

Data Structures in Python



Dra. M^a Dolores Rodríguez Moreno

Objectives

Specific Objectives

- Understanding the main data structures

Source

- <https://docs.python.org/3/reference/datamodel.html>
- Charles R. Severance (www.pythonlearn.com)
- <https://ellibrodepython.com/>
- Python Tutorial - Tapa blanda. Guido Van Rossum (2012)
- Abhijeet Anand on NumPy

Outline

- **Introduction**
- List
- Tuple
- Set
- Dictionary
- Enum
- Array

Introduction

- Programming focuses on the representation of information
- Simple data types like numbers, characters, and strings are straightforward to handle
- Real-world scenarios often involve more complexity
- A class can represent a single object, but we need to manage multiple objects effectively
- Representing complex data requires robust solutions
- This is where data structures come into play, providing powerful tools for organizing and storing information

Summary

- List: $li = [1, 2, 3]$
- Tuple: $tu = (1, 2, 3)$
 $tu = 1, 2, 3$
- Set: $se = \{1, 2, 3\}$
- Dictionary: $dic = \{'abc': 1, 'bca': 2\}$

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List

- List initialization: `list = [item1, ..., itemN]`
- Methods:
 - `list.append(x)`
 - `list.insert(i, x)`
 - `list.remove(x)`
 - `list.pop()`
 - `list.index(x)`
 - `list.count(x)`
 - `list.sort()`
 - `list.reverse()`

Example: List

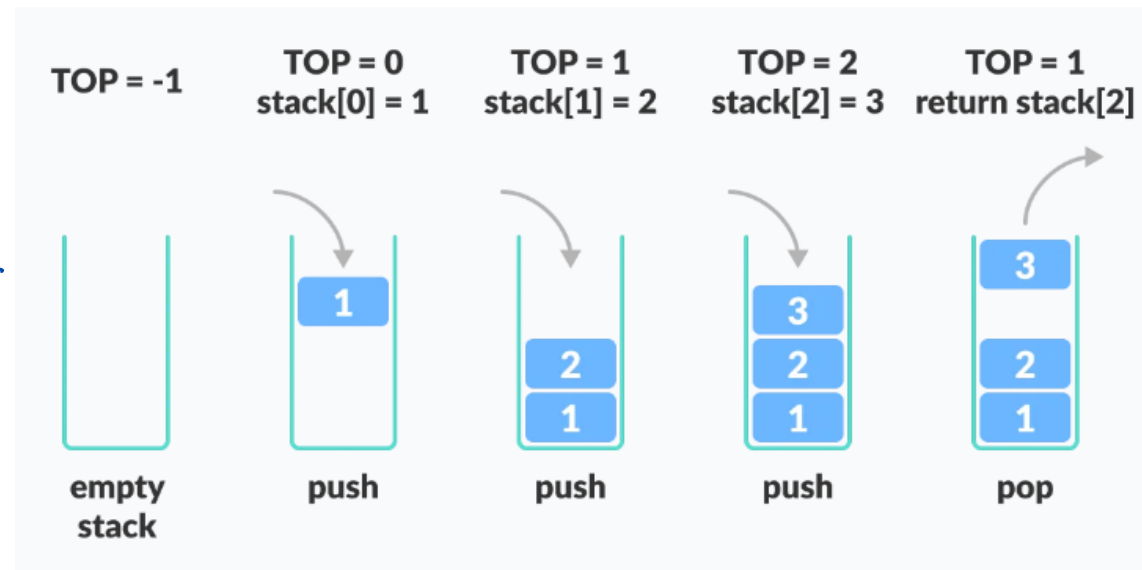
```
friends = ['Joseph', 'Glenn', 'Sally']  
  
print(len(friends)) #3  
  
print(list(range(len(friends))))  
  
#[0,1,2]
```

Example: Loops in List

```
friends = ['Joseph', 'Glenn', 'Sally']  
  
#Both loops do the same.  
  
for friend in friends :  
    print('Happy New Year:', friend)  
  
for i in range(len(friends)) :  
    friend = friends[i]  
    print('Happy New Year:', friend)
```


Stack (as a list)

- Collection of elements that follows the LIFO (Last In, First Out) principle
- Last element added is the first one to be removed
- Main Operations:
 - push: adds an element to the top of the stack
 - pop: removes and returns the element at the top of the stack
 - peek: returns the element at the top of the stack without removing it
 - is_empty: checks if the stack is empty
 - size: returns the number of elements in the stack



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Example: Stack

```
# Initialize an empty stack
stack = []

# Push operation: Add elements to the top of the stack
stack.append(1)  # Stack: [1]

stack.append(2)  # Stack: [1, 2]

stack.append(3)  # Stack: [1, 2, 3]

# Pop operation: Remove and return the top element of the stack
top_element = stack.pop()  # Returns 3, Stack: [1, 2]

# Peek operation: Return the top element without removing it
top_element = stack[-1]  # Returns 2, Stack: [1, 2]

# Check if the stack is empty
is_empty = len(stack) == 0  # Returns False

# Get the size of the stack
stack_size = len(stack)  # Returns 2
```

Queue

- Collection of elements that follows the FIFO (First In, First Out) principle
- First element added is the first one to be removed
- Main Operations:
 - enqueue: adds an element to the end of the queue
 - dequeue: removes and returns the element at the front of the queue
 - front: returns the element at the front of the queue without removing it
 - is_empty: checks if the queue is empty
 - size: returns the number of elements in the queue
- Queue with List not efficient → Class deque



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Example: Queue

```
from collections import deque

# Initialize an empty queue

queue = deque()

# Enqueue operation: Add elements to the end of the queue

queue.append('Eric')      # Queue: ['Eric']

queue.append('John')      # Queue: ['Eric', 'John']

queue.append('Michael')  # Queue: ['Eric', 'John', 'Michael']

# Dequeue operation: Remove and return the element at the front of the queue

front_element = queue.popleft()  # Returns 'Eric', Queue: ['John', 'Michael']
```

Exercise

- Create a class “Stack” with the functionality of the Stack previously explained

#Example Usage

```
stack = Stack()
```

```
stack.push(1)
```

```
stack.push(2)
```

```
stack.push(3)
```

```
print(stack.pop()) # Output: 3
```

```
print(stack.peek()) # Output: 2
```

```
print(stack.is_empty()) # Output: False
```

```
print(stack.size()) # Output: 2
```

```
print(stack)
```

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Tuple

- Function much like a list with elements indexed starting at 0
- An **immutable** sequence of elements (similar to a string), typically used to store collections of heterogeneous data
- Main Operations:
 - Creation: can be created using parentheses () or without them
 - Access: elements can be accessed using indexing
 - Slicing: similar to lists, tuples support slicing
 - Unpacking: can be unpacked into individual variables

Example: Tuple

Creating tuples

```
tup1 = (1, 2, 3)
```

```
tup2 = "a", "b", "c"
```

```
tup3 = (1, "a", 3.14)
```

Accessing elements

```
first_element = tup1[0] # Returns 1
```

Slicing

```
sub_tuple = tup1[1:3] # Returns (2, 3)
```

Adding

```
print(tup1+tup2) # (1, 2, 3, 'a', 'b', 'c')
```


Tuple: Unpacking

- You can assign a tuple of values to a tuple of variables in one step (i.e., it can be on the left side)
- Parentheses are optional in some contexts
- Python can infer that you are working with a tuple from the context
- Swapping values: is a common pattern without needing a temporary variable

Example with ()

```
(x, y) = (4, 'maria')  
  
print(y)  # Output: maria
```

Example without ()

```
a, b = 99, 98  
  
print(a)  # Output: 99
```

Example swapping

```
x, y = y, x
```

Example: Tuple (NOT to do)

```
x = (1, 2, 3)
```

```
x.sort()      #Traceback:AttributeError:  'tuple' object has no attribute 'sort'
```

```
x.append(5)   #Traceback:AttributeError:  'tuple' object has no attribute 'append'
```

```
x.reverse()  #Traceback:AttributeError:  'tuple' object has no attribute 'reverse'
```

```
dir(x)  #['count', 'index']
```

```
x.index(2)  # Output: 1 (index of the first occurrence of 2 in the tuple x)
```

```
x.count(1)  # Output: 1 (the number 1 appears once)
```

Tuples more efficient

- Since tuples don't need to be modifiable, they are simpler in design and translates to better memory usage and performance
- When your program needs temporary variables, reach for tuples instead of lists. Their efficient nature will give your code a boost!

Tuples are comparable

- You can compare tuples and other sequences
- If the first item is equal, Python goes on to the next element, and so on, until it finds elements that differ

Example with numbers

```
(2, 3, 4) < (3, 3, 4) #True
```

```
(2, 3, 4000000) < (2, 4, 1) #True
```

Example with strings

```
('Anna', 'Bob') < ('Anna', 'Carol') #True
```

```
('Anna', 'Bob') > ('Alice', 'David') #False
```

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Set

- An unordered collection of unique elements
- Mutable, for an immutable version, you can use *frozenset*
- It supports mathematical operations like union, intersection, and difference
- Main Operations:
 - Creation: sets can be created using curly braces {} or the `set()` function
 - Add: add an element to the set using `add()`
 - Remove: remove an element from the set using `remove()` or `discard()`
 - Membership: check if an element is in the set using the *in* keyword
 - Set Operations: union, intersection, and difference using operators or methods

Example: Set

Creating sets

```
set1 = {1, 2, 3}
```

```
set2 = set([2, 3, 4])
```

Adding elements

```
set1.add(4) # set1 = {1, 2, 3, 4}
```

Removing elements

```
set1.remove(1) # set1 = {2, 3, 4}
```

Membership check

```
is_member = 2 in set1 # Returns True
```

Example: Set

```
# Set operations

#set1 = {2, 3, 4}    #set2 = set([2, 3, 4])

# union_set = set1.union(set2)

union_set = set1 | set2  # Returns {2, 3, 4}

intersection_set = set1 & set2  # Returns {2, 3, 4}

difference_set = set1 - set2  # Returns set()

# Creating an immutable frozenset

frozen_set = frozenset([1, 2, 3])

# Attempting to modify the frozenset will raise an error

# frozen_set.add(4)  # Raises AttributeError
```


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What is a Collection

- Allows storage of multiple values in a single variable
- Contains multiple elements accessed via an index or key
- Convenient for managing groups of related data
- Types of Collections
 - List: ordered collection of elements
 - Dictionary: unordered collection of key-value pairs
- What is NOT a Collection?
 - Variables generally hold one value at a time
 - Assigning a new value overwrites the previous value

Dictionaries

- Also known as Associative Arrays, provide fast, flexible database-like operations
- Indexed by unique keys instead of numeric positions
- Other names in other languages
 - Dictionaries – Python, Objective-C, Smalltalk, REALbasic
 - Hashes – Ruby, Perl,
 - Maps – C++, Java, Go, Clojure, Scala, OCaml, Haskell
 - Property Bag - C#

Example: Dictionary

#Initialize an empty dictionary

```
purse = {}
```

#Add key-value pairs

```
purse['money'] = 15
```

```
purse['candy'] = 5
```

```
purse['tissues'] = 75
```

```
print(purse) # Output: {'money': 15, 'candy': 5, 'tissues': 75}
```

#Modifying Dictionary Values. Access and update values using keys

```
print(purse['candy']) # Output: 5
```

```
purse['candy'] += 2
```

```
print(purse) # Output: {'money': 15, 'candy': 7, 'tissues': 75}
```

Missing Keys

- Accessing a non-existent key raises an error

example

```
c = {}  
  
# print(c['unknown']) # Raises KeyError  
  
print('unknown' in c) # Output: False
```

Counting with dictionaries

- Track occurrences of elements: `get()`
- Simplifies checking and updating dictionary entries

example

```
counts = {}

names = ['alice', 'bob', 'alice', 'eve', 'bob']

for name in names:

    counts[name] = counts.get(name, 0) + 1

print(counts)  # Output: {'alice': 2, 'bob': 2, 'eve': 1}
```

Example: Words Count

```
counts = {}

print('Enter a line of text:')

line = input()

words = line.split()

print('Words:', words)

print('Counting...')

for word in words:

    counts[word] = counts.get(word, 0) + 1

print('Counts:', counts)
```

Iterating

- Even if there is not order, we can iterate on dictionaries

example

```
counts = {'alice': 1, 'bob': 42, 'eve': 100}
```

```
for key in counts:
```

```
    print(key, counts[key])
```

```
# Output:
```

```
# alice 1
```

```
# bob 42
```

```
# eve 100
```


Retrieving Keys, Values, and Items

- Get lists of keys, values, or key-value pairs

example

```
dict1 = {'alice': 1, 'bob': 42, 'eve': 100}

print(list(dict1))  # Output: ['alice', 'bob', 'eve']

print(dict1.keys())  # Output: dict_keys(['alice', 'bob', 'eve'])

print(dict1.values())  # Output: dict_values([1, 42, 100])

print(dict1.items())  # Output: dict_items([('alice', 1), ('bob', 42), ('eve', 100)])
```

Example: Two iteration values. Loop through key-value pairs using two variables

```
jjj = {'alice': 1, 'bob': 42, 'eve': 100}
```

```
for key, value in jjj.items():
```

```
    print(key, value)
```

```
# Output:
```

```
# alice 1
```

```
# bob 42
```

```
# eve 100
```

Exercise

- Create a program that allows a teacher to input student names and their grades
 - Create an empty dictionary to store student names (keys) and their grades (values)
 - Write a loop that asks the user to input a student's name and grade. Add these to the dictionary. Continue until the user enters 'done'
 - Print out all student names and their grades
 - Calculate and print the average grade of the class
 - Find and print the name(s) of the student(s) with the highest grade

Summary

- List: $li = [1, 2, 3]$
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What is an Enum?

- An enumeration is a set of symbolic names (members) bound to unique, constant values
- Useful when you have a collection of related constant values like days of the week, states in a process, etc.
- Part of the standard library: (*from enum import Enum*)
- Introduced in Python 3.4
- Purpose: define named constants that can be compared and iterated over

Why use Enums?

- Code Readability: Enums make code more expressive
- Prevent Magic Numbers: No need to remember arbitrary values
- Safety: Enum members are immutable and unique
- Maintainability: Simplifies updates when constant values change

Example: Definition

```
from enum import Enum

class Weekday(Enum):

    MONDAY = 1

    TUESDAY = 2

    WEDNESDAY = 3

    THURSDAY = 4

    FRIDAY = 5
```

Example: Accessing

```
print(Weekday.MONDAY)
print(Weekday.MONDAY.name)
print(Weekday.MONDAY.value)

#Output: Weekday.MONDAY, 'MONDAY', 1
```


Iterating

Example:

```
for day in Weekday:  
    print(day)
```

```
#Output: Weekday.MONDAY, Weekday.TUESDAY...
```

Comparing

Example:

```
if Weekday.MONDAY == Weekday.TUESDAY:  
    print("Same day")  
else:  
    print("Different days")
```

Enums with Automatic Values

- Use `auto()` to automatically assign increasing values starting from 1

Example: Auto

```
from enum import Enum, auto

class Weekday(Enum):

    MONDAY = auto()

    TUESDAY = auto()

    WEDNESDAY = auto()

    THURSDAY = auto()

    FRIDAY = auto()
```

Useful Enum Methods

- Enum members can be accessed by name or value:

Example:

```
Weekday [ 'MONDAY' ]  
Weekday (1)
```

- You can get a dictionary of all enum member: `__members__`

Example:

```
print (Weekday.__members__)
```

Exercise

- Represent different states in a task management system
- Create a function that prints a message depending on the values
- For example:
 NOT_STARTED
 IN_PROGRESS
 COMPLETED
 BLOCKED
- Call: `print_task_status("Exam corrections", TaskStatus. NOT_STARTED)`
 #The task 'Exam corrections' has not started yet.

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Array

- An array is a collection of items stored at memory locations
- Python has an “array” library but it is not used much
 - `import array`
 - `array_name = array.array(typecode, [elements])`
- Instead, *numpy* library is used for creating and handling arrays
- Key Characteristics:
 - Fixed size
 - Homogeneous elements (all elements are of the same type)
 - Efficient numerical operations
- Let's study NumPy