NED University of Engineering & Technology

Department of Electrical Engineering

LAB MANUAL

Data Structures and Algorithms
(EE-264)

For

SE Electrical

Instructor name: _____

Student name: _____

Roll no: _____ **Batch:** _____

Semester: _____ **Year:** _____

LAB MANUAL

Data Structures and Algorithms (EE-264)

For

SE Electrical

Content Revision Team: Ms Aiman Najeeb, Dr Mirza Muhammad Ali Baig

Last Revision Date: 13th March 2023

Approved By

The Board of Studies of Department of Electrical Engineering

_____ _____

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_____ _____

To be filled by lab technician

Attendance: Present out of _____ Lab sessions

Attendance Percentage _____

To be filled by Lab Instructor

Lab Score Sheet

Roll No.	Rubric based Lab I	Rubric based Lab II	Rubric based Lab III	Rubric based Lab IV	Rubric based Lab V	Rubric based Lab VI	OEL/PBL Rubric Score A	Final LAB Rubric Score B	Attendance Percentage C	Final weighted Score for MIS System [10(A)+10(B)+5(C)]/25 Round to next higher multiple of 5

EE-264 DSA Rubric Based Labs: 3, 4, 5, 8, 9, 10

Note: All Rubric Scores must be in the next higher multiple of 5 for correct entry in MIS system.

S. No.	Date	Title of Experiment	Signature
1		Introduction to programming with *Python*	
2		Developing and executing algorithms using *Python*	
3		To analyze the efficiency of sorting algorithms	
4		To develop and apply the recursive divide and conquer approach in sorting	
5		Extending the divide-and-conquer approach on sorting and searching problems	
6		Apply Asymptotic Notations to the Sorting Algorithms.	
7		Introduction to object oriented programming.	
8		Develop a system which can perform basic banking related tasks	
9		To implement fundamental data structures in Python (using list) a) Stack b) Queue	
10		Using Node class, develop Stacks and Queue	
11		Accomplish the open-ended task: Using Node class, develop Singly connected linked-list	

Laboratory Session No. 01

Objective:

To get introduced with fundamentals of programming with Python

Outcomes:

By the end of this lab, student should be able to

a) **Correctly code algorithms in python which may include**
   1) **Loops**
   2) **Conditions**
   3) **Lists**
   4) **User defined functions**
   5) **Importing libraries to program**

1) Loops:

In ***Python***, *for* and *while* loops follows the following syntax.

WHILE LOOP:-

```
In [10]: a,b=0,1
         while b<1000:
             print (b)
             a,b=b,a+b
```

```
1
1
2
3
5
8
13
21
34
55
89
144
233
377
610
987
```

while loop in Python

FOR LOOP:-

```
In [1]: for i in range(0,10):
            print(i)
            print('Marwa Ashfaq\n')
```

```
0
Marwa Ashfaq

1
Marwa Ashfaq

2
Marwa Ashfaq

3
Marwa Ashfaq

4
Marwa Ashfaq

5
Marwa Ashfaq

6
Marwa Ashfaq

7
Marwa Ashfaq

8
Marwa Ashfaq

9
Marwa Ashfaq
```

---

for loop in Python

---

2) Conditions:

```
In [2]: a=int(input('please enter a value:'))

        please enter a value:100

In [3]: if a<12:
            print('value is less than 12')
        else:
            print('value is greater than 12')

        value is greater than 12
```

if-else condition in Python

3) Lists:

A list is created by placing all items in “square brackets []”.
Elements can be added/appended in a list as well.

```
In [1]: #Defining a list
        list=[0,1,2,3]

In [2]: list

Out[2]: [0, 1, 2, 3]

In [3]: #Adding elements in a list
        list=list + [4]

In [4]: list

Out[4]: [0, 1, 2, 3, 4]

In [12]: #Appending a list
         list.append(5)

In [11]: list

Out[11]: [0, 1, 2, 3, 4, 5]
```

list example

4) User defined Functions:

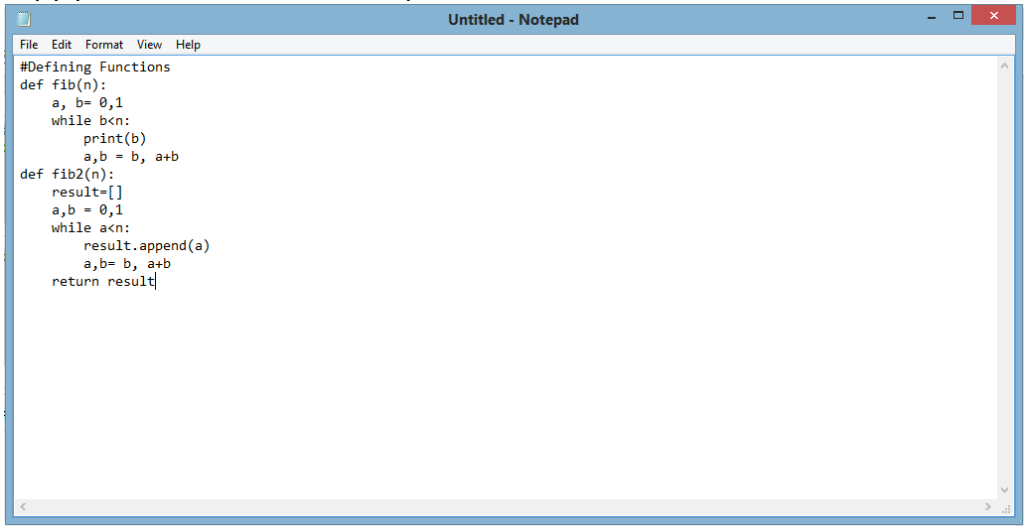
Functions in *Python* can be created by using the syntax shown below. A function is a block of code which only runs when it is called. Defining and calling a function are explained as follows:

```
In [1]: #Defining Functions
        def fib(n):
            a, b= 0,1
            while b<n:
                print(b)
                a,b = b, a+b

In [2]: def fib2(n):
            result=[]
            a,b = 0,1
            while a<n:
                result.append(a)
                a,b= b, a+b
            return result

In [3]: fib(100)

        1
        1
        2
        3
        5
        8
        13
        21
        34
        55
        89

In [4]: fib2(100)

Out[4]: [0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89]
```

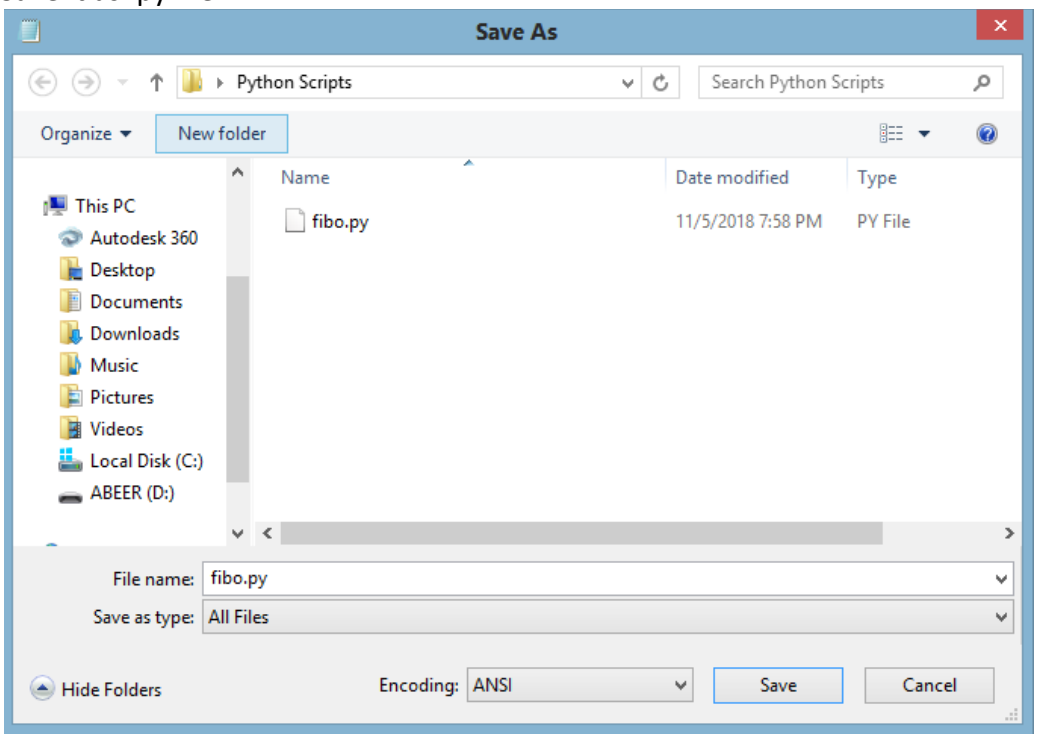
Working with functions in Python

Saving and Importing user-defined function to a program:

- Copy your desired code in notepad.



- Save it as .py file.



- Change its extension from.txt to .py.
- Import as follows:

```
In [2]: import fibo

In [3]: fibo.fib(100)
        1
        1
        2
        3
        5
        8
        13
        21
        34
        55
        89

In [4]: from fibo import fib2

In [5]: fib2(100)
Out[5]: [0, 1, 1, 2, 3, 5, 8, 13,

In [6]: from fibo import fib

In [7]: fib(100)
        1
        1
        2
        3
        5
        8
        13
        21
        34
        55
        89

In [8]: f=fib2(1000)

In [9]: f
Out[9]: [0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610, 987]
```

Calling user-defined function in Python

5) Importing libraries to program:

Python library is a collection of functions and methods that allows you to perform lots of actions without writing your own code. For importing libraries, the “import” command is used.
Once the library is imported, its different functions can be called. Following is an example which makes use of a library

```
In [1]: import math

In [2]: math.sqrt(121)
Out[2]: 11.0

In [4]: math.factorial(6)
Out[4]: 720

In [5]: math.acos(1)
Out[5]: 0.0

In [6]: math.asin(1)
Out[6]: 1.5707963267948966

In [8]: math.pi
Out[8]: 3.141592653589793
```

Making use of libraries in Python

Laboratory Session No. 02

Objective:

To developing and execute basic algorithms using Python

Outcomes:

By the end of this lab, student should be able to implement following exercises in *Python*

1) Write a program which could generate the following pattern. [hint: use 'end' option in pri nt command]

```
*
**
***
****
*****
******
*******
********
*********
**********
**********
*********
********
*******
******
*****
****
***
**
*
```

2) Write a program which can generate the following

Input a number: 10
10 x 1 = 10
10 x 2 = 20
10 x 3 = 30
10 x 4 = 40
10 x 5 = 50
10 x 6 = 60
10 x 7 = 70
10 x 8 = 80
10 x 9 = 90
10 x 10 = 100

3) Write a program to prompt for a score between 0.0 and 1.0. If the score is out of range, print an error message. If the score is between 0.0 and 1.0, print a grade using the following table:

>= 0.9 A
>= 0.8 B
>= 0.7 C
>= 0.6 D
< 0.6 F

Enter score: 0.95
A

Enter score: perfect
Bad score

Enter score: 10.0
Bad score
Enter score: 0.75
C

Enter score: 0.5
F

4) Re-write the above program using functions

5) Write a Python function to calculate the factorial of a number. [use recursive approach]

6) Write a function which can search for an entry in a list. Also show the entry count in the list.

7) Develop code in python for sorting a list using selection sort approach. In selection sort you find the minimum value first and place it at the end of the list.

Laboratory Session No. 03

Objective:

To analyze and evaluate experimentally the running time of

1) ***Selection Sort***
2) ***Bubble Sort***
3) ***Insertion Sort***

Special Instructions

1) **You are supposed to translate pseudocodes of the above mentioned codes in *Python*.**
2) **Show in tabulated form, the analytical expressions of computational times for the above algorithms based on RAM model**
3) **Now, evaluate the run time using *time* library functions**
4) **You would need to discuss the average run time of each algorithm for best and worst cases**

1. Selection Sort:

```
for i = 1 to A.length
        min_pos = i
        for j = i+1 to length_of_list
                if list[min_pos] > list[j]
                min_pos = j
        temp = list[i]
        list[i] = list[min_pos]
        list[min_pos] = temp
```

Pseudocode of Selection Sort

```
def Selection_Sort(M):
    for i in range(0,len(M)):
        min_pos=i
        for j in range (i+1,len(M)):
            if M[min_pos]> M[j]:
                min_pos=j
        temp=M[i]
        M[i]=M[min_pos]
        M[min_pos]=temp
    return(M)
Z=[10,12,6,89,43]
Selection_Sort(Z)
[6,10,12,43,89]


Out[2]:
      [6, 10, 12, 43, 89]
```

Python Code

Analysis of Selection Sort

	Pseudocode	Cost	Time (Worst)	Time (Best)
1	for i=1 to length_of_list	C_1	n+1	n+1
2	min_pos=i	C_2	n	n
3	for j=i+1 to length_of_list	C_3	$\sum_{j=1}^{n} j=\frac{n(n+1)}{2}$	$\sum_{j=1}^{n} j=\frac{n(n+1)}{2}$
4	if list[min_pos] > list[j]	C_4	$\sum_{j=1}^{n}(j-1)=\frac{n(n-1)}{2}$	$\sum_{j=1}^{n}(j-1)=\frac{n(n-1)}{2}$
5	min_pos = j	C_5	$\sum_{j=1}^{n}(j-1)=\frac{n(n-1)}{2}$	0
6	else	0	n	n
7	temp = list[i]	C_7	n	n
8	list[i] = list[min_pos]	C_8	n	n
9	list[min_pos] = temp	C_9	n	n
Analysis of Selection Sort				

Run time of Selection Sort

```
def Selection_Sort(M):
    for i in range(0,len(M)):
        min_pos=i
        for j in range (i+1,len(M)):
            if M[min_pos]> M[j]:
                min_pos=j
        temp=M[i]
        M[i]=M[min_pos]
        M[min_pos]=temp
    return(M)
Z=[10,12,6,89,43]
```

```
Selection_Sort(Z)
```

```
[6, 10, 12, 43, 89]
```

```
import time
a=time.time()
Selection_Sort(list(range(6000,1,-1)))
b=time.time()
c=b-a
print('run time=',c)
```

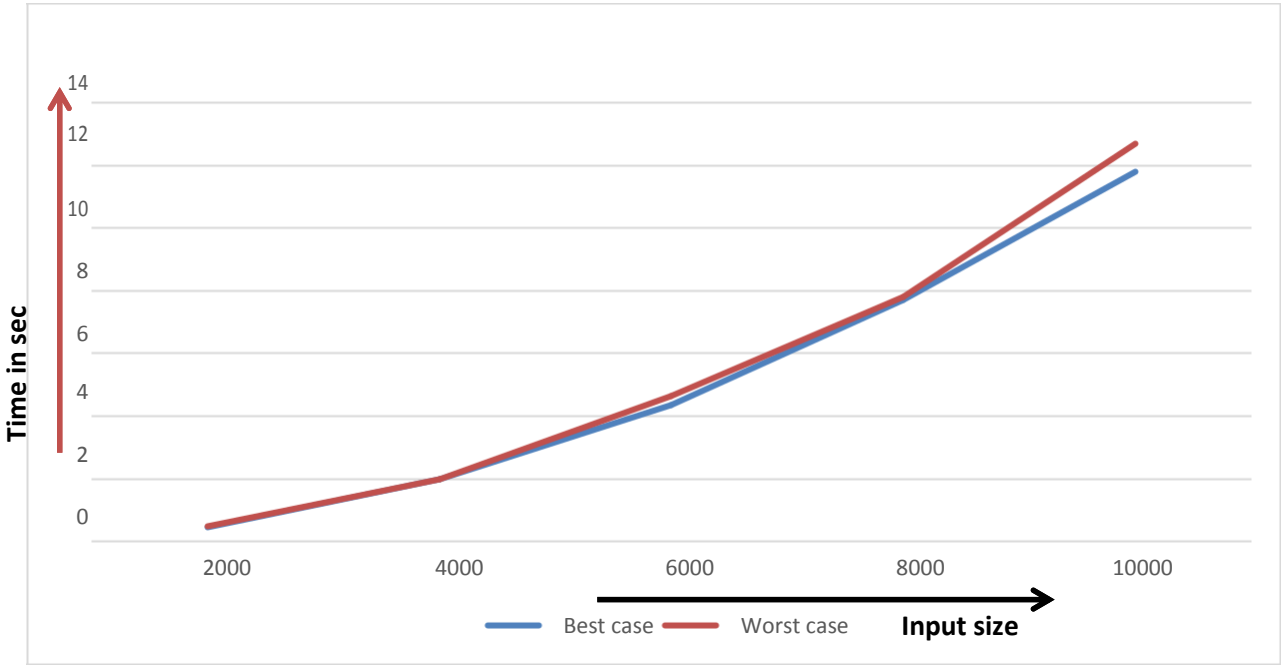
Python implementation for runtime assessment for a worst case

Tabulated run-time of Selection Sort:

After experimenting with the python code for five different sizes of inputs, following run-times were recorded.

S. No	Number of elements in array	Time of Best case(sec)	Time of worst case(sec)
1	2000	0.4653	0.4973
2	4000	1.9898	1.9856
3	6000	4.3554	4.6329
4	8000	7.7099	7.7937
5	10000	11.792	12.696

Growth Plot:



Note:

Student is supposed to repeat similar exercise, for *bubble* and *insertion sort* algorithms.

**keep in mind that your reading will depend on your computer's speed. The above tables and graphs are just for the verification of concepts*

NED University of Engineering & Technology
Department of Electrical Engineering

Course Code: **EE-264** Course Title: **Data Structures and Algorithms**

Laboratory Session No.: _____ Date: _____

Psychomotor Domain Assessment Rubric for Laboratory (Level P3)					
Skill(s) to be assessed	Extent of Achievement				
	0	1	2	3	4
Software Initialisation and Configuration: Set up and *recognise* software initialisation and configuration steps 10%	Completely unable to recognise initialisation and configuration 0	Able to recognise initialisation but could not configure 10	Able to recognise initialisation but configuration is erroneous 20	Able to recognise initialisation and configuration with minimal errors 30	Able to recognise initialisation and configuration with complete success 40
Input/Output Variable Recognition, Definition and Initialisation: *Recognise* and *perceive* correct input/output variables along with data types for testing a specific algorithm/data structure 15%	Incorrect perception for both Input/Output variables and data types 0	Correctly perceives the required Input/Output variables and data types but fails to initialise variables altogether 15	Correctly perceives the required Input/Output variables and data types and only initialises them partially 30	Correctly perceives the required Input/Output variables and data types and initialises them completely but with errors 45	Correctly perceives the required Input/Output variables and data types and initialises them with complete success 60
Procedural Programming of given Algorithm: *Practice* procedural programming techniques including recursion, in order to code specific algorithms from their pseudo code 15%	Little to no understanding of procedural programming techniques 0	Slight ability to use procedural programming techniques for coding given algorithm 15	Mostly correct recognition and application of procedural programming techniques but makes crucial errors for the given algorithm 30	Correctly recognises and uses procedural programming techniques with no errors but unable to run algorithm successfully 45	Correctly recognises and uses procedural programming techniques with no errors and runs algorithm successfully 60
Object Oriented Programming for given Algorithm and Data Structure Implementation: *Imitate* and *practice* given OOP instructions for making specific data structure/algorithm 15%	Incorrect selection and use of programming constructs and instructions 0	Correct selection of programming constructs and instructions but their use is incorrect 15	Correct selection and use of programming constructs and instructions with many syntax/semantic errors 30	Correct selection and use of programming constructs and instructions with little to no syntax/semantic errors 45	Correct selection and use of programming constructs and instructions with no syntax/semantic errors 60

Psychomotor Domain Assessment Rubric for Laboratory (Level P3)					
Skill(s) to be assessed	Extent of Achievement				
	0	1	2	3	4
Software Menu Identification and Usage: Ability to *operate* software environment *under supervision*, using menus, shortcuts, instructions etc. 15%	Unable to understand and use software menu 0	Little ability and understanding of software menu operation, makes many mistake 15	Moderate ability and understanding of software menu operation, makes lesser mistakes 30	Reasonable understanding of software menu operation, makes no major mistakes 45	Demonstrates command over software menu usage with frequent use of advance menu options 60
Detecting and Removing Errors/Exceptions: *Detect* Errors/Exceptions and *manipulate,* under supervision, to rectify the Code 10%	Unable to check and detect error messages in software 0	Able to find error messages in software but no understanding of detecting those errors and their types 10	Able to find error messages in software as well as understanding of detecting some of those errors and their types 20	Able to find error messages in software as well as understanding of detecting all of those errors and their types 30	Able to find error messages in software along with the understanding to detect and rectify them 40
Debugging and Troubleshooting: *Recognise and Practice* Debugging and Troubleshooting steps through line-by-line code execution 10%	Unable to recognise and use debugging options in software 0	Little ability to recognise and use debugging and troubleshooting options in software 10	Ability to recognise and use debugging and troubleshooting options with little ability to rectify code 20	Ability to recognise and use debugging and troubleshooting options with ability to rectify and step-through code 30	Ability to recognise, describe, and use debugging and troubleshooting with ability to rectify and step-through code 40
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Total Points (out of 400)	
Weighted CLO (Psychomotor Score)	(Points/4)
Remarks	
Instructor's Signature with Date	

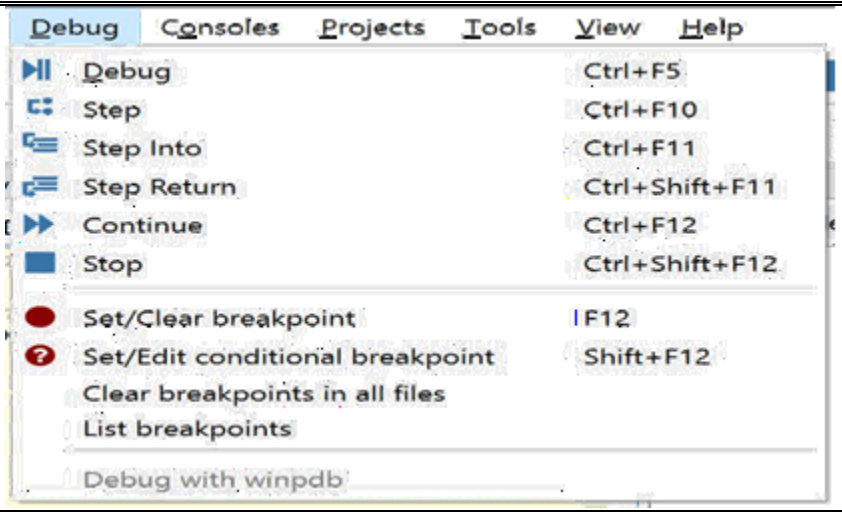
Laboratory Session No. 04

Objective:

To develop and apply the recursive divide and conquer approach in sorting (using debugging tools in Python)

Debugging:

Debugging is a process which involves identifying a problem, isolating the source of the problem and then either correcting the problem or determining a way to look around it. In debugging process, we run the program step-by-step and keep a look on the variables. To invoke the option for debugging in *spyder IDE* we take following steps:



Debugging tools in Spyder

Here, the *DEBUG* option, starts debugging. The *STEP* option, steps to next line of the code. The *STEP INTO* option, takes you inside the function's body. The *STEP RETURN* option, steps to return the function call. The *CONTINUE* option, continues with debugging mode. The *STOP* option, forces the current debugging to stop.

Merge-sort Algorithm:

Merge Sort is based on the approach of *Divide and Conquer*. It divides input array in two halves, calls itself for the two halves and then merges the two sorted halves. The merge() function is used for merging two halves.

Following is the python-code for mergesort algorithm :

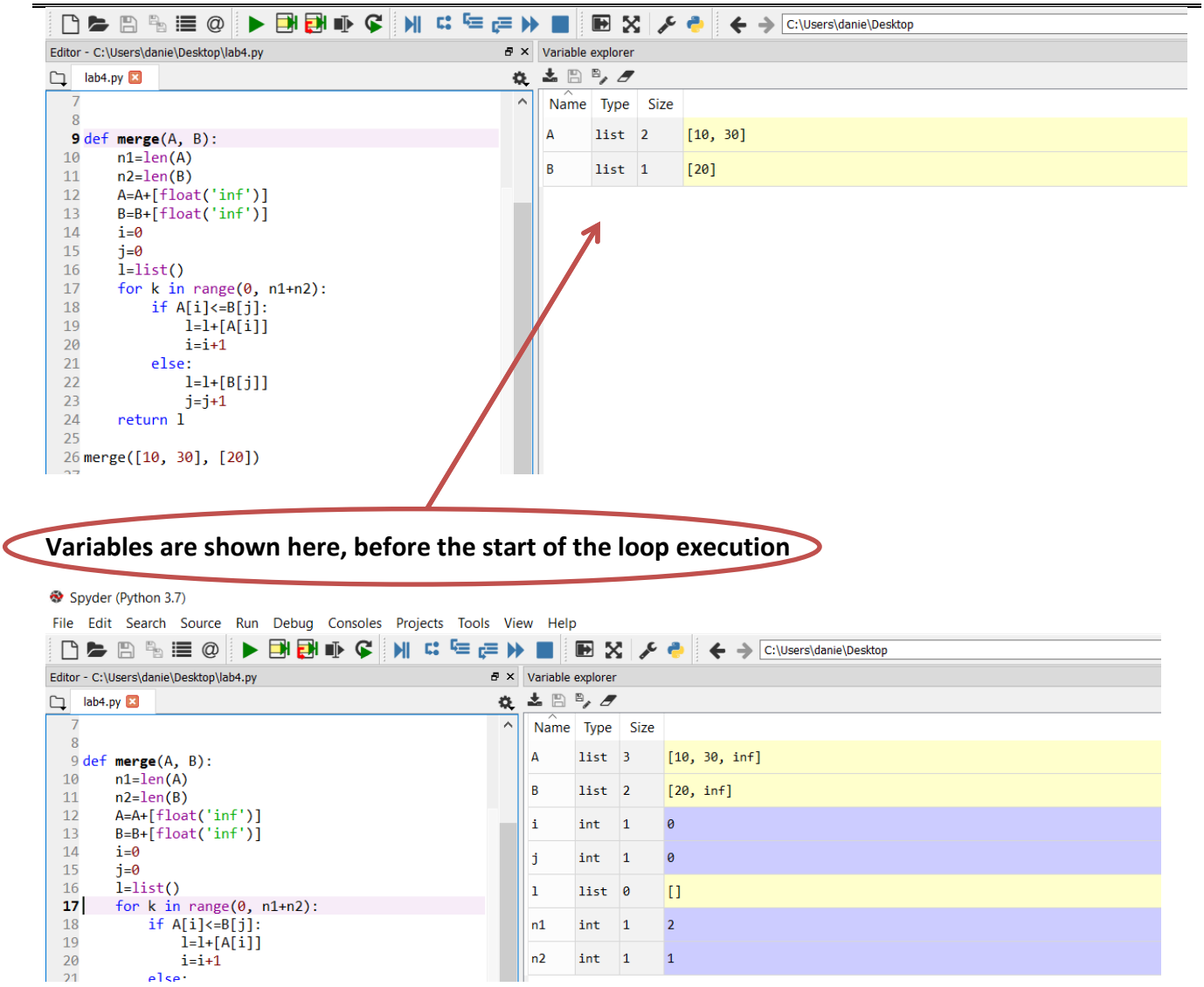
```
def MergeSort(A):
        n=len(A)
        s=list( )
        if n==1:
                s=A
        else:
                a=(n//2)
                s1=MergeSort(A[0:a])
                s2=MergeSort(A[a:n])
                s=merge(s1,s2)

def merge(A,B):
   n1=len(A)
   n2=len(B)
   A=A+[float('inf')]
   B=B+[float('inf')]
   i=0
   j=0
   l=list( )
   for k in range(0,n1+n2):
      if A[i]<=B[j]:
         l=l+[A[i]]
         i=i+1
      else:
         l=l+[B[j]]
         j=j+1
            return l
```

Megesort in Python

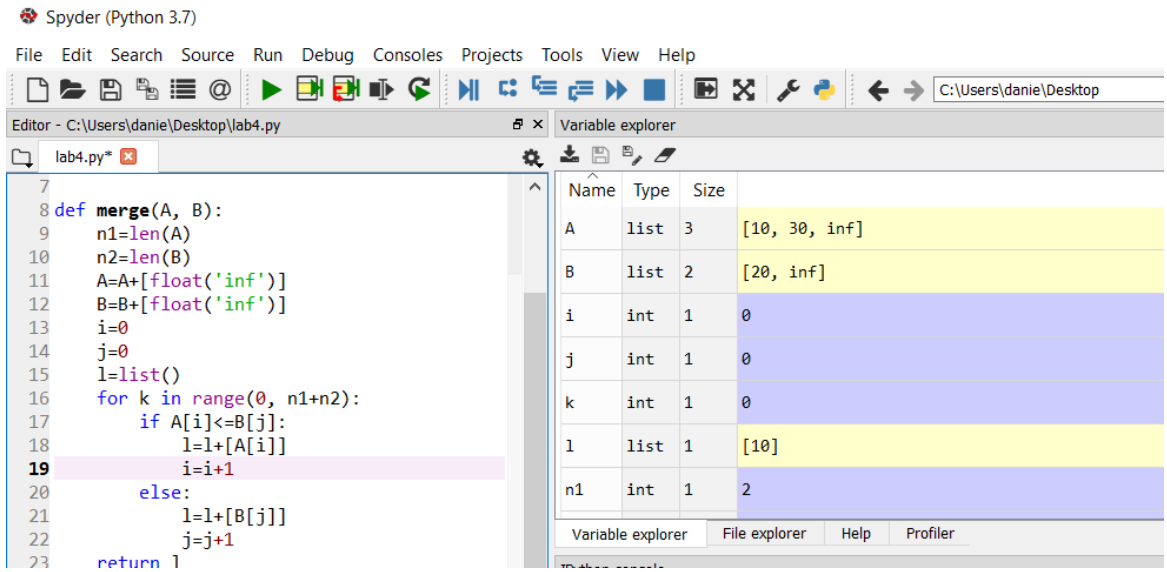
In the following section, we see how variables can be watched while running program in debugging mode.

In the following exercise, we see how we can merge two arrays of two and one elements through debugging mode.

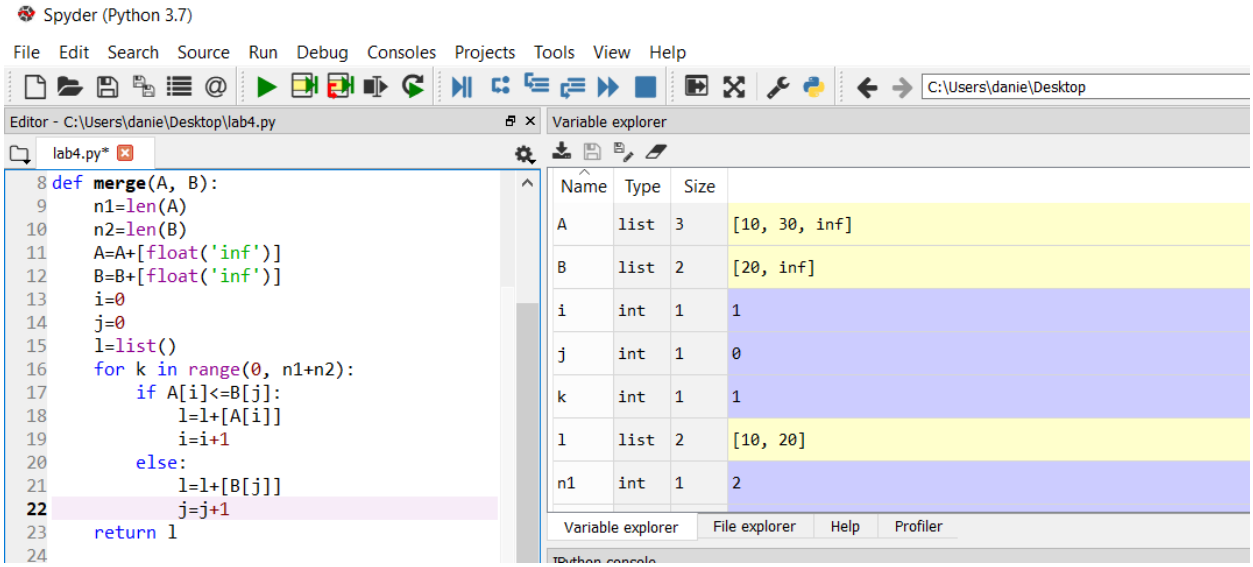


Running merge procedure in debugging mode

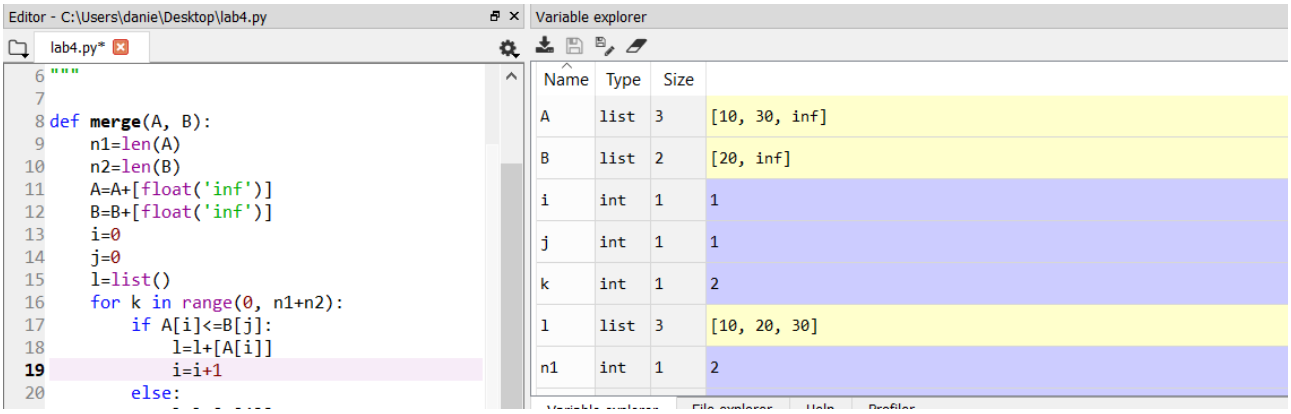
1st iteration of k:



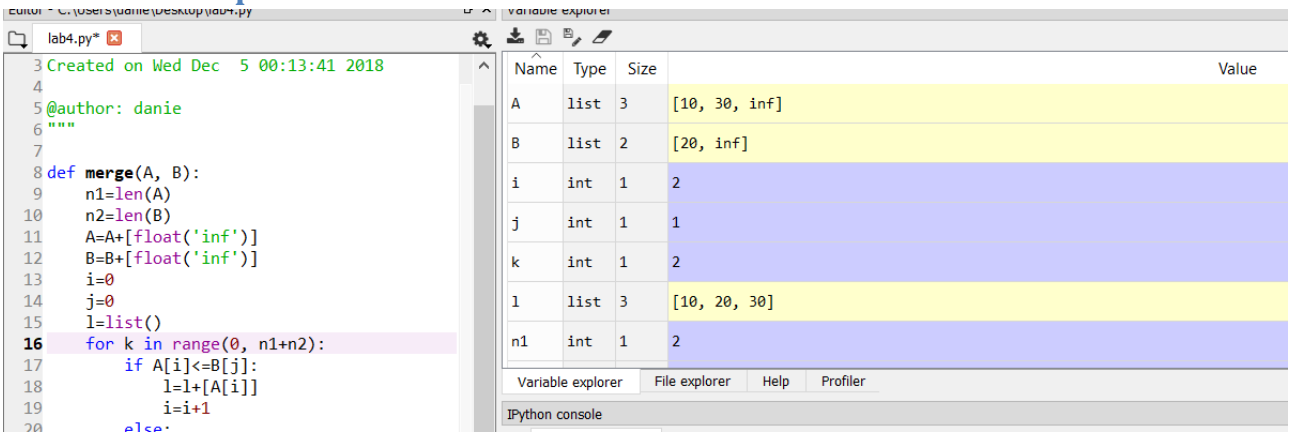
2nd iteration of k:



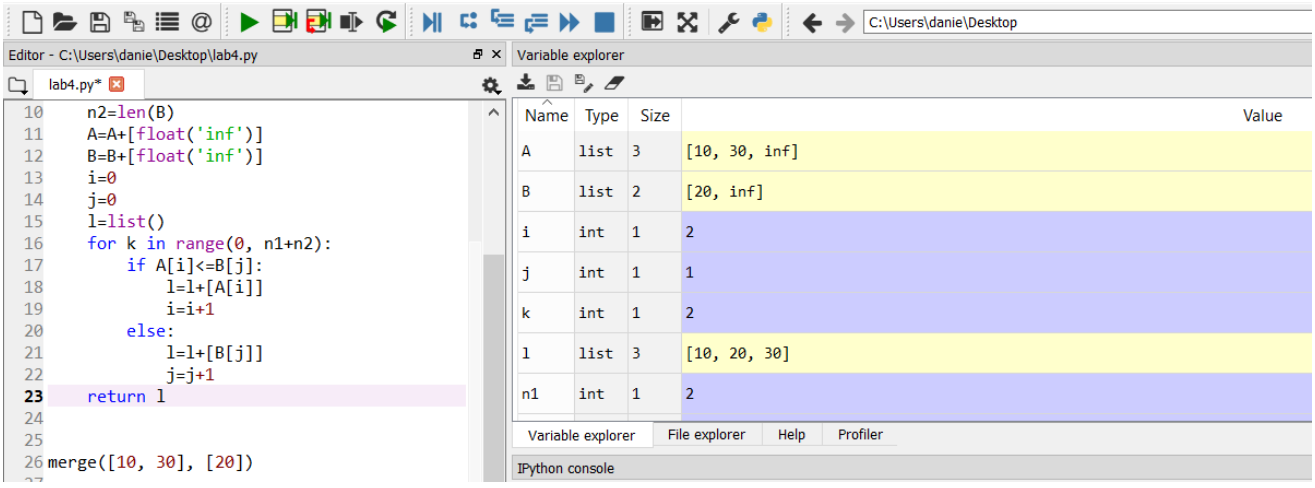
3rd iteration of k:



End of for...loop:



Sorted List returned:



Task:

There are going to be recursive calls in the *mergesort* procedure given above. Student is supposed to note the values of different variables during each recursive call and record their observations.

Further, student is supposed to compare the run-time of *mergesort* algorithm, with the sorting algorithms covered in lab session 03.

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Total Points (out of 400)	
Weighted CLO (Psychomotor Score)	(Points/4)
Remarks	
Instructor's Signature with Date	

Laboratory Session No. 05

Objective:

Extending the divide-and-conquer approach on sorting and searching problems

We first start with the analysis and experimental verification of the run-time of linear search algorithm. The linear search algorithm looks for an entry present in the array sequentially. In the second stage, we apply divide and conquer based approach for searching problem and compare the running time of both linear search and binary search analytically as well as empirically.

The linear search Algorithm

```
def linearsearch(x, key):
    count=0
    flag=0
    for i in range(len(x)):
        count=count+1
        if x[i]==key:
            flag=1
    return flag
```

Code of linear search algorithm in Python

Analysis of Linear Search (perform for best and worst cases)

	Pseudocode	frequency	Time
1	def linearsearch(x, y):		
2	count=0		
3	flag=0		
4	for i in range(len(x)):		
5	count=count+1		
6	if x[i]==y:		
7	flag=1		
8	return flag		

Code of linear search algorithm in Python

Best case

Worst case

Binary Search

Binary search is done on already sorted array. Program compares the value to be searched from the value present at the mid in the list. If value is lesser than value at mid in the list it looks for the value in the same way in the list on the left of mid. If value is larger than value at mid, it looks in the list on the right of mid. When the value is found it generates an output flag that value is found.

```
def bsearch(A, key):
        f_index=0
        l_index=len(A)-1
        flag=0
        while f_index<=l_index and flag==0:
                mid=(f_index+l_index)//2
                if A[mid]==key:
                        flag=1
                elif key<A[mid]:
                        l_index=mid-1
                else:
                        f_index=mid+1
        return flag
```

Code of binary search algorithm in Python

Analysis of Binary Search

	Pseudocode	Frequency	Time
1	def bsearch(A, key):		
2	f_index=0		
3	l_index=len(A)-1		
4	flag=0		
5	while f_index<=l_index and flag==0:		
6	mid=(f_index+l_index)//2		
7	if A[mid]==key:		
8	flag=1		
9	elif key<A[mid]:		
10	l_index=mid-1		
11	else:		
12	f_index=mid+1		
13	return flag		

Best case

Worst case

Compare the running times of linear search and binary search

Task:

Student is supposed to implement both searching algorithms and test them for different sizes of inputs. To summaries the observations, growth plots should be made.

NED University of Engineering & Technology
Department of Electrical Engineering

Course Code: **EE-264** Course Title: **Data Structures and Algorithms**

Laboratory Session No.: _____ Date: _____

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Remarks	
Instructor's Signature with Date	

Laboratory Session No. 06

Objective:

Apply Asymptotic Notations to the Sorting Algorithms.

Θ Notation:

The theta notation bounds a function from above and below, so it defines exact asymptotic behavior.
A simple way to get theta notation of an expression is to drop low order terms and ignore leading constants.

For a given function g(n), we denote Θ(g(n)) is following set of functions.

Θ(g(n)) = {f(n): there exist positive constants c1, c2 and n0 such
that 0 <= c1*g(n) <= f(n) <= c2*g(n) for all n >= n0}

The above definition means, if f(n) is theta of g(n), then the value f(n) is always between c1*g(n) and c2*g(n) for large values of n (n >= n0). The definition of theta also requires that f(n) must be non-negative for values of n greater than n0.

Θ Notation for Insertion Sort:

In order to apply theta notation for insertion sort we have to bound the time T(n) graph of insertion sort between two graphs of the same nature that of T(n) but with different constant terms C_1 and C_2 . The analysis is given by:

S.no	n	T(n)	$T(n)/n^2$	C_1n^2	C_2n^2
1	1000	0.06	**C_1=0.000000056**	0.056	0.064
2	5000	1.57	0.00000006	1.5	1.625
3	10000	6.37	0.00000006	6	6.5
4	15000	14.32	0.00000006	13.5	14.62
5	20000	25.5	**C_2=0.000000976**	24.4	26.5

Tabulation of Upper and lower bound asymptotes

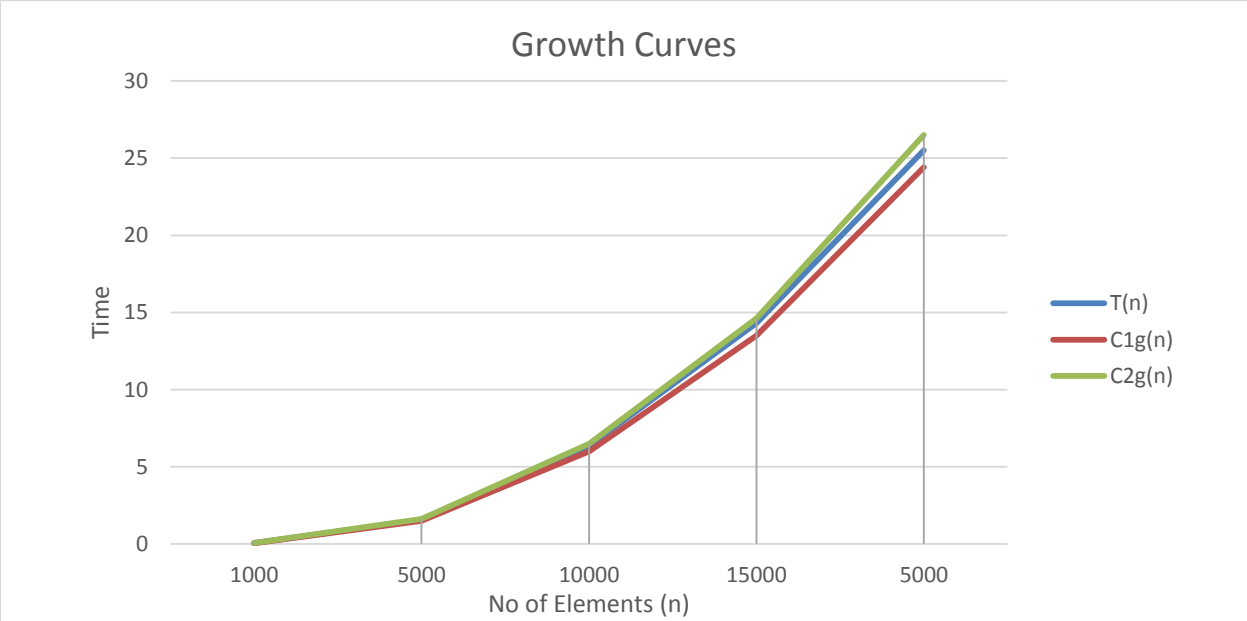
Here n = no of elements

T(n) = Time Complexity

C_1n^2 = Lower Bound

C_2n^2 = Upper Bound

Growth Curves with Asymptotes



Θ Notation for Merge Sort:

In order to apply theta notation for merge sort we have to bound the time T(n) graph of merge sort between two graphs of the same nature that of T(n) but with different constant terms C_1 and C_2 . The analysis is given by:

n	T(n)	T(n)/nlogn	C_1(nLogn)	C_2(nlogn)
1000	0.008	C_1=7.80E-07	0.007773	0.008272
5000	0.05	7.90E-07	0.048536	0.051608
10000	0.1152	C_2=8.22E-07	0.109225	0.118261
15000	0.1761	8.10E-07	0.168553	0.181038
20000	0.2477	8.20E-07	0.234318	0.25375

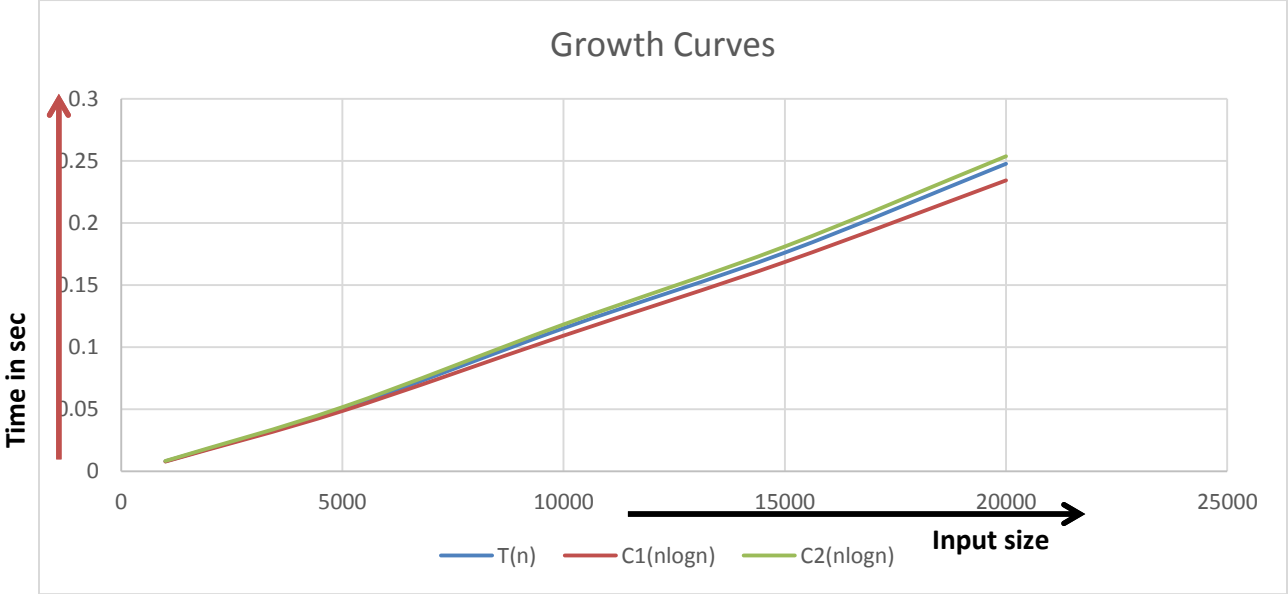
Tabulation of Upper and lower bound asymptotes

Here n = no of elements

T(n) = Time Complexity

C_1nlogn = Lower Bound

C_2nlogn = Upper Bound



**keep in mind that your reading will depend on your computer's speed. The above tables and graphs are just for the verification of concepts*

Laboratory Session No. 07

Objective:

Introduction to object oriented programming (OOP), creating classes and objects

SIGNIFICANCE of OOP:

Object-oriented programming is often the most natural approach, once we get the hang of it. OOP languages allow us to break down our software into bite-sized problems that we then can solve — one object at a time. This isn't to say that OOP is the One True Way. However, the advantages of object-oriented programming are many. When you need to solve complex programming challenges and want to add code tools to your skill set, OOP is your friend and has much greater longevity and utility. The concept of data classes allows a programmer to create any new data type that is not already defined in the language itself. The concept of a data class makes it possible to define subclasses of data objects that share some or all of the main class characteristics called inheritance, this property of OOP forces a more thorough data analysis, reduces development time, and ensures more accurate coding.

CONCEPT OF CLASS AND OBJECT:

A *class* is a template or set of instructions to build a specific type of object. Every object is built from a class. Each class should be designed and programmed to accomplish one, and only one, thing. An object's properties are what it knows and its methods are what it can do.

2) CLASSES IN PYTHON:

We can use classes in python in order to save data. We can also access or call the data from different operation when needed.

```
In [4]: class Student():
            '''A student with name, roll number and CGPA'''
            pass

In [7]: t=Student()

In [8]: type (t)
Out[8]: __main__.Student
```

Class creation in Python

In the above the making of a general class is shown. Now we are going to use data in the class. The following shows the calling and saving of the data.

```
In [9]: t.name='Subhan'

In [10]: t.roll=156

In [11]: t.cgpa=3.0

In [13]: t.name,t.roll,t.cgpa
Out[13]: ('Subhan', 156, 3.0)
```

Assigning attributes

3) USE OF __init__ FUNCTION IN PYTHON:

When a new instance of a python class is created, it is the __init__ method which is called and proves to be a very good place where we can modify the object after it has been created. There is no explicit variable declaration in Python. They spring into action on the first assignment. The use of self makes it easier to distinguish between instance attributes from local variables. Normal attributes are introduced in the __init__ method, but some attributes of a class hold for *all* instances in all cases. Following example can be used to understand __init__ and self construct:

```
In [14]: class Student():
             def __init__(Student, nam, cgp, rol):
                 Student.name = nam
                 Student.cgpa = cgp
                 Student.roll = rol
             def name_print(Student):
                 '''Print the name of the student.'''
                 print("The name assigned is",self.name)
             def cgpa_print(Student):
                 '''Print the name of the student.'''
                 print("The cgpa of",self.name, 'is', Student.cgpa)
             def all_print(Student):
                 '''Print the name of the student.'''
                 print(Student.name, 'has roll #',Student.roll,'and cgpa equals to', Student.cgpa)
```

inint function usage

Now after using the constructor the making and calling of the data become easier.

```
In [15]: a=Student('Subhan',3.0,156)
         b= Student('Humayun',4.0,150)
         c = Student('Osama',2.5,140)
         d = Student('Bilal',2.8,167)

In [16]: b.all_print()

         Humayun has roll # 150 and cgpa equals to 4.0

In [17]: a.all_print()

         Subhan has roll # 156 and cgpa equals to 3.0
```

Creating objects with attributes

LAB SESSION 08

OBJECTIVE: To apply the Object-Oriented Programming in Python for solution of real-life examples by creating class with appropriate attributes and methods

INTRODUCTION: In the last lab, you have been introduced to the concept of Object-Oriented Programming (OOP). Creating objects using the defined classes have been practiced. In this lab, you will practice it further by creating classes with the required attributes and adding methods to model behaviors.

Creating a list of Objects in Python class

We can create a list of objects in Python by appending class instances to the list. By this, every index in the list can point to a certain instance, through which the attributes and methods become easily accessible.

Consider the following code. A class named **geeks** is defined with attributes **name** and **roll.** Then an empty list is created **list.** Different objects are created using the class for example **geeks('Adil',2))** and this is appended to the list using the append method. After adding 4 elements to the list, a for loop is used to print attributed of each one by one. Understand and observe the syntax and try such an example.

```
# Python3 code here creating class
#Reference: https://www.geeksforgeeks.org/
class geeks:
    def __init__(self, name, roll):
        self.name = name
        self.roll = roll

# creating list
list = []

# appending instances to list
list.append(geeks('Adil', 2))
list.append(geeks('Dawood', 40))
list.append(geeks('Rayan', 44))
list.append(geeks('Ali', 67))

# Accessing object value using a for loop
for i in list:
    print(i.name, i.roll)

# Accessing individual elements
print(list[0].name)
print(list[1].name)
print (list[2].name)
print(list[3].name)
```

Task 1: To model the Weather conditions of a city

Create a class named *Weather.* The class has 4 attributes:

- City Name
- Humidity Level
- Temperature (in Centigrade)
- Atmospheric Pressure

The class should have following methods or behaviors:

- Convert and print the temperature in Fahrenheit
- Print all Weather Conditions
- Advice: If the temperature is above 40C, display a warning message and suggest precautions.

Create 3 objects using the class (for 3 different cities), and test the methods. Show your codes and results.

Task 2: To develop a system which can perform following basic banking related tasks

- Customer account could be created with name, NIC, account number and initial balance. All such attributes should be placed in a class.
- Balance of any customer could be updated
- Customer data could be sorted name-wise and balance-wise (any previously used sorting procedure may be applied).

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Laboratory Session No. 09

Objective:

To implement fundamental data structures in Python (using list)

Note:

Using *list* in python, implement the following

a) **Stacks(push and pop operations)**
b) **Queues(enqueue and dequeuer operations)**
c) **A dynamic set 'S' having following functionalities**
    a. **Search (S, key)**
    b. **Insert (an object)**
    c. **Delete (an object)**
    d. **Minimum(S)**
    e. **Maximum(S)**

a) Stacks (push and pop operations):

Stack is a linear data structure which follows a particular order in which the operations are performed. The order may be LIFO (Last in First Out) or FILO (First in Last Out). The code of the stack is given below for push and pop operations.

Implementation in Python

```
class stack():
    def __init__(self):
        self.stack=list()
    def push(self,data):
        self.stack.insert(0,data)
    def pop(self):
        print(self.stack[0])
        self.stack.remove(self.stack[0])
```

Python code for class *STACK*

b) Queues (enqueue and dequeuer operations):

A Queue is a linear structure which follows a particular order in which the operations are performed. The order is First-In-First-Out (FIFO). A good example of a queue is any queue of consumers for a resource where the consumer that came first is served first. The difference between stacks and queues is in removing. In a stack we remove the item the most recently added; in a queue, we remove the item the least recently added. The code of queue is given under

Implementation in Python

```
class queue():

    def __init__(self):

        self.queue=list()

    def enqueue(self,data):

        self.queue.insert(0,data)

    def dequeue(self):

        n=len(self.queue)

        print(self.queue[n-1])

        self.queue.remove(self.queue[n-1])
```

Python code for *QUEUE*

c) A dynamic Set

Dynamic set may refer to: A set (abstract data type) that supports insertion and/or deletion of elements. This data structure is frequently used in database access. The code for various performing operation of the dynamic set is provided below

Implementation in Python

```
class ds():
    l=list()
    def add(self,data):
        ds.l.append(data)
        print(ds.l)
    def delete(self,data):
        ds.l.remove(data)
        print(ds.l)
    def search(self,key):
        flag=0
        for i in range(len(ds.l)):
            if ds.l[i]==key:
                flag=1
        return flag
    def min(self):
        for j in range(1,len(ds.l)):
            key=ds.l[j]
            i=j-1
            while i>-1 and ds.l[i]>key:
                ds.l[i+1]=ds.l[i]
                i=i-1
            ds.l[i+1]=key
        print(ds.l[0])
    def max(self):
        n=len(ds.l)
        for j in range(1,len(ds.l)):
            key=ds.l[j]
            i=j-1
```

```
        while i>-1 and ds.l[i]>key:
            ds.l[i+1]=ds.l[i]
            i=i-1
            ds.l[i+1]=key
    print(ds.l[n-1])
```

Python code for *DYNAMIC SET*

Note:

Student is now supposed to create objects and perform relevant tasks using those objects for the above classes.

NED University of Engineering & Technology
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LAB SESSION 10

OBJECTIVE: To develop Stack and Queues data structures in Python using Node class.

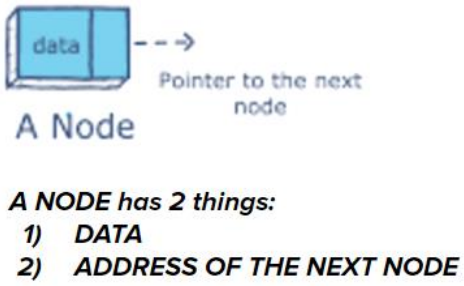
INTRODUCTION:

There are situations when the allocation of memory to store the data cannot be in a continuous block of memory (as done in arrays-static data structure). Dynamic data structures like linked lists allow us to store elements anywhere in the memory, but they are linked together by knowing their addresses. We take help of **nodes** where the along with the **data**, the **address of the next location of data element** is also stored. So, we know the address of the next node from the current node. (In Python we call these nodes)

Nodes are the foundations on which various other data structures linked-lists and trees can be handled in Python. In this lab, you will do dynamic implementation of the Stack and Queues data structures using Nodes.

NODE CLASS:

The implementation of Node is itself done using a class. The nodes are created by implementing a class which will hold the address of the next node along with the data element.



Example: A class named ***daynames*** to hold the name of the weekdays. The ***nextval*** is initialized to **null**. Four nodes and instantiated with values as shown. The ***nextval*** attribute of node e1 points to e3 while the ***nextval*** of node e3 points to e2 for the required connection. To verify you can print the reference or name of a node, for example print(e1). You will get a number in Hexadecimal which is neither the value of *data* nor the *nextval* of e1. This in fact represents the address of the node e1 itself. ***To get the address of any node, we will be using the name of node.***

```
#NODE CLASS
class daynames:
    def __init__(self, dataval=None):
        self.dataval = dataval
        self.nextval = None

#CREATING NODES USING NODE CLASS
e1 = daynames('Mon')# the node e1 has data "Mon", since the node is
independent for now, (not connected to any next node, so by default, the
nextval (or address field is None)

e2 = daynames('Wed')
e3 = daynames('Tue')
e4 = daynames('Thu')

#HOW TO GET NODE'S ADDRESS ?

print(e1) #to verify that e1 gives address of the node e1)

#CONNECTING NODES (ESTABLISH LINKS)
e1.nextval = e3 #connecting e1 with e3 , so Tue comes after Mon
e3.nextval = e2 #connecting e3 with e2
e2.nextval = e4 # connecting e2 with e4


# ACCESSING ALL NODES ONE BY ONE
thisvalue = e1 #address of the starting node
while thisvalue != None:
#thisvalue becomes null for the last node so loop terminates
        print(thisvalue.dataval)
        thisvalue = thisvalue.nextval
        #print(thisvalue)
```

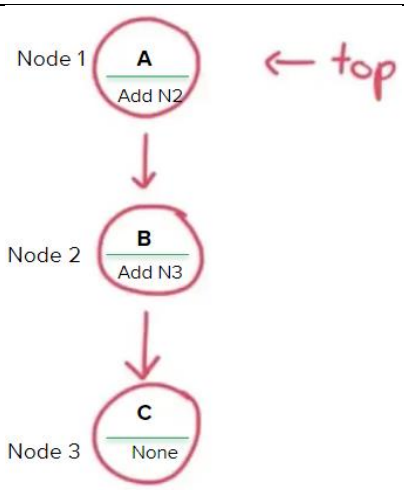
Stack Implementation in Python using Node Class:

Here, instead of using Python list or array, the elements of stack will be stored in individual nodes. Therefore, Node class must be defined first. After that a separate class Stack is needed which uses Node ( ) class for creation of nodes and storing stack elements. The approach is described step-by-step. This is to be used for the code given in Task 1.

1. **Create a Node Class**

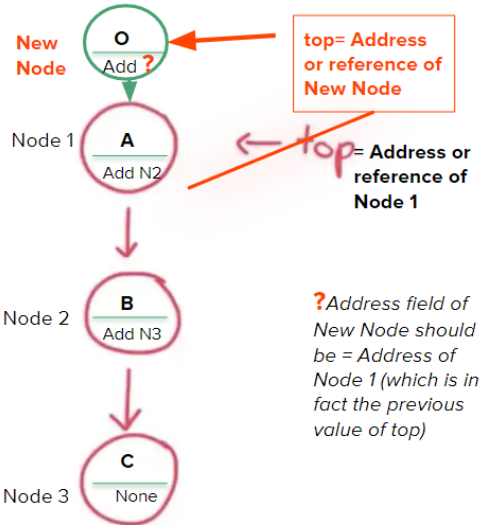
   The required attributes are **data** and **next**.

2. **Create a Class Stack** (to define a new DS stack, create a class)
   Add an Attribute (only 1) - TOP or HEAD (points to address of the top-most element of stack)
   For our Stack implementation, we need one reference object called top (representing the top of the stack). This will allow us to pop and push from the top of the stack.



3. Add a method Push (Add an item to stack)
   - Create a NODE (with data that is to be pushed in Stack)
   - Store previous or existing TOP to the address field of new node
   - Update TOP (with address of the new node)

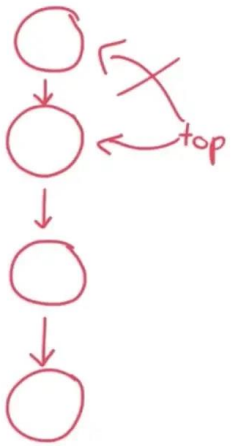
   To push a Node on top of the Stack, first we must create a new node new_data = Node(data). We then check to see if a top node exists, if not the new node becomes the top Node. If the top node does exist, the new node will point to the old top value *new_data.next = self.top* and then we refer to the new node as the top value *self.top = new_data*.



4. Add a method **Pop** (Remove an item from the stack)

- Data of the top most node (indicated by the TOP) is needed
- Update the stack's TOP (the next node now becomes top of the stack, so TOP will be updated by address of next node, that was already stored in the previous top node's address field)

  To pop a node from the top of a Stack, first you want to return the old head's data, so first we need to get that data
  data = self.top.data. Then top should be moved and pointed to the next element down top = top.next.
  Then we just need to return that data return data



Task 1: The code for Stack implementation using node class is given in the next slide. Complete the functionality of **Pop ( ), isEmpty( ) and Peek( ) methods.**

Test the stack DS by creating a stack object and verify the relevant methods. Push, pop, isempty and peek (like the last lab).

```
class Node:

    def __init__(self, data):

        self.data = data

        self.next = None

class Stack:

    def __init__(self): #top or Head is the only attribute needed to keep track of stack's recently created node

        self.top = None     #initially the stack is empty so head is None

    def push(self, data):  #adding an item to stack

        if self.top is None: #just create a node, and make head of stack = nodes address

            self.top= Node(data)

        else: #if the stack is not empty

            new_node = Node(data) #create a node

            new_node.next = self.top #connect the newly created node to the node present in stack (i.e. = top or head of stack)

            self.top = new_node #update head of stack with the address of newly created node

    def pop(self): #removing an item from stack

        if self.top is None: #if stack is empty (return none)

            return None

        else:  #stack is not empty

            # Complete this method for pop

    def isempty(self): #complete the method (return true if stack is empty)

    def peek(self): #complete the method (return top most element's data without updating stack)
```

TASK 2: STRING REVERSAL USING STACK

Consider a string, "BALLOON"

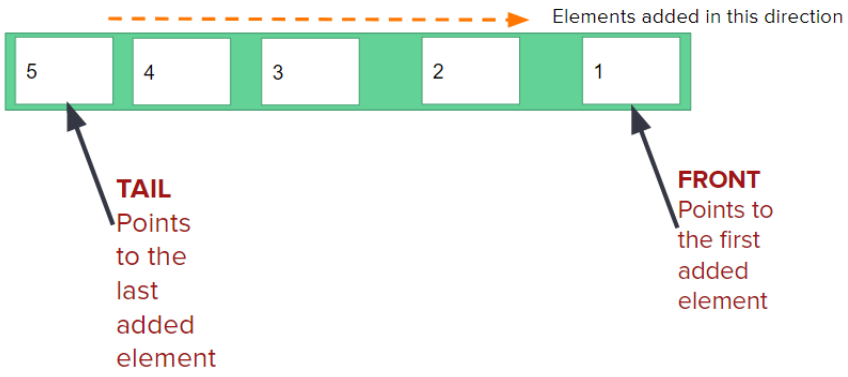
Perform string reversal using Stack Operations.

Hint: Keep pushing characters one by one, once all characters are pushed. Start popping elements.

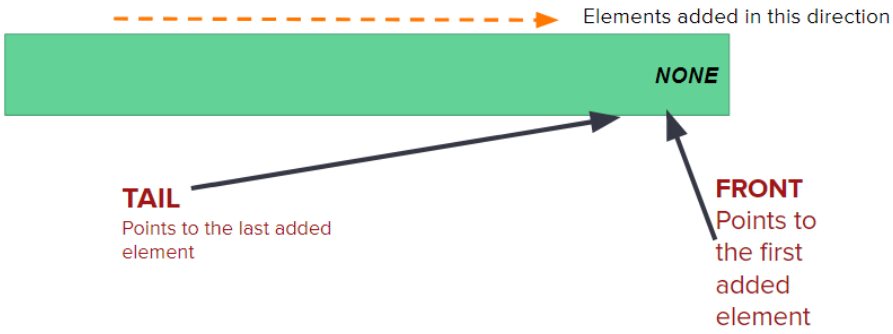
The string will get reversed as PUSH-POP follows FILO =LIFO

Queue Implementation in Python using Node Class:

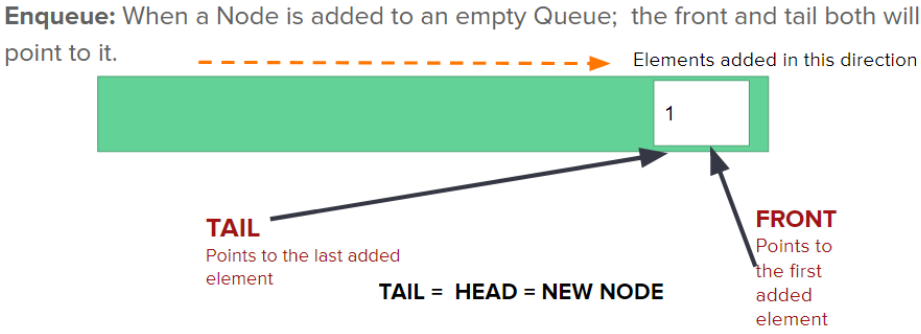
Like class Stack( ), create a class Queue( ). The class has 2 attributes: head or front and tail or rear to keep track of Queue (first added and last added elements).



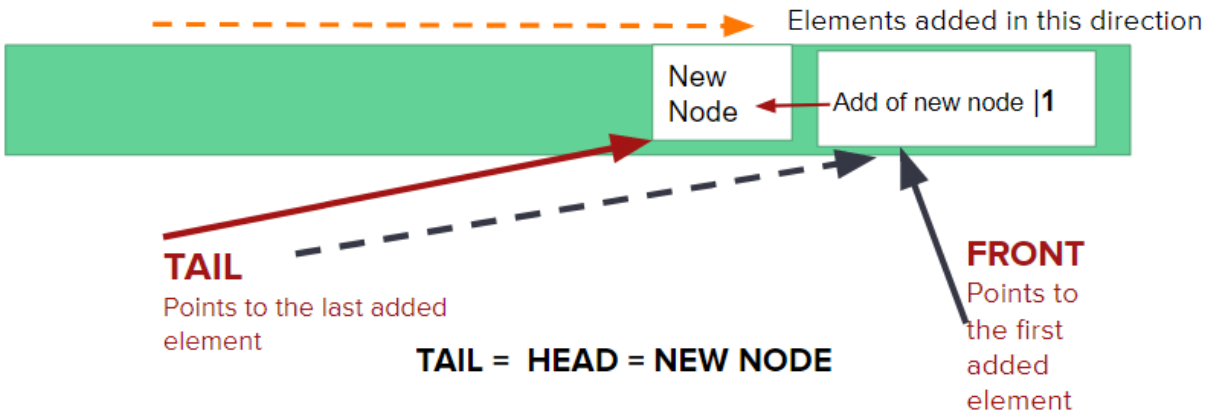
Initially when the queue is empty, front and tail both are None.



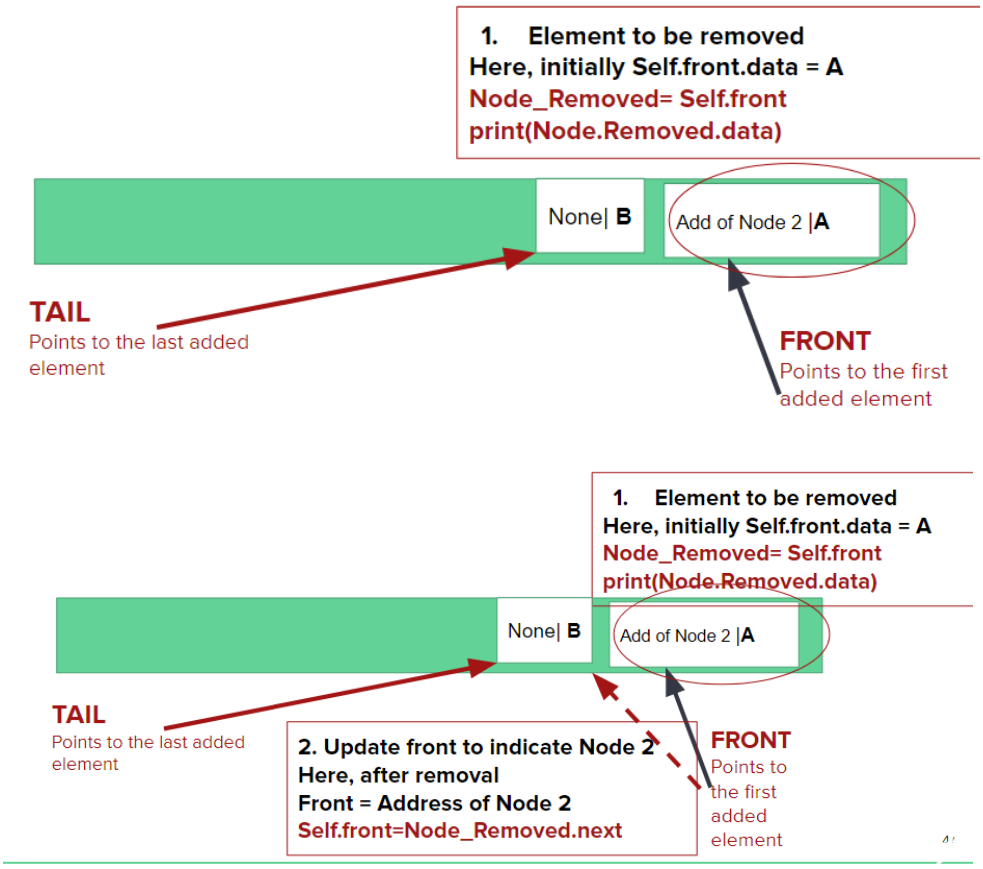
Enqueue: When a Node is added to an empty Queue; the front and tail both will point to it.



When a Node is added to a Queue that already has some nodes, then the new node should be connected to the last node (pointed by tail) in Queue, and Tail should be updated.



Dequeue: When a Node is to be removed from the Queue, the front should be used. And Front should be updated too (updated front will be the node right next to the previous front node).



TASK 3: Implementation of Queue Data Structure in Python using Node Class

Complete the methods of **enqueue** and **dequeue** for the Queue class define below.

```
class Node:
    def __init__(self, data):
        self.data = data
        self.next = None

class Queue:
    def __init__(self):
        self.head = None
        self.last = None
    def enqueue(self, data):
        if self.last is None: #empty QUEUE
            #complete the logic
        else:                    #Queue is not empty, already has node(s)
            #complete the logic
   def dequeue(self):
        if self.head is None: #empty QUEUE
            return None
        else:                    #Queue is not empty, already has node(s)
            #complete the logic
```

Create instance (object) using the defined DS of Queue and test it's methods for verification as done in the Lab 09.

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Psychomotor Domain Assessment Rubric for Laboratory (Level P3)					
Skill(s) to be assessed	Extent of Achievement				
	0	1	2	3	4
Software Initialisation and Configuration: Set up and *recognise* software initialisation and configuration steps 10%	Completely unable to recognise initialisation and configuration 0	Able to recognise initialisation but could not configure 10	Able to recognise initialisation but configuration is erroneous 20	Able to recognise initialisation and configuration with minimal errors 30	Able to recognise initialisation and configuration with complete success 40
Input/Output Variable Recognition, Definition and Initialisation: *Recognise* and *perceive* correct input/output variables along with data types for testing a specific algorithm/data structure 15%	Incorrect perception for both Input/Output variables and data types 0	Correctly perceives the required Input/Output variables and data types but fails to initialise variables altogether 15	Correctly perceives the required Input/Output variables and data types and only initialises them partially 30	Correctly perceives the required Input/Output variables and data types and initialises them completely but with errors 45	Correctly perceives the required Input/Output variables and data types and initialises them with complete success 60
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Total Points (out of 400)	
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Instructor's Signature with Date	

Cover Page for Each PBL/OEL

Course Code:	EE-264
Course Name:	Data Structures & Algorithms
Semester:	Fall
Year:	SE
Section:	
Batch:	
Lab Instructor name:	
Submission deadline:	

PBL or OEL Statement:

Accomplish the following open ended tasks

Using Node class, develop

1. Stack

2. Queues

3. Singly connected linked-list with following features

a. Add nodes

b. Traverse all nodes starting from top node

c. Search any key value in all nodes

d. Insert node between any two nodes

Deliverables:

Code for Stack class along with driver code

Code for Queue class along with driver code

Code for Linked list class along with driver code

Methodology:

On Jupyter notebook / Spyder-IDE write a code for Stack class along with following member functions using given Node class:

Push(), Pop(), top(), is_empty()

On Jupyter notebook / Spyder-IDE write a code for Queue class along with following member functions using given Node class:

Enqueue(), Dequeue(), First(), is_empty()

On Jupyter notebook / Spyder-IDE write a code for Linked List class along with following member functions using given Node class:

Add_node(), remove_node(), traverse_nodes()

Guidelines:

Using Node class below,

```
class _Node:
      def __init__(self,element,next):
             self._element = element self._next = next
```

write the above data structures along with their driver codes. Show the use of all member functions by taking suitable examples.

Rubrics:

Code for Stack class along with driver code

Code for Queue class along with driver code

Code for Linked list class along with driver code

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