Practical – 5

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Batch: B4

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Aim: Implement a dynamic algorithm for Longest Common Subsequence (LCS) to find the length and LCS for DNA sequences.

Problem Statement:

(i) DNA sequences can be viewed as strings of A, C, G, and T characters, which represent nucleotides. Finding the similarities between two DNA sequences are an important computation performed in bioinformatics.

[Note that a subsequence might not include consecutive elements of the original sequence.]

TASK 1: Find the similarity between the given X and Y sequence.

X=AGCCCTAAGGGCTACCTAGCTT

Y= GACAGCCTACAAGCGTTAGCTTG

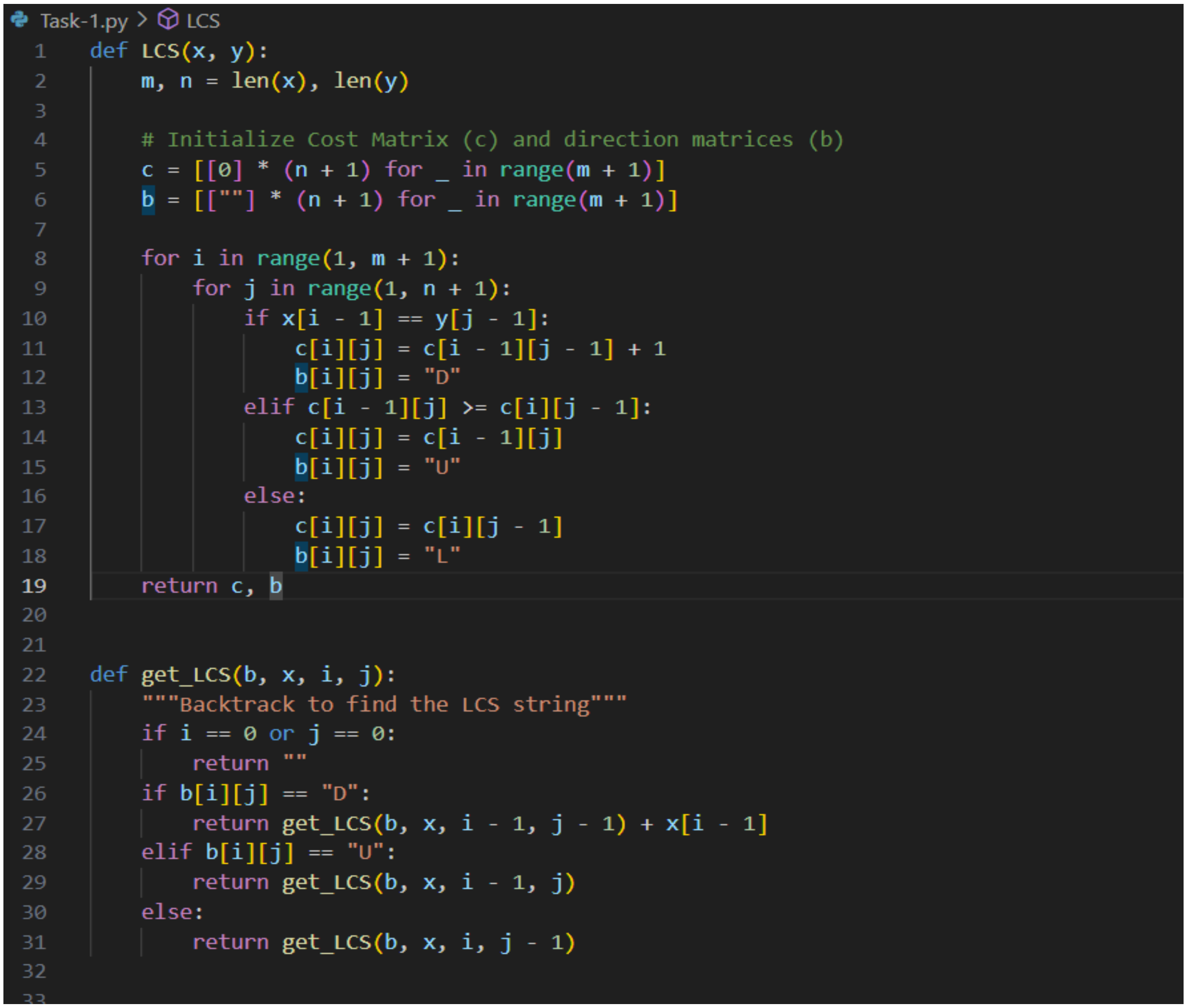
Output: Cost matrix with all costs and direction, final cost of LCS and the LCS.

Length of LCS=16

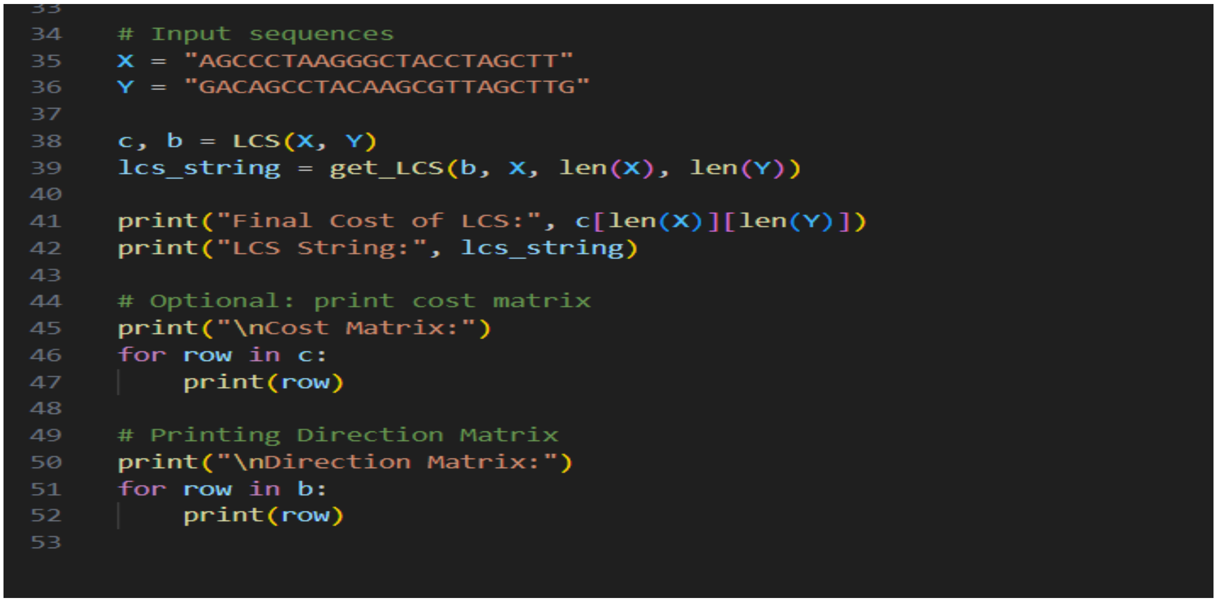
CODE:

```
def LCS(x, y):
    m, n = len(x), len(y)

    # Initialize Cost Matrix (c) and direction matrices (b)
    c = [[0] * (n + 1) for _ in range(m + 1)]
    b = [[""] * (n + 1) for _ in range(m + 1)]
    for i in range(1, m + 1):
        for j in range(1, n + 1):
            if x[i - 1] == y[j - 1]:
                c[i][j] = c[i - 1][j - 1] + 1
                b[i][j] = "D"
            elif c[i - 1][j] >= c[i][j - 1]:
                c[i][j] = c[i - 1][j]
                b[i][j] = "U"
            else:
                c[i][j] = c[i][j - 1]
                b[i][j] = "L"
    return c, b


def get_LCS(b, x, i, j):
    """Backtrack to find the LCS string"""
    if i == 0 or j == 0:
        return ""
    if b[i][j] == "D":
        return get_LCS(b, x, i - 1, j - 1) + x[i - 1]
    elif b[i][j] == "U":
        return get_LCS(b, x, i - 1, j)
    else:
        return get_LCS(b, x, i, j - 1)


# Input sequences
X = "AGCCCTAAGGGCTACCTAGCTT"
Y = "GACAGCCTACAAGCGTTAGCTTG"

c, b = LCS(X, Y)
lcs_string = get_LCS(b, X, len(X), len(Y))

print("Final Cost of LCS:", c[len(X)][len(Y)])
print("LCS String:", lcs_string)

# Optional: print cost matrix
print("\nCost Matrix:")
for row in c:
    print(row)

# Printing Direction Matrix
print("\nDirection Matrix:")
for row in b:
    print(row)
```

Code Screenshot:

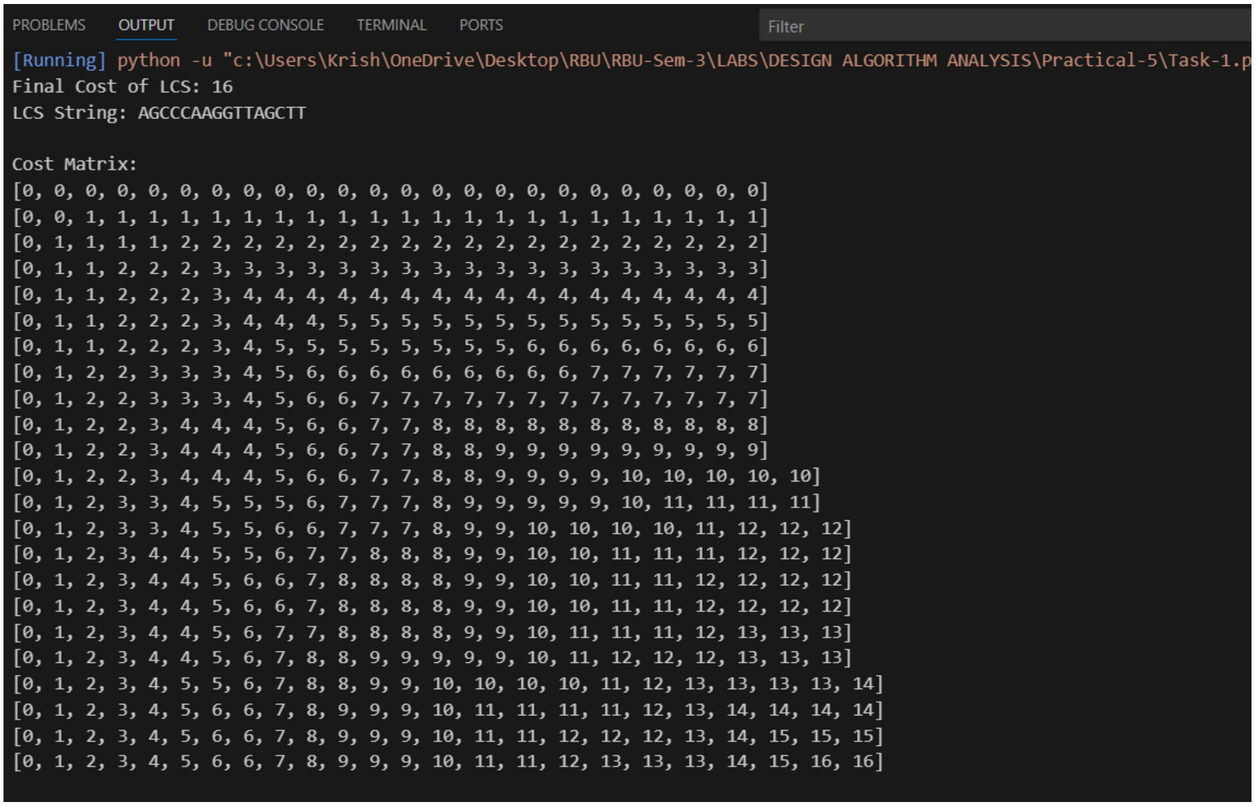


```python
def LCS(x, y):
    m, n = len(x), len(y)

    # Initialize Cost Matrix (c) and direction matrices (b)
    c = [[0] * (n + 1) for _ in range(m + 1)]
    b = [[""] * (n + 1) for _ in range(m + 1)]

    for i in range(1, m + 1):
        for j in range(1, n + 1):
            if x[i - 1] == y[j - 1]:
                c[i][j] = c[i - 1][j - 1] + 1
                b[i][j] = "D"
            elif c[i - 1][j] >= c[i][j - 1]:
                c[i][j] = c[i - 1][j]
                b[i][j] = "U"
            else:
                c[i][j] = c[i][j - 1]
                b[i][j] = "L"
    return c, b


def get_LCS(b, x, i, j):
    """Backtrack to find the LCS string"""
    if i == 0 or j == 0:
        return ""
    if b[i][j] == "D":
        return get_LCS(b, x, i - 1, j - 1) + x[i - 1]
    elif b[i][j] == "U":
        return get_LCS(b, x, i - 1, j)
    else:
        return get_LCS(b, x, i, j - 1)

```

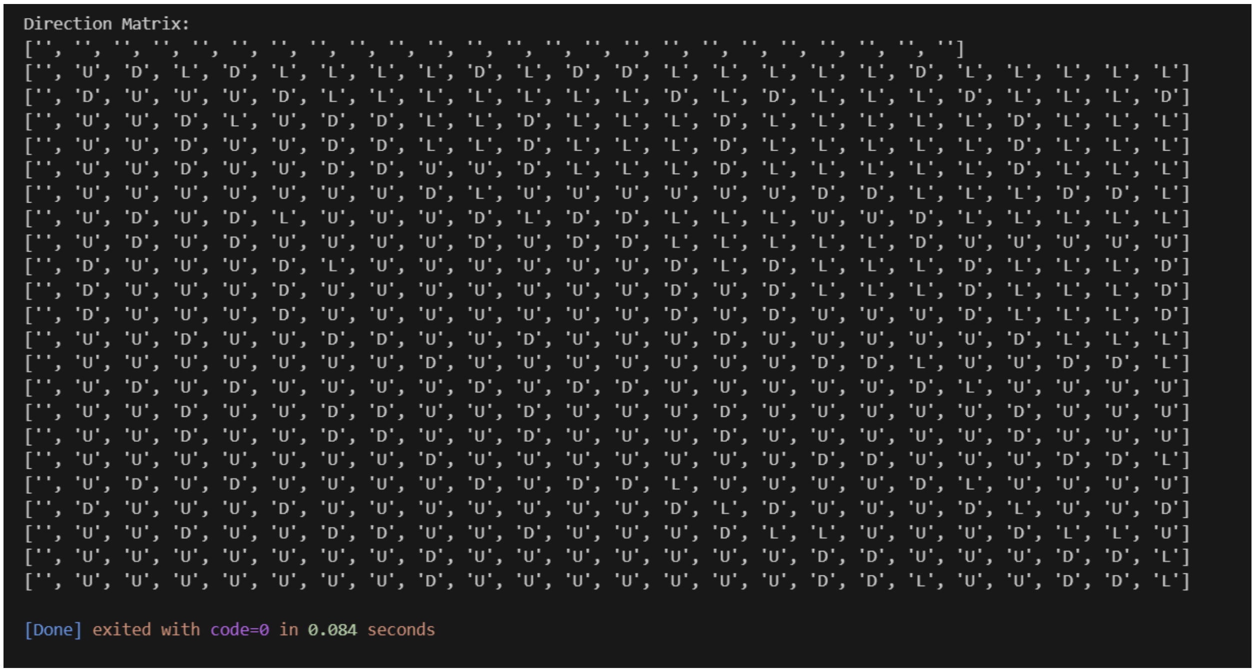


```python
# Input sequences
X = "AGCCCTAAGGGCTACCTAGCTT"
Y = "GACAGCCTACAAGCGTTAGCTTG"

c, b = LCS(X, Y)
lcs_string = get_LCS(b, X, len(X), len(Y))

print("Final Cost of LCS:", c[len(X)][len(Y)])
print("LCS String:", lcs_string)

# Optional: print cost matrix
print("\nCost Matrix:")
for row in c:
    print(row)

# Printing Direction Matrix
print("\nDirection Matrix:")
for row in b:
    print(row)

```

Code Output:



```
[Running] python -u "c:\Users\Krish\OneDrive\Desktop\RBU\RBU-Sem-3\LABS\DESIGN ALGORITHM ANALYSIS\Practical-5\Task-1.p
Final Cost of LCS: 16
LCS String: AGCCCAAGGTTAGCTT

Cost Matrix:
[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0]
[0, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1]
[0, 1, 1, 1, 1, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2]
[0, 1, 1, 2, 2, 2, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3]
[0, 1, 1, 2, 2, 2, 3, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4]
[0, 1, 1, 2, 2, 2, 3, 4, 4, 4, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5]
[0, 1, 1, 2, 2, 2, 3, 4, 5, 5, 5, 5, 5, 5, 5, 5, 6, 6, 6, 6, 6, 6, 6, 6]
[0, 1, 2, 2, 3, 3, 3, 4, 5, 6, 6, 6, 6, 6, 6, 6, 6, 6, 7, 7, 7, 7, 7, 7]
[0, 1, 2, 2, 3, 3, 3, 4, 5, 6, 6, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7]
[0, 1, 2, 2, 3, 4, 4, 4, 5, 6, 6, 7, 7, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8]
[0, 1, 2, 2, 3, 4, 4, 4, 5, 6, 6, 7, 7, 8, 8, 9, 9, 9, 9, 9, 9, 9, 9, 9]
[0, 1, 2, 2, 3, 4, 4, 4, 5, 6, 6, 7, 7, 8, 8, 9, 9, 9, 9, 10, 10, 10, 10, 10]
[0, 1, 2, 3, 3, 4, 5, 5, 5, 6, 7, 7, 7, 8, 9, 9, 9, 9, 9, 10, 11, 11, 11, 11]
[0, 1, 2, 3, 3, 4, 5, 5, 6, 6, 7, 7, 7, 8, 9, 9, 10, 10, 10, 10, 11, 12, 12, 12]
[0, 1, 2, 3, 4, 4, 5, 5, 6, 7, 7, 8, 8, 8, 9, 9, 10, 10, 11, 11, 11, 12, 12, 12]
[0, 1, 2, 3, 4, 4, 5, 6, 6, 7, 8, 8, 8, 8, 9, 9, 10, 10, 11, 11, 12, 12, 12, 12]
[0, 1, 2, 3, 4, 4, 5, 6, 6, 7, 8, 8, 8, 8, 9, 9, 10, 10, 11, 11, 12, 12, 12, 12]
[0, 1, 2, 3, 4, 4, 5, 6, 7, 7, 8, 8, 8, 8, 9, 9, 10, 11, 11, 11, 12, 13, 13, 13]
[0, 1, 2, 3, 4, 4, 5, 6, 7, 8, 8, 9, 9, 9, 9, 9, 10, 11, 12, 12, 12, 13, 13, 13]
[0, 1, 2, 3, 4, 5, 5, 6, 7, 8, 8, 9, 9, 10, 10, 10, 10, 11, 12, 13, 13, 13, 13, 14]
[0, 1, 2, 3, 4, 5, 6, 6, 7, 8, 9, 9, 9, 10, 11, 11, 11, 11, 12, 13, 14, 14, 14, 14]
[0, 1, 2, 3, 4, 5, 6, 6, 7, 8, 9, 9, 9, 10, 11, 11, 12, 12, 12, 13, 14, 15, 15, 15]
[0, 1, 2, 3, 4, 5, 6, 6, 7, 8, 9, 9, 9, 10, 11, 11, 12, 13, 13, 13, 14, 15, 16, 16]
```



```
Direction Matrix:
['', '', '', '', '', '', '', '', '', '', '', '', '', '', '', '', '', '', '', '', '', '', '', '']
['', 'U', 'D', 'L', 'D', 'L', 'L', 'L', 'L', 'D', 'L', 'D', 'D', 'L', 'L', 'L', 'L', 'L', 'D', 'L', 'L', 'L', 'L', 'L']
['', 'D', 'U', 'U', 'U', 'D', 'L', 'L', 'L', 'L', 'L', 'L', 'L', 'D', 'L', 'D', 'L', 'L', 'L', 'D', 'L', 'L', 'L', 'D']
['', 'U', 'U', 'D', 'L', 'U', 'D', 'D', 'L', 'L', 'D', 'L', 'L', 'L', 'D', 'L', 'L', 'L', 'L', 'L', 'D', 'L', 'L', 'L']
['', 'U', 'U', 'D', 'U', 'U', 'D', 'D', 'L', 'L', 'D', 'L', 'L', 'L', 'D', 'L', 'L', 'L', 'L', 'L', 'D', 'L', 'L', 'L']
['', 'U', 'U', 'D', 'U', 'U', 'D', 'D', 'U', 'U', 'D', 'L', 'L', 'L', 'D', 'L', 'L', 'L', 'L', 'L', 'D', 'L', 'L', 'L']
['', 'U', 'U', 'U', 'U', 'U', 'U', 'U', 'D', 'L', 'U', 'U', 'U', 'U', 'U', 'U', 'D', 'D', 'L', 'L', 'L', 'D', 'D', 'L']
['', 'U', 'D', 'U', 'D', 'L', 'U', 'U', 'U', 'D', 'L', 'D', 'D', 'L', 'L', 'L', 'U', 'U', 'D', 'L', 'L', 'L', 'L', 'L']
['', 'U', 'D', 'U', 'D', 'U', 'U', 'U', 'U', 'D', 'U', 'D', 'D', 'L', 'L', 'L', 'L', 'L', 'D', 'U', 'U', 'U', 'U', 'U']
['', 'D', 'U', 'U', 'U', 'D', 'L', 'U', 'U', 'U', 'U', 'U', 'U', 'D', 'L', 'D', 'L', 'L', 'L', 'D', 'L', 'L', 'L', 'D']
['', 'D', 'U', 'U', 'U', 'D', 'U', 'U', 'U', 'U', 'U', 'U', 'U', 'D', 'U', 'D', 'L', 'L', 'L', 'D', 'L', 'L', 'L', 'D']
['', 'D', 'U', 'U', 'U', 'D', 'U', 'U', 'U', 'U', 'U', 'U', 'U', 'D', 'U', 'D', 'U', 'U', 'U', 'D', 'L', 'L', 'L', 'D']
['', 'U', 'U', 'D', 'U', 'U', 'D', 'D', 'U', 'U', 'D', 'U', 'U', 'U', 'D', 'U', 'U', 'U', 'U', 'U', 'D', 'L', 'L', 'L']
['', 'U', 'U', 'U', 'U', 'U', 'U', 'U', 'D', 'U', 'U', 'U', 'U', 'U', 'U', 'U', 'D', 'D', 'L', 'U', 'U', 'D', 'D', 'L']
['', 'U', 'D', 'U', 'D', 'U', 'U', 'U', 'U', 'D', 'U', 'D', 'D', 'U', 'U', 'U', 'U', 'U', 'D', 'L', 'U', 'U', 'U', 'U']
['', 'U', 'U', 'D', 'U', 'U', 'D', 'D', 'U', 'U', 'D', 'U', 'U', 'U', 'D', 'U', 'U', 'U', 'U', 'U', 'D', 'U', 'U', 'U']
['', 'U', 'U', 'D', 'U', 'U', 'D', 'D', 'U', 'U', 'D', 'U', 'U', 'U', 'D', 'U', 'U', 'U', 'U', 'U', 'D', 'U', 'U', 'U']
['', 'U', 'U', 'U', 'U', 'U', 'U', 'U', 'D', 'U', 'U', 'U', 'U', 'U', 'U', 'U', 'D', 'D', 'U', 'U', 'U', 'D', 'D', 'L']
['', 'U', 'D', 'U', 'D', 'U', 'U', 'U', 'U', 'D', 'U', 'D', 'D', 'L', 'U', 'U', 'U', 'U', 'D', 'L', 'U', 'U', 'U', 'U']
['', 'D', 'U', 'U', 'U', 'D', 'U', 'U', 'U', 'U', 'U', 'U', 'U', 'D', 'L', 'D', 'U', 'U', 'U', 'D', 'L', 'U', 'U', 'D']
['', 'U', 'U', 'D', 'U', 'U', 'D', 'D', 'U', 'U', 'D', 'U', 'U', 'U', 'D', 'L', 'L', 'U', 'U', 'U', 'D', 'L', 'L', 'U']
['', 'U', 'U', 'U', 'U', 'U', 'U', 'U', 'D', 'U', 'U', 'U', 'U', 'U', 'U', 'U', 'D', 'D', 'U', 'U', 'U', 'D', 'D', 'L']
['', 'U', 'U', 'U', 'U', 'U', 'U', 'U', 'D', 'U', 'U', 'U', 'U', 'U', 'U', 'U', 'D', 'D', 'L', 'U', 'U', 'D', 'D', 'L']

[Done] exited with code=0 in 0.084 seconds
```

TASK-2: Find the longest repeating subsequence (LRS). Consider it as a variation of the

longest common subsequence (LCS) problem. Let the given string be S. You need to find the LRS within S. To use the LCS framework, you effectively compare S with itself. So, consider string1 = S and string2 = S.

Example:

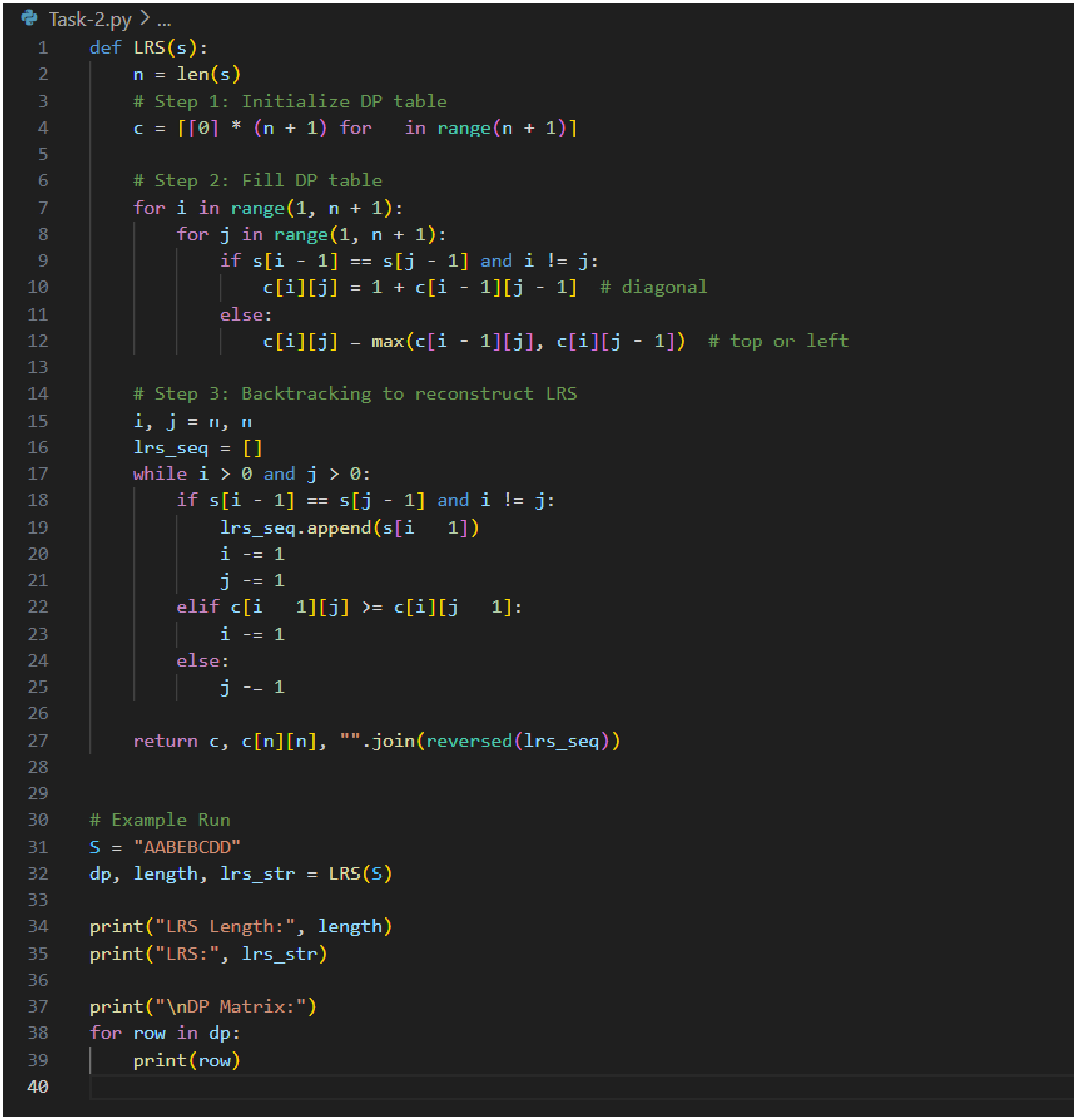
AABCBDC

LRS= ABC or ABD

CODE:

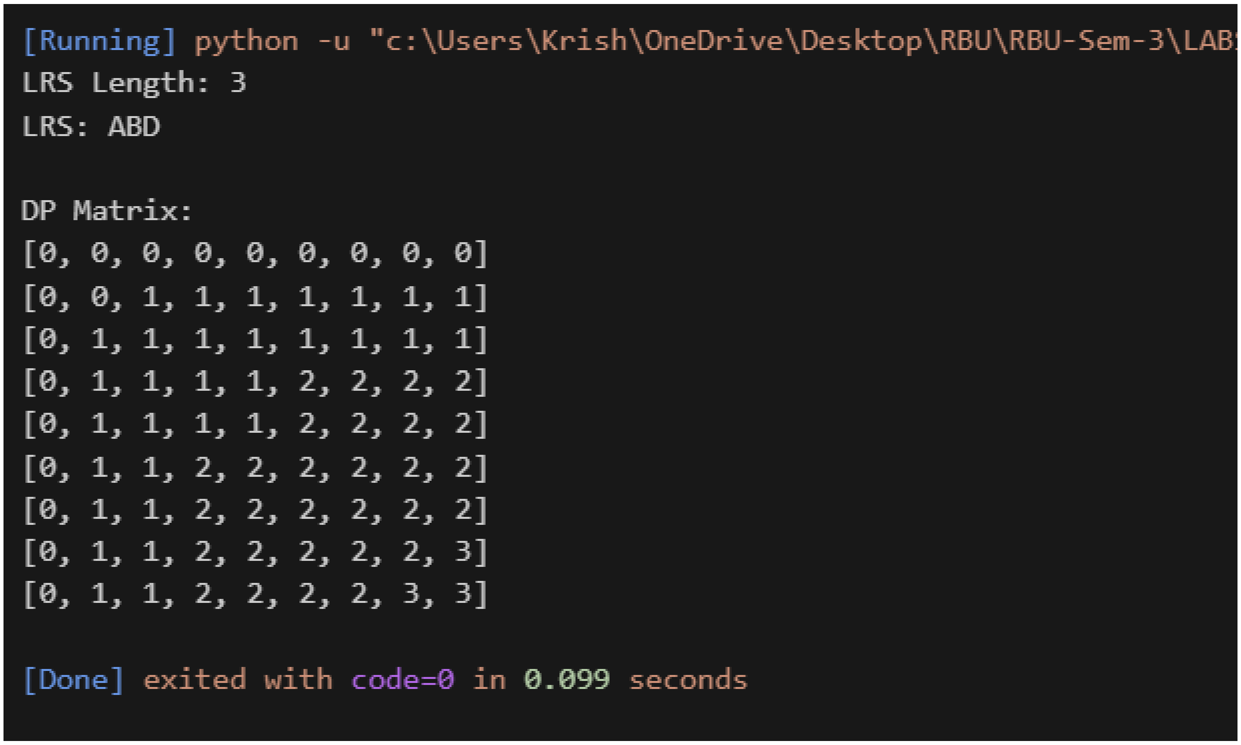
```
def LRS(s):
    n = len(s)
    # Step 1: Initialize DP table
    c = [[0] * (n + 1) for _ in range(n + 1)]

    # Step 2: Fill DP table
    for i in range(1, n + 1):
        for j in range(1, n + 1):
            if s[i - 1] == s[j - 1] and i != j:
                c[i][j] = 1 + c[i - 1][j - 1]  # diagonal
            else:
                c[i][j] = max(c[i - 1][j], c[i][j - 1])  # top or left

    # Step 3: Backtracking to reconstruct LRS
    i, j = n, n
    lrs_seq = []
    while i > 0 and j > 0:
        if s[i - 1] == s[j - 1] and i != j:
            lrs_seq.append(s[i - 1])
            i -= 1
            j -= 1
        elif c[i - 1][j] >= c[i][j - 1]:
            i -= 1
        else:
            j -= 1

    return c, c[n][n], "".join(reversed(lrs_seq))


# Example Run
S = "AABEBCDD"
dp, length, lrs_str = LRS(S)

print("LRS Length:", length)
print("LRS:", lrs_str)
print("\nDP Matrix:")
for row in dp:
    print(row)
```

Code Screenshot:



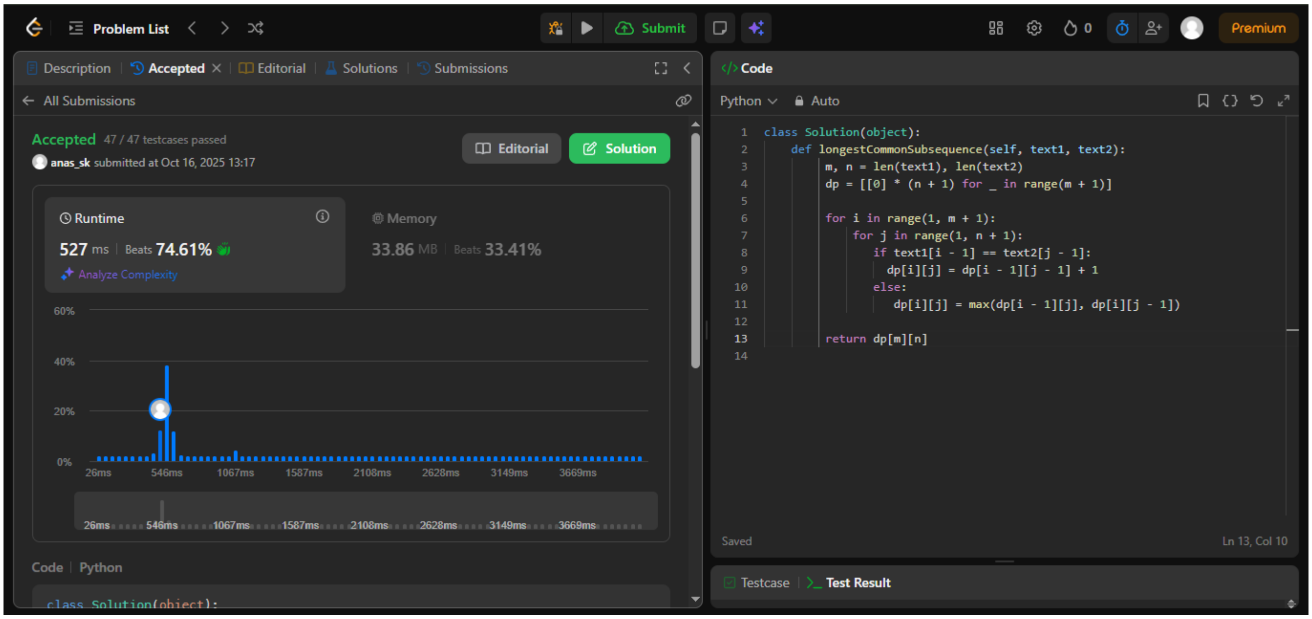
```
def LRS(s):
    n = len(s)
    # Step 1: Initialize DP table
    c = [[0] * (n + 1) for _ in range(n + 1)]

    # Step 2: Fill DP table
    for i in range(1, n + 1):
        for j in range(1, n + 1):
            if s[i - 1] == s[j - 1] and i != j:
                c[i][j] = 1 + c[i - 1][j - 1]  # diagonal
            else:
                c[i][j] = max(c[i - 1][j], c[i][j - 1])  # top or left

    # Step 3: Backtracking to reconstruct LRS
    i, j = n, n
    lrs_seq = []
    while i > 0 and j > 0:
        if s[i - 1] == s[j - 1] and i != j:
            lrs_seq.append(s[i - 1])
            i -= 1
            j -= 1
        elif c[i - 1][j] >= c[i][j - 1]:
            i -= 1
        else:
            j -= 1

    return c, c[n][n], "".join(reversed(lrs_seq))


# Example Run
S = "AABEBCDD"
dp, length, lrs_str = LRS(S)

print("LRS Length:", length)
print("LRS:", lrs_str)

print("\nDP Matrix:")
for row in dp:
    print(row)

```

Code Output:



```
[Running] python -u "c:\Users\Krish\OneDrive\Desktop\RBU\RBU-Sem-3\LAB
LRS Length: 3
LRS: ABD

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

[Done] exited with code=0 in 0.099 seconds
```

Leetcode Question:
linke : https://leetcode.com/problems/longest-common-subsequence/submissions/1803160931/



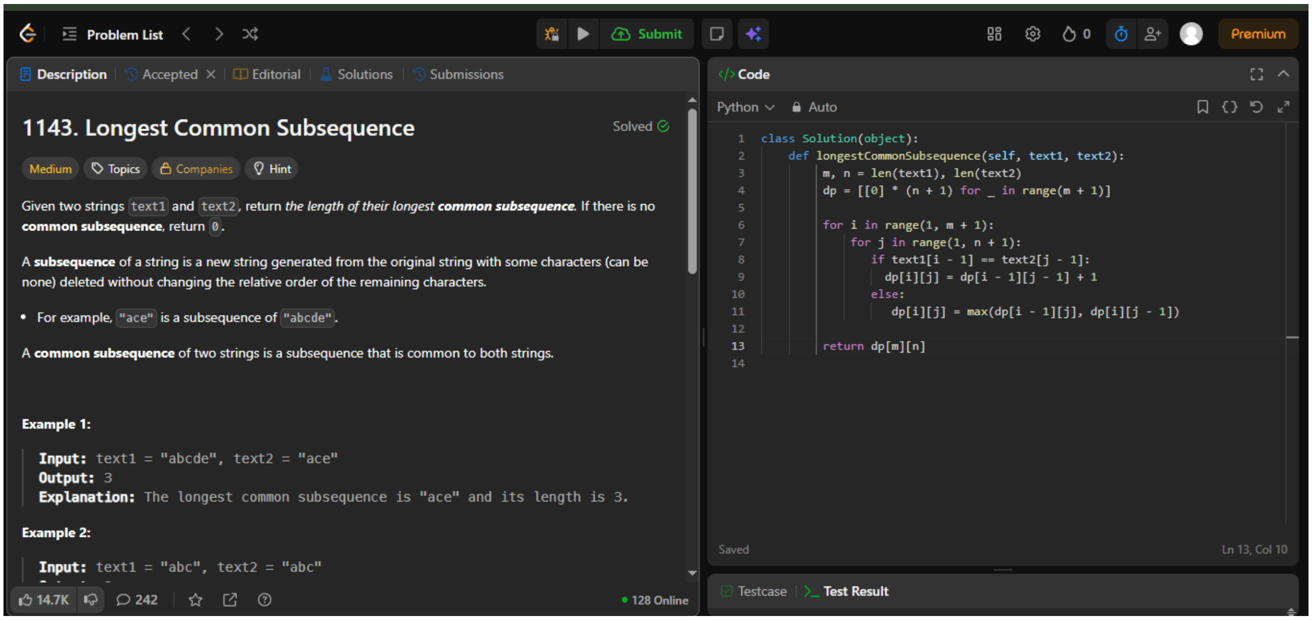
Accepted 47 / 47 testcases passed
anas_sk submitted at Oct 16, 2025 13:17

Runtime
527 ms | Beats 74.61%

Memory
33.86 MB | Beats 33.41%

Code | Python

```
class Solution(object):
    def longestCommonSubsequence(self, text1, text2):
        m, n = len(text1), len(text2)
        dp = [[0] * (n + 1) for _ in range(m + 1)]

        for i in range(1, m + 1):
            for j in range(1, n + 1):
                if text1[i - 1] == text2[j - 1]:
                  dp[i][j] = dp[i - 1][j - 1] + 1
                else:
                   dp[i][j] = max(dp[i - 1][j], dp[i][j - 1])

        return dp[m][n]

```



1143. Longest Common Subsequence

Given two strings `text1` and `text2`, return *the length of their longest* ***common subsequence***. If there is no **common subsequence**, return `0`.

A **subsequence** of a string is a new string generated from the original string with some characters (can be none) deleted without changing the relative order of the remaining characters.

- For example, `"ace"` is a subsequence of `"abcde"`.

A **common subsequence** of two strings is a subsequence that is common to both strings.

Example 1:

```
Input: text1 = "abcde", text2 = "ace"
Output: 3
Explanation: The longest common subsequence is "ace" and its length is 3.
```

Example 2:

```
Input: text1 = "abc", text2 = "abc"
```

```python
class Solution(object):
    def longestCommonSubsequence(self, text1, text2):
        m, n = len(text1), len(text2)
        dp = [[0] * (n + 1) for _ in range(m + 1)]

        for i in range(1, m + 1):
            for j in range(1, n + 1):
                if text1[i - 1] == text2[j - 1]:
                    dp[i][j] = dp[i - 1][j - 1] + 1
                else:
                    dp[i][j] = max(dp[i - 1][j], dp[i][j - 1])

        return dp[m][n]
```