CH-5 Sequences: Lists and Tuples

September 2024

Introduction

- Collections are built-in data structures for storing related items.
- Examples: songs, contacts, books, players, stocks, patients, shopping list.
- They allow data to be stored and accessed efficiently.

Lists

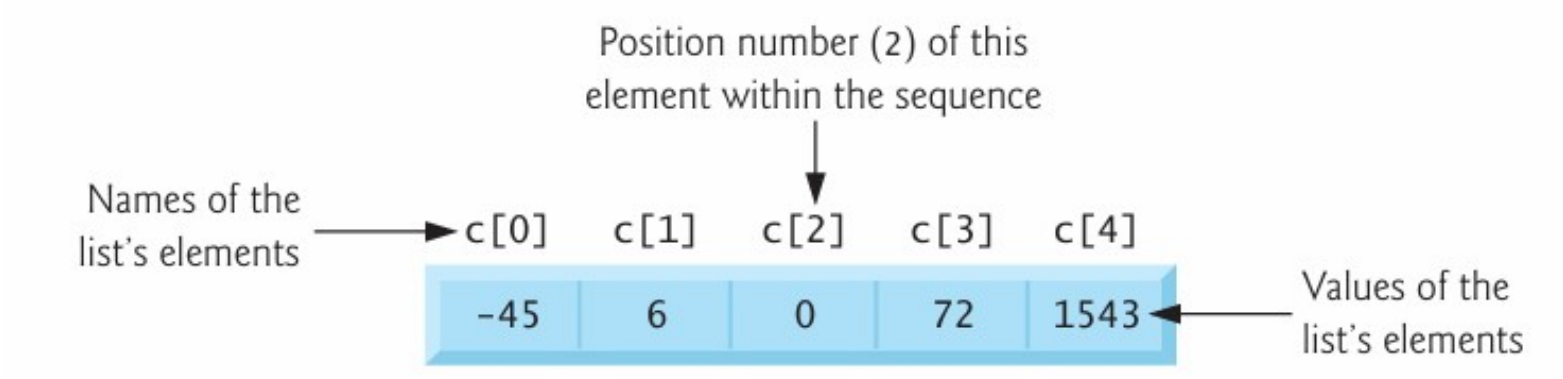
- Ordered sequence of information, accessible by index
- Lists typically store homogeneous data, that is, values of the same data type.

```
In [1]: c = [-45, 6, 0, 72, 1543]

In [2]: c
Out[2]: [-45, 6, 0, 72, 1543]
```

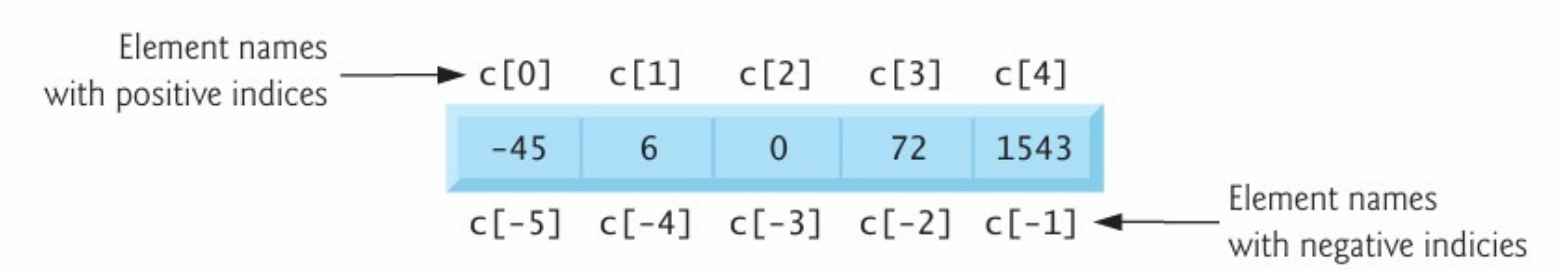
- They also may store heterogeneous data, that is, data of many different types.

```
"""student s first name, last name, grade point
average and graduation year"""
In [3]: d = ['Mary', 'Smith', 3.57, 2022]
```

- Accessing Elements of a List- lists name followed by the elements index (or position number) enclosed in square brackets ([ ], known as the subscription operator)



- Accessing Elements from the End of the List with Negative Indices-



- Determining a Lists Length- use built in len *function*

```
L = [2,4,5,6,7]
len(L)
OUTPUT: 5
```

- Indices Must Be Integers or Integer Expressions. Using a non-integer index value causes a `TypeError`.
- Lists are mutable!- their elements can be modified. Assigning to an element at an index changes the value.

```
In [1]: L = [1,2,3,4,5]
In [2]: L[2] = 100
In [3]: L
Out[3]: [1, 2, 100, 4, 5]
#Note that this is the same object L.
```

- List elements may be used as variables in expressions:

```
In [4]: L[1] + L[2]
Out[4]: 102
```

- Appending to a List with +=
  - += allows dynamic list expansion by adding each element from an iterable on the right side.
  - Examples of valid iterables: lists, tuples, and strings.

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

In [2]: for i in range(1,6):
...:      L += [i]
...:
In [3]: L
Out[3]: [1, 2, 3, 4, 5]
```

- Strings can also be appended character by character:

```
In [1]: letters = [ ]

In [2]: letters += 'Python'

In [3]: letters
Out[3]: ['P', 'y', 't', 'h', 'o', 'n']
```

- Attempting `L += non_iterable` (e.g., an integer) raises a `TypeError`.

- Concatenating Lists with +
  - You can concatenate two lists, two tuples or two strings using the + operator.
  - The result is a new sequence of the same type containing the left operands elements followed by the right operands elements.

```
In [4]: L1 = [10, 20, 30]

In [5]: L2 = [40, 50, 60, 70]

In [6]: L1 + L2
Out[6]: [10, 20, 30, 40, 50, 60, 70]
```

  - A TypeError occurs if the + operators operands are difference sequence types.

- Using for and range to Access List Indices and Values

```
In [1]: L = [10, 20, 30, 40, 50]

In [2]: for i in range(len(L)):
   ...:     print(f" {i}: {L[i]}")
   ...:
0: 10
1: 20
2: 30
3: 40
4: 50
```

- Comparison Operators

```
In [1]: L1 = [10, 20, 30]
In [2]: L2 = [40, 50, 60, 70]
In [3]: L1==L2
Out[3]: False
```

Tuples

- an ordered sequence of elements, can mix element types
- cannot change element values, immutable
- represented with parentheses
- Creating Tuples
  - To create an empty tuple, use empty parentheses:

```
In [4]: t = () # empty tuple
```

  - You can pack a tuple by separating its values with commas:

```
In [5]:  student_tuple = 'John', 'Green', 3.3

In [6]: student_tuple
Out[6]: ('John', 'Green', 3.3)
```

- Creating Tuples
  - The following is a tuple with one element only:

```
In [7]: s_t = 'red',
In [9]: s_t
Out[9]: ('red',)
```

- Accessing Tuple Elements

  Like list indices, tuple indices start at 0.

```
In [14]: t_t = (5, 20, 30)

In [15]: t_t
Out[15]: (5, 20, 30)

In [16]: s_c = t_t[0]*3600 + t_t[1]*60 + t_t[2]

In [17]: s_c # seconds
Out[17]: 18430
```

- Adding Items to a String or Tuple
  - As with lists, the += augmented assignment statement can be used with strings and tuples, even though theyre immutable.

```
In [18]: tuple1 = (10,20,30)

In [19]: tuple1 += (40,50)

In [20]: tuple1
Out[20]: (10, 20, 30, 40, 50)
```

  - For a string or tuple, the item to the right of += must be a string or tuple, respectively mixing types causes a `TypeError`.

- Appending Tuples to Lists
  - You can use $+=$ to append a tuple to a list:

```
In [21]: L = [1,2,3,4,5]

In [22]: t = (6,7,8)

In [23]: L += t

In [24]: L
Out[24]: [1, 2, 3, 4, 5, 6, 7, 8]
```

- Tuples May Contain Mutable Objects

```
In [23]: st_t = ('Amanda', 'Blue', [98, 75, 87])
```

  - Even though the tuple is immutable, its list element is mutable:

```
In [26]: st_t
Out[26]: ('Amanda', 'Blue', [98, 75, 87])

In [27]: st_t[2]
Out[27]: [98, 75, 87]

In [28]: st_t[2][0] = 5

In [29]: st_t
Out[29]: ('Amanda', 'Blue', [5, 75, 87])
```

Unpacking Sequences

- You can unpack any sequences elements by assigning the sequence to a comma-separated list of variables.
- A `ValueError` occurs if the number of variables to the left of the assignment symbol is not identical to the number of elements in the sequence on the right.

```
In [17]: student_t = ['Amanda', [98, 85, 87]]
In [18]: name, grades = student_t

In [19]: name
Out[19]: 'Amanda'

In [20]: grades
Out[20]: [98, 85, 87]
```

- The following code unpacks a string, a list and a sequence produced by range:

```
In [1]: f,s = 'HI'

In [2]: print(f, s)
H I

In [3]: f,s,t = [1,2,3]

In [4]: print(f,s,t)
1 2 3

In [5]: f,s,t = range(1,10,3) # start = 1, end = 10, step = 3

In [6]: print(f,s,t)
1 4 7
```

- You can swap two variables values using sequence packing and unpacking:

```
In [7]: a = 5

In [8]: b = 10

In [9]: a,b
Out[9]: (5, 10)

In [10]: a,b = b,a

In [11]: a,b
Out[11]: (10, 5)
```

Accessing Indices and Values Safely with Built-in Function enumerate:

- The preferred mechanism for accessing an elements index and value is the built-in function enumerate.
- This function receives an iterable and creates an iterator that, for each element, returns a tuple containing the elements index and value

```
In [12]: colors = ['red', 'green', 'blue']

In [13]: list(enumerate(colors))
Out[13]: [(0, 'red'), (1, 'green'), (2, 'blue')]

In [14]: tuple(enumerate(colors))
Out[14]: ((0, 'red'), (1, 'green'), (2, 'blue'))

In [15]: for index, value in enumerate(colors):
    ...:     print(f" {index}: {value}", end=' ')
    ...:
 0: red  1: green  2: blue
```

Creating a Primitive Bar Chart

```
# creating a bar chart
numbers = [2,5,3,6,7]
print('Creating a bar chart')
print(f"{'index':<5} {'value':<5} {'bar':<10}")
for index, value in enumerate(numbers):
    print(f"{index:<5} {value:<5} {'*'*value:<10}")
```

Output:

```
Creating a bar chart
index value bar
0     2     **
1     5     *****
2     3     ***
3     6     ******
4     7     *******
```

Sequence Slicing

- You can slice sequences to create new sequences of the same type containing subsets of the original elements.
- Slice operations can modify mutable sequencesthose that do not modify a sequence work identically for lists, tuples and strings.
- Specifying a Slice with Starting and Ending Indices:
  - The slice copies elements from the **starting index** to the left of the colon up to, but not including, the **ending index** to the right of the colon.
  - The original list is not modified.

```
In [1]: L = [1,2,3,4,5,6,7]

In [2]: L[2:5]
Out[2]: [3, 4, 5]
```

- Specifying a Slice with Only an Ending Index:
  - If you omit the starting index, 0 is assumed.
  - $[0:5] \equiv [:5]$

```
In [3]: L[0:5]
Out[3]: [1, 2, 3, 4, 5]

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

- Specifying a Slice with Only a Starting Index:
  - If you omit the ending index, Python assumes the sequences length.

```
In [5]: L[2:]
Out[5]: [3, 4, 5, 6, 7]
```

- Specifying a Slice with No Indices:
  - Omitting both the start and end indices copies the entire sequence.

```
In [6]: L[:]
Out[6]: [1, 2, 3, 4, 5, 6, 7]
```

  - Though slices create new objects, slices make shallow copies of the elementsthat is, they copy the elements references but not the objects they point to.
  - So, in the snippet above, the new lists elements refer to the same objects as the original lists elements, rather than to separate copies.
- Slicing with Steps:

```
In [7]: L[1:6:2]
Out[7]: [2, 4, 6]
```

- Slicing with Negative Indices and Steps:
  - You can use a **negative step** to select slices in **reverse order**.

```
In [8]: L[::-1]
Out[8]: [7, 6, 5, 4, 3, 2, 1]

#This is equivalent to L[-1:-8:-1]
In [10]: L[-1:-8:-1]
Out[10]: [7, 6, 5, 4, 3, 2, 1]
```

- Modifying Lists Via Slices:
  - You can modify a list by assigning to a slice of itthe rest of the list is unchanged.

```
In [14]: L[0:4] = ['A','B','C','D']

In [15]: L
Out[15]: ['A', 'B', 'C', 'D', 5, 6, 7]
```

- First k elements of the list can be deleted by assigning an empty list to the k-element slice:

```
In [1]: L = [1,2,3,4,5,6,7]

In [2]: L[0:4] = []

In [3]: L
Out[3]: [5, 6, 7]
```

- You can delete all the elements in the list, leaving the existing list empty.

```
In [7]: L = [1,2,3,4,5]

In [8]: L[:]=[]

In [9]: L
Out[9]: []
```

- Deleting contents keeps the list objects identity.
- Assigning a new list creates a different object in memory.

```
In [16]: L
Out[16]: [10, 4, 10]

In [17]: id(L)
Out[17]: 1884662403648

In [18]: L[:] = []

In [19]: L
Out[19]: []

In [20]: id(L)
Out[20]: 1884662403648

In [21]: L = []

In [22]: id(L)
Out[22]: 1884662936000
```

del Statement

- The del statement also can be used to remove elements from a list and to delete variables from the interactive session.
- You can remove the element at any valid index or the element(s) from any valid slice.
- Deleting the Element at a Specific List Index

```
In [2]: L = list(range(1,11))

In [3]: L
Out[3]: [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]

In [4]: del L[-5]

In [5]: L
Out[5]: [1, 2, 3, 4, 5, 7, 8, 9, 10]
```

- Deleting a Slice from a List

```
In [8]: del L[-1:-3:-1]

In [9]: L
Out[9]: [1, 2, 3, 4, 5, 7, 8]

In [10]: del L[::2]

In [11]: L
Out[11]: [2, 4, 7]
```

- Deleting a Slice Representing the Entire List

```
In [12]: del L[:]

In [13]: L
Out[13]: []
```

- Deleting a Variable from the Current Session

```
In [14]: del L
```

Passing Lists to Functions

- Passing Lists to a Function
  - Lists are mutable; functions receive a reference to the original list.
  - Modifying list elements within a function alters the original list.
- Passing Tuples to a Function
  - Tuples are immutable; attempting to modify elements causes a TypeError.
  - However, mutable elements (e.g., lists) within a tuple can still be modified in a function.

```
L = ['a', 'b', 'c']
T = ('a', 'b', 'c')
def modify_sequence(s):
    for i in range(len(s)):
        s[i]*=2
    return s

print(modify_sequence(L))
Output: === RESTART: C:/Users/jps15/OneDrive/
Desktop/Python/a51.py ==
['aa', 'bb', 'cc']

print(modify_sequence(T))
Output: TypeError: 'tuple' object does not
support item assignment
```

- Recall that tuples may contain mutable objects, such as lists. Those objects still can be modified when a tuple is passed to a function.

Sorting Lists

- Sorting arranges data in ascending or descending order.
- A key computing task, essential for data organization and retrieval.
- Extensively studied in computer science, especially in data structures and algorithms.
- Critical for improving data processing, search efficiency, and overall program performance.
- Detailed exploration in topics like recursion, search algorithms, and Big O analysis.

- Sorting a List in Ascending Order
  - List method `sort` modifies a list to arrange its elements in ascending order:

```
In [16]: n = [1,8,3,4,9,7,6,2,5,10]

In [17]: n.sort()

In [18]: n
Out[18]: [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
```

- Sorting a List in Descending Order
  - To sort a list in descending order, call list method sort with the optional keyword argument `reverse` set to True (False is the default).

```
In [19]: n = [1,8,3,4,9,7,6,2,5,10]

In [20]: n.sort(reverse = True)

In [21]: n
Out[21]: [10, 9, 8, 7, 6, 5, 4, 3, 2, 1]
```

- Built in Function *sorted*
  - Built-in function `sorted` returns a **new list** containing the sorted elements of its argument sequencethe original sequence is **unmodified**.
  - The built-in sorted function can be used on lists and tuples, but when applied to a string, it treats the string as a sequence of characters and returns a **list of sorted characters**, not a sorted string.
  - Use the optional keyword argument `reverse` with the value `True` to sort the elements in `descending order`.

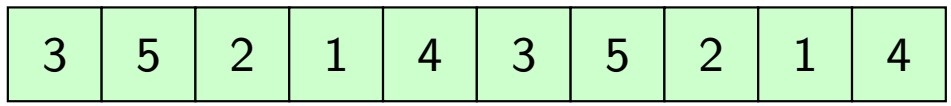
```
# Example 1: Sorting a list
numbers = [5, 1, 4, 2, 3]
print(sorted(numbers)) # [1, 2, 3, 4, 5]
print(numbers)         # original list unchanged

# Example 2: Sorting a tuple
t = (10, 7, 8, 9)
print(sorted(t))       # [7, 8, 9, 10]

# Example 3: Sorting a string
s = "python"
print(sorted(s))   # ['h', 'n', 'o', 'p', 't', 'y']

# Example 4: Sorting in descending order
print(sorted(numbers, reverse=True))   # [5, 4, 3, 2, 1]
```

Searching Sequences

- Purpose of Searching: Searching involves locating a specific key value within a sequence (e.g., list, tuple, or string) to determine if it exists in the collection.
- Application of Searching: This technique helps quickly identify whether a desired value is present in the sequence, which is essential for data retrieval and decision-making processes.
- List Method index: List method index takes as an argument a search keythe value to locate in the listthen searches through the list from index 0 and returns the index of the **first** element that matches the search key:

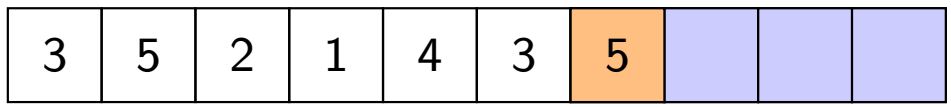
```
In [7]: L = [3, 5, 2, 1, 4]

In [8]: L.index(5)
Out[8]: 1

In [9]: L.index(7)

ValueError: 7 is not in list
```

- Specifying the Starting Index of a Search
  - **Multiplying the Sequence** `L *= 2`



List after `L *= 2`

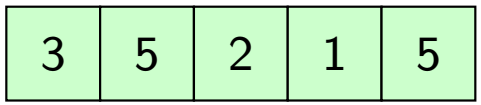
  - **Subset Search Using** `index(5, 6)`



Search Result: `L.index(5, 6)` $\rightarrow$ Index 6

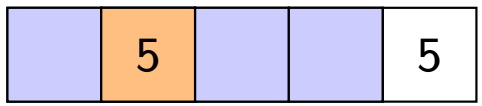
    - Highlights the subset from index 6 onward in blue and marks the found value 5 at index 6 in orange.

- Specifying the Starting and Ending Indices of a Search
  - **Original List:** `L = [3, 5, 2, 1, 5]`



Original List `L`

  - **Subset Search Using** `L.index(5, 0, 4)`



Search Result: `L.index(5, 0, 4)` $\rightarrow$ Index 1

  - Highlights the search subset from index 0 to 4 (not including 4) in blue, and marks the found value 5 at index 1 in orange.

- Operators `in` and `not in`
  - Operator in tests whether its right operands iterable contains the left operands value.
  - Similarly, operator not in tests whether its right operands iterable does not contain the left operands value.

```
L = [3, 5, 2, 1, 5]

# Operator in
print(1000 in L)   # Output: False
print(5 in L)      # Output: True

# Operator not in
print(1000 not in L)   # Output: True
print(5 not in L)      # Output: False
```

- Using Operator in to Prevent a `ValueError`
  - Python code:

```
key = 1000

if key in numbers:
    print(f'found {key} at index {L.index(key)}')
else:
    print(f'{key} not found')
```

  - In this snippet, the `in` operator is used to prevent a `ValueError` when searching for a key in the sequence `L`.
- Built-in Functions: `any` and `all`

$$\text{any(iterable)} = \begin{cases} \text{True}, & \text{if any item in iterable is True} \\ \text{False}, & \text{otherwise} \end{cases}$$

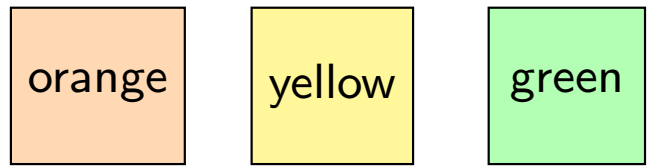
$$\text{all(iterable)} = \begin{cases} \text{True}, & \text{if all items in iterable are True} \\ \text{False}, & \text{otherwise} \end{cases}$$

- Nonzero values are considered **True**.
- Zero is considered **False**.
- Non-empty iterables evaluate to **True**.
- Empty iterables evaluate to **False**.

```
nums = [1, 2, 3]
print(all(nums))  # True, all nonzero      truthy
empty_list = ["apple", "", "cherry"]
print(all(empty_list))  # False, "" is falsy

nums1 = [0, 0, 3]
print(any(nums1))  # True, 3 is truthy
empty_list = ["", "", ""]
print(any(empty_list))  # False, all falsy
```

Other List Methods

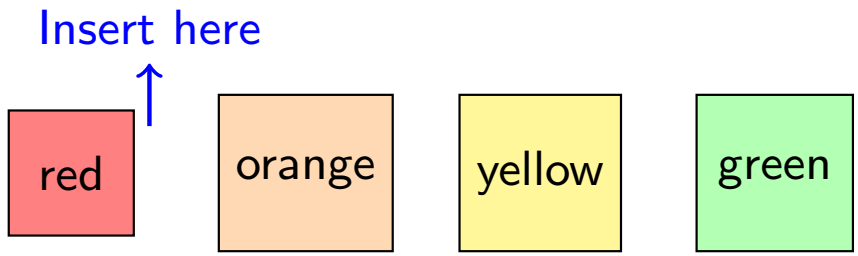
- Inserting an Element at a Specific List Index
  - **Original List:** `color_names = ['orange', 'yellow', 'green']`



Original List `color_names`

  - **Insert `'red'` at Index 0**

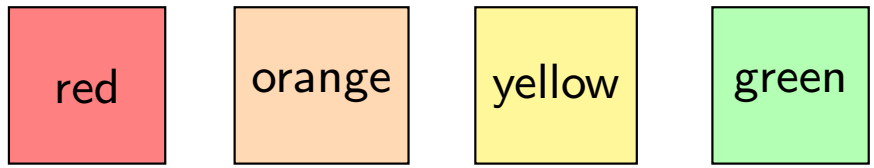
```
color_names.insert(0, 'red')
```



List After Insertion

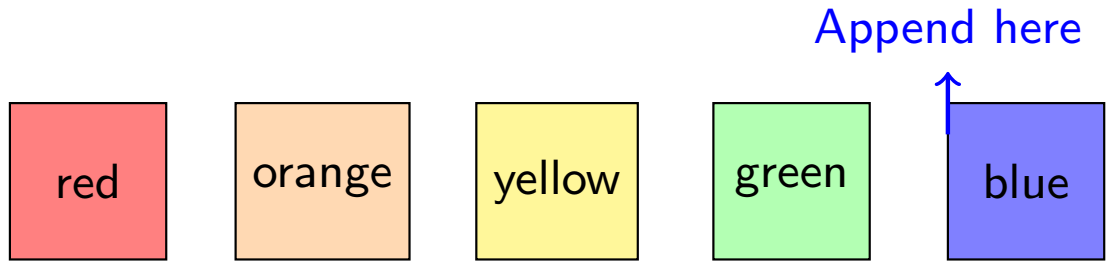
  - **Updated List:** `['red', 'orange', 'yellow', 'green']`

- Adding an Element to the End of a List
  - **Original List:** `color_names = ['red', 'orange', 'yellow', 'green']`



Original List `color_names`

  - **After Appending** `'blue'`: `color_names.append('blue')`



Updated List `['red', 'orange', 'yellow', 'green', 'blue']`

- Adding All the Elements of a Sequence to the End of a List
  - Use list method `extend` to add all the elements of another sequence to the end of a list:

```
colors = [ 'red', 'violet', 'green']
colors.extend(['BLUE', 'BLACK'])
print(colors)
#['red', 'violet', 'green', 'BLUE', 'BLACK']
#This is the equivalent of using +=
colors.extend('ABC')
print(colors)
#['red','violet','green','BLUE','BLACK','A','B','C']
colors.extend((1,2,3))
print(colors)
#['red','violet','green','BLUE','BLACK','A','B','C',1,2,3]
```

- Removing the First Occurrence of an Element in a List
  - Method remove deletes the first element with a specified valuea `ValueError` occurs if removes argument is not in the list:

```
print(colors)
['red','orange','yellow','green','blue','orange','white']

colors.remove('orange')
print(colors)
['red','yellow','green','blue','orange','white']
```

- Emptying a List
  - To delete all the elements in a list, call method clear:

```
In [22]: colors.clear()

In [23]: colors
Out[23]: []
```

- Counting the Number of Occurrences of an Item
  - List method count searches for its argument and returns the number of times it is found:

```
In [24]: responses = [1,2,1,4,5,1,3,2,5,4,6,3]

In [25]: responses.count(3)
Out[25]: 2
```

- Reversing a Lists Elements
  - List method reverse reverses the contents of a list in place, rather than creating a reversed copy, as we did with a slice previously:

```
In [36]: colors
Out[36]: ['red', 'orange', 'yellow', 'green', 'blue']

In [37]: colors.reverse()
In [38]: colors
Out[38]: ['blue', 'green', 'yellow', 'orange', 'red']
```

- Copying a List
  - List method copy returns a *new* list containing a *shallow* copy of the original list:

```
In [48]: colors
Out[48]: ['blue', 'green', 'yellow', 'orange', 'red']

In [49]: copied_colors = colors.copy()

In [50]: copied_colors
Out[50]: ['blue', 'green', 'yellow', 'orange', 'red']
```

  - This is equivalent to the previously demonstrated slice operation:

```
copied_colors = colors[:]
```

Simulating Stacks with Lists

- Python does not have a built-in stack type, but you can think of a stack as a constrained list.
- You push using list method append, which adds a new element to the end of the list.
- You pop using list method pop with no arguments, which removes and returns the item at the end of the list.

```
In [1]: stack = []
In [2]: stack.append('green')
In [3]: stack
Out[3]: ['green']
In [4]: stack.append('red')
In [5]: stack
Out[5]: ['green', 'red']
In [6]: stack.pop()
Out[6]: 'red'
In [7]: stack
Out[7]: ['green']
In [8]: stack.pop()
Out[8]: 'green'
In [9]: stack
Out[9]: []
```

List Comprehensions

- List comprehensions provide a concise way to create new lists from existing sequences.
- Replacement for Loops: They can often replace for loops used to populate lists, making the code shorter and clearer.

```
In [18]: for i in range(1,11):
    ...:     L.append(i)
    ...:

In [19]: L
Out[19]: [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
#Using a List Comprehension to Create a List of Integers
In [20]: L_New = [ i for i in range(1,11)]

In [21]: L_New
Out[21]: [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
```

- Structure of List Comprehensions:

```
new_list = [expression for item in iterable if condition]
```

  - **expression:** The operation or transformation to apply to each item.
  - **for item in iterable:** Iterates over each item in the specified iterable.
  - **if condition (optional):** A filter that only includes items for which the condition is true.

- List Comprehension That Processes Another Lists Elements

```
In [22]: c = ['RED', 'BLUE', 'WHITE']

In [23]: C = [color.lower() for color in c]

In [24]: C
Out[24]: ['red', 'blue', 'white']
```

Generator Expressions

- A generator expression is similar to a list comprehension, but it creates an iterable generator object rather than a list.
- Generates items one at a time on demand, known as lazy evaluation.
- Memory Efficiency: Uses less memory than list comprehensions for large data, as items are generated only when needed.
- **Syntax:** Defined with parentheses ( ) instead of square brackets [ ].
- **Performance:** Improves performance when you don't need the entire list immediately, reducing memory and computation time.

```
# Generator expression
nums_gen = (x**2 for x in range(5))
print(nums_gen)
----------OUTPUT-----------------
<generator object <genexpr> at 0x000001E7...>
---------------------------------
for num in nums_gen:
    print(num, end= ' ')
----------OUTPUT-----------------
0 1 4 9 16
```

Filter, Map and Reduce

- built-in `filter` and `map` functions for `filtering` and `mapping`, respectively
- reductions in which you process a collection of elements into a single value, such as their count, total, product, average, minimum or maximum.

Filtering a Sequences Values with the Built-In `filter` Function

```
In [1]: numbers = [10, 3, 7, 1, 9, 4, 2, 8, 5, 6]

In [2]: def is_odd(x):
   ...:     # returns True only if x is odd
   ...:     return x%2 !=0
   ...:
   ...:
In [3]: list(filter(is_odd, numbers))
# highter-order function
Out[3]: [3, 7, 1, 9, 5]
```

- Function `filter` returns an iterator, so filters results are not produced until you iterate through them. This is another example of *lazy evaluation*.
- We can obtain the same results as above by using a list comprehension with an if clause:

```
In [8]: [item for item in numbers if is_odd(item)]
Out[8]: [3, 7, 1, 9, 5]
```

Using a lambda Rather than a Function

- Lambda expressions (or simply "lambdas") are used to define small, anonymous functions inline, typically where a function is passed as an argument.
- **Syntax:** `lambda parameter_list: expression`

- Begins with lambda, followed by parameters, a colon, and an expression.
- Automatically returns the result of the expression.

```
In [10]: list(filter(lambda x: x%2!=0, numbers))
Out[10]: [3, 7, 1, 9, 5]
```

- Here, `lambda x: x % 2 != 0` is passed to filter, selecting only odd numbers from numbers.
- filter returns an iterator, so `list()` converts it to a list for display.

- **Comparison to Regular Functions:**

```
# Standard function definition
def is_odd(x):
    return x % 2 != 0

# Equivalent lambda expression
lambda x: x % 2 != 0
```

Mapping a Sequences Values to New Values

- The `map` function applies a specified function to each item in an iterable, returning an iterator with the results.
- **Syntax:** `map(function, iterable)`
  - The first argument is a function that takes one argument and returns a value.
  - The second argument is an iterable (e.g., list, tuple) containing values to transform.

```
numbers = [10, 3, 7, 1, 9, 4, 2, 8, 5, 6]
list(map(lambda x: x ** 2, numbers))
```

  - Here, `lambda x: x ** 2` squares each number in `numbers`.
  - `map` uses lazy evaluation, so `list()` is used to convert the iterator to a list for display.
- **Equivalent List Comprehension:** `[item ** 2 for item in numbers]`

Combining `filter` and `map` with Lambda Expressions

```
In [10]: numbers = [10, 3, 7, 1, 9, 4, 2, 8, 5, 6]

In [11]: list(map(lambda x: x**2, filter(lambda x: x%2!=0, num
Out[11]: [9, 49, 1, 81, 25]
```

- `filter(lambda x: x % 2 != 0, numbers)`: Filters out only the odd values in numbers.
- `map(lambda x: x ** 2, ...)`: Squares each of the filtered odd values.
- `list(...)`: Converts the resulting iterator to a list for display.

- **Equivalent List Comprehension:**

```
[x ** 2 for x in numbers if x % 2 != 0]
```

Reduction: Totaling the Elements of a Sequence with sum

- The `reduce()` function applies a specified function cumulatively to the items of an iterable.
- It is available in the `functools` module.
- **Syntax:** `reduce(function, iterable, initializer)`
- If the `initializer` (start value) is not given, the first element of the iterable is used as the initial value.
- If the iterable is empty and no initializer is given, it raises a `TypeError`.

```
from functools import reduce

# Example 1: Without initializer
numbers = [1, 2, 3, 4, 5]
result1 = reduce(lambda x, y: x + y, numbers)
print("Sum without initializer:", result1)
# Output: 15  -> (((1+2)+3)+4)+5

# Example 2: With initializer
result2 = reduce(lambda x, y: x + y, numbers, 10)
print("Sum with initializer 10:", result2)
# Output: 25  -> ((((10+1)+2)+3)+4)+5
```

- `reduce()` is ideal for cumulative operations like sum, product, gcd, etc.

Copy vs Deep Copy

Copy (Shallow Copy):

- A shallow copy creates a new list, but only at the top level.
- Nested elements (like lists within lists) are not copied; they are shared between the original and the copy.

```
import copy
l = [[1, 2], 3, 4] #l[0][0] = 1
m = copy.copy(l)  # or m = l[:]
m[0][0]=10
print(l[0][0]) #10
print(m[0][0]) #10
```

- Here, m is a new list, but `m[0]` and `l[0]` refer to the same nested list. So, modifying `m[0][0]` affects `l[0][0]`.
- **Shallow copy:** Only copies the top-level elements.

Copy (Deep Copy):

- A deep copy creates a completely independent copy, including nested elements. Changes to m will not affect l.

```
import copy
l = [[1, 2], 3, 4]
m = copy.deepcopy(l)
m[0][0] = 99
```

- Here, m is entirely separate from l, so changing `m[0][0]` does not change l.
- **Deep Copy:** Copies all elements, including nested ones.

Iterable and Iterator

Iterable

- An **iterable** is any Python object capable of returning its elements one at a time. Examples include lists, tuples, dictionaries, sets, and strings. These can be used in loops, such as `for` loops.
- To check if an object is iterable, it must implement the `__iter__()` method, which returns an iterator. However, an iterable itself does not keep track of its current position in the sequence.

```
my_list = [1, 2, 3]  # This is an iterable.
```

Iterator

- An **iterator** is a Python object that represents a stream of data. It keeps track of the current position in that data and knows how to return the next item in the sequence.
- An iterator implements two methods:

  `__iter__()`: Returns the iterator object itself.
  `__next__()`: Returns the next element in the sequence.
  Raises `StopIteration` when there are no more elements.

- You can obtain an iterator from an iterable by using the `iter()` function.

```
my_iter = iter(my_list)
# Creates an iterator from the iterable ‘my_list‘.
print(next(my_iter))  # Outputs: 1
print(next(my_iter))  # Outputs: 2
```

Other Sequence Processing Functions

Finding the Minimum and Maximum Values Using a Key Function

- By default, Pythons `min` and `max` compare strings based on their character's numerical values (ASCII/Unicode).
- Lowercase letters have higher numerical values than uppercase letters, affecting lexicographical order (e.g., `'Red' < 'orange'` is True because R has a lower numerical value than o).
- To get alphabetic ordering, convert each string to lowercase or uppercase during comparison.
- Use the key argument in `min` and `max` to apply a transformation for comparison without altering the original list.

- `min(colors, key=lambda s: s.lower())` returns `'Blue'` (alphabetically first).
- `max(colors, key=lambda s: s.lower())` returns `'Yellow'` (alphabetically last).
- Here, `lambda s: s.lower()` ensures comparison ignores case.

```
In [12]: colors=['Red','orange','Yellow','green','Blue']

In [13]: min(colors, key = lambda s: s.lower())
Out[13]: 'Blue'

In [14]: max(colors, key = lambda s: s.lower())
Out[14]: 'Yellow'
```

Iterating Backward Through a Sequence

- Built-in function `reversed` returns an iterator that enables you to iterate over a sequences values backward.

```
In [7]: numbers = [10, 3, 7, 1, 9, 4, 2, 8, 5, 6]
In [7]: rev_numbers=[item for item in reversed(numbers)]
In [8]: rev_numbers
Out[8]: [36, 25, 64, 4, 16, 81, 1, 49, 9, 100]
```

Combining Iterables into Tuples of Corresponding Elements

- Built-in function `zip` enables you to iterate over multiple iterables of data at the same time.

```
names = ['Bob', 'Sue', 'Amanda']
grade_point_avg = [3.5, 4.0, 3.75]
for name, gpa in zip(names, grade_point_avg):
    print(f'Name={name}; GPA={gpa}')
----------OUTPUT--------------------
Name=Bob; GPA=3.5
Name=Sue; GPA=4.0
Name=Amanda; GPA=3.75
```

Two-Dimensional Lists

- A two-dimensional list stores data in rows and columns like a table.
- Each element is accessed using two indices: one for row and one for column.
- Useful for representing matrices, game boards, or data tables.

```
matrix = [
    [1, 2, 3],
    [4, 5, 6],
    [7, 8, 9]
]
print(matrix[1][2])    # Output: 6
```

- Nested loops help access each element row by row.

```
for row in matrix:
    for e in row:
        print(e, end = ' ')
--------OUTPUT------------
1 2 3 4 5 6 7 8 9
```

Q.1 What, if anything, is wrong with each of the following code segments?

a)
```
day, high_temperature = ('Monday', 87, 65)
```

b)
```
numbers = [1, 2, 3, 4, 5]
numbers[10]
```

c)
```
name = 'amanda'
name[0] = 'A'
```

d)
```
numbers = [1, 2, 3, 4, 5]
numbers[3.4]
```

e)
```
student_tuple=('Amanda','Blue',[98, 75, 87])
student_tuple[0] = 'Ariana'
```

f)
```
('Monday', 87, 65) + 'Tuesday'
```

g)
```
'A' += ('B', 'C')
```

h)
```
x = 7
del x
print(x)
```

i)
```
numbers = [1, 2, 3, 4, 5]
numbers.index(10)
```

j)
```
numbers = [1, 2, 3, 4, 5]
numbers.extend(6, 7, 8)
```

Q.2 **(Iteration Order)** Create a 2-by-3 list, then use a nested loop to:

(a) Set each elements value to an integer indicating the order in which it was processed by the nested loop.
(b) Display the elements in tabular format. Use the column indices as headings across the top, and the row indices to the left of each row.

Q.3 **(IPython Session: Slicing)** Create a string called alphabet containing `'abcdefghijklmnopqrstuvwxyz'`, then perform the following separate slice operations to obtain:

(a) The first half of the string using starting and ending indices.
(b) The first half of the string using only the ending index.
(c) The second half of the string using starting and ending indices.
(d) The second half of the string using only the starting index.
(e) Every second letter in the string starting with 'a'.
(f) The entire string in reverse.
(g) Every third letter of the string in reverse starting with 'z'

Q.4 **(Functions Returning Tuples)** Define a function `rotate` that receives three arguments and returns a tuple in which the first argument is at index 1, the second argument is at index 2 and the third argument is at index 0. Define variables a, b and c containing 'Doug', 22 and 1984. Then call the function three times. For each call, unpack its result into a, b and c, then display their values.

Q.5 **(Duplicate Elimination)** Create a function that receives a list and returns a (possibly shorter) list containing only the unique values in sorted order. Test your function with a list of numbers and a list of strings.

Q.6 **(Sorting Letters and Removing Duplicates)** Insert 20 random letters in the range 'a' through 'f' into a list. Perform the following tasks and display your results:

(a) Sort the list in ascending order.
(b) Sort the list in descending order.
(c) Get the unique values sort them in ascending order.

Q.7 **(Fill in the Missing Code)** Replace the ***s in the following list comprehension and map function call, such that given a list of heights in inches, the code maps the list to a list of tuples containing the original height values and their corresponding values in meters. For example, if one element in the original list contains the height 69 inches, the corresponding element in the new list will contain the tuple (69, 1.7526), representing both the height in inches and the height in meters. There are 0.0254 meters per inch.

```
[*** for x in [69, 77, 54]]
list(map(lambda ***, [69, 77, 54]))
```

Q.8 **(Is a Sequence Sorted?)** Create a function `is_ordered` that receives a sequence and returns True if the elements are in sorted order. Test your function with sorted and unsorted lists, tuples and strings.