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Intermediate-1

Hierarchy of languages (Up to down)

- High-level languages (Python, JavaScript, etc)
- Mid-level languages (C, C++, Java, etc)
- Assembly code
- Machine code (byte code)
  Going ↑ in hierarchy => code simplicity ↑ but execution time ↓

Interpreter vs Compiler

- **Compiler**: Convert entire code to byte code which later get executed by cpu
- **Interpreter**: Read and execute the code line by line

Python (About)

- Dynamically typed language
- Interpreted language
- Supports: First Class Citizens (FCC)

Data Types

- **Primitives (static) dtypes:** Bound to some memory limit (1-byte store max int value of 255)
- **FCC**: Not bound to any memory limit, can store as much as available RAM
- Anything with value is an object
-

Getting the type of any object	>> type(3) # `int`
`isinstance`(a,b) can tell whether a is the type of b or not?	>> instance(3, int) # `True`
Complex number are supported in python	>> a = 1 + 2j >> type(a) # `complex`

Arithmetic Operators

Addition	>> 1 + 2 # `3`
Subtraction	>> 1 - 2 # `-1`
Division	>> 10 / 2

	# 5.0
Floor division operator (largest integer less than the result)	>> -8 // 3 # -3
Exponentiation operator	>> 2 ** 10 # 1024
Modulus operator: **+ve number:** returns remainder after division **-ve numbers**: a % b => b - (a % b)	# for positive numbers >> 8 % 3 # 2 # for negative numbers >> -8 % 3 # -1

Identifiers

- Names that are given to variables
- Rules:
    - Should start with alphabet or _
    - Can contain alphanumeric symbol or _ in between

_ symbol in python automatically stores the value of last executed expression

Mutable/Immutable

- **Mutable**: Whose value can change
- **Immutable**: Whose value cant change
-

Mutable dtypes: list, set, dictionary

-

Getting address of memory of variable	>> id(a) # 11256224
Deleting memory location of a variable	>> del a

If-else

-

```
if condition2:
    print("do this")
elif condition2:
    print("or this")
else:
    print("else this")
```

Iteration protocol

- ***Iterable***: Data structrure with atomic elements which can be iterated.
- ***Iterator***: variable used to store those atomic elements.
- ***Iteration block***: Entire Body of the loop

Getting numbers from [a, b) - Can also define step_size as 3rd argument	>> range(a, b) `# a, a+1, a+2, ……, b-1` >> range(1, 10, 2) `# 1, 3, 5, 7, 9`
Converting iterable to iterator	>> a = “this is a string” >> iter_a = iter(a)
Getting next value of an iterator	>> next(iter_a) `# ‘t’`

Loops

for loop	`for i in range(1, 11):` `    print(“do this”)`
While loop	`while condition:` `    print(“do this”)`

Functions

Definition	`def function_name(arg1, arg2):` `    print(“do something”)` `    return “output”`
Calling function	`>> function_name(1, 2)` `# “output”`

Positional argument: value reaching argument positionally	`>> def x(a,b):` `     pass` `>> x(3,4)`

Keywords argument: values passing according to keys	`>> def x(a,b):` `       pass` `>> x(a=3, b=4)`

Data Structures

List:

- Heterogeneous collection of objects
-

Initializing list	`>> a = ["abc", 23, 45.8, True]`

-

indexing	>> a[0] # `“abc”`
Negative indexing	>> a[-1] # `True`
Size of list	>> len(a) # `4`
Slicing: [`start : end : jump`]	>> a[1:3] # `[23, 45.8]` >> a[-1 : 1 : -1] # `[True, 45.8]`
+ operator	>> [1,2,3] + [4,5] # `[1,2,3,4,5]`
* operator	>> [1,2,3] * 2 # `[1,2,3,1,2,3]`
Iteration over list	`for element in [1,2,3]:` `    print(element, end=” ”)` `# 1 2 3`
Appending element in the last	>> [1,2,3].append(4) # `[1,2,3,4]`
Extending list	>> [1,2,3].extend([4,5,6]) # `[1,2,3,4,5,6]`
Popping element using index	>> [1,2,3].pop(0) # `1` `# list now is: [2,3]`
Removing element using value	>> [1,2,3].remove(1) # `list now is: [2,3]`
Checking if some value present in list	>> 1 in [2,3,1]

	# True
List comprehension	>> [k*2 for k in range(2,6) if k < 5] # [4,6,8]

Tuples

Initializing	>> a = (1,2,3,4)
immutability	>> a[0] = 10 # Error
Packing/Unpacking - need exact amount of variables as elements in tuple - unpacking can be used with `list` but not packing	>> a, b, c = (2, 3, 4) >> print(a, b, c) # 2, 3, 4

Dictionaries

Initializing : { key = value } Only immutable data structures can be key	`d1 = {` `"name" : "Bipin",` `"age": 5000,` `"subject": ["python", "JS"]` `}`
Accessing key: - If key not exist then \`d[key]\` will through error while \`d.get(key)\` will return `None`	>> `d1["name"]` # “Bipin” >> `d1.get("name")` # “Bipin”
Deleting a key-value pair	>> `d1.pop("age")`
Updating dictionary: changing existing values of keys or adding more key-value pairs	`>> d= {"lang": "JS"}` `>> d.update({"lang": "Python", "awesomeness": float("inf")})` `>> print(d)` # `{'lang': 'Python', 'awesomeness': inf}`
Iterating over dictionary	# iterating over keys `for key in d1:` `    print(key)` # iterating over values `for key in d1.values():` `    print(key)`

	# iterating over both keys and values `for key, value in d1.items():` `    print(key, value)`
Dictionary comprehension	>> `{i:i**2 for i in range(5)}` # `{0: 0, 1: 1, 2: 4, 3: 9, 4: 16, 5: 25}`

Sets

• unordered • non-indexable • mutable • stores unique values (repeated gets removed) • iterable • can only contain immutable data structures	>> `s1 = {1,2,3,3,3,4,4,5,5,}` `# s1 = {1,2,3,4,5}`
Adding values to set	>> s1.add(10)
Removing values from set	>> s1.remove(10)
Updating set	>> s1.update([1,2,3,6]) # `s1 = {1,2,3,4,5,6}`
Union	>> `s1 = {1,2}` >> `s2 = {1,3,4,5}` >> s1 | s2 # `{1,2,3,4,5}`
Intersection	>> `s1.intersection(s2)` `# {1}` `>> s1 & s2` `# {1}`
Difference	`>> s1.difference(s2)` # `{2}` `>> s1 - s2` `# {2}`
Symmetric difference	`>> s1.symmetric_difference(s2)` # `{2,3,4,5}` `>> s1 ^ s2` `# {2,3,4,5}`

Strings

Initializing: ***Whitespaces are preserved in string with ''''***	`>> s1 = "This is a string"` `>> s2 = 'this is a string'` `>> s3 = '''  this is a string  '''` `>> s = "python"`
Getting index of character	`>> s.index('t')` `# 2`
Captilizing all the characters	`>> s.upper()` `# "PYTHON"`
Lowercasing all characters	`>> s.lower()` `# "python"`
Title case	`>> s.title()` `# "Python"`
whether a string starts with a particular string or not	`>> s.startswith("THE")` `# False`
Splitting string into list via some `delimiter` character.	`>>s = "this is a string"` `>>s.split(" ")` `# ["this", "is", "a", "string"]`
Joining list element into a string via some joining character	`>> "-".join(s.split(" "))` `# "this-is-a-string"`
Combining strings	`>> age = 20` `>> "age = {}".format(age)` `# "age = 20"` `# using f-strings` `>> f"age = {age}"` `# "age = 20"`

Searching

Linear Search

Linear Search: Going to each element one by one and comparing with target	`def linear_search_enum(li, target):` ` for idx, ele in enumerate(li):` `   if ele == target:`

Time complexity: O(N) Space Complexity: O(1) # `N`: length of list	`        return idx` `    return -1` `a = ["a", "b", "c"]` `linear_search(a, "c")` `# 2`

Binary Search

• Sort the array and keep the start and **end** pointer to the first and last element of array resp. • Find the **mid** element • Compare **target** with **mid** element • If target found then return the mid element, else adjust **start** and **end** Time complexity: O(logN) Space complexity: O(1)	`def binary_search(a, target):` ` start, end = 0, len(a)-1` ` while start <= end:` `   mid = (start + end)//2` `   if a[mid] == target:` `     return mid` `   elif a[mid] > target:` `     end = mid - 1` `   else:` `     start = mid + 1` ` return -1`

Time Complexity

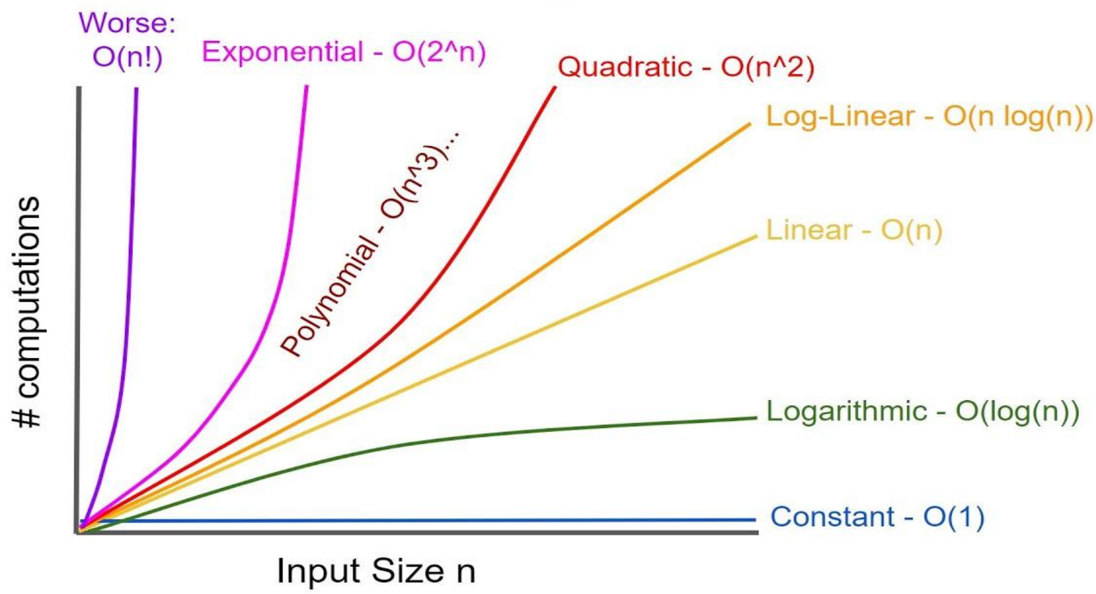
- Efficiency of algorithm evaluated using the count of CPU cycles.

Big O notation:

- Big O notation represents the worst time complexity trend of an algorithm.

Increasing order of Time complexity ↓(top => down)

O(1)	constant
O(logn)	logarithmic
O(n)	linear
O(nlogn)	Linear times logarithmic
$O(n^2)$	quadratic
$O(n^k)$	polynomial
$O(2^n)$	exponential
O(n!)	factorial



Sorting Algorithms

Bubble Sort

At each iteration the biggest element of the sub-array [0:n-i] , where n is the size of the array and i is the iteration number, will reach the last position.

Time complexity:
Worst: $O(n^2)$
Best: $O(n)$

```
def optimised_bubble_sort(a):
    counter = 0
    for i in range(len(a)-1):
        is_sorted = True
        for j in range(len(a)-i-1):
            counter += 1
            if a[j] > a[j+1]:
                a[j], a[j+1] = a[j+1], a[j]
                is_sorted = False
        if is_sorted == True:
            break
    print(counter)
    return a
```

Selection Sort

Loop the list and find the minimum and place it to the right position

Time complexity:
Worst: $O(n^2)$
Best: $O(n^2)$

```
def selection_sort(a):
    for i in range(len(a)-1):
        min_index = i
        for j in range(i+1, len(a)):
            if a[min_index] > a[j]:
                min_index = j
        if min_index != i:
            a[i], a[min_index] = a[min_index], a[i]
    return a
```

Insertion sort

- Start with the initial index = 1 and keep moving forward
- Left part is consider to be sorted and right is unsorted
- Pick the element from unsorted portion and put it into the right place at sorted portion

Worst case: $O(n^2)$
Best Case: $O(n)$

```
def insertion_sort(a):
    for i in range(1, len(a)):
        index_to_insert = i
        j = i - 1
        while j >= 0:
            if a[j] < a[index_to_insert]:
                break
            a[j], a[index_to_insert] = a[index_to_insert], a[j]
```

	`` index_to_insert = j j -= 1 return a ```

Recursion

- Recursion means calling a function from within the function body
- Recursive function must have, body and a base condition
- It uses a special data structure stack which works on LIFO
- Each time the function call is made, it'll store all the relevant sequence of calls in the stack and pops out when a particular call is over.

Merge Sort

- Follows the Divide and Conquer approach
- Keep dividing the list into list of halves until each list contain only 1 element
- Start merging the list in sorted order

Time complexity: O(NlogN)

```
def merge_sort(a):
    # Base condition
    if len(a) <= 1:
        return a
    n = len(a)
    # Splitting Logic
    left = merge_sort(a[:n//2])
    right = merge_sort(a[n//2:])
    # Merging Logic
    i, j = 0, 0
    result = []
    while i < len(left) and j <
len(right):
        if left[i] <= right[j]:
            result.append(left[i])
            i += 1
        else:
            result.append(right[j])
            j += 1
    if i < len(left):
        result += left[i:]
    elif j < len(right):
        result += right[j:]
    return result
```

Combinatorics

- ${}^{n}P_{r}$: number of ways of r different things can be selected and arranged out of n different things

- ${}^{n}C_{r}$: number of ways of selecting r different things from n different things
- Total number of subsets of a set with n elements are 2^{n}.
- Number of ways of arranging n different things at n places: n!

$$^{n}P_{r} = \frac{n!}{(n-r)!}$$

$$^{n}C_{r} = \frac{n!}{(n-r)!r!}$$

$$^{n}C_{r} =^{n} C_{(n-r)}$$

$$^{n-1}C_{r-1} +^{n-1} C_{r} =^{n} C_{r}$$

-