enrolment.*

Example

- ***Step 1:*** *let a student select a number of preferred subjects;*

```
# create a list of preferred subject, start with an empty list
subject_list = []

# repeatedly ask the user to enter subject code
while True:
    subject = input("Enter preferred subject code (enter QUIT to quit): ")

    if(subject == "QUIT"):
        break

    # add subject to subject list
    subject_list.append(subject)

# display subjects the user has entered
print("You have chosen: " + str(subject_list))
```

Example

- ***Step 1:*** *let a student select a number of preferred subjects;*

```
Enter preferred subject code (enter QUIT to quit): MATH300
Enter preferred subject code (enter QUIT to quit): COMP222
Enter preferred subject code (enter QUIT to quit): ACCY100
Enter preferred subject code (enter QUIT to quit): BUSS200
Enter preferred subject code (enter QUIT to quit): QUIT
You have chosen: ['MATH300', 'COMP222', 'ACCY100', 'BUSS200']
```

Example

- ***2:*** *then among the prefered subjects the student selected,* ***choose a random subject*** *for student enrolment.*

How can we choose a random subject?

```
Subject list: ['MATH300', 'COMP222', 'ACCY100', 'BUSS200']
Index:                 0          1          2          3
```

We need to choose a random list index:

The index is a random number from **0** *to* **`len(subject_list)-1`**

Example

- ***2:** then among the prefered subjects the student selected, **choose a random subject** for student enrolment.*

```
# choose a random index from 0 to len(subject_list)-1
random_index = random.randint(0, len(subject_list)-1)
random_subject = subject_list[random_index]

# display the random subject enrolled for the user
print("You have been approved to enrol into " + random_subject)
```

```
You have chosen: ['MATH300', 'COMP222', 'ACCY100', 'BUSS200']
You have been approved to enrol into ACCY100
```

```
# import random module
import random

# create a list of preferred subject, start with an empty list
subject_list = []

# repeatedly ask the user to enter subject code
while True:
    subject = input("Enter preferred subject code (enter QUIT to quit): ")
    if(subject == "QUIT"):
        break
    # add subject to subject list
    subject_list.append(subject)

# display subjects the user has entered
print("You have chosen: " + str(subject_list))

# choose a random index from 0 to len(subject_list)-1
random_index = random.randint(0, len(subject_list)-1)
random_subject = subject_list[random_index]

# display the random subject enrolled for the user
print("You have been approved to enrol into " + random_subject)
```

remember to import random module at the top of the code

usage

Two-dimensional list

```
list2d = [
   [1, 2, 3, 4],
   [9, 8, 7, 6]
]

print(list2d[0][1])
print(list2d[0][2])
print(list2d[1][0])
print(list2d[1][3])
```

```
2
3
9
6
```

list2d[0] → `[1, 2, 3, 4]`

list2d[0][1] → `2`

Two-dimensional list

```
list2d = [
   [1, 2, 3, 4],
   [9, 8, 7, 6]
]

print(list2d[0][1])
print(list2d[0][2])
print(list2d[1][0])
print(list2d[1][3])
```

```
2
3
9
6
```

list2d[1] → [9, 8, 7, 6]

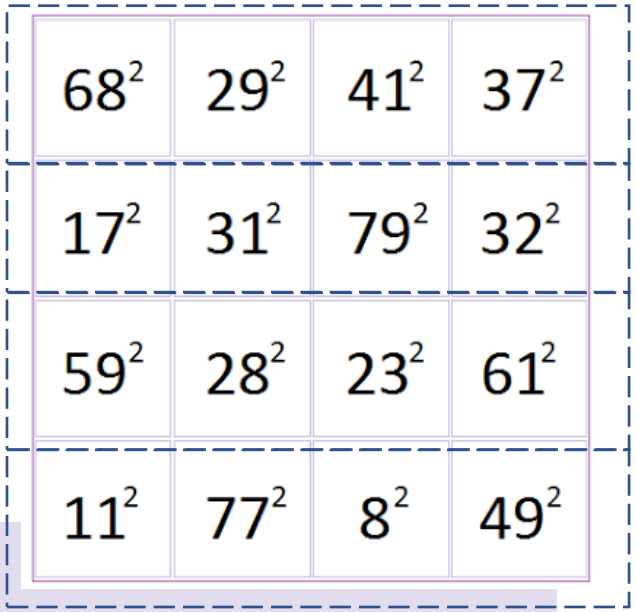
list2d[1][3] → 6

Euler's magic square

68^2	29^2	41^2	37^2
17^2	31^2	79^2	32^2
59^2	28^2	23^2	61^2
11^2	77^2	8^2	49^2

Sum of numbers on each row, each column, and each diagonal is the same!

Euler's magic square




```
euler = [
  [68**2, 29**2, 41**2, 37**2],
  [17**2, 31**2, 79**2, 32**2],
  [59**2, 28**2, 23**2, 61**2],
  [11**2, 77**2,  8**2, 49**2]
]

# row sums
row1 = euler[0][0] + euler[0][1] + euler[0][2] + euler[0][3]
row2 = euler[1][0] + euler[1][1] + euler[1][2] + euler[1][3]
row3 = euler[2][0] + euler[2][1] + euler[2][2] + euler[2][3]
row4 = euler[3][0] + euler[3][1] + euler[3][2] + euler[3][3]

# column sums
col1 = euler[0][0] + euler[1][0] + euler[2][0] + euler[3][0]
col2 = euler[0][1] + euler[1][1] + euler[2][1] + euler[3][1]
col3 = euler[0][2] + euler[1][2] + euler[2][2] + euler[3][2]
col4 = euler[0][3] + euler[1][3] + euler[2][3] + euler[3][3]

# diagonal sums
diagonal1 = euler[0][0] + euler[1][1] + euler[2][2] + euler[3][3]
diagonal2 = euler[0][3] + euler[1][2] + euler[2][1] + euler[3][0]
```

Euler’s magic square

```
euler = [
   [68**2, 29**2, 41**2, 37**2],
   [17**2, 31**2, 79**2, 32**2],
   [59**2, 28**2, 23**2, 61**2],
   [11**2, 77**2,  8**2, 49**2]
]
```

68^2	29^2	41^2	37^2
17^2	31^2	79^2	32^2
59^2	28^2	23^2	61^2
11^2	77^2	8^2	49^2

```
print(f"row1={row1}, row2={row2}, row3={row3}, row4={row4}")

print(f"col1={col1}, col2={2}, col3={col3}, col4={col4}")

print(f"diagonal1={diagonal1}, diagonal2={diagonal2}")
```

```
row1=8515, row2=8515, row3=8515, row4=8515
col1=8515, col2=8515, col3=8515, col4=8515
diagonal1=8515, diagonal2=8515
```

Tuple

A tuple is similar to list but:

- A list can be changed
- A tuple is fixed

```
animal_list = ["dog", "cat", "frog"]

animal_tuple = ("dog", "cat", "frog")

# we can change list
animal_list[0] = "elephant"

# but we canNOT change tuple
animal_tuple[0] = "elephant"   ERROR
```

Extra: Tuple (not tested)

- Unchanged and immutable
- Written with round brackets

```
x = ("apple", "banana", "cherry")
```

Extra: Tuple (not tested)

- Unchanged and immutable
- Written with round brackets
- Very similar to <class ‘list’>

```
x = ("apple", "banana", "cherry")
```

- Workaround to change a tuple:

```
# tuple -> convert to list -> change list-> convert to tuple
x = ("apple", "banana", "cherry")
y = list(x)
y[1] = "kiwi"
x = tuple(y)
```

Any questions?