- [x] Array
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- [ ] String
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Array

Reverse the array
Find the maximum and minimum element in an array
Find the "Kth" max and min element of an array
Given an array which consists of only 0, 1 and 2. Sort the array without using any sorting algo
Move all the negative elements to one side of the array
Find the Union and Intersection of the two sorted arrays.
Write a program to cyclically rotate an array by one.
Find Largest sum contiguous Subarray [V. IMP] / Kadne's Algorithm

Minimise the maximum difference between heights [V.IMP]
Minimum no. of Jumps to reach end of an array
Find duplicate in an array of N+1 Integers
Merge 2 sorted arrays without using Extra space.
Merge Intervals
Next Permutation
Count Inversion
Best time to buy and Sell stock
Find all pairs on integer array whose sum is equal to given number
Find common elements In 3 sorted arrays
Rearrange the array in alternating positive and negative items with O(1) extra space
Find if there is any subarray with sum equal to 0
Find factorial of a large number
Find maximum product subarray
Find longest consecutive subsequence
Given an array of size n and a number k, find all elements that appear more than " n/k " times.
Maximum profit by buying and selling a share atmost twice
Find whether an array is a subset of another array
Find the triplet that sum to a given value
Trapping Rain water problem
Chocolate Distribution problem
Smallest Subarray with sum greater than a given value
Three way partitioning of an array around a given value
Minimum swaps required bring elements less equal K together

- Minimum no. of operations required to make an array palindrome
- Median of 2 sorted arrays of different size

BackTracking

- Rat in a maze Problem
- Printing all solutions in N-Queen Problem
- Word Break Problem using Backtracking
- Remove Invalid Parentheses
- Sudoku Solver
- m-Colouring Problem
- Print all palindromic partitions of a string
- Subset Sum Problem
- The Knight's tour problem
- Tug of War
- Find shortest safe route in a path with landmines
- Combinational Sum
- Find Maximum number possible by doing at-most K swaps
- Print all permutations of a string
- Find if there is a path of more than k length from a source
- Longest Possible Route in a Matrix with Hurdles
- Print all possible paths from top left to bottom right of a mXn matrix
- Partition of a set intoK subsets with equal sum
- Find the K-th Permutation Sequence of first N natural numbers

Binary Trees

- level order traversal AKA BFS
- Reverse Level Order traversal
- Height of a tree
- Diameter of a tree
- Mirror of a tree / Invert Binary Tree
- Inorder, Preorder and Postorder Tree Traversal (Recursive Method)
- Left View of a tree
- Right View of Tree
- Top View of a tree
- Bottom View of a tree
- Zig-Zag traversal of a binary tree
- Check if a tree is balanced or not
- Diagonal Traversal of a Binary tree
- Boundary traversal of a Binary tree
- Construct Binary Tree from String with Bracket Representation
- Convert Binary tree into Doubly Linked List
- Convert Binary tree into Sum tree
- Construct Binary tree from Inorder and preorder traversal
- Find minimum swaps required to convert a Binary tree into BST
- Check if Binary tree is Sum tree or not
- Check if all leaf nodes are at same level or not
- Check if a Binary Tree contains duplicate subtrees of size 2 or more [IMP]
- Check if 2 trees are mirror or not
- Sum of Nodes on the Longest path from root to leaf node
- Check if given graph is tree or not. [IMP]
- Find Largest subtree sum in a tree
- Maximum Sum of nodes in Binary tree such that no two are adjacent
- Print all "K" Sum paths in a Binary tree
- Find Least Common Ancestor in a Binary tree
- Find distance between 2 nodes in a Binary tree
- Kth Ancestor of node in a Binary tree
- Find all Duplicate subtrees in a Binary tree [IMP]
- Tree Isomorphism Problem

Bit Manipulation

- Count set bits in an integer
- Find the two non-repeating elements in an array of repeating elements
- Count number of bits to be flipped to convert A to B

- Count total set bits in all numbers from 1 to n
- Program to find whether a no is power of two
- Find position of the only set bit
- Copy set bits in a range
- Divide two integers without using multiplication, division and mod operator
- Calculate square of a number without using *, / and pow()
- Power Set

Binary Search Trees

- Find a value in a BST
- Deletion of a node in a BST
- Find min and max value in a BST
- Find inorder successor and inorder predecessor in a BST
- Check if a tree is a BST or not
- Populate Inorder successor of all nodes
- Find LCA of 2 nodes in a BST
- Construct BST from preorder traversal
- Convert Binary tree into BST
- Convert a normal BST into a Balanced BST
- Merge two BST
- Find Kth largest element and Kth smallest element in a BST
- Count pairs from 2 BST whose sum is equal to given value "X"
- Find the median of BST in O(n) time and O(1) space
- Count BST nodes that lie in a given range
- Replace every element with the least greater element on its right
- Given "n" appointments, find the conflicting appointments
- Preorder to Postorder
- Check whether BST contains Dead end
- Largest BST in a Binary Tree [V.V.V.V.V IMP]
- Flatten BST to sorted list

Dynamic Programming

- Coin ChangeProblem
- Knapsack Problem
- Binomial CoefficientProblem
- Permutation CoefficientProblem
- Program for nth Catalan Number
- Matrix Chain Multiplication
- Edit Distance
- Subset Sum Problem
- Friends Pairing Problem
- Gold Mine Problem
- Assembly Line SchedulingProblem
- Painting the Fence Problem
- Rod Cutting Problem
- Longest Common Subsequence
- Longest Repeated Subsequence
- Longest Increasing Subsequence
- Space Optimized Solution of LCS (Print only length)
- LCS (Longest Common Subsequence) of three strings
- Maximum Sum Increasing Subsequence
- Count all subsequences having product less than K
- Longest subsequence such that difference between adjacent is one
- Maximum subsequence sum such that no three are consecutive
- Egg Dropping Problem
- Maximum Length Chain of Pairs
- Maximum size square sub-matrix with all 1s
- Maximum sum of pairs with specific difference
- Min Cost PathProblem
- Maximum difference of zeros and ones in binary string
- Minimum number of jumps to reach end
- Minimum cost to fill given weight in a bag

- Minimum removals from array to make max –min <= K
- Longest Common Substring
- Count number of ways to reacha given score in a game
- Count Balanced Binary Trees of Height h
- Smallest sum contiguous subarray
- Unbounded Knapsack (Repetition of items allowed)
- Largest Independent Set Problem
- Partition problem
- Longest Palindromic Subsequence
- Count All Palindromic Subsequence in a given String
- Longest Palindromic Substring
- Longest alternating subsequence
- Weighted Job Scheduling
- Coin game winner where every player has three choices
- Count Derangements (Permutation such that no element appears in its original position) [IMPORTANT]
- Maximum profit by buying and selling a share at most twice [IMP]
- Optimal Strategy for a Game
- Optimal Binary Search Tree
- Palindrome PartitioningProblem
- Word Wrap Problem
- Mobile Numeric Keypad Problem [IMP]
- Boolean Parenthesization Problem
- Largest rectangular sub-matrix whose sum is 0
- Maximum sum rectangle in a 2D matrix
- Maximum profit by buying and selling a share at most k times
- Find if a string is interleaved of two other strings

Graph

- Create a Graph, print it
- Create a Graph (for practice)
- Implement BFS algorithm
- Implement DFS Algo
- Detect Cycle in Directed Graph using BFS/DFS Algo
- Detect Cycle in UnDirected Graph using BFS/DFS Algo
- Search in a Maze
- Minimum Step by Knight
- flood fill algo
- Clone a graph
- Making wired Connections
- word Ladder
- Dijkstra algo
- Implement Topological Sort
- Minimum time taken by each job to be completed given by a Directed Acyclic Graph
- Find whether it is possible to finish all tasks or not from given dependencies
- Find the no. of Islands
- Given a sorted Dictionary of an Alien Language, find order of characters
- Implement Kruksal'sAlgorithm
- Implement Prim's Algorithm
- Total no. of Spanning tree in a graph
- Implement Bellman Ford Algorithm
- Implement Floyd warshallAlgorithm
- Travelling Salesman Problem
- Graph ColouringProblem
- Snake and Ladders Problem
- Find bridge in a graph
- Count Strongly connected Components(Kosaraju Algo)
- Check whether a graph is Bipartite or Not
- Detect Negative cycle in a graph
- Longest path in a Directed Acyclic Graph
- Journey to the Moon
- Cheapest Flights Within K Stops

- Oliver and the Game
- Water Jug problem using BFS
- Find if there is a path of more thank length from a source
- M-ColouringProblem
- Minimum edges to reverse o make path from source to destination
- Paths to travel each nodes using each edge(Seven Bridges)
- Vertex Cover Problem
- Chinese Postman or Route Inspection
- Number of Triangles in a Directed and Undirected Graph
- Minimise the cashflow among a given set of friends who have borrowed money from each other
- Two Clique Problem

Greedy

- Activity Selection Problem
- Job SequencingProblem
- Huffman Coding
- Water Connection Problem
- Fractional Knapsack Problem
- Greedy Algorithm to find Minimum number of Coins
- Maximum trains for which stoppage can be provided
- Minimum Platforms Problem
- Buy Maximum Stocks if i stocks can be bought on i-th day
- Find the minimum and maximum amount to buy all N candies
- Minimize Cash Flow among a given set of friends who have borrowed money from each other
- Minimum Cost to cut a board into squares
- Check if it is possible to survive on Island
- Find maximum meetings in one room
- Maximum product subset of an array
- Maximize array sum after K negations
- Maximize the sum of arr[i]*i
- Maximum sum of absolute difference of an array
- Maximize sum of consecutive differences in a circular array
- Minimum sum of absolute difference of pairs of two arrays
- Program for Shortest Job First (or SJF) CPU Scheduling
- Program for Least Recently Used (LRU) Page Replacement algorithm
- Smallest subset with sum greater than all other elements
- Chocolate Distribution Problem
- DEFKIN -Defense of a Kingdom
- DIEHARD -DIE HARD
- GERGOVIA -Wine trading in Gergovia
- Picking Up Chicks
- CHOCOLA –Chocolate
- ARRANGE -Arranging Amplifiers
- K Centers Problem
- Minimum Cost of ropes
- Find smallest number with given number of digits and sum of digits
- Rearrange characters in a string such that no two adjacent are same
- Find maximum sum possible equal sum of three stacks

Heap

- Implement a Maxheap/MinHeap using arrays and recursion.
- Sort an Array using heap. (HeapSort)
- Maximum of all subarrays of size k.
- “k” largest element in an array
- Kth smallest and largest element in an unsorted array
- Merge “K” sorted arrays. [IMP]
- Merge 2 Binary Max Heaps
- Kth largest sum continuous subarrays
- Leetcode- reorganize strings
- Merge “K” Sorted Linked Lists [V.IMP]
- Smallest range in “K” Lists
- Median in a stream of Integers

- Check if a Binary Tree is Heap
- Connect “n” ropes with minimum cost
- Convert BST to Min Heap
- Convert min heap to max heap
- Rearrange characters in a string such that no two adjacent are same.
- Minimum sum of two numbers formed from digits of an array

LinkedList

- Write a Program to reverse the Linked List. (Both Iterative and recursive)
- Reverse a Linked List in group of Given Size. [Very Imp]
- Write a program to Detect loop in a linked list.
- Write a program to Delete loop in a linked list.
- Find the starting point of the loop.
- Remove Duplicates in a sorted Linked List.
- Remove Duplicates in a Un-sorted Linked List.
- Write a Program to Move the last element to Front in a Linked List.
- Add “1” to a number represented as a Linked List.
- Add two numbers represented by linked lists.
- Intersection of two Sorted Linked List.
- Intersection Point of two Linked Lists.
- Merge Sort For Linked lists.[Very Important]
- Quicksort for Linked Lists.[Very Important]
- Find the middle Element of a linked list.
- Check if a linked list is a circular linked list.
- Split a Circular linked list into two halves.
- Write a Program to check whether the Singly Linked list is a palindrome or not.
- Deletion from a Circular Linked List.
- Reverse a Doubly Linked list.
- Find pairs with a given sum in a DLL.
- Count triplets in a sorted DLL whose sum is equal to given value “X”.
- Sort a “k”sorted Doubly Linked list.[Very IMP]
- Rotate DoublyLinked list by N nodes.
- Rotate a Doubly Linked list in group of Given Size.[Very IMP]
- Can we reverse a linked list in less than O(n) ?
- Why Quicksort is preferred for. Arrays and Merge Sort for LinkedLists ?
- Flatten a Linked List
- Sort a LL of 0's, 1's and 2's
- Clone a linked list with next and random pointer
- Merge K sorted Linked list
- Multiply 2 no. represented by LL
- Delete nodes which have a greater value on right side
- Segregate even and odd nodes in a Linked List
- Program for n’th node from the end of a Linked List
- Find the first non-repeating character from a stream of characters

Matrix

- Spiral traversal on a Matrix
- Search an element in a matriix
- Find median in a row wise sorted matrix
- Find row with maximum no. of 1's
- Print elements in sorted order using row-column wise sorted matrix
- Maximum size rectangle
- Find a specific pair in matrix
- Rotate matrix by 90 degrees
- Kth smallest element in a row-column wise sorted matrix
- Common elements in all rows of a given matrix

Searching & Sorting

- Bubble Sort
- Selection Sort
- Insertion Sort
- Merge Sort
- Quick Sort

- Counting Sort
- Heap Sort
- Radix Sort
- Linear Search
- Binary Search
- Binary Search
- Find first and last positions of an element in a sorted array
- Find a Fixed Point (Value equal to index) in a given array
- Search in a rotated sorted array
- square root of an integer
- Maximum and minimum of an array using minimum number of comparisons
- Optimum location of point to minimize total distance
- Find the repeating and the missing
- find majority element
- Searching in an array where adjacent differ by at most k
- find a pair with a given difference
- find four elements that sum to a given value
- maximum sum such that no 2 elements are adjacent
- Count triplet with sum smaller than a given value
- merge 2 sorted arrays
- print all subarrays with 0 sum
- Product array Puzzle
- Sort array according to count of set bits
- minimum no. of swaps required to sort the array
- Bishu and Soldiers
- Rasta and Kheshtak
- Kth smallest number again
- Find pivot element in a sorted array
- K-th Element of Two Sorted Arrays
- Aggressive cows
- Book Allocation Problem
- EKOSPOJ:
- Job Scheduling Algo
- Missing Number in AP
- Smallest number with atleastn trailing zeroes infactorial
- Painters Partition Problem:
- ROTI-Prata SPOJ
- DoubleHelix SPOJ
- Subset Sums
- Find the inversion count
- Implement Merge-sort in-place
- Partitioning and Sorting Arrays with Many Repeated Entries

Stacks & Queues

- Implement Stack from Scratch
- Implement Queue from Scratch
- Implement 2 stack in an array
- find the middle element of a stack
- Implement "N" stacks in an Array
- Check the expression has valid or Balanced parenthesis or not.
- Reverse a String using Stack
- Design a Stack that supports getMin() in O(1) time and O(1) extra space.
- Find the next Greater element
- The celebrity Problem
- Arithmetic Expression evaluation
- Evaluation of Postfix expression
- Implement a method to insert an element at its bottom without using any other data structure.
- Reverse a stack using recursion
- Sort a Stack using recursion
- Merge Overlapping Intervals
- Largest rectangular Area in Histogram

- Length of the Longest Valid Substring
- Expression contains redundant bracket or not
- Implement Stack using Queue
- Implement Stack using Deque
- Stack Permutations (Check if an array is stack permutation of other)
- Implement Queue using Stack
- Implement "n" queue in an array
- Implement a Circular queue
- LRU Cache Implementationa
- Reverse a Queue using recursion
- Reverse the first “K” elements of a queue
- Interleave the first half of the queue with second half
- Find the first circular tour that visits all Petrol Pumps
- Minimum time required to rot all oranges
- Distance of nearest cell having 1 in a binary matrix
- First negative integer in every window of size “k”
- Check if all levels of two trees are anagrams or not.
- Sum of minimum and maximum elements of all subarrays of size “k”.
- Minimum sum of squares of character counts in a given string after removing “k” characters.
- Queue based approach or first non-repeating character in a stream.
- Next Smaller Element

String

- Reverse a String
- Check whether a String is Palindrome or not
- Find Duplicate characters in a string
- Why strings are immutable in Java?
- Write a Code to check whether one string is a rotation of another
- Write a Program to check whether a string is a valid shuffle of two strings or not
- Count and Say problem
- Write a program to find the longest Palindrome in a string.[Longest palindromic Substring]
- Find Longest Recurring Subsequence in String
- Print all Subsequences of a string.
- Print all the permutations of the given string
- Split the Binary string into two substring with equal 0’s and 1’s
- Find next greater number with same set of digits. [Very Very IMP]
- Balanced Parenthesis problem.[Imp]
- Rabin Karp Algo
- KMP Algo
- Convert a Sentence into its equivalent mobile numeric keypad sequence.
- Minimum number of bracket reversals needed to make an expression balanced.
- Count All Palindromic Subsequence in a given String.
- Count of number of given string in 2D character array
- Search a Word in a 2D Grid of characters.
- Boyer Moore Algorithm for Pattern Searching.
- Converting Roman Numerals to Decimal
- Longest Common Prefix
- Number of flips to make binary string alternate
- Find the first repeated word in string.
- Minimum number of swaps for bracket balancing.
- Find the longest common subsequence between two strings.
- Program to generate all possible valid IP addresses from given string.
- Write a program to find the smallest window that contains all characters of string itself.
- Rearrange characters in a string such that no two adjacent are same
- Minimum characters to be added at front to make string palindrome
- Given a sequence of words, print all anagrams together
- Find the smallest window in a string containing all characters of another string
- Recursively remove all adjacent duplicates
- String matching where one string contains wildcard characters
- Function to find Number of customers who could not get a computer
- Transform One String to Another using Minimum Number of Given Operation

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Array

Reverse the array

```
def reverseArray(A: list):
    start, end= 0, len(A)-1
    while start<end:
        A[start], A[end]= A[end], A[start]
        start+=1
        end-=1


A=[1,54,21,51,2,353,2,1,99,121,5,5]
reverseArray(A)
print("After reversing:", A)
```

Find the maximum and minimum element in an array

```
def getMinMax(arr: list, n: int):
    min = 0
    max = 0

    # If there is only one element then return it as min and max both
    if n == 1:
        max = arr[0]
        min = arr[0]
        return min, max

    # If there are more than one elements, then initialize min
    # and max
    if arr[0] > arr[1]:
        max = arr[0]
        min = arr[1]
    else:
        max = arr[1]
        min = arr[0]

    for i in range(2, n):
        if arr[i] > max:
            max = arr[i]
        elif arr[i] < min:
            min = arr[i]

    return min, max

# Driver Code
```

```
if __name__ == "__main__":
    arr = [1000, 11, 445, 1, 330, 3000]
    arr_size = 6
    min, max = getMinMax(arr, arr_size)
    print("Minimum element is", min)
    print("Maximum element is", max)
```

Find the "Kth" max and min element of an array

```
import sys

# function to calculate number of elements less than equal to mid
def count(nums, mid):
    cnt = 0
    for i in range(len(nums)):
        if nums[i] <= mid:
            cnt += 1
    return cnt

def kthSmallest(nums, k):
    low = sys.maxsize
    high = -sys.maxsize

    # calculate minimum and maximum the array.
    for i in range(len(nums)):
        low = min(low, nums[i])
        high = max(high, nums[i])

        # Our answer range lies between minimum and maximum element
        # of the array on which Binary Search is Applied
    while low < high:
        mid = low + (high - low) // 2
        # if the count of number of elements in the array less than equal
        # to mid is less than k then increase the number. Otherwise decrement
        # the number and try to find a better answer.
        if count(nums, mid) < k:
            low = mid + 1
        else:
            high = mid
    return low

nums = [1, 4, 5, 3, 19, 3]
k = 3
print("K'th smallest element is", kthSmallest(nums, k))
```

Given an array which consists of only 0, 1 and 2. Sort the array without using any sorting algo

```
def sort012(arr):
        n=len(arr)
        low=0
        high=n-1
        mid=0
        while mid<=high:
            if arr[mid]==0:
                arr[mid] , arr[low] = arr[low] , arr[mid]
```

```
                mid+=1
                low+=1

            elif arr[mid]==1:
                mid+=1

            else:
                arr[mid] , arr[high] = arr[high] , arr[mid]
                high-=1

A=[0,0,0,2,2,2,1,1,1,0,2,1,1,2,0]
sort012(A)
print("After sorting:", A)
```

Move all the negative elements to one side of the array

```
def RearrangePosNeg(arr):
 n = len(arr)
 for i in range(1, n):
  key = arr[i]

  # if current element is positive do nothing
  if (key > 0):
   continue

  # if current element is negative, shift positive elements of arr[0..i-1], to one position to
their right
  j = i - 1
  while (j >= 0 and arr[j] > 0):
   arr[j + 1] = arr[j]
   j = j - 1

  # Put negative element at its
  # right position
  arr[j + 1] = key


# Driver Code
if __name__ == "__main__":
 arr = [-12, 11, -13, -5,
  6, -7, 5, -3, -6]
 RearrangePosNeg(arr)
 print(arr)
```

Find the Union and Intersection of the two sorted arrays.

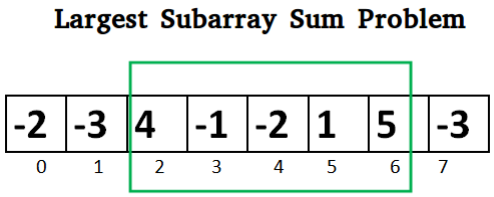
```
def printUnion(arr1, arr2, n1, n2):
    hs = set()
    # Insert the elements of arr1[] to set hs
    for i in range(0, n1):
     hs.add(arr1[i])
    # Insert the elements of arr2[] to set hs
    for i in range(0, n2):
     hs.add(arr2[i])
    for i in hs:
     print(i, end=" ")
    print("Union Count", len(hs))
```

```
def printIntersection(arr1, arr2, n1, n2):
    hs = set()
    # Insert the elements of arr1[] to set S
    for i in range(0, n1):
     hs.add(arr1[i])
    intersectCount=0
    for i in range(0, n2):
     # If element is present in set then
     # push it to vector V
     if arr2[i] in hs:
            print(arr2[i], end=" ")
            intersectCount+=1
    print("Intersection Count", intersectCount)

# Driver Program
arr1 = [7, 1, 5, 2, 3, 6]
arr2 = [3, 8, 6, 20, 7]
n1 = len(arr1)
n2 = len(arr2)

# Function call
printUnion(arr1, arr2, n1, n2)
printIntersection(arr1, arr2, n1, n2)
```

Write a program to cyclically rotate an array by one.

```
def rotate(arr):
    n = len(arr)
    i = 0
    j = n - 1
    while i != j:
        arr[i], arr[j] = arr[j], arr[i]
        i = i + 1

# Driver function
arr= [1, 2, 3, 4, 5]
rotate(arr)
print(arr)
```

Find Largest sum contiguous Subarray [V. IMP] / Kadne's Algorithm



4 + (-1) + (-2) + 1 + 5 = 7

Maximum Contiguous Array Sum is 7

```
def maxSubArraySum(a):
    size=len(a)
    max_so_far =a[0]
    curr_max = a[0]

    for i in range(1,size):
        curr_max = max(a[i], curr_max + a[i])
        max_so_far = max(max_so_far,curr_max)
    return max_so_far

a = [-2, -3, 4, -1, -2, 1, 5, -3]
print ("Maximum contiguous sum is" , maxSubArraySum(a))
```

Minimise the maximum difference between heights [V.IMP]

```
"""

Given heights of n towers and a value k. We need to either increase or decrease the height of
every tower by k (only once) where k > 0. The task is to minimize the difference between the
heights of the longest and the shortest tower after modifications and output this difference.
Input : arr[] = {1, 5, 15, 10} k = 3
Output : Maximum difference is 8 arr[] = {4, 8, 12, 7}

"""
def getMinDiff(arr, k):
    arr.sort()
    n=len(arr)
    ans = arr[n - 1] - arr[0]  # Maximum possible height difference

    tempmin = arr[0]
    tempmax = arr[n - 1]

    for i in range(1, n):
        tempmin = min(arr[0] + k, arr[i] - k)

        # Minimum element when we add k to whole array Maximum element when we
        tempmax = max(arr[i - 1] + k, arr[n - 1] - k)

        # subtract k from whole array
        ans = min(ans, tempmax - tempmin)

    return ans

# Driver Code Starts
k = 6 # total towers
arr = [7, 4, 8, 8, 8, 9] # height of each array
print("Maximum difference of height between all towers (minimized as much as possible) is",
getMinDiff(arr, k))
```

Minimum no. of Jumps to reach end of an array

```
"""
Given an array of integers where each element represents the max number of steps that can be made
forward from that element. Write a function to return the minimum number of jumps to reach the end
of the array (starting from the first element). If an element is 0, then we cannot move through
that element. If we can't reach the end, return -1.
```

```
Input:  arr[] = {1, 3, 5, 8, 9, 2, 6, 7, 6, 8, 9}
Output: 3 (1-> 3 -> 8 -> 9)
"""
# Returns minimum number of jumps to reach arr[n-1] from arr[0]
def minJumps(arr, n):
    # The number of jumps needed to reach the starting index is 0
    if (n <= 1):
      return 0

    # Return -1 if not possible to jump
    if (arr[0] == 0):
      return -1

    # initialization
    # stores all time the maximal reachable index in the array
    maxReach = arr[0]
    # stores the amount of steps we can still take
    step = arr[0]
    # stores the amount of jumps necessary to reach that maximal reachable position
    jump = 1

    # Start traversing array

    for i in range(1, n):
        # Check if we have reached the end of the array
        if (i == n-1):
          return jump

        # updating maxReach
        maxReach = max(maxReach, i + arr[i])

        # we use a step to get to the current index
        step -= 1;

        # If no further steps left
        if (step == 0):
          # we must have used a jump
            jump += 1

          # Check if the current index / position or lesser index
          # is the maximum reach point from the previous indexes
            if(i >= maxReach):
                return -1

          # re-initialize the steps to the amount
          # of steps to reach maxReach from position i.
            step = maxReach - i;
    return -1


arr = [1, 3, 5, 8, 9, 2, 6, 7, 6, 8, 9]
size = len(arr)
print("Minimum number of jumps to reach end is: ", minJumps(arr, size))
```

Find duplicate in an array of N+1 Integers

```
"""
Given a limited range array of size n containing elements between 1 and n-1 with one element repeating, find the duplicate number in it without using any extra space. NOTE : ARRAY IS LIMITED RANGE
"""
def findDuplicate(nums):
    actual_sum = sum(nums)
    expected_sum = len(nums) * (len(nums) - 1) // 2
    return actual_sum - expected_sum

A=[3,1,2,4,2]
print(findDuplicate(A))
```

Merge 2 sorted arrays without using Extra space.

```
def merge(X, Y):
    m = len(X)
    n = len(Y)

    # Consider each element `X[i]` of list `X[]` and ignore the element if it is
    # already in the correct order; otherwise, swap it with the next smaller
    # element, which happens to be the first element of `Y[]`.
    for i in range(m):

        # compare the current element of `X[]` with the first element of `Y[]`
        if X[i] > Y[0]:

            # swap `X[i] with `Y[0]`
            X[i],Y[0]=Y[0], X[i]

            first = Y[0]

            # move `Y[0]` to its correct position to maintain the sorted
            # order of `Y[]`. Note: `Y[1…n-1]` is already sorted
            k = 1
            while k < n and Y[k] < first:
                Y[k - 1] = Y[k]
                k = k + 1

            Y[k - 1] = first


X = [1, 4, 7, 8, 10]
Y = [2, 3, 9]
merge(X, Y)
print("X:", X)
print("Y:", Y)
```

Merge Intervals

```
def mergeIntervals(arr):

    # Sorting based on the increasing order
    # of the start intervals
    arr.sort(key=lambda x: x[0])

    # Stores index of last element in output array (modified arr[])
```

```
    index = 0

    # Traverse all input Intervals starting from second interval
    for i in range(1, len(arr)):

        # If this is not first Interval and overlaps with the previous one, Merge previous and
current Intervals
        if (arr[index][1] >= arr[i][0]):
            arr[index][1] = max(arr[index][1], arr[i][1])
        else:
            index = index + 1
            arr[index] = arr[i]

    print("The Merged Intervals are :", end=" ")
    for i in range(index+1):
        print(arr[i], end=" ")



arr = [[6, 8], [1, 3], [2, 4], [4, 7]]
mergeIntervals(arr)
```

Next Permutation

```
"""
If all digits sorted in descending order, then output is always "Not Possible". For example, 4321.
If all digits are sorted in ascending order, then we need to swap last two digits. For example,
1234.
For other cases, we need to process the number from rightmost side (why? because we need to find
the smallest of all greater numbers)
"""
def nextPermutation(arr):
    N=len(arr)
    ind = 0
    l = []
    l += arr
    for i in range(N-2, -1, -1):
        if l[i]<l[i+1]:
            ind = i
            break
    for i in range(N-1, ind, -1):
        if l[i]>l[ind]:
            l[i], l[ind] = l[ind], l[i]
            ind += 1
            break
    for i in range((N-ind)//2):
        l[i+ind], l[N-i-1] = l[N-i-1], l[i+ind]
    return "".join(l)

print(nextPermutation("218765"))
```

Count Inversion

```
def mergeSort(arr, n):
    # A temp_arr is created to store sorted array in merge function
    temp_arr = [0]*n
    return _mergeSort(arr, temp_arr, 0, n-1)
```

```
# This Function will use MergeSort to count inversions
def _mergeSort(arr, temp_arr, left, right):
    inv_count = 0

    # We will make a recursive call if and only if we have more than one elements
    if left < right:

        # mid is calculated to divide the array into two subarrays Floor division is must in case
of python
        mid = (left + right)//2

        # It will calculate inversion counts in the left subarray
        inv_count += _mergeSort(arr, temp_arr, left, mid)

        # It will calculate inversion counts in right subarray
        inv_count += _mergeSort(arr, temp_arr,mid + 1, right)

        # It will merge two subarrays in a sorted subarray
        inv_count += merge(arr, temp_arr, left, mid, right)
    return inv_count

# This function will merge two subarrays
# in a single sorted subarray


def merge(arr, temp_arr, left, mid, right):
    i = left     # Starting index of left subarray
    j = mid + 1  # Starting index of right subarray
    k = left     # Starting index of to be sorted subarray
    inv_count = 0

    # Conditions are checked to make sure that i and j don't exceed their subarray limits.
    while i <= mid and j <= right:

        # There will be no inversion if arr[i] <= arr[j]
        if arr[i] <= arr[j]:
            temp_arr[k] = arr[i]
            k += 1
            i += 1
        else:
            # Inversion will occur.
            temp_arr[k] = arr[j]
            inv_count += (mid-i + 1)
            k += 1
            j += 1

    # Copy the remaining elements of left subarray into temporary array
    while i <= mid:
        temp_arr[k] = arr[i]
        k += 1
        i += 1

    # Copy the remaining elements of right subarray into temporary array
    while j <= right:
        temp_arr[k] = arr[j]
        k += 1
        j += 1

    # Copy the sorted subarray into Original array
    for loop_var in range(left, right + 1):
```

```
        arr[loop_var] = temp_arr[loop_var]

    return inv_count

arr = [1, 20, 6, 4, 5]
n = len(arr)
result = mergeSort(arr, n)
print("Number of inversions are", result)
```

Best time to buy and Sell stock

```
"""
Input: [7,1,5,3,6,4]
Output: 5
Explanation: Buy on day 2 (price = 1) and sell on day 5 (price = 6), profit = 6-1 = 5.
             Not 7-1 = 6, as selling price needs to be larger than buying price.
"""
def maxProfit(prices):
        max_profit = 0
        min_buy = float('inf')
        for price in prices:
            min_buy=min(min_buy, price)
            max_profit=max(max_profit, price-min_buy)
        return max_profit
print(maxProfit([7,1,5,3,6,4]))
```

Find all pairs on integer array whose sum is equal to given number

```
"""
An extended version of the two sum problem
"""
# Returns number of pairs in arr[0..n-1] with sum equal to 'sum'
def getPairsCount(arr, n, sum):
  unordered_map = {}
  count = 0
  for i in range(n):
    if sum - arr[i] in unordered_map:
      count += unordered_map[sum - arr[i]]
    if arr[i] in unordered_map:
      unordered_map[arr[i]] += 1
    else:
      unordered_map[arr[i]] = 1
  return count

# Driver code
arr = [1, 5, 7, -1, 5]
n = len(arr)
sum = 6
print('Count of pairs is', getPairsCount(arr, n, sum))
```

Find common elements In 3 sorted arrays

```
"""
Given three arrays sorted in non-decreasing order, print all common elements in these arrays.
"""
```

```python
# Python function to print common elements in three sorted arrays
def findCommon(ar1, ar2, ar3, n1, n2, n3):

  # Initialize starting indexes for ar1[], ar2[] and ar3[]
  i, j, k = 0, 0, 0

  # Iterate through three arrays while all arrays have elements
  while (i < n1 and j < n2 and k < n3):

    # If x = y and y = z, print any of them and move ahead
    # in all arrays
    if (ar1[i] == ar2[j] and ar2[j] == ar3[k]):
      print (ar1[i])
      i += 1
      j += 1
      k += 1

    # x < y
    elif ar1[i] < ar2[j]:
      i += 1

    # y < z
    elif ar2[j] < ar3[k]:
      j += 1

    # We reach here when x > y and z < y, i.e., z is smallest
    else:
      k += 1


# Driver program to check above function
ar1 = [1, 5, 10, 20, 40, 80]
ar2 = [6, 7, 20, 80, 100]
ar3 = [3, 4, 15, 20, 30, 70, 80, 120]
n1 = len(ar1)
n2 = len(ar2)
n3 = len(ar3)

print ("Common elements are")
findCommon(ar1, ar2, ar3, n1, n2, n3)
```

Rearrange the array in alternating positive and negative items with O(1) extra space

```python
def rearrange(arr, n):
  i = 0
  j = n - 1

  # shift all negative values to the end
  while (i < j):

    while (i <= n - 1 and arr[i] > 0):
      i += 1
    while (j >= 0 and arr[j] < 0):
      j -= 1
```

```
    if (i < j):
      temp = arr[i]
      arr[i] = arr[j]
      arr[j] = temp

  # i has index of leftmost
  # negativ ement
  if (i == 0 or i == n):
    return 0

  # start with first positive element at index 0  array in alternating positive & negative items
  k = 0
  while (k < n and i < n):

    # swap next positive element at even position from next negative element.
    arr[k], arr[i]= arr[i], arr[k]
    i = i + 1
    k = k + 2

arr = [2, 3,-4, -1, 6, -9 ]
n = len(arr)
rearrange(arr, n)
print("Rearranged array is", arr)
```

Find if there is any subarray with sum equal to 0

```
"""
Given an array of positive and negative numbers, find if there is a subarray (of size at-least
one) with 0 sum.

"""
#Function to check whether there is a subarray present with 0-sum or not.

def subArrayExists(arr):
    n=len(arr)
    #using set to store the prefix sum which has appeared already.
    s = set()

    sum = 0
    #iterating over the array.
    for i in range(n):
        #storing prefix sum.
        sum += arr[i]

        #if prefix sum is 0 or if it is already present in set then it is
  #repeated which means there is a subarray whose summation was 0, so we return true.
        if sum == 0 or sum in s:
            return True

        #storing every prefix sum obtained in set.
        s.add(sum)

    #returning false if we don't get any subarray with 0 sum.
    return False

print(subArrayExists([4, 2, -3, 1, 6]))
```

Find factorial of a large number

```
def range_prod(low,high):
    if low+1 < high:
        mid = (high+low)//2
        return range_prod(low,mid) * range_prod(mid+1,high)
    if low == high:
        return low
    return low*high

def factorial(n):
    if n < 2:
        return 1
    return range_prod(1,n)

print(factorial(12))
```

Find maximum product subarray

```
def maxProduct(arr):
    n=len(arr)
    # Variables to store maximum and minimum product till ith index.
    minVal = arr[0]
    maxVal = arr[0]
    maxProduct = arr[0]
    for i in range(1, n):
        # When multiplied by -ve number, maxVal becomes minVal and minVal becomes maxVal.
        if (arr[i] < 0):
            minVal, maxVal = maxVal, minVal
        # maxVal and minVal stores the product of subarray ending at arr[i].
        maxVal = max(arr[i], maxVal * arr[i])
        minVal = min(arr[i], minVal * arr[i])
        # Max Product of array.
        maxProduct = max(maxProduct, maxVal)
    return maxProduct

print(maxProduct([6, -3, -10, 0, 2]))
```

Find longest consecutive subsequence

```
"""
Given an array of integers, find the length of the longest sub-sequence such that elements in the
subsequence are consecutive integers, the consecutive numbers can be in any order.
"""
def findLongestConseqSubseq(arr):
    n=len(arr)
    #using a Set to store elements.
    s = set()
    ans=0

    #inserting all the array elements in Set.
    for ele in arr:
        s.add(ele)

    #checking each possible sequence from the start.
    for i in range(n):
```

```
        #if current element is starting element of a sequence then only we try to find out the
length of sequence.
        if (arr[i]-1) not in s:

            j=arr[i]
            #then we keep checking whether the next consecutive elements are present in Set and
         #we keep incrementing the counter.
            while(j in s):
                j+=1

            #storing the maximum count.
            ans=max(ans, j-arr[i])

    #returning the length of longest subsequence.
    return ans

print(findLongestConseqSubseq([1, 9, 3, 10, 4, 20, 2]))
```

Given an array of size n and a number k, find all elements that appear more than " n/k " times.

```
"""
Given an integer array of size n, find all elements that appear more than ⌊ n/3 ⌋ times.
"""
def majorityElement(nums):
    if not nums:
        return []
    count1, count2, candidate1, candidate2 = 0, 0, None, None
    for x in nums:
        if candidate1 == x:
            count1 += 1
        elif candidate2 == x:
            count2 += 1
        elif count1 == 0:
            candidate1 = x
            count1 = 1
        elif count2 == 0:
            candidate2 = x
            count2 = 1
        else:
            count1 -= 1
            count2 -= 1
    res = []
    for c in [candidate1, candidate2]:
        if nums.count(c) > len(nums) // 3:
            res.append(c)
    return res
print(majorityElement([3,2,3]))
```

Maximum profit by buying and selling a share atmost twice

```
"""
Input: prices = [3,3,5,0,0,3,1,4]
Output: 6
Explanation: Buy on day 4 (price = 0) and sell on day 6 (price = 3), profit = 3-0 = 3.
Then buy on day 7 (price = 1) and sell on day 8 (price = 4), profit = 4-1 = 3.
"""
```

```
def maxProfit(prices):
    b1, b2= -float('inf'), -float('inf')
    s1, s2 = 0, 0
    for price in prices:
        s2 = max(s2, b2 + price)
        b2 = max(b2, s1 - price)
        s1 = max(s1, b1 + price)
        b1 = max(b1, -price)
    return s2

print(maxProfit([3,3,5,0,0,3,1,4]))
```

Find whether an array is a subset of another array

```
def isSubset( a1, a2):
    n,m =len(a1), len(a2)
    s = set()
    for i in range(n) :
        s.add(a1[i])

    p = len(s)
    for i in range(m) :
        s.add(a2[i])
    if (len(s) == p) :
        return "Yes"
    return "No"

a=[11, 1, 13, 21, 3, 7]
b=[11, 3, 7, 1]
print(isSubset(a, b))
```

Find the triplet that sum to a given value

```
def findTriplets(arr, X):
    n=len(arr)
    found = False
    for i in range(0, n-2):
        for j in range(i+1, n-1):
            for k in range(j+1, n):
                if (arr[i] + arr[j] + arr[k] == X):
                    print(arr[i], arr[j], arr[k])
                    found = True

    # If no triplet with 0 sum found in array
    if (found == False):
        print("Three Sum not exist ")

arr = [0, -1, 2, -3, 1]
sum= 3
findTriplets(arr, sum)
```

Trapping Rain water problem

```
def trap(heights):

    # maintain two pointers left and right, pointing to the leftmost and
    # rightmost index of the input list
```

```
    (left, right) = (0, len(heights) - 1)
    water = 0

    maxLeft = heights[left]
    maxRight = heights[right]

    while left < right:
        if heights[left] <= heights[right]:
            left = left + 1
            maxLeft = max(maxLeft, heights[left])
            water += (maxLeft - heights[left])
        else:
            right = right - 1
            maxRight = max(maxRight, heights[right])
            water += (maxRight - heights[right])

    return water


heights = [7, 0, 4, 2, 5, 0, 6, 4, 0, 5]
print("The maximum amount of water that can be trapped is", trap(heights))
```

Chocolate Distribution problem

```
"""
Input : arr[] = {7, 3, 2, 4, 9, 12, 56} , m = 3
Output: Minimum Difference is 2
Explanation: We have seven packets of chocolates and we need to pick three packets for 3 students.
If we pick 2, 3 and 4, we get the minimum  difference between maximum and minimum packet sizes.
"""
# arr[0..n-1] represents sizes of packets
# m is number of students.
# Returns minimum difference between maximum
# and minimum values of distribution.
def findMinDiff(arr, m):
    n=len(arr)
    if (m==0 or n==0):
        return 0
    arr.sort()

    # Number of students cannot be more than number of packets
    if (n < m):
     return -1

    # Largest number of chocolates
    min_diff = arr[n-1] - arr[0]

    # Find the subarray of size m such that difference between last (maximum in case of sorted)
and
    #first (minimum in case of sorted) elements of subarray is minimum.
    for i in range(len(arr) - m + 1):
     min_diff = min(min_diff , arr[i + m - 1] - arr[i])

    return min_diff


arr = [12, 4, 7, 9, 2, 23, 25, 41, 30, 40, 28, 42, 30, 44, 48, 43, 50]
m = 7 # Number of students
print("Minimum difference is", findMinDiff(arr, m))
```

Smallest Subarray with sum greater than a given value

```
"""
Input: target = 7, nums = [2,3,1,2,4,3]
Output: 2
Explanation: The subarray [4,3] has the minimal length under the problem constraint.
"""
def minSubArrayLen(nums, target):
    i, j, pres, res = 0 , 0 , 0, len(nums) + 1
    while j < len(nums):
        pres += nums[j]; j += 1
        while pres >= target:
            res = min(res, j - i)
            pres -= nums[i]
            i+= 1
    return res if res != len(nums) + 1 else 0

sum=7
print(minSubArrayLen([2,3,1,2,4,3], sum))
```

Three way partitioning of an array around a given value

```
def threeWayPartition(arr, lowVal, highVal):
    n = len(arr)
    # Initialize ext available positions for smaller (than range) and greater elements
    start = 0
    end = n - 1
    i = 0

    # Traverse elements from left
    while i <= end:

        # If current element is smaller than range, put it on next available smaller position.
        if arr[i] < lowVal:
            arr[i], arr[start] = arr[start], arr[i]
            i += 1
            start += 1

        # If current element is greater than range, put it on next available greater position.
        elif arr[i] > highVal:
              arr[i], arr[end] = arr[end], arr[i]
              end -= 1
        else:
            i += 1

arr = [1, 14, 5, 20, 4, 2, 54, 20, 87, 98, 3, 1, 32]
"""
1) All elements smaller than lowVal come first.
2) All elements in range lowVal to highVal come next.
3) All elements greater than highVal appear in the end.
"""
threeWayPartition(arr, 10, 20)
print(arr)
```

Minimum swaps required bring elements less equal K together

```
"""
Find the minimum number of swaps required to bring all the numbers less than or equal to k
together, i.e. make them a contiguous subarray.
"""
def minSwap(arr, k) :
    n=len(arr)
    # Find count of elements which are less than equals to k
    count = 0
    for i in range(0, n) :
        if (arr[i] <= k) :
            count = count + 1

    # Find unwanted elements in current window of size 'count'
    bad = 0
    for i in range(0, count) :
        if (arr[i] > k) :
            bad = bad + 1

    # Initialize answer with 'bad' value of current window
    ans = bad
    j = count
    for i in range(0, n) :

        if(j == n) :
            break

        # Decrement count of previous window
        if (arr[i] > k) :
            bad = bad - 1

        # Increment count of current window
        if (arr[j] > k) :
            bad = bad + 1

        # Update ans if count of 'bad' is less in current window
        ans = min(ans, bad)
        j = j + 1

    return ans


arr = [2, 1, 5, 6, 3]
k = 3
print (minSwap(arr, k))

arr1 = [2, 7, 9, 5, 8, 7, 4]
k = 5
print (minSwap(arr1, k))
```

Minimum no. of operations required to make an array palindrome

```
"""
Input:  [6, 1, 3, 7]
Output: 1
```

```
Explanation: [6, 1, 3, 7] -> Merge 6 and 1 -> [7, 3, 7]
"""
def findMin(arr):

    # stores the minimum number of merge operations needed
    count = 0

    # `i` and `j` initially points to endpoints of the array
    i = 0
    j = len(arr) - 1

    # loop till the search space is exhausted
    while i < j:
        if arr[i] < arr[j]:
            # merge item at i'th index with the item at (i+1)'th index
            arr[i + 1] += arr[i]
            i = i + 1
            count = count + 1
        elif arr[i] > arr[j]:
            # merge item at (j-1)'th index with the item at j'th index
            arr[j - 1] += arr[j]
            j = j - 1
            count = count + 1
        # otherwise, ignore both the elements
        else:
            i = i + 1
            j = j - 1

    return count


arr = [6, 1, 4, 3, 1, 7]
min = findMin(arr)
print("The minimum number of operations required:", min)
```

Median of 2 sorted arrays of different size

```
def Solution(arr1, arr2):
    arr = arr1 + arr2
    arr.sort()
    n = len(arr)

    # If length of array is even
    if n % 2 == 0:
        return (arr[n // 2] + arr[n // 2 - 1]) / 2

    # If length of array is odd
    else:
        return arr[n//2]


arr1 = [ -5, 3, 6, 12, 15]
arr2 = [ -12, -10, -6, -3, 4, 10 ]
print("Median = ", Solution(arr1, arr2))
```

BackTracking

Rat in a maze Problem

```
"""
N = 4
m[][] = {{1, 0, 0, 0},
         {1, 1, 0, 1},
         {1, 1, 0, 0},
         {0, 1, 1, 1}}
Output:
DDRDRR DRDDRR
Explanation:
The rat can reach the destination at
(3, 3) from (0, 0) by two paths - DRDDRR
and DDRDRR, when printed in sorted order
we get DDRDRR DRDDRR.
"""
def setup():
    global v
    v = [[0 for i in range(100)] for j in range(100)]
    global ans
    ans = []

def path(arr, x, y, pth, n):
    if x==n-1 and y==n-1:
        global ans
        ans.append(pth)
        return
    global v
    if arr[x][y]==0 or v[x][y]==1:
        return
    v[x][y]=1
    if x>0:
        path(arr, x-1, y, pth+'U', n)
    if y>0:
        path(arr, x, y-1, pth+'L', n)
    if x<n-1:
        path(arr, x+1, y, pth+'D', n)
    if y<n-1:
        path(arr, x, y+1, pth+'R', n)
    v[x][y]=0

def findPath(m, n):
    global ans
    ans= []
    if m[0][0] == 0 or m[n-1][n-1]==0 :
        return ans
    setup()
    path(m, 0, 0, "", n)
    ans.sort()
    return ans

m = [ [ 1, 0, 0, 0, 0 ], [ 1, 1, 1, 1, 1 ], [ 1, 1, 1, 0, 1 ], [ 0, 0, 0, 0, 1 ],[ 0, 0, 0, 0, 1 ]
]
n = len(m)
print(findPath(m, n))
```

Printing all solutions in N-Queen Problem

```
def isSafe(mat, r, c):

    # return false if two queens share the same column
    for i in range(r):
        if mat[i][c] == 'Q':
            return False

    # return false if two queens share the same `` diagonal
    (i, j) = (r, c)
    while i >= 0 and j >= 0:
        if mat[i][j] == 'Q':
            return False
        i = i - 1
        j = j - 1

    # return false if two queens share the same `/` diagonal
    (i, j) = (r, c)
    while i >= 0 and j < len(mat):
        if mat[i][j] == 'Q':
            return False
        i = i - 1
        j = j + 1

    return True


def printSolution(mat):
    for r in mat:
        print(str(r).replace(',', '').replace('\'', ''))
    print()


def nQueen(mat, r):

    # if `N` queens are placed successfully, print the solution
    if r == len(mat):
        printSolution(mat)
        return

    # place queen at every square in the current row `r`
    # and recur for each valid movement
    for i in range(len(mat)):

        # if no two queens threaten each other
        if isSafe(mat, r, i):
            # place queen on the current square
            mat[r][i] = 'Q'

            # recur for the next row
            nQueen(mat, r + 1)

            # backtrack and remove the queen from the current square
            mat[r][i] = '-'


# `N × N` chessboard
N = 8

# `mat[][]` keeps track of the position of queens in
```

```
# the current configuration
mat = [['-' for x in range(N)] for y in range(N)]

nQueen(mat, 0)
```

Word Break Problem using Backtracking

```
# A recursive program to print all possible partitions of a given string into dictionary words

# A utility function to check whether a word is present in dictionary or not.  An array of strings
is used for dictionary.  Using array of strings for dictionary is definitely not a good idea. We
have used for simplicity of the program
def dictionaryContains(word):
    dictionary = {"mobile", "samsung", "sam", "sung", "man",
                  "mango", "icecream", "and", "go", "i", "love", "ice", "cream"}
    return word in dictionary

# Prints all possible word breaks of given string
def wordBreak(string):

    # Last argument is prefix
    wordBreakUtil(string, len(string), "")

# Result store the current prefix with spaces
# between words
def wordBreakUtil(string, n, result):

    # Process all prefixes one by one
    for i in range(1, n + 1):

        # Extract substring from 0 to i in prefix
        prefix = string[:i]

        # If dictionary contains this prefix, then
        # we check for remaining string. Otherwise
        # we ignore this prefix (there is no else for
        # this if) and try next
        if dictionaryContains(prefix):

            # If no more elements are there, print it
            if i == n:

                # Add this element to previous prefix
                result += prefix
                print(result)
                return
            wordBreakUtil(string[i:], n - i, result+prefix+" ")


print("First Test:")
wordBreak("iloveicecreamandmango")

print("\nSecond Test:")
wordBreak("ilovesamsungmobile")
```

Remove Invalid Parentheses

```python
from collections import deque

def isValidString(string):
    left = 0
    right = 0
    index = 0

    while index < len(string):
        if string[index] == '(':
            left += 1

        elif string[index] == ')':
            if left > 0:
                left -= 1

            else:
                right += 1

            if right > left:
                return False

        index += 1

    return left == right

def removeInvalidParentheses(string):

    visited = set()
    result = []
    q = deque()
    valid = False

    visited.add(string)
    q.append(string)
    # BFS.
    while len(q) > 0:
        possibleAnswer = q.popleft()

        # Check whether 'possibleAnswer' is valid or not.
        if isValidString(possibleAnswer):
            result.append(possibleAnswer)
            valid = True

        # If true, then the solution exists at current level. No need to move at next state.
        if valid == True:
            continue

        # Generate all possible next state of Strings from current String.
        for i in range(len(possibleAnswer)):
            if possibleAnswer[i] == '(' or possibleAnswer[i] == ')':
                temp = possibleAnswer[0 : i] + possibleAnswer[i + 1 : len(possibleAnswer)]

                if temp not in visited:
                    q.append(temp)
                    visited.add(temp)

    return sorted(result)

print(removeInvalidParentheses(')(()))'))
```

```
print(removeInvalidParentheses('(((a))) ((a))()'))
```

Sudoku Solver

```
# N is the size of the 2D matrix N*N
N = 9

# A utility function to print grid
def printing(arr):
    for i in range(N):
        for j in range(N):
            print(arr[i][j], end = " ")
        print()

# Checks whether it will be legal to assign num to the given row, col
def isSafe(grid, row, col, num):

    # Check if we find the same num in the similar row , we return false
    for x in range(9):
        if grid[row][x] == num:
            return False

    # Check if we find the same num in the similar column , we return false
    for x in range(9):
        if grid[x][col] == num:
            return False

    # Check if we find the same num in the particular 3*3 matrix, we return false
    startRow = row - row % 3
    startCol = col - col % 3
    for i in range(3):
        for j in range(3):
            if grid[i + startRow][j + startCol] == num:
                return False
    return True

# Takes a partially filled-in grid and attempts to assign values to all unassigned locations in
# such a way to meet the requirements for Sudoku solution (non-duplication across rows, columns,
and boxes)
def solveSudoku(grid, row, col):

    # Check if we have reached the 8th row and 9th column (0 indexed matrix) , we are
    # returning true to avoid further backtracking
    if (row == N - 1 and col == N):
        return True

    # Check if column value becomes 9 , we move to next row and column start from 0
    if col == N:
        row += 1
        col = 0

    # Check if the current position of the grid already contains value >0, we iterate for next
column
    if grid[row][col] > 0:
        return solveSudoku(grid, row, col + 1)
    for num in range(1, N + 1, 1):
```

```
        # Check if it is safe to place the num (1-9) in the given row ,col ->we
        # move to next column
        if isSafe(grid, row, col, num):

            # Assigning the num in the current (row,col) position of the grid and assuming our
assigned
            # num in the position is correct
            grid[row][col] = num

            # Checking for next possibility with next column
            if solveSudoku(grid, row, col + 1):
                return True

        # Removing the assigned num , since our assumption was wrong , and we go for next
assumption with
     #diff num value
        grid[row][col] = 0
    return False


# 0 means unassigned cells
grid = [[3, 0, 6, 5, 0, 8, 4, 0, 0],
        [5, 2, 0, 0, 0, 0, 0, 0, 0],
        [0, 8, 7, 0, 0, 0, 0, 3, 1],
        [0, 0, 3, 0, 1, 0, 0, 8, 0],
        [9, 0, 0, 8, 6, 3, 0, 0, 5],
        [0, 5, 0, 0, 9, 0, 6, 0, 0],
        [1, 3, 0, 0, 0, 0, 2, 5, 0],
        [0, 0, 0, 0, 0, 0, 0, 7, 4],
        [0, 0, 5, 2, 0, 6, 3, 0, 0]]

if (solveSudoku(grid, 0, 0)):
    printing(grid)
else:
    print("no solution exists ")
```

m-Colouring Problem

```
"""
An array color[V] that should have numbers from 1 to m. color[i] should represent the color
assigned to the ith vertex.
The code should also return false if the graph cannot be colored with m colors.
"""

from queue import Queue

class node(object):
    color = 1
    edges = set()

def canPaint(nodes, n, m):

    # Create a visited array of n nodes, initialized to zero
    visited = [0 for _ in range(n+1)]

    # maxColors used till now are 1 as all nodes are painted color 1
    maxColors = 1

    # Do a full BFS traversal from all unvisited starting points
```

```
    for _ in range(1, n + 1):
        if visited[_]:
            continue

        # If the starting point is unvisited, mark it visited and push it in queue
        visited[_] = 1
        q = Queue()
        q.put(_)

        # BFS Travel starts here
        while not q.empty():
            top = q.get()

            # Checking all adjacent nodes to "top" edge in our queue
            for _ in nodes[top].edges:

                # IMPORTANT: If the color of the adjacent node is same, increase it by 1

                if nodes[top].color == nodes[_].color:
                    nodes[_].color += 1

                # If number of colors used shoots m, return 0
                maxColors = max(maxColors, max(
                    nodes[top].color, nodes[_].color))

                if maxColors > m:
                    print(maxColors)
                    return 0

                # If the adjacent node is not visited, mark it visited and push it in queue
                if not visited[_]:
                    visited[_] = 1
                    q.put(_)

    return 1


n = 4
graph = [ [ 0, 1, 1, 1 ],
          [ 1, 0, 1, 0 ],
          [ 1, 1, 0, 1 ],
          [ 1, 0, 1, 0 ] ]

# Number of colors
m = 3

# Create a vector of n+1 nodes of type "node" The zeroth position is just dummy (1 to n to be
used)
nodes = []
for _ in range(n+1):
    nodes.append(node())

# Add edges to each node as per given input
for _ in range(n):
    for __ in range(n):
        if graph[_][__]:

            # Connect the undirected graph
            nodes[_].edges.add(_)
            nodes[__].edges.add(__)
```

```
# Display final answer
print(canPaint(nodes, n, m))
```

Print all palindromic partitions of a string

```
def isPalindrome(string: str,
                 low: int, high: int):
    while low < high:
        if string[low] != string[high]:
            return False
        low += 1
        high -= 1
    return True

# Recursive function to find all palindromic partitions of str[start..n-1]
# allPart --> A vector of vector of strings.
#             Every vector inside it stores a partition
# currPart --> A vector of strings to store current partition
def allPalPartUtil(allPart: list, currPart: list,
                   start: int, n: int, string: str):

    # If 'start' has reached len
    if start >= n:

        # In Python list are passed by reference that is why it is needed to copy first and then
append
        x = currPart.copy()

        allPart.append(x)
        return

    # Pick all possible ending points for substrings
    for i in range(start, n):

        # If substring str[start..i] is palindrome
        if isPalindrome(string, start, i):

            # Add the substring to result
            currPart.append(string[start:i + 1])

            # Recur for remaining substring
            allPalPartUtil(allPart, currPart,
                           i + 1, n, string)

            # Remove substring str[start..i] from current partition
            currPart.pop()

# Function to print all possible palindromic partitions of str.
# It mainly creates vectors and calls allPalPartUtil()
def allPalPartitions(string: str):

    n = len(string)

    # To Store all palindromic partitions
    allPart = []

    # To store current palindromic partition
    currPart = []
```

```
    # Call recursive function to generate all partitions and store in allPart
    allPalPartUtil(allPart, currPart, 0, n, string)

    # Print all partitions generated by above call
    for i in range(len(allPart)):
        for j in range(len(allPart[i])):
            print(allPart[i][j], end = " ")
        print()


string = "nitin"
allPalPartitions(string)
```

Subset Sum Problem

```
"""
Input : arr[] = {4, 1, 10, 12, 5, 2},
          sum = 9
Output : TRUE
{4, 5} is a subset with sum 9.

Input : arr[] = {1, 8, 2, 5},
          sum = 4
Output : FALSE
There exists no subset with sum 4.
"""
def isPossible(elements, target):

    dp = [False]*(target+1)

    # initializing with 1 as sum 0 is always possible
    dp[0] = True

    # loop to go through every element of the elements array
    for ele in elements:

        # to change the value o all possible sum values to True
        for j in range(target, ele - 1, -1):
            if dp[j - ele]:
                dp[j] = True

    # If target is possible return True else False
    return dp[target]

# Driver code
arr = [6, 2, 5]
target = 7

if isPossible(arr, target):
    print("YES")
else:
    print("NO")
```

The Knight’s tour problem

```
# Chessboard Size
n = 6
```

```
def isSafe(x, y, board):
  '''
    A utility function to check if i,j are valid indexes
    for N*N chessboard
  '''
  if(x >= 0 and y >= 0 and x < n and y < n and board[x][y] == -1):
    return True
  return False


def printSolution(n, board):
  '''
    A utility function to print Chessboard matrix
  '''
  for i in range(n):
    for j in range(n):
      print(board[i][j], end=' ')
    print()


def solveKT(n):
  '''
    This function solves the Knight Tour problem using
    Backtracking. This function mainly uses solveKTUtil()
    to solve the problem. It returns false if no complete
    tour is possible, otherwise return true and prints the
    tour.
    Please note that there may be more than one solutions,
    this function prints one of the feasible solutions.
  '''

  # Initialization of Board matrix
  board = [[-1 for i in range(n)]for i in range(n)]

  # move_x and move_y define next move of Knight.
  # move_x is for next value of x coordinate
  # move_y is for next value of y coordinate
  move_x = [2, 1, -1, -2, -2, -1, 1, 2]
  move_y = [1, 2, 2, 1, -1, -2, -2, -1]

  # Since the Knight is initially at the first block
  board[0][0] = 0

  # Step counter for knight's position
  pos = 1

  # Checking if solution exists or not
  if(not solveKTUtil(n, board, 0, 0, move_x, move_y, pos)):
    print("Solution does not exist")
  else:
    printSolution(n, board)


def solveKTUtil(n, board, curr_x, curr_y, move_x, move_y, pos):
  '''
    A recursive utility function to solve Knight Tour
    problem
  '''
```

```
  if(pos == n**2):
    return True

  # Try all next moves from the current coordinate x, y
  for i in range(8):
    new_x = curr_x + move_x[i]
    new_y = curr_y + move_y[i]
    if(isSafe(new_x, new_y, board)):
      board[new_x][new_y] = pos
      if(solveKTUtil(n, board, new_x, new_y, move_x, move_y, pos+1)):
        return True

      # Backtracking
      board[new_x][new_y] = -1
  return False

solveKT(n)
```

Tug of War

```
# function that tries every possible solution by calling itself recursively
def TOWUtil(arr, n, curr_elements, no_of_selected_elements,
      soln, min_diff, Sum, curr_sum, curr_position):

  # checks whether the it is going out of bound
  if (curr_position == n):
    return

  # checks that the numbers of elements left are not less than the number of elements required to
form the solution
  if ((int(n / 2) - no_of_selected_elements) >(n - curr_position)):
    return

  # consider the cases when current element is not included in the solution
  TOWUtil(arr, n, curr_elements, no_of_selected_elements, soln, min_diff, Sum, curr_sum,
curr_position + 1)

  # add the current element to the solution
  no_of_selected_elements += 1
  curr_sum = curr_sum + arr[curr_position]
  curr_elements[curr_position] = True

  # checks if a solution is formed
  if (no_of_selected_elements == int(n / 2)):

    # checks if the solution formed is better than the best solution so far
    if (abs(int(Sum / 2) - curr_sum) < min_diff[0]):
      min_diff[0] = abs(int(Sum / 2) - curr_sum)
      for i in range(n):
        soln[i] = curr_elements[i]
  else:

    # consider the cases where current element is included in the solution
    TOWUtil(arr, n, curr_elements, no_of_selected_elements, soln, min_diff, Sum, curr_sum,
curr_position + 1)

  # removes current element before returning
  # to the caller of this function
  curr_elements[curr_position] = False
```

```
# main function that generate an arr
def tugOfWar(arr, n):

  # the boolean array that contains the inclusion and exclusion of an element
  # in current set. The number excluded automatically form the other set
  curr_elements = [None] * n

  # The inclusion/exclusion array for final solution
  soln = [None] * n

  min_diff = [999999999999]
  Sum = 0

  for i in range(n):
    Sum += arr[i]
    curr_elements[i] = soln[i] = False

  # Find the solution using recursive function TOWUtil()
  TOWUtil(arr, n, curr_elements, 0, soln, min_diff, Sum, 0, 0)

  # Print the solution
  print("The first subset is: ")
  for i in range(n):
    if (soln[i] == True):
      print(arr[i], end = " ")
  print()
  print("The second subset is: ")
  for i in range(n):
    if (soln[i] == False):
      print(arr[i], end = " ")


arr = [23, 45, -34, 12, 0, 98, -99, 4, 189, -1, 4]
n = len(arr)
tugOfWar(arr, n)
```

Find shortest safe route in a path with landmines

```
# Python3 program to find shortest safe Route
# in the matrix with landmines
import sys

R = 12
C = 10

# These arrays are used to get row and column
# numbers of 4 neighbours of a given cell
rowNum = [ -1, 0, 0, 1 ]
colNum = [ 0, -1, 1, 0 ]

min_dist = sys.maxsize

# A function to check if a given cell (x, y)
# can be visited or not
def isSafe(mat, visited, x, y):

  if (mat[x][y] == 0 or visited[x][y]):
```

```
    return False

  return True

# A function to check if a given cell (x, y) is
# a valid cell or not
def isValid(x, y):

  if (x < R and y < C and x >= 0 and y >= 0):
    return True

  return False

# A function to mark all adjacent cells of
# landmines as unsafe. Landmines are shown with
# number 0
def markUnsafeCells(mat):

  for i in range(R):
    for j in range(C):
      # If a landmines is found
      if (mat[i][j] == 0):
        # Mark all adjacent cells
        for k in range(4):
          if (isValid(i + rowNum[k], j + colNum[k])):
            mat[i + rowNum[k]][j + colNum[k]] = -1

  # Mark all found adjacent cells as unsafe
  for i in range(R):
    for j in range(C):
      if (mat[i][j] == -1):
        mat[i][j] = 0

  print(mat)
"""
      for i in range(R):
          for j in range(C):
              print(mat[i][j], end='')
          print()
"""

# Function to find shortest safe Route in the matrix with landmines
# mat[][] - binary input matrix with safe cells marked as 1
# visited[][] - store info about cells already visited in current route
# (i, j) are coordinates of the current cell
# min_dist --> stores minimum cost of shortest path so far
# dist --> stores current path cost

def findShortestPathUtil(mat, visited, i, j, dist):
  global min_dist

  # If destination is reached
  if (j == C - 1):
    # Update shortest path found so far
    min_dist = min(dist, min_dist)
    return

  # If current path cost exceeds minimum so far
  if (dist > min_dist):
    return
```

```
  # include (i, j) in current path
  visited[i][j] = True

  # Recurse for all safe adjacent neighbours
  for k in range(4):
    if (isValid(i + rowNum[k], j + colNum[k]) and isSafe(mat, visited, i + rowNum[k], j +
colNum[k])):
      findShortestPathUtil(mat, visited, i + rowNum[k], j + colNum[k], dist + 1)

  # Backtrack
  visited[i][j] = False

# A wrapper function over findshortestPathUtil()
def findShortestPath(mat):

  global min_dist

  # Stores minimum cost of shortest path so far
  min_dist = sys.maxsize

  # Create a boolean matrix to store info about
  # cells already visited in current route
  visited = [[False for i in range(C)] for j in range(R)]

  # Mark adjacent cells of landmines as unsafe
  markUnsafeCells(mat)

  # Start from first column and take minimum
  for i in range(R):
    # If path is safe from current cell
    if (mat[i][0] == 1):
      # Find shortest route from (i, 0) to any
      # cell of last column (x, C - 1) where
      # 0 <= x < R
      findShortestPathUtil(mat, visited, i, 0, 0)

      # If min distance is already found
      if (min_dist == C - 1):
        break

  # If destination can be reached
  if (min_dist != sys.maxsize):
    print("Length of shortest safe route is", min_dist)
  else:
    # If the destination is not reachable
    print("Destination not reachable from given source")

mat = [
    [ 1, 1, 1, 1, 1, 1, 1, 1, 1, 1 ],
    [ 1, 0, 1, 1, 1, 1, 1, 1, 1, 1 ],
    [ 1, 1, 1, 0, 1, 1, 1, 1, 1, 1 ],
    [ 1, 1, 1, 1, 0, 1, 1, 1, 1, 1 ],
    [ 1, 1, 1, 1, 1, 1, 1, 1, 1, 1 ],
    [ 1, 1, 1, 1, 1, 0, 1, 1, 1, 1 ],
    [ 1, 0, 1, 1, 1, 1, 1, 1, 0, 1 ],
    [ 1, 1, 1, 1, 1, 1, 1, 1, 1, 1 ],
    [ 1, 1, 1, 1, 1, 1, 1, 1, 1, 1 ],
    [ 0, 1, 1, 1, 1, 0, 1, 1, 1, 1 ],
    [ 1, 1, 1, 1, 1, 1, 1, 1, 1, 1 ],
```

```
    [ 1, 1, 1, 0, 1, 1, 1, 1, 1, 1 ] ]

# Find shortest path
findShortestPath(mat)
```

Combinational Sum

```
"""Find all combinations that sum to a given value.
Input : arr[] = 2, 4, 6, 8
            x = 8
Output : [2, 2, 2, 2]
         [2, 2, 4]
         [2, 6]
         [4, 4]
         [8]
"""
def combinationSum(arr, sum):
  ans = []
  temp = []

  # first do hashing nothing but set{} since set does not always sort removing the duplicates
  # using Set and Sorting the List
  arr = sorted(list(set(arr)))
  findNumbers(ans, arr, temp, sum, 0)
  return ans

def findNumbers(ans, arr, temp, sum, index):

  if(sum == 0):

    # Adding deep copy of list to ans
    ans.append(list(temp))
    return

  # Iterate from index to len(arr) - 1
  for i in range(index, len(arr)):

    # checking that sum does not become negative
    if(sum - arr[i]) >= 0:

      # adding element which can contribute to
      # sum
      temp.append(arr[i])
      findNumbers(ans, arr, temp, sum-arr[i], i)

      # removing element from list (backtracking)
      temp.remove(arr[i])


arr = [2, 4, 6, 8]
sum = 8
ans = combinationSum(arr, sum)

# If result is empty, then
if len(ans) <= 0:
  print("empty")

# print all combinations stored in ans
for i in range(len(ans)):
```

```
  print("(", end=' ')
  for j in range(len(ans[i])):
    print(str(ans[i][j])+" ", end=' ')
  print(")", end=' ')
```

Find Maximum number possible by doing at-most K swaps

```
"""
Given a positive integer, find the maximum integer possible by doing at-most K swap operations on
its digits.
Examples:
Input: M = 254, K = 1
Output: 524
Swap 5 with 2 so number becomes 524
"""

# function to find maximum integer possible by doing at-most K swap operations on its digits
def findMaximumNum(string, k, maxm, ctr):

  # return if no swaps left
  if k == 0:
    return

  n = len(string)
  # Consider every digit after the cur position
  mx = string[ctr]

  for i in range(ctr+1,n):
    # Find maximum digit greater than at ctr among rest
    if int(string[i]) > int(mx):
      mx=string[i]

  # If maxm is not equal to str[ctr], decrement k
  if(mx!=string[ctr]):
    k=k-1

  # search this maximum among the rest from behind first swap the last maximum digit if it occurs
more then 1 time
  # example str= 1293498 and k=1 then max string is 9293418 instead of 9213498
  for i in range(ctr,n):
    # If digit equals maxm swap the digit with current digit and recurse for the rest
    if(string[i]==mx):
      # swap str[ctr] with str[j]
      string[ctr], string[i] = string[i], string[ctr]
      new_str = "".join(string)
      # If current num is more than maximum so far
      if int(new_str) > int(maxm[0]):
        maxm[0] = new_str

      # recurse of the other k - 1 swaps
      findMaximumNum(string, k , maxm, ctr+1)

      # backtrack
      string[ctr], string[i] = string[i], string[ctr]


string = "129814999"
```

```
k = 4
maxm = [string]
string = [char for char in string]
findMaximumNum(string, k, maxm, 0)
print(maxm[0])
```

Print all permutations of a string

```
def permute(s, answer):
  if (len(s) == 0):
    print(answer, end = " ")
    return

  for i in range(len(s)):
    ch = s[i]
    left_substr = s[0:i]
    right_substr = s[i + 1:]
    rest = left_substr + right_substr
    permute(rest, answer + ch)

answer=""
s = "alex"
print("All possible strings are : ")
permute(s, answer)
```

Find if there is a path of more than k length from a source

```
# Program to find if there is a simple path with weight more than k

# This class represents a dipathted graph using adjacency list representation
class Graph:
  # Allocates memory for adjacency list
  def __init__(self, V):
    self.V = V
    self.adj = [[] for i in range(V)]

  # Returns true if graph has path more than k length
  def pathMoreThanK(self,src, k):
    # Create a path array with nothing included in path
    path = [False]*self.V

    # Add source vertex to path
    path[src] = 1

    return self.pathMoreThanKUtil(src, k, path)

  # Prints shortest paths from src to all other vertices
  def pathMoreThanKUtil(self,src, k, path):
    # If k is 0 or negative, return true
    if (k <= 0):
      return True

    # Get all adjacent vertices of source vertex src and recursively explore all paths from src.
    i = 0
    while i != len(self.adj[src]):
      # Get adjacent vertex and weight of edge
      v = self.adj[src][i][0]
```

```
      w = self.adj[src][i][1]
      i += 1

      # If vertex v is already there in path, then there is a cycle (we ignore this edge)
      if (path[v] == True):
        continue

      # If weight of is more than k, return true
      if (w >= k):
        return True

      # Else add this vertex to path
      path[v] = True

      # If this adjacent can provide a path longer than k, return true.
      if (self.pathMoreThanKUtil(v, k-w, path)):
        return True

      # Backtrack
      path[v] = False

    # If no adjacent could produce longer path, return false
    return False

  # Utility function to an edge (u, v) of weight w
  def addEdge(self,u, v, w):
    self.adj[u].append([v, w])
    self.adj[v].append([u, w])


# create the graph given in above figure
V = 9
g = Graph(V)
# making above shown graph
g.addEdge(0, 1, 4)
g.addEdge(0, 7, 8)
g.addEdge(1, 2, 8)
g.addEdge(1, 7, 11)
g.addEdge(2, 3, 7)
g.addEdge(2, 8, 2)
g.addEdge(2, 5, 4)
g.addEdge(3, 4, 9)
g.addEdge(3, 5, 14)
g.addEdge(4, 5, 10)
g.addEdge(5, 6, 2)
g.addEdge(6, 7, 1)
g.addEdge(6, 8, 6)
g.addEdge(7, 8, 7)

#calling in the function
src = 0
k = 62
print("Yes") if g.pathMoreThanK(src, k) else print("No")
k = 60
print("Yes") if g.pathMoreThanK(src, k) else print("No")
```

Longest Possible Route in a Matrix with Hurdles

```python
# Python program to find Longest Possible Route in a matrix with hurdles
import sys
R,C = 3,10

# A Pair to store status of a cell. found is set to True of destination is reachable and value stores
# distance of longest path
class Pair:
  def __init__(self, found, value):
    self.found = found
    self.value = value

# Function to find Longest Possible Route in the matrix with hurdles. If the destination is not reachable
# the function returns false with cost sys.maxsize. (i, j) is source cell and (x, y) is destination cell.
def findLongestPathUtil(mat, i, j, x, y, visited):

  # if (i, j) itself is destination, return True
  if (i == x and j == y):
    p = Pair( True, 0 )
    return p

  # if not a valid cell, return false
  if (i < 0 or i >= R or j < 0 or j >= C or mat[i][j] == 0 or visited[i][j]) :
    p = Pair( False, sys.maxsize )
    return p

  # include (i, j) in current path i.e. set visited(i, j) to True
  visited[i][j] = True

  # res stores longest path from current cell (i, j) to destination cell (x, y)
  res = -sys.maxsize -1

  # go left from current cell
  sol = findLongestPathUtil(mat, i, j - 1, x, y, visited)

  # if destination can be reached on going left from current cell, update res
  if (sol.found):
    res = max(res, sol.value)

  # go right from current cell
  sol = findLongestPathUtil(mat, i, j + 1, x, y, visited)

  # if destination can be reached on going right from current cell, update res
  if (sol.found):
    res = max(res, sol.value)

  # go up from current cell
  sol = findLongestPathUtil(mat, i - 1, j, x, y, visited)

  # if destination can be reached on going up from current cell, update res
  if (sol.found):
    res = max(res, sol.value)

  # go down from current cell
  sol = findLongestPathUtil(mat, i + 1, j, x, y, visited)

  # if destination can be reached on going down from current cell, update res
  if (sol.found):
```

```
    res = max(res, sol.value)

  # Backtrack
  visited[i][j] = False

  # if destination can be reached from current cell, return True
  if (res != -sys.maxsize -1):
    p = Pair( True, 1 + res )
    return p

  # if destination can't be reached from current cell, return false
  else:
    p = Pair( False, sys.maxsize )
    return p

# A wrapper function over findLongestPathUtil()
def findLongestPath(mat, i, j, x,y):

  # create a boolean matrix to store info about cells already visited in current route initialize
visited to false
  visited = [[False for i in range(C)]for j in range(R)]

  # find longest route from (i, j) to (x, y) and print its maximum cost
  p = findLongestPathUtil(mat, i, j, x, y, visited)
  if (p.found):
    print("Length of longest possible route is ",str(p.value))

  # If the destination is not reachable
  else:
    print("Destination not reachable from given source")

# input matrix with hurdles shown with number 0
mat = [ [ 1, 1, 1, 1, 1, 1, 1, 1, 1, 1 ],
    [ 1, 1, 0, 1, 1, 0, 1, 1, 0, 1 ],
    [ 1, 1, 1, 1, 1, 1, 1, 1, 1, 1 ] ]

# find longest path with source (0, 0) and destination (1, 7)
findLongestPath(mat, 0, 0, 1, 7)
```

Print all possible paths from top left to bottom right of a mXn matrix

```
"""
The problem is to print all the possible paths from top left to bottom right of a mXn matrix with
the constraints that from each cell you can either move only to right or down.

Examples :

Input : 1 2 3
        4 5 6
Output : 1 4 5 6
         1 2 5 6
         1 2 3 6

Input : 1 2
        3 4
Output : 1 2 4
         1 3 4
```

```
"""

def printAllPaths(M, m, n):
  mapping = {}
  if not mapping.get((m,n)):
    if m == 1 and n == 1:
      return [M[m-1][n-1]]
    else:
      res = []
      if n > 1:
        a = printAllPaths(M, m, n-1)
        for i in a:
          if not isinstance(i, list):
            i = [i]
          res.append(i+[M[m-1][n-1]])
      if m > 1:
        b =printAllPaths(M, m-1, n)
        for i in b:
          if not isinstance(i, list):
            i = [i]
          res.append(i+[M[m-1][n-1]])
    mapping[(m,n)] = res
  return mapping.get((m,n))

M = [[1, 2, 3], [4, 5, 6], [7,8,9]]
m, n = len(M), len(M[0])
res = printAllPaths(M, m, n)
for i in res:
  print(i)
```

Partition of a set intoK subsets with equal sum

```
"""
Input : arr = [2, 1, 4, 5, 6], K = 3
Output : Yes
we can divide above array into 3 parts with equal
sum as [[2, 4], [1, 5], [6]]

Input  : arr = [2, 1, 5, 5, 6], K = 3
Output : No
It is not possible to divide above array into 3
parts with equal sum
"""

"""*
array   - given input array
subsetSum array - sum to store each subset of the array
taken   -boolean array to check whether element
is taken into sum partition or not
K     - number of partitions needed
N     - total number of element in array
curIdx   - current subsetSum index
limitIdx   - lastIdx from where array element should
be taken """

def isKPartitionPossibleRec(arr, subsetSum, taken, subset, K, N, curIdx, limitIdx):
  if subsetSum[curIdx] == subset:
```

```
    """
    current index (K - 2) represents (K - 1)
    subsets of equal sum last partition will
    already remain with sum 'subset'
    """
    if (curIdx == K - 2):
      return True

    # recursive call for next subsetition
    return isKPartitionPossibleRec(arr, subsetSum, taken,
                  subset, K, N, curIdx + 1 , N - 1)

  # start from limitIdx and include elements into current partition
  for i in range(limitIdx, -1, -1):

    # if already taken, continue
    if (taken[i]):
      continue
    tmp = subsetSum[curIdx] + arr[i]

    # if temp is less than subset, then only include the element and call recursively
    if (tmp <= subset):

      # mark the element and include into current partition sum
      taken[i] = True
      subsetSum[curIdx] += arr[i]
      nxt = isKPartitionPossibleRec(arr, subsetSum, taken,
                    subset, K, N, curIdx, i - 1)

      # after recursive call unmark the element and remove from subsetition sum
      taken[i] = False
      subsetSum[curIdx] -= arr[i]
      if (nxt):
        return True
  return False

# Method returns True if arr can be partitioned into K subsets with equal sum
def isKPartitionPossible(arr, N, K):

  # If K is 1, then complete array will be our answer
  if (K == 1):
    return True

  # If total number of partitions are more than N, then division is not possible
  if (N < K):
    return False

  # if array sum is not divisible by K then we can't divide array into K partitions
  sum = 0
  for i in range(N):
    sum += arr[i]
  if (sum % K != 0):
    return False

  # the sum of each subset should be subset (= sum / K)
  subset = sum // K
  subsetSum = [0] * K
  taken = [0] * N

  # Initialize sum of each subset from 0
```

```
  for i in range(K):
    subsetSum[i] = 0

  # mark all elements as not taken
  for i in range(N):
    taken[i] = False

  # initialize first subset sum as last element of array and mark that as taken
  subsetSum[0] = arr[N - 1]
  taken[N - 1] = True

  # call recursive method to check K-substitution condition
  return isKPartitionPossibleRec(arr, subsetSum, taken,
                subset, K, N, 0, N - 1)

arr = [2, 1, 4, 5, 3, 3 ]
N = len(arr)
K = 3
if (isKPartitionPossible(arr, N, K)):
  print("Partitions into equal sum is possible.\n")
else:
  print("Partitions into equal sum is not possible.\n")
```

Find the K-th Permutation Sequence of first N natural numbers

```
"""
Input: N = 3, K = 4
Output: 231
Explanation:
The ordered list of permutation sequence from integer 1 to 3 is : 123, 132, 213, 231, 312, 321.
So, the 4th permutation sequence is “231”.

Input: N = 2, K = 1
Output: 12
Explanation:
For n = 2, only 2 permutations are possible 12 21. So, the 1st permutation sequence is “12”.
"""



# Function to find the index of number at first position of kth sequence of set of size n
def findFirstNumIndex(k, n):
  if (n == 1):
    return 0, k
  n -= 1
  first_num_index = 0

  # n_actual_fact = n!
  n_partial_fact = n

  while (k >= n_partial_fact and n > 1):
    n_partial_fact = n_partial_fact * (n - 1)
    n -= 1

  # First position of the kth sequence will be occupied by the number present at index = k / (n-1)!
  first_num_index = k // n_partial_fact
  k = k % n_partial_fact
```

```
  return first_num_index, k

# Function to find the kth permutation of n numbers
def findKthPermutation(n, k):

  # Store final answer
  ans = ""
  s = set()

  # Insert all natural number upto n in set
  for i in range(1, n + 1):
    s.add(i)

  # Subtract 1 to get 0 based indexing
  k = k - 1

  for i in range(n):

    # Mark the first position
    itr = list(s)

    index, k = findFirstNumIndex(k, n - i)

    # itr now points to the number at index in set s
    ans += str(itr[index])

    # remove current number from the set
    itr.pop(index)

    s = set(itr)

  return ans

n = 3
k = 4
kth_perm_seq = findKthPermutation(n, k)
print(kth_perm_seq)
```

Binary Trees

level order traversal AKA BFS

```
class Node:
  def __init__(self, key):
    self.data = key
    self.left = None
    self.right = None


def printLevelOrder(root):
  # Base Case
  if root is None:
    return

  # Create an empty queue for level order traversal
```

```
  queue = []

  # Enqueue Root and initialize height
  queue.append(root)

  while(len(queue) > 0):

    # Print front of queue and remove it from queue
    print(queue[0].data)
    node = queue.pop(0)

    # Enqueue left child
    if node.left is not None:
      queue.append(node.left)

    # Enqueue right child
    if node.right is not None:
      queue.append(node.right)


root = Node(1)
root.left = Node(2)
root.right = Node(3)
root.left.left = Node(4)
root.left.right = Node(5)

print("Level Order Traversal of binary tree is -")
printLevelOrder(root)
```

Reverse Level Order traversal

```
from collections import deque

class Node:
  def __init__(self, data):
    self.data = data
    self.left = None
    self.right = None

def reverseLevelOrder(root):
  q = deque()
  q.append(root)
  ans = deque()
  while q:
    node = q.popleft()
    if node is None:
      continue

    ans.appendleft(node.data)

    if node.right:
      q.append(node.right)

    if node.left:
      q.append(node.left)

  return ans

root = Node(1)
```

```
root.left = Node(2)
root.right = Node(3)
root.left.left = Node(4)
root.left.right = Node(5)
root.right.left = Node(6)
root.right.right = Node(7)

print ("Level Order traversal of binary tree is", reverseLevelOrder(root))
```

Height of a tree

```
"""
Given a binary tree, find height of it. Height of empty tree is -1, height of tree with one node
is 0
"""
class Node:

  # Constructor to create a new node
  def __init__(self, data):
    self.data = data
    self.left = None
    self.right = None

# Compute the "maxDepth" of a tree -- the number of nodes along the longest path from the root
node down to the
# farthest leaf node
def maxDepth(node):
  if node is None:
    return 0 ;

  else :

    # Compute the depth of each subtree
    lDepth = maxDepth(node.left)
    rDepth = maxDepth(node.right)

    # Use the larger one
    if (lDepth > rDepth):
      return lDepth+1
    else:
      return rDepth+1


root = Node(1)
root.left = Node(2)
root.right = Node(3)
root.left.left = Node(4)
root.left.right = Node(5)

print ("Height of tree is %d" %(maxDepth(root)))
```

Diameter of a tree

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

```
def height(node):

  # Base Case : Tree is empty
  if node is None:
    return 0

  # If tree is not empty then height = 1 + max of left
  # height and right heights
  return 1 + max(height(node.left), height(node.right))

# Function to get the diameter of a binary tree
def diameter(root):

  # Base Case when tree is empty
  if root is None:
    return 0

  # Get the height of left and right sub-trees
  lheight = height(root.left)
  rheight = height(root.right)

  # Get the diameter of left and right sub-trees
  ldiameter = diameter(root.left)
  rdiameter = diameter(root.right)

  # Return max of the following tree:
  # 1) Diameter of left subtree
  # 2) Diameter of right subtree
  # 3) Height of left subtree + height of right subtree +1
  return max(lheight + rheight + 1, max(ldiameter, rdiameter))

"""
Constructed binary tree is
      1
    / \
    2   3
  / \
  4   5
"""
root = Node(1)
root.left = Node(2)
root.right = Node(3)
root.left.left = Node(4)
root.left.right = Node(5)
print(diameter(root))
```

Mirror of a tree / Invert Binary Tree

```
from collections import deque

class Node:
    def __init__(self, data, left=None, right=None):
        self.data = data
        self.left = left
        self.right = right


# Function to perform preorder traversal on a given binary tree
```

```
def preorder(root):
    if root is None:
        return
    print(root.data, end=' ')
    preorder(root.left)
    preorder(root.right)

# Utility function to swap left subtree with right subtree
def swap(root):
    if root is None:
        return
    temp = root.left
    root.left = root.right
    root.right = temp


# Iterative function to invert a given binary tree using a queue
def invertBinaryTree(root):
    # base case: if the tree is empty
    if root is None:
        return

    # maintain a queue and push the root node
    q = deque()
    q.append(root)

    # loop till queue is empty
    while q:

        # dequeue front node
        curr = q.popleft()

        # swap the left child with the right child
        swap(curr)

        # enqueue left child of the popped node
        if curr.left:
            q.append(curr.left)

        # enqueue right child of the popped node
        if curr.right:
            q.append(curr.right)


'''
Construct the following tree
          1
        /   \
       /     \
      2       3
     / \     / \
    4   5   6   7
'''

root = Node(1)
root.left = Node(2)
root.right = Node(3)
root.left.left = Node(4)
root.left.right = Node(5)
root.right.left = Node(6)
```

```
root.right.right = Node(7)

invertBinaryTree(root)
preorder(root)
```

Inorder, Preorder and Postorder Tree Traversal (Recursive Method)

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

def preorder(root):
    if root is None:
        return
    print(root.data, end=' ')
    preorder(root.left)
    preorder(root.right)

def inorder(root):
    if root is None:
        return
    inorder(root.left)
    print(root.data, end=' ')
    inorder(root.right)

def postorder(root):
    if root is None:
        return
    postorder(root.left)
    postorder(root.right)
    print(root.data, end=' ')


''' Construct the following tree
           1
         /   \
        /     \
       2       3
      /       /   \
     /       /     \
    4       5       6
           / \
          /   \
         7     8
'''

root = Node(1)
root.left = Node(2)
root.right = Node(3)
root.left.left = Node(4)
root.right.left = Node(5)
root.right.right = Node(6)
root.right.left.left = Node(7)
root.right.left.right = Node(8)
```

```
print("Preorder: ",preorder(root))
print("Inorder: ",inorder(root))
print("PostOrder: ",postorder(root))
```

Left View of a tree

```
class Node:
    def __init__(self, key, left=None, right=None):
        self.key = key
        self.left = left
        self.right = right


def leftView(root, level=1, last_level=0):
    # base case: empty tree
    if root is None:
        return last_level

    # if the current node is the first node of the current level
    if last_level < level:

        # print the node's data
        print(root.key, end=' ')

        # update the last level to the current level
        last_level = level

    # recur for the left and right subtree by increasing the level by 1
    last_level = leftView(root.left, level + 1, last_level)
    last_level = leftView(root.right, level + 1, last_level)
    return last_level

root = Node(1)
root.left = Node(2)
root.right = Node(3)
root.left.right = Node(4)
root.right.left = Node(5)
root.right.right = Node(6)
root.right.left.left = Node(7)
root.right.left.right = Node(8)
leftView(root)
```

Right View of Tree

```
class Node:
    def __init__(self, key, left=None, right=None):
        self.key = key
        self.left = left
        self.right = right


def RightView(root, level=1, lastLevel=0):
    if root is None:
        return lastLevel

    # if the current node is the last node of the current level
    if lastLevel < level:
```

```
        # print the node's data
        print(root.key, end=' ')

        # update the last level to the current level
        lastLevel = level

    # recur for the right and left subtree by increasing level by 1
    lastLevel = RightView(root.right, level + 1, lastLevel)
    lastLevel = RightView(root.left, level + 1, lastLevel)
    return lastLevel

root = Node(1)
root.left = Node(2)
root.right = Node(3)
root.left.right = Node(4)
root.right.left = Node(5)
root.right.right = Node(6)
root.right.left.left = Node(7)
root.right.left.right = Node(8)
RightView(root)
```

Top View of a tree

```
class Node:
    def __init__(self, key=None, left=None, right=None):
        self.key = key
        self.left = left
        self.right = right

# Recursive function to perform preorder traversal on the tree and fill the dictionary.
# Here, the node has `dist` horizontal distance from the tree's root, and the level represents the
node's level.
def printTop(root, dist, level, d):
    if root is None:
        return

    # if the current level is less than the maximum level seen so far for the same horizontal
distance, or if
    # the horizontal distance is seen for the first time, update the dictionary
    if dist not in d or level < d[dist][1]:
        # update value and level for current distance
        d[dist] = (root.key, level)

    # recur for the left subtree by decreasing horizontal distance and increasing level by 1
    printTop(root.left, dist - 1, level + 1, d)

    # recur for the right subtree by increasing both level and horizontal distance by 1
    printTop(root.right, dist + 1, level + 1, d)


def printTopView(root):

    # create a dictionary where
    # key -> relative horizontal distance of the node from the root node, and
    # value -> pair containing the node's value and its level
    d = {}

    # perform preorder traversal on the tree and fill the dictionary
    printTop(root, 0, 0, d)
```

```
    # traverse the dictionary in sorted order of keys and print the top view
    for key in sorted(d.keys()):
        print(d.get(key)[0], end=' ')

root = Node(1)
root.left = Node(2)
root.right = Node(3)
root.left.right = Node(4)
root.right.left = Node(5)
root.right.right = Node(6)
root.right.left.left = Node(7)
root.right.left.right = Node(8)
printTopView(root)
```

Bottom View of a tree

```
class Node:
    def __init__(self, key=None, left=None, right=None):
        self.key = key
        self.left = left
        self.right = right

# Recursive function to perform preorder traversal on the tree and fill the map.
# Here, the node has `dist` horizontal distance from the tree's root, and the `level` represents
the node's level.
def printBottom(root, dist, level, d):

    # base case: empty tree
    if root is None:
        return

    # if the current level is more than or equal to the maximum level seen so far for the same
horizontal distance
    # or horizontal distance is seen for the first time, update the dictionary
    if dist not in d or level >= d[dist][1]:
        # update value and level for the current distance
        d[dist] = (root.key, level)

    # recur for the left subtree by decreasing horizontal distance and increasing level by 1
    printBottom(root.left, dist - 1, level + 1, d)

    # recur for the right subtree by increasing both level and horizontal distance by 1
    printBottom(root.right, dist + 1, level + 1, d)


# Function to print the bottom view of a given binary tree
def printBottomView(root):

    # create a dictionary where
    # key -> relative horizontal distance of the node from the root node, and
    # value -> pair containing the node's value and its level
    d = {}

    # perform preorder traversal on the tree and fill the dictionary
    printBottom(root, 0, 0, d)

    # traverse the dictionary in sorted order of their keys and print the bottom view
    for key in sorted(d.keys()):
```

```
        print(d.get(key)[0], end=' ')


root = Node(1)
root.left = Node(2)
root.right = Node(3)
root.left.right = Node(4)
root.right.left = Node(5)
root.right.right = Node(6)
root.right.left.left = Node(7)
root.right.left.right = Node(8)
printBottomView(root)
```

Zig-Zag traversal of a binary tree

```
from collections import deque

class Node:
    def __init__(self, key=None, left=None, right=None):
        self.key = key
        self.left = left
        self.right = right


# Traverse the tree in a preorder fashion and store nodes in a dictionary corresponding to their
level
def preorder(root, level, d):
    if root is None:
        return

    # insert the current node and its level into the dictionary
    # if the level is odd, insert at the back; otherwise, search at front
    if level % 2 == 1:
        d.setdefault(level, deque()).append(root.key)
    else:
        d.setdefault(level, deque()).appendleft(root.key)

    # recur for the left and right subtree by increasing the level by 1
    preorder(root.left, level + 1, d)
    preorder(root.right, level + 1, d)


# Recursive function to print spiral order traversal of a given binary tree
def SpiralOrderTraversal(root):

    # create an empty dictionary to store nodes between given levels
    d = {}

    # traverse the tree and insert its nodes into the dictionary corresponding to their level
    preorder(root, 1, d)

    # iterate through the dictionary and print all nodes present at every level
    for i in range(1, len(d) + 1):
        print(f'Level {i}:', list(d[i]))


root = Node(15)
root.left = Node(10)
root.right = Node(20)
```

```
root.left.left = Node(8)
root.left.right = Node(12)
root.right.left = Node(16)
root.right.right = Node(25)
root.left.left.left = Node(20)
root.right.right.right = Node(30)
SpiralOrderTraversal(root)
```

Check if a tree is balanced or not

```
"""
Given a binary tree, write an efficient algorithm to check if it is height-balanced or not. In a
height-balanced tree, the absolute difference between the height of the left and right subtree for
every node is 0 or 1.
"""
class Node:
    def __init__(self, key, left=None, right=None):
        self.key = key
        self.left = left
        self.right = right


# Recursive function to check if a given binary tree is height-balanced or not
def isHeightBalanced(root, isBalanced=True):

    # base case: tree is empty or not balanced
    if root is None or not isBalanced:
        return 0, isBalanced

    # get the height of the left subtree
    left_height, isBalanced = isHeightBalanced(root.left, isBalanced)

    # get the height of the right subtree
    right_height, isBalanced = isHeightBalanced(root.right, isBalanced)

    # tree is unbalanced if the absolute difference between the height of
    # its left and right subtree is more than 1
    if abs(left_height - right_height) > 1:
        isBalanced = False

    # return height of subtree rooted at the current node
    return max(left_height, right_height) + 1, isBalanced

'''
Construct the following tree
          1
        /   \
       /     \
      2       3
     / \     /
    4   5   6
'''
root = Node(1)
root.left = Node(2)
root.right = Node(3)
root.left.left = Node(4)
root.left.right = Node(5)
root.right.left = Node(6)
if isHeightBalanced(root)[1]:
```

```
    print('Binary tree is balanced')
else:
    print('Binary tree is not balanced')
```

Diagonal Traversal of a Binary tree

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


# Recursive function to perform preorder traversal on the tree and
# fill the dictionary with diagonal elements
def printDiagonal(node, diagonal, d):

    # base case: empty tree
    if node is None:
        return

    # insert the current node into the current diagonal
    d.setdefault(diagonal, []).append(node.data)

    # recur for the left subtree by increasing diagonal by 1
    printDiagonal(node.left, diagonal + 1, d)

    # recur for the right subtree with the same diagonal
    printDiagonal(node.right, diagonal, d)


# Function to print the diagonal elements of a given binary tree
def printDiagonalElements(root):

    # create an empty dictionary to store the diagonal element in every slope
    d = {}

    # perform preorder traversal on the tree and fill the dictionary
    printDiagonal(root, 0, d)

    # traverse the dictionary and print diagonal elements
    for i in range(len(d)):
        print(d.get(i))

''' Construct the following tree
            1
          /   \
         /     \
       2         3
     /         /  \
    /         /    \
   4         5      6
            / \
          /    \
         7      8
'''
root = Node(1)
root.left = Node(2)
root.right = Node(3)
```

```
root.left.left = Node(4)
root.right.left = Node(5)
root.right.right = Node(6)
root.right.left.left = Node(7)
root.right.left.right = Node(8)
printDiagonalElements(root)
```

Boundary traversal of a Binary tree

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

    def isLeaf(self):
        return self.left is None and self.right is None

# Recursive function to print the left boundary of the given binary tree
# in a top-down fashion, except for the leaf nodes
def printLeftBoundary(root):
    if root is None:
        return
    node = root

    while not node.isLeaf():
        print(node.data, end=' ')

        # next process, the left child of `root` if it exists; otherwise, move to the right child
        node = node.left if node.left else node.right

# Recursive function to print the right boundary of the given binary tree
# in a bottom-up fashion, except for the leaf nodes
def printRightBoundary(root):
    if root is None or root.isLeaf():
        return

    # recur for the right child of `root` if it exists; otherwise, recur for the left child
    printRightBoundary(root.right if root.right else root.left)

    # To ensure bottom-up order, print the value of the nodes after recursion unfolds
    print(root.data, end=' ')


# Recursive function to print the leaf nodes of the given binary tree in an inorder fashion
def printLeafNodes(root):
    if root is None:
        return
    printLeafNodes(root.left)

    # print only leaf nodes
    if root.isLeaf():
        print(root.data, end=' ')

    # recur for the right subtree
    printLeafNodes(root.right)


# Function to perform the boundary traversal on a given tree
```

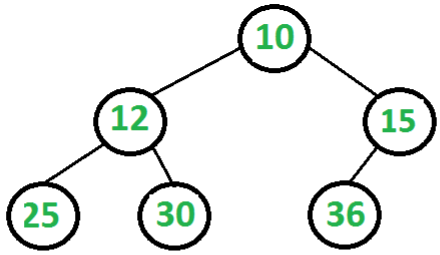
```
def performBoundaryTraversal(root):
    if root is None:
        return

    # print the root node
    print(root.data, end=' ')

    # print the left boundary (except leaf nodes)
    printLeftBoundary(root.left)

    # print all leaf nodes
    if not root.isLeaf():
        printLeafNodes(root)

    # print the right boundary (except leaf nodes)
    printRightBoundary(root.right)

root = Node(1)
root.left = Node(2)
root.right = Node(3)
root.left.left = Node(4)
root.left.right = Node(5)
root.right.left = Node(6)
root.right.right = Node(7)
root.left.left.left = Node(8)
root.left.left.right = Node(9)
root.left.right.right = Node(10)
root.right.right.left = Node(11)
root.left.left.right.left = Node(12)
root.left.left.right.right = Node(13)
root.right.right.left.left = Node(14)
performBoundaryTraversal(root)
```

Construct Binary Tree from String with Bracket Representation

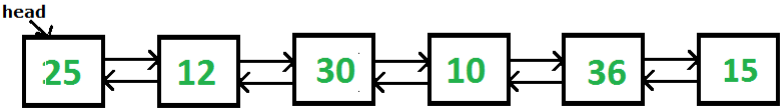
```
class newNode:
  def __init__(self, data):
    self.data = data
    self.left = self.right = None

def preOrder(node):
    if node is None:
        return
    print(node.data, end=" ")
    preOrder(node.left)
    preOrder(node.right)

# function to return the index of close parenthesis
def findIndex(Str, si, ei):
    if (si > ei):
        return -1

    s = []
    for i in range(si, ei + 1):

        # if open parenthesis, push it
        if (Str[i] == '('):
```

```
            s.append(Str[i])

        elif (Str[i] == ')'):
            if (s[-1] == '('):
                s.pop(-1)

                # if stack is empty, this is
                # the required index
                if len(s) == 0:
                    return i
    # if not found return -1
    return -1

# function to conStruct tree from String
def treeFromString(Str, si, ei):
    # Base case
    if (si > ei):
        return None

    # new root
    root = newNode(ord(Str[si]) - ord('0'))
    index = -1

    # if next char is '(' find the
    # index of its complement ')'
    if (si + 1 <= ei and Str[si + 1] == '('):
        index = findIndex(Str, si + 1, ei)

    # if index found
    if (index != -1):

        # call for left subtree
        root.left = treeFromString(Str, si + 2, index - 1)

        # call for right subtree
        root.right = treeFromString(Str, index + 2, ei - 1)
    return root


Str = "4(2(3)(1))(6(5))"
root = treeFromString(Str, 0, len(Str) - 1)
preOrder(root)
```

Convert Binary tree into Doubly Linked List



The above tree should be in-place converted to following Doubly Linked List(DLL).



```
class Node(object):
  def __init__(self, item):
    self.data = item
    self.left = None
    self.right = None

def BTToDLLUtil(root):

    """This is a utility function to convert the binary tree to doubly linked list.
    Most of the core task is done by this function."""
    if root is None:
        return root

    # Convert left subtree and link to root
    if root.left:

        # Convert the left subtree
        left = BTToDLLUtil(root.left)

        # Find inorder predecessor, After this loop, left will point to the
        # inorder predecessor of root
        while left.right:
            left = left.right

        # Make root as next of predecessor
        left.right = root

        # Make predecessor as previous of root
        root.left = left

    # Convert the right subtree and link to root
    if root.right:

        # Convert the right subtree
        right = BTToDLLUtil(root.right)

        # Find inorder successor, After this loop, right will point to the inorder successor of
root
        while right.left:
            right = right.left

        # Make root as previous of successor
        right.left = root

        # Make successor as next of root
        root.right = right

    return root

def BTToDLL(root):
    if root is None:
        return root

    # Convert to doubly linked list using BLLToDLLUtil
    root = BTToDLLUtil(root)

    # We need pointer to left most node which is head of the constructed Doubly Linked list
    while root.left:
        root = root.left
    return root
```

```
def print_list(head):
    if head is None:
        return
    while head:
        print(head.data, end = " ")
        head = head.right


root = Node(10)
root.left = Node(12)
root.right = Node(15)
root.left.left = Node(25)
root.left.right = Node(30)
root.right.left = Node(36)
head = BTToDLL(root)
print_list(head)
```

Convert Binary tree into Sum tree

```
# Given a Binary Tree where each node has positive and negative values. Convert this to a tree
where each node contains the sum of the left and right sub trees in the original tree. The values
of leaf nodes are changed to 0.

class node:
    def __init__(self, data):
        self.left = None
        self.right = None
        self.data = data

# Convert a given tree to a tree where every node contains sum of values of
# nodes in left and right subtrees in the original tree
def toSumTree(Node) :
    if Node is None:
        return 0

    # Store the old value
    old_val = Node.data

    # Recursively call for left and right subtrees and store the sum as new value of this node
    Node.data = toSumTree(Node.left) + toSumTree(Node.right)

    # Return the sum of values of nodes in left and right subtrees and old_value of this node
    return Node.data + old_val

# A utility function to print inorder traversal of a Binary Tree
def printInorder(Node):
    if Node is None:
        return
    printInorder(Node.left)
    print(Node.data, end = " ")
    printInorder(Node.right)

# Utility function to create a new Binary Tree node
def newNode(data) :
    temp = node(0)
    temp.data = data
    temp.left = None
    temp.right = None
```

```
    return temp

root = newNode(10)
root.left = newNode(-2)
root.right = newNode(6)
root.left.left = newNode(8)
root.left.right = newNode(-4)
root.right.left = newNode(7)
root.right.right = newNode(5)
toSumTree(root)
print("Inorder Traversal of the resultant tree is: ")
printInorder(root)
```

Construct Binary tree from Inorder and preorder traversal

```
# A class to store a binary tree node
class Node:
    # Constructor
    def __init__(self, data, left=None, right=None):
        self.data = data
        self.left = left
        self.right = right

# Recursive function to perform inorder traversal on a given binary tree
def inorderTraversal(root):
    if root is None:
        return
    inorderTraversal(root.left)
    print(root.data, end=' ')
    inorderTraversal(root.right)

# Recursive function to perform postorder traversal on a given binary tree
def preorderTraversal(root):
    if root is None:
        return
    print(root.data, end=' ')
    preorderTraversal(root.left)
    preorderTraversal(root.right)

# Recursive function to construct a binary tree from a given inorder and preorder sequence
def construct(start, end, preorder, pIndex, d):

    # base case
    if start > end:
        return None, pIndex

    # The next element in `preorder[]` will be the root node of subtree
    # formed by sequence represented by `inorder[start, end]`
    root = Node(preorder[pIndex])
    pIndex = pIndex + 1

    # get the index of the root node in inorder to determine the
    # left and right subtree boundary
    index = d[root.data]

    # recursively construct the left subtree
    root.left, pIndex = construct(start, index - 1, preorder, pIndex, d)

    # recursively construct the right subtree
```

```
    root.right, pIndex = construct(index + 1, end, preorder, pIndex, d)

    # return current node
    return root, pIndex


# Construct a binary tree from inorder and preorder traversals.
# This function assumes that the input is valid i.e., given inorder and preorder sequence forms a
binary tree
def constructTree(inorder, preorder):

    # create a dictionary to efficiently find the index of any element in a given inorder sequence
    d = {}
    for i, e in enumerate(inorder):
        d[e] = i

    # `pIndex` stores the index of the next unprocessed node in a preorder sequence;
    # start with the root node (present at 0th index)
    pIndex = 0

    return construct(0, len(inorder) - 1, preorder, pIndex, d)[0]


''' Construct the following tree
            1
          /   \
         /     \
        2       3
      /       / \
     /       /   \
    4       5     6
           / \
          /   \
         7     8
'''
inorder = [4, 2, 1, 7, 5, 8, 3, 6]
preorder = [1, 2, 4, 3, 5, 7, 8, 6]
root = constructTree(inorder, preorder)
print('The inorder traversal is ', end='')
inorderTraversal(root)
print('\nThe preorder traversal is ', end='')
preorderTraversal(root)
```

Find minimum swaps required to convert a Binary tree into BST

```
"""
The idea is to use the fact that inorder traversal of Binary Search Tree is in increasing order of
their value. So, find the inorder traversal of the Binary Tree and store it in the array and try
to sort the array. The minimum number of swap required to get the array sorted will be the answer.
"""
def inorder(a, n, index):
    global v

    # If index is greater or equal to vector size
    if (index >= n):
        return
```

```
    inorder(a, n, 2 * index + 1)

    # Push elements in vector
    v.append(a[index])
    inorder(a, n, 2 * index + 2)

def minSwaps():
    global v
    t = [[0, 0] for _ in range(len(v))]
    ans = -2

    for i in range(len(v)):
        t[i][0], t[i][1] = v[i], i

    t, i = sorted(t), 0

    while i < len(t):
        if (i == t[i][1]):
            i += 1
            continue
        else:
            # Swapping of elements
            t[i][0], t[t[i][1]][0] = t[t[i][1]][0], t[i][0]
            t[i][1], t[t[i][1]][1] = t[t[i][1]][1], t[i][1]

        # Second is not equal to i
        if (i == t[i][1]):
            i -= 1

        i += 1
        ans += 1
    return ans

v = []
a = [5, 6, 7, 8, 9, 10, 11]
n = len(a)
inorder(a, n, 0)
print(minSwaps())
```

Check if Binary tree is Sum tree or not

```
class node:
  def __init__(self, x):
    self.data = x
    self.left = None
    self.right = None

def isLeaf(node):
  if node is None:
    return 0
  if node.left is None and node.right is None:
    return 1
  return 0

# returns data if SumTree property holds for the given tree else return -1
def isSumTree(node):
  if node is None:
    return 0
  ls = isSumTree(node.left)
```

```
  #To stop for further traversal of tree if found not sumTree
  if(ls == -1):
    return -1

  rs = isSumTree(node.right)
  #To stop for further traversal of tree if found not sumTree
  if(rs == -1):
    return -1

  return ls + rs + node.data if (isLeaf(node) or ls + rs == node.data) else -1

root = node(26)
root.left = node(10)
root.right = node(3)
root.left.left = node(4)
root.left.right = node(6)
root.right.right = node(3)
if(isSumTree(root)):
  print("The given tree is a SumTree ")
else:
    print("The given tree is not a SumTree ")
```

Check if all leaf nodes are at same level or not

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

# Recursive function which check whether all leaves are at same level
def checkUtil(root, level):
  if root is None:
    return True

  # If a tree node is encountered
  if root.left is None and root.right is None:

    # When a leaf node is found first time
    if check.leafLevel == 0 :
      check.leafLevel = level # Set first leaf found
      return True

    # If this is not first leaf node, compare its level  with first leaf's level
    return level == check.leafLevel

  # If this is not first leaf node, compare its level with first leaf's level
  return (checkUtil(root.left, level+1)and
      checkUtil(root.right, level+1))

def check(root):
  level = 0
  check.leafLevel = 0
  return (checkUtil(root, level))

root = Node(12)
root.left = Node(5)
root.left.left = Node(3)
```

```
root.left.right = Node(9)
root.left.left.left = Node(1)
root.left.right.left = Node(2)
if(check(root)):
  print("Leaves are at same level")
else:
  print("Leaves are not at same level")
```

Check if a Binary Tree contains duplicate subtrees of size 2 or more [IMP]

```
# Helper function that allocates a new node with the given data and None left and right pointers.
class newNode:
  def __init__(self, data):
    self.data = data
    self.left = self.right = None

def inorder(node, m):
  if (not node):
    return ""

  Str = "("
  Str += inorder(node.left, m)
  Str += str(node.data)
  Str += inorder(node.right, m)
  Str += ")"

  # Subtree already present (Note that we use unordered_map instead of unordered_set because we
want to print multiple duplicates only once, consider example of 4 in above subtree, it should be
printed only once.
  if (Str in m and m[Str] == 1):
    print(node.data, end = " ")
  if Str in m:
    m[Str] += 1
  else:
    m[Str] = 1

  return Str

# Wrapper over inorder()
def printAllDups(root):
  m = {}
  inorder(root, m)


root = None
root = newNode(1)
root.left = newNode(2)
root.right = newNode(3)
root.left.left = newNode(4)
root.right.left = newNode(2)
root.right.left.left = newNode(4)
root.right.right = newNode(4)
printAllDups(root)
```

Check if 2 trees are mirror or not

```
def checkMirrorTree(M, N, u1, v1, u2, v2):
  mp = {}

  # Traverse first tree nodes
  for i in range(N):
    if u1[i] in mp:
      mp[u1[i]].append(v1[i])
    else:
      mp[u1[i]] = []

  # Traverse second tree nodes
  for i in range(N):
    if u2[i] in mp and len(mp[u2[i]]) > 0:
      if(mp[u2[i]][-1] != v2[i]):
        return 0
      mp[u2[i]].pop()
  return 1

M, N = 7, 6

#Tree 1
u1 = [ 1, 1, 1, 10, 10, 10 ]
v1 = [ 10, 7, 3, 4, 5, 6 ]

#Tree 2
u2 = [ 1, 1, 1, 10, 10, 10 ]
v2 = [ 3, 7, 10, 6, 5, 4 ]

if(checkMirrorTree(M, N, u1, v1, u2, v2)):
    print("Yes")
else:
    print("No")
```

Sum of Nodes on the Longest path from root to leaf node

```
"""
Input : Binary tree:
        4
       / \
      2   5
     / \ / \
    7  1 2  3
      /
     6
Output : 13

        4
       / \
      2   5
     / \ / \
    7  1 2  3
      /
     6

The highlighted nodes (4, 2, 1, 6) above are
part of the longest root to leaf path having
sum = (4 + 2 + 1 + 6) = 13
"""
```

```
class getNode:
    def __init__(self, data):
        self.data = data
        self.left = self.right = None

# function to find the Sum of nodes on the longest path from root to leaf node
def SumOfLongRootToLeafPath(root, Sum, Len, maxLen, maxSum):

    # if true, then we have traversed a root to leaf path
    if (not root):

        # update maximum Length and maximum Sum according to the given conditions
        if (maxLen[0] < Len):
            maxLen[0] = Len
            maxSum[0] = Sum
        elif (maxLen[0]== Len and
            maxSum[0] < Sum):
            maxSum[0] = Sum
        return

    # recur for left subtree
    SumOfLongRootToLeafPath(root.left, Sum + root.data, Len + 1, maxLen, maxSum)

    # recur for right subtree
    SumOfLongRootToLeafPath(root.right, Sum + root.data, Len + 1, maxLen, maxSum)

# utility function to find the Sum of nodes on the longest path from root to leaf node
def SumOfLongRootToLeafPathUtil(root):
    # if tree is NULL, then Sum is 0
    if (not root):
        return 0

    maxSum = [-999999999999]
    maxLen = [0]

    # finding the maximum Sum 'maxSum' for the maximum Length root to leaf path
    SumOfLongRootToLeafPath(root, 0, 0, maxLen, maxSum)
    return maxSum[0]

root = getNode(4)
root.left = getNode(2)
root.right = getNode(5)
root.left.left = getNode(7)
root.left.right = getNode(1)
root.right.left = getNode(2)
root.right.right = getNode(3)
root.left.right.left = getNode(6)
print("Sum = ", SumOfLongRootToLeafPathUtil(root))
```

Check if given graph is tree or not. [IMP]

```
from collections import defaultdict

class Graph():
  def __init__(self, V):
    self.V = V
    self.graph = defaultdict(list)
```

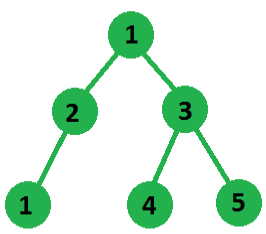
```
  def addEdge(self, v, w):
    self.graph[v].append(w)
    self.graph[w].append(v)

  # A recursive function that uses visited[] and parent to detect cycle in subgraph reachable from
vertex v.
  def isCyclicUtil(self, v, visited, parent):

    # Mark current node as visited
    visited[v] = True

    # Recur for all the vertices adjacent for this vertex
    for i in self.graph[v]:
      # If an adjacent is not visited, then recur for that adjacent
      if visited[i] == False:
        if self.isCyclicUtil(i, visited, v) == True:
          return True

      # If an adjacent is visited and not parent of current vertex, then there is a cycle.
      elif i != parent:
        return True

    return False

  # Returns true if the graph is a tree, else false.
  def isTree(self):

    # Mark all the vertices as not visited and not part of recursion stack
    visited = [False] * self.V

    # The call to isCyclicUtil serves multiple purposes. It returns true if graph reachable from
vertex 0 is cyclic.
    # It also marks all vertices reachable from 0.
    if self.isCyclicUtil(0, visited, -1) == True:
      return False

    return all(visited[i] != False for i in range(self.V))

# Driver program to test above functions
g1 = Graph(5)
g1.addEdge(1, 0)
g1.addEdge(0, 2)
g1.addEdge(0, 3)
g1.addEdge(3, 4)
print ("Graph is a Tree" if g1.isTree() == True else "Graph is a not a Tree")

g2 = Graph(5)
g2.addEdge(1, 0)
g2.addEdge(0, 2)
g2.addEdge(2, 1)
g2.addEdge(0, 3)
g2.addEdge(3, 4)
print ("Graph is a Tree" if g2.isTree() == True else "Graph is a not a Tree")
```

Find Largest subtree sum in a tree

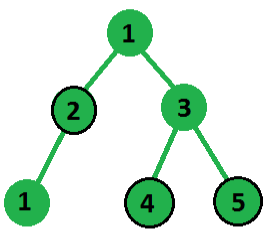
```
# Function to create new tree node.
class newNode:
 def __init__(self, key):
```

```
  self.key = key
  self.left = self.right = None

# Helper function to find largest subtree sum recursively.
def findLargestSubtreeSumUtil(root, ans):
 if (root == None):
  return 0

 # Subtree sum rooted at current node.
 currSum = (root.key + findLargestSubtreeSumUtil(root.left, ans) +
findLargestSubtreeSumUtil(root.right, ans))

 # Update answer if current subtree sum is greater than answer so far.
 ans[0] = max(ans[0], currSum)

 # Return current subtree sum to its parent node.
 return currSum

# Function to find largest subtree sum.
def findLargestSubtreeSum(root):
 if (root == None):
  return 0
 ans = [float('-inf')]
 findLargestSubtreeSumUtil(root, ans)
 return ans[0]

# Constructed Tree
#     1
#    / \
#      /  \
#     -2   3
#     /\   /\
#    / \    / \
#      4  5  -6  2
root = newNode(1)
root.left = newNode(-2)
root.right = newNode(3)
root.left.left = newNode(4)
root.left.right = newNode(5)
root.right.left = newNode(-6)
root.right.right = newNode(2)
print(findLargestSubtreeSum(root))
```

Maximum Sum of nodes in Binary tree such that no two are adjacent



Input Binary tree



Chosen nodes with maximum sum

```
"""
```

```
Given a binary tree with a value associated with each node, we need to choose a subset of these
nodes such that the sum of
selected nodes is maximum under a constraint that no two chosen nodes in the subset should be
directly connected, that is,
if we have taken a node in our sum then we can't take any of its children in consideration and
vice versa.
"""

class newNode:
 def __init__(self, key):
  self.data = key
  self.left = None
  self.right = None

def maxSumHelper(root) :
 if (root == None):
  sum = [0, 0]
  return sum

 sum1 = maxSumHelper(root.left)
 sum2 = maxSumHelper(root.right)
 sum = [0, 0]

 # This node is included (Left and right children are not included)
 sum[0] = sum1[1] + sum2[1] + root.data

 # This node is excluded (Either left or right child is included)
 sum[1] = (max(sum1[0], sum1[1]) + max(sum2[0], sum2[1]))
 return sum

def maxSum(root) :
 res = maxSumHelper(root)
 return max(res[0], res[1])

root = newNode(10)
root.left = newNode(1)
root.left.left = newNode(2)
root.left.left.left = newNode(1)
root.left.right = newNode(3)
root.left.right.left = newNode(4)
root.left.right.right = newNode(5)
print(maxSum(root))
```

Print all "K" Sum paths in a Binary tree

```
"""
A binary tree and a number k are given. Print every path in the tree with sum of the nodes in the
path as k.
A path can start from any node and end at any node and must be downward only,
i.e. they need not be root node and leaf node; and negative numbers can also be there in the tree.
"""
def printVector(v, i):
    for j in range(i, len(v)):
        print(v[j], end = " ")
    print()

class newNode:
    def __init__(self, key):
        self.data = key
```

```
        self.left = None
        self.right = None

# This function prints all paths   that have sum k
def printKPathUtil(root, path, k):
    if (not root) :
        return

    # add current node to the path
    path.append(root.data)

    # check if there's any k sum path in the left sub-tree.
    printKPathUtil(root.left, path, k)

    # check if there's any k sum path in the right sub-tree.
    printKPathUtil(root.right, path, k)

    # check if there's any k sum path that terminates at this node
    # Traverse the entire path as there can be negative elements too
    f = 0
    for j in range(len(path) - 1, -1, -1):
        f += path[j]

        # If path sum is k, prthe path
        if (f == k) :
            printVector(path, j)

    # Remove the current element from the path
    path.pop(-1)

# A wrapper over printKPathUtil()
def printKPath(root, k):
    path =[]
    printKPathUtil(root, path, k)

root = newNode(1)
root.left = newNode(3)
root.left.left = newNode(2)
root.left.right = newNode(1)
root.left.right.left = newNode(1)
root.right = newNode(-1)
root.right.left = newNode(4)
root.right.left.left = newNode(1)
root.right.left.right = newNode(2)
root.right.right = newNode(5)
root.right.right.right = newNode(2)
k = 5
printKPath(root, k)
```

Find Least Common Ancestor in a Binary tree

```
class Node:
 def __init__(self, key):
  self.key = key
  self.left = None
  self.right = None

# This function returns pointer to LCA of two given values n1 and n2
# This function assumes that n1 and n2 are present in Binary Tree
```

```
def findLCA(root, n1, n2):
 if root is None:
  return None

 # If either n1 or n2 matches with root's key, report the presence by returning root (Note that if
a key is
 # ancestor of other, then the ancestor key becomes LCA
 if root.key == n1 or root.key == n2:
  return root

 # Look for keys in left and right subtrees
 left_lca = findLCA(root.left, n1, n2)
 right_lca = findLCA(root.right, n1, n2)

 # If both of the above calls return Non-NULL, then one key is present in once subtree and other
is present in other,
 # So this node is the LCA
 if left_lca and right_lca:
  return root

 # Otherwise check if left subtree or right subtree is LCA
 return left_lca if left_lca is not None else right_lca


root = Node(1)
root.left = Node(2)
root.right = Node(3)
root.left.left = Node(4)
root.left.right = Node(5)
root.right.left = Node(6)
root.right.right = Node(7)
print ("LCA(4,5) = ", findLCA(root, 4, 5).key)
print ("LCA(4,6) = ", findLCA(root, 4, 6).key)
print ("LCA(3,4) = ", findLCA(root, 3, 4).key)
print ("LCA(2,4) = ", findLCA(root, 2, 4).key)
```

Find distance between 2 nodes in a Binary tree

```
"""
A python program to find distance between n1 and n2 in binary tree
"""

class Node:
 def __init__(self, data):
  self.data = data
  self.left = self.right = None


# This function returns pointer to LCA of two given values n1 and n2.
def find_least_common_ancestor(root, n1, n2):
 if root is None:
  return root

 # If either n1 or n2 matches with root's key, report the presence by returning root
 if root.data == n1 or root.data == n2:
  return root

 # Look for keys in left and right subtrees
 left = find_least_common_ancestor(root.left, n1, n2)
```

```
 right = find_least_common_ancestor(root.right, n1, n2)

 if left and right:
  return root

 # Otherwise check if left subtree or right subtree is Least Common Ancestor
 if left:
  return left
 else:
  return right

# function to find distance of any node from root
def find_distance_from_ancestor_node(root, data):
 # case when we reach a beyond leaf node or when tree is empty
 if root is None:
  return -1

 # Node is found then return 0
 if root.data == data:
  return 0

 left = find_distance_from_ancestor_node(root.left, data)
 right = find_distance_from_ancestor_node(root.right, data)
 distance = max(left, right)
 return distance+1 if distance >= 0 else -1

# function to find distance between two nodes in a binary tree
def find_distance_between_two_nodes(root: Node, n1: int, n2: int):
 lca = find_least_common_ancestor(root, n1, n2)
 return find_distance_from_ancestor_node(lca, n1) + find_distance_from_ancestor_node(lca, n2) if
lca else -1

root = Node(1)
root.left = Node(2)
root.right = Node(3)
root.left.left = Node(4)
root.left.right = Node(5)
root.right.left = Node(6)
root.right.right = Node(7)
root.right.left.right = Node(8)
print("Dist(4,5) = ", find_distance_between_two_nodes(root, 4, 5))
print("Dist(4,6) = ", find_distance_between_two_nodes(root, 4, 6))
print("Dist(3,4) = ", find_distance_between_two_nodes(root, 3, 4))
print("Dist(2,4) = ", find_distance_between_two_nodes(root, 2, 4))
print("Dist(8,5) = ", find_distance_between_two_nodes(root, 8, 5))
```

Kth Ancestor of node in a Binary tree

```
"""
Given a binary tree in which nodes are numbered from 1 to n. Given a node and a positive integer
K.
We have to print the Kth ancestor of the given node in the binary tree.
If there does not exist any such ancestor then print -1.
"""

class newNode:
    def __init__(self, data):
        self.data = data
```

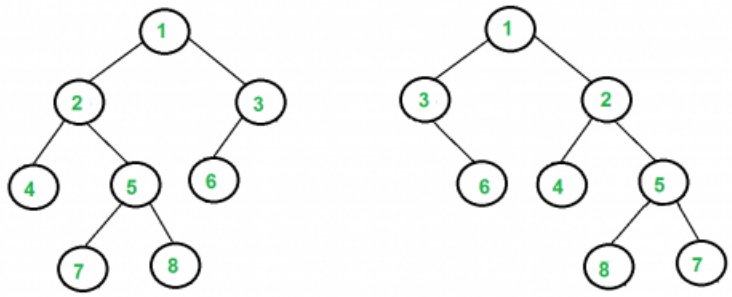
```
        self.left = None
        self.right = None

# recursive function to calculate Kth ancestor
def kthAncestorDFS(root, node, k):
    if (not root):
        return None

    if (root.data == node or
       (kthAncestorDFS(root.left, node, k)) or
       (kthAncestorDFS(root.right, node, k))):

        if (k[0] > 0):
            k[0] -= 1

        elif (k[0] == 0):

            # print the kth ancestor
            print("Kth ancestor is:", root.data)

            # return None to stop further backtracking
            return None

        # return current node to previous call
        return root


root = newNode(1)
root.left = newNode(2)
root.right = newNode(3)
root.left.left = newNode(4)
root.left.right = newNode(5)

k = [2]
node = 5

# print kth ancestor of given node
parent = kthAncestorDFS(root,node,k)

# check if parent is not None, it means there is no Kth ancestor of the node
if (parent):
    print("-1")
```

Find all Duplicate subtrees in a Binary tree [IMP]

```
# Helper function that allocates a new node with the given data and None left and right pointers.
class newNode:
 def __init__(self, data):
  self.data = data
  self.left = self.right = None

def inorder(node, m):
 if (not node):
  return ""

 Str = "("
 Str += inorder(node.left, m)
 Str += str(node.data)
 Str += inorder(node.right, m)
```

```
 Str += ")"

 # Subtree already present (Note that we use unordered_map instead of unordered_set because we
want to print
 # multiple duplicates only once, consider example of 4 in above subtree, it should be printed
only once.
 if (Str in m and m[Str] == 1):
  print(node.data, end = " ")
 if Str in m:
  m[Str] += 1
 else:
  m[Str] = 1

 return Str

# Wrapper over inorder()
def printAllDups(root):
 m = {}
 inorder(root, m)


root = None
root = newNode(1)
root.left = newNode(2)
root.right = newNode(3)
root.left.left = newNode(4)
root.right.left = newNode(2)
root.right.left.left = newNode(4)
root.right.right = newNode(4)
printAllDups(root)
```

Tree Isomorphism Problem




```
"""
Write a function to detect if two trees are isomorphic. Two trees are called isomorphic if one of
them can be obtained from
other by a series of flips, i.e. by swapping left and right children of a number of nodes.
Any number of nodes at any level can have their children swapped. Two empty trees are isomorphic.
"""

class Node:
 def __init__(self, data):
  self.data = data
  self.left = None
  self.right = None

# Check if the binary tree is isomorphic or not
def isIsomorphic(n1, n2):
```

```
 # Both roots are None, trees isomorphic by definition
 if n1 is None and n2 is None:
  return True

 # Exactly one of the n1 and n2 is None, trees are not isomorphic
 if n1 is None or n2 is None:
  return False

 if n1.data != n2.data :
  return False

 # There are two possible cases for n1 and n2 to be isomorphic

 # Case 1: The subtrees rooted at these nodes have NOT been "Flipped".
     # Both of these subtrees have to be isomorphic, hence the &&
 # Case 2: The subtrees rooted at these nodes have been "Flipped"

 return ((isIsomorphic(n1.left, n2.left)and
   isIsomorphic(n1.right, n2.right)) or
   (isIsomorphic(n1.left, n2.right) and
   isIsomorphic(n1.right, n2.left))
   )

n1 = Node(1)
n1.left = Node(2)
n1.right = Node(3)
n1.left.left = Node(4)
n1.left.right = Node(5)
n1.right.left = Node(6)
n1.left.right.left = Node(7)
n1.left.right.right = Node(8)

n2 = Node(1)
n2.left = Node(3)
n2.right = Node(2)
n2.right.left = Node(4)
n2.right.right = Node(5)
n2.left.right = Node(6)
n2.right.right.left = Node(8)
n2.right.right.right = Node(7)

print ("Yes" if (isIsomorphic(n1, n2) == True) else "No")
```

Bit Manipulation

Count set bits in an integer

```
def countSetBits(n):
    if (n == 0):
        return 0
    else:
        return 1 + countSetBits(n & (n - 1))

n = 9
print(countSetBits(n))
```

Find the two non-repeating elements in an array of repeating elements

```
def get2NonRepeatingNos(arr, n):
    s = set()
    for i in range(n):

        # Iterate through the array and check if each element is present or not in the set. If the
        # element is present, remove it from the array otherwise add it to the set

        if (arr[i] in s):
            s.remove(arr[i])
        else:
            s.add(arr[i])
    print("The 2 non repeating numbers are :",end=" ")
    for it in s:
        print(it,end=" ")
    print()

arr = [2, 3, 7, 9, 11, 2, 3, 11]
n = len(arr)
get2NonRepeatingNos(arr, n)
```

Count number of bits to be flipped to convert A to B

```
def countSetBits( n ):
    count = 0
    while n:
        count += 1
        n &= (n-1)
    return count

def FlippedCount(a , b):
    return countSetBits(a^b)

a = 10
b = 20
print(FlippedCount(a, b))
```

Count total set bits in all numbers from 1 to n

```
# Function to return the sum of the count of set bits in the integers from 1 to n
def countSetBits(n) :
  # Ignore 0 as all the bits are unset
  n += 1;
  # To store the powers of 2
  powerOf2 = 2;

  # To store the result, it is initialized with n/2 because the count of set
  # least significant bits in the integers from 1 to n is n/2
  cnt = n // 2;

  # Loop for every bit required to represent n
  while (powerOf2 <= n) :

    # Total count of pairs of 0s and 1s
```

```
    totalPairs = n // powerOf2;

    # totalPairs/2 gives the complete count of the pairs of 1s Multiplying it with the current
power of 2 will
    # give the count of 1s in the current bit
    cnt += (totalPairs // 2) * powerOf2;

    # If the count of pairs was odd then add the remaining 1s which could not be groupped together
    if (totalPairs & 1) :
      cnt += (n % powerOf2)
    else :
      cnt += 0

    # Next power of 2
    powerOf2 <<= 1;

  return cnt;

n = 14;
print(countSetBits(n));
```

Program to find whether a no is power of two

```
def isPowerOfTwo (x):
    # First x in the below expression is for the case when x is 0
    return (x and (not(x & (x - 1))) )

print('Yes') if(isPowerOfTwo(31)) else print('No')
print('Yes') if(isPowerOfTwo(64)) else print('No')
```

Find position of the only set bit

```
def isPowerOfTwo(n) :
    return (n and ( not (n & (n-1))))

# Returns position of the only set bit in 'n'
def findPosition(n) :
    if not isPowerOfTwo(n) :
        return "Invalid Number (has more than one set digits)"

    count = 0

    # One by one move the only set bit to right till it reaches end
    while (n) :
        n = n >> 1
        # increment count of shifts
        count += 1

    return count

n = 0
print(findPosition(n))
n = 12
print(findPosition(n))
n = 128
print(findPosition(n))
```

Copy set bits in a range

```
"""
Given two numbers x and y, and a range [l, r] where 1 <= l, r <= 32. The task is consider set bits
of y in range [l, r] and set these bits in x also.
Examples :

Input  : x = 10, y = 13, l = 2, r = 3
Output : x = 14
Binary representation of 10 is 1010 and
that of y is 1101. There is one set bit
in y at 3'rd position (in given range).
After we copy this bit to x, x becomes 1110
which is binary representation of 14.

Input  : x = 8, y = 7, l = 1, r = 2
Output : x = 11
"""
def copySetBits(x, y, l, r):

    # l and r must be between 1 to 3 (assuming ints are stored using 32 bits)
    if (l < 1 or r > 32):
        return x;

    # Traverse in given range
    for i in range(l, r + 1):

        # Find a mask (A number whose only set bit is at i'th position)
        mask = 1 << (i - 1);

        # If i'th bit is set in y, set i'th bit in x also.
        if ((y & mask) != 0):
            x = x | mask;
    return x;


x = 10;
y = 13;
l = 1;
r = 32;
x = copySetBits(x, y, l, r);
print("Modified x is ", x);
```

Divide two integers without using multiplication, division and mod operator

```
def divide(dividend, divisor):

    # Calculate sign of divisor i.e., sign will be negative only if
    # either one of them is negative otherwise it will be positive
    sign = -1 if ((dividend < 0) ^ (divisor < 0)) else 1

    # Update both divisor and dividend positive
    dividend = abs(dividend)
    divisor = abs(divisor)
```

```
    # Initialize the quotient
    quotient = 0
    while (dividend >= divisor):
        dividend -= divisor
        quotient += 1

    # if the sign value computed earlier is -1 then negate the value of quotient
    if sign == -1:
        quotient = -quotient
    return quotient

a = 10
b = 3
print(divide(a, b))
a = 43
b = -8
print(divide(a, b))
```

Calculate square of a number without using *, / and pow()

```
def square(n):
    # handle negative input
    if (n < 0):
        n = -n

    # Initialize result
    res = n

    # Add n to res n-1 times
    for i in range(1, n):
        res += n
    return res

for n in range(1, 6):
    print("n =", n, end=", ")
    print("n^2 =", square(n))
```

Power Set

```
#Python program to find powerset
from itertools import combinations
def print_powerset(string):
 for i in range(0,len(string)+1):
  for element in combinations(string,i):
   print(''.join(element))
string=['a','b','c']
print_powerset(string)
```

Binary Search Trees

Find a value in a BST

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

```
        self.right = right


# Recursive function to insert a key into a BST
def insert(root, key):

    # if the root is None, create a new node and return it
    if root is None:
        return Node(key)

    # if the given key is less than the root node, recur for the left subtree
    if key < root.data:
        root.left = insert(root.left, key)

    # if the given key is more than the root node, recur for the right subtree
    else:
        root.right = insert(root.right, key)

    return root


# Recursive function to search in a given BST
def search(root, key, parent):

    # if the key is not present in the key
    if root is None:
        print('Key not found')
        return

    # if the key is found
    if root.data == key:

        if parent is None:
            print(f'The node with key {key} is root node')
        elif key < parent.data:
            print('The given key is the left node of the node with key', parent.data)
        else:
            print('The given key is the right node of the node with key', parent.data)

        return

    # if the given key is less than the root node, recur for the left subtree;
    # otherwise, recur for the right subtree
    if key < root.data:
        search(root.left, key, root)
    else:
        search(root.right, key, root)


keys = [15, 10, 20, 8, 12, 16, 25]
root = None
for key in keys:
    root = insert(root, key)
search(root, 25, None)
```

Deletion of a node in a BST

```
class Node:
    def __init__(self, data, left=None, right=None):
```

```
        self.data = data
        self.left = left
        self.right = right


# Function to perform inorder traversal on the BST
def inorder(root):
    if root is None:
        return
    inorder(root.left)
    print(root.data, end=' ')
    inorder(root.right)


# Function to find the maximum value node in the subtree rooted at `ptr`
def findMaximumKey(ptr):
    while ptr.right:
        ptr = ptr.right
    return ptr


# Recursive function to insert a key into a BST
def insert(root, key):
    if root is None:
        return Node(key)

    # if the given key is less than the root node, recur for the left subtree
    if key < root.data:
        root.left = insert(root.left, key)

    # if the given key is more than the root node, recur for the right subtree
    else:
        root.right = insert(root.right, key)

    return root


# Function to delete a node from a BST
def deleteNode(root, key):
    if root is None:
        return root

    # if the given key is less than the root node, recur for the left subtree
    if key < root.data:
        root.left = deleteNode(root.left, key)

    # if the given key is more than the root node, recur for the right subtree
    elif key > root.data:
        root.right = deleteNode(root.right, key)

    # key found
    else:
        # Case 1: node to be deleted has no children (it is a leaf node)
        if root.left is None and root.right is None:
            # update root to None
            return None

        # Case 2: node to be deleted has two children
        elif root.left and root.right:
            # find its inorder predecessor node
```

```
            predecessor = findMaximumKey(root.left)

            # copy value of the predecessor to the current node
            root.data = predecessor.data

            # recursively delete the predecessor. Note that the
            # predecessor will have at most one child (left child)
            root.left = deleteNode(root.left, predecessor.data)

        # Case 3: node to be deleted has only one child
        else:
            # choose a child node
            child = root.left if root.left else root.right
            root = child

    return root


keys = [15, 10, 20, 8, 12, 25]
root = None
for key in keys:
    root = insert(root, key)
root = deleteNode(root, 12)
inorder(root)
```

Find min and max value in a BST

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

# Function to perform inorder traversal on the BST
def inorder(root):
    if root is None:
        return
    inorder(root.left)
    print(root.data, end=' ')
    inorder(root.right)

# Function to find the maximum value node in the subtree rooted at `ptr`
def findMaximumKey(ptr):
    while ptr.right:
        ptr = ptr.right
    return ptr.data

# Function to find the maximum value node in the subtree rooted at `ptr`
def findMinimumKey(ptr):
    while ptr.left:
        ptr = ptr.left
    return ptr.data


# Recursive function to insert a key into a BST
def insert(root, key):
    if root is None:
        return Node(key)
```

```
    # if the given key is less than the root node, recur for the left subtree
    if key < root.data:
        root.left = insert(root.left, key)

    # if the given key is more than the root node, recur for the right subtree
    else:
        root.right = insert(root.right, key)
    return root


keys = [15, 10, 20, 8, 12, 25]
root = None
for key in keys:
    root = insert(root, key)
inorder(root)
print()
print("Minimum: ",findMinimumKey(root))
print("Maximum: ",findMaximumKey(root))
```

Find inorder successor and inorder predecessor in a BST

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

def insert(root, key):
    if root is None:
        return Node(key)
    if key < root.data:
        root.left = insert(root.left, key)
    else:
        root.right = insert(root.right, key)
    return root

def findMinimum(root):
    while root.left:
        root = root.left
    return root

def findMaximum(root):
    while root.right:
        root = root.right
    return root

def findSuccessor(root, succ, key):
    if root is None:
        return succ

    # if a node with the desired value is found, the successor is the minimum value
    # node in its right subtree (if any)
    if root.data == key:
        if root.right:
            return findMinimum(root.right)

    # if the given key is less than the root node, recur for the left subtree
    elif key < root.data:
```

```
        # update successor to the current node before recursing in the left subtree
        succ = root
        return findSuccessor(root.left, succ, key)

    # if the given key is more than the root node, recur for the right subtree
    else:
        return findSuccessor(root.right, succ, key)
    return succ

def findPredecessor(root, prec, key):
    if root is None:
        return prec

    # if a node with the desired value is found, the predecessor is the maximum value
    # node in its left subtree (if any)
    if root.data == key:
        if root.left:
            return findMaximum(root.left)

    # if the given key is less than the root node, recur for the left subtree
    elif key < root.data:
        return findPredecessor(root.left, prec, key)

    # if the given key is more than the root node, recur for the right subtree
    else:
        # update predecessor to the current node before recursing in the right subtree
        prec = root
        return findPredecessor(root.right, prec, key)

    return prec

keys = [15, 10, 20, 8, 12, 16, 25]
''' Construct the following BST
           15
         /    \
        /      \
       10       20
      / \      /  \
     /   \    /    \
    8    12  16    25
'''
root = None
for key in keys:
    root = insert(root, key)

print("SUCCESSOR")
# find inorder successor for each key
for key in keys:
    succ = findSuccessor(root, None, key)
    if succ:
        print(f'The successor of node {key} is {succ.data}')
    else:
        print(f'No Successor exists for node {key}')


print("PREDECESSOR")
# find inorder predecessor for each key
for key in keys:
    prec = findPredecessor(root, None, key)
    if prec:
```

```
        print(f'Predecessor of node {key} is {prec.data}')
    else:
        print('The predecessor doesn\'t exist for node', key)
```

Check if a tree is a BST or not

```
import sys
class Node:
    def __init__(self, data, left=None, right=None):
        self.data = data
        self.left = left
        self.right = right


def insert(root, key):
    if root is None:
        return Node(key)
    if key < root.data:
        root.left = insert(root.left, key)
    else:
        root.right = insert(root.right, key)
    return root


# Function to perform inorder traversal on the given binary tree and
# check if it is a BST or not. Here, `prev` is the previously processed node
def isBST(root, prev):

    # base case: empty tree is a BST
    if root is None:
        return True

    # check if the left subtree is BST or not
    left = isBST(root.left, prev)

    # value of the current node should be more than that of the previous node
    if root.data <= prev.data:
        return False

    # update previous node data and check if the right subtree is BST or not
    prev.data = root.data
    return left and isBST(root.right, prev)


# Function to determine whether a given binary tree is a BST
def checkForBST(node):

    # pointer to store previously processed node in the inorder traversal
    prev = Node(-sys.maxsize)

    # check if nodes are processed in sorted order
    if isBST(node, prev):
        print('The tree is a BST!')
    else:
        print('The tree is not a BST!')

def swap(root):
    left = root.left
    root.left = root.right
```

```
    root.right = left


# keys = [15, 10, 20, 8, 12, 16, 25]
keys=[8,3,1,6,7,10,14,4]
root = None
for key in keys:
    root = insert(root, key)
# swap nodes
swap(root)
checkForBST(root)
```

Populate Inorder successor of all nodes

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

# Function to set the next pointer of all nodes in a binary tree.
# curr -> current node
# prev -> previously processed node
def setNextNode(curr, prev=None):
    if curr is None:
        return prev

    # recur for the left subtree
    prev = setNextNode(curr.left, prev)

    # set the previous node's next pointer to the current node
    if prev:
        prev.next = curr

    # update the previous node to the current node
    prev = curr

    # recur for the right subtree
    return setNextNode(curr.right, prev)


# Function to print inorder successor of all nodes of binary tree using the next pointer
def printInorderSuccessors(root):

    # go to the leftmost node
    curr = root
    while curr.left:
        curr = curr.left

    # print inorder successor of all nodes
    while curr.next:
        print(f'The inorder successor of {curr.data} is {curr.next.data}')
        curr = curr.next


''' Construct the following tree
          1
        /   \
```

```
        /     \
       2       3
      /       /  \
     /       /    \
    4       5      6
           / \
          /   \
         7     8
'''
root = Node(1)
root.left = Node(2)
root.right = Node(3)
root.left.left = Node(4)
root.right.left = Node(5)
root.right.right = Node(6)
root.right.left.left = Node(7)
root.right.left.right = Node(8)
setNextNode(root)
printInorderSuccessors(root)
```

Find LCA of 2 nodes in a BST

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


def insert(root, key):
    if root is None:
        return Node(key)

    # if the given key is less than the root node, recur for the left subtree
    if key < root.data:
        root.left = insert(root.left, key)

    # if the given key is more than the root node, recur for the right subtree
    else:
        root.right = insert(root.right, key)

    return root


# Iterative function to search a given node in a BST
def search(root, key):

    # traverse the tree and search for the key
    while root:

        # if the given key is less than the current node, go to the left
        # subtree; otherwise, go to the right subtree

        if key.data < root.data:
            root = root.left
        elif key.data > root.data:
            root = root.right
        # if the key is found, return true
        elif key == root:
```

```
            return True
        else:
            return False

    # we reach here if the key is not present in the BST
    return False


# Recursive function to find the lowest common ancestor of given nodes
# `x` and `y`, where both `x` and `y` are present in a BST
def LCARecursive(root, x, y):
    if root is None:
        return None

    # if both `x` and `y` is smaller than the root, LCA exists in the left subtree
    if root.data > max(x.data, y.data):
        return LCARecursive(root.left, x, y)

    # if both `x` and `y` are greater than the root, LCA exists in the right subtree
    elif root.data < min(x.data, y.data):
        return LCARecursive(root.right, x, y)

    # if one key is greater (or equal) than the root and one key is smaller
    # (or equal) than the root, then the current node is LCA
    return root


# Print lowest common ancestor of two nodes in a BST
def LCA(root, x, y):

    # return if the tree is empty, or `x` or `y` is not present in the tree
    if not root or not search(root, x) or not search(root, y):
        return

    # `lca` stores the lowest common ancestor of `x` and `y`
    lca = LCARecursive(root, x, y)

    # if the lowest common ancestor exists, print it
    if lca:
        print('LCA is', lca.data)
    else:
        print('LCA does not exist')

keys = [15, 10, 20, 8, 12, 16, 25]
''' Construct the following tree
          15
         /  \
        /    \
       10     20
      / \     / \
     /   \   /   \
    8    12 16   25
'''
root = None
for key in keys:
    root = insert(root, key)
LCA(root, root.left.left, root.left.right)
```

Construct BST from preorder traversal

```
import sys

class Node:
    def __init__(self, key, left=None, right=None):
        self.key = key
        self.left = left
        self.right = right

def inorder(root):
    if root is None:
        return
    inorder(root.left)
    print(root.key, end=' ')
    inorder(root.right)

# Recursive function to build a BST from a preorder sequence.
# start from the root node (the first element in a preorder sequence)
# set the root node's range as [-INFINITY, INFINITY]
def buildBST(preorder, pIndex=0, min=-sys.maxsize, max=sys.maxsize):

    # Base case
    if pIndex == len(preorder):
        return None, pIndex

    # Return if the next element of preorder traversal is not in the valid range
    val = preorder[pIndex]
    if val < min or val > max:
        return None, pIndex

    # Construct the root node and increment `pIndex`
    root = Node(val)
    pIndex = pIndex + 1

    # Since all elements in the left subtree of a BST must be less
    # than the root node's value, set range as `[min, val-1]` and recur
    root.left, pIndex = buildBST(preorder, pIndex, min, val - 1)

    # Since all elements in the right subtree of a BST must be greater
    # than the root node's value, set range as `[val+1…max]` and recur
    root.right, pIndex = buildBST(preorder, pIndex, val + 1, max)

    return root, pIndex


''' Construct the following BST
          15
        /    \
       /      \
      10       20
     /  \     /  \
    /    \   /    \
   8     12 16    25
'''
preorder = [15, 10, 8, 12, 20, 16, 25]
root = buildBST(preorder)[0]
print('Inorder traversal of BST is:', end=' ')
inorder(root)
```

Convert Binary tree into BST

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

# Function to perform inorder traversal on the tree
def inorder(root):
    if root is None:
        return
    inorder(root.left)
    print(root.data, end=' ')
    inorder(root.right)

# Function to traverse the binary tree and store its keys in a set
def extractKeys(root, keys):
    # base case
    if root is None:
        return
    extractKeys(root.left, keys)
    keys.append(root.data)
    extractKeys(root.right, keys)


# Function to put keys back into a set in their correct order in a BST
# by doing inorder traversal
def convertToBST(root, it):
    if root is None:
        return
    convertToBST(root.left, it)
    root.data = next(it)
    convertToBST(root.right, it)


# Function to convert a binary tree to BST by maintaining its original structure
def convert(root):
    # traverse the binary tree and store its keys in a set
    keys = []
    extractKeys(root, keys)

    # put back keys present in the set to their correct order in the BST
    it = iter(sorted(keys))
    convertToBST(root, it)

'''
Construct the following tree
           8
         /   \
        /     \
       3       5
      / \     / \
     /   \   /   \
    10    2 4     6
'''
root = Node(8)
root.left = Node(3)
root.right = Node(5)
root.left.left = Node(10)
root.left.right = Node(2)
```

```
root.right.left = Node(4)
root.right.right = Node(6)
convert(root)
inorder(root)
```

Convert a normal BST into a Balanced BST

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


# Function to perform the preorder traversal on a BST
def preorder(root):
    if root is None:
        return
    print(root.data, end=' ')
    preorder(root.left)
    preorder(root.right)


# Recursive function to push nodes of a given binary search tree into a
# list in an inorder fashion
def pushTreeNodes(root, nodes):
    if root is None:
        return

    pushTreeNodes(root.left, nodes)
    nodes.append(root)
    pushTreeNodes(root.right, nodes)


# Recursive function to construct a height-balanced BST from
# given nodes in sorted order
def buildBalancedBST(nodes, start, end):
    if start > end:
        return None

    # find the middle index
    mid = (start + end) // 2

    # The root node will be a node present at the mid-index
    root = nodes[mid]

    # recursively construct left and right subtree
    root.left = buildBalancedBST(nodes, start, mid - 1)
    root.right = buildBalancedBST(nodes, mid + 1, end)

    # return root node
    return root


# Function to construct a height-balanced BST from an unbalanced BST
def constructBalancedBST(root):

    # Push nodes of a given binary search tree into a list in sorted order
    nodes = []
```

```
    pushTreeNodes(root, nodes)

    # Construct a height-balanced BST from sorted BST nodes
    return buildBalancedBST(nodes, 0, len(nodes) - 1)


root = Node(20)
root.left = Node(15)
root.left.left = Node(10)
root.left.left.left = Node(5)
root.left.left.left.left = Node(2)
root.left.left.left.right = Node(8)
root = constructBalancedBST(root)
print('Preorder traversal of the constructed BST is ', end='')
preorder(root)
```

Merge two BST

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

# Function to push a BST node at the front of a doubly linked list
def push(root, head):
    root.right = head
    if head:
        head.left = root
    head = root
    return head

# Function to print and count the total number of nodes in a doubly-linked list
def size(node):
    counter = 0
    while node:
        node = node.right
        counter = counter + 1
    return counter

# Function to print preorder traversal of the BST
def preorder(root):
    if root is None:
        return
    print(root.data, end=' ')
    preorder(root.left)
    preorder(root.right)

# Recursive method to construct a balanced BST from a sorted doubly linked list
def convertSortedDLLToBalancedBST(head, n):
    if n <= 0:
        return None, head

    # recursively construct the left subtree
    leftSubTree, head = convertSortedDLLToBalancedBST(head, n // 2)

    # `head` now points to the middle node of the sorted DDL
    # make the middle node of the sorted DDL as the root node of the BST
    root = head
```

```
    # update left child of the root node
    root.left = leftSubTree

    # update the head reference of the doubly linked list
    head = head.right

    # recursively construct the right subtree with the remaining nodes
    root.right, head = convertSortedDLLToBalancedBST(head, n - (n // 2 + 1))
    # +1 for the root
    # return the root node
    return root, head


# Recursive method to convert a BST into a doubly-linked list. It takes
# the BST's root node and the head node of the doubly linked list as an argument
def convertBSTtoSortedDLL(root, head=None):
    if root is None:
        return head

    # recursively convert the right subtree
    head = convertBSTtoSortedDLL(root.right, head)

    # push the current node at the front of the doubly linked list
    head = push(root, head)

    # recursively convert the left subtree
    head = convertBSTtoSortedDLL(root.left, head)

    return head


# Recursive method to merge two doubly-linked lists into a
# single doubly linked list in sorted order
def sortedMerge(first, second):

    # if the first list is empty, return the second list
    if first is None:
        return second

    # if the second list is empty, return the first list
    if second is None:
        return first

    # if the head node of the first list is smaller
    if first.data < second.data:
        first.right = sortedMerge(first.right, second)
        first.right.left = first
        return first

    # if the head node of the second list is smaller
    else:
        second.right = sortedMerge(first, second.right)
        second.right.left = second
        return second


# Function to merge two balanced BSTs into a single balanced BST
def merge(first, second):
```

```
    # merge both BSTs into a sorted doubly linked list
    head = sortedMerge(convertBSTtoSortedDLL(first), convertBSTtoSortedDLL(second))

    # construct a balanced BST from a sorted doubly linked list
    root, head = convertSortedDLLToBalancedBST(head, size(head))
    return root


'''
Construct the first BST
      20
     /  \
    10  30
        / \
       25 100
'''
first = Node(20)
first.left = Node(10)
first.right = Node(30)
first.right.left = Node(25)
first.right.right = Node(100)
'''
Construct the second BST
      50
     /  \
    5   70
'''
second = Node(50)
second.left = Node(5)
second.right = Node(70)
# merge both BSTs
root = merge(first, second)
preorder(root)
```

Find Kth largest element and Kth smallest element in a BST

```
import sys
class Node:
    def __init__(self, data, left=None, right=None):
        self.data = data
        self.left = left
        self.right = right

def insert(root, key):
    if root is None:
        return Node(key)
    if key < root.data:
        root.left = insert(root.left, key)
    else:
        root.right = insert(root.right, key)

    return root

# Function to find the k'th largest node in a BST. Here, `i` denotes the total number of nodes
processed so far
def kthLargest(root, i, k):
    if root is None:
        return None, i
```

```
    # search in the right subtree
    left, i = kthLargest(root.right, i, k)

    # if k'th largest is found in the left subtree, return it
    if left:
        return left, i

    i = i + 1

    # if the current node is k'th largest, return its value
    if i == k:
        return root, i

    # otherwise, search in the left subtree
    return kthLargest(root.left, i, k)


def findKthLargest(root, k):
    i = 0
    # traverse the tree in an inorder fashion and return k'th node
    return kthLargest(root, i, k)[0]


def kthSmallest(root, counter, k):
    if root is None:
        return None, counter

    # recur for the left subtree
    left, counter = kthSmallest(root.left, counter, k)

    # if k'th smallest node is found
    if left:
        return left, counter

    # if the root is k'th smallest node
    counter = counter + 1
    if counter == k:
        return root, counter

    # recur for the right subtree only if k'th smallest node is not found
    # in the right subtree
    ret, counter = kthSmallest(root.right, counter, k)
    return ret, counter

def findKthSmallest(root, k):
    counter = 0
    # recursively find the k'th smallest node
    return kthSmallest(root, counter, k)[0]

keys = [15, 10, 20, 8, 12, 16, 25]
root = None
for key in keys:
    root = insert(root, key)


k = 2
print(f"{k}th LARGEST NODE")
result = findKthLargest(root, k)
if result != sys.maxsize:
    print(result.data)
```

```
else:
    print('Invalid Input')


k = 4
print(f"{k}th SMALLEST NODE")
result = findKthSmallest(root, k)
if result:
    print(result.data)
else:
    print(f'{k}\'th smallest node does not exist.')
```

Count pairs from 2 BST whose sum is equal to given value "X"

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

root1,root2 = None,None

# def to count pairs from two BSTs whose sum is equal to a given value x
pairCount = 0
def traverseTree(root1, root2, sum):
 if root1 is None or root2 is None:
  return
 traverseTree(root1.left, root2, sum)
 traverseTree(root1.right, root2, sum)
 diff = sum - root1.data
 findPairs(root2, diff)


def findPairs(root2 , diff):
 global pairCount
 if root2 is None:
  return

 if (diff > root2.data) :
  findPairs(root2.right, diff)
 else :
  findPairs(root2.left, diff)
 if (root2.data == diff):
  pairCount += 1

def countPairs(root1, root2, sum):
 global pairCount

 traverseTree(root1, root2, sum)
 return pairCount


root1 = Node(5)
root1.left = Node(3)
root1.right = Node(7)
root1.left.left = Node(2)
root1.left.right = Node(4)
root1.right.left = Node(6)
root1.right.right = Node(8)
```

```
# formation of BST 2
root2 = Node(10)
root2.left = Node(6)
root2.right = Node(15)
root2.left.left = Node(3)
root2.left.right = Node(8)
root2.right.left = Node(11)
root2.right.right = Node(18)

x = 16
print(f"Pairs = {countPairs(root1, root2, x)}")
```

Find the median of BST in O(n) time and O(1) space

```
_MIN=float('-inf')
_MAX=float('inf')

# Helper function that allocates a new node with the given data and None left and right pointers.

class newNode:
 def __init__(self, data):
  self.data = data
  self.left = None
  self.right = None

# A utility function to insert a new node with given key in BST
def insert(node,key):
 if node is None:
  return newNode(key)

 # Otherwise, recur down the tree
 if (key < node.data):
  node.left = insert(node.left, key)
 elif (key > node.data):
  node.right = insert(node.right, key)

 # return the (unchanged) node pointer
 return node


#Function to count nodes in a binary search tree using Morris Inorder traversal
def counNodes(root):
 count = 0
 if root is None:
  return count

 current = root
 while (current != None):
  if current.left is None:
   # Count node if its left is None
   count+=1
   # Move to its right
   current = current.right

  else:
   # Find the inorder predecessor of current
   pre = current.left
```

```
    while pre.right not in [None, current]:
     pre = pre.right

    #Make current as right child of its inorder predecessor
    if pre.right is None:
     pre.right = current
     current = current.left
    else:
     pre.right = None
     # Increment count if the current node is to be visited
     count += 1
     current = current.right

 return count


def findMedian(root):
 if root is None:
  return 0
 count = counNodes(root)
 currCount = 0
 current = root

 while (current != None):

  if current.left is None:

   # count current node
   currCount += 1

   # check if current node is the median
   # Odd case
   if (count % 2 != 0 and
    currCount == (count + 1)//2):
    return prev.data

   # Even case
   elif (count % 2 == 0 and
     currCount == (count//2)+1):
    return (prev.data + current.data)//2

   # Update prev for even no. of nodes
   prev = current

   #Move to the right
   current = current.right

  else:

   # Find the inorder predecessor of current
   pre = current.left
   while pre.right not in [None, current]:
    pre = pre.right

   # Make current as right child of its inorder predecessor
   if pre.right is None:

    pre.right = current
    current = current.left
   else:
```

```
    pre.right = None

    prev = pre

    # Count current node
    currCount+= 1

    # Check if the current node is the median
    if (count % 2 != 0 and
     currCount == (count + 1) // 2 ):
     return current.data

    elif (count%2 == 0 and
     currCount == (count // 2) + 1):
     return (prev.data+current.data)//2

    # update prev node for the case of even
    # no. of nodes
    prev = current
    current = current.right

"""
Constructed binary tree is
 50
 / \
    30 70
    / \ / \
    20 40 60 80
"""
root = newNode(50)
insert(root, 30)
insert(root, 20)
insert(root, 40)
insert(root, 70)
insert(root, 60)
insert(root, 80)
print("Median of BST is ",findMedian(root))
```

Count BST nodes that lie in a given range

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

def insert(root, key):
    if root is None:
        return Node(key)
    if key < root.data:
        root.left = insert(root.left, key)
    else:
        root.right = insert(root.right, key)
    return root

def countNodes(root, low, high):
    if root is None:
```

```
        return 0

    # keep track of the total number of nodes in the tree rooted with `root`.
    # that lies within the current range [low, high]
    count = 0

    # increment count if the current node lies within the current range
    if low <= root.data <= high:
        count += 1

    # recur for the left subtree
    count += countNodes(root.left, low, high)

    # recur for the right subtree and return the total count
    return count + countNodes(root.right, low, high)


low, high = 12, 20
keys = [15, 25, 20, 22, 30, 18, 10, 8, 9, 12, 6]
root = None
for key in keys:
    root = insert(root, key)

print('The total number of nodes is', countNodes(root, low, high))
```

Replace every element with the least greater element on its right

```
"""
Given an array of integers, replace every element with the least greater element on its right side
in the array. If there are no greater elements on the right side, replace it with -1.

Examples:
Input: [8, 58, 71, 18, 31, 32, 63, 92,
         43, 3, 91, 93, 25, 80, 28]
Output: [18, 63, 80, 25, 32, 43, 80, 93,
         80, 25, 93, -1, 28, -1, -1]
"""

class Node:
 def __init__(self, d):
  self.data = d
  self.left = None
  self.right = None

# A utility function to insert a new node with given data in BST and find its successor
def insert(node, data):
 global succ
 # If the tree is empty, return a new node
 root = node

 if node is None:
  return Node(data)

 # If key is smaller than root's key, go to left subtree and set successor as current node
 if (data < node.data):

  #print("1")
```

```
  succ = node
  root.left = insert(node.left, data)

 # Go to right subtree
 elif (data > node.data):
  root.right = insert(node.right, data)

 return root

# Function to replace every element with the least greater element on its right
def replace(arr, n):

 global succ
 root = None

 # Start from right to left
 for i in range(n - 1, -1, -1):
  succ = None

  # Insert current element into BST and find its inorder successor
  root = insert(root, arr[i])

  # Replace element by its inorder successor in BST
  arr[i] = succ.data if succ else -1
 return arr



arr = [ 8, 58, 71, 18, 31, 32, 63,
  92, 43, 3, 91, 93, 25, 80, 28 ]
n = len(arr)
succ = None
arr = replace(arr, n)
print(*arr)
```

Given "n" appointments, find the conflicting appointments

```
"""
Input: appointments[] = { {1, 5} {3, 7}, {2, 6}, {10, 15}, {5, 6}, {4, 100}}
Output: Following are conflicting intervals
[3,7] Conflicts with [1,5]
[2,6] Conflicts with [1,5]
[5,6] Conflicts with [3,7]
[4,100] Conflicts with [1,5]
"""


class Interval:
 def __init__(self):
  self.low = None
  self.high = None

# Structure to represent a node in Interval Search Tree
class ITNode:
 def __init__(self):
  self.max = None
  self.i = None
  self.left = None
  self.right = None
```

```
def newNode(j):
 #print(j)
 temp = ITNode()
 temp.i = j
 temp.max = j[1]
 return temp

# A utility function to check if given two intervals overlap
def doOverlap(i1, i2):
 if (i1[0] < i2[1] and i2[0] < i1[1]):
  return True
 return False

# Function to create a new node
def insert(node, data):
 global succ

 # If the tree is empty, return a new node
 root = node
 if node is None:
  return newNode(data)

 # If key is smaller than root's key, go to left subtree and set successor as current node
print(node)
 if (data[0] < node.i[0]):
  root.left = insert(node.left, data)

 # Go to right subtree
 else:
  root.right = insert(node.right, data)
 if root.max < data[1]:
  root.max = data[1]

 return root

# The main function that searches a given interval i in a given Interval Tree.
def overlapSearch(root, i):
 if root is None:
  return None

 # If given interval overlaps with root
 if (doOverlap(root.i, i)):
  return root.i

 # If left child of root is present and max of left child is greater than or
 # equal to given interval, then i may overlap with an interval is left subtree
 if (root.left != None and root.left.max >= i[0]):
  return overlapSearch(root.left, i)

 # Else interval can only overlap with right subtree
 return overlapSearch(root.right, i)

# This function prints all conflicting appointments in a given array of appointments.
def printConflicting(appt, n):
 # Create an empty Interval Search Tree, add first appointment
 root = None
 root = insert(root, appt[0])

 # Process rest of the intervals
```

```
 for i in range(1, n):
  # If current appointment conflicts with any of the existing intervals, print it
  res = overlapSearch(root, appt[i])

  if (res != None):
   print("[", appt[i][0], ",", appt[i][1],
    "] Conflicts with [", res[0],
    ",", res[1], "]")

  # Insert this appointment
  root = insert(root, appt[i])



appt = [ [ 1, 5 ], [ 3, 7 ],
  [ 2, 6 ], [ 10, 15 ],
  [ 5, 6 ], [ 4, 100 ]
    ]
n = len(appt)
print("Following are conflicting intervals")
printConflicting(appt, n)
```

Preorder to Postorder

```
#  A class to store a binary tree node
class Node:
    def __init__(self, key):
        self.key = key

def postorder(root):
    if root is None:
        return
    postorder(root.left)
    postorder(root.right)
    print(root.key, end=' ')



# Recursive function to build a BST from a preorder sequence.
def constructBST(preorder, start, end):

    # base case
    if start > end:
        return None

    # Construct the root node of the subtree formed by keys of the
    # preorder sequence in range `[start, end]`
    node = Node(preorder[start])

    # search the index of the first element in the current range of preorder
    # sequence larger than the root node's value
    i = start
    while i <= end:
        if preorder[i] > node.key:
            break
        i = i + 1
```

```
    # recursively construct the left subtree
    node.left = constructBST(preorder, start + 1, i - 1)

    # recursively construct the right subtree
    node.right = constructBST(preorder, i, end)

    # return current node
    return node


'''
Construct the following BST
          15
        /    \
       /      \
      10       20
     /  \     /  \
    /    \   /    \
   8     12 16    25
'''

preorder = [15, 10, 8, 12, 20, 16, 25]
root = constructBST(preorder, 0, len(preorder) - 1)
print('Postorder traversal of BST is ', end='')
postorder(root)
```

Check whether BST contains Dead end

```
"""
Given a Binary search Tree that contains positive integer values greater than 0. The task is to
check whether the BST contains a dead end or not. Here Dead End means, we are not able to insert
any element after that node.

Examples:

Input :        8
             /   \
            5     9
          /   \
         2     7
        /
       1
Output : Yes
Explanation : Node "1" is the dead End because after that we cant insert any element.

Input :       8
            /   \
           7     10
         /      /   \
        2      9     13

Output : Yes
Explanation : We can't insert any element at node 9.
"""

all_nodes = set()
leaf_nodes = set()

# A BST node
```

```
class newNode:

 def __init__(self, data):

  self.data = data
  self.left = None
  self.right = None

# A utility function to insert a new Node with given key in BST
def insert(node, key):
 if node is None:
  return newNode(key)

 # Otherwise, recur down the tree
 if (key < node.data):
  node.left = insert(node.left,
      key)
 elif (key > node.data):
  node.right = insert(node.right,
       key)

 # return the (unchanged) Node pointer
 return node

# Function to store all node of given binary search tree
def storeNodes(root):

 global all_nodes
 global leaf_nodes
 if root is None:
  return

 # store all node of binary search tree
 all_nodes.add(root.data)

 # store leaf node in leaf_hash
 if root.left is None and root.right is None:
  leaf_nodes.add(root.data)
  return

 # recur call rest tree
 storeNodes(root. left)
 storeNodes(root.right)

# Returns true if there is a dead end in tree, else false.
def isDeadEnd(root):

 global all_nodes
 global leaf_nodes

 if root is None:
  return False

 # create two empty hash sets that store all BST elements and leaf nodes respectively.

 # insert 0 in 'all_nodes' for handle case if bst contain value 1
 all_nodes.add(0)

 # Call storeNodes function to store all BST Node
 storeNodes(root)
```

```
 return any(((x + 1) in all_nodes and (x - 1) in all_nodes) for x in leaf_nodes)

root = None
root = insert(root, 8)
root = insert(root, 5)
root = insert(root, 2)
root = insert(root, 3)
root = insert(root, 7)
root = insert(root, 11)
root = insert(root, 4)

if(isDeadEnd(root) == True):
 print("Yes")
else:
 print("No")
```

Largest BST in a Binary Tree [V.V.V.V.V IMP]

```
import sys
sys.setrecursionlimit(1000000)
from collections import deque

IMIN = float('-inf')
IMAX = float('inf')

class newNode:
 def __init__(self, val):
  self.right = None
  self.data = val
  self.left = None

def largestBst(root):
 if root is None:
  return IMAX,IMIN,0
 if root.left is None and root.right is None:
  return root.data,root.data,1

 left=largestBst(root.left)
 right=largestBst(root.right)

 ans=[0,0,0]

 if left[1]<root.data and right[0]>root.data:
  ans[0]=min(left[0],right[0],root.data)
  ans[1]=max(right[1],left[1],root.data)
  ans[2]=1+left[2]+right[2]
  return ans

 ans[0]=IMIN
 ans[1]=IMAX
 ans[2]=max(left[2],right[2])
 return ans[2]


"""
 50
```

```
 / \
  75  45
 /
40
"""
root = newNode(50)
root.left = newNode(75)
root.right = newNode(45)
root.left.left = newNode(40)
print("Size of the largest BST is",largestBst(root))
```

Flatten BST to sorted list

```
global prev
class node :
 def __init__(self, data):
  self.data = data
  self.left = None
  self.right = None

def printTree(parent):
 root = parent
 while root is not None:
  print(root.data,end=' ')
  root = root.right

def inorder(root):
 global prev
 if root is None:
  return
 inorder(root.left)
 print(root.data,end=' ')
 inorder(root.right)


# Function to flatten binary tree using level order traversal BFS
def flatten(parent):
 global prev
    # Dummy node
 dummy = node(-1)

 # Pointer to previous element
 prev = dummy

 # Calling in-order traversal
 inorder(parent)

 prev.left = None
 prev.right = None

 # Delete dummy node
 return dummy.right

root = node(5)
root.left = node(3)
root.right = node(7)
root.left.left = node(2)
root.left.right = node(4)
root.right.left = node(6)
```

```
root.right.right = node(8)
printTree(flatten(root))
```

Dynamic Programming

Coin ChangeProblem

```
"""
Given an unlimited supply of coins of given denominations, find the total number of distinct ways
to get the desired change.

For example,

Input: S = { 1, 3, 5, 7 }, target = 8

The total number of ways is 6

{ 1, 7 }
{ 3, 5 }
{ 1, 1, 3, 3 }
{ 1, 1, 1, 5 }
{ 1, 1, 1, 1, 1, 3 }
{ 1, 1, 1, 1, 1, 1, 1, 1 }


Input: S = { 1, 2, 3 }, target = 4

The total number of ways is 4

{ 1, 3 }
{ 2, 2 }
{ 1, 1, 2 }
{ 1, 1, 1, 1 }
"""

def count(S, n, target):
    if target == 0:
        return 1

    # return 0 (solution does not exist) if total becomes negative, no elements are left
    if target < 0 or n < 0:
        return 0

    # Case 1. Include current coin `S[n]` in solution and recur
    # with remaining change `target-S[n]` with the same number of coins
    incl = count(S, n, target - S[n])

    # Case 2. Exclude current coin `S[n]` from solution and recur for remaining coins `n-1`
    excl = count(S, n - 1, target)

    # return total ways by including or excluding current coin
    return incl + excl


# `n` coins of given denominations
S = [1, 2, 3]
# total change required
target = 4
```

```
print('The total number of ways to get the desired change is',
    count(S, len(S) - 1, target))
```

Knapsack Problem

```
"""
In the 0-1 Knapsack problem, we are given a set of items, each with a weight and a value, and we
need to determine the number of each item to include in a collection so that the total weight is
less than or equal to a given limit and the total value is as large as possible.

Please note that the items are indivisible; we can either take an item or not (0-1 property). For
example,

Input:

value = [ 20, 5, 10, 40, 15, 25 ]
weight = [ 1, 2, 3, 8, 7, 4 ]
int W = 10

Output: Knapsack value is 60

value = 20 + 40 = 60
weight = 1 + 8 = 9 < W
"""

import sys


# Values (stored in list `v`)
# Weights (stored in list `w`)
# Total number of distinct items `n`
# Knapsack capacity `W`
def knapsack(v, w, n, W):
    if W < 0:
        return -sys.maxsize

    # base case: no items left or capacity becomes 0
    if n < 0 or W == 0:
        return 0

    # Case 1. Include current item `n` in knapsack `v[n]` and recur for
    # remaining items `n-1` with decreased capacity `W-w[n]`
    include = v[n] + knapsack(v, w, n - 1, W - w[n])

    # Case 2. Exclude current item `v[n]` from the knapsack and recur for
    # remaining items `n-1`
    exclude = knapsack(v, w, n - 1, W)

    # return maximum value we get by including or excluding the current item
    return max(include, exclude)



# input: a set of items, each with a weight and a value
v = [20, 5, 10, 40, 15, 25]
w = [1, 2, 3, 8, 7, 4]
# knapsack capacity
W = 10
```

```
print('Knapsack value is', knapsack(v, w, len(v) - 1, W))
```

Binomial CoefficientProblem

```
"""
A binomial coefficient C(n, k) also gives the number of ways, disregarding order, that k objects
can be chosen from among n objects more formally, the number of k-element subsets (or k-
combinations) of a n-element set.
"""

def binomialCoeff(n, k):
    C = [0 for i in range(k+1)]
    C[0] = 1  # since nC0 is 1

    for i in range(1, n+1):
        # Compute next row of pascal triangle using the previous row
        j = min(i, k)
        while (j > 0):
            C[j] = C[j] + C[j-1]
            j -= 1

    return C[k]


n = 5
k = 2
print ("Value of C(%d,%d) is %d" % (n, k, binomialCoeff(n, k)))
```

Permutation CoefficientProblem

```
"""
P(10, 2) = 90
P(10, 3) = 720
P(10, 0) = 1
P(10, 1) = 10
"""

def permutationCoeff(n, k):
    # P(n,k)=n*(n-1)*(n-2)*....(n-k-1)
    f=1
    for i in range(k):
        f*=(n-i)
    return f

n = 10
k = 2
print("Value of P(", n, ",", k, ") is ", permutationCoeff(n, k))
```

Program for nth Catalan Number

```
"""
Catalan numbers are a sequence of natural numbers that occurs in many interesting counting
problems like the following.
1) Count the number of expressions containing n pairs of parentheses which are correctly matched.
For n = 3, possible expressions are ((())), ()(()), ()()(), (())(), (()()).
```

```
2) Count the number of possible Binary Search Trees with n keys (See this)

The first few Catalan numbers for n = 0, 1, 2, 3, … are 1, 1, 2, 5, 14, 42, 132, 429, 1430, 4862,
…
"""

def catalan(n):
    return 1 if n <= 1 else sum(catalan(i) * catalan(n-i-1) for i in range(n))

for i in range(10):
    print(catalan(i), end=' ')
```

Matrix Chain Multiplication

```
"""
Input: p[] = {40, 20, 30, 10, 30}
Output: 26000
There are 4 matrices of dimensions 40x20, 20x30, 30x10 and 10x30.
Let the input 4 matrices be A, B, C and D.  The minimum number of
multiplications are obtained by putting parenthesis in following way
(A(BC))D --> 20*30*10 + 40*20*10 + 40*10*30

Input: p[] = {10, 20, 30, 40, 30}
Output: 30000
There are 4 matrices of dimensions 10x20, 20x30, 30x40 and 40x30.
Let the input 4 matrices be A, B, C and D.  The minimum number of
multiplications are obtained by putting parenthesis in following way
((AB)C)D --> 10*20*30 + 10*30*40 + 10*40*30

Input: p[] = {10, 20, 30}
Output: 6000
There are only two matrices of dimensions 10x20 and 20x30. So there
is only one way to multiply the matrices, cost of which is 10*20*30
"""

import sys

# Matrix A[i] has dimension p[i-1] x p[i] for i = 1..n
def MatrixChainOrder(p, i, j):
    if i == j:
        return 0
    _min = sys.maxsize

    # place parenthesis at different places between first and last matrix,
    # recursively calculate count of multiplications for each parenthesis
    # placement and return the minimum count
    for k in range(i, j):
        count = (MatrixChainOrder(p, i, k) + MatrixChainOrder(p, k + 1, j) + p[i-1] * p[k] * p[j])
        if count < _min:
            _min = count
    # Return minimum count
    return _min

arr = [1, 2, 3, 4, 3]
n = len(arr)
print("Minimum number of multiplications is ",
    MatrixChainOrder(arr, 1, n-1))
```

Edit Distance

```
"""
The Levenshtein distance (or Edit distance) is a way of quantifying how different two strings are
from one another by counting the minimum number of operations required to transform one string
into the other
('ABA', 'ABC') --> ('ABAC', 'ABC') == ('ABA', 'AB')
"""

def dist(X, Y):
    # `m` and `n` is the total number of characters in `X` and `Y`, respectively
    (m, n) = (len(X), len(Y))
    # For all pairs of `i` and `j`, `T[i, j]` will hold the Levenshtein distance
    # between the first `i` characters of `X` and the first `j` characters of `Y`.
    # Note that `T` holds `(m+1)×(n+1)` values.
    T = [[0 for _ in range(n + 1)] for _ in range(m + 1)]

    # we can transform source prefixes into an empty string by dropping all characters
    for i in range(1, m + 1):
        T[i][0] = i                    # (case 1)

    # we can reach target prefixes from empty source prefix by inserting every character
    for j in range(1, n + 1):
        T[0][j] = j                    # (case 1)

    # fill the lookup table in a bottom-up manner
    for i in range(1, m + 1):

        for j in range(1, n + 1):
            cost = 0 if X[i - 1] == Y[j - 1] else 1
            T[i][j] = min(T[i - 1][j] + 1,      # deletion
                          T[i][j - 1] + 1,      # insertion
                          T[i - 1][j - 1] + cost) # replace

    return T[m][n]


X = 'kitten'
Y = 'sitting'
print('The Levenshtein distance is', dist(X, Y))
```

Subset Sum Problem

```
"""
Given a set of positive integers and an integer k, check if there is any non-empty subset that
sums to k.
A = { 7, 3, 2, 5, 8 }
k = 14

Output: Subset with the given sum exists
Subset { 7, 2, 5 } sums to 14
"""

def subsetSum(A, k):
    n = len(A)
    # `T[i][j]` stores true if subset with sum `j` can be attained
    # using items up to first `i` items
```

```
    T = [[False for _ in range(k + 1)] for _ in range(n + 1)]

    # if the sum is zero
    for i in range(n + 1):
        T[i][0] = True

    # do for i'th item
    for i in range(1, n + 1):
        # consider all sum from 1 to sum
        for j in range(1, k + 1):
            # don't include the i'th element if `j-A[i-1]` is negative
            if A[i - 1] > j:
                T[i][j] = T[i - 1][j]
            else:
                # find the subset with sum `j` by excluding or including the i'th item
                T[i][j] = T[i - 1][j] or T[i - 1][j - A[i - 1]]

    # return maximum value
    return T[n][k]


# Input: a set of items and a sum
A = [7, 3, 2, 5, 8]
k = 18
if subsetSum(A, k):
    print('Subsequence with the given sum exists')
else:
    print('Subsequence with the given sum does not exist')
```

Friends Pairing Problem

```
"""
 Input  : n = 3
 Output : 4
 Explanation:
 {1}, {2}, {3} : all single
 {1}, {2, 3} : 2 and 3 paired but 1 is single.
 {1, 2}, {3} : 1 and 2 are paired but 3 is single.
 {1, 3}, {2} : 1 and 3 are paired but 2 is single.
 Note that {1, 2} and {2, 1} are considered same.

 Mathematical Explanation:
 The problem is simplified version of how many ways we can divide n elements into multiple groups.
 (here group size will be max of 2 elements).
 In case of n = 3, we have only 2 ways to make a group:
     1) all elements are individual(1,1,1)
     2) a pair and individual (2,1)
 In case of n = 4, we have 3 ways to form a group:
     1) all elements are individual (1,1,1,1)
     2) 2 individuals and one pair (2,1,1)
     3) 2 separate pairs (2,2)
"""


# Returns count of ways n people can remain single or paired up.
def countFriendsPairings(n):

    dp = [0 for _ in range(n + 1)]
```

```
    # Filling dp[] in bottom-up manner using recursive formula explained above.
    for i in range(n + 1):

        dp[i] = i if (i <= 2) else dp[i - 1] + (i - 1) * dp[i - 2]
    return dp[n]

n = 4
print(countFriendsPairings(n))
```

Gold Mine Problem

```
"""
Given a gold mine of n*m dimensions. Each field in this mine contains a positive integer which is
the amount of gold in tons. Initially the miner is at first column but can be at any row. He can
move only (right->,right up /,right down\) that is from a given cell, the miner can move to the
cell diagonally up towards the right or right or diagonally down towards the right. Find out
maximum amount of gold he can collect.
Examples:


Input : mat[][] = {{1, 3, 3},
                   {2, 1, 4},
                  {0, 6, 4}};
Output : 12
{(1,0)->(2,1)->(1,2)}

Input: mat[][] = { {1, 3, 1, 5},
                   {2, 2, 4, 1},
                   {5, 0, 2, 3},
                   {0, 6, 1, 2}};
Output : 16
(2,0) -> (1,1) -> (1,2) -> (0,3) OR
(2,0) -> (3,1) -> (2,2) -> (2,3)

"""


def collectGold(gold, x, y, n, m):
    if ((x < 0) or (x == n) or (y == m)):
        return 0

    # Right upper diagonal
    rightUpperDiagonal = collectGold(gold, x - 1, y + 1, n, m)

    # right
    right = collectGold(gold, x, y + 1, n, m)

    # Lower right diagonal
    rightLowerDiagonal = collectGold(gold, x + 1, y + 1, n, m)

    # Return the maximum and store the value
    return gold[x][y] + max(max(rightUpperDiagonal, rightLowerDiagonal), right)


def getMaxGold(gold,n,m):
    maxGold = 0
    for i in range(n):
        goldCollected = collectGold(gold, i, 0, n, m)
        maxGold = max(maxGold, goldCollected)
```

```
    return maxGold

gold = [[1, 3, 1, 5],
        [2, 2, 4, 1],
        [5, 0, 2, 3],
        [0, 6, 1, 2]
]
m,n = 4,4
print(getMaxGold(gold, n, m))
```

Assembly Line SchedulingProblem

```
def carAssembly(a, t, e, x):
    NUM_STATION = len(a[0])
    T1 = [0 for _ in range(NUM_STATION)]
    T2 = [0 for _ in range(NUM_STATION)]

    # time taken to leave first station in line 1
    T1[0] = e[0] + a[0][0]
    # time taken to leave first station in line 2
    T2[0] = e[1] + a[1][0]

    # Fill tables T1[] and T2[] using above given recursive relations
    for i in range(1, NUM_STATION):
        T1[i] = min(T1[i-1] + a[0][i], T2[i-1] + t[1][i] + a[0][i])
        T2[i] = min(T2[i-1] + a[1][i], T1[i-1] + t[0][i] + a[1][i] )

    # consider exit times and return minimum
    return min(T1[NUM_STATION - 1] + x[0], T2[NUM_STATION - 1] + x[1])

a = [[4, 5, 3, 2],
     [2, 10, 1, 4]]
t = [[0, 7, 4, 5],
     [0, 9, 2, 8]]
e = [10, 12]
x = [18, 7]

print(carAssembly(a, t, e, x))
```

Painting the Fence Problem

```
'''
Given a fence with n posts and k colors, find out the number of ways of painting the fence such
that at most 2 adjacent posts have the same color. Since answer can be large return it modulo 10^9
+ 7.
Examples:

Input : n = 2 k = 4
Output : 16
We have 4 colors and 2 posts.
Ways when both posts have same color : 4
Ways when both posts have diff color :
4(choices for 1st post) * 3(choices for
2nd post) = 12

Input : n = 3 k = 2
Output : 6
'''
```

```
# Returns count of ways to color k posts using k colors
def countWays(n, k):
    # There are k ways to color first post
    total = k
    mod = 1000000007

    # There are 0 ways for single post to violate (same color_ and k ways to not violate
(different color)
    same, diff = 0, k

    # Fill for 2 posts onwards
    for _ in range(2, n + 1):
        # Current same is same as previous diff
        same = diff

        # We always have k-1 choices for next post
        diff = total * (k - 1)
        diff = diff % mod

        # Total choices till i.
        total = (same + diff) % mod
    return total

n, k = 3, 2
print(countWays(n, k))
```

Rod Cutting Problem

```
'''
Given a rod of length n and a list of rod prices of length i, where 1 <= i <= n, find the optimal
way to cut the rod into smaller rods to maximize profit.
For example, consider the following rod lengths and values:
Input:
length[] = [1, 2, 3, 4, 5, 6, 7, 8]
price[] = [1, 5, 8, 9, 10, 17, 17, 20]
Rod length: 4
Best: Cut the rod into two pieces of length 2 each to gain revenue of 5 + 5 = 10
'''

def rodCut(price, n):

    # `T[i]` stores the maximum profit achieved from a rod of length `i`
    T = [0] * (n + 1)

    # consider a rod of length `i`
    for i in range(1, n + 1):
        # divide the rod of length `i` into two rods of length `j` and `i-j` each and take maximum
        for j in range(1, i + 1):
            T[i] = max(T[i], price[j - 1] + T[i - j])

    # `T[n]` stores the maximum profit achieved from a rod of length `n`
    return T[n]

price = [1, 5, 8, 9, 10, 17, 17, 20]
n = 4        # rod length
print('Profit is', rodCut(price, n))
```

Longest Common Subsequence

```
# Function to return all LCS of substrings `X[0…m-1]`, `Y[0…n-1]`
def LCS(X, Y, m, n, lookup):
    # if the end of either sequence is reached
    if m == 0 or n == 0:
        # create a list with one empty string and return
        return ['']

    # if the last character of `X` and `Y` matches
    if X[m - 1] == Y[n - 1]:
        # ignore the last characters of `X` and `Y` and find all LCS of substring
        # `X[0…m-2]`, `Y[0…n-2]` and store it in a list
        lcs = LCS(X, Y, m - 1, n - 1, lookup)

        # append current character `X[m-1]` or `Y[n-1]`
        # to all LCS of substring `X[0…m-2]` and `Y[0…n-2]`
        for i in range(len(lcs)):
            lcs[i] = lcs[i] + (X[m - 1])
        return lcs

    # we reach here when the last character of `X` and `Y` don't match

    # if a top cell of the current cell has more value than the left cell,
    # then ignore the current character of string `X` and find all LCS of
    # substring `X[0…m-2]`, `Y[0…n-1]`
    if lookup[m - 1][n] > lookup[m][n - 1]:
        return LCS(X, Y, m - 1, n, lookup)

    # if a left cell of the current cell has more value than the top cell,
    # then ignore the current character of string `Y` and find all LCS of
    # substring `X[0…m-1]`, `Y[0…n-2]`
    if lookup[m][n - 1] > lookup[m - 1][n]:
        return LCS(X, Y, m, n - 1, lookup)

    # if the top cell has equal value to the left cell, then consider both characters

    top = LCS(X, Y, m - 1, n, lookup)
    left = LCS(X, Y, m, n - 1, lookup)

    # merge two lists and return
    return top + left


# Function to fill the lookup table by finding the length of LCS
# of substring `X` and `Y`
def LCSLength(X, Y, lookup):

    # fill the lookup table in a bottom-up manner
    for i in range(1, len(X) + 1):
        for j in range(1, len(Y) + 1):
            # if current character of `X` and `Y` matches
            if X[i - 1] == Y[j - 1]:
                lookup[i][j] = lookup[i - 1][j - 1] + 1

            # otherwise, if the current character of `X` and `Y` don't match
            else:
                lookup[i][j] = max(lookup[i - 1][j], lookup[i][j - 1])
```

```
# Function to find all LCS of string `X[0…m-1]` and `Y[0…n-1]`
def findLCS(X, Y):

    # lookup[i][j] stores the length of LCS of substring `X[0…i-1]` and `Y[0…j-1]`
    lookup = [[0 for _ in range(len(Y) + 1)] for _ in range(len(X) + 1)]

    # fill lookup table
    LCSLength(X, Y, lookup)

    # find all the longest common subsequences
    lcs = LCS(X, Y, len(X), len(Y), lookup)

    # since a list can contain duplicates, "convert" it to a set and return
    return set(lcs)

X = 'ABCBDAB'
Y = 'BDCABA'
lcs = findLCS(X, Y)
print(lcs)
```

Longest Repeated Subsequence

```
def LRS(X, m, n, lookup):
    # if the end of either sequence is reached, return an empty string
    if m == 0 or n == 0:
        return ''

    if X[m - 1] == X[n - 1] and m != n:
        return LRS(X, m - 1, n - 1, lookup) + X[m - 1]
    # otherwise, if characters at index `m` and `n` don't match
    if lookup[m - 1][n] > lookup[m][n - 1]:
        return LRS(X, m - 1, n, lookup)
    else:
        return LRS(X, m, n - 1, lookup)


# Function to fill the lookup table by finding the length of LRS of substring `X[0…n-1]`
def LRSLength(X, lookup):
    # Fill the lookup table in a bottom-up manner.The first row and first column of the lookup
table are already 0.
    for i in range(1, len(X) + 1):
        for j in range(1, len(X) + 1):
            # if characters at index `i` and `j` matches and the index are different
            if X[i - 1] == X[j - 1] and i != j:
                lookup[i][j] = lookup[i - 1][j - 1] + 1
            # otherwise, if characters at index `i` and `j` are different
            else:
                lookup[i][j] = max(lookup[i - 1][j], lookup[i][j - 1])

X = 'ATACTCGGA'
# lookup[i][j] stores the length of LRS of substring `X[0…i-1]` and `X[0…j-1]`
lookup = [[0 for _ in range(len(X) + 1)] for _ in range(len(X) + 1)]
# fill lookup table
LRSLength(X, lookup)
# find the longest repeating subsequence
print(LRS(X, len(X), len(X), lookup))
```

Longest Increasing Subsequence

```
def findLIS(arr):
    if not arr:
        return []

    # LIS[i] stores the longest increasing subsequence of sublist `arr[0…i]` that ends with
`arr[i]`
    LIS = [[] for _ in range(len(arr))]

    # LIS[0] denotes the longest increasing subsequence ending at `arr[0]`
    LIS[0].append(arr[0])

    # start from the second element in the list
    for i in range(1, len(arr)):
        # do for each element in sublist `arr[0…i-1]`
        for j in range(i):

            # find the longest increasing subsequence that ends with `arr[j]`
            # where `arr[j]` is less than the current element `arr[i]`
            if arr[j] < arr[i] and len(LIS[j]) > len(LIS[i]):
                LIS[i] = LIS[j].copy()

        # include `arr[i]` in `LIS[i]`
        LIS[i].append(arr[i])

    # `j` will store the index of LIS
    j = 0
    for i in range(len(arr)):
        if len(LIS[j]) < len(LIS[i]):
            j = i
    print(LIS[j])

arr = [0, 8, 4, 12, 2, 10, 6, 14, 1, 9, 5, 13, 3, 11, 7, 15]
findLIS(arr)
```

Space Optimized Solution of LCS (Print only length)

```
def lcs(text1, text2):
    m, n = len(text1), len(text2)
    if m > n : text1, text2 = text2, text1
    dp = [0] * (n + 1)
    for c in text1:
        prev = 0
        for i, d in enumerate(text2):
            prev, dp[i + 1] = dp[i + 1], prev + 1 if c == d else max(dp[i], dp[i + 1])
    return dp[-1]
X = "AGGTAB"
Y = "GXTXAYB"

print("Length of LCS is", lcs(X, Y))
```

LCS (Longest Common Subsequence) of three strings

```
"""
Given 3 strings of all having length < 100,the task is to find the longest common sub-sequence in
all three given sequences.
```

```
Examples:

Input : str1 = "geeks"
        str2 = "geeksfor"
        str3 = "geeksforgeeks"
Output : 5
Longest common subsequence is "geeks"
i.e., length = 5
"""

X = "AGGT12"
Y = "12TXAYB"
Z = "12XBA"

dp = [[[-1 for _ in range(100)] for _ in range(100)] for _ in range(100)]

# Returns length of LCS for X[0..m-1], Y[0..n-1] and Z[0..o-1]
def lcsOf3(i, j, k):

    if(i == -1 or j == -1 or k == -1) :
        return 0

    if(dp[i][j][k] != -1) :
        return dp[i][j][k]

    if X[i] == Y[j] == Z[k]:
        dp[i][j][k] = 1 + lcsOf3(i - 1, j - 1, k - 1)

    else:
        dp[i][j][k] = max(max(lcsOf3(i - 1, j, k), lcsOf3(i, j - 1, k)), lcsOf3(i, j, k - 1))

    return dp[i][j][k]


m = len(X)
n = len(Y)
o = len(Z)
print("Length of LCS is", lcsOf3(m - 1, n - 1, o - 1))
```

Maximum Sum Increasing Subsequence

```
"""
Given an array of n positive integers. Write a program to find the sum of maximum sum subsequence
of the given array such that the integers in the subsequence are sorted in increasing order. For
example, if input is {1, 101, 2, 3, 100, 4, 5}, then output should be 106 (1 + 2 + 3 + 100), if
the input array is {3, 4, 5, 10}, then output should be 22 (3 + 4 + 5 + 10) and if the input array
is {10, 5, 4, 3}, then output should be 10
"""

def maxSumIS(arr, n):
    maxx = 0
    msis = [0 for _ in range(n)]

    # Initialize msis values for all indexes
    for i in range(n):
        msis[i] = arr[i]

    # Compute maximum sum values in bottom up manner
```

```
    for i in range(1, n):
        for j in range(i):
            if (arr[i] > arr[j] and
                msis[i] < msis[j] + arr[i]):
                msis[i] = msis[j] + arr[i]

    # Pick maximum of all msis values
    for i in range(n):
        if maxx < msis[i]:
            maxx = msis[i]
    return maxx

arr = [1, 101, 2, 3, 100, 4, 5]
n = len(arr)
print("Sum of maximum sum increasing " + "subsequence is " +str(maxSumIS(arr, n)))
```

Count all subsequences having product less than K

```
"""
Input : [1, 2, 3, 4]
        k = 10
Output :11
Explanation: The subsequences are {1}, {2}, {3}, {4}, {1, 2}, {1, 3}, {1, 4}, {2, 3}, {2, 4}, {1,
2, 3}, {1, 2, 4}

Input  : [4, 8, 7, 2]
         k = 50
Output : 9
"""

def productSubSeqCount(arr, k):
    n = len(arr)
    dp = [[0 for _ in range(n + 1)] for _ in range(k + 1)]
    for i in range(1, k + 1):
        for j in range(1, n + 1):

            # number of subsequence using j-1 terms
            dp[i][j] = dp[i][j - 1]

            # if arr[j-1] > i it will surely make product greater thus it won't contribute then
            if arr[j - 1] <= i and arr[j - 1] > 0:

                # number of subsequence using 1 to j-1 terms and j-th term
                dp[i][j] += dp[i // arr[j - 1]][j - 1] + 1
    return dp[k][n]

A = [1,2,3,4]
k = 10
print(productSubSeqCount(A, k))
```

Longest subsequence such that difference between adjacent is one

```
"""
Input :  arr[] = {10, 9, 4, 5, 4, 8, 6}
Output :  3
As longest subsequences with difference 1 are, "10, 9, 8",
```

```
"4, 5, 4" and "4, 5, 6"

Input :  arr[] = {1, 2, 3, 2, 3, 7, 2, 1}
Output :  7
As longest consecutive sequence is "1, 2, 3, 2, 3, 2, 1"
"""

def longestSubseqWithDiffOne(arr, n):
    # Initialize the dp[] array with 1 as a single element will be of 1 length
    dp = [1 for _ in range(n)]

    # Start traversing the given array
    for i in range(n):
        # Compare with all the previous elements
        for j in range(i):
            # If the element is consecutive then consider this subsequence and update dp[i] if
required.
            if arr[i] in [arr[j] + 1, arr[j] - 1]:
                dp[i] = max(dp[i], dp[j]+1)

    # Longest length will be the maximum value of dp array.
    result = 1
    for i in range(n):
        if (result < dp[i]):
            result = dp[i]
    return result

arr = [1, 2, 3, 4, 5, 3, 2]
# Longest subsequence with one difference is {1, 2, 3, 4, 3, 2}
n = len(arr)
print (longestSubseqWithDiffOne(arr, n))
```

Maximum subsequence sum such that no three are consecutive

```
# sourcery skip: avoid-builtin-shadow
"""
Input: arr[] = {1, 2, 3}
Output: 5
We can't take three of them, so answer is
2 + 3 = 5

Input: arr[] = {3000, 2000, 1000, 3, 10}
Output: 5013
3000 + 2000 + 3 + 10 = 5013
"""
arr = [100, 1000, 100, 1000, 1]
sum = [-1] * 10000

# Returns maximum subsequence sum such
# that no three elements are consecutive
def maxSumWO3Consec(n) :
    if(sum[n] != -1):
        return sum[n]

    # 3 Base cases (process first three elements)
    if(n == 0) :
        sum[n] = 0
```

```
        return sum[n]

    if(n == 1) :
        sum[n] = arr[0]
        return sum[n]

    if(n == 2) :
        sum[n] = arr[1] + arr[0]
        return sum[n]

    # Process rest of the elements We have three cases
    sum[n] = max(max(maxSumWO3Consec(n - 1), maxSumWO3Consec(n - 2) + arr[n-1]), arr[n-1] + arr[n
- 2] + maxSumWO3Consec(n - 3))
    return sum[n]

n = len(arr)
print(maxSumWO3Consec(n))
```

Egg Dropping Problem

```
import sys

# Function to get minimum number of trials needed in worst case with n eggs and k floors
def eggDrop(n, k):
    # If there are no floors, then no trials needed. OR if there is one floor, one trial needed.
    if k in [1, 0]:
        return k

    # We need k trials for one egg and k floors
    if (n == 1):
        return k
    min = sys.maxsize

    # Consider all droppings from 1st floor to kth floor and return the minimum of these values
plus 1.
    for x in range(1, k + 1):
        res = max(eggDrop(n - 1, x - 1),
                  eggDrop(n, k - x))
        if (res < min):
            min = res
    return min + 1

n = 2
k = 10
print("Minimum number of trials in worst case with", n, "eggs and", k, "floors is", eggDrop(n, k))
```

Maximum Length Chain of Pairs

```
"""
You are given n pairs of numbers. In every pair, the first number is always smaller than the
second number. A pair (c, d) can follow another pair (a, b) if b < c. Chain of pairs can be formed
in this fashion. Find the longest chain which can be formed from a given set of pairs.

For example, if the given pairs are {{5, 24}, {39, 60}, {15, 28}, {27, 40}, {50, 90} }, then the
longest chain that can be formed is of length 3, and the chain is {{5, 24}, {27, 40}, {50, 90}}
"""
```

```
class Pair(object):
    def __init__(self, a, b):
        self.a = a
        self.b = b

# This function assumes that arr[] is sorted in increasing
# order according the first (or smaller) values in pairs.
def maxChainLength(arr, n):
    max = 0

    # Initialize MCL(max chain length) values for all indices
    mcl = [1 for _ in range(n)]

    # Compute optimized chain length values in bottom up manner
    for i in range(1, n):
        for j in range(i):
            if (arr[i].a > arr[j].b and
                mcl[i] < mcl[j] + 1):
                mcl[i] = mcl[j] + 1

    # mcl[i] now stores the maximum chain length ending with pair i
    # Pick maximum of all MCL values
    for i in range(n):
        if (max < mcl[i]):
            max = mcl[i]
    return max

arr = [Pair(5, 24), Pair(15, 25),
    Pair(27, 40), Pair(50, 60)]
print('Length of maximum size chain is', maxChainLength(arr, len(arr)))
```

Maximum size square sub-matrix with all 1s

```
R = 6
C = 5

def printMaxSubSquare(M):
    global R,C
    Max = 0
    # set all elements of S to 0 first
    S = [[0 for _ in range(C)] for _ in range(2)]

    # Construct the entries
    for i in range(R):
        for j in range(C):

            # Compute the entrie at the current position
            Entrie = M[i][j]
            if Entrie and j:
                Entrie = 1 + min(S[1][j - 1],min(S[0][j - 1], S[1][j]))

            # Save the last entrie and add the new one
            S[0][j] = S[1][j]
            S[1][j] = Entrie

            # Keep track of the max square length
            Max = max(Max, Entrie)

    # Print the square
```

```
    print("Maximum size sub-matrix is: ")
    for _ in range(Max):
        for _ in range(Max):
            print("1",end=" ")
        print()

M = [[0, 1, 1, 0, 1],
    [1, 1, 0, 1, 0],
    [0, 1, 1, 1, 0],
    [1, 1, 1, 1, 0],
    [1, 1, 1, 1, 1],
    [0, 0, 0, 0, 0]]
printMaxSubSquare(M)
```

Maximum sum of pairs with specific difference

```
"""
Input  : arr[] = {3, 5, 10, 15, 17, 12, 9}, K = 4
Output : 62
Explanation:
Then disjoint pairs with difference less than K are, (3, 5), (10, 12), (15, 17)
So maximum sum which we can get is 3 + 5 + 12 + 10 + 15 + 17 = 62
Note that an alternate way to form disjoint pairs is, (3, 5), (9, 12), (15, 17), but this pairing
produces lesser sum.

Input  : arr[] = {5, 15, 10, 300}, k = 12
Output : 25
"""

def maxSumPairWithDifferenceLessThanK(arr, N, k):
    maxSum = 0

    # Sort elements to ensure every i and i-1 is closest possible pair
    arr.sort()

    # To get maximum possible sum, iterate from largest to smallest, giving larger numbers
priority over smaller numbers.
    i = N - 1
    while (i > 0):

        # Case I: Diff of arr[i] and arr[i-1] is less than K, add to maxSum
        # Case II: Diff between arr[i] and arr[i-1] is not less than K, move to next i since with
sorting we know,
        # arr[i]-arr[i-1] < arr[i]-arr[i-2] and so on.

        if (arr[i] - arr[i - 1] < k):
            # Assuming only positive numbers.
            maxSum += arr[i]
            maxSum += arr[i - 1]

            # When a match is found skip this pair
            i -= 1
        i -= 1
    return maxSum

arr = [3, 5, 10, 15, 17, 12, 9]
N = len(arr)
K = 4
print(maxSumPairWithDifferenceLessThanK(arr, N, K))
```

Min Cost PathProblem

```
"""
Given a n*n matrix where all numbers are distinct, find the maximum length path (starting from any
cell) such that all cells along the path are in increasing order with a difference of 1.
We can move in 4 directions from a given cell (i, j), i.e., we can move to (i+1, j) or (i, j+1) or
(i-1, j) or (i, j-1) with the condition that the adjacent cells have a difference of 1.

Example:

Input:  mat[][] = {{1, 2, 9}
                   {5, 3, 8}
                   {4, 6, 7}}
Output: 4
The longest path is 6-7-8-9.
"""
n = 3
# Returns length of the longest path beginning with mat[i][j]. This function mainly uses lookup
table dp[n][n]
def findLongestFromACell(i, j, mat, dp):
    if (i < 0 or i >= n or j < 0 or j >= n):
        return 0

    # If this subproblem is already solved
    if (dp[i][j] != -1):
        return dp[i][j]

    # To store the path lengths in all the four directions
    x, y, z, w = -1, -1, -1, -1

    # Since all numbers are unique and in range from 1 to n * n,
    # there is atmost one possible direction from any cell
    if (j < n-1 and ((mat[i][j] + 1) == mat[i][j + 1])):
        x = 1 + findLongestFromACell(i, j + 1, mat, dp)

    if (j > 0 and (mat[i][j] + 1 == mat[i][j-1])):
        y = 1 + findLongestFromACell(i, j-1, mat, dp)

    if (i > 0 and (mat[i][j] + 1 == mat[i-1][j])):
        z = 1 + findLongestFromACell(i-1, j, mat, dp)

    if (i < n-1 and (mat[i][j] + 1 == mat[i + 1][j])):
        w = 1 + findLongestFromACell(i + 1, j, mat, dp)

    # If none of the adjacent fours is one greater we will take 1
    # otherwise we will pick maximum from all the four directions
    dp[i][j] = max(x, max(y, max(z, max(w, 1))))
    return dp[i][j]

# Returns length of the longest path beginning with any cell
def finLongestOverAll(mat):
    result = 1 # Initialize result

    # Create a lookup table and fill all entries in it as -1
    dp = [[-1 for _ in range(n)] for _ in range(n)]

    # Compute longest path beginning from all cells
    for i in range(n):
```

```
        for j in range(n):
            if (dp[i][j] == -1):
                findLongestFromACell(i, j, mat, dp)
            # Update result if needed
            result = max(result, dp[i][j])
    return result

mat = [[1, 2, 9],
    [5, 3, 8],
    [4, 6, 7]]
print("Length of the longest path is ", finLongestOverAll(mat))
```

Maximum difference of zeros and ones in binary string

```
"""
Given a binary string of Os and 1s. The task is to find the length of the substring which is
having a maximum difference between the number of Os and the number of 1s (number of Os – number
of 1s). In case of all 1s print -1.

Examples:

Input : S = "11000010001"
Output : 6
From index 2 to index 9, there are 7
Os and 1 1s, so number of Os - number
of 1s is 6.
Input : S = "1111"
Output : -1
"""


MAX = 100

# Return true if there all 1s
def allones(s, n):
    # Checking each index is 0 or not.
    co = sum(1 if i == '1' else 0 for i in s)
    return co == n

# Find the length of substring with maximum difference of zeroes and ones in binary string
def findlength(arr, s, n, ind, st, dp):

    # If string is over
    if ind >= n:
        return 0

    # If the state is already calculated.
    if dp[ind][st] != -1:
        return dp[ind][st]

    if not st:
        dp[ind][st] = max(arr[ind] +
        findlength(arr, s, n, ind + 1, 1, dp),
            (findlength(arr, s, n, ind + 1, 0, dp)))
    else:
        dp[ind][st] = max(arr[ind] +
        findlength(arr, s, n, ind + 1, 1, dp), 0)
    return dp[ind][st]
```

```
# Returns length of substring which is having maximum difference of number of 0s and number of 1s
def maxLen(s, n):
    # If all 1s return -1.
    if allones(s, n):
        return -1

    # Else find the length.
    arr = [0] * MAX
    for i in range(n):
        arr[i] = 1 if s[i] == '0' else -1
    dp = [[-1] * 3 for _ in range(MAX)]
    return findlength(arr, s, n, 0, 0, dp)

s = "11000010001"
n = 11
print(maxLen(s, n))
```

Minimum number of jumps to reach end

```
"""
Given an array of integers where each element represents the max number of steps that can be made
forward from that element. Write a function to return the minimum number of jumps to reach the end
of the array (starting from the first element). If an element is 0, then we cannot move through
that element. If we can't reach the end, return -1.

Examples:
    Input:  arr[] = {1, 3, 5, 8, 9, 2, 6, 7, 6, 8, 9}
    Output: 3 (1-> 3 -> 8 -> 9)
    Explanation: Jump from 1st element to
    2nd element as there is only 1 step,
    now there are three options 5, 8 or 9.
    If 8 or 9 is chosen then the end node 9
    can be reached. So 3 jumps are made.

    Input:  arr[] = {1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1}
    Output: 10
    Explanation: In every step a jump is
    needed so the count of jumps is 10.
"""

def minJumps(arr, n):
  # The number of jumps needed to reach the starting index is 0
  if (n <= 1):
    return 0

  # Return -1 if not possible to jump
  if (arr[0] == 0):
    return -1

  # initialization
  maxReach = arr[0]    # stores all time the maximal reachable index in the array
  step = arr[0]   # stores the amount of steps we can still take
  jump = 1   # stores the amount of jumps necessary to reach that maximal reachable position

  # Start traversing array

  for i in range(1, n):
    # Check if we have reached the end of the array
    if (i == n-1):
```

```
      return jump

    # updating maxReach
    maxReach = max(maxReach, i + arr[i])

    # we use a step to get to the current index
    step -= 1;

    # If no further steps left
    if (step == 0):
      # we must have used a jump
      jump += 1

      # Check if the current index / position or lesser index is the maximum reach point from the
previous indexes
      if(i >= maxReach):
        return -1

      # re-initialize the steps to the amount of steps to reach maxReach from position i.
      step = maxReach - i;
  return -1


arr = [1, 3, 5, 8, 9, 2, 6, 7, 6, 8, 9]
size = len(arr)
print("Minimum number of jumps to reach end is % d " % minJumps(arr, size))
```

Minimum cost to fill given weight in a bag

```
"""
You are given a bag of size W kg and you are provided costs of packets different weights of
oranges in array cost[] where cost[i] is basically the cost of ‘i’ kg packet of oranges. Where
cost[i] = -1 means that ‘i’ kg packet of orange is unavailable
Find the minimum total cost to buy exactly W kg oranges and if it is not possible to buy exactly W
kg oranges then print -1. It may be assumed that there is an infinite supply of all available
packet types.
Note: array starts from index 1.

Examples:

Input  : W = 5, cost[] = {20, 10, 4, 50, 100}
Output : 14
We can choose two oranges to minimize cost. First
orange of 2Kg and cost 10. Second orange of 3Kg
and cost 4.

Input  : W = 5, cost[] = {1, 10, 4, 50, 100}
Output : 5
We can choose five oranges of weight 1 kg.
"""

import sys

# Returns the best obtainable price for a rod of length n and price[] as prices of different
pieces
def minCost(cost, n):
    dp = [0 for _ in range(n + 1)]
    # Build the table val[] in bottom up manner and return the last entry from the table
    for i in range(1, n + 1):
```

```
        min_cost = sys.maxsize
        for j in range(i):
            if j<len(cost) and cost[j]!=-1:
                min_cost = min(min_cost, cost[j] + dp[i - j - 1])
        dp[i] = min_cost

    return dp[n]

cost = [ 10,-1,-1,-1,-1 ]
W = len(cost)
print(minCost(cost, W))
```

Minimum removals from array to make max –min <= K

```
"""
Input : a[] = {1, 3, 4, 9, 10, 11, 12, 17, 20}
          k = 4
Output : 5
Explanation: Remove 1, 3, 4 from beginning
and 17, 20 from the end.

Input : a[] = {1, 5, 6, 2, 8}  K=2
Output : 3
Explanation: There are multiple ways to
remove elements in this case.
One among them is to remove 5, 6, 8.
The other is to remove 1, 2, 5
"""
def removal(a, n, k):
    # sort the array
    a.sort()
    # to store the max length of array with difference <= k
    maxLen = 0
    # pointer to keep track of starting of each subarray
    i = 0
    for j in range(i+1, n):
        # if the subarray from i to j index is valid the store it's length
        if a[j]-a[i] <= k:
            maxLen = max(maxLen, j-i+1)
        else:
            i += 1
        if i >= n:
            break
    return n-maxLen

a = [1, 3, 4, 9, 10, 11, 12, 17, 20]
n = len(a)
k = 4
print(removal(a, n, k))
```

Longest Common Substring

```
"""
Input : X = “GeeksforGeeks”, y = “GeeksQuiz”
Output : 5
Explanation:
The longest common substring is “Geeks” and is of length 5.
"""
```

```
def lcs(i, j, count):
    if (i == 0 or j == 0):
        return count
    if (X[i - 1] == Y[j - 1]):
        count = lcs(i - 1, j - 1, count + 1)
    count = max(count, max(lcs(i, j - 1, 0), lcs(i - 1, j, 0)))
    return count

X = "abcdxyz"
Y = "xyzabcd"
n = len(X)
m = len(Y)
print(lcs(n, m, 0))
```

Count number of ways to reacha given score in a game

```
"""
Consider a game where a player can score 3 or 5 or 10 points in a move. Given a total score n,
find number of ways to reach the given score.
Examples:

Input: n = 20
Output: 4
There are following 4 ways to reach 20
(10, 10)
(5, 5, 10)
(5, 5, 5, 5)
(3, 3, 3, 3, 3, 5)
"""

def count(n):
    # table[i] will store count of solutions for value i. Initialize all table values as 0.
    table = [0 for _ in range(n+1)]

    # Base case (If given value is 0)
    table[0] = 1

    # One by one consider given 3 moves and update the table[] values after the index greater than
    # or equal to the value of the picked move.
    for i in range(3, n+1):
        table[i] += table[i-3]
    for i in range(5, n+1):
        table[i] += table[i-5]
    for i in range(10, n+1):
        table[i] += table[i-10]
    return table[n]

n = 20
print('Count for', n, 'is', count(n))
n = 13
print('Count for', n, 'is', count(n))
```

Count Balanced Binary Trees of Height h

```
"""
```

```
Given a height h, count and return the maximum number of balanced binary trees possible with
height h. A balanced binary tree is one in which for every node, the difference between heights of
left and right subtree is not more than 1.

Input : h = 3
Output : 15

Input : h = 4
Output : 315
"""
def countBT(h) :
    BIG_PRIME = 1000000007
    if h < 2:
          return 1
    dp0 = dp1 = 1
    dp2 = 3
    for _ in range(2,h+1):
        dp2 = (dp1*dp1 + 2*dp1*dp0)%BIG_PRIME
        dp0 = dp1
        dp1 = dp2
    return dp2

h = 3
print(f"No. of balanced binary trees of height {h} is: {str(countBT(h))}")
```

Smallest sum contiguous subarray

```
"""
Given an array containing n integers. The problem is to find the sum of the elements of the
contiguous subarray having the smallest(minimum) sum.
Examples:
Input : arr[] = {3, -4, 2, -3, -1, 7, -5}
Output : -6
Subarray is {-4, 2, -3, -1} = -6
"""

maxsize=float('inf')

def smallestSumSubarr(arr, n):
    # to store the minimum value that is ending up to the current index
    min_ending_here = maxsize

    # to store the minimum value encountered so far
    min_so_far = maxsize

    # traverse the array elements
    for i in range(n):
        # if min_ending_here > 0, then it could not possibly contribute to the minimum sum further
        if (min_ending_here > 0):
            min_ending_here = arr[i]

        # else add the value arr[i] to min_ending_here
        else:
            min_ending_here += arr[i]

        # update min_so_far
        min_so_far = min(min_so_far, min_ending_here)
    return min_so_far
```

```
arr = [3, -4, 2, -3, -1, 7, -5]
n = len(arr)
print ("Smallest sum: ", smallestSumSubarr(arr, n))
```

Unbounded Knapsack (Repetition of items allowed)

```
"""
Given a knapsack weight W and a set of n items with certain value vali and weight wti, we need to
calculate the maximum amount that could make up this quantity exactly. This is different from
classical Knapsack problem, here we are allowed to use unlimited number of instances of an item.
Examples:

Input : W = 100
       val[]  = {1, 30}
       wt[] = {1, 50}
Output : 100
There are many ways to fill knapsack.
1) 2 instances of 50 unit weight item.
2) 100 instances of 1 unit weight item.
3) 1 instance of 50 unit weight item and 50
   instances of 1 unit weight items.
We get maximum value with option 2.
"""
def unboundedKnapsack(W, n, val, wt):
    # dp[i] is going to store maximum value with knapsack capacity i.
    dp = [0 for _ in range(W + 1)]
    ans = 0

    # Fill dp[] using above recursive formula
    for i in range(W + 1):
        for j in range(n):
            if (wt[j] <= i):
                dp[i] = max(dp[i], dp[i - wt[j]] + val[j])
    return dp[W]

W = 100
val = [10, 30, 20]
wt = [5, 10, 15]
n = len(val)
print(unboundedKnapsack(W, n, val, wt))
```

Largest Independent Set Problem

```
"""
Given a Binary Tree, find size of the Largest Independent Set(LIS) in it. A subset of all tree
nodes is an independent set if there is no edge between any two nodes of the subset.

For example, consider the following binary tree. The largest independent set(LIS) is {10, 40, 60,
70, 80} and size of the LIS is 5.
"""

class node:
    def __init__(self, data):

        self.data = data
        self.left = self.right = None
        self.liss = 0
```

```
# A memoization function returns size of the largest independent set in a given binary tree
def liss(root):
    if root is None:
        return 0
    if root.liss != 0:
        return root.liss
    if root.left is None and root.right is None:
        root.liss = 1
        return root.liss

    # Calculate size excluding the current node
    liss_excl = (liss(root.left) + liss(root.right))

    # Calculate size including the current node
    liss_incl = 1
    if root.left != None:
        liss_incl += (liss(root.left.left) + liss(root.left.right))

    if root.right != None:
        liss_incl += (liss(root.right.left) + liss(root.right.right))

    # Maximum of two sizes is LISS, store it for future uses.
    root.liss = max(liss_excl, liss_incl)
    return root.liss

root = node(20)
root.left = node(8)
root.left.left = node(4)
root.left.right = node(12)
root.left.right.left = node(10)
root.left.right.right = node(14)
root.right = node(22)
root.right.right = node(25)
print("Size of the Largest Independent Set is ", liss(root))
```

Partition problem

```
def isPossible(elements, target):
    dp = [False]*(target+1)
    dp[0] = True
    for ele in elements:
        for j in range(target, ele - 1, -1):
            if dp[j - ele]:
                dp[j] = True
    return dp[target]

arr = [6, 2, 5]
target = 7
if isPossible(arr, target):
    print("YES")
else:
    print("NO")
```

Longest Palindromic Subsequence

```
"""
```

```
As another example, if the given sequence is “BBABCBCAB”, then the output should be 7 as “BABCBAB”
is the longest palindromic subsequence in it. “BBBBB” and “BBCBB” are also palindromic
subsequences of the given sequence, but not the longest ones.
"""

dp = [[-1 for _ in range(1001)] for _ in range(1001)]
def lps(s1, s2, n1, n2):
    if (n1 == 0 or n2 == 0):
        return 0

    if (dp[n1][n2] != -1):
        return dp[n1][n2]

    if (s1[n1 - 1] == s2[n2 - 1]):
        dp[n1][n2] = 1 + lps(s1, s2, n1 - 1, n2 - 1)
    else:
        dp[n1][n2] = max(lps(s1, s2, n1 - 1, n2), lps(s1, s2, n1, n2 - 1))

    return dp[n1][n2]


seq = "GEEKSFORGEEKS"
n = len(seq)
s2 = seq
s2 = s2[::-1]
print(f"The length of the LPS is {lps(s2, seq, n, n)}")
```

Count All Palindromic Subsequence in a given String

```
"""
Input : str = "abcd"
Output : 4
Explanation :- palindromic  subsequence are : "a" ,"b", "c" ,"d"

Input : str = "aab"
Output : 4
Explanation :- palindromic subsequence are :"a", "a", "b", "aa"

Input : str = "aaaa"
Output : 15
"""

def countPS(i, j):
    if(i > j):
        return 0

    if(dp[i][j] != -1):
        return dp[i][j]

    if (i == j):
        dp[i][j] = 1
    elif str[i] == str[j]:
        dp[i][j] = (countPS(i + 1, j) + countPS(i, j - 1) + 1)
    else:
        dp[i][j] = (countPS(i + 1, j) + countPS(i, j - 1) - countPS(i + 1, j - 1))

    return dp[i][j]

str = "abcb" # remember to use variable name str otherwise program will fail
```

```
dp = [[-1 for _ in range(1000)] for _ in range(1000)]
n = len(str)
print("Total palindromic subsequence are :", countPS(0, n - 1))
```

Longest Palindromic Substring

```
"""
Suppose we have a string S. We have to find the longest palindromic substring in S. We are
assuming that the length of the string S is 1000. So if the string is “BABAC”, then the longest
palindromic substring is “BAB”.
"""

def longestPalindrome( s):
   dp = [[False for _ in range(len(s))] for _ in range(len(s))]
   for i in range(len(s)):
      dp[i][i] = True
   max_length = 1
   start = 0
   for l in range(2,len(s)+1):
      for i in range(len(s)-l+1):
         end = i+l
         if l==2:
            if s[i] == s[end-1]:
               dp[i][end-1]=True
               max_length = l
               start = i
         elif s[i] == s[end-1] and dp[i+1][end-2]:
            dp[i][end-1]=True
            max_length = l
            start = i
   return s[start:start+max_length]

print(longestPalindrome("ABBABBC"))
```

Longest alternating subsequence

```
"""
Input: arr[] = {1, 5, 4}
Output: 3
The whole arrays is of the form  x1 < x2 > x3

Input: arr[] = {1, 4, 5}
Output: 2
All subsequences of length 2 are either of the form
x1 < x2; or x1 > x2

Input: arr[] = {10, 22, 9, 33, 49, 50, 31, 60}
Output: 6
The subsequences {10, 22, 9, 33, 31, 60} or
{10, 22, 9, 49, 31, 60} or {10, 22, 9, 50, 31, 60}
are longest subsequence of length 6.
"""

def LAS(arr, n):
    # "inc" and "dec" initialized as 1 as single element is still LAS
    inc = 1
    dec = 1
```

```
    # Iterate from second element
    for i in range(1,n):
        if (arr[i] > arr[i-1]):
            # "inc" changes iff "dec" changes
            inc = dec + 1

        elif (arr[i] < arr[i-1]):
            # "dec" changes iff "inc" changes
            dec = inc + 1

    # Return the maximum length
    return max(inc, dec)

arr = [10, 22, 9, 33, 49, 50, 31, 60]
n = len(arr)
print(LAS(arr, n))
```

Weighted Job Scheduling

```
"""
Given N jobs where every job is represented by following three elements of it.

Start Time
Finish Time
Profit or Value Associated (>= 0)
Find the maximum profit subset of jobs such that no two jobs in the subset overlap.

Example:

Input: Number of Jobs n = 4
       Job Details {Start Time, Finish Time, Profit}
       Job 1:  {1, 2, 50}
       Job 2:  {3, 5, 20}
       Job 3:  {6, 19, 100}
       Job 4:  {2, 100, 200}
Output: The maximum profit is 250.
We can get the maximum profit by scheduling jobs 1 and 4.
Note that there is longer schedules possible Jobs 1, 2 and 3
but the profit with this schedule is 20+50+100 which is less than 250.
"""

# Importing the following module to sort array based on our custom comparison function
from functools import cmp_to_key

# A job has start time, finish time and profit
class Job:
    def __init__(self, start, finish, profit):
        self.start = start
        self.finish = finish
        self.profit = profit

# A utility function that is used for sorting events according to finish time
def jobComparator(s1, s2):
    return s1.finish < s2.finish

# Find the latest job (in sorted array) that doesn't conflict with the job[i]. If there is no
compatible job, then it returns -1
```

```
def latestNonConflict(arr, i):
    for j in range(i - 1, -1, -1):
        if arr[j].finish <= arr[i - 1].start:
            return j
    return -1

# A recursive function that returns the maximum possible profit from given array of jobs. The
array of jobs must be sorted according to finish time
def findMaxProfitRec(arr, n):
    # Base case
    if n == 1:
        return arr[n - 1].profit

    # Find profit when current job is included
    inclProf = arr[n - 1].profit
    i = latestNonConflict(arr, n)

    if i != -1:
        inclProf += findMaxProfitRec(arr, i + 1)

    # Find profit when current job is excluded
    exclProf = findMaxProfitRec(arr, n - 1)
    return max(inclProf, exclProf)

# The main function that returns the maximum possible profit from given array of jobs
def findMaxProfit(arr, n):

    # Sort jobs according to finish time
    arr = sorted(arr, key = cmp_to_key(jobComparator))
    return findMaxProfitRec(arr, n)

values = [ (3, 10, 20), (1, 2, 50), (6, 19, 100), (2, 100, 200) ]
arr = [Job(i[0], i[1], i[2]) for i in values]
n = len(arr)
print("The optimal profit is", findMaxProfit(arr, n))
```

Coin game winner where every player has three choices

```
"""
A and B are playing a game. At the beginning there are n coins. Given two more numbers x and y. In
each move a player can pick x or y or 1 coins. A always starts the game. The player who picks the
last coin wins the game or the person who is not able to pick any coin loses the game. For a given
value of n, find whether A will win the game or not if both are playing optimally.

Examples:

Input :  n = 5, x = 3, y = 4
Output : A
There are 5 coins, every player can pick 1 or
3 or 4 coins on his/her turn.
A can win by picking 3 coins in first chance.
Now 2 coins will be left so B will pick one
coin and now A can win by picking the last coin.

Input : 2 3 4
Output : B
"""

# To find winner of game
```

```
def findWinner(x, y, n):

    # To store results
    dp = [0 for _ in range(n + 1)]

    # Initial values
    dp[0] = False
    dp[1] = True

    # Computing other values.
    for i in range(2, n + 1):
        # If A losses any of i-1 or i-x or i-y game then he will definitely win game i
        if i >= 1 and not dp[i - 1]:
            dp[i] = True
        elif (i - x >= 0 and not dp[i - x]):
            dp[i] = True
        elif (i - y >= 0 and not dp[i - y]):
            dp[i] = True
        else:
            dp[i] = False

    # If dp[n] is true then A will game otherwise he losses
    return dp[n]

x = 3; y = 4; n = 5
if (findWinner(x, y, n)):
    print('A')
else:
    print('B')
```

Count Derangements (Permutation such that no element appears in its original position) [IMPORTANT]

```
"""
A and B are playing a game. At the beginning there are n coins. Given two more numbers x and y. In
each move a player can pick x or y or 1 coins. A always starts the game. The player who picks the
last coin wins the game or the person who is not able to pick any coin loses the game. For a given
value of n, find whether A will win the game or not if both are playing optimally.

Examples:

A Derangement is a permutation of n elements, such that no element appears in its original
position. For example, a derangement of {0, 1, 2, 3} is {2, 3, 1, 0}.
Given a number n, find the total number of Derangements of a set of n elements.

Examples :

Input: n = 2
Output: 1
For two elements say {0, 1}, there is only one
possible derangement {1, 0}

Input: n = 3
Output: 2
For three elements say {0, 1, 2}, there are two
possible derangements {2, 0, 1} and {1, 2, 0}
"""
```

```
def countDer(n):
    if n in [1, 2]:
        return n-1
    a = 0
    b = 1
    for i in range(3, n + 1):
        cur = (i-1)*(a+b)
        a = b
        b = cur
    return b

n = 4
print("Count of Derangements is ", countDer(n))
```

Maximum profit by buying and selling a share at most twice [IMP]

```
"""
In daily share trading, a buyer buys shares in the morning and sells them on the same day. If the
trader is allowed to make at most 2 transactions in a day, whereas the second transaction can only
start after the first one is complete (Buy->sell->Buy->sell). Given stock prices throughout the
day, find out the maximum profit that a share trader could have made.

Examples:

Input:   price[] = {10, 22, 5, 75, 65, 80}
Output:  87
Trader earns 87 as sum of 12, 75
Buy at 10, sell at 22,
Buy at 5 and sell at 80
Input:   price[] = {2, 30, 15, 10, 8, 25, 80}
Output:  100
Trader earns 100 as sum of 28 and 72
Buy at price 2, sell at 30, buy at 8 and sell at 80
Input:   price[] = {100, 30, 15, 10, 8, 25, 80};
Output:  72
Buy at price 8 and sell at 80.
Input:   price[] = {90, 80, 70, 60, 50}
Output:  0
Not possible to earn.
"""

import sys
def maxtwobuysell(arr, size):
    first_buy = -sys.maxsize;
    first_sell = 0;
    second_buy = -sys.maxsize;
    second_sell = 0;

    for i in range(size):
        first_buy = max(first_buy, -arr[i]);
        first_sell = max(first_sell, first_buy + arr[i]);
        second_buy = max(second_buy, first_sell - arr[i]);
        second_sell = max(second_sell, second_buy + arr[i]);
    return second_sell;

arr = [ 2, 30, 15, 10, 8, 25, 80 ];
size = len(arr);
```

```
print(maxtwobuysell(arr, size));
```

Optimal Strategy for a Game

```
"""
Consider a row of n coins of values v1 . . . vn, where n is even. We play a game against an
opponent by alternating turns. In each turn, a player selects either the first or last coin from
the row, removes it from the row permanently, and receives the value of the coin. Determine the
maximum possible amount of money we can definitely win if we move first.
Note: The opponent is as clever as the user.

Let us understand the problem with few examples:

5, 3, 7, 10 : The user collects maximum value as 15(10 + 5)
8, 15, 3, 7 : The user collects maximum value as 22(7 + 15)
Does choosing the best at each move gives an optimal solution? No.
In the second example, this is how the game can be finished:

> User chooses 8.
> Opponent chooses 15.
> User chooses 7.
> Opponent chooses 3.
Total value collected by user is 15(8 + 7)
> User chooses 7.
> Opponent chooses 8.
> User chooses 15.
> Opponent chooses 3.
Total value collected by user is 22(7 + 15)
So if the user follows the second game state, the maximum value can be collected although the
first move is not the best.
"""
def optimalStrategyOfGame(arr, n):
    memo = {}
    # recursive top down memoized solution
    def solve(i, j):
        if i > j or i >= n or j < 0:
            return 0

        k = (i, j)
        if k in memo:
            return memo[k]

        # if the user chooses ith coin, the opponent can choose from i+1th or jth coin.
        # if he chooses i+1th coin, user is left with [i+2,j] range.
        # if opp chooses jth coin, then user is left with [i+1,j-1] range to choose from.
        # Also opponent tries to choose in such a way that the user has minimum value left.
        option1 = arr[i] + min(solve(i+2, j), solve(i+1, j-1))

        # if user chooses jth coin, opponent can choose ith coin or j-1th coin.
        # if opp chooses ith coin, user can choose in range [i+1,j-1].
        # if opp chooses j-1th coin, user can choose in range [i,j-2].
        option2 = arr[j] + min(solve(i+1, j-1), solve(i, j-2))

        # since the user wants to get maximum money
        memo[k] = max(option1, option2)
        return memo[k]

    return solve(0, n-1)
```

```
arr1 = [8, 15, 3, 7]
n = len(arr1)
print(optimalStrategyOfGame(arr1, n))

arr2 = [2, 2, 2, 2]
n = len(arr2)
print(optimalStrategyOfGame(arr2, n))

arr3 = [20, 30, 2, 2, 2, 10]
n = len(arr3)
print(optimalStrategyOfGame(arr3, n))
```

Optimal Binary Search Tree

```
"""
Given a sorted array key [0.. n-1] of search keys and an array freq[0.. n-1] of frequency counts,
where freq[i] is the number of searches for keys[i]. Construct a binary search tree of all keys
such that the total cost of all the searches is as small as possible.
Let us first define the cost of a BST. The cost of a BST node is the level of that node multiplied
by its frequency. The level of the root is 1.

Examples:

Input:  keys[] = {10, 12}, freq[] = {34, 50}
There can be following two possible BSTs
        10                       12
          \                     /
           12                 10
          I                     II
Frequency of searches of 10 and 12 are 34 and 50 respectively.
The cost of tree I is 34*1 + 50*2 = 134
The cost of tree II is 50*1 + 34*2 = 118
"""

def optCost(freq, i, j):
    if j < i:    # no elements in this subarray
        return 0
    if j == i:   # one element in this subarray
        return freq[i]

    # Get sum of freq[i], freq[i+1], ... freq[j]
    fsum = Sum(freq, i, j)

    # Initialize minimum value
    Min = float('inf')

    # One by one consider all elements as root and recursively find cost of the BST, compare the
cost with min and update min if needed
    for r in range(i, j + 1):
        cost = (optCost(freq, i, r - 1) +
                optCost(freq, r + 1, j))
        if cost < Min:
            Min = cost

    # Return minimum value
    return Min + fsum

# The main function that calculates minimum cost of a Binary Search Tree. It mainly uses optCost()
to find the optimal cost.
```

```
def optimalSearchTree(keys, freq, n):

    # Here array keys[] is assumed to be sorted in increasing order. If keys[]
    # is not sorted, then add code to sort keys, and rearrange freq[] accordingly.
    return optCost(freq, 0, n - 1)

# A utility function to get sum of array elements freq[i] to freq[j]
def Sum(freq, i, j):
    return sum(freq[k] for k in range(i, j + 1))

if __name__ == '__main__':
    keys = [10, 12, 20]
    freq = [34, 8, 50]
    n = len(keys)
    print("Cost of Optimal BST is",
        optimalSearchTree(keys, freq, n))
```

Palindrome PartitioningProblem

```
"""
Input : str = “geek”
Output : 2
We need to make minimum 2 cuts, i.e., “g ee k”
Input : str = “aaaa”
Output : 0
The string is already a palindrome.
Input : str = “abcde”
Output : 4
Input : str = “abbac”
Output : 1

"""

def isPalindrome(x):
    return x == x[::-1]

def minPalPartion(string, i, j):
    if i >= j or isPalindrome(string[i:j + 1]):
        return 0
    ans = float('inf')
    for k in range(i, j):
        count = (
            1 + minPalPartion(string, i, k)
            + minPalPartion(string, k + 1, j)
        )
        ans = min(ans, count)
    return ans

string = "ababbbabbababa"
print("Min cuts needed for Palindrome Partitioning is ", minPalPartion(string, 0, len(string) -
1))
```

Word Wrap Problem

```
"""
```

```
Given a sequence of words, and a limit on the number of characters that can be put in one line
(line width). Put line breaks in the given sequence such that the lines are printed neatly. Assume
that the length of each word is smaller than the line width.
The word processors like MS Word do task of placing line breaks. The idea is to have balanced
lines. In other words, not have few lines with lots of extra spaces and some lines with small
amount of extra spaces.


The extra spaces includes spaces put at the end of every line except the last one.
The problem is to minimize the following total cost.
 Cost of a line = (Number of extra spaces in the line)^3
 Total Cost = Sum of costs for all lines

For example, consider the following string and line width M = 15
 "Geeks for Geeks presents word wrap problem"

Following is the optimized arrangement of words in 3 lines
Geeks for Geeks
presents word
wrap problem

The total extra spaces in line 1, line 2 and line 3 are 0, 2 and 3 respectively.
So optimal value of total cost is 0 + 2*2*2 + 3*3*3 = 35
Please note that the total cost function is not sum of extra spaces, but sum of cubes (or square
is also used) of extra spaces.
"""

# A Dynamic programming solution
# for Word Wrap Problem

# A utility function to print
# the solution
# l[] represents lengths of different
# words in input sequence. For example,
# l[] = {3, 2, 2, 5} is for a sentence
# like "aaa bb cc ddddd". n is size of
# l[] and M is line width (maximum no.
# of characters that can fit in a line)
INF = 2147483647
def printSolution(p, n):
    k = 0
    if p[n] == 1:
        k = 1
    else:
        k = printSolution(p, p[n] - 1) + 1
    print('Line number ', k, ': From word no. ',
                              p[n], 'to ', n)
    return k

def solveWordWrap(l, n, M):
    # For simplicity, 1 extra space is used in all below arrays
    # extras[i][j] will have number of extra spaces if words from i to j are put in a single line
    extras = [[0 for _ in range(n + 1)] for _ in range(n + 1)]

    # lc[i][j] will have cost of a line which has words from i to j
    lc = [[0 for _ in range(n + 1)] for _ in range(n + 1)]

    # c[i] will have total cost of optimal arrangement of words from 1 to i
    c = [0 for _ in range(n + 1)]
```

```
    # p[] is used to print the solution.
    p = [0 for _ in range(n + 1)]

    # calculate extra spaces in a single line. The value extra[i][j] indicates
    # extra spaces if words from word number i to j are placed in a single line
    for i in range(n + 1):
        extras[i][i] = M - l[i - 1]
        for j in range(i + 1, n + 1):
            extras[i][j] = (extras[i][j - 1] -
                                    l[j - 1] - 1)

    # Calculate line cost corresponding to the above calculated extra
    # spaces. The value lc[i][j] indicates cost of putting words from word number i to j in a
single line
    for i in range(n + 1):
        for j in range(i, n + 1):
            if extras[i][j] < 0:
                lc[i][j] = INF;
            elif j == n:
                lc[i][j] = 0
            else:
                lc[i][j] = (extras[i][j] *
                            extras[i][j])

    # Calculate minimum cost and find minimum cost arrangement. The value
    # c[j] indicates optimized cost to arrange words from word number 1 to j.
    c[0] = 0
    for j in range(1, n + 1):
        c[j] = INF
        for i in range(1, j + 1):
            if (c[i - 1] != INF and
                lc[i][j] != INF and
                ((c[i - 1] + lc[i][j]) < c[j])):
                c[j] = c[i-1] + lc[i][j]
                p[j] = i
    printSolution(p, n)

l = [3, 2, 2, 5]
n = len(l)
M = 6
solveWordWrap(l, n, M)
```

Mobile Numeric Keypad Problem [IMP]

```
"""
Given the mobile numeric keypad. You can only press buttons that are up, left, right or down to
the current button. You are not allowed to press bottom row corner buttons (i.e. * and # ).

Mobile-keypad

Given a number N, find out the number of possible numbers of given length.

Examples:

For N=1, number of possible numbers would be 10 (0, 1, 2, 3, …., 9)
For N=2, number of possible numbers would be 36
Possible numbers: 00,08 11,12,14 22,21,23,25 and so on.
If we start with 0, valid numbers will be 00, 08 (count: 2)
If we start with 1, valid numbers will be 11, 12, 14 (count: 3)
```

```
If we start with 2, valid numbers will be 22, 21, 23,25 (count: 4)
If we start with 3, valid numbers will be 33, 32, 36 (count: 3)
If we start with 4, valid numbers will be 44,41,45,47 (count: 4)
If we start with 5, valid numbers will be 55,54,52,56,58 (count: 5)
.....................................
.....................................
We need to print the count of possible numbers.
"""

# left, up, right, down move from current location
row = [0, 0, -1, 0, 1]
col = [0, -1, 0, 1, 0]

# Returns count of numbers of length n starting from key position (i, j) in a numeric keyboard.
def getCountUtil(keypad, i, j, n):
    if (keypad == None or n <= 0):
        return 0

    # From a given key, only one number is possible of length 1
    if (n == 1):
        return 1
    k = 0
    move = 0
    ro = 0
    co = 0
    totalCount = 0

    # move left, up, right, down from current location and if
    # new location is valid, then get number count of length
    # (n-1) from that new position and add in count obtained so far
    for move in range(5):
        ro = i + row[move]
        co = j + col[move]
        if (ro >= 0 and ro <= 3 and co >= 0 and co <= 2 and
                keypad[ro][co] != '*' and keypad[ro][co] != '#'):
            totalCount += getCountUtil(keypad, ro, co, n - 1)
    return totalCount

# Return count of all possible numbers of length n in a given numeric keyboard
def getCount(keypad, n):
    if keypad is None or n <= 0:
        return 0
    if (n == 1):
        return 10
    i = 0
    j = 0
    totalCount = 0
    for i in range(4): # Loop on keypad row
        for j in range(3): # Loop on keypad column
            # Process for 0 to 9 digits
            if (keypad[i][j] != '*' and keypad[i][j] != '#'):
            # Get count when number is starting from key position (i, j) and add in count obtained
so far
                totalCount += getCountUtil(keypad, i, j, n)
    return totalCount

keypad = [['1', '2', '3'],
        ['4', '5', '6'],
        ['7', '8', '9'],
        ['*', '0', '#']]
```

```
print("Count for numbers of length 1:", getCount(keypad, 1))
print("Count for numbers of length 2:", getCount(keypad, 2))
print("Count for numbers of length 3:", getCount(keypad, 3))
print("Count for numbers of length 4:", getCount(keypad, 4))
print("Count for numbers of length 5:", getCount(keypad, 5))
```

Boolean Parenthesization Problem

```
"""
Given a boolean expression with the following symbols.

Symbols
    'T' ---> true
    'F' ---> false
And following operators filled between symbols

Operators
    &   ---> boolean AND
    |   ---> boolean OR
    ^   ---> boolean XOR
Count the number of ways we can parenthesize the expression so that the value of expression
evaluates to true.
Let the input be in form of two arrays one contains the symbols (T and F) in order and the other
contains operators (&, | and ^}

Examples:

Input: symbol[]    = {T, F, T}
       operator[]  = {^, &}
Output: 2
The given expression is "T ^ F & T", it evaluates true
in two ways "((T ^ F) & T)" and "(T ^ (F & T))"

Input: symbol[]    = {T, F, F}
       operator[]  = {^, |}
Output: 2
The given expression is "T ^ F | F", it evaluates true
in two ways "( (T ^ F) | F )" and "( T ^ (F | F) )".

Input: symbol[]    = {T, T, F, T}
       operator[]  = {|, &, ^}
"""

def countParenth(symb, oper, n):
    F = [[0 for _ in range(n + 1)] for _ in range(n + 1)]
    T = [[0 for _ in range(n + 1)] for _ in range(n + 1)]

    # Fill diagonal entries first
    # All diagonal entries in T[i][i] are 1 if symbol[i] is T (true). Similarly, all F[i][i]
entries are 1 if
    # symbol[i] is F (False)
    for i in range(n):
        F[i][i] = 1 if symb[i] == 'F' else 0
        T[i][i] = 1 if symb[i] == 'T' else 0

    # Now fill T[i][i+1], T[i][i+2],
    # T[i][i+3]... in order And F[i][i+1], F[i][i+2], F[i][i+3]... in order
    for gap in range(1, n):
        for i, j in enumerate(range(gap, n)):
```

```
            T[i][j] = F[i][j] = 0
            for g in range(gap):

                # Find place of parenthesization using current value of gap
                k = i + g

                # Store Total[i][k] and Total[k+1][j]
                tik = T[i][k] + F[i][k]
                tkj = T[k + 1][j] + F[k + 1][j]

                # Follow the recursive formulas according to the current operator
                if oper[k] == '&':
                    T[i][j] += T[i][k] * T[k + 1][j]
                    F[i][j] += (tik * tkj - T[i][k] *
                                T[k + 1][j])
                if oper[k] == '|':
                    F[i][j] += F[i][k] * F[k + 1][j]
                    T[i][j] += (tik * tkj - F[i][k] *
                                F[k + 1][j])
                if oper[k] == '^':
                    T[i][j] += (F[i][k] * T[k + 1][j] +
                                T[i][k] * F[k + 1][j])
                    F[i][j] += (T[i][k] * T[k + 1][j] +
                                F[i][k] * F[k + 1][j])
    return T[0][n - 1]


symbols = "TTFT"
operators = "|&^"
n = len(symbols)

# There are 4 ways
# ((T|T)&(F^T)), (T|(T&(F^T))),
# (((T|T)&F)^T) and (T|((T&F)^T))
print(countParenth(symbols, operators, n))
```

Largest rectangular sub-matrix whose sum is 0

```
"""
Given a 2D matrix, find the number non-empty sub matrices, such that the sum of the elements
inside the sub matrix is equal to 0. (note:  elements might be negative).
"""
import itertools
def solve(A):
    if not A or not A[0]: return 0  # SC & guard
    cols = len(A[0]) + 1            # pad left to guard [c - 1]
    A = [[0] + row for row in A]
    for row, c in itertools.product(A, range(2, cols)):
        row[c] += row[c - 1]
    zeros = 0
    for c1 in range(cols - 1):                  # each pair of (c, c2]
        for c2 in range(c1 + 1, cols):
            sofar = 0
            seen = {0: 1}                   # {sum : cnt}, dict to cnt dups
            for row in A:                   # scan top-down as 1D sum 0
                sofar += row[c2] - row[c1]
                if sofar-0 in seen:
                    zeros += seen[sofar-0]
                if sofar in seen:
```

```
                    seen[sofar] += 1
                else: seen[sofar] = 1
    return zeros

A=[[-8, 5,  7],
[3 , 7, -8],
[5 ,-8,  9]
]
print(solve(A))
```

Maximum sum rectangle in a 2D matrix

```
# Implementation of Kadane's algorithm for 1D array. The function returns the maximum sum and
stores starting
#  and ending indexes of the maximum sum subarray at addresses pointed by start and finish
pointers respectively.
def kadane(arr, start, finish, n):
    Sum = 0
    maxSum = -999999999999
    i = None

    # Just some initial value to check for all negative values case
    finish[0] = -1

    # local variable
    local_start = 0

    for i in range(n):
        Sum += arr[i]
        if Sum < 0:
            Sum = 0
            local_start = i + 1
        elif Sum > maxSum:
            maxSum = Sum
            start[0] = local_start
            finish[0] = i

    # There is at-least one non-negative number
    if finish[0] != -1:
        return maxSum

    # Special Case: When all numbers in arr[] are negative
    maxSum = arr[0]
    start[0] = finish[0] = 0

    # Find the maximum element in array
    for i in range(1, n):
        if arr[i] > maxSum:
            maxSum = arr[i]
            start[0] = finish[0] = i
    return maxSum

def findMaxSum(M):
    global ROW, COL

    # Variables to store the final output
    maxSum, finalLeft = -999999999999, None
    finalRight, finalTop, finalBottom = None, None, None
    left, right, i = None, None, None
```

```
    temp = [None] * ROW
    Sum = 0
    start = [0]
    finish = [0]

    # Set the left column
    for left in range(COL):

        # Initialize all elements of temp as 0
        temp = [0] * ROW

        # Set the right column for the left column set by outer loop
        for right in range(left, COL):

            # Calculate sum between current left and right for every row 'i'
            for i in range(ROW):
                temp[i] += M[i][right]

            # Find the maximum sum subarray in temp[]. The kadane() function also
            # sets values of start and finish So 'sum' is sum of rectangle between
            # (start, left) and (finish, right) which is the maximum sum with boundary columns
            # strictly as left and right.
            Sum = kadane(temp, start, finish, ROW)

            # Compare sum with maximum sum so far. If sum is more, then update maxSum and other
output values
            if Sum > maxSum:
                maxSum = Sum
                finalLeft = left
                finalRight = right
                finalTop = start[0]
                finalBottom = finish[0]

    # Prfinal values
    print("(Top, Left)", "(", finalTop,
        finalLeft, ")")
    print("(Bottom, Right)", "(", finalBottom,
        finalRight, ")")
    print("Max sum is:", maxSum)

ROW = 4
COL = 5
M = [[1, 2, -1, -4, -20],
    [-8, -3, 4, 2, 1],
    [3, 8, 10, 1, 3],
    [-4, -1, 1, 7, -6]]
findMaxSum(M)
```

Maximum profit by buying and selling a share at most k times

```
"""
Input:
Price = [10, 22, 5, 75, 65, 80]
    K = 2
Output:  87
Trader earns 87 as sum of 12 and 75
Buy at price 10, sell at 22, buy at
5 and sell at 80
```

```
Input:
Price = [12, 14, 17, 10, 14, 13, 12, 15]
    K = 3
Output:  12
Trader earns 12 as the sum of 5, 4 and 3
Buy at price 12, sell at 17, buy at 10
and sell at 14 and buy at 12 and sell
at 15

Input:
Price = [100, 30, 15, 10, 8, 25, 80]
    K = 3
Output:  72
Only one transaction. Buy at price 8
and sell at 80.

Input:
Price = [90, 80, 70, 60, 50]
    K = 1
Output:  0
Not possible to earn.
"""
def maxProfit(prices, n, k):
    profit = [[0 for _ in range(k + 1)] for _ in range(n)]
    # Profit is zero for the first day and for zero transactions
    for i in range(1, n):
        for j in range(1, k + 1):
            max_so_far = 0
            for l in range(i):
                max_so_far = max(max_so_far, prices[i] -
                                 prices[l] + profit[l][j - 1])
            profit[i][j] = max(profit[i - 1][j], max_so_far)
    return profit[n - 1][k]

k = 2
prices = [10, 22, 5, 75, 65, 80]
n = len(prices)
print("Maximum profit is:",
    maxProfit(prices, n, k))
```

Find if a string is interleaved of two other strings

```
"""
Given three strings A, B and C. Write a function that checks whether C is an interleaving of A and
B. C is said to be interleaving A and B, if it contains all and only characters of A and B and
order of all characters in individual strings is preserved.

Example:

Input: strings: "XXXXZY", "XXY", "XXZ"
Output: XXXXZY is interleaved of XXY and XXZ
The string XXXXZY can be made by
interleaving XXY and XXZ
String:    XXXXZY
String 1:    XX Y
String 2:  XX  Z

Input: strings: "XXY", "YX", "X"
```

```
Output: XXY is not interleaved of YX and X
XXY cannot be formed by interleaving YX and X.
The strings that can be formed are YXX and XYX
"""

dp = [[0]*101]*101
def dfs(i, j, A, B, C):

    # If path has already been calculated from this index then return calculated value.
    if(dp[i][j]!=-1):
        return dp[i][j]

    # If we reach the destination return 1
    n,m=len(A),len(B)
    if(i==n and j==m):
        return 1

    # If C[i+j] matches with both A[i] and B[j] we explore both the paths
    if (i<n and A[i]==C[i + j] and j<m and B[j]==C[i + j]):
        # go down and store the calculated value in x
        # and go right and store the calculated value in y.
        x = dfs(i + 1, j, A, B, C)
        y = dfs(i, j + 1, A, B, C)

        # return the best of both.
        dp[i][j] = x|y
        return dp[i][j]

    # If C[i+j] matches with A[i].
    if (i < n and A[i] == C[i + j]):
        # go down
        x = dfs(i + 1, j, A, B, C)

        # Return the calculated value.
        dp[i][j] = x
        return dp[i][j]

    # If C[i+j] matches with B[j].
    if (j < m and B[j] == C[i + j]):
        y = dfs(i, j + 1, A, B, C)

        # Return the calculated value.
        dp[i][j] = y
        return dp[i][j]

    # if nothing matches we return 0
    dp[i][j] = 0
    return dp[i][j]

# The main function that returns true if C is
# an interleaving of A and B, otherwise false.
def isInterleaved(A, B, C):

    # Storing the length in n,m
    n = len(A)
    m = len(B)

    # C can be an interleaving of A and B only of the sum
    # of lengths of A & B is equal to the length of C.
    if((n+m)!=len(C)):
```

```
        return 0
    # initializing dp array with -1
    for i in range(n+1):
        for j in range(m+1):
            dp[i][j]=-1
    # calling and returning the answer
    return dfs(0,0,A,B,C)

def test(A, B, C):
    if (isInterleaved(A, B, C)):
        print(C, "is interleaved of", A, "and", B)
    else:
        print(C, "is not interleaved of", A, "and", B)

test("XXY", "XXZ", "XXZXXXY")
test("XY", "WZ", "WZXY")
test("XY", "X", "XXY")
test("YX", "X", "XXY")
test("XXY", "XXZ", "XXXXZY")
test("ACA", "DAS", "DAACSA")
```

Graph

Create a Graph, print it

Create a Graph (for practice)

Implement BFS algorithm

Implement DFS Algo

Detect Cycle in Directed Graph using BFS/DFS Algo

Detect Cycle in UnDirected Graph using BFS/DFS Algo

Search in a Maze

Minimum Step by Knight

flood fill algo

Clone a graph

Making wired Connections

word Ladder

Dijkstra algo

Implement Topological Sort

Minimum time taken by each job to be completed given by a Directed Acyclic Graph

Find whether it is possible to finish all tasks or not from given dependencies

Find the no. of Islands

Given a sorted Dictionary of an Alien Language, find order of characters

Implement Kruksal'sAlgorithm

Implement Prim's Algorithm

Total no. of Spanning tree in a graph

Implement Bellman Ford Algorithm

Implement Floyd warshallAlgorithm

Travelling Salesman Problem

Graph ColouringProblem

Snake and Ladders Problem

Find bridge in a graph

Count Strongly connected Components(Kosaraju Algo)

Check whether a graph is Bipartite or Not

Detect Negative cycle in a graph

Longest path in a Directed Acyclic Graph

Journey to the Moon

Cheapest Flights Within K Stops

Oliver and the Game

Water Jug problem using BFS

Find if there is a path of more thank length from a source

M-ColouringProblem

Minimum edges to reverse o make path from source to destination

Paths to travel each nodes using each edge(Seven Bridges)

Vertex Cover Problem

Chinese Postman or Route Inspection

Number of Triangles in a Directed and Undirected Graph

Minimise the cashflow among a given set of friends who have borrowed money from each other

Two Clique Problem

Greedy

Activity Selection Problem

Job SequencingProblem

Huffman Coding

Water Connection Problem

Fractional Knapsack Problem

Greedy Algorithm to find Minimum number of Coins

Maximum trains for which stoppage can be provided

Minimum Platforms Problem

Buy Maximum Stocks if i stocks can be bought on i-th day

Find the minimum and maximum amount to buy all N candies

Minimize Cash Flow among a given set of friends who have borrowed money from each other

Minimum Cost to cut a board into squares

Check if it is possible to survive on Island

Find maximum meetings in one room

Maximum product subset of an array

Maximize array sum after K negations

Maximize the sum of arr[i]*i

Maximum sum of absolute difference of an array

Maximize sum of consecutive differences in a circular array

Minimum sum of absolute difference of pairs of two arrays

Program for Shortest Job First (or SJF) CPU Scheduling

Program for Least Recently Used (LRU) Page Replacement algorithm

Smallest subset with sum greater than all other elements

Chocolate Distribution Problem

DEFKIN -Defense of a Kingdom

DIEHARD -DIE HARD

GERGOVIA -Wine trading in Gergovia

Picking Up Chicks

CHOCOLA –Chocolate

ARRANGE -Arranging Amplifiers

K Centers Problem

Minimum Cost of ropes

Find smallest number with given number of digits and sum of digits

Rearrange characters in a string such that no two adjacent are same

Find maximum sum possible equal sum of three stacks

Heap

Implement a Maxheap/MinHeap using arrays and recursion.

Sort an Array using heap. (HeapSort)

Maximum of all subarrays of size k.

“k” largest element in an array

Kth smallest and largest element in an unsorted array

Merge “K” sorted arrays. [IMP]

Merge 2 Binary Max Heaps

Kth largest sum continuous subarrays

Leetcode- reorganize strings

Merge “K” Sorted Linked Lists [V.IMP]

Smallest range in “K” Lists

Median in a stream of Integers

Check if a Binary Tree is Heap

Connect “n” ropes with minimum cost

Convert BST to Min Heap

Convert min heap to max heap

Rearrange characters in a string such that no two adjacent are same.

Minimum sum of two numbers formed from digits of an array

LinkedList

Write a Program to reverse the Linked List. (Both Iterative and recursive)

Reverse a Linked List in group of Given Size. [Very Imp]

Write a program to Detect loop in a linked list.

Write a program to Delete loop in a linked list.

Find the starting point of the loop.

Remove Duplicates in a sorted Linked List.

Remove Duplicates in a Un-sorted Linked List.

Write a Program to Move the last element to Front in a Linked List.

Add “1” to a number represented as a Linked List.

Add two numbers represented by linked lists.

Intersection of two Sorted Linked List.

Intersection Point of two Linked Lists.

Merge Sort For Linked lists.[Very Important]

Quicksort for Linked Lists.[Very Important]

Find the middle Element of a linked list.

Check if a linked list is a circular linked list.

Split a Circular linked list into two halves.

Write a Program to check whether the Singly Linked list is a palindrome or not.

Deletion from a Circular Linked List.

Reverse a Doubly Linked list.

Find pairs with a given sum in a DLL.

Count triplets in a sorted DLL whose sum is equal to given value “X”.

Sort a “k”sorted Doubly Linked list.[Very IMP]

Rotate DoublyLinked list by N nodes.

Rotate a Doubly Linked list in group of Given Size.[Very IMP]

Can we reverse a linked list in less than O(n) ?

Why Quicksort is preferred for. Arrays and Merge Sort for LinkedLists ?

Flatten a Linked List

Sort a LL of 0's, 1's and 2's

Clone a linked list with next and random pointer

Merge K sorted Linked list

Multiply 2 no. represented by LL

Delete nodes which have a greater value on right side

Segregate even and odd nodes in a Linked List

Program for n’th node from the end of a Linked List

Find the first non-repeating character from a stream of characters

Matrix

Spiral traversal on a Matrix

Search an element in a matriix

Find median in a row wise sorted matrix

Find row with maximum no. of 1's

Print elements in sorted order using row-column wise sorted matrix

Maximum size rectangle

Find a specific pair in matrix

Rotate matrix by 90 degrees

Kth smallest element in a row-column wise sorted matrix

Common elements in all rows of a given matrix

Searching & Sorting

Bubble Sort

```
def bubble_sort(array):
    n=len(array)
    for i in range(n):
        for j in range(n-i-1):
            if array[j] > array[j + 1]:
                array[j], array[j + 1] = array[j + 1], array[j]


array=[5,2,3,1,4, -99, 0]
bubble_sort(array)
print(array)
```

Selection Sort

```
def selection_sort(array):
    global iterations
    iterations = 0
    for i in range(len(array)):
        minimum_index = i
        for j in range(i + 1, len(array)):
            iterations += 1
            if array[minimum_index] > array[j]:
                minimum_index = j

        # Swap the found minimum element with  the first element
        if minimum_index != i:
            array[i], array[minimum_index] = array[minimum_index], array[i]

array=[5,2,3,1,4, -99, 0]
selection_sort(array)
print(array)
```

Insertion Sort

```
def insertion_sort(array):
    global iterations
    iterations = 0
    for i in range(1, len(array)):
        current_value = array[i]
```

```
        for j in range(i - 1, -1, -1):
            iterations += 1
            if array[j] > current_value:
                array[j], array[j + 1] = array[j + 1], array[j] # swap
            else:
                array[j + 1] = current_value
                break

array=[5,2,3,1,4, -99, 0]
insertion_sort(array)
print(array)
```

Merge Sort

```
def merge_sort(array):
    if len(array) < 2:
        return array
    mid = len(array) // 2
    left = merge_sort(array[:mid])
    right = merge_sort(array[mid:])
    return merge(left, right)

def merge(left, right):
    result = []
    i, j = 0, 0
    while i < len(left) or 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) or j == len(right):
            result.extend(left[i:] or right[j:])
            break
    return result

array=[5,2,3,1,4, -99, 0]
print(merge_sort(array))
```

Quick Sort

```
def partition(array, low, high):
    i = low - 1            # index of smaller element
    pivot = array[high]    # pivot

    for j in range(low, high):
        # If current element is smaller than the pivot

        if array[j] < pivot:
        # increment index of smaller element

            i += 1
            array[i], array[j] = array[j], array[i]

    array[i + 1], array[high] = array[high], array[i + 1]
    return i + 1
```

```
def quick_sort(array, low, high):
    if low < high:
        # pi is partitioning index, arr[p] is now at right place
        temp = partition(array, low, high)

        # Separately sort elements before partition and after partition
        quick_sort(array, low, temp - 1)
        quick_sort(array, temp + 1, high)

array=[5,2,3,1,4, -99, 0]
quick_sort(array, 0, len(array)-1)
print(array)
```

Counting Sort

```
# Counting sort in Python programming


def countingSort(array):
    size = len(array)
    output = [0] * size

    # Initialize count array
    count = [0] * 10

    # Store the count of each elements in count array
    for i in range(size):
        count[array[i]] += 1

    # Store the cummulative count
    for i in range(1, 10):
        count[i] += count[i - 1]

    # Find the index of each element of the original array in count array
    # place the elements in output array
    i = size - 1
    while i >= 0:
        output[count[array[i]] - 1] = array[i]
        count[array[i]] -= 1
        i -= 1

    # Copy the sorted elements into original array
    for i in range(size):
        array[i] = output[i]


array = [4,0,2, 2, 8, 3, 3, 1]
countingSort(array)
print(array)
```

Heap Sort

```
def heapify(nums, heap_size, root_index):
    # Assume the index of the largest element is the root index
    largest = root_index
    left_child = (2 * root_index) + 1
    right_child = (2 * root_index) + 2
```

```
    if left_child < heap_size and nums[left_child] > nums[largest]:
        largest = left_child

    if right_child < heap_size and nums[right_child] > nums[largest]:
        largest = right_child

    if largest != root_index:
        nums[root_index], nums[largest] = nums[largest], nums[root_index]
        # Heapify the new root element to ensure it's the largest
        heapify(nums, heap_size, largest)


def heap_sort(nums):
    n = len(nums)

    for i in range(n, -1, -1):
        heapify(nums, n, i)

    # Move the root of the max heap to the end of
    for i in range(n - 1, 0, -1):
        nums[i], nums[0] = nums[0], nums[i]
        heapify(nums, i, 0)

random_list_of_nums = [35, 12, 43, 8, 51]
heap_sort(random_list_of_nums)
print(random_list_of_nums)
```

Radix Sort

```
from math import log10
from random import randint

def get_num(num, base, pos):
  return (num // base ** pos) % base

def prefix_sum(array):
  for i in range(1, len(array)):
    array[i] = array[i] + array[i-1]
  return array

def radixsort(l, base=10):
  passes = int(log10(max(l))+1)
  output = [0] * len(l)

  for pos in range(passes):
    count = [0] * base

    for i in l:
      digit = get_num(i, base, pos)
      count[digit] +=1

    count = prefix_sum(count)

    for i in reversed(l):
      digit = get_num(i, base, pos)
      count[digit] -= 1
      new_pos = count[digit]
      output[new_pos] = i
```

```
    l = list(output)
  return output

l = [randint(1, 99999) for _ in range(100)]
sortedarr = radixsort(l)
print(sortedarr)
```

Linear Search

```
def linearSearch(array, n, x):
    for i in range(n):
        if (array[i] == x):
            return i
    return -1

array = [2, 4, 0, 1, 9]
x = 1
n = len(array)
result = linearSearch(array, n, x)
if(result == -1):
    print("Element not found")
else:
    print("Element found at index: ", result)
```

Binary Search

```
def binarySearch(array, x, low, high):
    while low <= high:
        mid = low + (high - low)//2
        if array[mid] == x:
            return mid
        elif array[mid] < x:
            low = mid + 1
        else:
            high = mid - 1
    return -1

array = [3, 4, 5, 6, 7, 8, 9]
x = 4
result = binarySearch(array, x, 0, len(array)-1)
if result != -1:
    print(f"Element is present at index {str(result)}")
else:
    print("Not found")
```

Binary Search

```
# Function to determine if target exists in the sorted list `A` or not
# using an interpolation search algorithm
def interpolationSearch(A, target):
    if not A:
        return -1
    (left, right) = (0, len(A) - 1)
    while A[right] != A[left] and A[left] <= target <= A[right]:
        mid = left + (target - A[left]) * (right - left) // (A[right] - A[left])
        if target == A[mid]:
```

```
            return mid
        elif target < A[mid]:
            right = mid - 1
        else:
            left = mid + 1
    if target == A[left]:
        return left
    return -1

A = [2, 5, 6, 8, 9, 10]
key = 5
index = interpolationSearch(A, key)
if index != -1:
    print('Element found at index', index)
else:
    print('Element found not in the list')
```

Find first and last positions of an element in a sorted array

Find a Fixed Point (Value equal to index) in a given array

Search in a rotated sorted array

square root of an integer

Maximum and minimum of an array using minimum number of comparisons

Optimum location of point to minimize total distance

Find the repeating and the missing

find majority element

Searching in an array where adjacent differ by at most k

find a pair with a given difference

find four elements that sum to a given value

maximum sum such that no 2 elements are adjacent

Count triplet with sum smaller than a given value

merge 2 sorted arrays

print all subarrays with 0 sum

Product array Puzzle

Sort array according to count of set bits

minimum no. of swaps required to sort the array

Bishu and Soldiers

Rasta and Kheshtak

Kth smallest number again

Find pivot element in a sorted array

K-th Element of Two Sorted Arrays

Aggressive cows

Book Allocation Problem

EKOSPOJ:

Job Scheduling Algo

Missing Number in AP

Smallest number with atleastn trailing zeroes infactorial

Painters Partition Problem:

ROTI-Prata SPOJ

DoubleHelix SPOJ

Subset Sums

Find the inversion count

Implement Merge-sort in-place

Partitioning and Sorting Arrays with Many Repeated Entries

Stacks & Queues

Implement Stack from Scratch

Implement Queue from Scratch

Implement 2 stack in an array

find the middle element of a stack

Implement "N" stacks in an Array

Check the expression has valid or Balanced parenthesis or not.

Reverse a String using Stack

Design a Stack that supports getMin() in O(1) time and O(1) extra space.

Find the next Greater element

The celebrity Problem

Arithmetic Expression evaluation

Evaluation of Postfix expression

Implement a method to insert an element at its bottom without using any other data structure.

Reverse a stack using recursion

Sort a Stack using recursion

Merge Overlapping Intervals

Largest rectangular Area in Histogram

Length of the Longest Valid Substring

Expression contains redundant bracket or not

Implement Stack using Queue

Implement Stack using Deque

Stack Permutations (Check if an array is stack permutation of other)

Implement Queue using Stack

Implement "n" queue in an array

Implement a Circular queue

LRU Cache Implementationa

Reverse a Queue using recursion

Reverse the first “K” elements of a queue

Interleave the first half of the queue with second half

Find the first circular tour that visits all Petrol Pumps

Minimum time required to rot all oranges

Distance of nearest cell having 1 in a binary matrix

First negative integer in every window of size “k”

Check if all levels of two trees are anagrams or not.

Sum of minimum and maximum elements of all subarrays of size “k”.

Minimum sum of squares of character counts in a given string after removing “k” characters.

Queue based approach or first non-repeating character in a stream.

Next Smaller Element

String

Reverse a String

Check whether a String is Palindrome or not

Find Duplicate characters in a string

Why strings are immutable in Java?

Write a Code to check whether one string is a rotation of another

Write a Program to check whether a string is a valid shuffle of two strings or not

Count and Say problem

Write a program to find the longest Palindrome in a string.[Longest palindromic Substring]

Find Longest Recurring Subsequence in String

Print all Subsequences of a string.

Print all the permutations of the given string

Split the Binary string into two substring with equal 0's and 1's

Find next greater number with same set of digits. [Very Very IMP]

Balanced Parenthesis problem.[Imp]

Rabin Karp Algo

KMP Algo

Convert a Sentence into its equivalent mobile numeric keypad sequence.

Minimum number of bracket reversals needed to make an expression balanced.

Count All Palindromic Subsequence in a given String.

Count of number of given string in 2D character array

Search a Word in a 2D Grid of characters.

Boyer Moore Algorithm for Pattern Searching.

Converting Roman Numerals to Decimal

Longest Common Prefix

Number of flips to make binary string alternate

Find the first repeated word in string.

Minimum number of swaps for bracket balancing.

Find the longest common subsequence between two strings.

Program to generate all possible valid IP addresses from given string.

Write a program to find the smallest window that contains all characters of string itself.

Rearrange characters in a string such that no two adjacent are same

Minimum characters to be added at front to make string palindrome

Given a sequence of words, print all anagrams together

Find the smallest window in a string containing all characters of another string

Recursively remove all adjacent duplicates

String matching where one string contains wildcard characters

Function to find Number of customers who could not get a computer

Transform One String to Another using Minimum Number of Given Operation

Check if two given strings are isomorphic to each other

Recursively print all sentences that can be formed from list of word lists

Trie

Construct a trie from scratch

```
class TrieNode:
    def __init__(self):
        self.children = [None]*26
        # isEndOfWord is True if node represent the end of the word
        self.isEndOfWord = False

class Trie:
    def __init__(self):
        self.root = self.getNode()

    def getNode(self):
        # Returns new trie node (initialized to NULLs)
        return TrieNode()

    def _charToIndex(self,ch):
        # private helper function.
```

```
        # Converts key current character into index use only 'a' through 'z' and lower case
        return ord(ch)-ord('a')


    def insert(self,key):

        # If not present, inserts key into trie
        # If the key is prefix of trie node, just marks leaf node
        pCrawl = self.root
        length = len(key)
        for level in range(length):
            index = self._charToIndex(key[level])

            # if current character is not present
            if not pCrawl.children[index]:
                pCrawl.children[index] = self.getNode()
            pCrawl = pCrawl.children[index]

        # mark last node as leaf
        pCrawl.isEndOfWord = True

    def search(self, key):

        # Search key in the trie
        # Returns true if key presents in trie, else false
        pCrawl = self.root
        length = len(key)
        for level in range(length):
            index = self._charToIndex(key[level])
            if not pCrawl.children[index]:
                return False
            pCrawl = pCrawl.children[index]

        return pCrawl.isEndOfWord


def constructTrie():

    # Input keys (use only 'a' through 'z' and lower case)
    keys = ["the","a","there","answer","any", "by","their", "these"]
    output = ["Not present in trie", "Present in trie"]

    # Trie object
    t = Trie()

    # Construct trie
    for key in keys:
        t.insert(key)

    # Search for different keys
    print("the->",output[t.search("the")])
    print("these->",output[t.search("these")])
    print("their->",output[t.search("their")])
    print("thaw->",output[t.search("thaw")])

if __name__ == '__main__':
    constructTrie()
```

Find shortest unique prefix for every word in a given list

```
"""
Input:  [AND, BONFIRE, BOOL, CASE, CATCH, CHAR]
Output: [A, BON, BOO, CAS, CAT, CH]
Explanation:
A can uniquely identify AND
BON can uniquely identify BONFIRE
BOO can uniquely identify BOOL
CAS can uniquely identify CASE
CAT can uniquely identify CATCH
CH can uniquely identify CHAR
"""
# A class to store a Trie node
class TrieNode:
    def __init__(self):
        # each node stores a dictionary to its child nodes
        self.child = {}

        # keep track of the total number of times the current node is visited
        # while inserting data in Trie
        self.freq = 0


# Function to insert a given string into a Trie
def insert(root, word):

    # start from the root node
    curr = root
    for c in word:
        # create a new node if the path doesn't exist
        curr.child.setdefault(c, TrieNode())

        # increment frequency
        curr.child[c].freq += 1

        # go to the next node
        curr = curr.child[c]


# Function to recursively traverse the Trie in a preorder fashion and
# print the shortest unique prefix for each word in the Trie
def printShortestPrefix(root, word_so_far):
    if root is None:
        return

    # print `word_so_far` if the current Trie node is visited only once
    if root.freq == 1:
        print(word_so_far)
        return

    # recur for all child nodes
    for k, v in root.child.items():
        printShortestPrefix(v, word_so_far + k)


# Find the shortest unique prefix for every word in a given array
def findShortestPrefix(words):

    # construct a Trie from the given items
    root = TrieNode()
```

```
    for s in words:
        insert(root, s)

    # Recursively traverse the Trie in a preorder fashion to list all prefixes
    printShortestPrefix(root, '')


if __name__ == '__main__':
    words = ['AND', 'BONFIRE', 'BOOL', 'CASE', 'CATCH', 'CHAR']
    findShortestPrefix(words)
```

Word Break Problem | (Trie solution)

```
# Currently, Trie supports lowercase English characters. So, the character size is 26.
CHAR_SIZE = 26


# A class to store a Trie node
class Node:
    next = [None] * CHAR_SIZE
    exist = False       # true when the node is a leaf node


# Iterative function to insert a string into a Trie
def insertTrie(head, s):

    # start from the root node
    node = head

    # do for each character in the string
    for c in s:

        index = ord(c) - ord('a')

        # create a new node if the path doesn't exist
        if node.next[index] is None:
            node.next[index] = Node()

        # go to the next node
        node = node.next[index]

    # mark the last node as a leaf
    node.exist = True


# Function to determine if a string can be segmented into space-separated
# sequence of one or more dictionary words
def wordBreak(head, s):

    # get the length of the string
    n = len(s)

    # `good[i]` is true if the first `i` characters of `s` can be segmented
    good = [None] * (n + 1)
    good[0] = True      # base case

    for i in range(n):
        if good[i]:
            node = head
```

```
            for j in range(i, n):
                if node is None:
                    break

                index = ord(s[j]) - ord('a')
                node = node.next[index]

                # we can make [0, i] using our known decomposition
                # and [i+1, j] using this string in a Trie
                if node and node.exist:
                    good[j + 1] = True

    # `good[n]` would be true if all characters of `s` can be segmented
    return good[n]


if __name__ == '__main__':

    # List of strings to represent a dictionary
    words = ['self', 'th', 'is', 'famous', 'word', 'break', 'b', 'r', 'e', 'a', 'k', 'br', 'bre',
'brea', 'ak', 'prob', 'lem']

    # given string
    s = 'wordbreakproblem'

    # create a Trie to store the dictionary
    t = Node()
    for word in words:
        insertTrie(t, word)

    # check if the string can be segmented or not
    if wordBreak(t, s):
        print('The string can be segmented')
    else:
        print('The string can\'t be segmented')
```

Given a sequence of words, print all anagrams together

```
class TrieNode:
    def __init__(self):
        # each node stores a dictionary to its child nodes
        self.child = {}

        # stores anagrams in the leaf node
        self.words = []


# Function to insert a string into a Trie
def insert(root, word, originalWord):

    # start from the root node
    curr = root
    for c in word:
        # create a new node if the path doesn't exist
        curr.child.setdefault(c, TrieNode())
        # go to the next node
        curr = curr.child[c]

    # anagrams will end up at the same leaf node
```

```
    curr.words.append(originalWord)


# A recursive function that traverses a Trie in preorder fashion and
# prints all anagrams together
def printAnagrams(root):

    # base case
    if root is None:
        return

    # print the current word
    if len(root.words) > 1:
        print(root.words)

    # recur for all child nodes
    for child in root.child.values():
        printAnagrams(child)


# Function to group anagrams from a given list of words
def groupAnagrams(words):

    # construct an empty trie
    root = TrieNode()

    # do for each word
    for word in words:
        # Sort the characters of the current word and insert it into the Trie.
        # Note that the original word gets stored on the leaf
        insert(root, ''.join(sorted(word)), word)

    # print all anagrams together
    printAnagrams(root)


if __name__ == '__main__':

    words = ['auctioned', 'actors', 'altered', 'streaming', 'related', 'education', 'aspired',
'costar', 'despair', 'mastering', 'act','cat','tac'
    ]
    groupAnagrams(words)
```

Print unique rows in a given boolean matrix

```
# Given a binary matrix of M X N of integers, you need to return only unique rows of binary array
ROW = 4
COL = 5

def findUniqueRows(M):

    # Traverse through the matrix
    for i in range(ROW):
        flag = 0

        # Check if there is similar column is already printed, i.e if i and jth column match.
        for j in range(i):
            flag = 1
```

```
            for k in range(COL):
                if (M[i][k] != M[j][k]):
                    flag = 0

            if (flag == 1):
                break

        # If no row is similar
        if (flag == 0):

            # Print the row
            for j in range(COL):
                print(M[i][j], end = " ")
            print()


M = [ [ 0, 1, 0, 0, 1 ],
      [ 1, 0, 1, 1, 0 ],
      [ 0, 1, 0, 0, 1 ],
      [ 1, 0, 1, 0, 0 ] ]
findUniqueRows(M)
```