DOMAIN WINTER WINNING CAMP ASSIGNMENT

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Semester: 5th

Day 8 : Dynamic Programming

Very Easy:

1. N-th Tribonacci Number

The Tribonacci sequence Tn is defined as follows:
T0 = 0, T1 = 1, T2 = 1, and Tn+3 = Tn + Tn+1 + Tn+2 for n >= 0.
Given n, return the value of Tn.

Example 1:
Input: n = 4
Output: 4
Explanation:
T_3 = 0 + 1 + 1 = 2
T_4 = 1 + 1 + 2 = 4

Example 2: Input: n = 25
Output: 1389537

Constraints: 0 <= n <= 37
The answer is guaranteed to fit within a 32-bit integer, ie. answer <= 2^31 - 1.

URL-https://leetcode.com/problems/n-th-tribonacci-number/description/?envType=problem-list-v2&envId=dynamic-programmin

CODE:

```
#include <iostream>
using namespace std;

int tribonacci(int n) {
    if (n == 0) return 0;
    if (n == 1 || n == 2) return 1;

    int t0 = 0, t1 = 1, t2 = 1;
```

```
    int t3 = 0;

    for (int i = 3; i <= n; ++i) {
        t3 = t0 + t1 + t2;
        t0 = t1;
        t1 = t2;
        t2 = t3;
    }

    return t2;
}

int main() {
    cout << tribonacci(4) << endl;  // Output: 4
    cout << tribonacci(25) << endl; // Output: 1389537
    return 0;
}
```

OUTPUT:

```
4
1389537
```

Easy:

2. Climbing Stairs

You are climbing a staircase. It takes n steps to reach the top. Each time you can either climb 1 or 2 steps. In how many distinct ways can you climb to the top?

Example 1: Input: n = 2
Output: 2
Explanation: There are two ways to climb to the top.
1. 1 step + 1 step
2. 2 steps

Example 2:Input: n = 3
Output: 3
Explanation: There are three ways to climb to the top.
1. 1 step + 1 step + 1 step
2. 1 step + 2 steps
3. 2 steps + 1 step

Constraints:1 <= n <= 45

URL-https://leetcode.com/problems/climbing-stairs/description/?envType=problem-list-

v2&envId=dynamic-programming

CODE:

```
#include <iostream>
using namespace std;

int climbStairs(int n) {
    if (n == 1) return 1;
    if (n == 2) return 2;

    int prev1 = 1, prev2 = 2;
    for (int i = 3; i <= n; ++i) {
        int current = prev1 + prev2;
        prev1 = prev2;
        prev2 = current;
    }
    return prev2;
}

int main() {
    cout << climbStairs(2) << endl;  // Output: 2
    cout << climbStairs(3) << endl;  // Output: 3
    cout << climbStairs(10) << endl; // Example for larger input
    return 0;
}
```

OUTPUT:

Medium:

3. Longest Palindromic Substring

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

Example 1: Input: s = "babad"
Output: "bab"
Explanation: "aba" is also a valid answer.

Example 2: Input: s = "cbbd"
Output: "bb"

Constraints: 1 <= s.length <= 1000

s consist of only digits and English letters.

URL- https://leetcode.com/problems/longest-palindromic-substring/description/?envType=problem-list-v2&envId=dynamic-programming

CODE:

```
#include <iostream>
#include <string>
using namespace std;

string longestPalindrome(string s) {
    int n = s.size();
    if (n == 0) return "";

    int start = 0, maxLength = 1;

    auto expandAroundCenter = [&](int left, int right) {
        while (left >= 0 && right < n && s[left] == s[right]) {
            int currentLength = right - left + 1;
            if (currentLength > maxLength) {
                start = left;
                maxLength = currentLength;
            }
            --left;
            ++right;
        }
    };

    for (int i = 0; i < n; ++i) {
        expandAroundCenter(i, i);       // Odd-length palindrome
        expandAroundCenter(i, i + 1);   // Even-length palindrome
    }

    return s.substr(start, maxLength);
}

int main() {
    cout << longestPalindrome("babad") << endl;  // Output: "bab" or "aba"
    cout << longestPalindrome("cbbd") << endl;  // Output: "bb"
    return 0;
}
```

OUTPUT:

Hard:

4. Maximal Rectangle

Given a rows x cols binary matrix filled with 0's and 1's, find the largest rectangle containing only 1's and return its area.

Example-

1	0	1	0	0
1	0	1	1	1
1	1	1	1	1
1	0	0	1	0

Input:matrix=
[["1","0","1","0","0"],["1","0","1","1","1"],["1","1","1","1","1"],["1","0","0","1","0"]]
Output: 6
Explanation: The maximal rectangle is shown in the above picture.
Example 2: Input: matrix = [["0"]]
Output: 0

Example 3: Input: matrix = [["1"]]
Output: 1

Constraints:
rows == matrix.length
cols == matrix[i].length
1 <= row, cols <= 200
matrix[i][j] is '0' or '1'.

URL-https://leetcode.com/problems/maximal-rectangle/description/?envType=problem-list-v2&envId=dynamic-programming

CODE:

```
#include <iostream>
#include <vector>
#include <stack>
using namespace std;

int largestRectangleArea(vector<int>& heights) {
    stack<int> s;
    heights.push_back(0); // Append a zero to handle remaining elements
    int maxArea = 0;
```

```
    for (int i = 0; i < heights.size(); ++i) {
        while (!s.empty() && heights[i] < heights[s.top()]) {
            int h = heights[s.top()];
            s.pop();
            int width = s.empty() ? i : (i - s.top() - 1);
            maxArea = max(maxArea, h * width);
        }
        s.push(i);
    }
    return maxArea;
}

int maximalRectangle(vector<vector<char>>& matrix) {
    if (matrix.empty()) return 0;

    int rows = matrix.size(), cols = matrix[0].size();
    vector<int> heights(cols, 0);
    int maxArea = 0;

    for (int i = 0; i < rows; ++i) {
        for (int j = 0; j < cols; ++j) {
            heights[j] = (matrix[i][j] == '1') ? heights[j] + 1 : 0;
        }
        maxArea = max(maxArea, largestRectangleArea(heights));
    }
    return maxArea;
}

int main() {
    vector<vector<char>> matrix = {
        {'1', '0', '1', '0', '0'},
        {'1', '0', '1', '1', '1'},
        {'1', '1', '1', '1', '1'},
        {'1', '0', '0', '1', '0'}
    };
    cout << maximalRectangle(matrix) << endl; // Output: 6

    vector<vector<char>> matrix2 = {{'0'}};
    cout << maximalRectangle(matrix2) << endl; // Output: 0

    vector<vector<char>> matrix3 = {{'1'}};
    cout << maximalRectangle(matrix3) << endl; // Output: 1

    return 0;
}
```

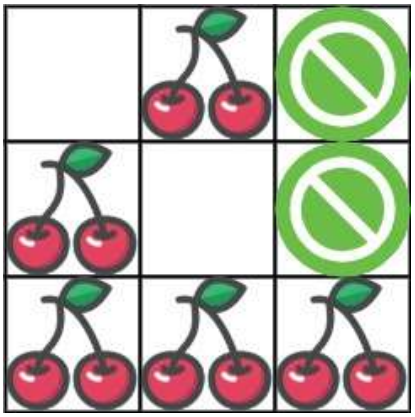
OUTPUT:

```
6
0
1
```

Very Hard:

5. Cherry Pickup

You are given an n x n grid representing a field of cherries, each cell is one of three possible integers.
0 means the cell is empty, so you can pass through,
1 means the cell contains a cherry that you can pick up and pass through, or
-1 means the cell contains a thorn that blocks your way.
Return the maximum number of cherries you can collect by following the rules below:
Starting at the position (0, 0) and reaching (n - 1, n - 1) by moving right or down through valid path cells (cells with value 0 or 1).
After reaching (n - 1, n - 1), returning to (0, 0) by moving left or up through valid path cells.
When passing through a path cell containing a cherry, you pick it up, and the cell becomes an empty cell 0.
If there is no valid path between (0, 0) and (n - 1, n - 1), then no cherries can be collected.



Input: grid = [[0,1,-1],[1,0,-1],[1,1,1]]
Output: 5
Explanation: The player started at (0, 0) and went down, down, right right to reach (2, 2).
4 cherries were picked up during this single trip, and the matrix becomes [[0,1,-1],[0,0,-1],[0,0,0]].
Then, the player went left, up, up, left to return home, picking up one more cherry.
The total number of cherries picked up is 5, and this is the maximum possible.

Example 2: Input: grid = [[1,1,-1],[1,-1,1],[-1,1,1]]
Output: 0

Constraints:

n == grid.length
n == grid[i].length
1 <= n <= 50
grid[i][j] is -1, 0, or 1.
grid[0][0] != -1
grid[n - 1][n - 1] != -1

URL-https://leetcode.com/problems/cherry-pickup/description/?envType=problem-list-v2&envId=dynamic-programming

CODE:

```
#include <iostream>
#include <vector>
#include <algorithm>
#include <climits> // Include this for INT_MIN

using namespace std;

int cherryPickup(vector<vector<int>>& grid) {
    int n = grid.size();
    vector<vector<vector<int>>> dp(n, vector<vector<int>>(n, vector<int>(n, INT_MIN)));
    dp[0][0][0] = grid[0][0];

    for (int t = 1; t <= 2 * (n - 1); ++t) {
        for (int x1 = min(n - 1, t); x1 >= max(0, t - (n - 1)); --x1) {
            for (int x2 = min(n - 1, t); x2 >= max(0, t - (n - 1)); --x2) {
                int y1 = t - x1, y2 = t - x2;
                if (y1 >= n || y2 >= n || grid[x1][y1] == -1 || grid[x2][y2] == -1) continue;

                int cherries = grid[x1][y1];
                if (x1 != x2) cherries += grid[x2][y2];

                int bestPrev = INT_MIN;
                for (int dx1 : {0, -1}) {
                    for (int dx2 : {0, -1}) {
                        int px1 = x1 + dx1, px2 = x2 + dx2;
                        if (px1 >= 0 && px2 >= 0 && px1 < n && px2 < n) {
                            bestPrev = max(bestPrev, dp[px1][t - px1][px2]);
                        }
                    }
                }

                if (bestPrev != INT_MIN) {
                    dp[x1][y1][x2] = bestPrev + cherries;
                }
            }
        }
    }
```

```
    return max(0, dp[n - 1][n - 1][n - 1]);
}

int main() {
    vector<vector<int>> grid1 = {
        {0, 1, -1},
        {1, 0, -1},
        {1, 1, 1}
    };
    cout << cherryPickup(grid1) << endl;  // Output: 5

    vector<vector<int>> grid2 = {
        {1, 1, -1},
        {1, -1, 1},
        {-1, 1, 1}
    };
    cout << cherryPickup(grid2) << endl;  // Output: 0

    return 0;
}
```

OUTPUT:

```
5
0
```