At the end of this lecture, students should be able to use:

- lists and the + and * operators
- list slices
- list methods
- understand the difference between '==' and '1.9s'

### Learning outcomes

### Lists and the + Operator (concatenation)

Applying the + operator to two lists produces a new list containing all the elements of the first list followed by all the elements of the second list.

You can only **concatenate two list objects** (not a list object and a string object, not a list object and an integer object).

```python
list1 = [10, 20, 30, 40, 50]
list2 = [100, 200]
list3 = list1 + list2
print("1.", list3)
print("2.", 100 in list1)
print("3.", 40 not in list2)
list3 = list3 + [-4]
print("4.", list3)
```

1. [10, 20, 30, 40, 50, 100, 200]
2. False
3. True
4. [10, 20, 30, 40, 50, 100, 200, -4]

---

**Recap**

- Complete the code in the main() function which adds 1 to each list element which has odd value.

```python
def main():
    a_list = [69, 98, 7, 92, 13, 9, 27, 36, 96, 46]
    print("1.", a_list)
    for index in range(len(a_list)):
        if a_list[index] % 2 == 1:
            a_list[index] = a_list[index] + 1
    print("2.", a_list)
main()
```

1. [69, 98, 7, 92, 13, 9, 27, 36, 96, 46]
2. [70, 98, 8, 92, 14, 10, 28, 36, 96, 46]
Lists and the * Operator (repeat)

- The * operator produces a new list which "repeats" the original list's contents.

```python
list1 = [10, 20]
list2 = list1 * 2
list3 = list2 * 3
print("1.", list1)
print("2.", list2)
print("3.", list3)
```

You can only repeat a list in combination with an integer, i.e., the_list * an_integer.

Getting slices of lists

- The slice operation behaves the same way as it does with the elements of a string. Within square brackets, you may have one or two colons (:). The number before the first colon is the start index, the number after the first colon is the end index (one greater than the last index), and the number after the second colon is the step.
- The step indicates the gap between elements in the slice taken. The default step is 1.
- Slicing returns a new list object.

```python
list1 = [10, 20, 30, 40, 50]
list2 = list1[0:3:1]
print("1.", list2)
list3 = list1[3:5:1]
print("2.", list3)
```

Does the same job as:

```python
list1 = [10, 20, 30, 40, 50]
list2 = list1[0:3:1]
print("1.", list2)
list3 = list1[3:5:1]
print("2.", list3)
```

1. [10, 20]
2. [10, 20, 10, 20]
3. [10, 20, 10, 20, 10, 20, 10, 20, 10, 20, 10, 20]

```
list1 = [10, 20, 30, 40, 50]
list2 = list1[0:3:1]
print("1.", list2)
list3 = list1[3:5:1]
print("2.", list3)
```

1. [10, 20, 30]
2. [40, 50]
Getting slices of lists

- Three numbers in square brackets separated by colons define the **start**, **end** and **step** of the slice, e.g., `list1[1:6:3]`.
- The default for the first number is the beginning of the list, e.g.,
  ```python
  list1 = [10, 20, 30, 40, 50, 55]
  list2 = list1[1::1]  # same as list2 = list1[0:4:1]
  print(list2)
  [10, 20, 30, 40]
  ```
- The default for the second number is the end of the list, e.g.,
  ```python
  list1 = [10, 20, 30, 40, 50, 55]
  list2 = list1[2::2]  # same as list2 = list1[2:len(list1):2]
  print(list2)
  [30, 50]
  ```

The default for the step value is 1.

Strings are Immutable

- Strings are "immutable", i.e., the characters in a string object cannot be changed. Whenever a string is changed in some way, a new string object (with a new memory address) is created.
  ```python
  word1 = "sweet"
  word2 = word1
  print("1.", word1, word2)
  print("2.", word1 is word2)
  word2 = word2 + " dumpling"
  print("3.", word1, word2)
  print("4.", word1 is word2)
  1. sweet sweet
   2. True
   3. sweet sweet dumpling
   4. False
  ```

Lists are Mutable

- Lists are "mutable", i.e., the elements in a list object can be updated and adjusted.
  ```python
  list1 = [10, 20, 30, 40, 50]
  list2 = [1, 5]  # A
  print("1.", list1)
  print("2.", list1)
  print("3.", list1)
  list2 = list1  # B
  print("4.", list2)
  print("5.", list1)
  list1[3] = 99
  list2[1] = 3  # C
  print("6.", list2)
  print("7.", list1)
  ```

- The `==` operator is used to test if two objects contain the same information.
- The `is` operator is used to test if two variables reference (point to) the same object.
  ```python
  word1 = "sweet"
  word2 = word1
  print("1.", word1 == word2)
  print("2.", word1 is word2)
  word2 = word2.upper()
  word2 = word2.lower()
  print("3.", word1 == word2)
  print("4.", word1 is word2)
  1. True
   2. True
   3. True
   4. False
  ```
Some inbuilt functions which work with lists

- Below are four in-built functions which can be used with lists:
  - `len(a_list)` returns the number of elements.
  - `min(a_list)` returns the minimum element in the list.
  - `max(a_list)` returns the maximum element in the list.
  - `sum(a_list)` returns the sum of the elements in the list (only for numbers).

```python
list1 = [10, 20, 30, 40, 50, 55]
minimum = min(list1)
total = sum(list1)
print("length: ", len(list1), ", min: ", minimum, ", max: ",
      max(list1), ", sum: ", total, sep="")
length: 6, min: 10, max: 55, sum: 205
```

Dot notation

- We use **dot notation** to call a method on a specific object. In dot notation, a dot is placed between the object and the method which is to be applied to the object.
- Each type of object has many methods which can be called with that type of object. For example a string object has the methods `find()`, `upper()`, `lower()`, `strip()`, `isdigit()`, `isalpha()`, and many more:

```python
words = "Over the rainbow"
position = words.find("x")
words = words.lower()
result = words.isalpha()
print("position: ", position, "words: ", words, "result: ", result)
position: 3 words: over the rainbow result: False
```

Some list methods

- There are many methods which can be used with list objects. Below and on the next slides are five methods which can be used with lists:
  - `index(x)` returns the index of the first element from the left in the list with a value equal to x. Python throws an error if there is no such value in the list. Because of this, `index(x)` is usually preceded by a check for that element using the `in` operator.

```python
list1 = [10, 20, 30, 40, 50, 55]
if 40 in list1:
    position = list1.index(40)
    print("40 is in position", position, "in the list")
else:
    print("40 is not in the list")
40 is in position 3 in the list
```

- `pop(index)` removes and returns the item at the position given by the index number. The 'popped' element is returned by the method. An error results if there is no such index in the list. `pop()` with no index removes and returns the last item.

```python
list1 = [10, 20, 30, 40, 50, 55]
if len(list1) > 2:
    popped = list1.pop(2)
print("Popped", popped, " from the list", list1)
popped = list1.pop()
print(list1)
Popped 30 from the list [10, 20, 40, 50, 55] 55
```
Another list method

- `insert(i, x)` inserts an element at a given index. The first argument is the index at which to insert the element, e.g., `my_list.insert(1, 62)` inserts 62 into position 1 of the list, moving the rest of the elements along one (the element at index 1 moves to index 2, the element at index 2 moves to index 3, and so on).

```python
list1 = [10, 20, 30, 40, 50, 55]
list1.insert(3, 77)
print(list1)  # [10, 20, 30, 77, 40, 50, 55]
list1.insert(6, 99)
print(list1)  # [10, 20, 30, 77, 40, 99, 55]
list1.insert(0, 44)
print(list1)  # [44, 10, 20, 30, 77, 40, 99, 55]
```

More useful list methods

- `sort()` sorts the elements of the list, in place. If sorting a list of lists, only the first element in each list is considered in the comparison operations. Only the order of the list elements is modified (unless already sorted).

```python
list1 = [60, 20, 80, 10, 30, 55]
print(list1)  # [60, 20, 80, 10, 30, 55]
list1.sort()
print(list1)  # [10, 20, 30, 55, 60, 80]
```

- `reverse()` reverses the elements of the list, in place. Only the order of the list elements is modified.

```python
list1 = [10, 20, 30, 40, 50, 55]
print(list1)  # [10, 20, 30, 40, 50, 55]
list1.reverse()
print(list1)  # [55, 50, 40, 30, 20, 10]
```

Exercise

- `append(x)` adds the element to the end of the list.

```python
list1 = [10, 20, 30, 40, 50, 55]
list1.append(77)
print("1.", list1)  # [10, 20, 30, 40, 50, 55, 77]
list1.append(99)
print("2.", list1)  # [10, 20, 30, 40, 50, 55, 77, 99]
list1.append(44)
print("3.", list1)  # [10, 20, 30, 40, 55, 77, 99, 44]
```

Complete the `get_index_list()` function which returns a `sorted` list of all the `indices` of the numbers to look for which exist in the list parameter, `number_list`.

```python
def get_index_list(number_list, numbers_to_look_for):

def main():
    numbers = [1206, 1216, 475, 1038, 1481, 135]
    search_numbers = [1038, 1367, 1206, 740, 1281, 1216]
    index_list = get_index_list(numbers, search_numbers)
    print("indices of the numbers found", index_list)
    print("indices of the numbers found [0, 1, 3]")
maintest()
```
Exercise

- Complete the `remove_multiples()` function which removes all the elements in the parameter list, `number_list`, which are multiples of the parameter, `multiples_of`.

```python
def remove_multiples(number_list, multiples_of):
    # Implementation
```

```python
def main():
    numbers = [25, 5, 9, 10, 15, 8]
    print(numbers)
    remove_multiples(numbers, 5) # remove multiples of 5
    print("Numbers left", numbers)

main()
```

Summary

- A list stores data as a sequence
  - We use a for ... in ... to iterate through the elements of a list
  - `len()` returns the number of elements in a list
  - `min()` returns the minimum of the elements in a list
  - `max()` returns the maximum of the elements in a list
  - `sum()` returns the sum of the elements in a list
  - Each element of the list can be accessed using the index operator. The index can be negative (starting from the end of the list)
  - Slices of lists can be obtained by using `[slice_start: slice_end: step]`
  - `index(element)` returns the index of the element in a list
  - `insert(index, element)` inserts an element into a list into the required index
  - `append(element)` adds the element to the end of the list
  - `reverse()` reverses the elements of a list in place
  - `sort()` sorts the elements of a list in place
  - Lists are mutable

Examples of Python features used in this lecture

```python
list1 = [4, 6, 2, 5, 8]
result = 8 in list1
for element in list1:
    ...
min_value = len(list1)
min_value = min(list1)
max_value = max(list1)  # If the list elements are numbers
total = sum(list1)  # If the list elements are numbers
element_from_end = list1[-2]
list2 = list1[1:5:2]
position = list1.index(3)
element = list1.pop(1)
list1.insert(4, 66)
list1.append(54)
list1.reverse()
list1.sort()
```