

## TOPIC 4 : DYNAMIC PROGRAMMING

1. You are given the number of sides on a die (num\_sides), the number of dice to throw (num\_dice), and a target sum (target). Develop a program that utilizes dynamic programming to solve the Dice Throw Problem.

**Program:**

```
num_sides = 6
```

```
num_dice = 2
```

```
target = 7
```

```
dp = [[0] * (target + 1) for _ in range(num_dice + 1)]
```

```
dp[0][0] = 1
```

```
for dice in range(1, num_dice + 1):
```

```
    for curr_sum in range(1, target + 1):
```

```
        for face in range(1, num_sides + 1):
```

```
            if curr_sum - face >= 0:
```

```
                dp[dice][curr_sum] += dp[dice - 1][curr_sum - face]
```

```
print("Number of ways to get sum", target, "with",
```

```
     num_dice, "dice:", dp[num_dice][target])
```

**Sample Input:**

Simple Case:

- Number of sides: 6

- Number of dice: 2

- Target sum: 7

**Output:**

```
Number of ways to get sum 7 with 2 dice: 6
```

```
...Program finished with exit code 0
```

```
Press ENTER to exit console.
```

2. In a factory, there are two assembly lines, each with n stations. Each station performs a specific task and takes a certain amount of time to complete. The task must go through each station in order, and there is also a transfer time for

**switching from one line to another. Given the time taken at each station on both lines and the transfer time between the lines, the goal is to find the minimum time required to process a product from start to end.**

**Program:**

n = 4

a1 = [4, 5, 3, 2]

a2 = [2, 10, 1, 4]

t1 = [0, 7, 4, 5]

t2 = [0, 9, 2, 8]

e1 = 10

e2 = 12

x1 = 18

x2 = 7

f1 = [0] \* n

f2 = [0] \* n

f1[0] = e1 + a1[0]

f2[0] = e2 + a2[0]

for i in range(1, n):

    f1[i] = min(

        f1[i - 1] + a1[i],

        f2[i - 1] + t2[i] + a1[i]

    )

    f2[i] = min(

        f2[i - 1] + a2[i],

        f1[i - 1] + t1[i] + a2[i]

    )

result = min(f1[n - 1] + x1, f2[n - 1] + x2)

print("Minimum time required to process the product:", result)

**Sample Input:**

n: Number of stations on each line.

a1[i]: Time taken at station i on assembly line 1.

a2[i]: Time taken at station i on assembly line 2.

t1[i]: Transfer time from assembly line 1 to assembly line 2 after station i.

t2[i]: Transfer time from assembly line 2 to assembly line 1 after station i.

e1: Entry time to assembly line 1.

e2: Entry time to assembly line 2.

x1: Exit time from assembly line 1.

x2: Exit time from assembly line 2.

#### Output:

```
Minimum time required to process the product: 35
...Program finished with exit code 0
Press ENTER to exit console.
```

3. An automotive company has three assembly lines (Line 1, Line 2, Line 3) to produce different car models. Each line has a series of stations, and each station takes a certain amount of time to complete its task. Additionally, there are transfer times between lines, and certain dependencies must be respected due to the sequential nature of some tasks. Your goal is to minimize the total production time by determining the optimal scheduling of tasks across these lines, considering the transfer times and dependencies.

#### Program:

n = 3

```
line_times = [
    [5, 9, 3],
    [6, 8, 4],
    [7, 6, 5]
]
```

```
transfer = [
    [0, 2, 3],
    [2, 0, 4],
    [3, 4, 0]
]
```

```

dp = [[0] * 3 for _ in range(n)]

for line in range(3):
    dp[0][line] = line_times[line][0]

for station in range(1, n):
    for curr_line in range(3):
        dp[station][curr_line] = min(
            dp[station - 1][prev_line] +
            transfer[prev_line][curr_line] +
            line_times[curr_line][station]
            for prev_line in range(3)
        )
result = min(dp[n - 1])
print("Minimum total production time:", result)

```

**Sample Input:**

Number of stations: 3

- Station times:
- Line 1: [5, 9, 3]
- Line 2: [6, 8, 4]
- Line 3: [7, 6, 5]
- Transfer times:

```
[
[0, 2, 3],
[2, 0, 4],
[3, 4, 0]
]
```

**Output:**

```
Minimum total production time: 17
```

```
...Program finished with exit code 0
Press ENTER to exit console.
```

4. Write a c program to find the minimum path distance by using matrix form.

**Program:**

```
import sys
```

```

matrix = [
    [0, 10, 15, 20],
    [10, 0, 35, 25],
    [15, 35, 0, 30],
    [20, 25, 30, 0]
]

n = len(matrix)
VISITED_ALL = (1 << n) - 1

dp = [[sys.maxsize] * n for _ in range(1 << n)]

dp[1][0] = 0

for mask in range(1 << n):
    for i in range(n):
        if mask & (1 << i):
            for j in range(n):
                if not mask & (1 << j):
                    dp[mask | (1 << j)][j] = min(
                        dp[mask | (1 << j)][j],
                        dp[mask][i] + matrix[i][j]
                    )

ans = sys.maxsize
for i in range(1, n):
    ans = min(ans, dp[VISITED_ALL][i] + matrix[i][0])

print("Minimum path distance:", ans)

```

**Sample Input:**

```

{0,10,15,20}
{10,0,35,25}
{15,35,0,30}
{20,25,30,0}

```

**Output:**

```
Minimum path distance: 80
...
...Program finished with exit code 0
Press ENTER to exit console.
```

5. Assume you are solving the Traveling Salesperson Problem for 4 cities (A, B, C, D) with known distances between each pair of cities. Now, you need to add a fifth city (E) to the problem.

**Program:**

```
import itertools
```

```
cities = ['A', 'B', 'C', 'D', 'E']
```

```
dist = {
    ('A','B'): 10, ('B','A'): 10,
    ('A','C'): 15, ('C','A'): 15,
    ('A','D'): 20, ('D','A'): 20,
    ('A','E'): 25, ('E','A'): 25,
    ('B','C'): 35, ('C','B'): 35,
    ('B','D'): 25, ('D','B'): 25,
    ('B','E'): 30, ('E','B'): 30,
    ('C','D'): 30, ('D','C'): 30,
    ('C','E'): 20, ('E','C'): 20,
    ('D','E'): 15, ('E','D'): 15
}
```

```
perms = itertools.permutations(['B','C','D','E'])
```

```
min_distance = float('inf')
```

```
best_route = []
```

```
for perm in perms:
```

```
    route = ['A'] + list(perm) + ['A']
```

```
    distance = 0
```

```
    for i in range(len(route)-1):
```

```
        distance += dist[(route[i], route[i+1])]
```

```
    if distance < min_distance:
```

```
        min_distance = distance
```

```
best_route = route

print("Shortest route:", ' -> '.join(best_route))
print("Total distance:", min_distance)
```

**Sample Input:**

Symmetric Distances

- Description: All distances are symmetric (distance from A to B is the same as B to A).

Distances:

A-B: 10, A-C: 15, A-D: 20, A-E: 25 B-C: 35, B-D: 25, B-E: 30 C-D: 30, C-E: 20  
D-E: 15

**Output:**

```
Shortest route: A -> B -> D -> E -> C -> A
Total distance: 85
```

```
...Program finished with exit code 0
Press ENTER to exit console.
```

6.Given a string s, return the longest palindromic substring in S.

**Program:**

```
s = "babad"
```

```
start = 0
max_len = 1
n = len(s)
```

```
for i in range(n):
    left = i
    right = i
    while left >= 0 and right < n and s[left] == s[right]:
        if right - left + 1 > max_len:
            start = left
            max_len = right - left + 1

        left -= 1
        right += 1
```

```
left = i
right = i + 1
while left >= 0 and right < n and s[left] == s[right]:
    if right - left + 1 > max_len:
        start = left
        max_len = right - left + 1
    left -= 1
    right += 1
result = s[start:start + max_len]
print(result)
```

**Sample Input:**

```
s = "babad"
```

**Output:**

```
bab
```

```
...Program finished with exit code 0
Press ENTER to exit console.
```

7.Given a string s, find the length of the longest substring without repeating Characters.

**Program:**

```
s = "abcabcbb"
```

```
char_set = set()
left = 0
max_length = 0

for right in range(len(s)):
    while s[right] in char_set:
        char_set.remove(s[left])
        left += 1
    char_set.add(s[right])
    max_length = max(max_length, right - left + 1)

print(max_length)
```

**Sample Input:**

**Input:** s = "abcabcbb"

**Output:**

```
3
```

```
...Program finished with exit code 0
Press ENTER to exit console.
```

**8.** Given a string s and a dictionary of strings wordDict, return true if s can be segmented into a space-separated sequence of one or more dictionary words.

**Program:**

```
s = "leetcode"
wordDict = ["leet", "code"]
```

```
n = len(s)
dp = [False] * (n + 1)
dp[0] = True # Empty string can be segmented

for i in range(1, n + 1):
    for word in wordDict:
        if i >= len(word) and dp[i - len(word)] and s[i - len(word):i] == word:
            dp[i] = True
            break

print(dp[n])
```

**Sample Input:**

```
s = "leetcode", wordDict = ["leet", "code"]
```

**Output:**

```
True
```

```
...Program finished with exit code 0
Press ENTER to exit console.
```

**9.** Given an input string and a dictionary of words, find out if the input string can

**be segmented into a space-separated sequence of dictionary words.** Consider the following dictionary { i, like, sam, sung, samsung, mobile, ice, cream, icecream, man, go, mango}

**Program:**

```
s = "ilike"
wordDict = {"i", "like", "sam", "sung", "samsung", "mobile", "ice", "cream", "icecream", "man", "go", "mango"}

n = len(s)
dp = [False] * (n + 1)
dp[0] = True # Empty string can be segmented
backtrack = [0] * (n + 1)

for i in range(1, n + 1):
    for word in wordDict:
        if i >= len(word) and dp[i - len(word)] and s[i - len(word):i] == word:
            dp[i] = True
            backtrack[i] = i - len(word)
            break

if dp[n]:
    print("Yes")

    words = []
    idx = n
    while idx > 0:
        start = backtrack[idx]
        words.append(s[start:idx])
        idx = start
    words.reverse()
    print("Segmented string:", " ".join(words))
else:
    print("No")
```

**Sample Input:**

Ilike

**Output:**

```
Yes
Segmented string: i like

...Program finished with exit code 0
Press ENTER to exit console.
```

10. Given an array of strings words and a width maxWidth, format the text such that each line has exactly maxWidth characters and is fully (left and right) justified. You should pack your words in a greedy approach; that is, pack as many words as you can in each line. Pad extra spaces ' ' when necessary so that each line has exactly maxWidth characters. Extra spaces between words should be distributed as evenly as possible. If the number of spaces on a line does not divide evenly between words, the empty slots on the left will be assigned more spaces than the slots on the right. For the last line of text, it should be left-justified, and no extra space is inserted between words. A word is defined as a character sequence consisting of non-space characters only. Each word's length is guaranteed to be greater than 0 and not exceed maxWidth. The input array words contains at least one word.

**Program:**

```
words = ["This", "is", "an", "example", "of", "text", "justification."]
maxWidth = 16
```

```
res = []
i = 0
n = len(words)

while i < n:
```

```
    line_len = len(words[i])
    j = i + 1

    while j < n and line_len + 1 + len(words[j]) <= maxWidth:
        line_len += 1 + len(words[j])
        j += 1
```

```
    line_words = words[i:j]
    num_words = j - i
    line = ""
```

```

if j == n or num_words == 1:
    line = " ".join(line_words)
    line += " " * (maxWidth - len(line))
else:
    total_spaces = maxWidth - sum(len(word) for word in line_words)
    space_between = total_spaces // (num_words - 1)
    extra_spaces = total_spaces % (num_words - 1)

    for k in range(num_words - 1):
        line +== line_words[k]
        line +== " " * (space_between + (1 if k < extra_spaces else 0))
    line +== line_words[-1]

res.append(line)
i = j

for l in res:
    print(f"{l}")

```

**Sample Input:**

```

words = ["This", "is", "an", "example", "of", "text", "justification."]
maxWidth = 16

```

**Output:**

```

"This      is      an"
"example  of text"
"justification.  "

```

...Program finished with exit code 0  
 Press ENTER to exit console.

11.Design a special dictionary that searches the words in it by a prefix and a suffix.  
 Implement the WordFilter class: WordFilter(string[] words) Initializes the object with the words in the dictionary.f(string pref, string suff) Returns the index of the word in the dictionary, which has the prefix pref and the suffix suff. If there is more than one valid index, return the largest of them. If there is no such word in the dictionary, return -1

**Program:**

```
words = ["apple"]
queries = [("a", "e")] # List of (prefix, suffix) queries

word_dict = { }
for i, word in enumerate(words):
    word_dict[word] = i

for pref, suff in queries:
    max_index = -1
    for i, word in enumerate(words):
        if word.startswith(pref) and word.endswith(suff):
            max_index = max(max_index, i)
    print(max_index)
```

**Sample Input:**

```
["WordFilter", "f"]
[[["apple"]], ["a", "e"]]
```

**Output:**

```
0

...Program finished with exit code 0
Press ENTER to exit console.
```

12. Implement Floyd's Algorithm to find the shortest path between all pairs of cities. Display the distance matrix before and after applying the algorithm.

Identify and print the shortest path.

**Program:**

```
import math
n = 4
edges = [[0,1,3],[1,2,1],[1,3,4],[2,3,1]]
distanceThreshold = 4

dist = [[math.inf]*n for _ in range(n)]
for i in range(n):
    dist[i][i] = 0
```

```

for u, v, w in edges:
    dist[u][v] = w
    dist[v][u] = w

print("Distance matrix before Floyd-Warshall:")
for row in dist:
    print(row)

for k in range(n):
    for i in range(n):
        for j in range(n):
            if dist[i][j] > dist[i][k] + dist[k][j]:
                dist[i][j] = dist[i][k] + dist[k][j]
print("\nDistance matrix after Floyd-Warshall:")
for row in dist:
    print(row)
reachable_count = []
for i in range(n):
    count = sum(1 for d in dist[i] if 0 < d <= distanceThreshold)
    reachable_count.append(count)
    print(f"City {i} can reach {count} cities within distance {distanceThreshold}")
print("\nOutput:", max(reachable_count))

Sample Input:
n = 4, edges = [[0,1,3],[1,2,1],[1,3,4],[2,3,1]], distanceThreshold = 4

```

### Output:

```

Distance matrix before Floyd-Warshall:
[0, 3, inf, inf]
[3, 0, 1, 4]
[inf, 1, 0, 1]
[inf, 4, 1, 0]

Distance matrix after Floyd-Warshall:
[0, 3, 4, 5]
[3, 0, 1, 2]
[4, 1, 0, 1]
[5, 2, 1, 0]
City 0 can reach 2 cities within distance 4
City 1 can reach 3 cities within distance 4
City 2 can reach 3 cities within distance 4
City 3 can reach 2 cities within distance 4

Output: 3

... Program finished with exit code 0
Press ENTER to exit console.

```

13. Write a Program to implement Floyd's Algorithm to calculate the shortest paths between all pairs of routers. Simulate a change where the link

**between Router B and Router D fails. Update the distance matrix accordingly.  
Display the shortest path from Router A to Router F before and after the link  
Failure.**

**Program:**

```
import math
```

```
n = 6
```

```
edges = [
```

```
    [0,1,2],
```

```
    [0,2,5],
```

```
    [1,2,4],
```

```
    [1,3,6],
```

```
    [2,3,2],
```

```
    [2,4,3],
```

```
    [3,4,1],
```

```
    [4,5,2],
```

```
    [3,5,5]
```

```
]
```

```
dist = [[math.inf]*n for _ in range(n)]
```

```
for i in range(n):
```

```
    dist[i][i] = 0
```

```
for u,v,w in edges:
```

```
    dist[u][v] = w
```

```
    dist[v][u] = w
```

```
print("Distance matrix before link failure:")
```

```
for row in dist:
```

```
    print(row)
```

```
for k in range(n):
```

```
    for i in range(n):
```

```
        for j in range(n):
```

```
            if dist[i][j] > dist[i][k] + dist[k][j]:
```

```
                dist[i][j] = dist[i][k] + dist[k][j]
```

```
print("\nShortest path from Router A to Router F before link failure:", dist[0][5])
```

```
dist[1][3] = math.inf
```

```
dist[3][1] = math.inf
```

```

for k in range(n):
    for i in range(n):
        for j in range(n):
            if dist[i][j] > dist[i][k] + dist[k][j]:
                dist[i][j] = dist[i][k] + dist[k][j]

print("Shortest path from Router A to Router F after link failure:", dist[0][5])

```

**Sample Input:**

as above

**Output:**

```

Distance matrix before link failure:
[0, 2, 5, inf, inf, inf]
[2, 0, 4, 6, inf, inf]
[5, 4, 0, 2, 3, inf]
[inf, 6, 2, 0, 1, 5]
[inf, inf, 3, 1, 0, 2]
[inf, inf, inf, 5, 2, 0]

Shortest path from Router A to Router F before link failure: 10
Shortest path from Router A to Router F after link failure: 10

...Program finished with exit code 0
Press ENTER to exit console.

```

**14.Implement Floyd's Algorithm to find the shortest path between all pairs of cities. Display the distance matrix before and after applying the algorithm.**

**Identify and print the shortest path.**

**Program:**

import math

```

n = 5
edges = [[0,1,2],[0,4,8],[1,2,3],[1,4,2],[2,3,1],[3,4,1]]
distanceThreshold = 2

dist = [[math.inf]*n for _ in range(n)]
for i in range(n):

```

```

dist[i][i] = 0

for u, v, w in edges:
    dist[u][v] = w
    dist[v][u] = w

print("Distance matrix before Floyd-Warshall:")
for row in dist:
    print(row)

for k in range(n):
    for i in range(n):
        for j in range(n):
            if dist[i][j] > dist[i][k] + dist[k][j]:
                dist[i][j] = dist[i][k] + dist[k][j]

print("\nDistance matrix after Floyd-Warshall:")
for row in dist:
    print(row)

reachable_count = []
for i in range(n):
    count = sum(1 for d in dist[i] if 0 < d <= distanceThreshold)
    reachable_count.append(count)
    print(f"City {i} can reach {count} cities within distance {distanceThreshold}")

min_reachable = min(reachable_count)
print("\nOutput:", min_reachable)

```

**Sample Input:**

n = 5, edges = [[0,1,2],[0,4,8],[1,2,3],[1,4,2],[2,3,1],[3,4,1]],  
distanceThreshold = 2

**Output:**

```

Distance matrix before Floyd-Warshall:
[0, 2, inf, inf, 8]
[2, 0, 3, inf, 2]
[inf, 3, 0, 1, inf]
[inf, inf, 1, 0, 1]
[8, 2, inf, 1, 0]

Distance matrix after Floyd-Warshall:
[0, 2, 5, 5, 4]
[2, 0, 3, 3, 2]
[5, 3, 0, 1, 2]
[5, 3, 1, 0, 1]
[4, 2, 2, 1, 0]
City 0 can reach 1 cities within distance 2
City 1 can reach 2 cities within distance 2
City 2 can reach 2 cities within distance 2
City 3 can reach 2 cities within distance 2
City 4 can reach 3 cities within distance 2

Output: 1

...Program finished with exit code 0
Press ENTER to exit console.

```

**15.**Implement the Optimal Binary Search Tree algorithm for the keys A,B,C,D with frequencies 0.1,0.2,0.4,0.3 Write the code using any programming language to construct the OBST for the given keys and frequencies. Execute your code and display the resulting OBST and its cost. Print the cost and root matrix.

**Program:**

```
import pprint
```

```

keys = ['A', 'B', 'C', 'D']
freq = [0.1, 0.2, 0.4, 0.3]
n = len(keys)

cost = [[0 for _ in range(n)] for _ in range(n)]
root = [[0 for _ in range(n)] for _ in range(n)]

for i in range(n):
    cost[i][i] = freq[i]
    root[i][i] = i

for l in range(2, n+1):
    for i in range(n-l+1):
        j = i + l - 1
        cost[i][j] = float('inf')

        fsum = sum(freq[i:j+1])

        for r in range(i, j+1):
            c = (0 if r==i else cost[i][r-1]) + \

```

```

(0 if r==j else cost[r+1][j]) + fsum
if c < cost[i][j]:
    cost[i][j] = c
    root[i][j] = r

def print_obst(root, keys, i, j, parent=None, side='root'):
    if i > j:
        return
    r = root[i][j]
    node = keys[r]
    if parent is None:
        print(f"{node} is {side}")
    else:
        print(f"{node} is {side} child of {parent}")
    print_obst(root, keys, i, r-1, node, 'left')
    print_obst(root, keys, r+1, j, node, 'right')

print("Cost Matrix:")
pprint.pprint(cost)
print("\nRoot Matrix:")
pprint.pprint(root)

print("\nOptimal BST Structure:")
print_obst(root, keys, 0, n-1)

print("\nCost of Optimal BST:", round(cost[0][n-1],2))

```

**Sample Input:**

N = 4, Keys = {A,B,C,D} Frequencies = {0.1, 0.2, 0.3, 0.4}

**Output:**

```

Cost Matrix:
[[0.1, 0.4, 1.1, 1.7], [0, 0.2, 0.8, 1.4], [0, 0, 0.4, 1.0], [0, 0, 0, 0.3]]

Root Matrix:
[[0, 1, 2, 2], [0, 1, 2, 2], [0, 0, 2, 2], [0, 0, 0, 3]]

Optimal BST Structure:
C is root
B is left child of C
A is left child of B
D is right child of C

Cost of Optimal BST: 1.7

...Program finished with exit code 0
Press ENTER to exit console.

```

**16.** Consider a set of keys 10,12,16,21 with frequencies 4,2,6,3 and the respective probabilities. Write a Program to construct an OBST in a programming language of your choice. Execute your code and display the resulting OBST, its cost and root matrix.

**Program:**

```
import pprint
```

```
keys = [10, 12, 16, 21]
freq = [4, 2, 6, 3]
n = len(keys)

cost = [[0 for _ in range(n)] for _ in range(n)]
root = [[0 for _ in range(n)] for _ in range(n)]
```

```
for i in range(n):
```

```
    cost[i][i] = freq[i]
```

```
    root[i][i] = i
```

```
for l in range(2, n+1):
```

```
    for i in range(n - l + 1):
```

```
        j = i + l - 1
```

```
        cost[i][j] = float('inf')
```

```
        fsum = sum(freq[i:j+1])
```

```
        for r in range(i, j+1):
```

```
            left = 0 if r == i else cost[i][r-1]
```

```
            right = 0 if r == j else cost[r+1][j]
```

```
            c = left + right + fsum
```

```

if c < cost[i][j]:
    cost[i][j] = c
    root[i][j] = r

print("Cost Matrix:")
pprint.pprint(cost)

print("\nRoot Matrix:")
pprint.pprint(root)

stack = [(0, n-1, None, 'root')] # (i,j,parent,side)
while stack:
    i, j, parent, side = stack.pop()
    if i > j:
        continue
    r = root[i][j]
    node = keys[r]
    if parent is None:
        print(f"{node} is {side}")
    else:
        print(f"{node} is {side} child of {parent}")

    stack.append((r+1, j, node, 'right'))
    stack.append((i, r-1, node, 'left'))

print("\nCost of Optimal BST:", cost[0][n-1])

```

### Sample Input:

N = 4, Keys = {10, 12, 16, 21} Frequencies = {4, 2, 6, 3}

### Output:

```

Cost Matrix:
[[4, 8, 20, 26], [0, 2, 10, 16], [0, 0, 6, 12], [0, 0, 0, 3]]

Root Matrix:
[[0, 0, 2, 2], [0, 1, 2, 2], [0, 0, 2, 2], [0, 0, 0, 3]]
16 is root
10 is left child of 16
12 is right child of 10
21 is right child of 16

Cost of Optimal BST: 26

...Program finished with exit code 0
Press ENTER to exit console.

```

**17.A game on an undirected graph is played by two players, Mouse and Cat, who alternate turns. The graph is given as follows: graph[a] is a list of all nodes b such that ab is an edge of the graph. The mouse starts at node 1 and goes first, the cat starts at node 2 and goes second, and there is a hole at node 0. During each player's turn, they must travel along one edge of the graph that meets where they are. For example, if the Mouse is at node 1, it must travel to any node in graph[1]. Additionally, it is not allowed for the Cat to travel to the Hole (node 0).Then, the game can end in three ways:**

**Program:**

```
from collections import deque
```

```
graph = [[1,3],[0],[3],[0,2]]  
n = len(graph)  
wins)  
memo = [[[[-1]*2 for _ in range(n)] for _ in range(n)]
```

```
queue = deque()
```

```
for c in range(n):  
    if c != 0:  
        memo[0][c][0] = 1  
        memo[0][c][1] = 1  
        queue.append((0,c,0))  
        queue.append((0,c,1))
```

```
for m in range(1,n):  
    memo[m][m][0] = 2  
    memo[m][m][1] = 2  
    queue.append((m,m,0))  
    queue.append((m,m,1))
```

```
def next_positions(mouse, cat, turn):  
    if turn == 0:  
        for mnex in graph[mouse]:  
            yield (mnex, cat, 1)  
    else:  
        for cnex in graph[cat]:  
            if cnex != 0:  
                yield (mouse, cnex, 0)
```

```

while queue:
    mouse, cat, turn = queue.popleft()
    result = memo[mouse][cat][turn]
    prev_turn = 1 - turn
    for pmouse, pcat, _ in next_positions(mouse, cat, prev_turn):
        if memo[pmouse][pcat][prev_turn] == -1:
            if result == (prev_turn + 1):
                memo[pmouse][pcat][prev_turn] = result
                queue.append((pmouse, pcat, prev_turn))
res = memo[1][2][0]
print(res)

```

**Sample Input:**

```
graph = [[1,3],[0],[3],[0,2]]
```

**Output:**

```
1

...Program finished with exit code 0
Press ENTER to exit console.
```

**18.** You are given an undirected weighted graph of n nodes (0-indexed), represented by an edge list where edges[i] = [a, b] is an undirected edge connecting the nodes a and b with a probability of success of traversing that edge succProb[i]. Given two nodes start and end, find the path with the maximum probability of success to go from start to end and return its success probability. If there is no path from start to end, return 0. Your answer will be accepted if it differs from the correct answer by at most 1e-5.

**Program:**

```
import heapq
```

```
n = 3
edges = [[0,1],[1,2],[0,2]]
succProb = [0.5,0.5,0.2]
start = 0
end = 2
```

```

graph = [[] for _ in range(n)]
for (u, v), prob in zip(edges, succProb):
    graph[u].append((v, prob))
    graph[v].append((u, prob))

heap = [(-1.0, start)]
visited = [0.0] * n
visited[start] = 1.0

while heap:
    prob, node = heapq.heappop(heap)
    prob = -prob
    if node == end:
        print(f"{prob:.5f}")
        break
    for nei, p in graph[node]:
        new_prob = prob * p
        if new_prob > visited[nei]:
            visited[nei] = new_prob
            heapq.heappush(heap, (-new_prob, nei))
else:
    print("0.00000")

```

**Sample Input:**

n = 3, edges = [[0,1],[1,2],[0,2]], succProb = [0.5,0.5,0.2], start = 0, end = 2

**Output:**

0.25000

...Program finished with exit code 0  
Press ENTER to exit console.

19. There is a robot on an  $m \times n$  grid. The robot is initially located at the top-left corner (i.e.,  $\text{grid}[0][0]$ ). The robot tries to move to the bottom-right corner (i.e.,  $\text{grid}[m - 1][n - 1]$ ). The robot can only move either down or right at any point in time. Given the two integers  $m$  and  $n$ , return the number of possible unique paths that the robot can take to reach the bottom-right corner. The test cases are generated so that the answer will be less than or equal to  $2 * 10^9$ .

**Program:**

```
m = 3
```

```
n = 7
```

```
dp = [[1]*n for _ in range(m)]
for i in range(1, m):
    for j in range(1, n):
        dp[i][j] = dp[i-1][j] + dp[i][j-1]
print(dp[m-1][n-1])
```

**Sample Input:**

```
m = 3, n = 7
```

**Output:**

```
28
```

```
...Program finished with exit code 0
Press ENTER to exit console.
```

20. Given an array of integers nums, return the number of good pairs. A pair (i, j) is called good if  $\text{nums}[i] == \text{nums}[j]$  and  $i < j$ .

**Program:**

```
nums = [1,2,3,1,1,3]
```

```
count = 0
for i in range(len(nums)):
    for j in range(i+1, len(nums)):
        if nums[i] == nums[j]:
            count += 1
print(count)
```

**Sample Input:**

```
nums = [1,2,3,1,1,3]
```

**Output:**

```
4
```

```
...Program finished with exit code 0
Press ENTER to exit console.
```

21. There are n cities numbered from 0 to n-1. Given the array edges where edges[i] = [fromi, toi, weighti] represents a bidirectional and weighted edge between cities fromi and toi, and given the integer distanceThreshold. Return the city with the smallest number of cities that are reachable through some path and whose distance is at most distanceThreshold. If there are multiple such cities, return the city with the greatest number. Notice that the distance of a path connecting cities i and j is equal to the sum of the edges' weights along that path.

**Program:**

```
n = 4
edges = [[0,1,3],[1,2,1],[1,3,4],[2,3,1]]
distanceThreshold = 4
```

```
INF = float('inf')
dist = [[INF]*n for _ in range(n)]
for i in range(n):
    dist[i][i] = 0

for u, v, w in edges:
    dist[u][v] = w
    dist[v][u] = w

for k in range(n):
    for i in range(n):
        for j in range(n):
            if dist[i][j] > dist[i][k] + dist[k][j]:
                dist[i][j] = dist[i][k] + dist[k][j]

min_count = n
result_city = -1
for i in range(n):
    count = sum(1 for j in range(n) if i != j and dist[i][j] <= distanceThreshold)
    if count <= min_count:
        min_count = count
        result_city = i # pick greatest city in case of tie
```

```
print(result_city)
```

**Sample Input:**

n = 4, edges = [[0,1,3],[1,2,1],[1,3,4],[2,3,1]], distanceThreshold = 4

**Output:**

```
3
```

```
...Program finished with exit code 0
```

```
Press ENTER to exit console.
```

22. You are given a network of n nodes, labeled from 1 to n. You are also given times, a list of travel times as directed edges times[i] = (ui, vi, wi), where ui is the source node, vi is the target node, and wi is the time it takes for a signal to travel from source to target. We will send a signal from a given node k. Return the minimum time it takes for all the n nodes to receive the signal. If it is impossible for all the n nodes to receive the signal, return -1.

**Program:**

```
import heapq
```

```
times = [[2,1,1],[2,3,1],[3,4,1]]
```

```
n = 4
```

```
k = 2
```

```
graph = [[] for _ in range(n+1)]
```

```
for u, v, w in times:
```

```
    graph[u].append((v, w))
```

```
dist = [float('inf')] * (n + 1)
```

```
dist[k] = 0
```

```
heap = [(0, k)]
```

```
while heap:
```

```
    time, node = heapq.heappop(heap)
```

```
    if time > dist[node]:
```

```
        continue
```

```
    for nei, w in graph[node]:
```

```
        if dist[nei] > time + w:
```

```
dist[nei] = time + w
heapq.heappush(heap, (dist[nei], nei))

res = max(dist[1:])
print(res if res != float('inf') else -1)
```

**Sample Input:**

```
times = [[2,1,1],[2,3,1],[3,4,1]], n = 4, k = 2
```

**Output:**

```
2
```

```
...Program finished with exit code 0
Press ENTER to exit console.
```