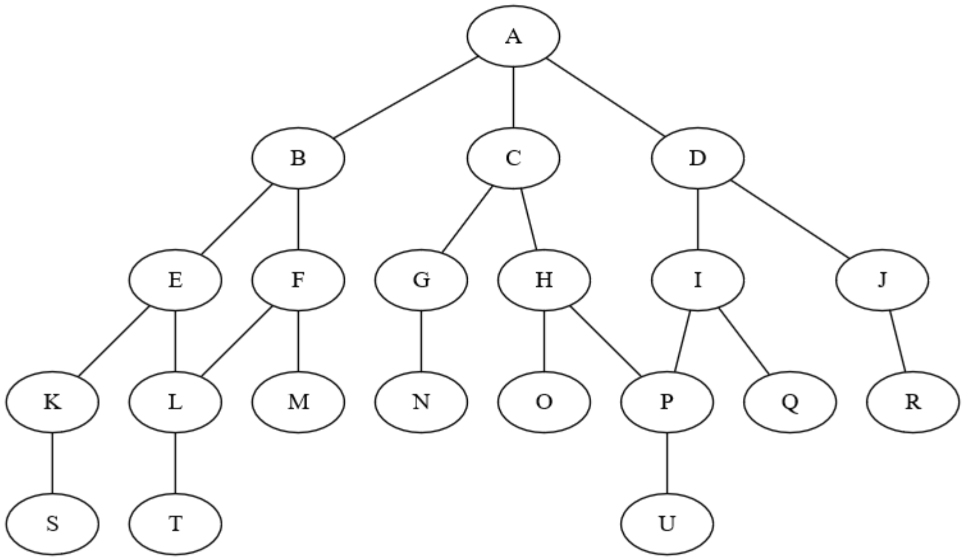
1. Implement Exhaustive search techniques using

a.BFS

Program:

```
n=int(input("Enter number of nodes in graph:"))  #READING INPUT
for i in range(n):
    print(chr(65+i),end=' ')
print("are the nodes")
d={}
for i in range(n):
    print("Enter the child nodes of",chr(i+65),end='')
    c=list(map(str,input(":").split()))
    if c[0]!='0':
        d[chr(i+65)]=c
    else:
        d[chr(i+65)]=[]
source=input("Enter source node:")
key=input("Enter destination node:")
#INITIALISING OPEN AND CLOSED LISTS
open_list=[source]
closed_list=[]
print("Open List--Closed List")
print(''.join(open_list),''.join(closed_list),sep='--')
while open_list:
    source=open_list.pop(0)
    closed_list.append(source)
    if source==key:
        print('Required node is found',key)
        break
    for i in d[source]:
        if i not in closed_list and i not in open_list:
            open_list.append(i)
#PRINTING OPEN AND CLOSED LIST FOR EACH ITERATION.
        print(''.join(open_list),''.join(closed_list),sep='--')
```

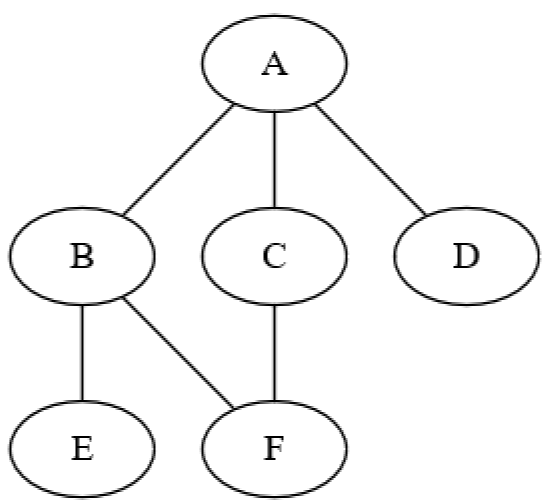
OUTPUT:
I.
GRAPH:




```
Enter number of nodes in graph:21
A B C D E F G H I J K L M N O P Q R S T U are the nodes
Enter the child nodes of A:B C D
Enter the child nodes of B:E F
Enter the child nodes of C:G H
Enter the child nodes of D:I J
Enter the child nodes of E:K L
Enter the child nodes of F:L M
Enter the child nodes of G:N
Enter the child nodes of H:O P
Enter the child nodes of I:P Q
Enter the child nodes of J:R
Enter the child nodes of K:S
Enter the child nodes of L:T
Enter the child nodes of M:0
Enter the child nodes of N:0
Enter the child nodes of O:0
Enter the child nodes of P:U
Enter the child nodes of Q:0
Enter the child nodes of R:0
Enter the child nodes of S:0
Enter the child nodes of T:0
Enter the child nodes of U:0
Enter source node:A
Enter destination node:U
Open List--Closed List
A--
B--A
BC--A
```

```
BCD--A
CDE--AB
CDEF--AB
DEFG--ABC
DEFGH--ABC
EFGHI--ABCD
EFGHIJ--ABCD
FGHIJK--ABCDE
FGHIJKL--ABCDE
GHIJKL--ABCDEF
GHIJKLM--ABCDEF
HIJKLMN--ABCDEFG
IJKLMNO--ABCDEFGH
IJKLMNOP--ABCDEFGH
JKLMNOP--ABCDEFGHI
JKLMNOPQ--ABCDEFGHI
KLMNOPQR--ABCDEFGHIJ
LMNOPQRS--ABCDEFGHIJK
MNOPQRST--ABCDEFGHIJKL
QRSTU--ABCDEFGHIJKLMNOP
Required node is found U
```

II.
GRAPH:




```
Enter number of nodes in graph:6
A B C D E F are the nodes
Enter the child nodes of A:B C D
Enter the child nodes of B:E F
Enter the child nodes of C:F
Enter the child nodes of D:0
Enter the child nodes of E:0
Enter the child nodes of F:0
Enter source node:A
Enter destination node:E
```

```
Open List--Closed List
A--
B--A
BC--A
BCD--A
CDE--AB
CDEF--AB
DEF--ABC
Required node is found E
```

b.DFS

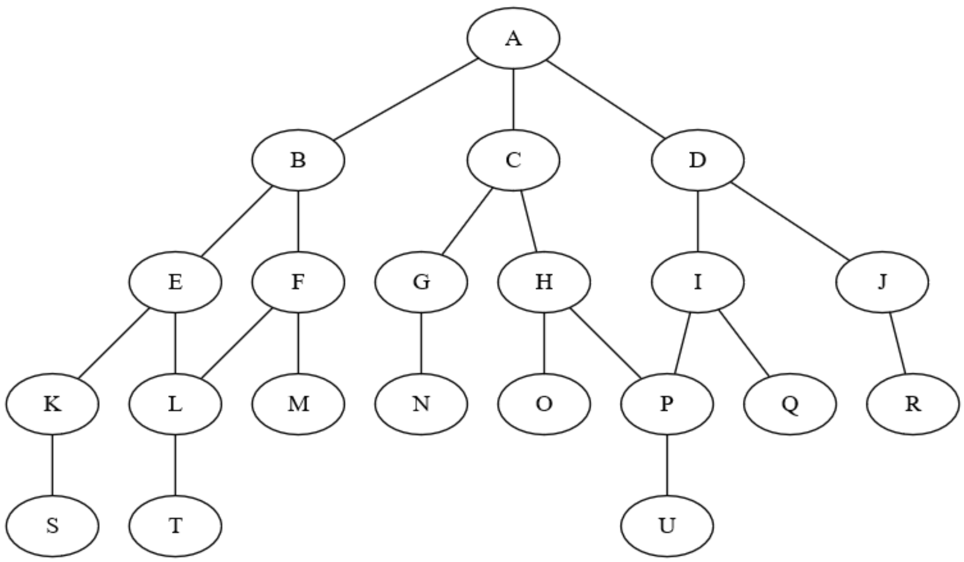
Program:

```
n=int(input("Enter number of nodes in graph:")) # READING INPUT
for i in range(n):
    print(chr(65+i),end=' ')
print("are the nodes")
d={}
for i in range(n):
    print("Enter the child nodes of",chr(i+65),end='')
    c=list(map(str,input(":").split()))
    if c[0]!='0':
        d[chr(i+65)]=c
    else:
        d[chr(i+65)]=[]
source=input("Enter source node:")
key=input("Enter destination node:")
#INITIALISING OPEN AND CLOSED LISTS.
open_list=[source]
closed_list=[]
print("Open List--Closed List")
print(''.join(open_list),''.join(closed_list),sep='--')
while open_list:
    source=open_list.pop(0)
    closed_list.append(source)
    if source==key:
        print('Required node is found',key)
        break
    for i in d[source]:
        if i not in closed_list and i not in open_list:
            open_list.insert(0,i)
#PRINTING OPEN AND CLOSED LIST FOR EACH ITERATION.
        print(''.join(open_list),''.join(closed_list),sep='--')
```

OUTPUT:

I.

GRAPH:

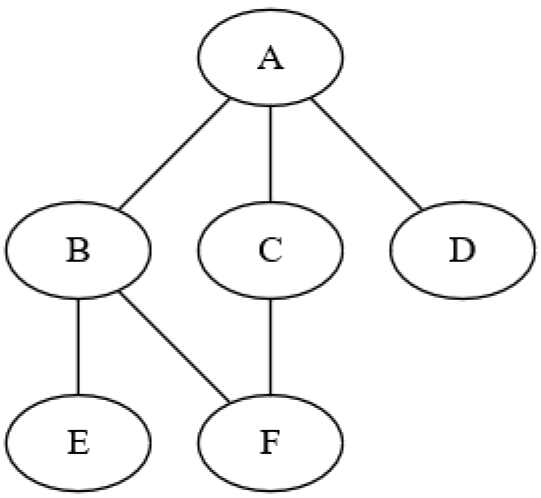



```
Enter number of nodes in graph:21
A B C D E F G H I J K L M N O P Q R S T U are the nodes
Enter the child nodes of A:B C D
Enter the child nodes of B:E F
Enter the child nodes of C:G H
Enter the child nodes of D:I J
Enter the child nodes of E:K L
Enter the child nodes of F:L M
Enter the child nodes of G:N
Enter the child nodes of H:O P
Enter the child nodes of I:P Q
Enter the child nodes of J:R
Enter the child nodes of K:S
Enter the child nodes of L:T
Enter the child nodes of M:0
Enter the child nodes of N:0
Enter the child nodes of O:0
Enter the child nodes of P:U
Enter the child nodes of Q:0
Enter the child nodes of R:0
Enter the child nodes of S:0
Enter the child nodes of T:0
Enter the child nodes of U:0
Enter source node:A
Enter destination node:U
Open List--Closed List
A--
B--A
```

```
CB--A
DCB--A
ICB--AD
JICB--AD
RICB--ADJ
PCB--ADJRI
QPCB--ADJRI
UCB--ADJRIQP
Required node is found U
```

II.

GRAPH:




```
Enter number of nodes in graph:6
A B C D E F are the nodes
Enter the child nodes of A:B C D
Enter the child nodes of B:E F
Enter the child nodes of C:F
Enter the child nodes of D:0
Enter the child nodes of E:0
Enter the child nodes of F:0
Enter source node:A
Enter destination node:E
Open List--Closed List
A--
B--A
CB--A
DCB--A
FB--ADC
E--ADCFB
E--ADCFB
Required node is found E
```

c.Uniform Cost Search

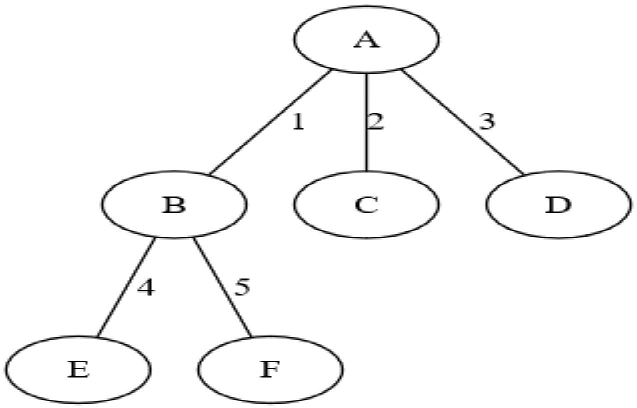
Program:

```
def UCS(graph, s, goal):
# FRONTIER IS THE DICTIONARY THAT STORES THE PATH AND ITS COST.
    frontier = {s: 0}
#EXPLORED IS A LIST THAT HAS ALL THE NODES THAT ARE ALREADY EXPLORED TO
AVOID INFINITE LOOPING.
    explored = []
    while frontier:
        print(f"Open list: {frontier}")
        print(f"Closed list: {explored}")
        node = min(frontier, key=frontier.get)
        val = frontier[node]
        print(node, " : ", val)
        del frontier[node]
        if goal == node:
            return f"Goal reached with cost: {val}"
        explored.append(node)
        for neighbour, pathCost in graph[node].items():
            if neighbour not in explored or neighbour not in frontier:
                frontier.update({neighbour: val + pathCost})
            elif neighbour in frontier and pathCost > val:
                frontier.update({neighbour: val})
    return "Goal not found"
# A FUNCTION TO READ INPUT GRAPH
def create_graph():
    num_nodes = int(input("Enter number of nodes in graph: "))
    graph = {}
    nodes = input("Enter the nodes separated by space: ").split()
    for node in nodes:
        children = input(f"Enter the child nodes of {node}: ").split()
        graph[node] = {}
        for child in children:
            if child != '0':
                cost = int(input(f"Enter the cost from {node} to {child}: "))
                graph[node][child] = cost
    return graph

graph = create_graph() #READING INPUT
s = input("Enter source node: ")
g = input("Enter goal node: ")
print(UCS(graph, s, g)) #FUNCTION CALL
```

OUTPUT:

I.

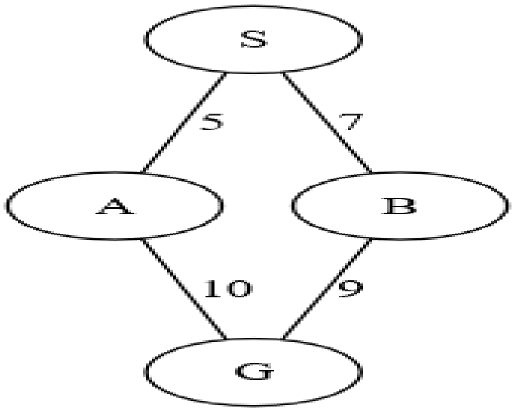
Graph:




```
Enter number of nodes in graph: 6
Enter the nodes separated by space: A B C D E F
Enter the child nodes of A: B C D
Enter the child nodes of B: E F
Enter the child nodes of C: F
Enter the child nodes of D: 0
Enter the child nodes of E: 0
Enter the child nodes of F: 0
Enter source node: A
Enter goal node: E
Enter the cost from A to B: 1
Enter the cost from A to C: 2
Enter the cost from A to D: 3
Enter the cost from B to E: 4
Enter the cost from B to F: 5
Open list: {'A': 0}
Closed list: []
A  :  0
Open list: {'B': 1, 'C': 2, 'D': 3}
Closed list: ['A']
B  :  1
Open list: {'C': 2, 'D': 3, 'E': 5, 'F': 6}
Closed list: ['A', 'B']
E  :  5
Goal reached with cost: 5
```

II.

Graph:




```
Enter number of nodes in graph: 4
Enter the nodes separated by space: S A B G
Enter the child nodes of S: A B
Enter the child nodes of A: G
Enter the child nodes of B: G
Enter the child nodes of G: 0
Enter source node: S
Enter goal node: G
Enter the cost from S to A: 5
Enter the cost from S to B: 7
Enter the cost from A to G: 10
Enter the cost from B to G: 9
Open list: {'S': 0}
Closed list: []
S  :  0
Open list: {'A': 5, 'B': 7}
Closed list: ['S']
A  :  5
Open list: {'B': 7, 'G': 15}
Closed list: ['S', 'A']
B  :  7
Open list: {'G': 15}
Closed list: ['S', 'A', 'B']
G  :  15
Goal reached with cost: 15
```

d.Depth-First Iterative Deepening

Program:

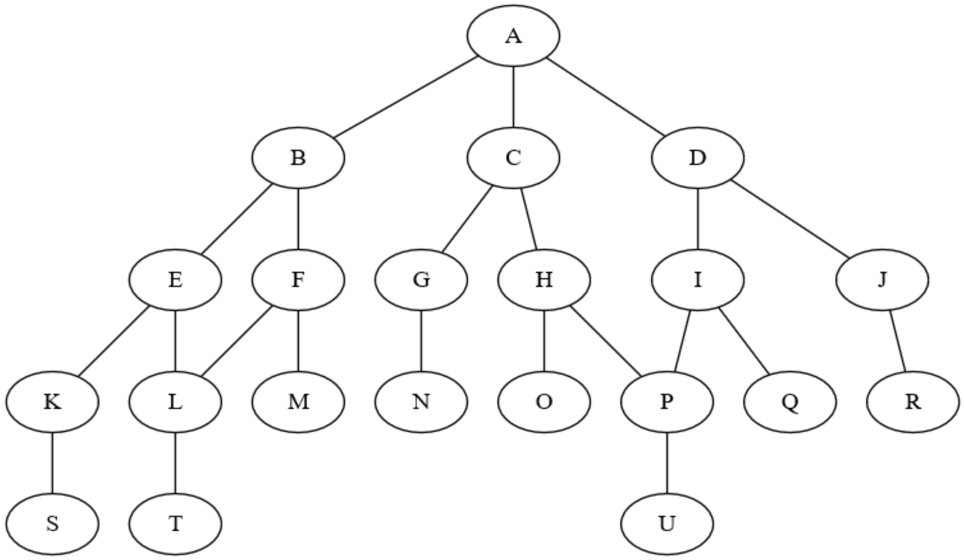
```
def dfs(d, source, key):
#BASIC DFS FUNCTION
    open_list = [source]
    closed_list = []
    while open_list:
        source = open_list.pop(0)
        closed_list.append(source)
        if source == key:
            return [closed_list, open_list, 1]
        for i in d[source]:
            if i not in closed_list and i not in open_list:
                open_list.insert(0, i)
    return [closed_list, open_list, 0]

def depthxtree(graph, depth, source):
#THIS FUNCTION GENERATES TREES/GRAPHS TILL A CERTAIN LEVEL (HEIGHT)
    c = 1
    d = {}
    templis = []
    all_nodes = []
    all_nodes.append(source + str(c))
    while c <= depth:
        if c == 1:
            d[source] = []
            templis = graph[source]
            parent = source
        if c == 2:
            for i in templis:
                d[i] = []
                d[parent].append(i)
                all_nodes.append(i + str(c))
        else:
            for j in all_nodes:
                if j[-1] == str(c - 1):
                    templis = graph[j[:-1]]
                    for i in templis:
                        d[i] = []
                        d[j[:-1]].append(i)
                        all_nodes.append(i + str(c))
        c += 1
    return d
```

```
def iddfs(graph, source, key):
    depth = 1
    while 1:
        d = depthxtree(graph, depth, source)
        y = dfs(d, source, key)
        print("DEPTH=", depth)
        print("Open_list=", y[1])
        print("Closed_list=", y[0])
        depth += 1
        if len(d) == len(graph) or y[2] == 1:
            break
# READING INPUT
n = int(input("Enter number of nodes in graph: "))
for i in range(n):
    print(chr(65 + i), end=' ')
print("are the nodes")
graph = {}
for i in range(n):
    print("Enter the child nodes of", chr(65 + i), end='')
    c = list(map(str, input(": ").split()))
    if c[0] != '0':
        graph[chr(65 + i)] = c
    else:
        graph[chr(65 + i)] = []

source = input("Enter source node: ")
destination = input("Enter destination node: ")
iddfs(graph, source, destination) #FUNCUTION CALL
```

OUTPUT:

I.

GRAPH:

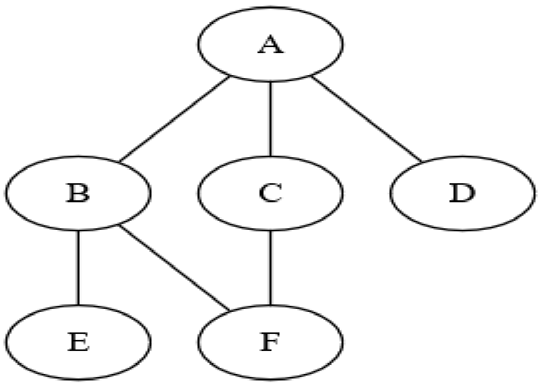



```
Enter number of nodes in graph:21
A B C D E F G H I J K L M N O P Q R S T U are the nodes
Enter the child nodes of A:B C D
Enter the child nodes of B:E F
Enter the child nodes of C:G H
Enter the child nodes of D:I J
Enter the child nodes of E:K L
Enter the child nodes of F:L M
Enter the child nodes of G:N
Enter the child nodes of H:O P
Enter the child nodes of I:P Q
Enter the child nodes of J:R
Enter the child nodes of K:S
Enter the child nodes of L:T
Enter the child nodes of M:0
Enter the child nodes of N:0
Enter the child nodes of O:0
Enter the child nodes of P:U
Enter the child nodes of Q:0
Enter the child nodes of R:0
Enter the child nodes of S:0
Enter the child nodes of T:0
Enter the child nodes of U:0
DEPTH= 1
Open_list= []
Closed_list= ['A']
DEPTH= 2
Open_list= []
Closed_list= ['A', 'D', 'C', 'B']
DEPTH= 3
Open_list= []
```

```
Closed_list= ['A', 'D', 'J', 'I', 'C', 'H', 'G', 'B', 'F', 'E']
DEPTH= 4
Open_list= []
Closed_list= ['A', 'D', 'J', 'R', 'I', 'Q', 'P', 'C', 'H', 'O', 'G', '
N', 'B', 'F', 'M', 'L', 'E', 'K']
DEPTH= 5
Open_list= ['C', 'B']
Closed_list= ['A', 'D', 'J', 'R', 'I', 'Q', 'P', 'U']
```

II.

GRAPH:




```
Enter number of nodes in graph: 6
A B C D E F are the nodes
Enter the child nodes of A: B C D
Enter the child nodes of B: E F
Enter the child nodes of C: F
Enter the child nodes of D: 0
Enter the child nodes of E: 0
Enter the child nodes of F: 0
Enter source node: A
Enter destination node: F
DEPTH= 1
Open_list= ['B', 'C', 'D']
Closed_list= ['A']
DEPTH= 2
Open_list= ['E', 'F']
Closed_list= ['A', 'B', 'C', 'D']
DEPTH= 3
Open_list= []
Closed_list= ['A', 'B', 'C', 'D', 'E', 'F']
```

e.Bidirectional Search

Program:

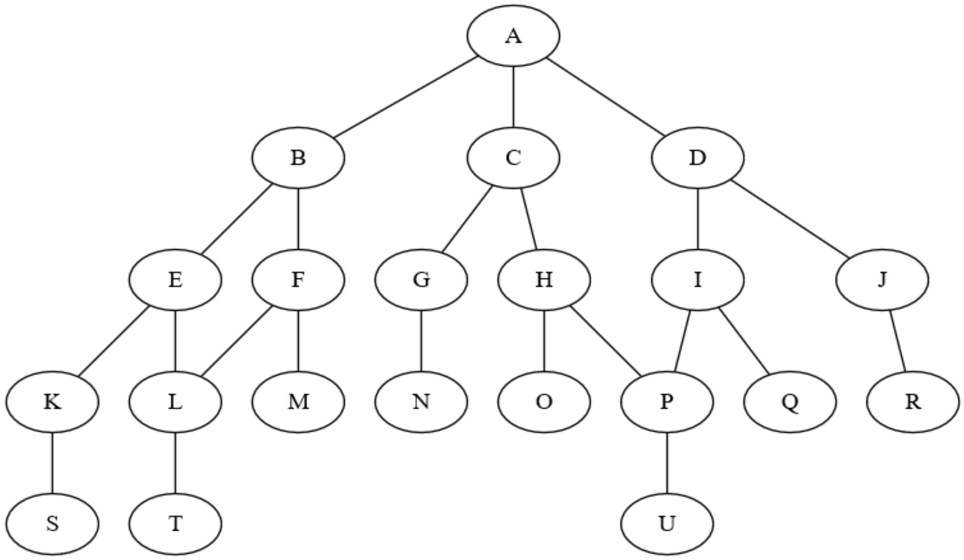
```
def BFS(direction, graph, frontier, reached):
    if direction == 'F':  # FROM ONE SIDE(SAY FRONT F)
        d = 'c'
    elif direction == 'B': :  # FROM ONE SIDE(SAY BACK B)
        d = 'p'
    node = frontier.pop(0)
    for child in graph[node][d]:
        if child not in reached:
            reached.append(child)
            frontier.append(child)
    return frontier, reached

def isIntersecting(reachedF, reachedB):
    intersecting = set(reachedF).intersection(set(reachedB))
    return list(intersecting)[0] if intersecting else -1

def BidirectionalSearch(graph, source, dest):
    frontierF = [source]
    frontierB = [dest]
    reachedF = [source]
    reachedB = [dest]
    while frontierF and frontierB:
        print("From front: ")
        print(f"\tFrontier: {frontierF}")
        print(f"\tReached: {reachedF}")
        print("From back: ")
        print(f"\tFrontier: {frontierB}")
        print(f"\tReached: {reachedB}")
        frontierF, reachedF = BFS('F', graph, frontierF, reachedF)
        frontierB, reachedB = BFS('B', graph, frontierB, reachedB)
        intersectingNode = isIntersecting(reachedF, reachedB)
        if intersectingNode != -1:
            print("From front: ")
            print(f"\tFrontier: {frontierF}")
            print(f"\tReached: {reachedF}")
            print("From back: ")
            print(f"\tFrontier: {frontierB}")
            print(f"\tReached: {reachedB}")
            print("Path found!")
            path = reachedF[:-1] + reachedB[::-1]
            return path
    print("No path found!")
```

```
    return []

def create_graph():
    graph = {}
    n = int(input("Enter number of nodes in graph: "))
    for i in range(n):
        print(chr(65 + i), end=' ')
    print("are the nodes")
    for i in range(n):
        node = chr(65 + i)
        children = input(f"Enter the child nodes of {node}: ").split()
        graph[node] = {'c': [], 'p': []}
        for child in children:
            if child != '0':
                graph[node]['c'].append(child)
                graph[child]['p'].append(node)
    return graph

s = input("Enter source node: ")
g = input("Enter goal node: ")

graph = create_graph()
path = BidirectionalSearch(graph, s, g)
if len(path):
    print("Path:", path)
```

OUTPUT:

I.

GRAPH:

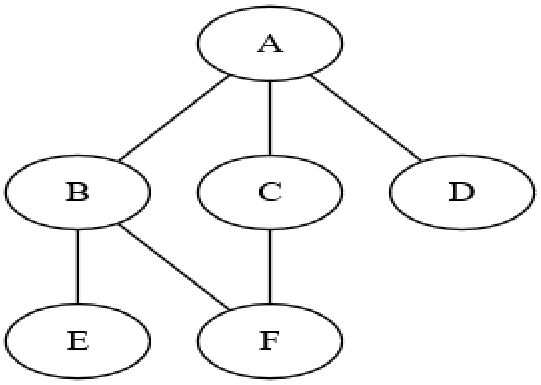



```
Enter number of nodes in graph: 21
A B C D E F G H I J K L M N O P Q R S T U are the nodes
Enter the child nodes of A: B C D
Enter the child nodes of B: E F
Enter the child nodes of C: G H
Enter the child nodes of D: I J
Enter the child nodes of E: K L
Enter the child nodes of F: L M
Enter the child nodes of G: N
Enter the child nodes of H: O P
Enter the child nodes of I: P Q
Enter the child nodes of J: R
Enter the child nodes of K: S
Enter the child nodes of L: T
Enter the child nodes of M: 0
Enter the child nodes of N: 0
Enter the child nodes of O: 0
Enter the child nodes of P: U
Enter the child nodes of Q: 0
Enter the child nodes of R: 0
Enter the child nodes of S: 0
Enter the child nodes of T: 0
Enter the child nodes of U: 0
Enter source node: A
Enter destination node: U
From front:
```

```
       Frontier: ['A']
       Reached: ['A']
From back:
       Frontier: ['U']
       Reached: ['U']
Path found!
Path: ['A', 'P', 'U'] ['A']
```

II.

GRAPH:




```
Enter number of nodes in graph: 7
A B C D E F G are the nodes
Enter the child nodes of A: B C
Enter the child nodes of B: D
Enter the child nodes of C: D E
Enter the child nodes of D: F
Enter the child nodes of E: F G
Enter the child nodes of F: 0
Enter the child nodes of G: 0
Enter source node: A
Enter goal node: G
From front:
     Frontier: ['A']
     Reached: ['A']
From back:
     Frontier: ['G']
     Reached: ['G']
Path found!
Path: ['A', 'C', 'E', 'G']
```

2. a) Implement water jug problem with Search tree generation using BFS

Program:

```
def fill(x,jug,i): # FILL FUNCTION RETURNS A STATE WITH MENTIONED FILLED JUG
    x=list(x)
    x[i]=jug
    return tuple(x)
def empty(x,i): # EMPTY FUNCTION RETURNS A STATE WITH MENTIONED JUG EMPTY
    x=list(x)
    x[i]=0
    return tuple(x)
def transfer(x,jug1,jug2,i): # TRANSFER FUNCTION RETURNS A STATE WITH POSSIBLE
TRANSFER FROM JUG i TO j.
    x=list(x)
    if i==1:
        available=jug2-x[1]
        if x[0]>available:
            x[0]-=available
            x[1]+=available
        else:
            x[1]+=x[0]
            x[0]=0
    elif i==2:
        available=jug1-x[0]
        if x[1]>available:
            x[1]-=available
            x[0]+=available
        else:
            x[0]+=x[1]
            x[1]=0
    return tuple(x)
def make_tree(d,jug1,jug2,vol): #GENERATING STATE SPACE TREE
    all_nodes=[(0,0)]
    flag=1
    while(flag):
        if flag==2:
            break
        flag=0
        source=all_nodes[0]
        for i in [1,2]:
            x=jug2
            if i==1:
                x=jug1
            f=fill(source,x,i-1)
            if f not in all_nodes:
```

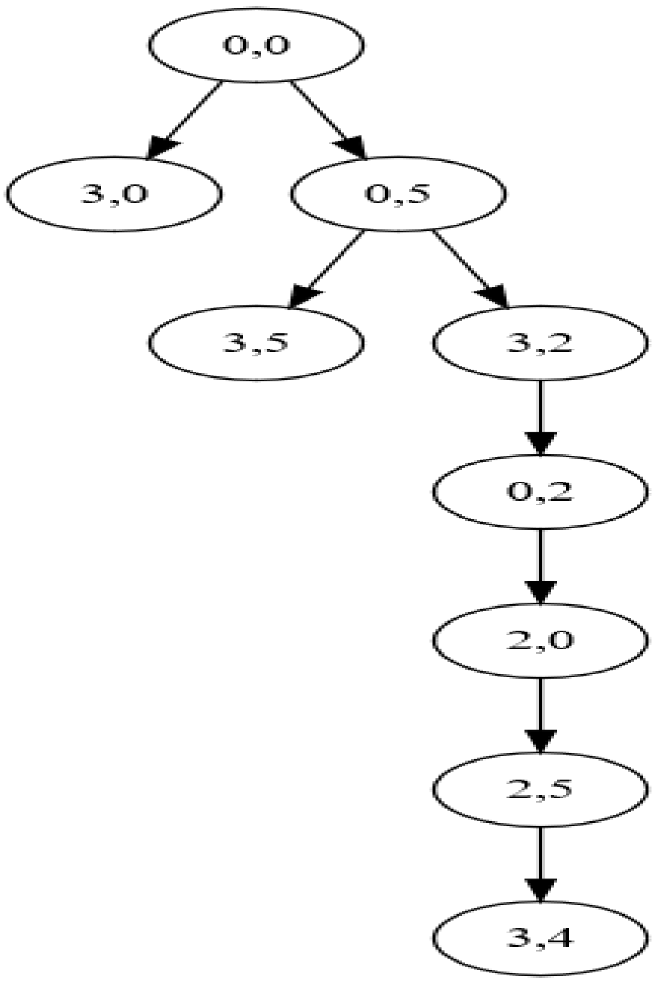
```
            all_nodes.insert(0,f)
            d[source].append(f)
            d[f]=[]
            flag=1
            if f[0]==vol or f[1]==vol:
                break
        f=empty(source,i-1)
        if f not in all_nodes:
            all_nodes.insert(0,f)
            d[source].append(f)
            d[f]=[]
            flag=1
            if f[0]==vol or f[1]==vol:
                break
        f=transfer(source,jug1,jug2,i)
        if f not in all_nodes:
            all_nodes.insert(0,f)
            d[source].append(f)
            d[f]=[]
            flag=1
            if f[0]==vol or f[1]==vol:
                flag=2
                break

jug1,jug2=map(int,input('Enter capacities of jug1 and jug2:').split()) #INPUT READING
vol=int(input('Enter Volume to make:'))
d={}
d[(0,0)]=[]
make_tree(d,jug1,jug2,vol)  #FUNCTION CALL TO GENERATE STATE SPACE TREE
final=[]  # FINAL[-1] HOLDS THE FINAL REQUIRED STATE
for i,j in d.items():
    if j==[]:
        if i[0]!=vol and i[1]!=vol:
            pass
        else:
            final.append(i)
    else:
        final.append(i)
#BFS
open_list=[(0,0)]
closed_list=[]
print("Open List--Closed List")
print(''.join(str(open_list)),''.join(str(closed_list)),sep='--')
while open_list:
```

```
    source=open_list.pop(0)
    closed_list.append(source)
    if source==final[-1]:
        break
    for i in d[source]:
        if i not in closed_list and i not in open_list:
            open_list.append(i)
    print(''.join(str(open_list)),''.join(str(closed_list)),sep='--',end='\n\n')
```

OUTPUT:

I.

GRAPH:

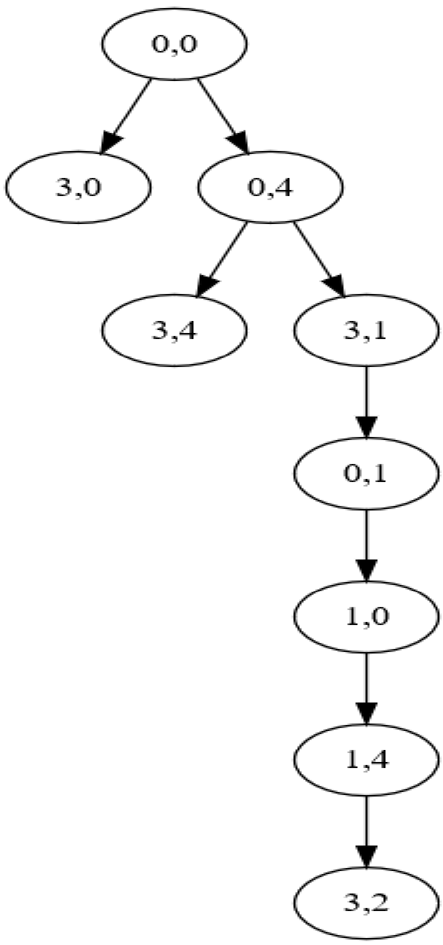



```
Enter capacities of jug1 and jug2:3 5
Enter Volume to make:4
Open List--Closed List
[(0, 0)]--[]
[(3, 0), (0, 5)]--[(0, 0)]

[(0, 5)]--[(0, 0), (3, 0)]
```

```
[(3, 5), (3, 2)]--[(0, 0), (3, 0), (0, 5)]

[(3, 2)]--[(0, 0), (3, 0), (0, 5), (3, 5)]

[(0, 2)]--[(0, 0), (3, 0), (0, 5), (3, 5), (3, 2)]

[(2, 0)]--[(0, 0), (3, 0), (0, 5), (3, 5), (3, 2), (0, 2)]

[(2, 5)]--[(0, 0), (3, 0), (0, 5), (3, 5), (3, 2), (0, 2), (2, 0)]

[(3, 4)]--[(0, 0), (3, 0), (0, 5), (3, 5), (3, 2), (0, 2), (2, 0), (2,
5)]
```

II.

GRAPH:




```
Enter capacities of jug1 and jug2:3 4
Enter Volume to make:2
Open List--Closed List
[(0, 0)]--[]
[(3, 0), (0, 4)]--[(0, 0)]

[(0, 4)]--[(0, 0), (3, 0)]
```

```
[(3, 4), (3, 1)]--[(0, 0), (3, 0), (0, 4)]

[(3, 1)]--[(0, 0), (3, 0), (0, 4), (3, 4)]

[(0, 1)]--[(0, 0), (3, 0), (0, 4), (3, 4), (3, 1)]

[(1, 0)]--[(0, 0), (3, 0), (0, 4), (3, 4), (3, 1), (0, 1)]

[(1, 4)]--[(0, 0), (3, 0), (0, 4), (3, 4), (3, 1), (0, 1), (1, 0)]

[(3, 2)]--[(0, 0), (3, 0), (0, 4), (3, 4), (3, 1), (0, 1), (1, 0), (1,
4)]
```

2. b) Implement water jug problem with Search tree generation using DFS

Program:

```
def fill(x,jug,i):
    x=list(x)
    x[i]=jug
    return tuple(x)
def empty(x,i):
    x=list(x)
    x[i]=0
    return tuple(x)
def transfer(x,jug1,jug2,i):
    x=list(x)
    if i==1:
        available=jug2-x[1]
        if x[0]>available:
            x[0]-=available
            x[1]+=available
        else:
            x[1]+=x[0]
            x[0]=0
    elif i==2:
        available=jug1-x[0]
        if x[1]>available:
            x[1]-=available
            x[0]+=available
        else:
            x[0]+=x[1]
            x[1]=0
    return tuple(x)
def make_tree(d,jug1,jug2,vol):
    all_nodes=[(0,0)]
    flag=1
    while(flag):
        if flag==2:
            break
        flag=0
        source=all_nodes[0]
        for i in [1,2]:
            x=jug2
            if i==1:
                x=jug1
            f=fill(source,x,i-1)
            if f not in all_nodes:
```

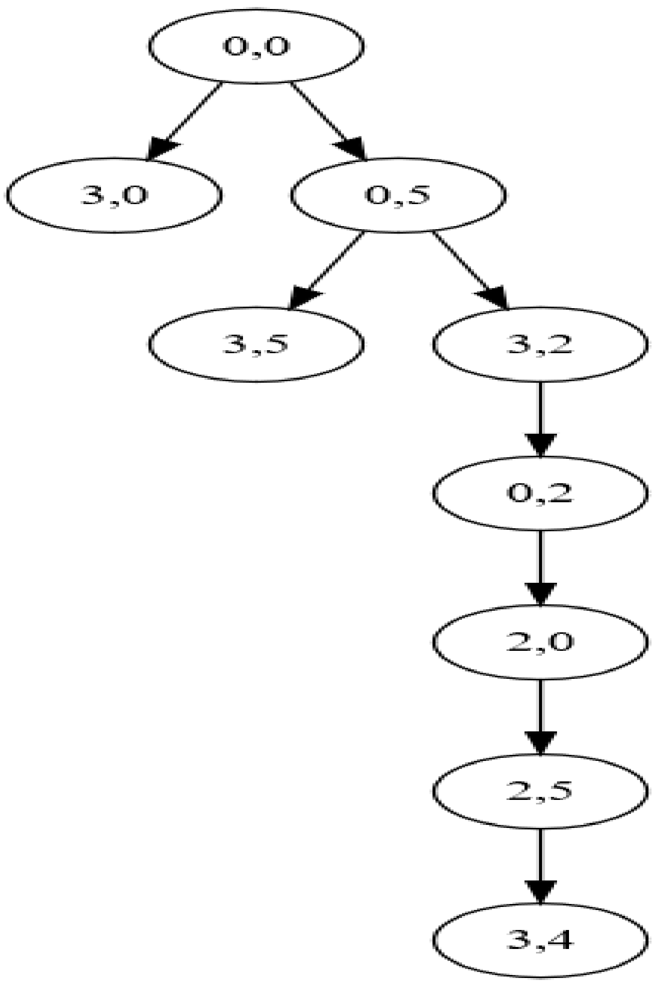
```
            all_nodes.insert(0,f)
            d[source].append(f)
            d[f]=[]
            flag=1
            if f[0]==vol or f[1]==vol:
                break
        f=empty(source,i-1)
        if f not in all_nodes:
            all_nodes.insert(0,f)
            d[source].append(f)
            d[f]=[]
            flag=1
            if f[0]==vol or f[1]==vol:
                break
        f=transfer(source,jug1,jug2,i)
        if f not in all_nodes:
            all_nodes.insert(0,f)
            d[source].append(f)
            d[f]=[]
            flag=1
            if f[0]==vol or f[1]==vol:
                flag=2
                break

jug1,jug2=map(int,input('Enter capacities of jug1 and jug2:').split())
vol=int(input('Enter Volume to make:'))
d={}
d[(0,0)]=[]
make_tree(d,jug1,jug2,vol)
final=[]
for i,j in d.items():
    if j==[]:
        if i[0]!=vol and i[1]!=vol:
            pass
        else:
            final.append(i)
    else:
        final.append(i)
#DFS
open_list=[(0,0)]
closed_list=[]
print("Open List--Closed List")
print(''.join(str(open_list)),''.join(str(closed_list)),sep='--')
while open_list:
```

```
    source=open_list.pop(0)
    closed_list.append(source)
    if source==final[-1]:
        break
    for i in d[source]:
        if i not in closed_list and i not in open_list:
            open_list.insert(0,i)
    print(".join(str(open_list)),".join(str(closed_list)),sep='--',end='\n\n')
```

OUTPUT:

I.

GRAPH:

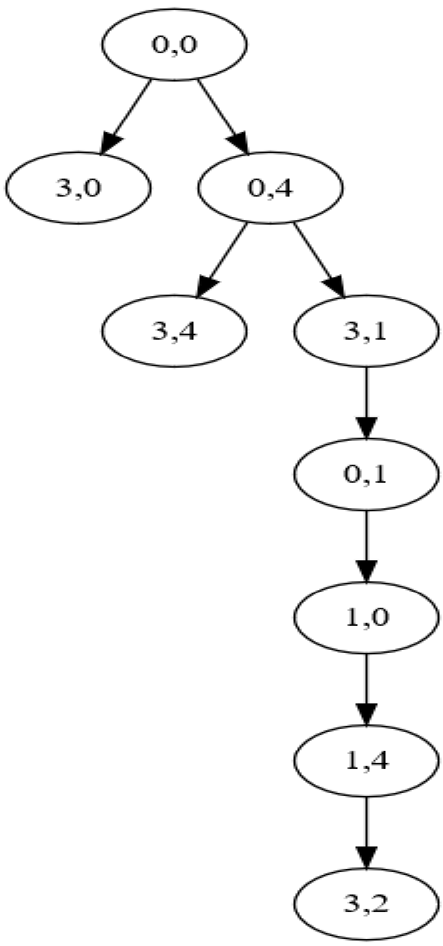



```
Enter capacities of jug1 and jug2:3 5
Enter Volume to make:4
Open List--Closed List
[(0, 0)]--[]
[(0, 5), (3, 0)]--[(0, 0)]
```

```
[(3, 2), (3, 5), (3, 0)]--[(0, 0), (0, 5)]

[(0, 2), (3, 5), (3, 0)]--[(0, 0), (0, 5), (3, 2)]

[(2, 0), (3, 5), (3, 0)]--[(0, 0), (0, 5), (3, 2), (0, 2)]

[(2, 5), (3, 5), (3, 0)]--[(0, 0), (0, 5), (3, 2), (0, 2), (2, 0)]

[(3, 4), (3, 5), (3, 0)]--[(0, 0), (0, 5), (3, 2), (0, 2), (2, 0), (2,
5)]
```

II.

GRAPH:




```
Enter capacities of jug1 and jug2:3 4
Enter Volume to make:2
Open List--Closed List
[(0, 0)]--[]
[(0, 4), (3, 0)]--[(0, 0)]

[(3, 1), (3, 4), (3, 0)]--[(0, 0), (0, 4)]

[(0, 1), (3, 4), (3, 0)]--[(0, 0), (0, 4), (3, 1)]
```

```
[(1, 0), (3, 4), (3, 0)]--[(0, 0), (0, 4), (3, 1), (0, 1)]

[(1, 4), (3, 4), (3, 0)]--[(0, 0), (0, 4), (3, 1), (0, 1), (1, 0)]

[(3, 2), (3, 4), (3, 0)]--[(0, 0), (0, 4), (3, 1), (0, 1), (1, 0), (1,
4)]
```

3.a)Implement Missionaries and Cannibals problem with Search tree generation using BFS

Program:

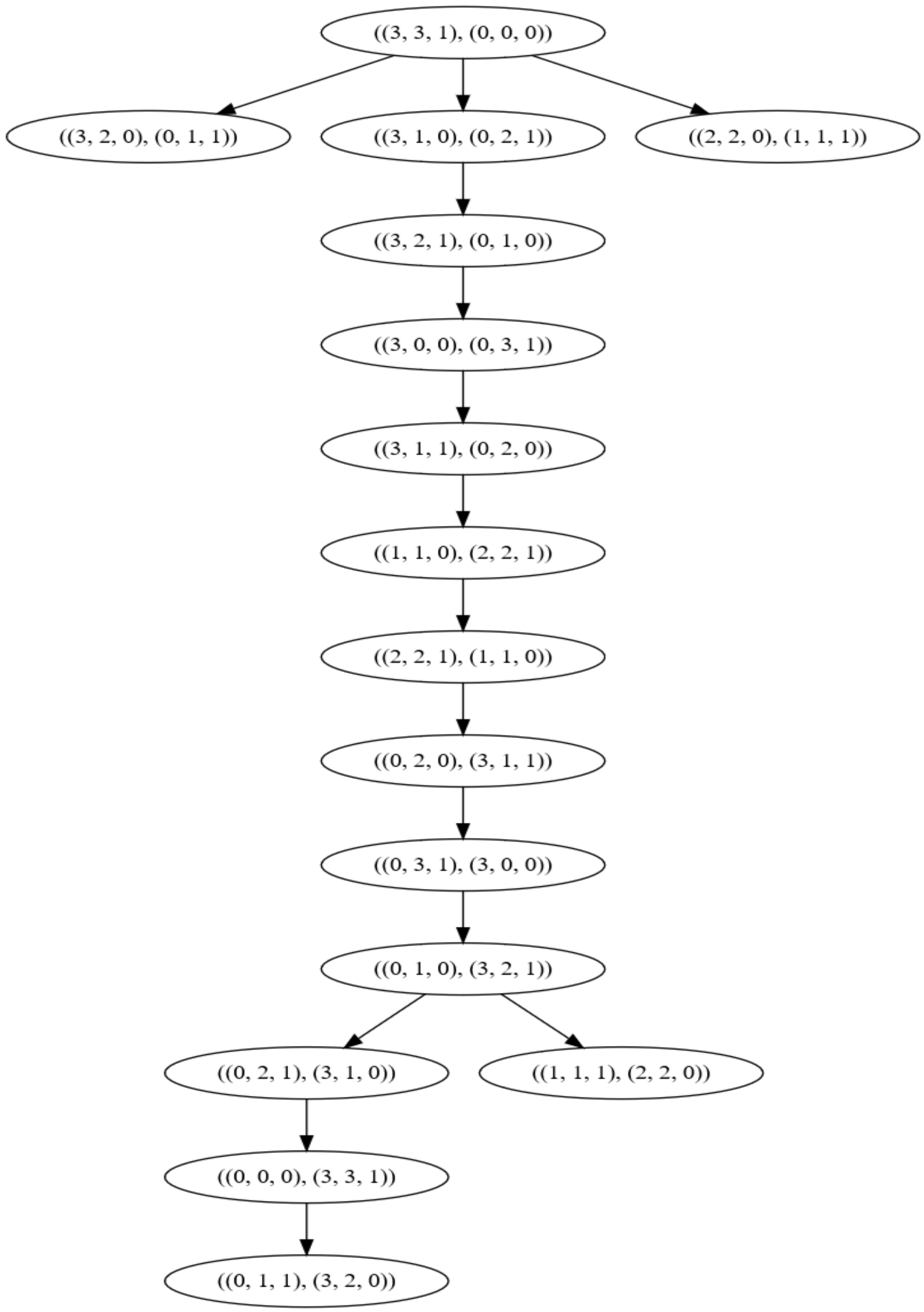
```
def travel(state,s):  # TRAVEL FUNCTION RETURNS THE POSSIBLE STATE IF TRAVEL ACTION IS PERFORMED ELSE RETURNS A NULL STRING .
    state=list(state)
    state[0]=list(state[0])
    state[1]=list(state[1])
    if state[0][-1]==1:
        for i in [0,1]:
            state[0][i]-=s[i]
            state[1][i]+=s[i]
        state[0][-1]=0
        state[1][-1]=1
        state[0]=tuple(state[0])
        state[1]=tuple(state[1])
        state=tuple(state)
        return state
    elif state[1][-1]==1:
        for i in [0,1]:
            state[1][i]-=s[i]
            state[0][i]+=s[i]
        state[1][-1]=0
        state[0][-1]=1
        state[0]=tuple(state[0])
        state[1]=tuple(state[1])
        state=tuple(state)
        return state
    else:
        return ""
def make_tree(start,end): # GENERATES STATE SPACE TREE
    d={}
    d[start]=[]
    all_nodes=[start]
    c=1
    h=-1
    source=start
    while(h<c and source!=end):
        h+=1
        source=all_nodes[h]
        for i in [0,1,2]: #EITHER 0,1 OR 2 MISSIONARIES
            for j in [0,1,2]: # EITHER 0,1 OR 2 CANNIBALS
                if i+j<=2 and i+j>0: # ATLEAST 1 ON BOAT OR ATMOST 2
```

```
                    state=travel(source,[i,j])
                    if state!="" and state not in all_nodes: # GENERATING ONLY NEW STATES.
                        if (state[0][0]>=state[0][1] or state[0][0]==0) and (state[1][0]>=state[1][1]or
state[1][0]==0):
                            if state[0][0]>=0 and state[0][1]>=0 and state[1][0]>=0 and state[1][1]>=0:
                                all_nodes.append(state)
                                d[source].append(state)
                                d[state]=[]
                                if state==end:
                                    break
        c=len(all_nodes)
    return d
m,n =map(int,input("Enter the number of missionaries and cannibals:").split()) #INPUT READING
start = ((m,n,1),(0,0,0))
end = ((0,0,0),(m,n,1))
key=end
state=start
d=make_tree(start,end) #FUNCTION CALL
#BFS
open_list=[start]
closed_list=[]
print("Open List--Closed List")
print(''.join(str(open_list)),''.join(str(closed_list)),sep='--')
while open_list:
    source=open_list.pop(0)
    closed_list.append(source)
    if source==key:
        print('Required node is found',key)
        break
    for i in d[source]:
        if i not in closed_list and i not in open_list:
            open_list.append(i)
    print(''.join(str(open_list)),''.join(str(closed_list)),sep='--',end='\n\n')
```

OUTPUT:

I.

GRAPH:

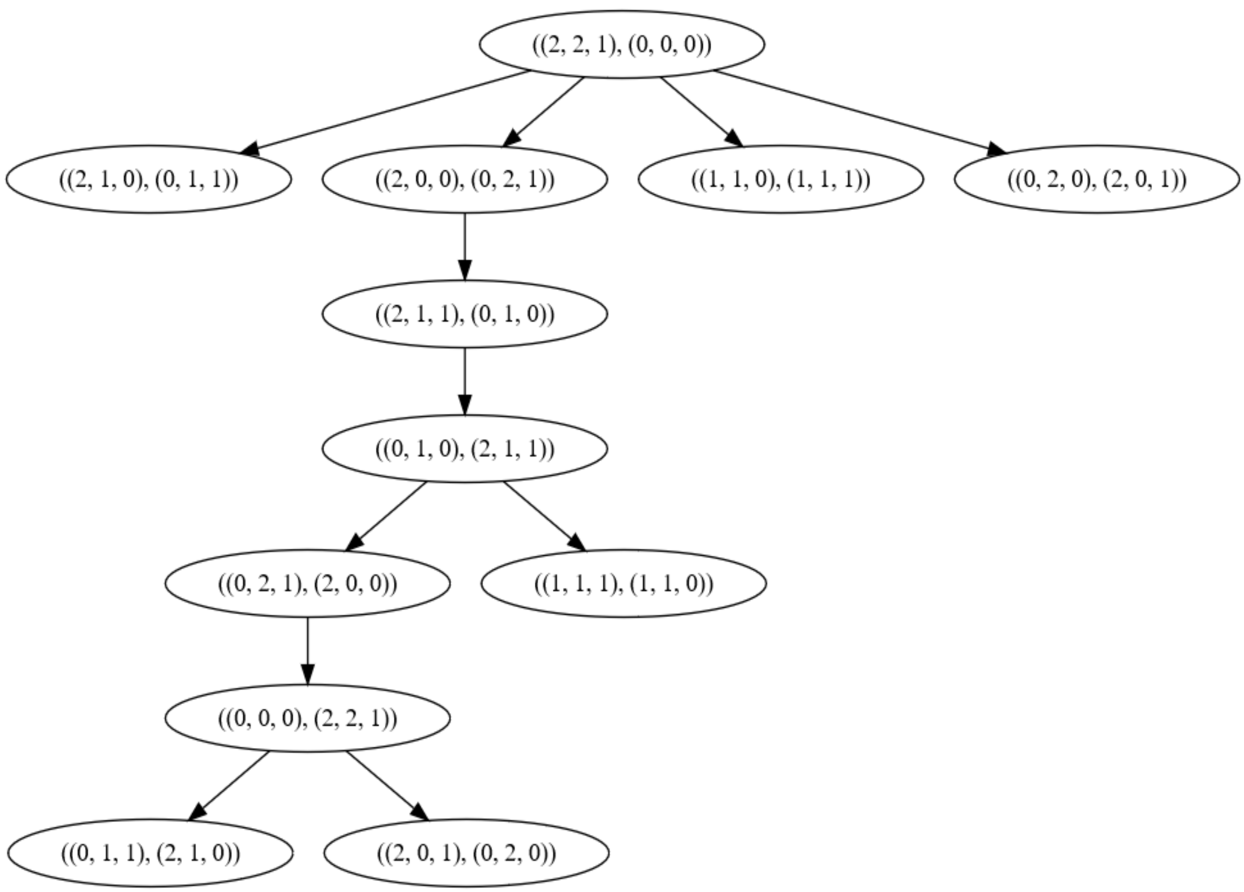



```
Enter the number of missionaries and cannibals:3 3
Open List--Closed List
[((3, 3, 1), (0, 0, 0))]--[]
```

```
[((3, 2, 0), (0, 1, 1)), ((3, 1, 0), (0, 2, 1)), ((2, 2, 0), (1, 1, 1)
)]--[((3, 3, 1), (0, 0, 0))]

[((3, 1, 0), (0, 2, 1)), ((2, 2, 0), (1, 1, 1))]--[((3, 3, 1), (0, 0,
0)), ((3, 2, 0), (0, 1, 1))]

[((2, 2, 0), (1, 1, 1)), ((3, 2, 1), (0, 1, 0))]--[((3, 3, 1), (0, 0,
0)), ((3, 2, 0), (0, 1, 1)), ((3, 1, 0), (0, 2, 1))]

[((3, 2, 1), (0, 1, 0))]--[((3, 3, 1), (0, 0, 0)), ((3, 2, 0), (0, 1,
1)), ((3, 1, 0), (0, 2, 1)), ((2, 2, 0), (1, 1, 1))]

[((3, 0, 0), (0, 3, 1))]--[((3, 3, 1), (0, 0, 0)), ((3, 2, 0), (0, 1,
1)), ((3, 1, 0), (0, 2, 1)), ((2, 2, 0), (1, 1, 1)), ((3, 2, 1), (0, 1
, 0))]

[((3, 1, 1), (0, 2, 0))]--[((3, 3, 1), (0, 0, 0)), ((3, 2, 0), (0, 1,
1)), ((3, 1, 0), (0, 2, 1)), ((2, 2, 0), (1, 1, 1)), ((3, 2, 1), (0, 1
, 0)), ((3, 0, 0), (0, 3, 1))]

[((1, 1, 0), (2, 2, 1))]--[((3, 3, 1), (0, 0, 0)), ((3, 2, 0), (0, 1,
1)), ((3, 1, 0), (0, 2, 1)), ((2, 2, 0), (1, 1, 1)), ((3, 2, 1), (0, 1
, 0)), ((3, 0, 0), (0, 3, 1)), ((3, 1, 1), (0, 2, 0))]

[((2, 2, 1), (1, 1, 0))]--[((3, 3, 1), (0, 0, 0)), ((3, 2, 0), (0, 1,
1)), ((3, 1, 0), (0, 2, 1)), ((2, 2, 0), (1, 1, 1)), ((3, 2, 1), (0, 1
, 0)), ((3, 0, 0), (0, 3, 1)), ((3, 1, 1), (0, 2, 0)), ((1, 1, 0), (2,
2, 1))]

[((0, 2, 0), (3, 1, 1))]--[((3, 3, 1), (0, 0, 0)), ((3, 2, 0), (0, 1,
1)), ((3, 1, 0), (0, 2, 1)), ((2, 2, 0), (1, 1, 1)), ((3, 2, 1), (0, 1
, 0)), ((3, 0, 0), (0, 3, 1)), ((3, 1, 1), (0, 2, 0)), ((1, 1, 0), (2,
2, 1)), ((2, 2, 1), (1, 1, 0))]

[((0, 3, 1), (3, 0, 0))]--[((3, 3, 1), (0, 0, 0)), ((3, 2, 0), (0, 1,
1)), ((3, 1, 0), (0, 2, 1)), ((2, 2, 0), (1, 1, 1)), ((3, 2, 1), (0, 1
, 0)), ((3, 0, 0), (0, 3, 1)), ((3, 1, 1), (0, 2, 0)), ((1, 1, 0), (2,
2, 1)), ((2, 2, 1), (1, 1, 0)), ((0, 2, 0), (3, 1, 1))]

[((0, 1, 0), (3, 2, 1))]--[((3, 3, 1), (0, 0, 0)), ((3, 2, 0), (0, 1,
1)), ((3, 1, 0), (0, 2, 1)), ((2, 2, 0), (1, 1, 1)), ((3, 2, 1), (0, 1
, 0)), ((3, 0, 0), (0, 3, 1)), ((3, 1, 1), (0, 2, 0)), ((1, 1, 0), (2,
2, 1)), ((2, 2, 1), (1, 1, 0)), ((0, 2, 0), (3, 1, 1)), ((0, 3, 1), (3
, 0, 0))]

[((0, 2, 1), (3, 1, 0)), ((1, 1, 1), (2, 2, 0))]--[((3, 3, 1), (0, 0,
0)), ((3, 2, 0), (0, 1, 1)), ((3, 1, 0), (0, 2, 1)), ((2, 2, 0), (1, 1
, 1)), ((3, 2, 1), (0, 1, 0)), ((3, 0, 0), (0, 3, 1)), ((3, 1, 1), (0,
2, 0)), ((1, 1, 0), (2, 2, 1)), ((2, 2, 1), (1, 1, 0)), ((0, 2, 0), (3
, 1, 1)), ((0, 3, 1), (3, 0, 0)), ((0, 1, 0), (3, 2, 1))]
```

```
[((1, 1, 1), (2, 2, 0)), ((0, 0, 0), (3, 3, 1))]--[((3, 3, 1), (0, 0,
0)), ((3, 2, 0), (0, 1, 1)), ((3, 1, 0), (0, 2, 1)), ((2, 2, 0), (1, 1
, 1)), ((3, 2, 1), (0, 1, 0)), ((3, 0, 0), (0, 3, 1)), ((3, 1, 1), (0,
2, 0)), ((1, 1, 0), (2, 2, 1)), ((2, 2, 1), (1, 1, 0)), ((0, 2, 0), (3
, 1, 1)), ((0, 3, 1), (3, 0, 0)), ((0, 1, 0), (3, 2, 1)), ((0, 2, 1),
(3, 1, 0))]

[((0, 0, 0), (3, 3, 1))]--[((3, 3, 1), (0, 0, 0)), ((3, 2, 0), (0, 1,
1)), ((3, 1, 0), (0, 2, 1)), ((2, 2, 0), (1, 1, 1)), ((3, 2, 1), (0, 1
, 0)), ((3, 0, 0), (0, 3, 1)), ((3, 1, 1), (0, 2, 0)), ((1, 1, 0), (2,
2, 1)), ((2, 2, 1), (1, 1, 0)), ((0, 2, 0), (3, 1, 1)), ((0, 3, 1), (3
, 0, 0)), ((0, 1, 0), (3, 2, 1)), ((0, 2, 1), (3, 1, 0)), ((1, 1, 1),
(2, 2, 0))]

Required node is found ((0, 0, 0), (3, 3, 1))
```

II.
GRAPH:




```
Enter the number of missionaries and cannibals:2 2
Open List--Closed List
[((2, 2, 1), (0, 0, 0))]--[]
[((2, 1, 0), (0, 1, 1)), ((2, 0, 0), (0, 2, 1)), ((1, 1, 0), (1, 1,
1)), ((0, 2, 0), (2, 0, 1))]--[((2, 2, 1), (0, 0, 0))]
```

```
[((2, 0, 0), (0, 2, 1)), ((1, 1, 0), (1, 1, 1)), ((0, 2, 0), (2, 0,
1))]--[((2, 2, 1), (0, 0, 0)), ((2, 1, 0), (0, 1, 1))]

[((1, 1, 0), (1, 1, 1)), ((0, 2, 0), (2, 0, 1)), ((2, 1, 1), (0, 1,
0))]--[((2, 2, 1), (0, 0, 0)), ((2, 1, 0), (0, 1, 1)), ((2, 0, 0), (0,
2, 1))]

[((0, 2, 0), (2, 0, 1)), ((2, 1, 1), (0, 1, 0))]--[((2, 2, 1), (0, 0,
0)), ((2, 1, 0), (0, 1, 1)), ((2, 0, 0), (0, 2, 1)), ((1, 1, 0), (1,
1, 1))]

[((2, 1, 1), (0, 1, 0))]--[((2, 2, 1), (0, 0, 0)), ((2, 1, 0), (0, 1,
1)), ((2, 0, 0), (0, 2, 1)), ((1, 1, 0), (1, 1, 1)), ((0, 2, 0), (2,
0, 1))]

[((0, 1, 0), (2, 1, 1))]--[((2, 2, 1), (0, 0, 0)), ((2, 1, 0), (0, 1,
1)), ((2, 0, 0), (0, 2, 1)), ((1, 1, 0), (1, 1, 1)), ((0, 2, 0), (2,
0, 1)), ((2, 1, 1), (0, 1, 0))]

[((0, 2, 1), (2, 0, 0)), ((1, 1, 1), (1, 1, 0))]--[((2, 2, 1), (0, 0,
0)), ((2, 1, 0), (0, 1, 1)), ((2, 0, 0), (0, 2, 1)), ((1, 1, 0), (1,
1, 1)), ((0, 2, 0), (2, 0, 1)), ((2, 1, 1), (0, 1, 0)), ((0, 1, 0),
(2, 1, 1))]

[((1, 1, 1), (1, 1, 0)), ((0, 0, 0), (2, 2, 1))]--[((2, 2, 1), (0, 0,
0)), ((2, 1, 0), (0, 1, 1)), ((2, 0, 0), (0, 2, 1)), ((1, 1, 0), (1,
1, 1)), ((0, 2, 0), (2, 0, 1)), ((2, 1, 1), (0, 1, 0)), ((0, 1, 0),
(2, 1, 1)), ((0, 2, 1), (2, 0, 0))]

[((0, 0, 0), (2, 2, 1))]--[((2, 2, 1), (0, 0, 0)), ((2, 1, 0), (0, 1,
1)), ((2, 0, 0), (0, 2, 1)), ((1, 1, 0), (1, 1, 1)), ((0, 2, 0), (2,
0, 1)), ((2, 1, 1), (0, 1, 0)), ((0, 1, 0), (2, 1, 1)), ((0, 2, 1),
(2, 0, 0)), ((1, 1, 1), (1, 1, 0))]

Required node is found ((0, 0, 0), (2, 2, 1))
```

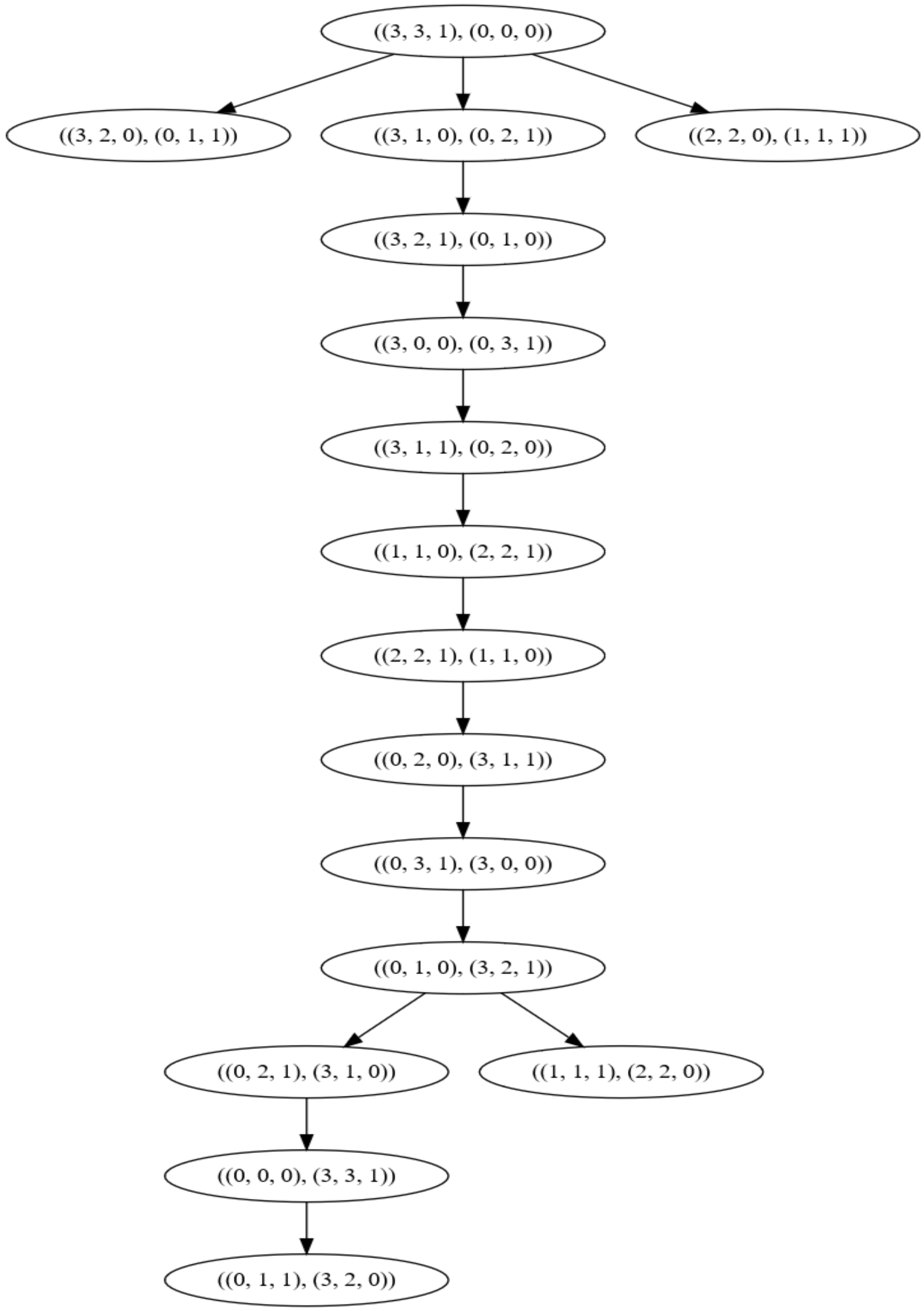
3.b)Implement Missionaries and Cannibals problem with Search tree generation using DFS

Program:

```
def travel(state,s):
    state=list(state)
    state[0]=list(state[0])
    state[1]=list(state[1])
    if state[0][-1]==1:
        for i in [0,1]:
            state[0][i]-=s[i]
            state[1][i]+=s[i]
        state[0][-1]=0
        state[1][-1]=1

        state[0]=tuple(state[0])
        state[1]=tuple(state[1])
        state=tuple(state)
        return state
    elif state[1][-1]==1:
        for i in [0,1]:
            state[1][i]-=s[i]
            state[0][i]+=s[i]
        state[1][-1]=0
        state[0][-1]=1
        state[0]=tuple(state[0])
        state[1]=tuple(state[1])
        state=tuple(state)
        return state
    else:
        return ""
def make_tree(start,end):
    d={}
    d[start]=[]
    all_nodes=[start]
    c=1
    h=-1
    source=start
    while(h<c and source!=end):
        h+=1
        source=all_nodes[h]
        for i in [0,1,2]:
            for j in [0,1,2]:
                if i+j<=2 and i+j>0:
```

```
                state=travel(source,[i,j])
                if state!="" and state not in all_nodes:
                    if (state[0][0]>=state[0][1] or state[0][0]==0) and (state[1][0]>=state[1][1]or
state[1][0]==0):
                        if state[0][0]>=0 and state[0][1]>=0 and state[1][0]>=0 and state[1][1]>=0:
                            all_nodes.append(state)
                            d[source].append(state)
                            d[state]=[]
                            if state==end:
                                break
        c=len(all_nodes)
    return d
m,n =map(int,input("Enter the number of missionaries and cannibals:").split())
start = ((m,n,1),(0,0,0))
end = ((0,0,0),(m,n,1))
key=end
state=start
d=make_tree(start,end)
#DFS
open_list=[start]
closed_list=[]
print("Open List--Closed List")
print(''.join(str(open_list)),''.join(str(closed_list)),sep='--')
while open_list:
    source=open_list.pop(0)
    closed_list.append(source)
    if source==key:
        print('Required node is found',key)
        break
    for i in d[source]:
        if i not in closed_list and i not in open_list:
            open_list.insert(0,i)
    print(''.join(str(open_list)),''.join(str(closed_list)),sep='--',end='\n\n')
```

OUTPUT:
I.
GRAPH:



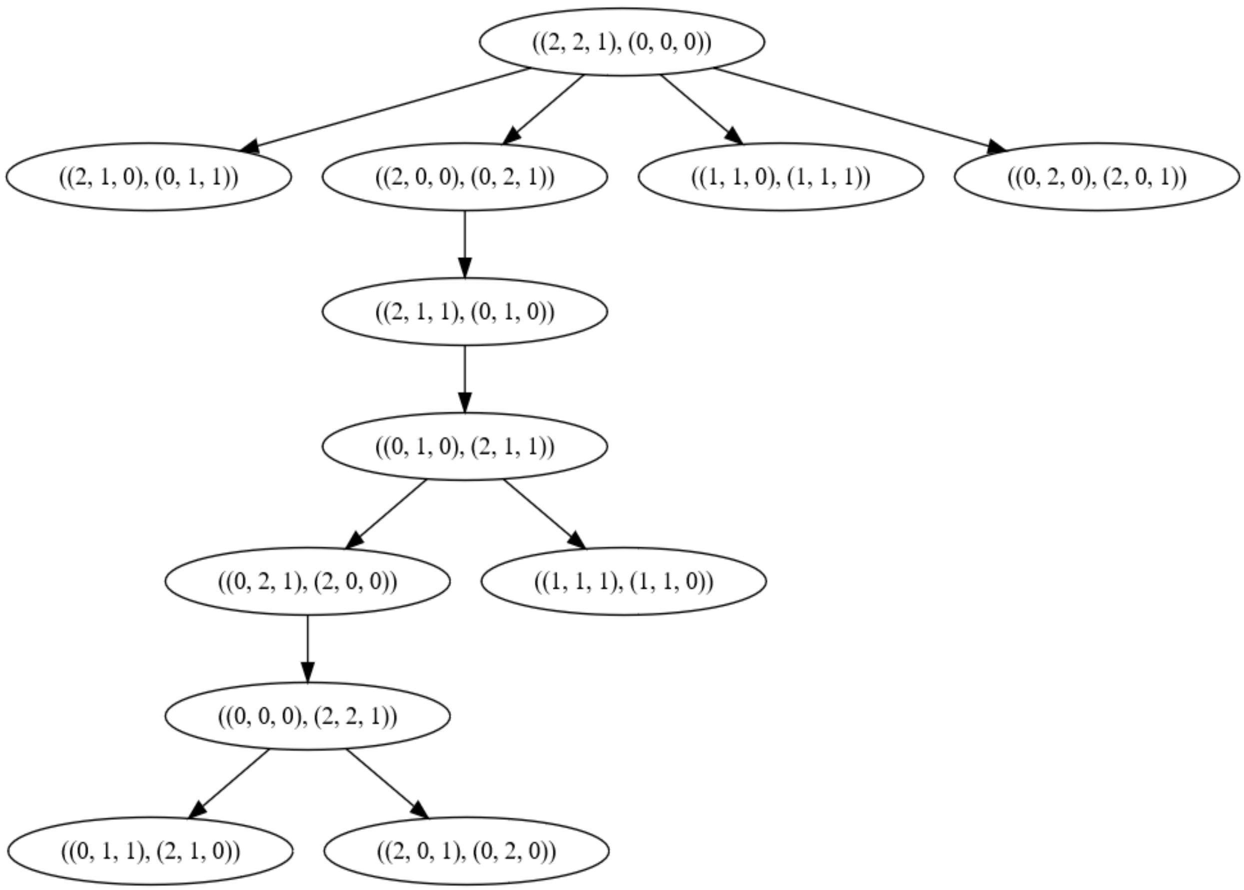

```
Enter the number of missionaries and cannibals:3 3
Open List--Closed List
[((3, 3, 1), (0, 0, 0))]--[]
```

```
[((2, 2, 0), (1, 1, 1)), ((3, 1, 0), (0, 2, 1)), ((3, 2, 0), (0, 1, 1)
)]--[((3, 3, 1), (0, 0, 0))]
[((3, 1, 0), (0, 2, 1)), ((3, 2, 0), (0, 1, 1))]--[((3, 3, 1), (0, 0,
0)), ((2, 2, 0), (1, 1, 1))]
[((3, 2, 1), (0, 1, 0)), ((3, 2, 0), (0, 1, 1))]--[((3, 3, 1), (0, 0,
0)), ((2, 2, 0), (1, 1, 1)), ((3, 1, 0), (0, 2, 1))]

[((3, 0, 0), (0, 3, 1)), ((3, 2, 0), (0, 1, 1))]--[((3, 3, 1), (0, 0,
0)), ((2, 2, 0), (1, 1, 1)), ((3, 1, 0), (0, 2, 1)), ((3, 2, 1), (0, 1
, 0))]

[((3, 1, 1), (0, 2, 0)), ((3, 2, 0), (0, 1, 1))]--[((3, 3, 1), (0, 0,
0)), ((2, 2, 0), (1, 1, 1)), ((3, 1, 0), (0, 2, 1)), ((3, 2, 1), (0, 1
, 0)), ((3, 0, 0), (0, 3, 1))]

[((1, 1, 0), (2, 2, 1)), ((3, 2, 0), (0, 1, 1))]--[((3, 3, 1), (0, 0,
0)), ((2, 2, 0), (1, 1, 1)), ((3, 1, 0), (0, 2, 1)), ((3, 2, 1), (0, 1
, 0)), ((3, 0, 0), (0, 3, 1)), ((3, 1, 1), (0, 2, 0))]

[((2, 2, 1), (1, 1, 0)), ((3, 2, 0), (0, 1, 1))]--[((3, 3, 1), (0, 0,
0)), ((2, 2, 0), (1, 1, 1)), ((3, 1, 0), (0, 2, 1)), ((3, 2, 1), (0, 1
, 0)), ((3, 0, 0), (0, 3, 1)), ((3, 1, 1), (0, 2, 0)), ((1, 1, 0), (2,
2, 1))]

[((0, 2, 0), (3, 1, 1)), ((3, 2, 0), (0, 1, 1))]--[((3, 3, 1), (0, 0,
0)), ((2, 2, 0), (1, 1, 1)), ((3, 1, 0), (0, 2, 1)), ((3, 2, 1), (0, 1
, 0)), ((3, 0, 0), (0, 3, 1)), ((3, 1, 1), (0, 2, 0)), ((1, 1, 0), (2,
2, 1)), ((2, 2, 1), (1, 1, 0))]

[((0, 3, 1), (3, 0, 0)), ((3, 2, 0), (0, 1, 1))]--[((3, 3, 1), (0, 0,
0)), ((2, 2, 0), (1, 1, 1)), ((3, 1, 0), (0, 2, 1)), ((3, 2, 1), (0, 1
, 0)), ((3, 0, 0), (0, 3, 1)), ((3, 1, 1), (0, 2, 0)), ((1, 1, 0), (2,
2, 1)), ((2, 2, 1), (1, 1, 0)), ((0, 2, 0), (3, 1, 1))]

[((0, 1, 0), (3, 2, 1)), ((3, 2, 0), (0, 1, 1))]--[((3, 3, 1), (0, 0,
0)), ((2, 2, 0), (1, 1, 1)), ((3, 1, 0), (0, 2, 1)), ((3, 2, 1), (0, 1
, 0)), ((3, 0, 0), (0, 3, 1)), ((3, 1, 1), (0, 2, 0)), ((1, 1, 0), (2,
2, 1)), ((2, 2, 1), (1, 1, 0)), ((0, 2, 0), (3, 1, 1)), ((0, 3, 1), (3
, 0, 0))]

[((1, 1, 1), (2, 2, 0)), ((0, 2, 1), (3, 1, 0)), ((3, 2, 0), (0, 1, 1)
)]--[((3, 3, 1), (0, 0, 0)), ((2, 2, 0), (1, 1, 1)), ((3, 1, 0), (0, 2
, 1)), ((3, 2, 1), (0, 1, 0)), ((3, 0, 0), (0, 3, 1)), ((3, 1, 1), (0,
2, 0)), ((1, 1, 0), (2, 2, 1)), ((2, 2, 1), (1, 1, 0)), ((0, 2, 0), (3
, 1, 1)), ((0, 3, 1), (3, 0, 0)), ((0, 1, 0), (3, 2, 1))]

[((0, 2, 1), (3, 1, 0)), ((3, 2, 0), (0, 1, 1))]--[((3, 3, 1), (0, 0,
0)), ((2, 2, 0), (1, 1, 1)), ((3, 1, 0), (0, 2, 1)), ((3, 2, 1), (0, 1
, 0)), ((3, 0, 0), (0, 3, 1)), ((3, 1, 1), (0, 2, 0)), ((1, 1, 0), (2,
2, 1)), ((2, 2, 1), (1, 1, 0)), ((0, 2, 0), (3, 1, 1)), ((0, 3, 1), (3
, 0, 0)), ((0, 1, 0), (3, 2, 1)), ((1, 1, 1), (2, 2, 0))]
```

```
[((0, 0, 0), (3, 3, 1)), ((3, 2, 0), (0, 1, 1))]--[((3, 3, 1), (0, 0,
0)), ((2, 2, 0), (1, 1, 1)), ((3, 1, 0), (0, 2, 1)), ((3, 2, 1), (0, 1
, 0)), ((3, 0, 0), (0, 3, 1)), ((3, 1, 1), (0, 2, 0)), ((1, 1, 0), (2,
2, 1)), ((2, 2, 1), (1, 1, 0)), ((0, 2, 0), (3, 1, 1)), ((0, 3, 1), (3
, 0, 0)), ((0, 1, 0), (3, 2, 1)), ((1, 1, 1), (2, 2, 0)), ((0, 2, 1),
(3, 1, 0))]

Required node is found ((0, 0, 0), (3, 3, 1))
```

II.

GRAPH:




```
Enter the number of missionaries and cannibals:2 2
Open List--Closed List
[((2, 2, 1), (0, 0, 0))]--[]
[((0, 2, 0), (2, 0, 1)), ((1, 1, 0), (1, 1, 1)), ((2, 0, 0), (0, 2,
1)), ((2, 1, 0), (0, 1, 1))]--[((2, 2, 1), (0, 0, 0))]

[((1, 1, 0), (1, 1, 1)), ((2, 0, 0), (0, 2, 1)), ((2, 1, 0), (0, 1,
1))]--[((2, 2, 1), (0, 0, 0)), ((0, 2, 0), (2, 0, 1))]

[((2, 0, 0), (0, 2, 1)), ((2, 1, 0), (0, 1, 1))]--[((2, 2, 1), (0, 0,
0)), ((0, 2, 0), (2, 0, 1)), ((1, 1, 0), (1, 1, 1))]
```

```
[((2, 1, 1), (0, 1, 0)), ((2, 1, 0), (0, 1, 1))]--[((2, 2, 1), (0, 0, 0)), ((0, 2, 0), (2, 0, 1)), ((1, 1, 0), (1, 1, 1)), ((2, 0, 0), (0, 2, 1))]

[((0, 1, 0), (2, 1, 1)), ((2, 1, 0), (0, 1, 1))]--[((2, 2, 1), (0, 0, 0)), ((0, 2, 0), (2, 0, 1)), ((1, 1, 0), (1, 1, 1)), ((2, 0, 0), (0, 2, 1)), ((2, 1, 1), (0, 1, 0))]

[((1, 1, 1), (1, 1, 0)), ((0, 2, 1), (2, 0, 0)), ((2, 1, 0), (0, 1, 1))]--[((2, 2, 1), (0, 0, 0)), ((0, 2, 0), (2, 0, 1)), ((1, 1, 0), (1, 1, 1)), ((2, 0, 0), (0, 2, 1)), ((2, 1, 1), (0, 1, 0)), ((0, 1, 0), (2, 1, 1))]

[((0, 2, 1), (2, 0, 0)), ((2, 1, 0), (0, 1, 1))]--[((2, 2, 1), (0, 0, 0)), ((0, 2, 0), (2, 0, 1)), ((1, 1, 0), (1, 1, 1)), ((2, 0, 0), (0, 2, 1)), ((2, 1, 1), (0, 1, 0)), ((0, 1, 0), (2, 1, 1)), ((1, 1, 1), (1, 1, 0))]

[((0, 0, 0), (2, 2, 1)), ((2, 1, 0), (0, 1, 1))]--[((2, 2, 1), (0, 0, 0)), ((0, 2, 0), (2, 0, 1)), ((1, 1, 0), (1, 1, 1)), ((2, 0, 0), (0, 2, 1)), ((2, 1, 1), (0, 1, 0)), ((0, 1, 0), (2, 1, 1)), ((1, 1, 1), (1, 1, 0)), ((0, 2, 1), (2, 0, 0))]

Required node is found ((0, 0, 0), (2, 2, 1))
```

4.a) Implement Vacuum World problem with Search tree generation using BFS

Program:

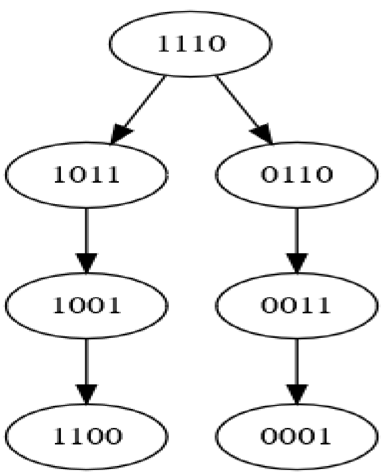
```
def move(state): #FUNCTION TO PERFROM LEFT TO RIGHT OR RIGHT TO LEFT MOVE.
    state=list(state)
    temp=state[1]
    state[1]=state[-1]
    state[-1]=temp
    return ''.join(state)
def clean(state): #FUNCTION TO CLEAN THE DIRT IF EXISTS.
    state=list(state)
    if state[0]=='1' and state[1]=='1':
        state[0]='0'
    if state[2]=='1' and state[3]=='1':
        state[2]='0'
    return ''.join(state)
def make_tree(start,final): # GENERATE STATE SPACE TREE.
    d={}
    d[start]=[]
    all_nodes=[start]
    c=1
    h=-1
    source=start
    while(h<c and source not in final):
        h+=1
        source=all_nodes[h]
        state=move(source)
        if state not in all_nodes:
            all_nodes.append(state)
            d[source].append(state)
            d[state]=[]
            if state in final:
                break
        state=clean(source)
        if state not in all_nodes:
            all_nodes.append(state)
            d[source].append(state)
            d[state]=[]
            if state in final:
                break
        c=len(all_nodes)
    return d,state
start=input("Enter start state:") #READING INPUT
```

```
final=['0100','0001']
d,st=make_tree(start,final)
print(d)
#BFS
open_list=[(0,0)]
closed_list=[]
print("Open List--Closed List")
print(''.join(str(open_list)),''.join(str(closed_list)),sep='--')
while open_list:
    source=open_list.pop(0)
    closed_list.append(source)
    if source==final[-1]:
        break
    for i in d[source]:
        if i not in closed_list and i not in open_list:
            open_list.append(i)
    print(''.join(str(open_list)),''.join(str(closed_list)),sep='--',end='\n\n')
```

OUTPUT:

I.

GRAPH:

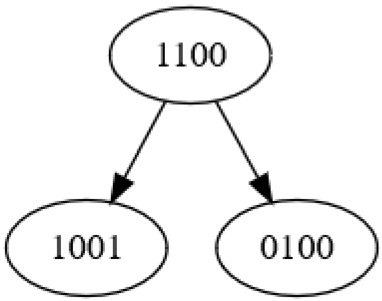



```
Enter start state:1110
{'1110': ['1011', '0110'], '1011': ['1001'], '0110': ['0011'], '1001':
['1100'], '0011': ['0001'], '1100': [], '0001': []}
Open List--Closed List
['1110']--[]
['1011', '0110']--['1110']

['0110', '1001']--['1110', '1011']

['1001', '0011']--['1110', '1011', '0110']

['0011', '1100']--['1110', '1011', '0110', '1001']
```

```
['1100', '0001']--['1110', '1011', '0110', '1001', '0011']

['0001']--['1110', '1011', '0110', '1001', '0011', '1100']
```

II.

GRAPH:




```
Enter start state:1100
{'1100': ['1001', '0100'], '1001': [], '0100': []}
Open List--Closed List
['1100']--[]
['1001', '0100']--['1100']

['0100']--['1100', '1001']
```

4.b) Implement Vacuum World problem with Search tree generation using DFS

Program:

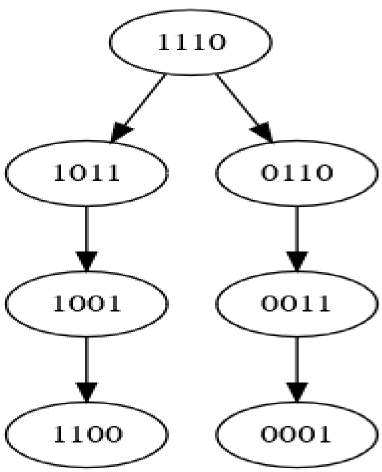
```
def move(state):
    state=list(state)
    temp=state[1]
    state[1]=state[-1]
    state[-1]=temp
    return ''.join(state)
def clean(state):
    state=list(state)
    if state[0]=='1' and state[1]=='1':
        state[0]='0'
    if state[2]=='1' and state[3]=='1':
        state[2]='0'
    return ''.join(state)
def make_tree(start,final):
    d={}
    d[start]=[]
    all_nodes=[start]
    c=1
    h=-1
    source=start
    while(h<c and source not in final):
        h+=1
        source=all_nodes[h]
        state=move(source)
        if state not in all_nodes:
            all_nodes.append(state)
            d[source].append(state)
            d[state]=[]
            if state in final:
                break
        state=clean(source)
        if state not in all_nodes:
            all_nodes.append(state)
            d[source].append(state)
            d[state]=[]
            if state in final:
                break
        c=len(all_nodes)
    return d,state
start=input("Enter start state:")
```

```
final=['0100','0001']
d,st=make_tree(start,final)
print(d)
#DFS
open_list=[start]
closed_list=[]
print("Open List--Closed List")
print(''.join(str(open_list)),''.join(str(closed_list)),sep='--')
while open_list:
    source=open_list.pop(0)
    closed_list.append(source)
    if source in final:
        break
    for i in d[source]:
        if i not in closed_list and i not in open_list:
            open_list.insert(0,i)
    print(''.join(str(open_list)),''.join(str(closed_list)),sep='--',end='\n\n')
```

OUTPUT:

I.

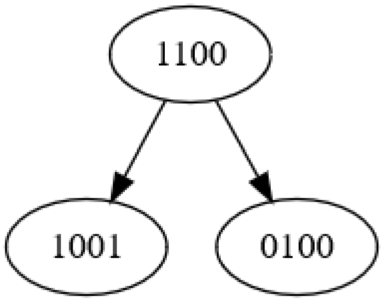
GRAPH:




```
Enter start state:1110
{'1110': ['1011', '0110'], '1011': ['1001'], '0110': ['0011'], '1001':
['1100'], '0011': ['0001'], '1100': [], '0001': []}
Open List--Closed List
['1110']--[]
['0110', '1011']--['1110']

['0011', '1011']--['1110', '0110']

['0001', '1011']--['1110', '0110', '0011']
```

II.

GRAPH:




```
Enter start state:1100
{'1100': ['1001', '0100'], '1001': [], '0100': []}
Open List--Closed List
['1100']--[]
['0100', '1001']--['1100']
```

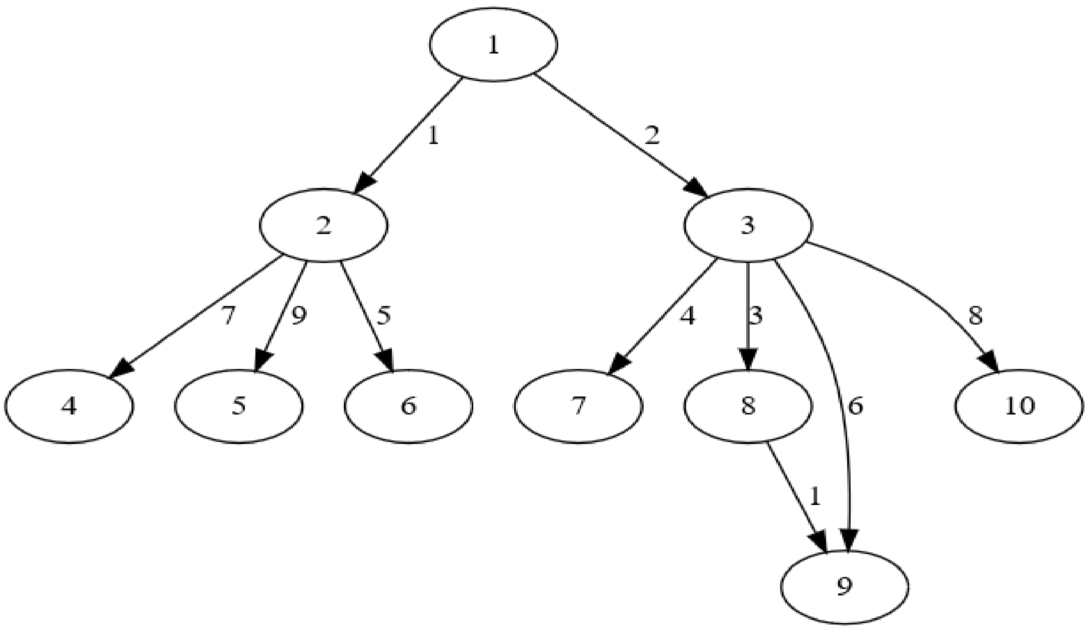
5.Implement the following
a)Greedy Best First Search
Program:

```
n=int(input("Enter number of nodes in the graph:")) #INPUT READING
cost = [[0] * n for i in range(n)]
for i in range(n):
    print(i+1,end=' ')
print("are the names of nodes")
print("Enter path costs as follows for each node accordingly and x to quit reading costs:")
print("<from_node> <to_node> <cost>")
while True:
    s=input("Enter:")
    if s=='x' or s=='X':
        break
    s=s.split()
    cost[int(s[0])-1][int(s[1])-1]=int(s[2])
h= list(map(int,input("Enter heuristic values in order:").split()))
source=int(input("Enter source node:"))-1
destination=int(input("Enter destination node:"))-1
def greed(cost,h,source,destination):
    op=[] #OPEN LIST
    c=[0] # CLOSED LIST
    while source!=destination:
        op.append(source)
        children=[]
        children_f=[]
        for i in range(len(cost[0])):
            if cost[source][i]>0: # TO CHECK IF CHILD EXISTS
                children.append(i)
                children_f.append(h[i])
        if len(children)>0:
            index=children_f.index(min(children_f)) #FINDING CHEAPEST PATH AVAILABLE
        source=children[index] #UPDATING SOURCE
    op.append(source)
    return op,c
op,c=greed(cost,h,source,destination)
print('Nodes travelled are:')
for i in op[:-1]:
    print(i+1,end='->')
print(op[-1]+1)
```

OUTPUT:

I.

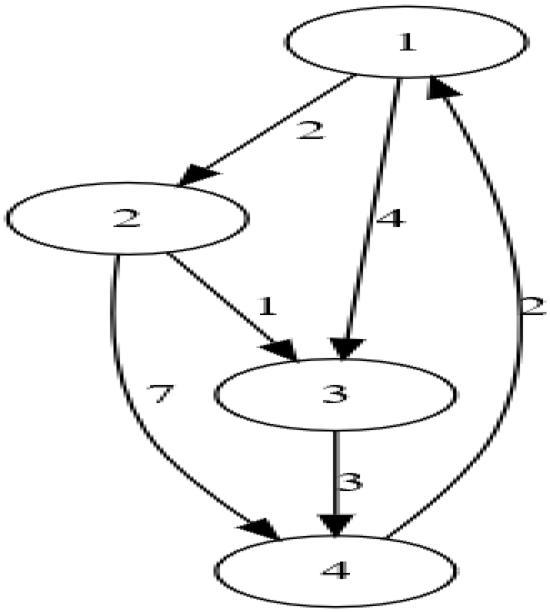
GRAPH:




```
Enter number of nodes in the graph:10
1 2 3 4 5 6 7 8 9 10 are the names of nodes
Enter path costs as follows for each node accordingly and x to quit re
ading costs:
<from_node> <to_node> <cost>
Enter:1 2 1
Enter:1 3 2
Enter:2 4 7
Enter:2 5 9
Enter:2 6 5
Enter:3 7 4
Enter:3 8 3
Enter:3 9 6
Enter:3 10 8
Enter:8 9 1
Enter:x
Enter heuristic values in order:8 10 4 15 14 12 7 2 0 4
Enter source node:1
Enter destination node:9
Nodes travelled are:
1->3->9
```

II.

GRAPH:




```
Enter number of nodes in the graph: 4
1 2 3 4 are the names of nodes
Enter path costs as follows for each node accordingly and x to quit
reading costs:
<from_node> <to_node> <cost>
Enter: 1 2 2
Enter: 1 3 4
Enter: 2 3 1
Enter: 2 4 7
Enter: 3 4 3
Enter: 4 1 2
Enter: x
Enter heuristic values in order: 5 3 2 0
Enter source node: 1
Enter destination node: 4
Nodes travelled are:
1->2->3->4
```

b)A* algorithm

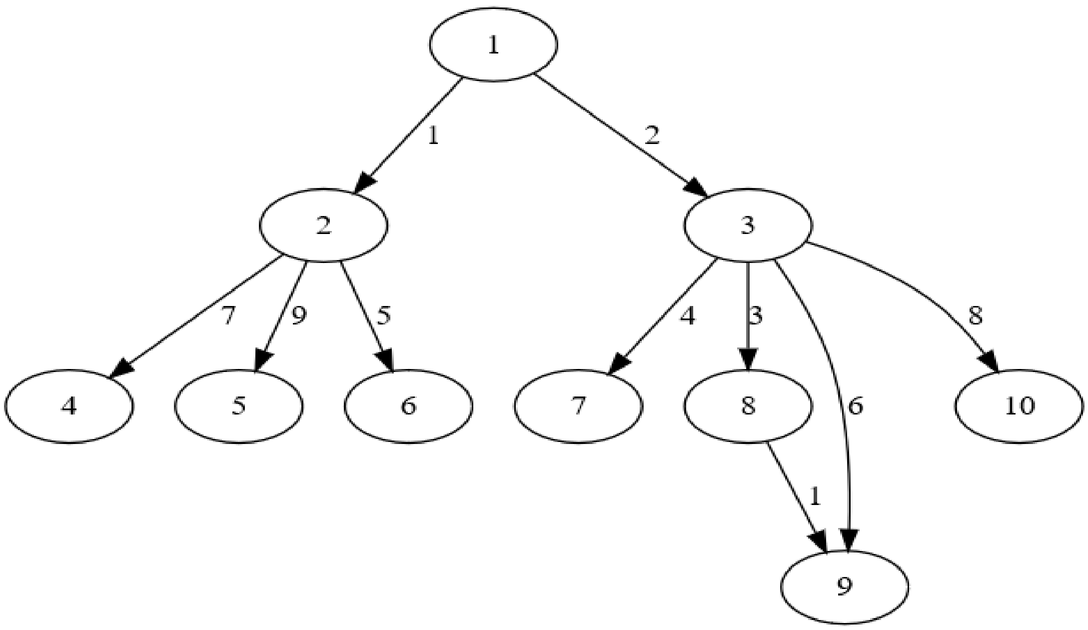
Program:

```
n=int(input("Enter number of nodes in the graph:")) #INPUT READING
cost = [[0] * n for i in range(n)]
for i in range(n):
    print(i+1,end=' ')
print("are the names of nodes")
print("Enter path costs as follows for each node accordingly and x to quit reading costs:")
print("<from_node> <to_node> <cost>")
while True:
    s=input("Enter:")
    if s=='x' or s=='X':
        break
    s=s.split()
    cost[int(s[0])-1][int(s[1])-1]=int(s[2])
h= list(map(int,input("Enter heuristic values in order:").split()))
source=int(input("Enter source node:"))-1
destination=int(input("Enter destination node:"))-1
def Astar(cost,h,source,destination):
    op=[]
    c=[0]
    while source!=destination:
        op.append(source)
        if len(op)>1:
            c.append(cost[op[-2]][op[-1]])
        children=[]
        children_f=[] #F(N) VALUES
        for i in range(len(cost[0])):
            if cost[source][i]>0:
                children.append(i)
                children_f.append(sum(c)+h[i]+cost[source][i]) #F(N)=G(N)+H(N)
        if len(children)>0:
            index=children_f.index(min(children_f)) #SLECTING CHILD BASED ON  F(N) VLAUES
        source=children[index]
    op.append(source)
    c.append(cost[op[-2]][op[-1]])
    return op,c
op,c=Astar(cost,h,source,destination)
print('Nodes travelled are:')
for i in op[:-1]:
    print(i+1,end='->')
print(op[-1]+1)
print("Cost to traverse is ",sum(c))
```

OUTPUT:

I.

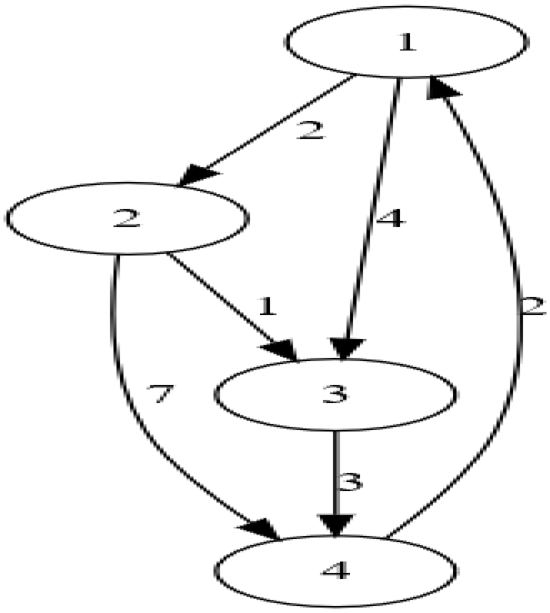
GRAPH:




```
Enter number of nodes in the graph:10
1 2 3 4 5 6 7 8 9 10 are the names of nodes
Enter path costs as follows for each node accordingly and x to quit re
ading costs:
<from_node> <to_node> <cost>
Enter:1 2 1
Enter:1 3 2
Enter:2 4 7
Enter:2 5 9
Enter:2 6 5
Enter:3 7 4
Enter:3 8 3
Enter:3 9 6
Enter:3 10 8
Enter:8 9 1
Enter:x
Enter heuristic values in order:8 10 4 15 14 12 7 2 0 4
Enter source node:1
Enter destination node:9
Nodes travelled are:
1->3->8->9
Cost to traverse is 6
```

II.

GRAPH:




```
Enter number of nodes in the graph: 4
1 2 3 4 are the names of nodes
Enter path costs as follows for each node accordingly and x to quit
reading costs:
<from_node> <to_node> <cost>
Enter: 1 2 2
Enter: 1 3 4
Enter: 2 3 1
Enter: 2 4 7
Enter: 3 4 3
Enter: 4 1 2
Enter: x
Enter heuristic values in order: 5 3 2 0
Enter source node: 1
Enter destination node: 4
Nodes travelled are:
1->2->3->4
Cost to traverse is  6
```

6. Implement 8-puzzle problem using A* algorithm.

Program:

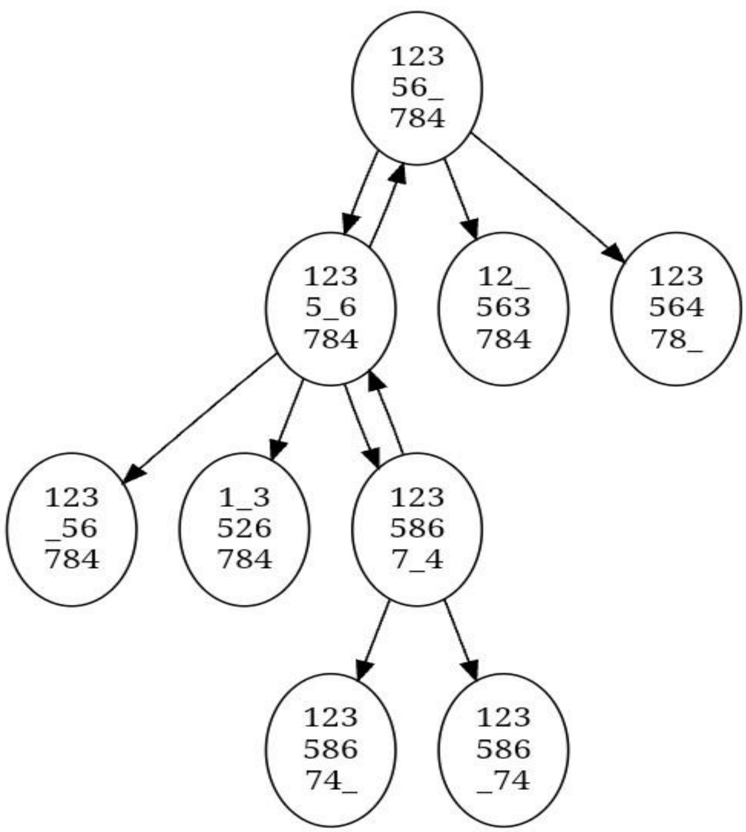
```
print("If the puzzle is \n1 2 3\n4   6\n7 5 8\ninput shall be given as 1234_6758")
start=input("Enter puzzle start state:")
final=input("Enter puzzle expected end state:")
def allpossible(state):
    l=[]
    index=state.index("_")
    if index in [0,1,3,4,6,7]: # MOVE RIGHT
        source=state[:]
        source[index],source[index+1]=source[index+1],source[index]
        l.append(''.join(source))
    if index in [1,2,4,5,7,8]: #MOVE LEFT
        source=state[:]
        source[index],source[index-1]=source[index-1],source[index]
        l.append(''.join(source))
    if index in [3,4,5,6,7,8]: #MOVE UP
        source=state[:]
        source[index],source[index-3]=source[index-3],source[index]
        l.append(''.join(source))
    if index in [0,1,2,3,4,5]: #MOVE  DOWN
        source=state[:]
        source[index],source[index+3]=source[index+3],source[index]
        l.append(''.join(source))
    return l
def heuristics(state,final): #HEURISTIC FUNCTION FINDS NUMBER OF WRONG TILES.
    state=list(state)
    final=list(final)
    c=0
    for i in range(len(state)):
        if state[i]!=final[i]:
            c+=1
    return c
def EightPuzzle(source,final):
    all_nodes=[source]
    closed_list=[]
    d={}
    cost=0
    while source!=final:
        closed_list.append(source)
        l=allpossible(list(source))
        heur=[]
        for i in l:
            heur.append(heuristics(i,final))
```

```
        index=heur.index(min(heur))
        d[source]=l
        source=l[index]
        cost=cost+1
    closed_list.append(source)
    return d,closed_list
EightPuzzle(start,final) #FUNCUTION CALL
```

OUTPUT:

I.

GRAPH:

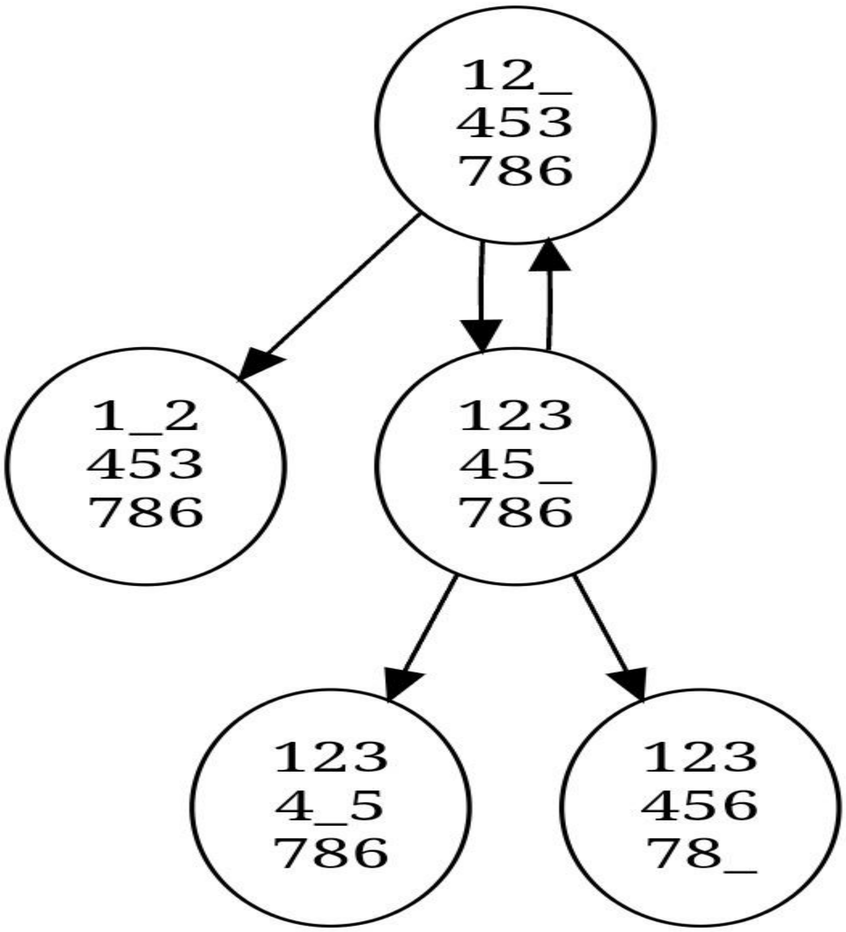



```
If the puzzle is
1 2 3
4   6
7 5 8
input shall be given as 1234_6758
Enter puzzle start state:12356_784
Enter puzzle expected end state:123586_74

({'12356_784': ['1235_6784', '12_563784', '12356478_'],
```

```
  '1235_6784': ['12356_784', '123_56784', '1_3526784', '1235867_4'],
  '1235867_4': ['12358674_', '123586_74', '1235_6784']},
 ['12356_784', '1235_6784', '1235867_4', '123586_74'])
```

II.

GRAPH:




```
If the puzzle is
1 2 3
4   6
7 5 8
input shall be given as 1234_6758
Enter puzzle start state:12_453786
Enter puzzle expected end state:12345678_
({'12_453786': ['1_2453786', '12345_786'],
  '12345_786': ['1234_5786', '12_453786', '12345678_']},
 ['12_453786', '12345_786', '12345678_'])
```

7. Implement AO* algorithm for General graph problem.

Program:

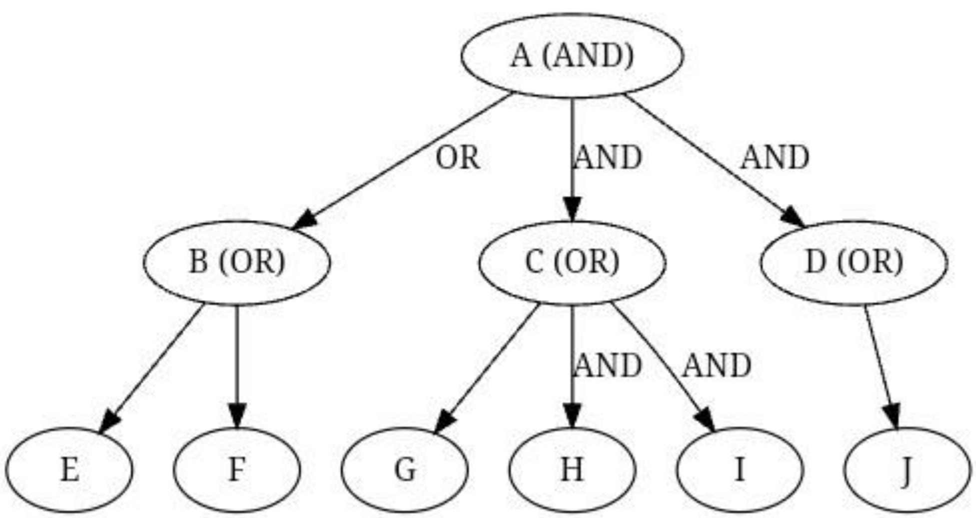
```
def cost(H, condition, weight=1):
    costs = {}
    if 'AND' in condition:
        AND_nodes = condition['AND']
        Path_A = ' AND '.join(AND_nodes)
        PathA = sum(H[node] + weight for node in AND_nodes)
        costs[Path_A] = PathA

    if  'OR' in condition:
        OR_nodes = condition['OR']
        Path_B = ' OR '.join(OR_nodes)
        PathB = min(H[node] + weight for node in OR_nodes)
        costs[Path_B] = PathB
    return costs


def  update_cost(H, Conditions, weight=1):
    main_nodes = list(Conditions.keys())
    main_nodes.reverse()
    least_cost = {}
    for key in main_nodes:
        condition = Conditions[key]
        print(key, ':', Conditions[key], '>>>', cost(H, condition, weight))
        c = cost(H, condition, weight)
        H[key] = min(c.values())
        least_cost[key] = cost(H, condition, weight)
    return least_cost


def shortest_path(Start, Updated_cost, H):
    Path = Start
    if Start in Updated_cost.keys():
        Min_cost = min(Updated_cost[Start].values())
        key = list(Updated_cost[Start].keys())
        values = list(Updated_cost[Start].values())
        Index = values.index(Min_cost)
        Next = key[Index].split()
        if len(Next) == 1:
            Start = Next[0]
            Path += '<--' + shortest_path(Start, Updated_cost, H)
        else:
            Path += '<--(' + key[Index] + ') '
```

```
            Start = Next[0]
            Path += '[' + shortest_path(Start, Updated_cost, H) + ' + '

            Start = Next[-1]
            Path += shortest_path(Start, Updated_cost, H) + ']'

    return Path
H = eval(input('Enter nodes with heuristic costs: '))
Conditions = eval(input('Enter graph: '))
weight = 1
print('Updated Cost:')
Updated_cost = update_cost(H, Conditions, weight=1)
print('Shortest Path:\n', shortest_path('A', Updated_cost, H))
```

OUTPUT:

I.

GRAPH:

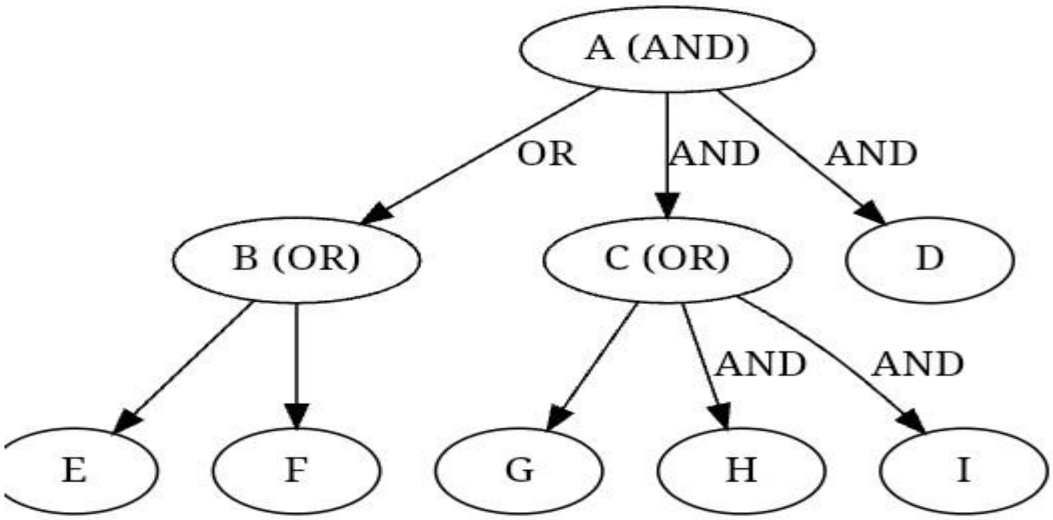



```
Enter nodes with heuristic costs: {'A': -1, 'B': 5, 'C': 2, 'D': 4,
'E': 7, 'F': 9, 'G': 3, 'H': 0, 'I': 0, 'J': 0}
Enter graph: {'A': {'OR': ['B'], 'AND': ['C', 'D']}, 'B': {'OR': ['E',
'F']}, 'C': {'OR': ['G'], 'AND': ['H', 'I']}, 'D': {'OR': ['J']}}

Updated Cost:
D : {'OR': ['J']} >>> {'J OR': 0}
C : {'OR': ['G'], 'AND': ['H', 'I']} >>> {'G OR': 3, 'H AND I': 2}
B : {'OR': ['E', 'F']} >>> {'E OR F': 6}
A : {'OR': ['B'], 'AND': ['C', 'D']} >>> {'B OR': 5, 'C AND D': 6}
```

```
Shortest Path:
 A<--(B OR) [F + E] + (C AND D) [I + H]
```

II.

GRAPH:




```
Enter nodes with heuristic costs: {'A': -1, 'B': 5, 'C': 2, 'D': 4, 'E
': 7, 'F': 9, 'G': 3, 'H': 0, 'I': 0, 'J': 0}
Enter graph: {'A': {'OR': ['B'], 'AND': ['C', 'D']}, 'B': {'OR': ['E',
'F']}, 'C': {'OR': ['G'], 'AND': ['H', 'I']}}
Updated Cost:
C : {'OR': ['G'], 'AND': ['H', 'I']} >>> {'H AND I': 2, 'G': 4}
B : {'OR': ['E', 'F']} >>> {'E OR F': 8}
A : {'OR': ['B'], 'AND': ['C', 'D']} >>> {'C AND D': 8, 'B': 9}
Shortest Path:
 A<--(C AND D) [C<--(H AND I) [H + I] + D]
```

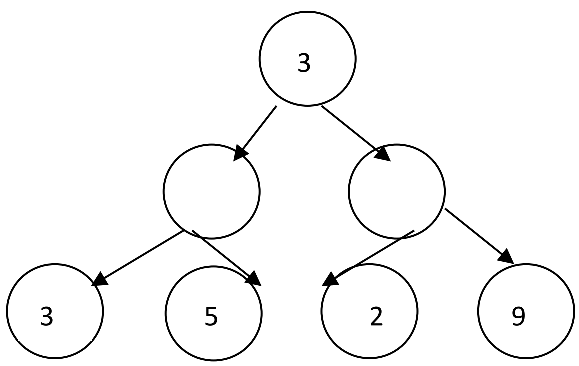
8. Implement Game trees using
a)MINIMAX algorithm
Program:

```
import math

def minimax(curDepth, nodeIndex, maxTurn, scores, targetDepth):
    if curDepth == targetDepth:
        return scores[nodeIndex]

    if maxTurn:
        return max(minimax(curDepth + 1, nodeIndex * 2, False, scores, targetDepth),
                   minimax(curDepth + 1, nodeIndex * 2 + 1, False, scores, targetDepth))
    else:
        return min(minimax(curDepth + 1, nodeIndex * 2, True, scores, targetDepth),
                   minimax(curDepth + 1, nodeIndex * 2 + 1, True, scores, targetDepth))

scores = list(map(int,input("Enter scores:").split()))
treeDepth = int(math.log(len(scores), 2))

print("The optimal value is:", minimax(0, 0, True, scores, treeDepth))
```

OUTPUT:

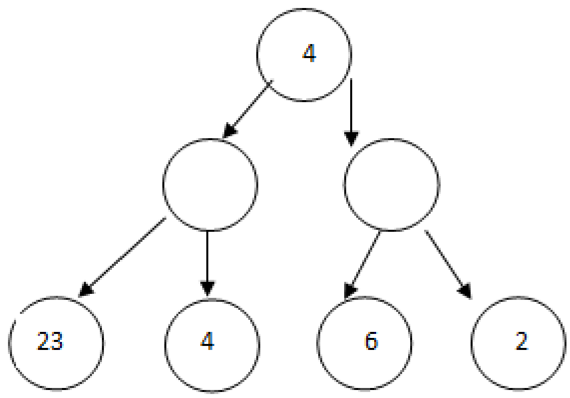
I.

GRAPH:




```
Enter scores:3 5 2 9
The optimal value is: 3
```

II.
GRAPH:




```
Enter scores:23 4 6 2
The optimal value is: 4
```

b) Alpha-Beta pruning

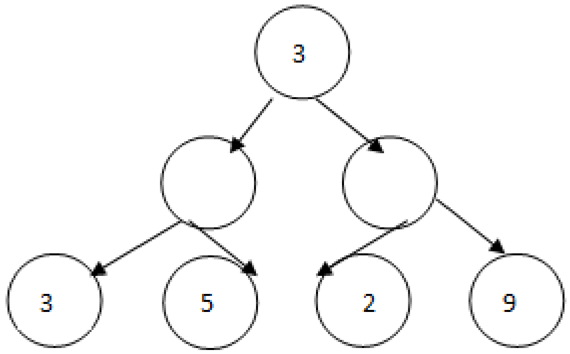
Program:

```
MAX, MIN = 1000, -1000
def minimax(depth, nodeIndex, maximizingPlayer, values, alpha, beta):
    if depth == 3:
        return values[nodeIndex]
    if maximizingPlayer:
        best = MIN
        for i in range(2):
            val = minimax(depth + 1, nodeIndex * 2 + i, False, values, alpha, beta)
            best = max(best, val)
            alpha = max(alpha, best)
            if beta <= alpha:
                break
        return best
    else:
        best = MAX
        for i in range(2):
            val = minimax(depth + 1, nodeIndex * 2 + i, True, values, alpha, beta)
            best = min(best, val)
            beta = min(beta, best)
            if beta <= alpha:
                break
        return best
values = list(map(int,input("Enter scores:").split()))
print("The optimal value is:", minimax(0, 0, True, values, MIN, MAX))
```

OUTPUT:

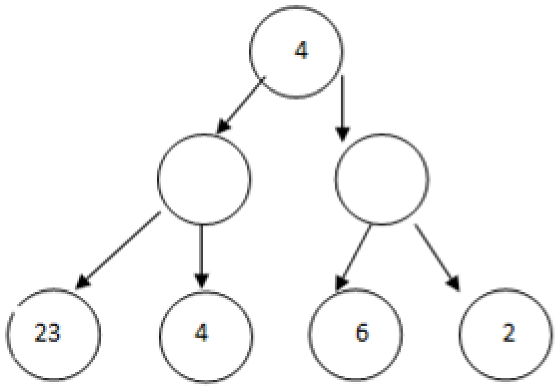
I.

GRAPH:




```
Enter scores:3 5 2 9
The optimal value is: 12
```

II.
GRAPH:




```
Enter scores: 23 4 6 2
The optimal value is: 6
```

9. Implement Crypt arithmetic problems.

Program:

```
import itertools
def number(word, digit_map):
    return int(''.join(str(digit_map[letter]) for letter in word))
def solve_cryptarithmetic(puzzle): # TRYING ALL POSSIBLE MOVES WITH CONSTRIANTS
    words = puzzle.split()
    unique_characters = set(''.join(words))
    if len(unique_characters) > 10: #NO MORE THAN 10 UNIQUE CHARS (0-9)
        return "Invalid puzzle: More than 10 unique characters"
    leading_characters = set(word[0] for word in words)
    if len(leading_characters) > 2:
        return "Invalid puzzle: More than 2 words start with the same character"
    for digits in itertools.permutations(range(10), len(unique_characters)):
        digit_map = dict(zip(unique_characters, digits))
        if all(digit_map[word[0]] != 0 for word in leading_characters):
            if sum(number(word, digit_map) for word in words[:-1]) == number(words[-1], digit_map):
                return digit_map
    return "No solution found"
puzzle = input("Enter the cryptarithmetic puzzle (words separated by spaces): ")
solution = solve_cryptarithmetic(puzzle)
print("Solution:", solution)
```

OUTPUT:

I.

```
Enter the cryptarithmetic puzzle (words separated by spaces): send
more money
Solution: {'s': 9, 'e': 5, 'n': 6, 'd': 7, 'm': 1, 'o': 0, 'r': 8,
'y': 2}
```

II.

```
Enter the cryptarithmetic puzzle (words separated by spaces): TWO TWO
FOUR
Solution: {'O': 4, 'R': 8, 'T': 7, 'U': 6, 'F': 1, 'W': 3}
```