# Ex No:01 IMPLEMENT RSA ASYMMETRIC (SECRET KEY ENCRYPTION) ALGORITHM

# Date:

## AIM:

To execute RSA Algorithm Using python and encrypt and decrypt.

## ALGORITHM:

1. Start.
2. **Key Generation:**
   1. Choose two distinct prime numbers, p and q.
   2. Compute n = p\*q.
   3. Compute Φ (n)=(p-1)\*(q-1).where Φ is Eucler’s totient function.
   4. Choose an integer e such that 1 < e < Φ (n) and e is coprime to Φ (n).
   5. Compute the integer d such that d\*e ≡1(modΦ (n)), i.e., d is the modular multiplicative inverse of e modulo Φ (n).
   6. The public key is (n,e) and the private key is (n,d).
3. Encryption:
   1. Encrypt the message M using public key(n,e).
      1. Compute C ≡ Me (mad n).
4. Decryption:
   1. Decrypt the ciphertext C using the private key (n, d).
      1. Compute M ≡ cd (mod N).
5. Stop

## PROGRAM:

import random

def gcd(a, b):

while b != 0:

a, b = b, a % b

return a

def multiplicative\_inverse(e, phi):

d = 0

x1, x2, y1, y2 = 0, 1, 1, 0

temp\_phi = phi

while e > 0:

temp1 = temp\_phi // e

temp2 = temp\_phi - temp1 \* e

temp\_phi = e

e = temp2

x = x2 - temp1 \* x1

y = y2 - temp1 \* y1

x2 = x1

x1 = x

y2 = y1

y1 = y

if temp\_phi == 1:

d = y2 + phi

return d

def generate\_keypair(p, q):

if not (is\_prime(p) and is\_prime(q)):

raise ValueError("Both numbers must be prime.")

elif p == q:

raise ValueError("p and q cannot be equal")

n = p \* q

phi = (p - 1) \* (q - 1)

e = random.randrange(1, phi)

g = gcd(e, phi)

while g != 1:

e = random.randrange(1, phi)

g = gcd(e, phi)

d = multiplicative\_inverse(e, phi)

return ((e, n), (d, n))

def encrypt(pk, plaintext):

key, n = pk

cipher = [pow(ord(char), key, n) for char in plaintext]

return cipher

def decrypt(pk, ciphertext):

key, n = pk

plain = [chr(pow(char, key, n)) for char in ciphertext]

return ''.join(plain)

def is\_prime(num):

if num == 2 or num == 3:

return True

if num < 2 or num % 2 == 0:

return False

for n in range(3, int(num\*\*0.5)+2, 2):

if num % n == 0:

return False

return True

# Example usage:

p = 61

q = 53

public\_key, private\_key = generate\_keypair(p, q)

print("Public Key:", public\_key)

print("Private Key:", private\_key)

message = "Hello, World!"

print("Original Message:", message)

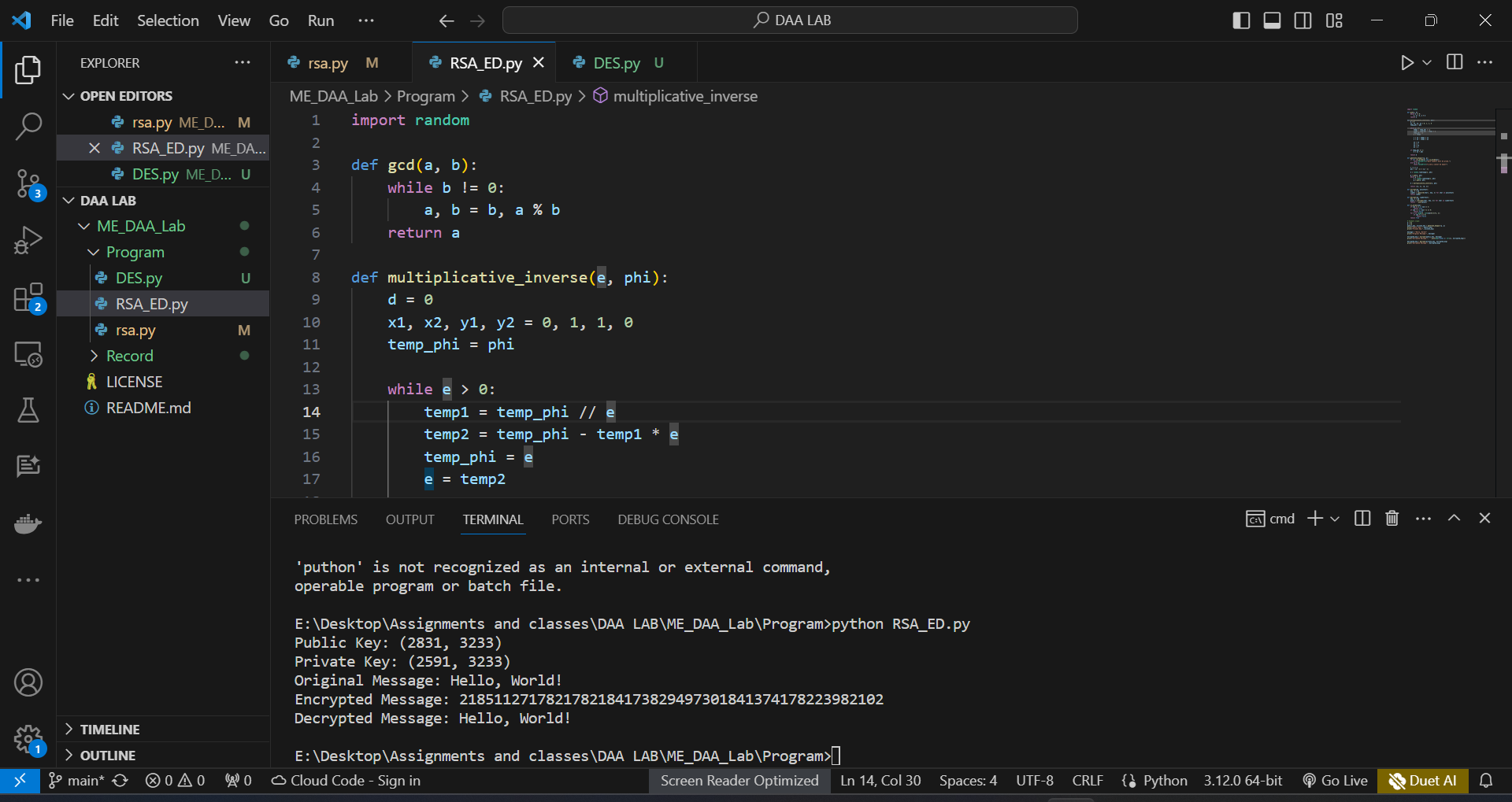
encrypted\_msg = encrypt(public\_key, message)

print("Encrypted Message:", ''.join(map(lambda x: str(x), encrypted\_msg)))

decrypted\_msg = decrypt(private\_key, encrypted\_msg)

print("Decrypted Message:", decrypted\_msg)

## OUTPUT:



## RESULT:

This RSA algorithm was executed successfully.

# Ex No:02 IMPLEMENT DATA ENCRYPTION STANDARD (DES) A SYMMETRIC ENCRYPTION ALGORITHM

# Date:

## AIM:

To implement DES to encode and decode a plain text using key in python.

## ALGORITHM:

1. Start.
2. Get the values of Li, Ri, Ci, Di in hex format from the user.
3. Perform left circular shift of Ci Di with respective to the round with table values.
4. Using PC2 table arrange the elements in the same order.
5. Compute expansion permutation of ith round (Ri) and arrange elements in 6x8 matrix.
6. Convert PC2 matrix in 8x6 order.
7. Perform A=PC2 EX-OR E/P(Ri)
8. Find the value of ‘A’ in S-Box Table.
9. Arrange the ‘A’ Matrix in permutation Function table order.
10. Li+1=Ri Ri+1=Li EX-OR P32.
11. To decrypt, apply the same algorithm with subkey used in reverse order.
12. Stop.

## PROGRAM:

def main():

print()

# Taking inputs from the user

plaintext = input("Enter the message to be encrypted : ")

key = input("Enter a key of 8 length (64-bits) (characters or numbers only) : ")

print()

# Checking if key is valid or not

if len(key) != 8:

print("Invalid Key. Key should be of 8 length (8 bytes).")

return

# Determining if padding is required

isPaddingRequired = (len(plaintext) % 8 != 0)

# Encryption

ciphertext = DESEncryption(key, plaintext, isPaddingRequired)

# Decryption

plaintext = DESDecryption(key, ciphertext, isPaddingRequired)

# Printing result

print()

print("Encrypted Ciphertext is : %r " % ciphertext)

print("Decrypted plaintext is : ", plaintext)

print()

# Permutation Matrix used after each SBox substitution for each round

eachRoundPermutationMatrix = [

16, 7, 20, 21, 29, 12, 28, 17,

1, 15, 23, 26, 5, 18, 31, 10,

2, 8, 24, 14, 32, 27, 3, 9,

19, 13, 30, 6, 22, 11, 4, 25

]

# Final Permutation Matrix for data after 16 rounds

finalPermutationMatrix = [

40, 8, 48, 16, 56, 24, 64, 32,

39, 7, 47, 15, 55, 23, 63, 31,

38, 6, 46, 14, 54, 22, 62, 30,

37, 5, 45, 13, 53, 21, 61, 29,

36, 4, 44, 12, 52, 20, 60, 28,

35, 3, 43, 11, 51, 19, 59, 27,

34, 2, 42, 10, 50, 18, 58, 26,

33, 1, 41, 9, 49, 17, 57, 25

]

def DESEncryption(key, text, padding):

"""Function for DES Encryption."""

# Adding padding if required

if padding == True:

text = addPadding(text)

# Encryption

ciphertext = DES(text, key, padding, True)

# Returning ciphertext

return ciphertext

def DESDecryption(key, text, padding):

"""Function for DES Decryption."""

# Decryption

plaintext = DES(text, key, padding, False)

# Removing padding if required

if padding == True:

# Removing padding and returning plaintext

return removePadding(plaintext)

# Returning plaintext

return plaintext

# Initial Permutation Matrix for data

initialPermutationMatrix = [

58, 50, 42, 34, 26, 18, 10, 2,

60, 52, 44, 36, 28, 20, 12, 4,

62, 54, 46, 38, 30, 22, 14, 6,

64, 56, 48, 40, 32, 24, 16, 8,

57, 49, 41, 33, 25, 17, 9, 1,

59, 51, 43, 35, 27, 19, 11, 3,

61, 53, 45, 37, 29, 21, 13, 5,

63, 55, 47, 39, 31, 23, 15, 7

]

#Expand matrix to get a 48bits matrix of datas to apply the xor with Ki

expandMatrix = [

32, 1, 2, 3, 4, 5,

4, 5, 6, 7, 8, 9,

8, 9, 10, 11, 12, 13,

12, 13, 14, 15, 16, 17,

16, 17, 18, 19, 20, 21,

20, 21, 22, 23, 24, 25,

24, 25, 26, 27, 28, 29,

28, 29, 30, 31, 32, 1

]

def DES(text, key, padding, isEncrypt):

"""Function to implement DES Algorithm."""

# Initializing variables required

isDecrypt = not isEncrypt

# Generating keys

keys = generateKeys(key)

# Splitting text into 8 byte blocks

plaintext8byteBlocks = nSplit(text, 8)

result = []

# For all 8-byte blocks of text

for block in plaintext8byteBlocks:

# Convert the block into bit array

block = stringToBitArray(block)

# Do the initial permutation

block = permutation(block, initialPermutationMatrix)

# Splitting block into two 4 byte (32 bit) sized blocks

leftBlock, rightBlock = nSplit(block, 32)

temp = None

# Running 16 identical DES Rounds for each block of text

for i in range(16):

# Expand rightBlock to match round key size(48-bit)

expandedRightBlock = expand(rightBlock, expandMatrix)

# Xor right block with appropriate key

if isEncrypt == True:

# For encryption, starting from first key in normal order

temp = xor(keys[i], expandedRightBlock)

elif isDecrypt == True:

# For decryption, starting from last key in reverse order

temp = xor(keys[15 - i], expandedRightBlock)

# Sbox substitution Step

temp = SboxSubstitution(temp)

# Permutation Step

temp = permutation(temp, eachRoundPermutationMatrix)

# XOR Step with leftBlock

temp = xor(leftBlock, temp)

# Blocks swapping

leftBlock = rightBlock

rightBlock = temp

# Final permutation then appending result

result += permutation(rightBlock + leftBlock, finalPermutationMatrix)

# Converting bit array to string

finalResult = bitArrayToString(result)

return finalResult

# Matrix used for shifting after each round of keys

SHIFT = [1, 1, 2, 2, 2, 2, 2, 2, 1, 2, 2, 2, 2, 2, 2, 1]

# Permutation matrix for key

keyPermutationMatrix1 = [

57, 49, 41, 33, 25, 17, 9,

1, 58, 50, 42, 34, 26, 18,

10, 2, 59, 51, 43, 35, 27,

19, 11, 3, 60, 52, 44, 36,

63, 55, 47, 39, 31, 23, 15,

7, 62, 54, 46, 38, 30, 22,

14, 6, 61, 53, 45, 37, 29,

21, 13, 5, 28, 20, 12, 4

]

# Permutation matrix for shifted key to get next key

keyPermutationMatrix2 = [

14, 17, 11, 24, 1, 5, 3, 28,

15, 6, 21, 10, 23, 19, 12, 4,

26, 8, 16, 7, 27, 20, 13, 2,

41, 52, 31, 37, 47, 55, 30, 40,

51, 45, 33, 48, 44, 49, 39, 56,

34, 53, 46, 42, 50, 36, 29, 32

]

def generateKeys(key):

"""Function to generate keys for different rounds of DES."""

# Inititalizing variables required

keys = []

key = stringToBitArray(key)

# Initial permutation on key

key = permutation(key, keyPermutationMatrix1)

# Split key in to (leftBlock->LEFT), (rightBlock->RIGHT)

leftBlock, rightBlock = nSplit(key, 28)

# 16 rounds of keys

for i in range(16):

# Do left shifting (different for different rounds)

leftBlock, rightBlock = leftShift(leftBlock, rightBlock, SHIFT[i])

# Merge them

temp = leftBlock + rightBlock

# Permutation on shifted key to get next key

keys.append(permutation(temp, keyPermutationMatrix2))

# Return generated keys

return keys

# Sboxes used in the DES Algorithm

SboxesArray = [

[

[14, 4, 13, 1, 2, 15, 11, 8, 3, 10, 6, 12, 5, 9, 0, 7],

[0, 15, 7, 4, 14, 2, 13, 1, 10, 6, 12, 11, 9, 5, 3, 8],

[4, 1, 14, 8, 13, 6, 2, 11, 15, 12, 9, 7, 3, 10, 5, 0],

[15, 12, 8, 2, 4, 9, 1, 7, 5, 11, 3, 14, 10, 0, 6, 13],

],

[

[15, 1, 8, 14, 6, 11, 3, 4, 9, 7, 2, 13, 12, 0, 5, 10],

[3, 13, 4, 7, 15, 2, 8, 14, 12, 0, 1, 10, 6, 9, 11, 5],

[0, 14, 7, 11, 10, 4, 13, 1, 5, 8, 12, 6, 9, 3, 2, 15],

[13, 8, 10, 1, 3, 15, 4, 2, 11, 6, 7, 12, 0, 5, 14, 9],

],

[

[10, 0, 9, 14, 6, 3, 15, 5, 1, 13, 12, 7, 11, 4, 2, 8],

[13, 7, 0, 9, 3, 4, 6, 10, 2, 8, 5, 14, 12, 11, 15, 1],

[13, 6, 4, 9, 8, 15, 3, 0, 11, 1, 2, 12, 5, 10, 14, 7],

[1, 10, 13, 0, 6, 9, 8, 7, 4, 15, 14, 3, 11, 5, 2, 12],

],

[

[7, 13, 14, 3, 0, 6, 9, 10, 1, 2, 8, 5, 11, 12, 4, 15],

[13, 8, 11, 5, 6, 15, 0, 3, 4, 7, 2, 12, 1, 10, 14, 9],

[10, 6, 9, 0, 12, 11, 7, 13, 15, 1, 3, 14, 5, 2, 8, 4],

[3, 15, 0, 6, 10, 1, 13, 8, 9, 4, 5, 11, 12, 7, 2, 14],

],

[

[2, 12, 4, 1, 7, 10, 11, 6, 8, 5, 3, 15, 13, 0, 14, 9],

[14, 11, 2, 12, 4, 7, 13, 1, 5, 0, 15, 10, 3, 9, 8, 6],

[4, 2, 1, 11, 10, 13, 7, 8, 15, 9, 12, 5, 6, 3, 0, 14],

[11, 8, 12, 7, 1, 14, 2, 13, 6, 15, 0, 9, 10, 4, 5, 3],

],

[

[12, 1, 10, 15, 9, 2, 6, 8, 0, 13, 3, 4, 14, 7, 5, 11],

[10, 15, 4, 2, 7, 12, 9, 5, 6, 1, 13, 14, 0, 11, 3, 8],

[9, 14, 15, 5, 2, 8, 12, 3, 7, 0, 4, 10, 1, 13, 11, 6],

[4, 3, 2, 12, 9, 5, 15, 10, 11, 14, 1, 7, 6, 0, 8, 13],

],

[

[4, 11, 2, 14, 15, 0, 8, 13, 3, 12, 9, 7, 5, 10, 6, 1],

[13, 0, 11, 7, 4, 9, 1, 10, 14, 3, 5, 12, 2, 15, 8, 6],

[1, 4, 11, 13, 12, 3, 7, 14, 10, 15, 6, 8, 0, 5, 9, 2],

[6, 11, 13, 8, 1, 4, 10, 7, 9, 5, 0, 15, 14, 2, 3, 12],

],

[

[13, 2, 8, 4, 6, 15, 11, 1, 10, 9, 3, 14, 5, 0, 12, 7],

[1, 15, 13, 8, 10, 3, 7, 4, 12, 5, 6, 11, 0, 14, 9, 2],

[7, 11, 4, 1, 9, 12, 14, 2, 0, 6, 10, 13, 15, 3, 5, 8],

[2, 1, 14, 7, 4, 10, 8, 13, 15, 12, 9, 0, 3, 5, 6, 11],

]

]

def SboxSubstitution(bitArray):

"""Function to substitute all the bytes using Sbox."""

# Split bit array into 6 sized chunks

# For Sbox indexing

blocks = nSplit(bitArray, 6)

result = []

for i in range(len(blocks)):

block = blocks[i]

# Row number to be obtained from first and last bit

row = int( str(block[0]) + str(block[5]), 2 )

# Getting column number from the 2,3,4,5 position bits

column = int(''.join([str(x) for x in block[1:-1]]), 2)

# Taking value from ith Sbox in ith round

sboxValue = SboxesArray[i][row][column]

# Convert the sbox value to binary

binVal = binValue(sboxValue, 4)

# Appending to result

result += [int(bit) for bit in binVal]

# Returning result

return result

def addPadding(text):

"""Function to add padding according to PKCS5 standard."""

# Determining padding length

paddingLength = 8 - (len(text) % 8)

# Adding paddingLength number of chr(paddingLength) to text

text += chr(paddingLength) \* paddingLength

# Returning text

return text

def removePadding(data):

"""Function to remove padding from plaintext according to PKCS5."""

# Getting padding length

paddingLength = ord(data[-1])

# Returning data with removed padding

return data[ : -paddingLength]

def expand(array, table):

"""Function to expand the array using table."""

# Returning expanded result

return [array[element - 1] for element in table]

def permutation(array, table):

"""Function to do permutation on the array using table."""

# Returning permuted result

return [array[element - 1] for element in table]

def leftShift(list1, list2, n):

"""Function to left shift the arrays by n."""

# Left shifting the two arrays

return list1[n:] + list1[:n], list2[n:] + list2[:n]

def nSplit(list, n):

"""Function to split a list into chunks of size n."""

# Chunking and returning the array of chunks of size n

# and last remainder

return [ list[i : i + n] for i in range(0, len(list), n)]

def xor(list1, list2):

"""Function to return the XOR of two lists."""

# Returning the xor of the two lists

return [element1 ^ element2 for element1, element2 in zip(list1,list2)]

def binValue(val, bitSize):

"""Function to return the binary value as a string of given size."""

binVal = bin(val)[2:] if isinstance(val, int) else bin(ord(val))[2:]

# Appending with required number of zeros in front

while len(binVal) < bitSize:

binVal = "0" + binVal

# Returning binary value

return binVal

def stringToBitArray(text):

"""Funtion to convert a string into a list of bits."""

# Initializing variable required

bitArray = []

for letter in text:

# Getting binary (8-bit) value of letter

binVal = binValue(letter, 8)

# Making list of the bits

binValArr = [int(x) for x in list(binVal)]

# Apending the bits to array

bitArray += binValArr

# Returning answer

return bitArray

def bitArrayToString(array):

"""Function to convert a list of bits to string."""

# Chunking array of bits to 8 sized bytes

byteChunks = nSplit(array, 8)

# Initializing variables required

stringBytesList = []

stringResult = ''

# For each byte

for byte in byteChunks:

bitsList = []

for bit in byte:

bitsList += str(bit)

stringBytesList.append(''.join(bitsList))

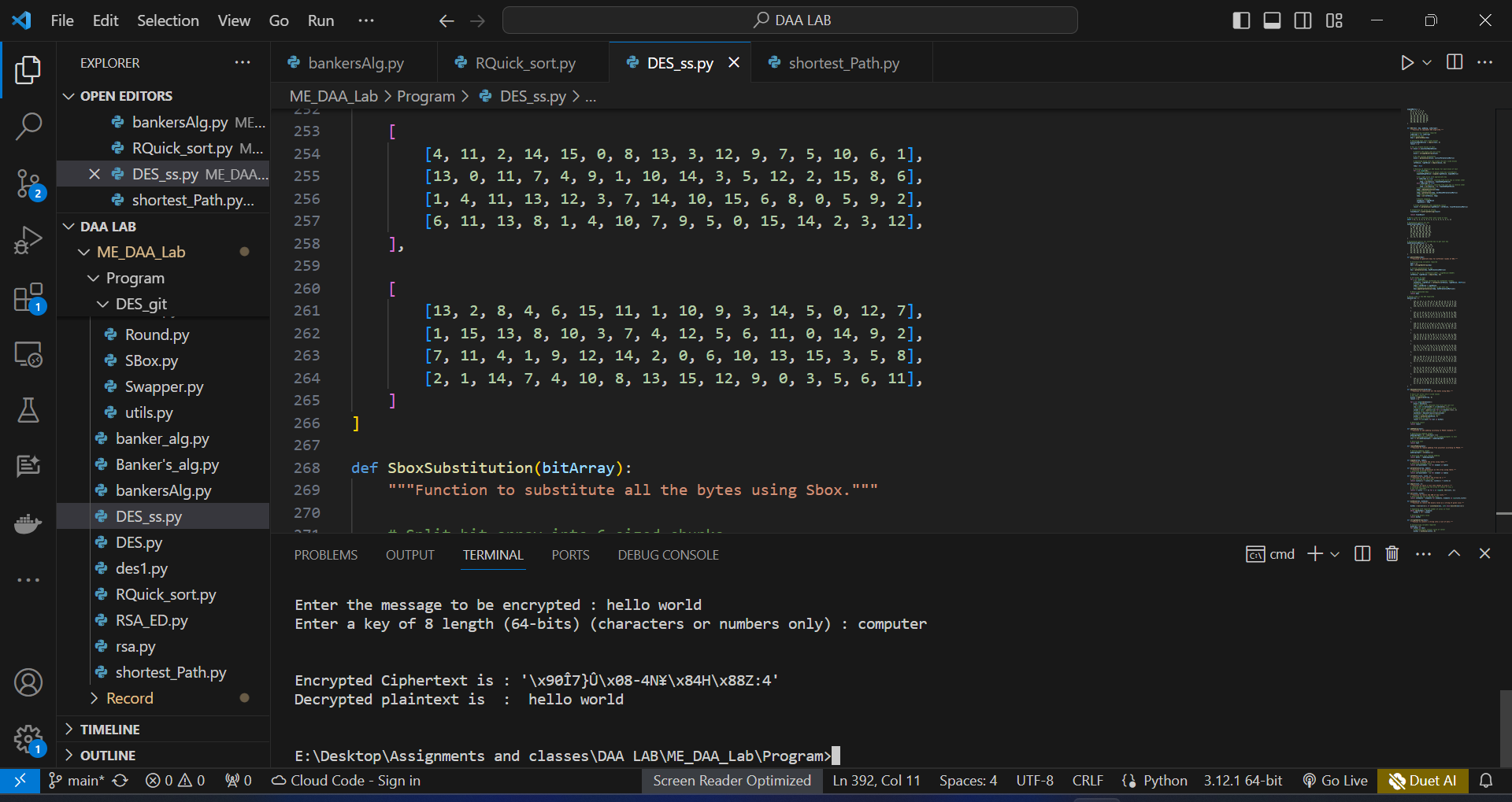
result = ''.join([chr(int(stringByte, 2)) for stringByte in stringBytesList])

return result

if \_\_name\_\_ == '\_\_main\_\_':

main()

## OUTPUT:



## RESULT:

Thus implementation of DES algorithm was completed successfully.

# Ex No:03 IMPLEMENTATION OF BANKER’S ALGORITHM FOR DEADLOCK AVOIDANCE

# Date:

## AIM:

To implement Banker’s algorithm for deadlock avoidance using python.

## ALGORITHM:

1. Start.
2. Get the input from the user.
3. If request<=need, go to step 4, else it shows an error.
4. If request<=available, go to step 5, else it must wait as the resource it requires is not
5. available.
6. If the resulting resource allocation is safe, the process is allocated to resources.
7. If it is unsafe, the old state process is restored.
8. Stop .

## PROGRAM:

def main():

# Get input from the user

n = int(input("Enter the number of processes: ")) # Number of processes

m = int(input("Enter the number of resource types: ")) # Number of resource types

# Allocation Matrix

print("Allocation matrix")

alloc = []

for i in range(n):

alloc.append(list(map(int, input(f"Enter allocation for Process {i}: ").split())))

# MAX Matrix

print("MAX matrix")

max = []

for i in range(n):

max.append(list(map(int, input(f"Enter MAX for Process {i}: ").split())))

# Available Resources

avail = list(map(int, input("Enter the available resources: ").split()))

# Initialization

f = [0] \* n

ans = [0] \* n

ind = 0

for k in range(n):

f[k] = 0

need = [[0 for i in range(m)] for i in range(n)]

for i in range(n):

for j in range(m):

need[i][j] = max[i][j] - alloc[i][j]

# Applying Banker's Algorithm

for k in range(n):

for i in range(n):

if f[i] == 0:

flag = 0

for j in range(m):

if need[i][j] > avail[j]:

flag = 1

break

if flag == 0:

ans[ind] = i

ind += 1

for y in range(m):

avail[y] += alloc[i][y]

f[i] = 1

# Determine whether the system is safe or unsafe

safe = all(f)

if safe:

print("The system is in a safe state.")

print("The safe sequence:")

for i in range(n - 1):

print("P", ans[i], " -> ", sep="", end="")

print("P", ans[n - 1], sep="")

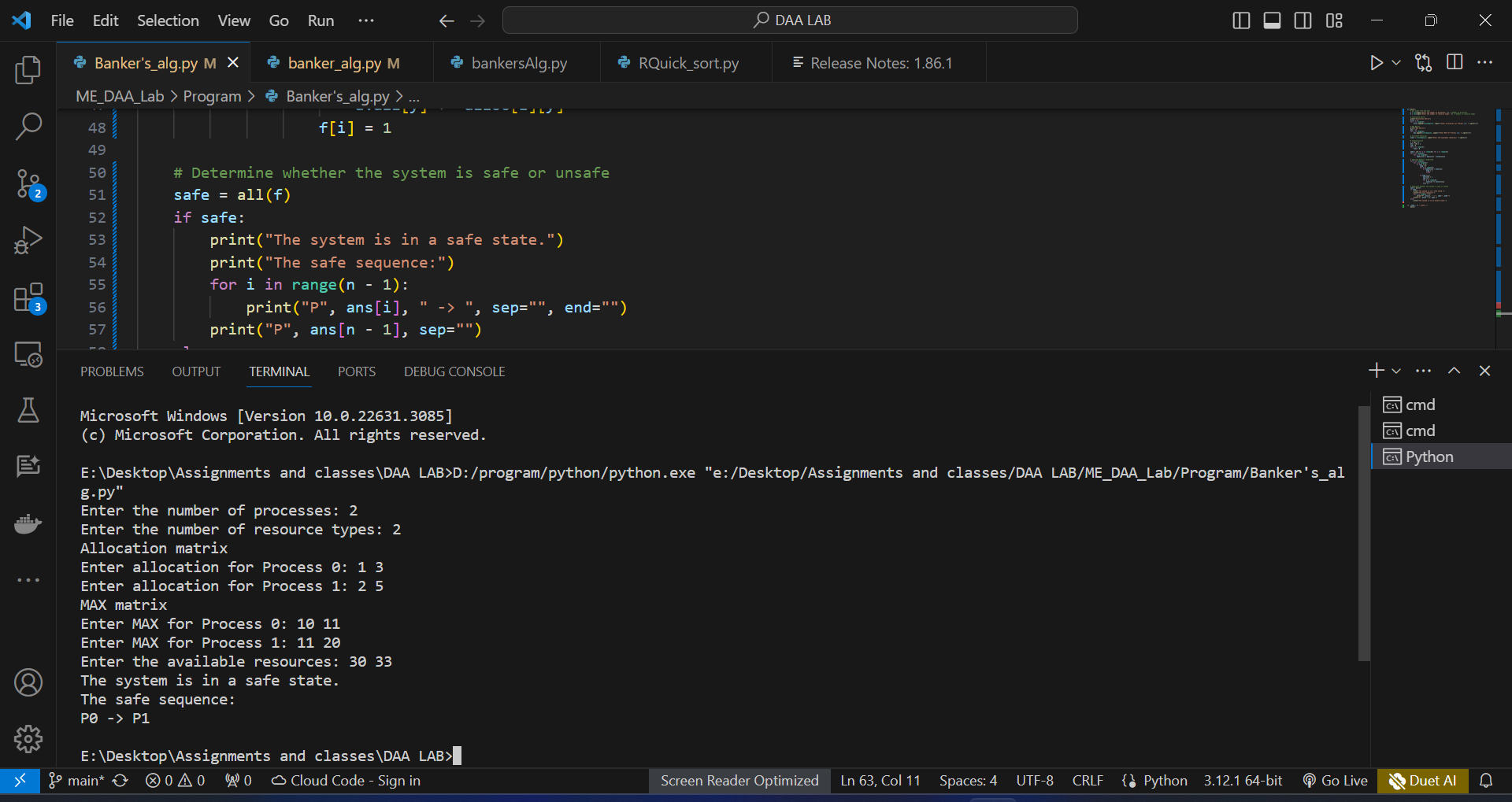
else:

print("The system is in an unsafe state.")

if \_\_name\_\_ == "\_\_main\_\_":

main()

## OUTPUT:



## RESULT:

Thus implementation of bancker’s algorithm was completes successfully.

# Ex No:04 IMPLEMENTATION OF RANDOMIZED QUICK SORT USING DIVIDE AND CONQUER STRATEGY

# Date:

## AIM:

To implement randomized quick sort using divide and conquer strategy.

## ALGORITHM:

1. Start the program.
2. Read an input array.
3. Select a pivot randomly, then swap it with the right most position of the array.
4. Fix two pointers i.e., pivot element and the left most element.
5. Pivot is now compared with all other elements, if any number smaller than pivot is found,

swap that element with the greatest number found.

1. Repeat step 5 until it reaches the end of the array, then swap the pivot element with the second pointer.
2. Pivot elements are again chosen for the left and right sub arrays separately.
3. Repeat steps from 3 to 6.
4. Print the sorted array.
5. Stop the program.

## PROGRAM:

import random

# Function to find the partition position

def partition(array, low, high):

# Choose a random pivot position

randomNumber = random.randint(low, high)

# Swap the pivot element with the last element of the array

array[randomNumber], array[high] = array[high], array[randomNumber]

# Choose the rightmost element as pivot

pivot = array[high]

# Pointer for the greater element

i = low - 1

swap = 0

# Traverse through all elements

# Compare each element with pivot

for j in range(low, high):

if array[j] <= pivot:

# If element smaller than pivot is found

# Swap it with the greater element pointed by i

i += 1

array[i], array[j] = array[j], array[i]

swap += 1

# Swap the pivot element with the greater element specified by i

array[i + 1], array[high] = array[high], array[i + 1]

# Return the position from where partition is done

return i + 1

# Function to perform quicksort

def quickSort(array, low, high):

if low < high:

# Find pivot element such that

# elements smaller than pivot are on the left

# elements greater than pivot are on the right

pi = partition(array, low, high)

# Recursive call on the left of pivot

quickSort(array, low, pi - 1)

# Recursive call on the right of pivot

quickSort(array, pi + 1, high)

# Input

data = []

n = int(input("\nEnter number of elements: "))

for i in range(n):

ele = int(input("Enter the element: "))

data.append(ele)

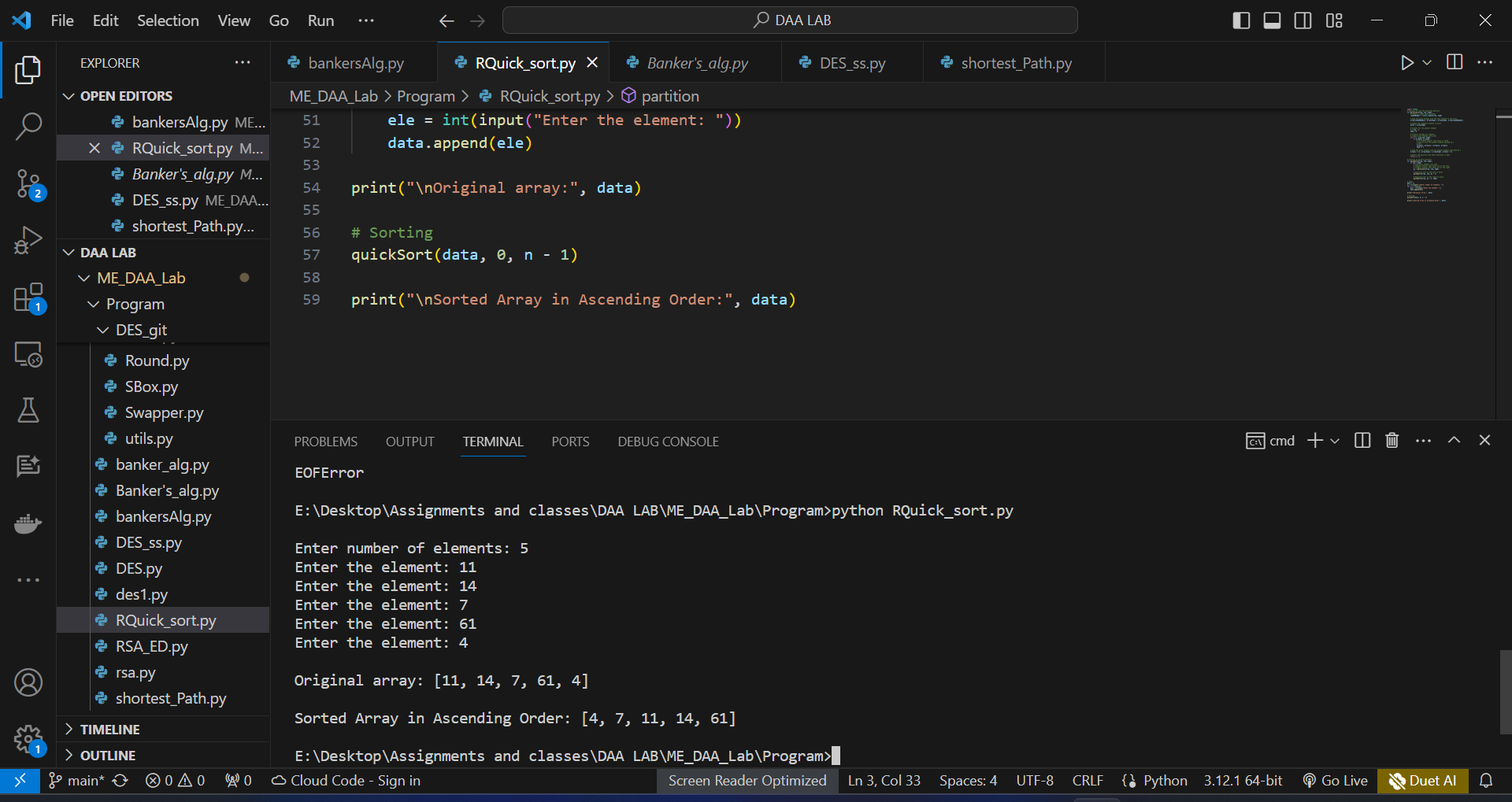
print("\nOriginal array:", data)

# Sorting

quickSort(data, 0, n - 1)

print("\nSorted Array in Ascending Order:", data)

## OUTPUT:



## RESULT:

Thus, the implementation of randomized quick sort using divide and conquer strategy in python was executed and verified successfully.

|  |  |
| --- | --- |
| Ex No :DATE: | IMPLEMENT SHORTEST PATH USING DYNAMIC PROGRAMMING IN A MULTI-STAGED GRAPH |

## AIM:

To implement shortest path using dynamic programming in a multi staged graph using python.

## ALGORITHM:

1. Start.
2. Create a cast table with dimensions (num stages+1)\*min-nodes.
3. Initialize all entries to positive infinity except for the destination node in the last stage which is initialize to 0.
4. Iterate through each stage starting from the second-to last stage down to the first.
5. For each node in the current stage starting.
   1. Calculate the minimum cost to reach each neighbor in the next stage.
   2. Update the cost table with the minimum cost to reach each node.
6. The entry at position (0,0) in the cost table represents the shortest path cost from source node to the destination node..
7. Return the shortest path cost.
8. Stop.

## PROGRAM:

# Define a function to find the minimum cost and optimal path in a multistage graph

def min\_cost\_multistage\_graph(graph, stages):

num\_stages = len(stages)

num\_nodes = len(graph)

# Initialize cost and parent arrays

cost = [float('inf')] \* num\_nodes

parent = [None] \* num\_nodes

# Set costs for nodes in the first stage to 0

for node in stages[0]:

cost[node] = 0

# Dynamic Programming approach to calculate minimum cost

for i in range(1, num\_stages):

for node in stages[i]:

min\_cost = float('inf')

for parent\_node in stages[i - 1]:

edge\_cost = graph[parent\_node][node]

total\_cost = cost[parent\_node] + edge\_cost

if total\_cost < min\_cost:

min\_cost = total\_cost

parent[node] = parent\_node

cost[node] = min\_cost

# Reconstruct the shortest path

path = [None] \* num\_stages

path[num\_stages - 1] = stages[num\_stages - 1][0]

for i in range(num\_stages - 2, -1, -1):

path[i] = parent[path[i + 1]]

return cost[stages[num\_stages - 1][0]], path

# Get input from the user

num\_nodes = int(input("Enter the number of nodes: "))

graph = [[0] \* num\_nodes for \_ in range(num\_nodes)]

# Input weights for edges

for i in range(num\_nodes):

edges = input(f"Enter weights for edges from node {i}: ").split()

graph[i] = [int(weight) for weight in edges]

num\_stages = int(input("Enter the number of stages: "))

stages = [list(map(int, input(f"Enter nodes for stage {i}: ").split())) for i in range(num\_stages)]

# Call the min\_cost\_multistage\_graph function with user input

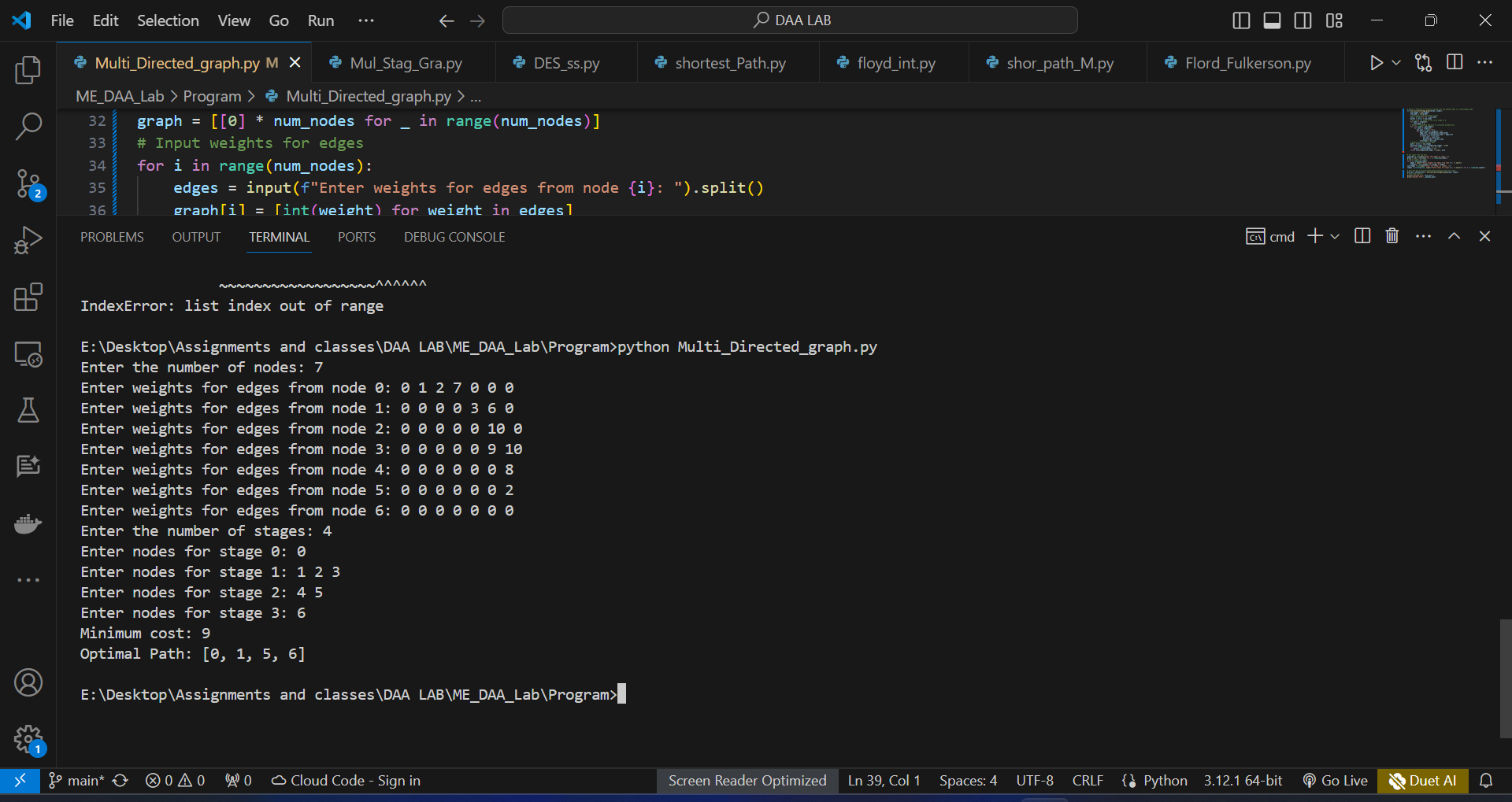
min\_cost, optimal\_path = min\_cost\_multistage\_graph(graph, stages)

# Print the results

print(f"Minimum cost: {min\_cost}")

print("Optimal Path:", optimal\_path)

## OUTPUT:



## RESULT:

Thus, the implementation of shortest path using dynamic programming in a multistage graph using python was executed and verified successfully.

|  |  |
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| Ex No :DATE: | IMPLEMENTATION OF FORD FULKERSON ALGORITHM TO COMPUTE THE MAXIMUM FLOW IN A GRAPH |

## AIM:

To implement Ford Fulkerson algorithm to compute the maximum flow in a graph using python.

## ALGORITHM:

1. Start.
2. Initialize the flow in all the edges to 0.
3. While there is an augmenting path between the source and the sink and add this path to the flow.
4. Repeat search for an s-t path p while it exists.
5. Find if there is a path from s to t using breadth first search. A path exists if f(e) <c(e) for every edge e on the path.
6. If no path found, return max flow.
7. Else find minimum edge value for path p.
8. Flow=min(c(e)-f(e)) for path p, max\_flow+=flow.
9. For all edge e of path incremented flow, f(e)+=flow.
10. Update the residual graph.
11. Stop.

## PROGRAM:

class Graph:

def \_\_init\_\_(self, vertices):

self.V = vertices

self.graph = [[0] \* vertices for \_ in range(vertices)]

def is\_valid\_edge(self, u, v, capacity):

return 0 <= u < self.V and 0 <= v < self.V and capacity >= 0

def add\_edge(self, u, v, capacity):

if self.is\_valid\_edge(u, v, capacity):

self.graph[u][v] = capacity

def print\_solution(self, flow):

print("Edge\tFlow")

for i in range(self.V):

for j in range(self.V):

if flow[i][j] > 0:

print(f"{i} -> {j}\t{flow[i][j]}")

def ford\_fulkerson(self, source, sink):

parent = [-1] \* self.V

max\_flow = 0

flow = [[0] \* self.V for \_ in range(self.V)]

while self.bfs(source, sink, parent):

path\_flow = float("inf")

s = sink

while s != source:

path\_flow = min(path\_flow, self.graph[parent[s]][s])

s = parent[s]

max\_flow += path\_flow

v = sink

while v != source:

u = parent[v]

flow[u][v] += path\_flow

flow[v][u] -= path\_flow

v = parent[v]

# Update the residual capacities of edges along the path

v = sink

while v != source:

u = parent[v]

self.graph[u][v] -= path\_flow

self.graph[v][u] += path\_flow

v = parent[v]

# Reset parent array for next BFS

parent = [-1] \* self.V

self.print\_solution(flow)

return max\_flow

def bfs(self, source, sink, parent):

visited = [False] \* self.V

queue = [source]

visited[source] = True

while queue:

u = queue.pop(0)

for ind, val in enumerate(self.graph[u]):

if not visited[ind] and val > 0:

queue.append(ind)

visited[ind] = True

parent[ind] = u

return visited[sink]

if \_\_name\_\_ == "\_\_main\_\_":

vertices = int(input("Enter the number of vertices: "))

g = Graph(vertices)

edges = int(input("Enter the number of edges: "))

print("Enter the edges (source, destination, capacity): ")

for \_ in range(edges):

u, v, capacity = map(int, input().split())

g.add\_edge(u, v, capacity)

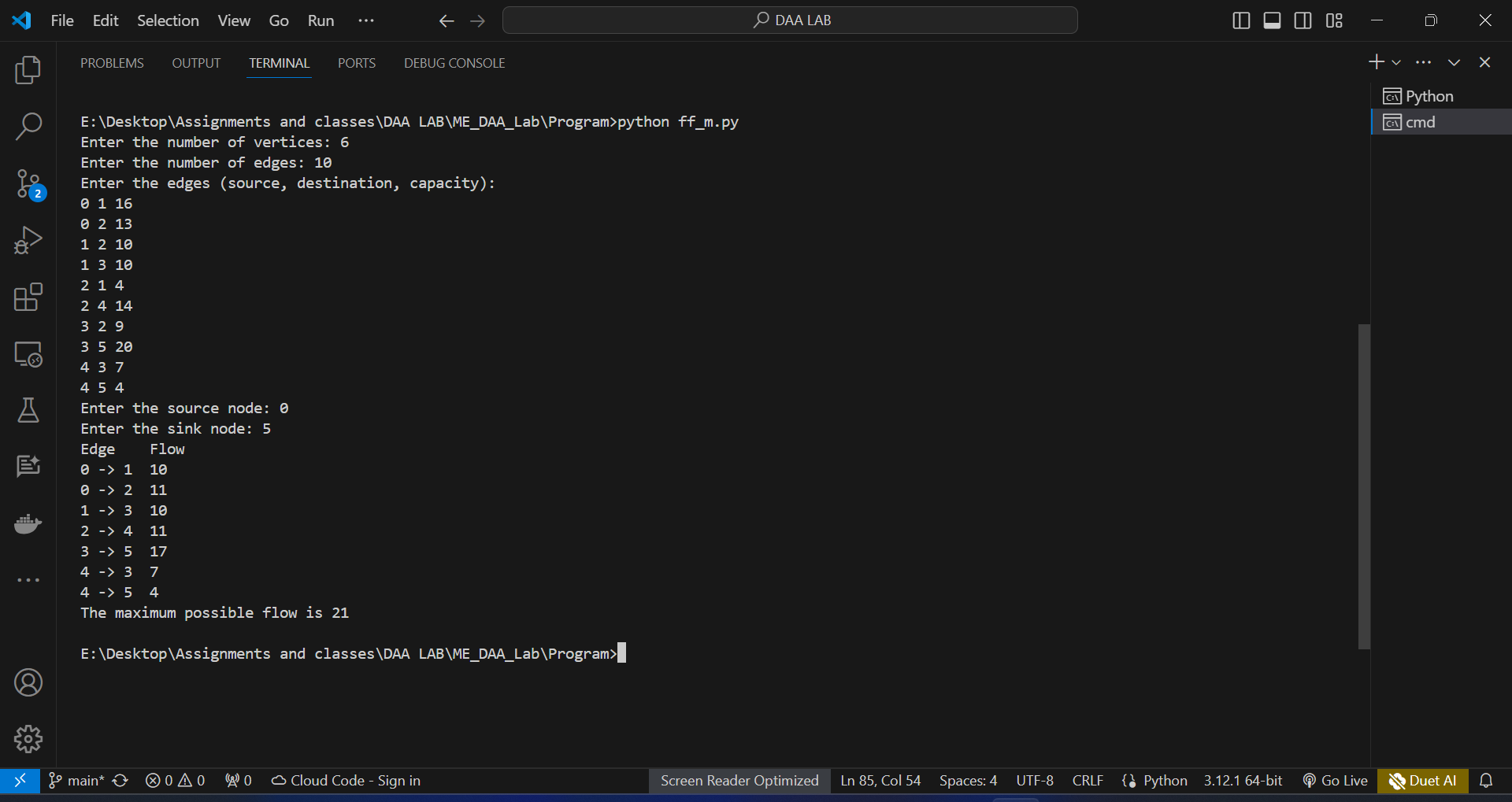
source = int(input("Enter the source node: "))

sink = int(input("Enter the sink node: "))

max\_flow = g.ford\_fulkerson(source, sink)

print(f"The maximum flow is {max\_flow}")

## OUTPUT:



## RESULT:

Thus, the implementation of Ford Fulkerson algorithm to compute maximum flow in a graph using python was executed and verified successfully.

|  |  |
| --- | --- |
| Ex No :DATE: | IMPLEMENTATION OF BOYER-MOORE ALGORITHM FOR PATTERN SEARCHING |

## AIM:

Implementation of boyer-moore algorithm for pattern searching

## ALGORITHM:

1. Start.
2. Create Bad Character Shift table for pattern characters.
3. Create Good Suffix Shift table.
4. Start matching from the right end of the pattern.
5. If a mismatch occurs:
   1. Use Bad Character Shift to calculate the shift based on the mismatched character.
   2. Use Good Suffix Shift for additional shifts.
   3. Shift the pattern by the maximum of the calculated values.
6. Continue matching until a match is found or the end of the text is reached.
7. Return the starting index of the first occurrence if found, otherwise, return -1.
8. Stop.

## PROGRAM:

def preprocess\_pattern(pattern):

bad\_char\_shift = {}

pattern\_length = len(pattern)

for i in range(pattern\_length - 1):

bad\_char\_shift[pattern[i]] = pattern\_length - i - 1

return bad\_char\_shift

def boyer\_moore\_search(text, pattern):

bad\_char\_shift = preprocess\_pattern(pattern)

text\_length = len(text)

pattern\_length = len(pattern)

occurrences = []

i = pattern\_length - 1

while i < text\_length:

j = pattern\_length - 1

k = i

while j >= 0 and text[k] == pattern[j]:

k -= 1

j -= 1

if j == -1:

occurrences.append(k + 1)

bad\_char\_shift\_value = bad\_char\_shift.get(text[i], pattern\_length)

i += max(1, pattern\_length - j, bad\_char\_shift\_value)

else:

bad\_char\_shift\_value = bad\_char\_shift.get(text[i], pattern\_length)

i += max(1, bad\_char\_shift\_value)

return occurrences

# Get input from the user

text = input("Enter the text: ")

pattern = input("Enter the pattern to search: ")

# Perform search

results = boyer\_moore\_search(text, pattern)

# Display result

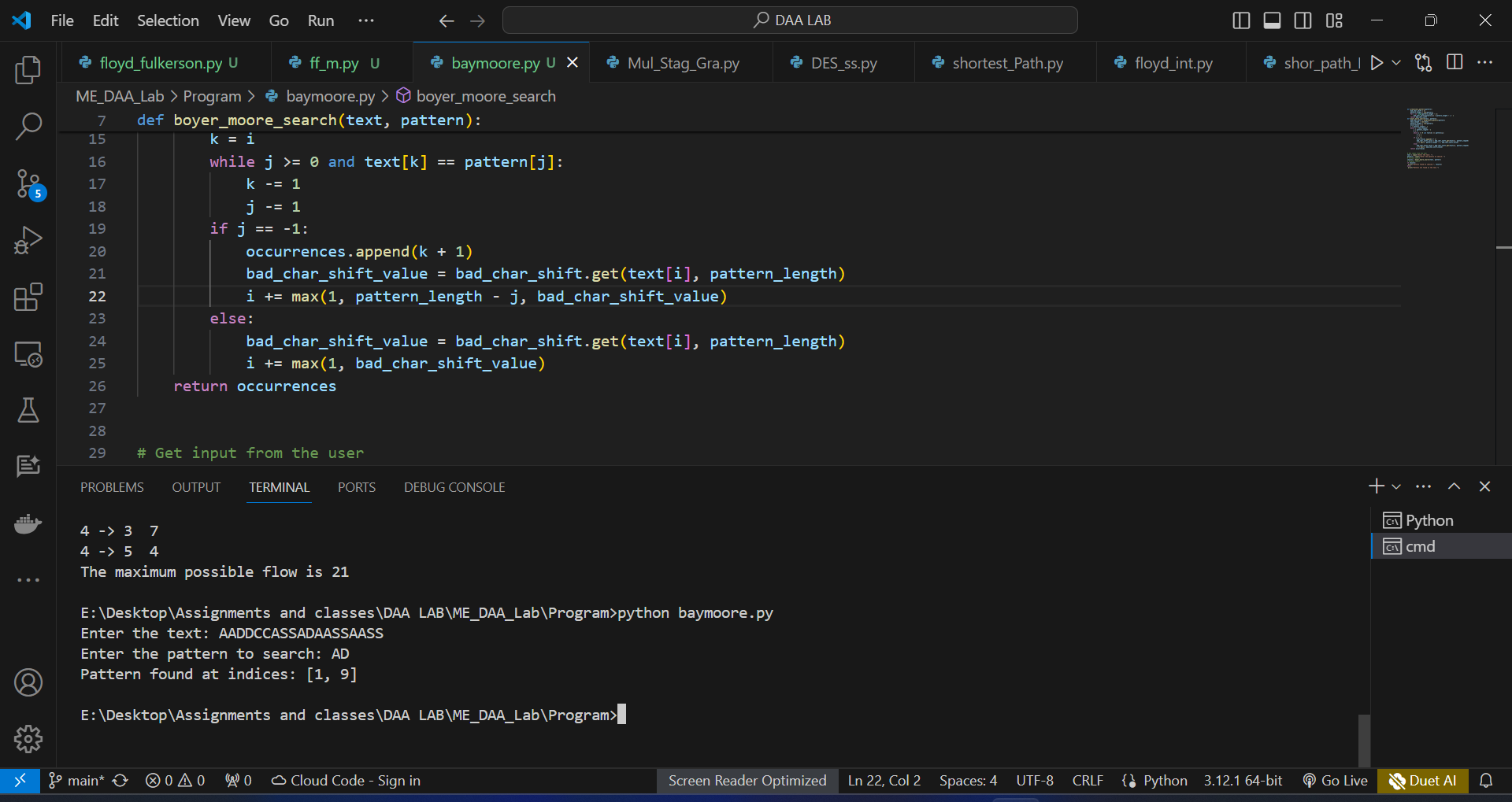
if results:

print("Pattern found at indices:", results)

else:

print("Pattern not found in the text.")

## OUTPUT:



## RESULT:

Thus, the implementation of Boyer-Moore algorithm for pattern searching was executed and verified successfully.

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| --- | --- |
| Ex No :DATE: | SOLVE THE GRAPH COLORING PROBLEM BY BACKTRACKING AND CONSTRAINT PROPAGATION (USING HEURISTICS) |

## AIM:

To solve the graph colouring problem by backtracking and constraint propagation using heuristics in python.

## ALGORITHM:

1. Start.
2. Get the number of vertices and edges from the user.
3. If the nearby edge is adjacent, colour the edge with different colour.
4. Else nearby edge is not adjacent, colour the edge with same colour.
5. Create a recursive function that takes the graph, current index, number of vertices and output colour array.
6. If the current index is equal to the number of vertices, print the colour configuration in the output array.
7. Assign a colour to vertex (1 to m).
8. For every assigned colour, check if the configuration is safe.
9. If any recursive function returns the true, break the loop and return true.
10. If no recursive function returns true, then return false.
11. Stop.

## PROGRAM:

import matplotlib.pyplot as plt

import networkx as nx

class Graph:

def \_\_init\_\_(self, vertices):

self.vertices = vertices

self.graph = [[0 for \_ in range(vertices)] for \_ in range(vertices)]

def add\_edge(self, u, v):

self.graph[u][v] = 1

self.graph[v][u] = 1

def is\_safe(self, v, color, c):

for i in range(self.vertices):

if self.graph[v][i] == 1 and color[i] == c:

return False

return True

def graph\_coloring\_util(self, m, color, v):

if v == self.vertices:

return True

for c in range(1, m + 1):

if self.is\_safe(v, color, c):

color[v] = c

if self.graph\_coloring\_util(m, color, v + 1):

return True

color[v] = 0

def graph\_coloring(self, m):

color = [0] \* self.vertices

if not self.graph\_coloring\_util(m, color, 0):

print("No solution exists")

return False

print("Solution exists with the following coloring:")

for c in color:

print(c, end=" ")

# Plotting the colored graph

G = nx.Graph()

for i in range(self.vertices):

G.add\_node(i)

for i in range(self.vertices):

for j in range(i + 1, self.vertices):

if self.graph[i][j] == 1:

G.add\_edge(i, j)

node\_colors = [color[i] for i in range(self.vertices)]

nx.draw(G, with\_labels=True, node\_color=node\_colors, cmap=plt.cm.rainbow, node\_size=1000)

plt.show()

return True

if \_\_name\_\_ == "\_\_main\_\_":

# Get input from the user

vertices = int(input("Enter the number of vertices: "))

edges = int(input("Enter the number of edges: "))

g = Graph(vertices)

# Get edges from the user

print("Enter the edges (vertex1 vertex2):")

for \_ in range(edges):

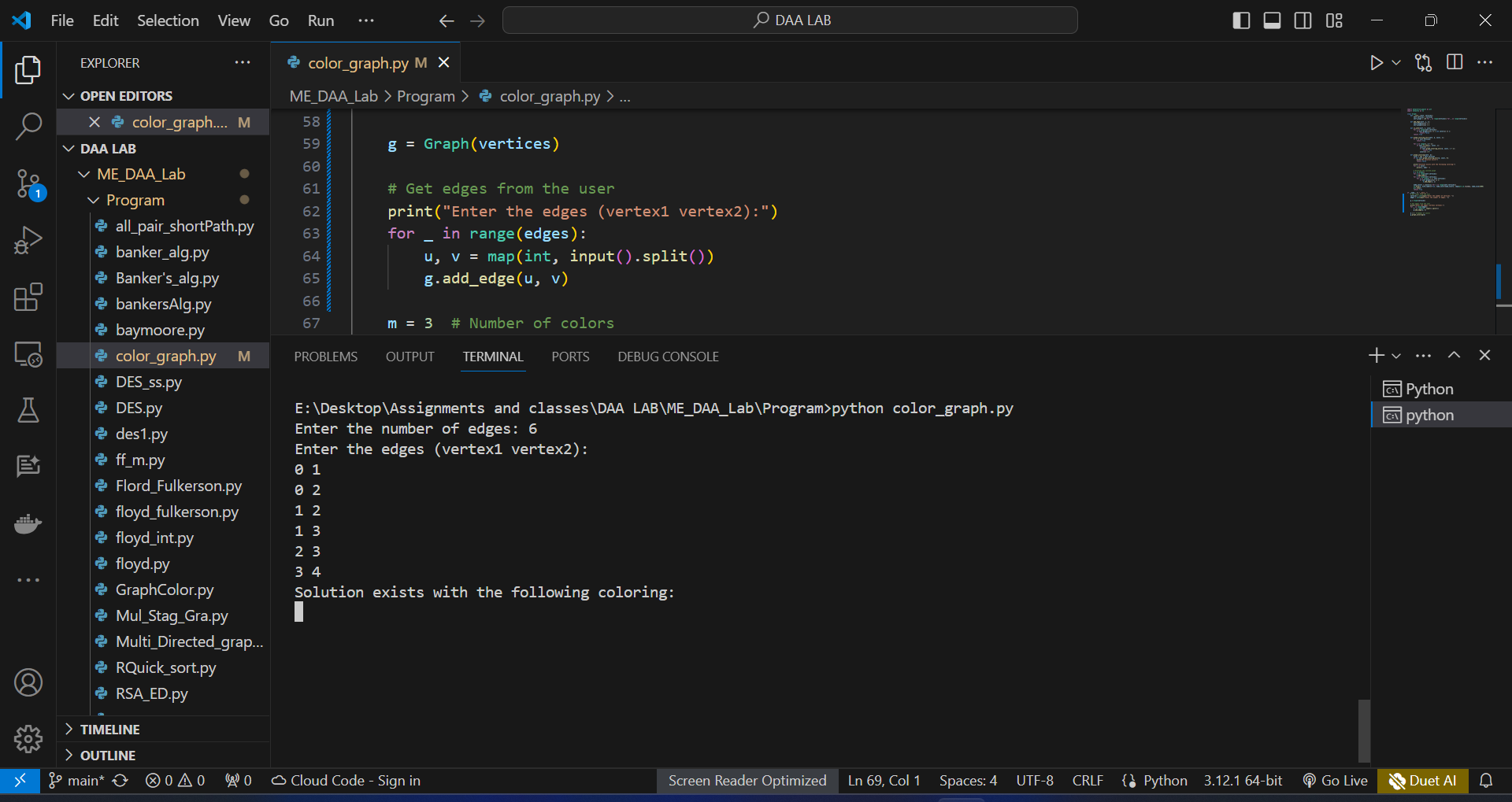
u, v = map(int, input().split())

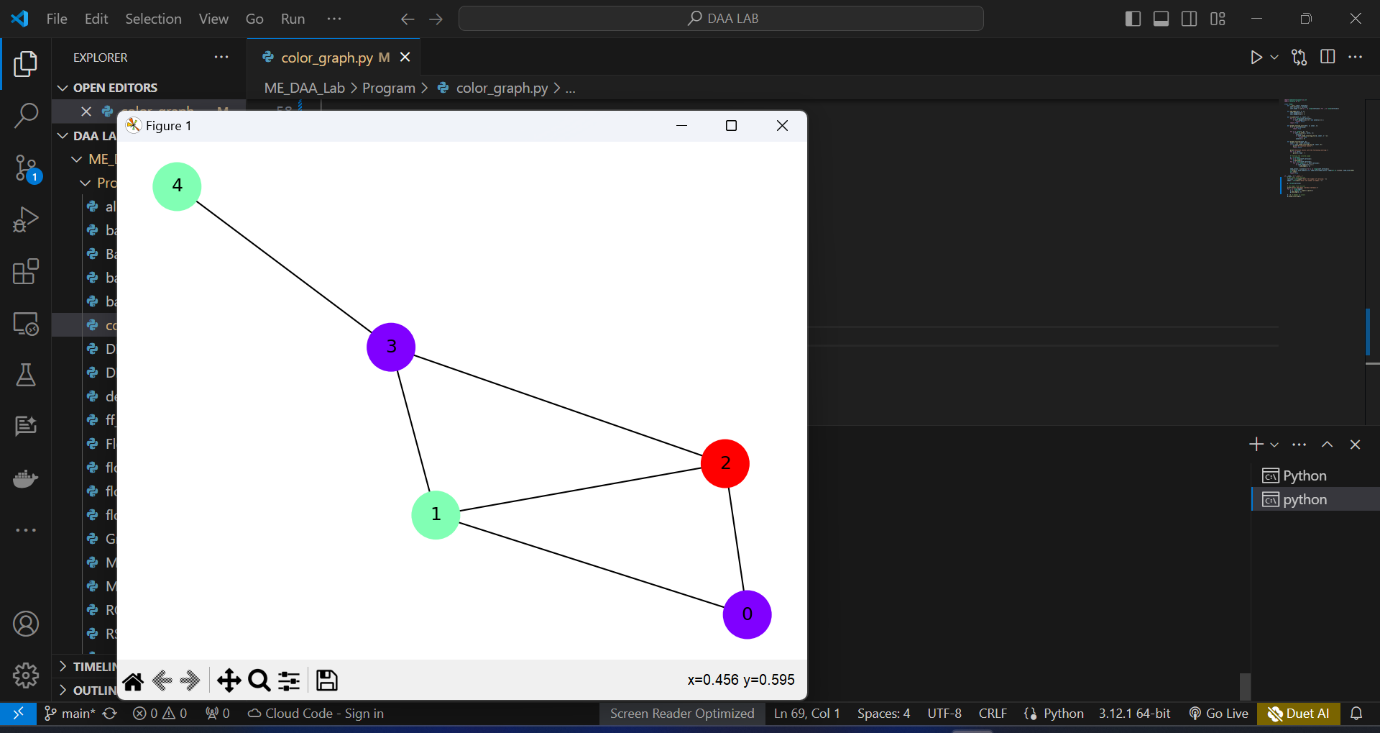
g.add\_edge(u, v)

m = 3 # Number of colors

g.graph\_coloring(m)

## OUTPUT:





## RESULT:

Thus, the graph colouring problem by backtracking and constraint propagation using heuristics in python was executed and verified successfully.

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| Ex No : 9DATE: | IMPLEMENTATION OF MAXIMUM CLIQUES PROBLEM USING THE BRANCH AND CUT ALGORITHM |

## AIM:

To implementation of maximum cliques problem using the branch and cut algorithm.

## ALGORITHM:

1. Start.
2. Selection an undirected graph which consists of vertices and edges.
3. Use a heuristics or algorithm to find lower bound on the maximum clique size
4. Choose a vertex from the graph and branch in to subproblem.
   1. In one subproblem, Include the chosen vertex in the clique and remove all vertices adjacent to it.
   2. In other subproblem, exclude the chosen vertex form the cliques and remove it from the graph.
5. Solve each sub problem using relaxation techniques i.e. finding maximum cliques in the reduced graph.
6. Repeat the steps 4 and 5 for each subproblem until an optimal clique is found or the maximum cliques size equals the lower bound .
7. Stop.

## PROGRAM:

MAX = 100

# Stores the vertices

store = [0] \* MAX

# Graph

graph = [[0] \* MAX for \_ in range(MAX)]

# Degree of the vertices

d = [0] \* MAX

# Function to check if the given set of vertices

# in the store array is a clique or not

def is\_clique(b):

# Run a loop for all the set of edges

# for the select vertex

for i in range(1, b):

for j in range(i + 1, b):

# If any edge is missing

if graph[store[i]][store[j]] == 0:

return False

return True

# Function to print the clique

def print\_cli(n):

for i in range(1, n):

print(store[i], end=" ")

print(",", end=" ")

# Function to find all the cliques of size s

def findCliques(i, l, s):

# Check if any vertices from i+1 can be inserted

for j in range(i + 1, n - (s - l) + 1):

# If the degree of the graph is sufficient

if d[j] >= s - 1:

# Add the vertex to store

store[l] = j

# If the graph is not a clique of size k

# then it cannot be a clique by adding another edge

if is\_clique(l + 1):

# If the length of the clique is still less than the desired size

if l < s:

# Recursion to add vertices

findCliques(j, l + 1, s)

# Size is met

else:

print\_cli(l + 1)

# Driver code

if \_\_name\_\_ == "\_\_main\_\_":

edges = int(input("Enter the number of edges: "))

print("Enter the edges (format: vertex1 vertex2):")

for \_ in range(edges):

edge = list(map(int, input().split()))

graph[edge[0]][edge[1]] = 1

graph[edge[1]][edge[0]] = 1

d[edge[0]] += 1

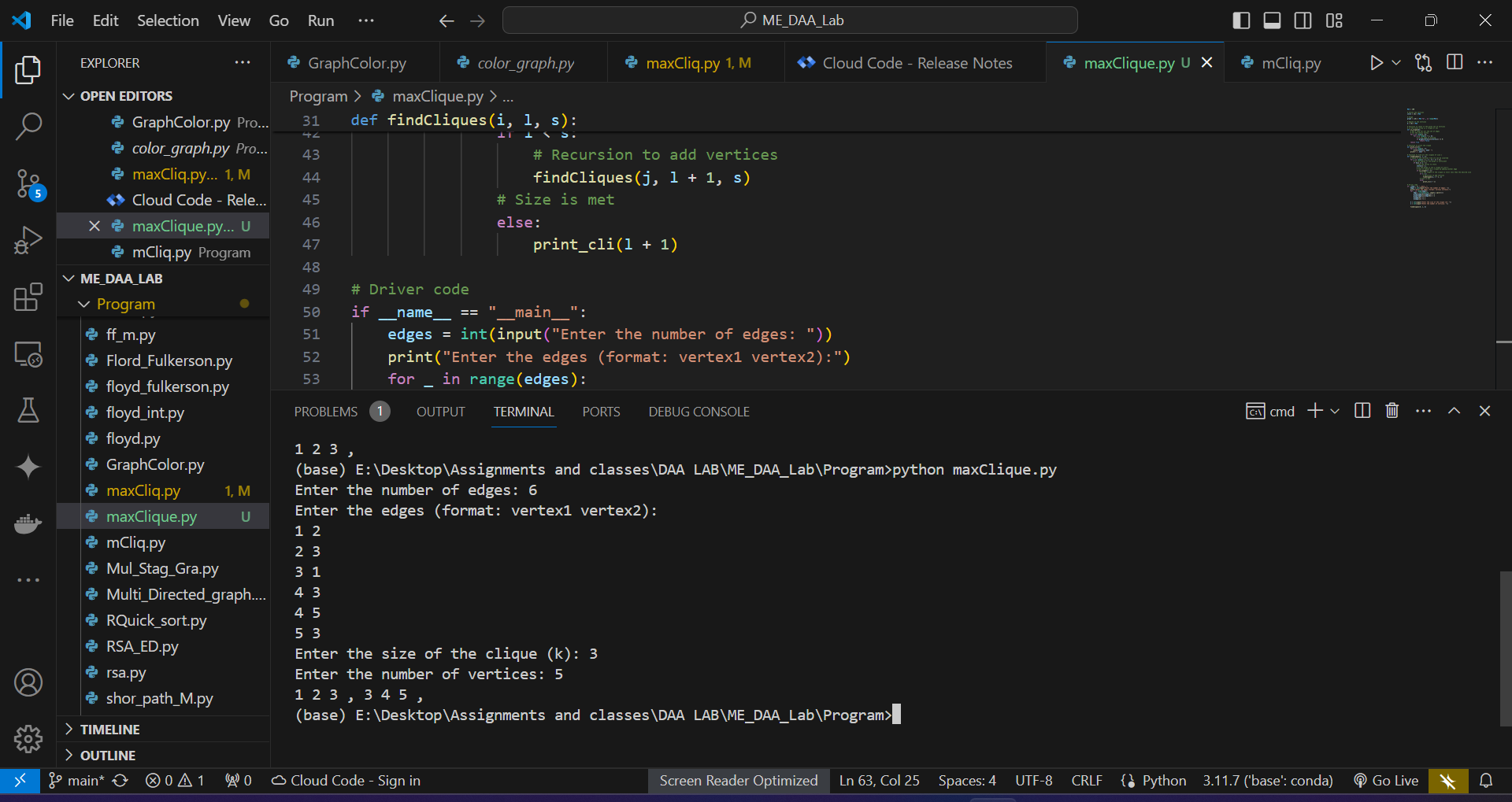
d[edge[1]] += 1

k = int(input("Enter the size of the clique (k): "))

n = int(input("Enter the number of vertices: "))

findCliques(0, 1, k)

## OUTPUT:



## 

## RESULT:

Thus an implementation of maximum clique problem using branch and cut method was executed and verified successfully.

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| --- | --- |
| Ex No : 10DATE: | IMPLEMENTATION OF CLOCK SYNCHRONISATION ALGORITHM |

## AIM:

## To implement clock synchronization algorithms using python. ALGORITHM:

## BANKER’S ALGORITHM:

1. Start.
2. Each node in the distributed system periodically sends its local time to a designated master node.
3. Choose one of the node to act as the master node responsible for coordinating the clock synchronization process.
4. The master node collects the local times sent by all the participating nodes in the system.
5. The master node calculates the average of the collected local times.
6. Calculate the difference between each node’s local time and the average time calculated by the master node.
7. The master node send the time adjustment values back to each participating node.
8. Each participating node adjustment value recived from the master node.
9. Repeat the process to ensure continuous synchronization in the distributed system.
10. Stop.

## CRISTIAN ALGORITHM:

1. The process on the client machine sends the request for fetching clock time to clock server at time to.
2. The clock server listens to the request made by the client process and return the response in from of clock server time.
3. The client process fetches the response from the clock server at time T1 and calculates the synchronized client clock time using the formula.

Tclient = Tserver +(T1-T2)/2

## PROGRAM:

## OUTPUT:

## RESULT:

Thus the implementation of clock synchronization algorithm using python was executed successfully.

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| Ex No : 11DATE: | IMPLEMENTATION OF CROSSEWORD PUZZLES AS CONSTRAINT SATISFACTION PROBLEM |

## AIM:

## To implement crossword puzzle as constant satisfaction problem using python. ALGORITHM:

## Start.

1. Sort all the words by length in descending order.
2. Take the first word and place it on the board.
3. Take next word.
4. If there is a possible location for this word, loop through all the words that are on the board and check to see if the new interfaces.
5. If the word doesn’t break the board then place it there and go to step 4 otherwise go to step 5.
6. Stop.

## PROGRAM:

ways = 0

def printMatrix(matrix, n):

for i in range(n):

print(matrix[i])

def checkHorizontal(x, y, matrix, currentWord):

n = len(currentWord)

for i in range(n):

if matrix[x][y + i] == '#' or matrix[x][y + i] == currentWord[i]:

matrix[x] = matrix[x][:y + i] + currentWord[i] + matrix[x][y + i + 1:]

else:

matrix[0] = "@"

return matrix

return matrix

def checkVertical(x, y, matrix, currentWord):

n = len(currentWord)

for i in range(n):

if matrix[x + i][y] == '#' or matrix[x + i][y] == currentWord[i]:

matrix[x + i] = matrix[x + i][:y] + currentWord[i] + matrix[x + i][y + 1:]

else:

matrix[0] = "@"

return matrix

return matrix

def solvePuzzle(words, matrix, index, n):

global ways

if index < len(words):

currentWord = words[index]

maxLen = n - len(currentWord)

for i in range(n):

for j in range(maxLen + 1):

temp = checkVertical(j, i, matrix.copy(), currentWord)

if temp[0] != "@":

solvePuzzle(words, temp, index + 1, n)

for i in range(n):

for j in range(maxLen + 1):

temp = checkHorizontal(i, j, matrix.copy(), currentWord)

if temp[0] != "@":

solvePuzzle(words, temp, index + 1, n)

else:

# Calling of print function to

# Print the crossword puzzle

print(str(ways + 1) + " way to solve the puzzle ")

printMatrix(matrix, n)

print()

# Increase the ways

ways += 1

return

if \_\_name\_\_ == '\_\_main\_\_':

n1 = 10

matrix = []

matrix.append("\*#\*\*\*\*\*\*\*\*")

matrix.append("\*#\*\*\*\*\*\*\*\*")

matrix.append("\*#\*\*\*\*#\*\*\*")

matrix.append("\*##\*\*\*##\*\*")

matrix.append("\*#\*\*\*\*#\*\*\*")

matrix.append("\*#\*\*\*\*#\*\*\*")

matrix.append("\*#\*\*\*\*#\*\*\*")

matrix.append("\*#\*######\*")

matrix.append("\*#\*\*\*\*\*\*\*\*")

matrix.append("\*\*\*#######")

words = []

words.append("PUNJAB")

words.append("JHARKHAND")

words.append("MIZORAM")

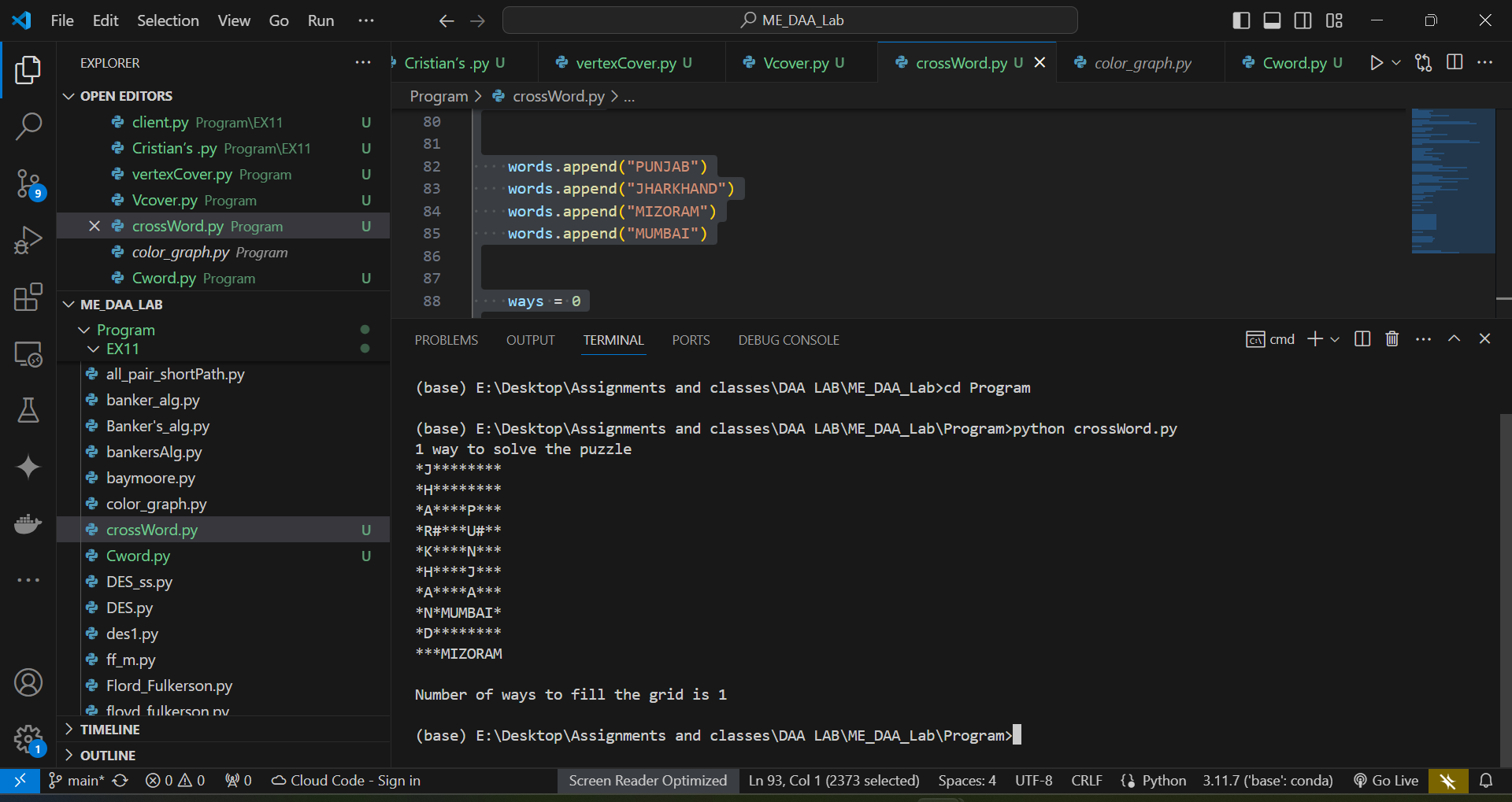
words.append("MUMBAI")

ways = 0

solvePuzzle(words, matrix, 0, n1)

print("Number of ways to fill the grid is " + str(ways))

## OUTPUT:



## RESULT:

Thus the implementation of crossed puzzle as constraint satisfaction problem using python was executed and verified successfully.

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| --- | --- |
| Ex No : 12DATE: | IMPLEMENTATION OF VERTEX COVER PROBLEM |

## AIM:

## To implement the vertex cover problem using python. ALGORITHM:

## Start.

## Initialize the result as {}.

## Do the following while E is not empty.

## Pick an arbitrary edge (u, v ) from set E and add |u| and |v| to result.

## Remove all edges from E which are either incident on u or v.

## Return the result.

## Stop.

## PROGRAM:

class Graph:

def \_\_init\_\_(self, num\_nodes):

self.num\_nodes = num\_nodes

self.adj\_list = [[] for \_ in range(num\_nodes)]

def add\_edge(self, u, v):

self.adj\_list[u].append(v)

self.adj\_list[v].append(u)

def print\_graph(self):

for node in range(self.num\_nodes):

print(f"Adjacent nodes of node {node}: {self.adj\_list[node]}")

def print\_vertex\_cover(self):

visited = [False] \* self.num\_nodes

for u in range(self.num\_nodes):

if not visited[u]:

for v in self.adj\_list[u]:

if not visited[v]:

visited[u] = True

visited[v] = True

break

print("Vertex Cover:")

for i in range(self.num\_nodes):

if visited[i]:

print(i, end=" ")

print()

if \_\_name\_\_ == "\_\_main\_\_":

num\_nodes = int(input("Enter the number of nodes: "))

num\_edges = int(input("Enter the number of edges: "))

graph = Graph(num\_nodes)

print("Enter edges (node1 node2):")

for \_ in range(num\_edges):

u, v = map(int, input().split())

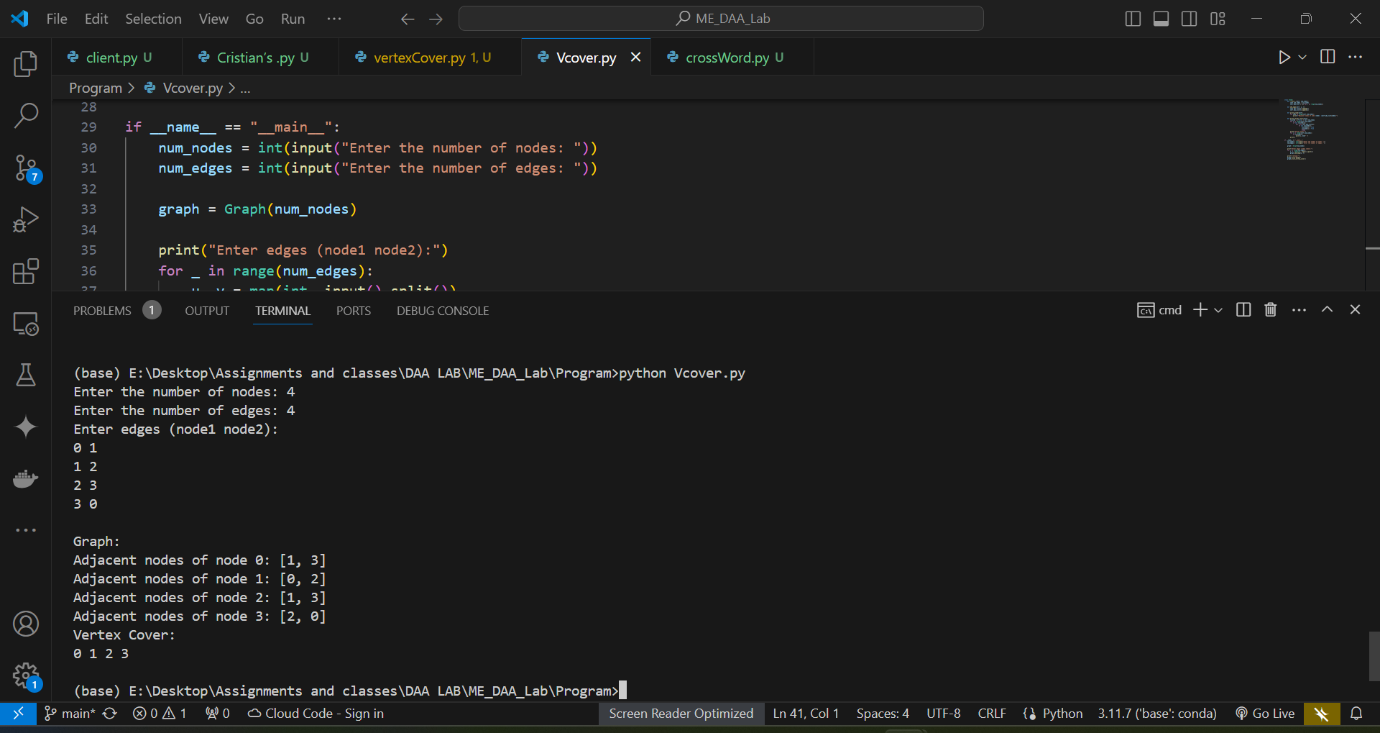
graph.add\_edge(u, v)

print("\nGraph:")

graph.print\_graph()

graph.print\_vertex\_cover()

## OUTPUT:



## RESULT:

Thus the implementation of the vertex cover problem using python was executed and verified successfully.